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Awareness and Adoption of Soil and Water Conservation Technologies in a Developing Country: A Case of Nabajuzi Watershed in Central Uganda

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Abstract Soil and water conservation technologies have been widely available in most parts of Uganda. However, not only has the adoption rate been low but also many farmers seem not to be aware of these technologies. This study aims at identifying the factors that influence awareness and adoption of soil and water conservation technologies in Nabajuzi watershed in central Uganda. A bivariate probit model was used to examine farmers' awareness and adoption of soil and water conservation technologies in the watershed. We use data collected from the interview of 400 households located in the watershed to understand the factors affecting the awareness and adoption of these technologies in the study area. Findings indicate that the likelihood of being aware and adopting the technologies are explained by the age of household head, being a tenant, and number of years of access to farmland. To increase awareness and adoption of technologies in Uganda, policymakers may expedite the process of land titling as farmers may feel secure about landholding and thus adopt these technologies to increase profitability and productivity in the long run. Incentive payments to farmers residing in the vulnerable region to adopt these considered technologies may help to alleviate soil deterioration problems in the affected area.

Keywords Bivariate probit · Household data · Land tenure · Watershed

Introduction

Countries in the Sub-Saharan Africa have low agricultural productivity partly due to the deterioration of the natural resources (Bationo et al. 2007). Land as a natural resource faces degradation due to soil erosion and also because of nutrient depletion when there is little or no replenishment. Farmers in the region have been expanding their crop cultivated area as a way to respond to lower production. This expansion forces some farmers to encroach on marginal areas, such as wetlands, steep hill slopes, forests, river banks and lake shores leading to soil erosion, nutrient mining and loss during harvest time (Jayne et al. 2014). Viable options for sustainable land management practices are urgently needed to enable farmers to increase soil and water conservation (SWC), restore degraded lands, prevent further land degradation and enhance food security (DSIP 2010/11–2014/15; Zegeye et al. 2010).

Land degradation is a serious problem in Lake Victoria basin, as well as most of the other parts of Uganda (NEMA 2007). There has been the dissemination of many SWC practices in Uganda through the Uganda Strategic Investment Framework for Sustainable Land Management (2010–2020) by the Ministry of Agriculture, Animal Industry, and Fisheries (MAAIF). A component in the MAAIF was established to scale-up proven best land management practices in the targeted fragile and high-risk areas that have experienced accelerated land degradation in the form of soil erosion and nutrient depletion. The major

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best management practices promoted are mulching, contour ridging, terracing, agroforestry, conservation agriculture, integrated nutrient management, and grass barrier strips. The MAAIF mandate emphasizes promotion and adoption of these best management practices commonly known as SWC practices (DSIP 2010/11–2014/15). Nabajuzi watershed is one of the vulnerable watersheds that have experienced accelerated land degradation, so it would benefit from adoption of SWC practices. However, despite the promotion of these SWC practices in vulnerable areas, their adoption remains low.

This study aims at examining the factors affecting awareness and adoption of SWC practices in Nabajuzi watershed in central Uganda. The specific practices considered in this study are mulching, contour ridging, deep tillage, grass barrier strips, and trash lines.

This paper is organized as follow. In section "Literature Review", the literature review on adoption of agricultural technologies and a conceptual model is presented. Section "Research Method" describes study area, data collection method, econometrics model used, data analysis techniques, and provides details on SWC practices considered in this paper. Section "Results and Discussions" presents the results and discussions. Finally, the last section concludes the paper.

Literature Review

By definition, adoption is an innovation-decision process involving a series of steps through which decision-making units pass from the time of awareness of the new technology to the time they adopt the technology. The adoption process is divided into five stages: knowledge (awareness), persuasion, decision, implementation, and confirmation (Prokopy et al. 2008).

In this study, adoption of SWC technologies is defined as the presence of any of the SWC technologies at the farmer's fields (Sanginga et al. 2007). Adoption of innovations at the farm level has been modeled mostly by assuming that economic agents face two decision alternatives: adopt or not. The smallholder farmers' decisions to adopt a technology are affected by the availability of information, economic, institutional, bio-physical factors, perceptions, attitudes, and household's socio-economic characteristics (Moyo et al. 2007).

The variables used in this study are those which are considered to influence conservation agriculture adoption (Knowler and Bradshaw 2007; Prokopy et al. 2008). These factors are grouped into four categories: farmer and farm household characteristics, farm biophysical characteristics, farm financial/management characteristics, and exogenous factors. Farmer's age, education level, gender, awareness, and years of accessibility of farmland fall in the first category. Farm size, slope, and land quality fall in the second category. Land ownership and family size (a proxy for family labor) fall in the third category, and the last category had an attendance of training by a farmer. It is expected that the factors used in agricultural technology adoption have similar effects on SWC technologies in Nabajuzi watershed in Uganda.

Farmer and Farm Household Characteristics

The education level of the household head, age, gender, and awareness significantly influence the adoption of new agricultural technologies (Bayard et al. 2007; Knowler and Bradshaw 2007). Education of the household head is expected to increase the adoption of SWC technologies because educated farmers have better access to new information, since they can read and write (Mugonola et al. 2013). Arslan et al. (2014) indicate that education and training positively and significantly influence adoption of SWC, such as crop rotation in Zambia. However, more educated farmers may devote most of their time into off-farm employment than in farming thereby decreasing adoption of agricultural technologies. Pender et al. (2006) point out that farmers who had completed primary education were less likely to apply manure and mulch compared with their non-educated counterparts according to their study carried out in Eastern Uganda.

Age of the farmer influences adoption of new agricultural technologies. Age can either positively or negatively influence technology adoption. It is argued that risk aversion goes up as farmers advance in age and they become less likely to adopt any given new technology. Age variable is expected to negatively affect the adoption of technologies (Baumgart-Getz et al. 2012).

Gender significantly influences technology adoption (Sanginga et al. 2007). Female and male farmers play different roles in technology adoption depending on the nature of the technology. In the highlands of South Western Uganda, most conservation measures require high physical labor input and therefore the gender division of labor is found significant as the men build conservation structures while women devote themselves to production and farm maintenance (Mugonola et al. 2013).

Farmers' awareness of the soil problems on their farms is more likely to influence their adoption of soil conservation technologies (Lemke et al. 2010; Obubuafo et al. 2008). In conservation agriculture, adoption awareness has played a significant role in its uptake and dissemination (Knowler and Bradshaw 2007). Farmers' experience can either increase or decrease their confidence in the uptake of new technology then they decide on to adopt a new technology or not (Knowler and Bradshaw 2007).

Farm Biophysical Characteristics

Land size and tenure security have been reported to influence adoption of new technologies. Farm size could have a positive, negatively significant, or insignificant effect on agricultural technology adoption (Knowler and Bradshaw 2007).

Land terrain/slope or land quality are known to influence technology adoption. If farming operations are carried out within steep slopes, there is a high probability of land management technology adoption. The steepness of the farmland is expected to influence technology adoption. Steeper slopes expected to positively and significantly influence SWC technology (Amsalu and De Graaff 2007). Land quality is expected to positively affect conservation decision by a farmer (Mango et al. 2017). Similarly, if farm operations are carried out on poor land quality that has been eroded, there is a high probability of adopting soil conservation technologies (Knowler and Bradshaw 2007).

Farm Management/Financial Characteristics

Family size is used as a proxy for family labor and is expected to positively or negatively influence technology adoption. Big family size may become reluctant about providing labor required in the running of the technology, or big family size may provide adequate labor demanded as most of the technologies are labor intensive (Amsalu and De Graaff 2007).

Similarly, Amsalu and De Graaff (2007) reported that adoption of stone terraces for SWC is significantly influenced by farmer's age, farm size, anticipated profitability from technology use, slope, livestock size, and soil fertility. Also, the continued use of the stone terraces is affected by farmers' expected profitability, land terrain or land slope, family size, farm size, soil fertility, and if the farmers have off-farm work or not.

Exogenous Variables

Training in soil conservation practices significantly and positively influenced the adoption of alley cropping in Haiti (Bayard et al. 2007). Farmers that have contact with extension workers are more likely to adopt new technologies (Läpple and Van Rensburg 2011). The unavailability of technical expertize to support the new technology and the inaccessibility of information has been shown to limit the possibility of smallholder farmers from investing in soil improving technologies (Knowler and Bradshaw 2007).

Research Method

Study Area

We use cross-sectional data collected from the study area in 2012 by Makerere University Kampala, Uganda. The study was conducted in Nabajuzi watershed of the Lake Victoria Basin of Uganda in Africa (Fig. 1). It is located at latitude 0°00′01″N and 0°20′01″S, and longitude 31°33′00″ and 31° 50′00″E and at an elevation of 1200–1290 meters above the sea level covering ~939 km^2 (Nadhomi et al. 2013). Nabajuzi watershed falls within four districts of Kalungu, Bukomansimbi, Masaka, and Lwengo, which are in North Western part of Lake Victoria.

The study site has a population density of 123 persons per square kilometer (UBOS 2008) and has a high level of soil loss that ranges from 25 to 140 tons per hectare per year. The major crops grown are banana, coffee, annual field crops, and farmers also raise livestock.

Sampling Producedure Applied

Our target population was low-income farmers who were affected severly by soil erorsion. Information about income of households located in all 66 administrative units within the watershed are obtained from Uganda Bureau of Standard. Sample size was chosen to represent the population (24,000) of all low-income households. Pre-testing of the survey was done in the population using a semi-structured interview. The final survey questionnaire was developed based on the comments obtained during the pre-test interview.

Data Collection Techniques Used

Interview was conducted to collect information from randomly selected 400 households. Survey assistants were trained to interview household heads. Interviewers read consent statments before conducting the survey. There was no refusal from selected sample of farmers to participate in the survey.

Econometrics Model Used

We consider a farmer an adopter of SWC technologies if at least one of the technologies is in practice in the operated farmland (adopters). Non-adopters are those farmers who have never implemented the SWC technology in any of their farmland (non-adopters). There is a concern that the decision to adopt is interrelated or interdependent with awareness and they need to be estimated jointly. A bivariate model is appropriate (Obubuafo et al. 2008; Amsalu and De Graaff 2007).

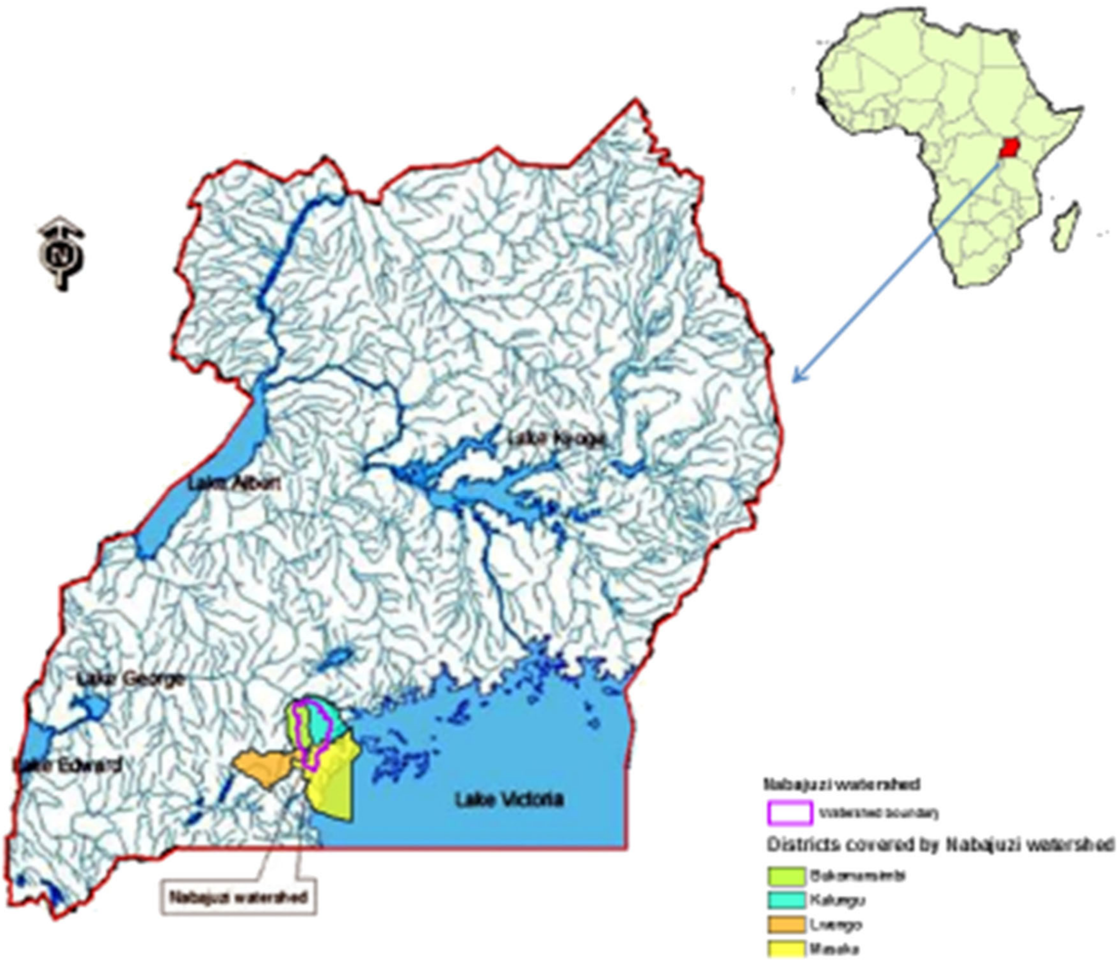

Fig. 1 Map of Uganda showing drainage and study area

A bivariate probit model was utilized to analyze the awareness of SWC practices and their adoption. It involved two binary dependent variables y_i whereby each is a probit equation in the form below:

$$y_1 = \beta_0 + \beta_i X_1 + \varepsilon_1$$

$$y_2 = \alpha_0 + \alpha_i X_2 + \varepsilon_2.$$

Here, y_1 is awareness variable (=1 if a farmer is aware of SWC technologies, 0 otherwise) and y_2 is adoption variable (=1 if a farmer adopts SWC technologies, 0 otherwise). β_i and α_i are parameters to be estimated, ε_1 and ε_2 are normally distributed error terms. X_1 and X_2 are matrices of explanatory variables. Explanatory variables in this analysis are household head family size (HHDSIZE), age (AGE), years of schooling (EDUCATION), agricultural training (TRAINING = 1 if attended any agricultural/extension training, 0 otherwise), land size (FARMSIZE), land ownership (TENANT=1 if tenant, 0 otherwise) and years accessed land by household head (LACESS), estimated land quality (LAQUALITY), and steep slope (SSLOPE). The selection of these variables is consistent with the literature.

Soil conditions were captured through soil fertility and the slope of the land. The fertility of the individual farms was measured through farmers' perception of estimated land quality in terms of fertility. We created dummy variables for land quality (LAQUALITY=1 if the farmer said his/her land is good quality/fertile, 0 otherwise) and land slope (SSLOPE=1 if the farm is on steep sleep, 0 otherwise).

The probability of being aware is

$$p(y_1 = 1, y_2 = 1) = \phi\left(X_1^{'}\beta_1\right)$$

Here, ϕ is the cumulative density function of the standard normal distribution.

The joint probability that the producer is both aware of SWC and adopts is

$$P(y_1 = 1, y_2 = 1) = \phi_2\left(X_1^{'}\beta_{1,}X_2^{'}\beta_{2,}\rho\right)$$

Table 1 Definition and a priori signs of explanatory variables ($n = 400$)

Variable	Units	Definition	A priori sign
HHDSIZE	Number	Family members in household	+/−
AGE	Years	Age of household head	+/−
EDUCATION	Years	Years of schooling of household head	+/−
TRAINING	0–1	Whether got any agricultural training (1: yes; 0: no)	+/−
FARMSIZE	Acres	Total land size owned by household	+/−
LAQUALITY	0–1	Quality of land (1: good; 0: bad)	−
SSLOPE	0–1	Land operated on steep slope (1: yes; 0: no)	−/+
TENANT	0–1	Is head land owner or tenant (1: tenant; 0: otherwise)	−
LACCESS	Years	Years household accessed the land	+

Table 2 Summary statistics of explanatory variables used in the model ($n = 400$)

Variable	Mean	Std. dev.	Min	Max
HHDSIZE	4.600	1.675	0	10
AGE	48.702	14.427	17	84
EDUCATION	8.468	3.528	0	20
TRAINING	0.643	0.479	0	1
FARMSIZE	10.018	3.480	3	20
LQUALITY	0.415	0.493	0	1
SSLOPE	0.355	0.479	0	1
TENANT	0.08	0.271	0	1
LACCESS	12.603	9.019	1	52

where ϕ_2 is the bivariate standard normal distribution and ρ is the correlation between ε_1 and ε_2.

Definition and a priori sign of explanatory variables are shown in Table 1. Summary statistics of variables used in the regression models are presented in Table 2.

Data Analysis Techniques Applied

Data are analyzed using univariate and bivariate probit methods. Stata version 14 is used for all statistical analyses.

SWC Practices Used

Soil conservation is defined as the rational use of land resources, the application of erosion control measures, water conservation technologies, and the adoption of appropriate cropping patterns to improve soil productivity and prevent land degradation (FAO 2017). The soil conservation practices being promoted in the watershed are described below.

i. Mulching (Fig. 2): Farmers use crop residues like banana leaves, banana fibers, corn and sorghum stover, bean crop residues and many others to cover the soil surface. This technology prevents soil from being washed away through soil erosion, control weeds growth, encourages rain water infiltration and conserves soil moisture.

Fig. 2 Mulching

ii. Contour farming (Fig. 3): It involves digging contours across the slope to reduce runoff and soil erosion. Erosion is more intensified on cropping land where more than half of the soil contained in the splashes is carried downhill. Contour farming helps retain soil and water that would have been lost as erosion and run off, respectively.

iii. Minimum or no tillage (Fig. 4): It helps in rain water infiltration to reduce water runoff. Use of a heavier machine to till the land damages the entire soil ecosystem. When the soil ecosystem is damaged, its productivity declines.

iv. Grass barrier strips (Fig. 5): These are planted within or around the farm land. Living and dead plant biomass left on fields reduce soil erosion and water runoff by intercepting and dissipating rain drop and wind energy. They can be planted across a slope to reduce runoff and enhance infiltration into the soil.

Fig. 3 Contour farming

Fig. 4 Minimum tillage

Benefits of grass barrier strip to reduce soil deterioration and improve soil quality has been reported in the literature (Mekonnen et al. 2015).

v. Terraces (Fig. 6): These are used as a form of soil conservation technique on steep slopes. Steep slopes are converted into agricultural land due to increasing land degradation and population pressure.

vi. Agroforestry (Fig. 7): It is mixing of crops and trees and used as a natural resource management strategy. It balances the goals of agricultural development with the conservation of soil, water, climate, and biodiversity. When agroforestry is used, trees will cover a significant portion of the landscape and influence microclimate, matter and energy cycles, and biotic processes (Jose 2009).

Fig. 5 Grass strip

Fig. 6 Terraces

Results and Discussion

Probit Model for Awareness and Adoption of SWC

Pairwise correlations of all independent variables are quite low, and variance inflation factors for all variables are less than five indicating that there is no multicollinearity problem. We also tested the endogeneity of tenant variable using the Durbin–Wu–Watson Endogeneity test. The instrument variable used was Mailoland, which is land for

Fig. 7 Agroforestry

the king of Buganda kingdom, locally referred to as "Kabaka's land. " The basic unit of mailoland is a square mile from where it derived its name mailo. This is a good instrument because it is related to the variable tenant but not related to the regression error term. Test statistics indicated that there is no problem with endogeneity. We estimated separate probit models for awareness and adoption; the results of which are shown in Tables 3 and 4 together with their marginal effects.

The farmers who were more likely to be aware of SWC technologies were younger, not tenants and had accessed farmland for more years. Famers who were more likely to adopt SWC technologies were younger, not tenants, had received agricultural training and had access to farmland for more years. Young farmers may be more flexible, dynamic, and energetic in the adoption of technologies, especially those that are labor intensive.

The finding that agricultural training positively influences adoption of agricultural technology is consistent with Bayard et al. (2007), where it was argued that farmers are trained either individually or in groups, and it was revealed that training and group membership in soil conservation practices significantly and positively influenced the adoption of alley cropping in Haiti.

There is a concern that the decision to adopt is interrelated or interdependent with awareness and they need not be estimated independently. The correlation coefficient (ρ) between the errors of the two equations is 0.99. A positive value for ρ indicates that unobserved factors that influence awareness of SWC technologies also increase the likelihood of adopting SWC technologies. The likelihood ratio test for $\mathrm{H0}: \rho = 0$ against $\mathrm{H1}: \rho \neq 0$ is rejected at a 5% level indicating that two dependent variables (awareness and adoption) are not jointly determined. This implies the decisions are interrelated, and the two models cannot be estimated separately. There could be unobserved factors that affect the likelihood of awareness and adoption of SWC technologies jointly. In this case, a bivariate model is more appropriate (Obubuafo et al. 2008; Amsalu and De Graaff 2007).

Table 3 Probit estimates of farmers' awareness of SWC technologies ($n = 400$)

Variable	Coefficient	Marginal effect
HHDSIZE	−0.0269491	−0.007 (0.012)
AGE	−0.0144946	−0.004* (0.002)
EDUCATION	−0.0068141	−0.002 (0.006)
TRAINING	0.1959447	0.054 (0.042)
FARMSIZE	−0.0112438	−0.003 (0.006)
LAQUALITY	−0.1005412	−0.028 (0.040)
SSLOPE	−0.1837605	−0.051 (0.041)
TENANT	−0.6145683	−0.170*(0.069)
LACCESS	0.0222768	0.006** (0.003)

Note: $*p < 5\%$, $**p < 10\%$, $***p < 1\%$ are levels of significance. Values in parentheses are standard errors

Table 4 Probit estimates of farmers adoption of SWC technologies ($n = 400$)

Variable	Coefficient	Marginal effects
HHDSIZE	−0.0387195	−0.011 (0.012)
AGE	−0.0131909	−0.003* (0.002)
EDUCATION	−0.0082928	−0.002 (0.006)
TRAINING	0.2523199	0.070* (0.042)
FARMSIZE	−0.0128604	−0.004 (0.006)
LAQUALITY	−0.0739223	−0.020 (0.040)
SSLOPE	−0.1963799	−0.054 (0.040)
TENANT	−0.6228662	−0.171 (0.069)
LACCESS	0.0210799	0.006** (0.003)

Note: $*p < 5\%$, $**p < 10\%$, $***p < 1\%$ are levels of significance. Values in parentheses are standard errors

Probability of Farmers being Aware and Adopting SWC Technologies: Bivariate Probit

The marginal effects of the bivariate probit model with partial observability results are presented in Table 5. The variables that affect the probability of a farmer being aware and adopting SWC technologies were age of the household head, being a tenant and the number of years a household head had accessed farm land (Table 5).

The likelihood of being aware and adoption of SWC technologies was negatively related to the age of the household head. This is consistent with previous findings (Knowler and Bradshaw 2007; Knowler 2004). The age of

Table 5 Bivariate probit with partial observability estimates of marginal effects of farmers' awareness and the adoption of SWC technologies ($n = 400$)

Variable	Marginal effects
HHDSIZE	−0.008 (0.012)
AGE	−0.004*(0.002)
EDUCATION	−0.002 (0.006)
TRAINING	0.064 (0.042)
FARMSIZE	−0.003 (0.006
LAQUALITY	−0.026 (0.041)
SSLOPE	−0.052 (0.041)
TENANT	−0.170* (0.071)
LACESS	0.006* (0.003)

Note: *$p < 5\%$, **$p < 10\%$, ***$p < 1\%$ levels of significance. Values in parentheses are standard errors.

the household head is believed to influence adoption because it reflects life cycle impacts on investment behavior. Aged farmers may have a wealth of experience but may be unwilling to invest in long-term soil conservation given his or her short time horizon. Young farmers may be more flexible, dynamic, and energetic in the adoption of technologies especially those that are labor-intensive. The younger farmers also have a longer planning horizon and their willingness to make agricultural technology investments with long payback periods may be higher than that of older farmers (Amsalu and De Graaff 2007). Another reason is that some of these technologies are labor intensive such that they need a lot of energy which the aged farmers may lack.

The likelihood of being aware and adoption of SWC technologies was negatively influenced by a household being a tenant. This is consistent with Kabubo-Mariara (2007) who indicated that farmers with land tenure adopt conservation practices in Kenya. Secure land tenure rights give farmers an incentive to make long-term investments in soil conservation practices.

Household heads who had accessed farmland for many years positively influenced awareness and adoption of SWC technologies. Years of access to farmland significantly increases the likelihood of awareness and adoption of SWC technologies. This is consistent with findings that the decision concerning technology adoption are affected by access to land (Doss 2001). Doss argued that farmers are always concerned with accessibility to the farmland and the benefits they will accrue from that land. If there is a high probability that a farmer will lose the land where the investments are being made, they will always not adopt that investment technology. The more years a farmer has accessed the land, the more tenure secure he will be, and the more adoption of the technology will take place.

Conclusions

Our objective of this paper was to identify the impact of different factors on farmers' awareness and adoption of SWC technologies in Nabajuzi watershed in South Western Uganda using survey data collected in 2012. We estimated both probit and bivariate probit models; however, since awareness and adoption are correlated, results from a bivariate probit model were interpreted.

Results from this study indicated that age of the household head and being tenant negatively influenced, whereas numbers of years of farm accessibility positively influenced the probability of awareness and adoption of SWC Technology in Nabajuzi watershed. Given that agriculture is the mainstay of Uganda's economy and the crop yields are declining substantially, the focus should be to train landowners who have lived and farmed in the area for a long time.

Since average crop yields over the years have been declining because of undefined land rights, there is a need to reinforce land policies in Uganda. There can be a policy to encourage farmers to get full land ownership than making them mere occupants. Deininger and Ali (2008) reported that full land ownership compared to mere land occupancy had statistically significant and economically large land use productivity. They further noted that the predicted impact of shifting from land occupancy to land ownership doubled soil conservation technologies adoption and fivefold tree planting technologies adoption. Land tenure security is likely to increase the probability of SWC technology adoption. Additionally, targeting young farmers in SWC technology training programs would increase awareness, adoption, and continuation of these technologies for foreseeable future.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no competing interests.

References

Arslan A, McCarthy N, Lipper L, Asfaw S, Cattaneo A (2014) Adoption and intensity of adoption of conservation farming practices in Zambia. Agric Ecosyst Environ 187:72–86

Amsalu A, De Graaff J (2007) Determinants of adoption and continued use of stone terraces for soil and water conservation in an Ethiopian highland watershed. Ecol Econ 61(2):294–302

Baumgart-Getz A, Prokopy LS, Floress K (2012) Why farmers adopt best management practice in the United States: a meta-analysis of the adoption literature. J Environ Manag 96(1):17–25

Bayard B, Jolly CM, Shannon DA (2007) The economics of adoption and management of alley cropping in Haiti. J Environ Manag 84 (1):62–70

Bationo A, Kihara J, Kimetu J, Waswa B (eds) (2007) Advances in integrated soil fertility management in sub-Saharan Africa: challenges and opportunities. Springer, Dordrecht, p 1091

De Graaff J, Amsalu A, Bodnar F, Kessler A, Posthumus H, Tenge A (2008) Factors influencing adoption and continued use of long-term soil and water conservation measures in five developing countries. Appl Geogr 28(4):271–280

Deininger K, Ali DA (2008) Do overlapping land rights reduce agricultural investment? Evidence from Uganda. Am J Agric Econ 90 (4):869–882

Doss CR (2001) Designing agricultural technology for African women farmers: lessons from 25 years of experience. World Dev 29 (12):2075–2092

DSIP (2010/11–2014/15) Development Strategy and Investment Plan (DSIP). MAAIF Ministry of Agriculture Animal Industry and Fisheries: Agricultural for Food and Income Security, Kampala, Uganda, p 9–68

FAO (2017) Soil conservation. http://www.fao.org/soils-portal/soil-management/soil-conservation/en/ Accessed 1 Aug 2017

Jayne TS, Chamberlin J, Heady DD (2014) Land pressures, the evolution of farming systems, and development strategies in Africa: a synthesis. Food Policy 48:1–17

Jose S (2009) Agroforestry for ecosystem services and environmental benefits: an overview. Agrofor Syst 76(1):1–10

Kabubo-Mariara J (2007) Land conservation and tenure security in Kenya: Boserup's hypothesis revisited. Ecol Econ 64(1):25–35

Knowler D, Bradshaw B (2007) Farmers' adoption of conservation agriculture: a review and synthesis of recent research. Food Policy 32(1):25–48

Knowler DJ (2004) The economics of soil productivity: local, national and global perspectives. Land Degrad Dev 15(6):543–561

Läpple D, Van Rensburg T (2011) Adoption of organic farming: are there differences between early and late adoption? Ecol Econ 70 (7):1406–1414

Lemke AM, Lindenbaum TT, Perry WL, Herbert ME, Tear TH, Herkert JR (2010) Effects of outreach on the awareness and adoption of conservation practices by farmers in two agricultural watersheds of the Mackinaw River, Illinois. J Soil Water Conserv 65(5):304–315

Mango N, Makate C, Tamene L, Mponela P, Ndengu G (2017) Awareness and adoption of land, soil and water conservation practices in the Chinyanja Triangle, Southern Africa. Int Soil Water Conserv Res 5(2):122–129

Mekonnen M, Keesstra SD, Stroosnijder L, Baartman JE, Maroulis J (2015) Soil conservation through sediment trapping: a review. Land Degrad Dev 26(6):544–556

Moyo S, Norton GW, Alwang J, Rhinehart I, Deom CM (2007) Peanut research and poverty reduction: impacts of variety improvement to control peanut viruses in Uganda. Am J Agric Econ 89 (2):448–460

Mugonola B, Deckers J, Poesen J, Isabirye M, Mathijs E (2013) Adoption of soil and water conservation technologies in the Rwizi catchment of south western Uganda. Int J Agric Sustain 11 (3):264–281

Nadhomi DL, Tenywa JS, Musali P, Nakileza BR (2013) Farmers' perception of erosion risk and its implication on the adoption of soil and water conservation practices. Int J Adv Agric Sci Technol 2(1):28–44

National Environment Management Authority (NEMA) (2007) State of the environment report for Uganda. NEMA, Kampala, Uganda

Obubuafo J, Gillespie J, Paudel K, Kim S (2008) Awareness of and application to the environmental quality incentives program by cow-calf producers. J Agric Appl Econ 40(1):357–368

Pender J, Place F, Ehui S (eds) (2006) Strategies for sustainable land management in the East African highlands. International Food Policy Research Institute, Washington, D.C

Prokopy LS, Floress K, Klotthor-Weinkauf D, Baumgart-Getz A (2008) Determinants of agricultural best management practice adoption: evidence from the literature. J Soil Water Conserv 63 (5):300–311

Sanginga PC, Kamugisha RN, Martin AM (2007) Conflicts management, social capital and adoption of agroforestry technologies: empirical findings from the highlands of southwestern Uganda. Agrofor Syst 69(1):67–76

Uganda Bureau of Statistics (UBOS) 2008. Uganda national household survey, Entebbe, Uganda. 2008 Statistical abstract

Zegeye AD, Steenhuis TS, Blake RW, Kidnau S, Collick AS, Dadgari F (2010) Assessment of soil erosion processes and farmer perception of land conservation in Debre Mewi watershed near Lake Tana, Ethiopia. Ecohydrol Hydrobiol 10(2):297–306