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DETERMINANTS OF FARMERS' INVESTMENTS IN SOIL FERTILITY MANAGEMENT AND CONSERVATION INNOVATIONS IN THE POTATO CROPPING SYSTEMS IN THE HIGHLANDS OF SOUTH-WESTERN UGANDA

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ABSTRACT

An allied project "Enabling Rural Innovations – ERI" was introduced in the potato farming systems in the highlands of south-western Uganda with the objective to empower farmers to invest in soil fertility management and conservation through enhanced knowledge in soil management and profitable market linkages. The objective of this paper was to assess the determinants in addition to enhanced farmers' knowledge and market linkages on farm households' decision to adopt soil fertility management and conservation innovations in potato grown fields. Household survey was conducted on 104 households that had consistently grown and sold potato in urban and non-urban markets in five consecutive years. It was revealed that enhancements of farmers' knowledge in soil fertility management and market linkages did not influence farmers' investments in soil fertility improving innovations. Nonetheless, enhancements influenced farmers' adoption of trenches and woodlots as mechanisms of controlling soil erosion and surface runoff within and outside potato grown fields, respectively. Adoption of soil fertility management and conservation innovations in potato grown fields was variously influenced by household characteristics other than the age of the household head. Number of soil fertility management and conservation innovations adopted by households was significantly influenced by household wealth category, number of field owned, household size and education level of the household head.

KEYWORDS: soil fertility, conservation, farmers' knowledge, market linkages, potato.

INTRODUCTION

Soil nutrient exhaustion and erosion have become a major concern in the highlands of south-western Uganda, as in many areas of sub Saharan Africa (SSA). Although soils in the highlands of south-western Uganda were once considered to be among the most fertile in the SSA [1], problems of soil nutrient exhaustion and erosion have intensified in recent decades. [2] estimated that soil nutrient losses in the highlands of south-western Uganda were among the highest in the country. This has led to low potato productivity, unsustainable land use and poverty among rural households [3].

In a survey conducted in 2001 in the highlands of south-western Uganda, more than half of farmers reported soil nutrient exhaustion, erosion and poor management as direct (proximate) causes of low soil fertility [4]. On the other hand, limited knowledge in soil fertility management and conservation and poor access to profitable markets were underlying causes of soil fertility decline and erosion [4].

In response, International Center for Tropical Agriculture (CIAT) in partnership with National Agricultural Research Organization (NARO) and Africare-Uganda, engaged potato farmers in a development and research project titled "Enabling Rural Innovations" [5].

Farmers were sensitized and trained in soil fertility management and conservation for sustainable potato production using farmers' field school approach. After two years of hands-on training and selecting appropriate soil fertility improving and conservation innovations, 120 households under the project had improved potato yields [6]. Project farmers were later linked to fast food restaurant (NANDOS) and other potato processing outlets in Kampala city located 350 km away from farmers [6]. Through Memorandum of Understanding between potato producers and processors, 5.6 ton of potato tubers were sold every fortnight to urban markets at relatively higher prices compared to non-urban markets [5]. Hence, this research was conducted to assess the determinants that influence farmers' adoption of soil fertility management and conservation innovations under urban and non-urban market linkages.

Sampling procedure and sample size

Among the 120 households with urban market linkages, 76 households had consistently supplied potato to the market for at least five consecutive years. Hence, 68 households were purposively selected using a formula adopted from [10] after cluster analysis based on wealth categories (Eq. i). On the other hand, all the 46 households that consistently produced potato for non-urban markets were considered for interviews.

$$n = \frac{N}{[1 + N(e)^2]} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (Eq. i)$$

Where; n – sample size
N – Population size
e – Level of significance

$$n = \frac{76}{[1 + 76(0.05)^2]} = 68$$

Data collection

Focus Group Discussions (FGDs) and household surveys were conducted to capture data on household characteristics as well as nature and number of soil fertility management and conservation innovations used by the households in potato grown fields. The data captured included (i) types of farmer-market access, (ii) wealth endowment of the household, (iii) sex of the household head, (iv) age of the household head, (v) education level of the household head, (vi) household size, (vii) use of hire labor, and (viii) number of potato grown fields. During FGDs, household typologies were developed based on stratified according to wealth categories and gender. Criteria used for placement of households in different wealth categories were (i) nature of the main house, (ii) possession of farm animals, (iii) number of fields owned, (iv) nature of schools attended by children, (v) number of meals per day eaten, (vi) nature of transport used, and (vii) number of bags of potato harvested.

Data analyses

Household characteristics and soil fertility management and conservation data were subject to an extensive data cleaning process for consistency, completeness and correctness. Consistency checking included systematic reviewing to avoid data duplications. Data were entered into Microsoft Excel spreadsheet for cleaning and management. For instance, some categories were re-categorized or collapsed, depending on inconsistencies or similarities observed.

Using the R-statistical package, descriptive statistics that included frequencies, percentage distributions, and comparison of means were evaluated. Assessment of categorical data for demographic characteristics of was done by percentage and standard errors of distributions using cross-tabulations. The level of significance was determined by standard errors of means. The independent variables were market types, wealth categories of households, use of hired labor, characteristics of the household head (gender, age, education level, marital status) and household size. The dependent variables included use of soil fertility improving and conservation innovations. A decision tree forest model was developed to assess the influence of different factors on farmers' decision to adopt one or more soil fertility management and conservation innovations. Hence, multiple regression analysis was used to understand the determinants of adoption of soil fertility management and conservation innovations in the highlands of south-western Uganda (Eq. ii). During the analysis, the predictor variables that were not significant were eliminated to get the best fit model.

$$\gamma = (\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n) + \mathcal{E}_1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . (Eq. ii)$$

Where,

$\gamma = Predicted\ outcome\ variable$

$\beta_0 = intercept$

$\beta_1 = Coefficient\ of\ the\ first\ predictor\ (x_1)$.

$\beta_2 = Coefficient\ of\ the\ second\ predictor\ (x_2)$

$\beta_n = Coefficient\ of\ the\ nth\ predictor\ (x_n)$

$\mathcal{E}_1 = Difference\ between\ the\ predicted\ and\ the\ observed\ value\ of\ \gamma.$

Results and discussion

Influence of household characteristics on adoption of soil fertility management and conservation innovations. Adoption of soil fertility management and conservation innovations in the highlands of south-western Uganda was affected by socioeconomic factors at different levels (Table 1). Age of the household head had no significant influence on farmers adoption of any of the seven promoted soil fertility management and conservation innovations (p>0.05). Enhancing farmers' knowledge and skills in soil nutrient management and conservation as well as linkage to urban markets had significant influence on farmers' adoption of woodlots and trenches ($p<0.05$).

Table 1: Effects of socioeconomic factors on use of soil fertility management and conservation innovations under urban and non-urban market linkages.
(See table after references)

It had no significant influence on the adoption of the five of seven soil fertility management and conservation innovations promoted in the highlands ($p>0.05$). Potato is grown on the hill-slopes during the rain seasons while in the dry seasons potato production occurs in the valley bottoms. Soil erosion is mostly on hill-slopes and farmers under urban market linkages use trenches within potato grown fields.

Highly degraded fields were often bare and experienced gully erosion. In order to reduce damage in potato grown fields, woodlots were planted on the highly degraded fields to slow down surface runoff and erosion in potato fields on lower hill-slopes. Household wealth category had significant influence on farmers' adoption of mineral fertilizers, woodlots, trenches, agro-forestry and fallows ($p<0.05$). Resource rich households had relatively more land on which to practice some of the soil fertility management and conservation innovations that required space. Such household could also afford mineral fertilizers for potato production. On the other hand, resource poor households had limited land on which to construct soil conservation barriers and could afford expensive mineral fertilizers. Hence, such households could not integrate some of the innovations such as mineral fertilizers, fallows, trenches, agro-forestry and woodlots in potato growing systems. Therefore, resource poor households continually planted potato without significantly applying any soil fertility and conservation innovations. Gender had significantly influence on farmers' adoption of trenches as a measure against soil erosion and surface runoff ($p<0.05$). Land was owned by men who access and use. Land in the highlands of south-western Uganda like all other areas of the country is owned through purchase, rent (lease) and inheritance. Land is often inherited by men and therefore women have limited ownership, access and use of the land. Construction of trenches was labor intensive and required specialized tools such as spades and pick axes.

Male headed households had more resources compared to the female headed households and therefore could afford to use trenches as soil conservation measure in potato grown fields. Nonetheless, gender had significant influence in the use of the other six soil fertility and conservation innovations in the potato grown fields ($p>0.05$).

Education level of the household head had significant influence on farmers' adoption of mineral fertilizers, woodlots, trenches, agro-forestry and fallows ($p<0.05$). Household heads with post-primary education often were able to comprehend literal extension materials given out during training. They took longer period in school and therefore had classroom and practical lessons in soil fertility management and conservation. The interface between extension workers and such farmers was often longer and therefore more knowledge and skills were given to them.

Household size had significant influence on farmers' adoption of agro-forestry ($p<0.05$). However, it did not have significant influence on farmers' adoption of the other soil fertility management and conservation innovations ($p>0.05$). Agro-forestry also was observed as source of timber, wood fuel, poles and stakes. Therefore, it was an additional source of household income to cater for the demands of large household sizes. Harvesting poles, stakes and fuel wood which had immediate use required labor. Labor was often more available with households with more family members to work on the highly fragmented fields located on undulating landscape.

Use of hired labor and number of fields cultivated had significant influence on adoption of farmyard manure, mineral fertilizers, trenches, agro-forestry and fallows as means for improving soil fertility and conserving the soils ($p<0.05$). Also adoption of woodlots was significantly influenced by number of fields. Use of hire labor was one of the indicators for wealth endowments of the households. Therefore households that were able to hire labor had resources to use these soil fertility management and conservation innovations. Use of fallows, trenches and woodlots required farmers to have adequate land. For instance, construction of trenches required one meter width in which to use and trenches were constructed at intervals within the field. On the other hand, woodlots occupied land for years before that land is brought back to cultivation. Similarly, use of fallow as means of soil fertility rejuvenation required farmers to put the land to rest for a number of seasons without cultivation. Nonetheless, the fallow period is often one or two seasons under natural fallows, which is commonly used. Given that most farmers hardly used any mineral fertilizers, short fallow periods continually led to soil nutrient mining and erosion in the highlands of south-western Uganda. Farmers with limited number of fields placed them under continuous cultivation without rest and hardly used any of the seven promoted soil fertility and conservation innovations. These practices exacerbated soil degradation in form of soil nutrient mining and erosion and explain the low potato yields in the highlands of south-western Uganda [7].

Adoption of trenches was significantly influenced by number of cultivated fields, use of hired labor, education level of the household head, gender of the household head and household wealth category ($p<0.05$). Trenches, an innovation for soil conservation required reservation of strips of land to be constructed. Effectiveness of trenches as soil conservation measures in potato grown fields depended on their number, size and spacing between them. This measure for soil conservation was not adopted by farmers with few fields to compensate land taken by trenches. Construction of trenches required hired labor and specialized tools such as pick-axes and spades. Hence, trenches were often used by resource rich households that had the capacity to use hired labor and specialized tools. Use of trenches was common in potato grown fields for household heads with post-primary education. Farmers with post-primary education were able to adopt the use of trenches in potato grown fields because they were able to read and comprehend extension literal materials as guides to construct soil conservation measures in the field. Such farmers often consulted extension workers for guidance. They also learnt about soil conservation while in school. Hence, the grasp of knowledge in soil conservation depended on the length of time farmers got exposed while in schools. Gender of the household head was an important factor in adoption of trenches as soil conservation measure in potato grown fields. Land in the highlands of south-western Uganda like elsewhere in Uganda, mostly belonged to men. Therefore men often had ownership, access and use of the land compared to women. Furthermore male headed households had more land compared to female headed households. Since trenches required land their construction, they were more common with the male headed households. Female headed households were often more constrained in terms of resources. Therefore low adoption of trenches like any other soil fertility management and conservation innovations was observed in female headed households.

Enhancing farmers' knowledge in soil nutrient management and market linkages had no significant influence on adoption of farmyard manure, mineral fertilizers, agro-forestry, grass bunds and fallows ($p>0.05$). Nonetheless, adoption of farmyard manure was significantly influenced by use of hired labor, education level of the household head and number of cultivated fields ($p<0.05$). Farmyard manure was bulk in nature and required intensive use of labor to use it under highly land fragmentation that existed in the highlands of south-western Uganda [11]. Use of labor was associated with households that were resource rich to pay workers and also had livestock for manure production. Keeping livestock also required land and knowledge or skills. Hence, use of farmyard manure in potato grown fields was common with households with more fields in which to use the material other than providing space for keeping livestock or producing pastures. Use of farmyard manure was more profitable with households that had large number of fields due to high costs of labor. Farmers with post-primary education were able to use farmyard manure in potato grown fields due to experiences and skills gained while in schools. They were able to apply it for the benefit of potato grown.

Influence of wealth endowment on number of soil fertility management and conservation innovations adoption under urban and non-urban market linkages.

Wealth endowment had significant influence of the number of soil fertility management and conservation under urban marker linkages ($p<0.05$). On the other hand under non-urban market linkages, number of soil fertility management and conservation innovations adopted by households were not significantly different ($p>0.05$). There were high proportions of households that were resource constrained under with the urban market linkages that did not adopt any of the seven promoted soil fertility management and conservation innovations (Table 3). This was because some of the promoted innovations required farmers to have some land to spare and also to have resource to use the innovations. For example use of farmyard manure required the households to have either livestock to produce manure or resources to purchase the manure from off-farm. Further land in the highlands of south-western Uganda was highly fragmented with no access roads. This required hired labor to carry manure and incorporate it into the soil, making it less affordable to most households.

Table 2: Influence of wealth category on number of soil fertility management and conservation innovations used by households under urban and non urban market linkages.
(See table after References)

Farmers under urban market linkages used a number of alternatives in an effort to improve soil fertility and conserve soils depending on the resources at their disposal. Majority of the households were able to use two of the seven promoted soil fertility management and conservation innovations. Resource rich households were able to adopt up to seven soil fertility management and conservation innovations compared to other categories of households. Resource constrained households hardly used any of the promoted soil fertility management and conservation innovations due to high prices, low availability and limited land to use [12].

Influence of gender on number of soil fertility management and conservation innovations adoption under urban and non-urban market linkages.

Number of soil fertility management and conservation innovations adopted by households was not significantly influenced by gender under urban market linkages ($p>0.05$). On the other hand, gender had significant influence on the number of soil fertility management and conservation innovations adopted by the household under non-urban market linkages ($p<0.05$). The highest proportion of the female headed households (38.5 %) adopted none of the seven promoted soil fertility management and conservation innovations (Table 3). Female headed households often had limited resources in terms of land and livestock for manure production. They were also unable to purchase them. This was because they constrained in terms of resources and therefore could not afford to use the most of the promoted soil fertility management and conservation innovations [13]. In the highlands of south-western Uganda as elsewhere in the county, customs assigned home and reproductive roles to women, which limited their commercial potential and therefore not investing in soil fertility management and conservation innovations. They most produced potato for home consumption rather for household income.

On the other hand, the highest proportion of the male headed household (30.3 %) adopted one of the seven soil fertility management and conservation innovations. None of the male or female headed households adopted all the seven soil fertility management and conservation innovations. Farmers often had logical decisions to adopt a number of soil fertility management and conservation innovations depending on the resources available and how these can perform with niches where potato was grown.

Education level of the household head had significant influence on the number of soil fertility management and conservation innovations adopted by the households ($p<0.05$). High proportions of household heads without formal education under urban (36.4 %) and non-urban (45.0%) market linkages adopted none of the seven promoted soil fertility management and conservation innovations

(Table 4). Under non-urban market linkages, most household heads without formal education adopted one (36.8 %) and four (26.3 %) of the seven promoted soil fertility management and conservation innovations. Lack of education, which is often associated with poverty, was a disincentive to farmers' adoption of soil fertility management and conservation innovations. Lack of education caused farmers to be less aware of soil degradation problems and often attributed challenges of soil degradation beyond their control. Lack of education led to low farmers' skills in addressing challenges associated with soil nutrient decline and erosion.

Table 3: Influenced of gender on numbers of soil fertility management and conservation innovations used by households under urban and non-urban market linkages.

Table 4: Influence of education on number of soil fertility management and conservation innovations used by households under urban and non-urban market linkages.
(See table after references)

Socioeconomic factors that best described the model that favored farmer's adoption of at least one of the seven promoted soil fertility management and soil conservation innovations were (i) market type, (ii) age of the household head, and (iii) wealth category of the household and household size (Eq. iii).

$$In_1 = \beta + MrktType + Age + WC + HHSize + \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (eq. iii)$$

Where:

$In_1 = At\ least\ one\ soil\ fertility\ management\ and\ conservation\ innovation\ adopted$

$\beta = Intercept$

$MrktType = Market\ type$

$Age = Age\ of\ the\ household\ head$

$WC = wealth\ category\ of\ the\ household$

$HHSize = Household\ size$

$\varepsilon_i = Residual\ term$

Adoption of at least one of the seven promoted soil fertility management and conservation was significantly influenced by (i) wealth category of the household, (ii) education level of the household head, and (iii) household size (Table 5).

Table 5: Influence of socioeconomic factors on farmers' adoption of at least one of the soil fertility management and conservation innovations promoted.

Factor	Estimate	Std. error	Z-value	Pr(>|z|)
Intercept	3.0772	1.5887	1.937	0.05276
Market type	1.2555	0.7377	1.702	0.08878
Age	-1.7371	0.9217	-1.885	0.05948
Wealth category	-1.1190	0.4353	-2.570	0.01016 *
Education	3.3408	1.0734	3.112	0.00186 **
Household size	2.1964	0.8696	2.526	0.01155 *
Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				

At least one of the seven soil fertility management and conservation innovation promoted was most likely adopted by households with more resource, post-primary education and large families.

Socioeconomic factors that best describe the model that favor adoption of at least three soil fertility management and conservation innovations were (i) market type, (ii) age of the household head, (iii) number of fields, and (iv) wealth category of the household (**Eq. iv**)

$$In_3 = \beta + MrktType + Age + Fields + WC + \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (eq. iv)$$

$Where,$

In_3 = *At least three soil fertility management and conservation innovations adopted*

$\beta = Intercept$

$MrktType = Market\ type$

$Age = Age\ of\ the\ household\ head$

$Fields = Total\ number\ of\ fields\ owned$

WC = *Wealth category of the household*

$\varepsilon_i = Residual\ term$

Socioeconomic factors that led to significant adoption of at least three soil fertility management and conservation innovations were (i) wealth category of the household, and (ii) number of fields owned by the household ($p<0.05$). Nonetheless, types of farmer-market linkages and age of the household head had no significant influence on adoption of at least three soil fertility management and conservation innovations ($p>0.05$). Hence, wealth endowment of the household and number of fields owned by the households were significant factors in farmer's decisions to adopt at three soil fertility management and conservation innovations.

Table 6: Influence of socioeconomic factors on farmers' adoption of at least three soil fertility management and conservation innovations

Factor	Estimate	Std. error	Z-value	Pr(>|z|)
Intercept	0.2313	0.8623	0.268	0.788470
Market type	0.6946	0.5114	1.358	0.174384
Age	0.2613	0.5167	-0.506	0.613061
Number of fields	2.0098	0.5311	3.785	0.000154 ***
Wealth category	-0.5663	0.2571	-2.202	0.027644 *
Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				

Enhanced farmers' knowledge and skills in soil fertility management and conservation did not significantly influence farmers' adoption of at least three of the promoted soil fertility management and conservation innovations (p>0.05). Resource rich households with more fields were more likely to adopt at least three soil fertility management and conservation innovations compared to their counterparts with few. Likewise households constrained with resources were less likely to adopt at least three soil fertility management and conservation innovations.

On the other hand, adoption of at least four soil fertility management and conservation innovations were best determined by (i) type of farmer-market linkages, (ii) wealth category of the household, and (iii) number fields owned by the household (**Eq. v**).

$$In_3 = \beta + MrktType + fields + WC + \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (Eq. v)$$

$Where,$

In_3 = *At least four soil fertility management and conservation innovations adopted*

$\beta = Intercept$

$MrktType = Market\ type$

$Fields = Total\ number\ of\ fields\ owned$

WC = *Wealth category of the household*

$\varepsilon_i = Residual\ term$

Nonetheless, wealth category of the households had high significant influence on farmers adoption of at least four soil fertility management and soil conservation innovations (p<0.05) (**Table 7**). Hence, four soil fertility management and conservation innovations were most likely to be adopted by resource rich households compared to other wealth categories. This was mainly associated with cost of the innovations, hired labor and high number of fields that were often afforded by the resource rich households.

Table 7: Influence of socioeconomic factors on farmers' adoption of at least four soil fertility management and conservation innovations.

Factor	Estimate	Std. error	Z-value	Pr(>|z|)
Intercept	0.1654	0.8091	0.204	0.8381
Market type	0.2632	0.4776	0.551	0.5816
Wealth category	-0.5271	0.2446	-2.155	0.0312 *
Number of fields	0.2495	0.5142	0.485	0.6275
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				

CONCLUSIONS

In view of the data and analysis, it can be concluded as follows:

- Enhancing farmers' knowledge in soil fertility management and conservation and increasing their access to urban profitable markets did not increase farmers' adoption of soil fertility management innovations. However, it had significant influence on adoption of woodlots and trenches as measures to control soil erosion coming into and within potato grown fields.
- Farmers had a choice of numbers of soil fertility management and conservation innovations to use in potato production systems in the highlands of south-western Uganda. The number of soil fertility management and conservation innovations adopted depended majorly on household wealth category, household size, number of fields owned, gender and education level of the household head. On the other hand, enhancing farmers' knowledge and linking them to profitable urban markets did not significantly influence on the number of soil fertility management and conservation innovations adopted by farmers.

REFERENCES

[1] E. M. Chenery, An introduction to the soils of the Uganda Protectorate. Memoirs of the Research Division, Department of Agriculture, series 1, no. 1. Kampala, Uganda: Department of Agriculture. 1960.

[2] S. M. Nandwa and M. A. Bekunda, "Research on nutrient flows and balances in East and Southern Africa: state-of-the-art.," Agric. Ecosyst. Environ., vol. 71, p. 5–18., 1998.

[3] R. Muzira, J. S. Tenywa, and T. Basamba, "Linking Soil Conservation in Potato Production Systems in the Highlands of Southwestern Uganda to Gender and Farmer-Market Types," OALib, vol. 05, no. 04, pp. 1–10, 2018.

[4] D. Sserunkuuma and J. Pender, "Land Management in Uganda : Characterization of Problems and Hypotheses about Causes and Strategies for Improvement Project on Policies for Improved Land Management in Uganda," 2001.
[5] S. and E. K. Ferris, Linking farmers to markets : the Nyabyumba potato farmers in Uganda. Highlight No. 22. CIAT in Africa, no. 22. 2005, p. 2.
[6] S. Kaaria, A. Abenakyo, W. Alum, F. Asiimwe, R. Best, C. Chisike, R. Delve, D. Gracious, I. Kahiu, E. Kaganzi, R. Muzira, G. Nalukwago, J. Njuki, and N. Sangole, "Enabling Rural Innovation: Empowering Farmers to take advantage of Market Opportunities and improve livelihoods," 2008.
[7] E. Nkonya, "Soil conservation practices and non -agricultural land use in t he south western highlands o f Uganda," no. April, 2002.
[8] P. Mbabazi, R. Bagenda, and R. Muzira, "Participatory Land Degradation Assessment in the Highlands of Kabale District , Southwestern Uganda Report," 2003.
[9] NEMA, Environmental Sensitivity Atlas for the Albertine Graben., vol. Second Edi. 2010.
[10] U. Diwekar and A. David, "Uncertainty Analysis and Sampling Techniques," in BONUS Algorithm for Large Scale Stochastic Nonlinear Programming Problems SE - 2, Springer New York, 2015, pp. 9–25.
[11] A. a Laudati, "The encroaching forest: Struggles over land and resources on the boundary of Bwindi Impenetrable National Park, Uganda," Soc. Nat. Resour. An Int. J., vol. 23, no. 8, pp. 776–789, 2010.
[12] N. Sanginga and P. L. (Eds. . Woomer, Integrated Soil Fertility Management in Africa: Principles, Practices and Developmental Process. 2009.
[13] J. N. Chianu, J. N. Chianu, and F. Mairura, "Mineral fertilizers in the farming systems of sub-Saharan Africa. A review," Agron. Sustain. Dev., vol. 32, no. 2, pp. 545–566, 2012.

Table 1: Effects of socioeconomic factors on use of soil fertility management and conservation innovations under urban and non-urban market linkages.															
		FYM		Fertilizers		Woodlots		Trenches		Agro-forestry		Grass bunds		Fallows	
Factor	Definition	X^2	p-value	X^2	p-value	X^2	p-value	X^2	p-value	X^2	p-value	X^2	p-value	X^2	p-value
Market type	Type of market accessed by farmers	0.01	0.973	1.045	0.307	5.740	0.017	4.768	0.029	1.559	0.212	0.131	0.195	0.052	0.608
Wealth category (WC)	Household typology based on WC	0.001	0.973	12.619	0.006	10.975	0.012	12.294	0.006	46.576	0.000	6.040	0.110	21.265	0.000
Gender	Household typology based on gender	0.04	0.950	0.013	0.910	0.044	0.834	7.916	0.005	3.688	0.055	0.006	0.940	2.148	0.143
Age	Age of the household head	3.145	0.208	4.122	0.127	1.871	0.392	0.878	0.645	1.795	0.408	0.654	0.721	0.028	0.963
Education	Education level of the household head	6.046	0.049	8.264	0.016	11.476	0.003	7.174	0.028	7.293	0.026	3.221	0.200	4.638	0.047
Household size	Number of household members	3.237	0.198	4.998	0.082	3.222	0.200	0.459	0.795	11.760	0.003	2.359	0.307	0.557	0.757
Hired labor	Use of hired labor	7.168	0.007	7.243	0.007	1.948	0.163	4.149	0.042	7.056	0.008	5.326	0.021	4.965	0.026
No. of fields	Fields cultivated	8.287	0.040	10356	0.016	10.423	0.015	10.086	0.018	12.769	0.005	14.642	0.002	9.823	0.020

Table 2: Influence of wealth category on number of soil fertility management and conservation innovations used by households under urban and non urban market linkages.

Number of innovations	Non-urban								Urban						
	Rich	Moderate	Poor	very poor	Total	X^2	p-Value		Rich	Moderate	Poor	very poor	Total	X^2	p-Value
None of the seven innovations	0.0	22.2	14.3	43.8	23.9	24.480	0.140		0.0	0.0	21.4	46.2	17.6	35.140	0.011
One of the seven innovations	14.3	11.1	28.6	31.2	23.9				0.0	13.3	0.0	15.4	7.8		
Two of the seven innovations	28.6	11.1	28.6	6.2	17.4				22.2	20.0	21.4	23.1	21.6		
Three of the seven innovations	0.0	0.0	7.1	12.5	6.5				0.0	20.0	21.4	7.7	13.7		
Four of the seven innovations	28.6	33.3	21.4	0.0	17.4				33.3	13.3	7.1	7.7	13.7		
Five of the seven innovations	14.3	0.0	0.0	6.2	4.3				11.1	33.3	28.6	0.0	19.6		
Six of the seven innovations	14.3	22.2	0.0	0.0	6.5				11.1	0.0	0.0	0.0	2.0		
All of the seven innovations	0.0	0.0	0.0	0.0	0.0				22.2	0.0	0.0	0.0	3.9		

Table 3: Influenced of gender on numbers of soil fertility management and conservation innovations used by households under urban and non-urban market linkages.

Number of innovations	Non-urban						Urban				
	Male Headed house	Female headed house	Total	X^2	p-Value		Male Headed house	Female headed house	Total	X^2	p-Value
None of the seven innovations	18.2	38.5	23.9	7.101	0.011		15.6	21.1	17.6	7.550	0.374
One of the seven innovations	30.3	7.7	23.9				9.4	5.3	7.8		
Two of the seven innovations	15.2	23.1	17.4				18.8	26.3	21.6		
Three of the seven innovations	9.1	0.0	6.5				6.2	26.3	13.7		
Four of the seven innovations	15.2	23.1	17.4				15.6	10.5	13.7		
Five of the seven innovations	3.0	7.7	4.3				25.0	10.5	19.6		
Six of the seven innovations	9.1	0.0	6.5				3.1	0.0	2.0		
All of the seven innovations	0.0	0.0	0.0				6.2	0.0	3.9		

Table 4: Influence of education on number of soil fertility management and conservation innovations used by households under urban and non-urban market linkages.

Number of innovations	Non-urban							Urban					
	No formal education	Primary	Post primary	Total	X^2	p-Value		No formal education	Primary	Post primary	Total	X^2	p-Value
None of the seven innovations	45.0	10.5	0.0	23.9	21.093	0.049		36.4	0.0	33.3	17.6	24.259	0.043
One of the seven innovations	15.0	36.8	14.3	23.9				4.5	7.7	33.3	7.8		
Two of the seven innovations	15.0	15.8	28.6	17.4				22.7	23.1	0.0	21.6		
Three of the seven innovations	10.0	5.3	0.0	6.5				22.7	7.7	0.0	13.7		
Four of the seven innovations	10.0	26.3	14.3	17.4				4.5	23.1	0.0	13.7		
Five of the seven innovations	5.0	0.0	14.3	4.3				4.5	30.8	33.3	19.6		
Six of the seven innovations	0.0	5.3	28.6	6.5				0.0	3.8	0.0	2.0		
All of the seven innovations	0.0	0.0	0.0	0.0				4.5	3.8	0.0	3.9		