Factors Affecting the Adoption of Soil and Water Conservation Practices by Small-Holder Farmers in Muyembe Sub-County, Eastern Uganda

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Abstract

Farmers in tropical rural areas are confronted with several challenges but outstanding among these challenges is soil degradation arising from soil erosion. This study involved identifying the dominant soil and water conservation practices and assessing the factors affecting their adoption in the Muyembe sub-county, Eastern Uganda. A total of 500 respondents were used to obtain primary data. As the study adopted a cross-sectional design, we used questionnaires, interviews, focus group discussions and field observations to collect the required data. Data were analyzed using descriptive statistics and the non-parametric (Chi-square) test. The results indicated that the dominant soil and water conservation practices adopted in the study area were, contour cropping (77%), mixed cropping (59% and crop rotation (51%). The remaining five practices had less than a 50% adoption rate. The chi-square test revealed that the age and gender of the farmers had a significant association with the levels of the adoption of soil and water conservation practices among farmers at P<0.001. We concluded that the adoption of soil and water conservation practices was low, which left the majority of farmers vulnerable to soil erosion effects such as low yields and crop failure. We recommend that stakeholders who work on soil and water conservation programs use model farmers in the area to educate and demonstrate the importance of soil and water conservation practices to other farmers.

Keywords: Conservation practices, Chi-square, adoption, soil erosion, contour cropping.

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Introduction

Smallholder farmers in many developed and developing countries are used to farming using the traditional rudimentary methods that involve the simple sowing of seeds in ploughed fields. This is because ploughing is known for easing the infiltration of rainwater and is said to increase soil and organic manure mixing (Nabalegwa et al., 2015). This, however, comes with the acceleration of soil erosion and promoting salinization of the soil, which has in most cases, caused significant annual soil and nutrient losses. FAO2001, 2001a& b, and Shiferaw et al. (2007), indicated that improved soil and water conservation practices ensure improved water infiltration and soil surface aggregation and reduced soil erosion and compaction. In line with the claim, many African agricultural scientists have advocated for the use of improved soil and water conservation practices with a mind to creating resilience against soil erosion and climate change and increasing crop yields (Shiferaw et al., 2007). Among them include agronomic, physical, and biological practices. The advocacies of agricultural scientists to improve soil and water conservation practices have underscored their objectives due to varied political, social, and economic factors. For example, according to Gerbi and Megersa (2020), the younger farmers in Ethiopia were more amenable to changing old practices than older farmers because they tended to be less aware and knowledgeable about new technologies. Conversely, older farmers were in a better position to adopt new technologies due to their comparative advantage in terms of capital accumulated, number of extension contacts/visits and creditworthiness, etc. In Kenya, the lack of access to cash or credit by farmers in the Kenyan highlands hampered smallholder maize farmers from adopting new soil and water conservation technologies that required initial investments (Alufah et al., 2012). On the other hand, Langyintuo (2008) observed that education and age positively influenced the adoption of soil and water conservation practices in the Shamva District of Zimbabwe.

Different African countries have come up with region-specific coping mechanisms for enhancing soil and water conservation technologies to ensure the sustainability of agricultural productivity, food security, and land protection. For example, in Ethiopia, farmers have embarked on afforestation, agro-forestry, soil and stone banding, grass stripping, and pond construction (water harvesting) technologies (Shiferaw et al., 2007). In Kenya, Mugendi et al. (1999) observed that farmers concentrated on agroforestry to manage land and water in crop farms to improve farm productivity.

The dissemination and use of soil and water conservation practices in Uganda have been met with some resistance (Bwambale et al., 2015). Where adoption has been observed, not all components have been adopted due to biophysical factors (soils, climate, and topography), socioeconomic factors, institutional factors, and technical characteristics.

The government of Uganda through the Ministry of Agriculture Animal Industry and Fisheries and its parastatals like National Agricultural Advisory Services (NAADs), National Agricultural Research Organization (NARO), Operation Wealth Creation (OWC) with support from the Food and Agriculture Organization (FAO) have urged farmers in Uganda and particularly in Muyembe sub-county, Bulambuli district to adopt soil and water conservation technologies. This has been emphasized and enhanced by extending agricultural extension services to the grass-root level through political structures like District Agriculture Officers (DAOs) to teach farmers how to use appropriate soil and water conservation technologies such as contour banding, terracing, mulching, No-till, crop rotation especially with legumes, agroforestry among others.

Despite these efforts, the rate of adoption of soil conservation practices by smallholder farmers has remained as low as < 50% adoption rate (NEMA, 2010). The majority of the farmers in the Muyembe sub-county have not embraced these technologies save for very few farmers in the mountain and low land agro-ecological zones. Some of those who attempted dropped the technologies on the way and only a few have persisted. Based on observation, the majority of the crop farms found on the steep slopes of the mountain Elgon in Muyembe sub-county such as banana plantations, onion farms, and some tomato gardens are left bare without protection against erosion susceptible to erosion at the start of the rainy season. This was confirmed by NEMA (2002), who indicated that 80% of the farmers on mountain Elgon slopes in Bulambuli would continue to make crop losses due to the persistent soil erosion caused by their low compliance to the adoption of soil conservation measures put in place by the Ministry of Agriculture. The factors underscoring these efforts to adopt soil and water conservation technologies are not known and documented about the Muyembe sub-county.

The objectives of this paper were to identify the components of soil and water conservation practices that were adopted by farmers in the Muyembe sub-county of the Bulambuli district, eastern Uganda, and to analyze the area-specific factors that influence farmers' adoption decisions. The findings will assist the government, and other development partners involved in the development and promotion of soil and water conservation to design the appropriate interventions that will help increase the adoption rates of soil and water conservation practices among farmers in similar ecologies in Uganda.

Materials and Methods

Study area

The study was conducted in the Muyembe sub-county in the Bulambuli District of Eastern Uganda. It stretches between $33.5^0 – 36^0$ E and $2^0 – 5^0$ N (Figure 1). It lies at an approximate altitude ranging between 1089 - 2247 m above sea level. A big part of the sub-county lies in a mountain agro-ecological zone (ranging between 1862-2247m ASL) with a smaller part in the lowland agro-ecological zone (ranging between 1089-1861m ASL). Muyembe sub-county covers a surface area of approximately 710.96 km^2 and is comprised of six (6) parishes namely Bufukhula, Bulako, Bungwanyi, Bufumbula and Buyaka, and Nabongo. The Muyembe sub-county has a montane climate with a bimodal rainfall pattern. The first rain season stretches from April to June and the second rainfall season from October to December with two dry periods of July to September and January to March. The Muyembe sub-county has a mean annual rainfall of 1280 mm and depending on altitude and season, the mean temperature varies from 10 °C to over 22 °C (Turyahabwe et al., 2021). The soils are generally volcanic although some parts are comprised of ferralisols and vertisols. The population of Bulambuli District is 28209 while that of Muyembe sub-county is 9560 people based on the 2014 Uganda National Housing and Population Census. The area is found in the Bugisu Kingdom with the majority of the population speaking the Lumasaaba language (UBoS, 2014). The upper slopes of the study area are dominated by coffee and banana crop gardens and other annual crop gardens, while the low land region is dominated by rice gardens and other annual crop gardens of cabbages, beans, maize, sorghum, sunflower, and soybeans. Most of these crops are grown as mixed and or single crops. Animal grazing is found in lowlands where pasture and wetlands are the grazing points. Some woodlots are also found in both agro-ecological zones.

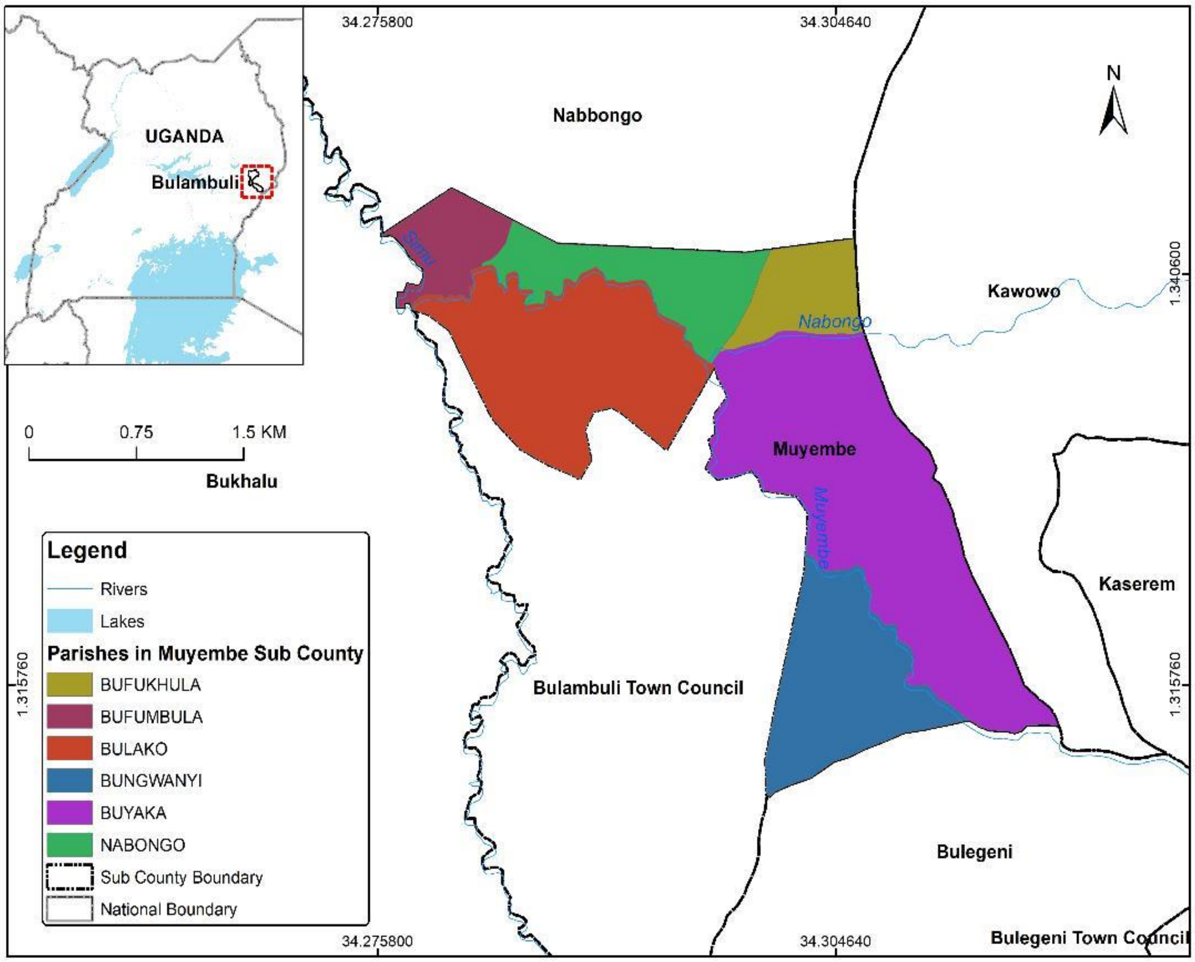

Figure 1: Muyembe sub-county and study clusters (Parishes)

Data collection

The study adopted a cross-sectional design. First, purposive sampling was applied to select the Bulambuli district from the eastern part of Uganda. The key reasons for the selection were that the district is characterized by two different agro-ecological zones (mountain and lowland), where adaptation strategies differ due to spatial differences, high population growth with limited and eroded farmland, and the prevalence of food insecurity, and widespread poverty. Based on the different population sizes of parishes in the descending order; Bufukhula, Bulako, Buyaka, Nabongo, and Bufumbura parishes (UBOS, 2014), we selected 128, 113,94,89, and 76 respondents from the respective parishes giving a total of 500.

The categories of respondents included smallholder farmers and the Key Informants. Within each parish, owing to the accessibility to the target population, we employed convenience sampling where only accessible farmers were selected for the study to obtain information about both adopters and non-adopters. Primary data were collected using structured interviews, focus group discussions, and questionnaires. Three focus group discussions were carried out in each of the two agro-ecological areas (low land, and high land) with between 5 - 10 people where gender balance was considered. These included farmers, and extension workers e.g., (2 OWC, 2 NAADs, and 2NARO officers). Similarly, key informant interviews were conducted with 1 district agriculture officer, 5 parish[1] chiefs, and 1 community development officer. Questionnaires, interviews, and discussions were used to obtain data about the demographic characteristics of respondents e.g., age, sex, marital status, and other social characteristics of the respondents such as level of education, farmers' annual incomes, accessibility to extension services, history of use of soil/water conservation technologies, nature of adaptation practices and factors that influence farmers' adoption of these practices in the area of study. Field observation was conducted to ensure the validity of the information obtained through discussion, interviews, and questionnaires. The questionnaires were administered by trained research assistants who were university graduate students and the researchers played the supervisory role.

[1] A parish is a collection of villages and the second smallest local government administrative unit in Uganda.

Data analysis

Data obtained from questionnaires were analyzed using statistical techniques while qualitative data collected by way of discussions, interviews, and field observations were analyzed qualitatively. Statistical analyses took the form of simple descriptive statistics that is, frequencies and percentages with the findings presented in tables. Owing to the categorical nature of the variables, a Chi-square (χ^2) test was adopted to examine the association between adoption rate and the characteristics of respondents.

Results

Soil and water conservation practices adopted in the Muyembe sub-county

The soil and water conservation practices adopted in the Muyembe sub-county were categorized into three; agronomic (contour cropping, mixed cropping, mulching, agroforestry, cover cropping, and crop rotation), biological (vegetative strips), and physical practices (including retention ditches). Table 1 shows the popularity of adoption of each of the technology in the study area.

Table 1: Sustainable soil and water conservation practices adopted in Muyembe sub-county

Soil and water conservation practices used in Muyembe	Number of respondents from different clusters (parishes) N=500						
	Bufukhula	Bulako	Buyaka	Bufumbula	Nabongo	Total	%age
Agronomic							
Contour cropping	30	50	120	100	87	387	77
Mixed cropping	69	113	23	74	17	296	59
Mulching	58	40	30	50	20	198	40
Agro-forestry	16	23	26	14	20	99	20
Cover cropping	29	40	77	53	41	240	48
Crop rotation	58	44	82	37	31	254	51
Biological							
Vegetative stripping	30	29	31	22	40	152	31
Physical							
Retention ditches	17	19	16	20	14	86	17

Contour ploughing was done across the slopes rather than up and down ploughing following a line/contour that was guided by the configuration of the ground. Hedgerows and soil bunds were established within contours to reinforce the strength of contours against runoff. Crops such as onions, maize, sorghum, and sometimes beans were then planted on the contour lines across gentle slopes with the intention that when crops grew, they would break the runoff and increase nutrients and water infiltration into the soil during rains. This was the most dominantly adopted practice by 77% of the population sampled (Table 1).

In the mixed cropping technique also known as inter-cropping, farmers in the Muyembe sub-county planted two or more crops on the same land and at the same time. They mainly intercrop beans and maize, maize and millet, banana and coffee, and groundnuts with maize. This offered several benefits which included better utilization of soil nutrients, an increase in soil productivity, and resistance to climate extremes. This practice was more popular in the Bulako parish with 113 respondents (Table 1)

Mulching was done by covering the soil between crop rows and or around trees or vegetables like cabbages and tomatoes, and banana plants. This was done using cut grass, crop residues, straw, and other plant material. Forty percent of the farmers reported that this practice helps in retaining soil moisture by limiting evaporation, preventing weed growth, and enhancing soil structure. The layer of plant material protects the soil from splash erosion.

Agroforestry was incorporated within other farming systems by planting tree crops in crop gardens such as fruit trees like mangoes, jack fruits, and oranges. Other trees planted included eucalyptus and coffee. It was reported that the tree roots bound soil particles together, reduced soil erosion, increased infiltration, and provided additional needs such as fuelwood and food to the farmers. Although the practice was second least popular in Muyembe, it was the most popular on the gentle slopes of the Buyaka parish as reported by 26 respondents (Table1).

Cover crops mainly leguminous crops such as beans, peas, and pumpkins were grown to protect the soil from erosion and to improve soil fertility. These cover crops protected the soil from splashing raindrops and too much heat from the sun. These were grown with crops that had longer growing seasons like coffee, banana, and maize. To ensure that the cover crop did not compete with the main crop, the cover crops were planted at the same time as sowing the main crop like for the case of maize, or after the main crop had been established, to avoid competition at the crop nutrition level.

More than half (51%) of the respondents indicated that farmers practiced crop rotation by succeeding different crops on the same piece of land seasonally. Rotation of crops reduced erosion and increased the fertility of the soil by different crops being grown on the same patch of land as this enabled the intake of plant nutrients from different layers of soil. In addition, crop rotation increased crop yields and net profit. For example, leguminous crops like beans and groundnuts were grown alternately with rice, maize, sorghum, and cotton or millet.

Grass vegetative strips appeared to be a cheaper alternative for farmers in the Muyembe sub-county to terracing. In this method, the local veld grasses were planted in a dense strip up to 1-meter-wide along a contour line to create a barrier to soil erosion and runoff. The space between each grass strip and another ranged between10-13m and the space between strips was cultivated as gardens. The silt was observed to pile up in front of and along each strip forming a bench like that of the terrace. The grass, however, required regular trimming to prevent them from spreading to the cropped area.

Farmers in the Muyembe sub-county constructed retention ditches to catch and retain all incoming runoff and hold it until it infiltrated into the ground mostly in banana plantations. Some crops were planted in the ditch and thereby got an increased supply of moisture. The ditch size ranged between 0.3-0.6 m deep and 0.5-1 m wide and 20-30 meters long. The top width of the ditch was wider than the bottom width. The spacing between the ditches ranged between 20m-10m depending on the soil depth. This practice was reported to be the most laborious one and this explains why it was the least popular practice employed in the Muyembe Sub County as observed in (Table 1).

Factors influencing the adoption of sustainable soil and water conservation practices by small-holder farmers in Muyembe sub-county

Age and farmers' experience and adoption

Mature and experienced farmers adopted soil and water conservation practices more than inexperienced youth farmers. For example, age groups 20-39,40-59,60-79 and 80+ had their adoption rates at 47%,59%, 83% and 87%respectively. The most popular soil and water conservation practices among the 20-39 age group were vegetative stripping and mulching. Respondents between the age group of 40-59 adopted all soil and water conservation practices concentrating mostly on mulching, mixed cropping, and contour cropping (Table2). The very old age group of 80+ preferred mulching and mixed cropping to contour cropping, vegetative stripping, and agro-forestry. Based on the Chi $\chi 2$ test, there was a significant association between adopters and non-adopters and age at $P<0.0001$.

Level of education of a farmer and adoption

The least adoption rate was associated with farmers who attained secondary level education with only 51% adoption while the highest adoption rate was associated with the uneducated farmers at 87% adoption. The uneducated tried all the soil and water conservation practices and mostly more technical practices such as mixed cropping, crop rotation, and contour cropping. Farmers who attained education up to the primary level adopted all the soil and water conservation practices mainly concentrating on constructing retention ditches and crop rotation (Table 2). On the other hand, those farmers who had attained tertiary education adopted only four soil and water conservation practices, concentrating mainly on crop rotation, mulching, contour cropping, and construction of retention ditches. As expected, there was a significant correlation between the level of education and the level of adoption with $\chi 2$ (56.09) at $P<0.0001$

Level of income of a farmer and adoption

Farmers who earned <10 million Uganda shillings p.a, had the lowest adoption rate of 49%, while those who earned 41+ million Uganda shillings p.a were all capable of adopting soil and water conservation practices and thus, had the highest percentage of adopters of 100% (Table2). Unlike farmers in the middle-income categories of 10-20 and 21-40 million earners, the farmers in the category of 41+ million did not adopt all the conservation practices, they ignored cover cropping and construction of retention ditches. The poorest farmers tried adopting all soil and water conservation practices apart from agroforestry, (which required buying seedlings) and vegetative stripping, (which were costly in terms of buying grass seedlings and maintenance). There was a significant difference between adopters and non-adopters in relation to levels of income with $\chi 2$ (65.81) at $P<0.0001$.

Size of the farm and adoption

Farmers with the smallest land size of <3 acres were limited in soil and water conservation practices adoption and hence had the least percentage of adopters (67%). These did not adopt agroforestry, cover cropping, and contour cropping but concentrated mostly on a mixed cropping and crop rotation with 45 and 13 adapters respectively. Most farmers in this category of land size owned rented land. Some farmers in this category indicated that they had already footed the high cost of renting and that they did not want to add more for conserving the land when they could shift to another land soon after the harvest. Conversely, farmers who had 9+ acres of land had the highest potential of adopting soil and water conservation practices up to 86% although they did not practice agro-forestry, cover cropping, and construction of retention ditches but concentrated most on mulching and contour cropping. This was supported by the Chi $\chi 2$ (20.16) at $P<0.0401$, which indicated that there was a significant association between the land sizes owned by farmers and the level of adoption with $\chi 2$ among farmers (Table2).

Family size of the farmer's household and adoption

The families that had the fewest members (<5members) scored the highest number of adopters (115) and adoption rate at 100% majority adopting contour and mixed cropping practices. On the other hand, families that had16+members had a 69% adoption rate with farmers concentrating on labour-intensive practices like contour cropping and crop rotation ignoring space-demanding practices like agroforestry (Table2). The family sizes of 11-15 members scored the least percentage of adopters (53%). However, the overall Chi $\chi 2$ (76.34) at $P<0.0001$ showed that there was a significant association between the adoption rate and family sizes of farmers.

Gender /sex and adoption

Even though there were more males (340) involved in agriculture than females (160) in the Muyembe sub-county, female farmers highly adopted water and soil conservation practices (82%) than their male counterparts (47%). Females adopted less of agro-forestry and vegetative stripping, but adopted more of cover cropping and crop rotation while males practiced mostly contour ploughing, mixed cropping, and mulching, but less of agroforestry, cover cropping, and vegetative stripping.

Social capital and adoption

The adoption rate of farmers who belonged to at least a farming group was (71%) almost twice of those who belonged to no groups (40%). Those who belonged to groups had access to agricultural extension services to rural farmers through operation wealth creation (OWC), and National agricultural advisory services (NAADs) programs and information like training on soil conservation practices and therefore, adopted all the soil and water conservation practices, while those who never belonged to any group missed out on benefits of conserving soil and water for crop production like higher yields and climate change resilience. This is because they had not gotten any chance of attending a workshop/seminar where such things relating to soil and water conservation practices are talked about. This category of farmers was, therefore, still locked up in their traditional rudimentary farming practices. The stronghold statement /slogan of farmers who belonged to farming groups was *unity is strength* which literally meant the importance of social capital.

Table 2. Distribution of responses and Chi-square analysis results

Factor	Category	Tot rpdts	No and %tage of adopters of different soil and water conservation practices per factor category									%age adopters	%age non-adopters	χ2	P-value
			CNT	MX	MUL	AGF	CC	CR	STRIP	RET	Total				
Age (years)	20-39	70	5	6	8	0	0	0	9	5	33	47	53		
	40-59	330	27	32	84	10	8	20	6	9	196	59	41		
	60-79	60	10	9	7	3	6	15	0	0	50	83	17	37.74	<0.0001*
	80+	40	0	11	14	0	3	6	0	4	38	95	5		
Educ level	Uneduc	150	26	29	13	5	3	31	19	4	130	87	13		
	Primary	210	14	18	10	6	0	29	2	39	118	56	44		
	Second	90	8	9	15	2	1	7	-	4	46	51	49		
	Tertiary	50	7	0	16	0	0	17	0	3	43	86	14	-56.09	<0.0001*
Farmer income (mil Shs)	<10	200		30	4	0	24	32	0	8	98	49	51		
	10-20	180	10	19	18	3	7	12	19	13	101	56	44		
	21-40	80	11	8	10	4	8	11	10	9	71	89	11	65.81	<0.0611
	41+	40	5	22		1	0	3	9		40	100	00		
Farm size (acres)	<3	120	0	45	12	0	0	13	4	6	80	67	33		
	3-5	190	9	39	22	5	11	29	13	12	140	74	26		
	6-8	110	12	21	10	4	16	17	9	8	97	88	12	20.16	<0.0401*
	9+	80	19	17	20			10	3		69	86	14		
Fam size	<5	115	17	25	32		12	19	2	8	115	100	00		
	5-10	99	7	16	19	4	5	9		2	62	63			
	11-15	201	18	27	19	6	12		12	13	107	53	47	76.34	<0.0591
	16+	85	16	10	9	0	0	18	0	6	59	69	31		
Gender	Males	340	72	41	42	12	18	22	17	34	158	47	53		
	Female	160	20	22	11	2	42	23	5	6	131	82	18	55.91	<0.0001*
Social capital		268	36	27	42	14	12	28	12	19	190	71	29		
	Singles	232	19	18	16	9	0	0	12	9	92	40	60	49.35	<0.0501

Note. χ^2 is the Chi-square, P is the significance level, * means significant at 5%

Educ –Education, Fam – Family, MX- mixed cropping, MU- mulching, AGF- agroforestry, RET- retention ditches, CNT- contour cropping, CC – cover crops, CR- crop rotation, rpdts- respondents.

Based on field observations and group-guided discussions with farmers, several factors were raised but were not captured in the chi-square. These include agricultural extension services to rural farmers through OWC, and NAADs programs with 78% of field respondents attesting to having received these. Access to extension services like training on soil conservation practices has remained limited in the Muyembe sub-county with 29% of the respondents indicating that they had not gotten any chance of attending a workshop/seminar where such things related to soil/water conservation practices are talked about. Therefore, they are still locked up in their traditional rudimentary farming practices where soil/water conservation practices conservation was either by coincidence and/or not there at all. For this reason, several pieces of evidence of soil erosion were observed in some arable farms in the Muyembe sub-county.

Most of the farmers who did not adopt soil/water conservation practices owned rented land and because they were to use the land for a short time, they found conserving a waste of time since the use was for a short time. Some farmers indicated that they had already footed the high cost of renting and that spending more on conservation would make farming less economically viable on their part. The story was different for the farmers who owned land permanently (freehold/bought land). These attempted to ensure sustainability by ensuring soil/water conservation practices on their lands such as mulching, mixed cropping, and crop rotation.

Farmers who had gardens on steep slopes realized that without soil/water conservation practices, the yields would be limited and so dominated the adopters. These adopted vegetative stripping, contour cropping, and agroforestry. Conversely, the farmers in lowland areas felt less soil erosion; however, prolonged drought forced them to practice mulching to conserve soil moisture. Those on gentle slopes took up the construction of retention ditches to harvest water that the plants would use during the dry season.

Discussion

Sustainable soil and water conservation practices adopted in the Muyembe sub-county

Based on the observation in crop farms of Muyembe sub-county, vegetative strips played a filtration role of soil and therefore nutrients out of runoff downslope, increased infiltration of water into the soil thereby reducing the rate of soil loss. This was evidenced by piles of soil that were observed behind each grass strip after each rain event. This is in agreement with Nabalegwa et al., (2016) who indicated that the use of grass strips of 20-30cm width reduced the rate of soil erosion by 79%, and reduced runoff by 42%.

Contours that were created by farmers in the Muyembe sub-county proved effective as they, eased weeding, retained runoff downslope and the crops on contours trapped soil, and increased infiltration. The only problem was that the contours were associated with the habitation of rodents which disturbed crops. Despite this problem, the performance of the contour cropping in Muyembe did not differ from Morgan's (2005), expectation that contours conserve soil and increase rainwater seepage through the soil profile and hence recharge underground water.

Farmers in the Muyembe sub-county adopted mixed/intercropping in which they cultivated two or more crops at the same time in the same field because it had been found to protect the soil surface from the direct impact of the raindrops, which can cause a splash and sheet erosion, (Morgan, 2005). The farmers in the Muyembe sub-county who adopted this practice confessed that it reduced the rate of soil erosion on their farms.

The crop residues dominated mulching in the Muyembe sub-county. The straws that were used did not only improve soil nutrients and infiltration of rainwater but also reduced the effects of raindrops on the soil. In gardens where mulching was deemed important and farmers hesitated using the practice, soil and crops were swept causing big losses to farmers. This is in line with the findings of Nabalegwa et al. (2019), who reported that mulching dominated the soil and water conservation technologies among small-scale farmers in the Lwengo District of Uganda.

Farmers in Muyembe embraced agroforestry because of the economic and ecological benefits that were associated with the practice. For example, the trees like mangoes, and oranges were given for free by the government through Operation Wealth creation and the NAADs programs bore edible fruits (sold for income), withstood climate change vagaries, and roots of the same trees bound soil particles together against erosion. Similar reasoning for the adoption of agroforestry was given by Young (1989) when he indicated that farmers in Ethiopia integrated trees, shrubs, and crops for ecological and economic diversification.

Although there was no direct quantification of the amount of soil controlled or lost, farmers in our study area attested that crop rotation played a pivotal role in reducing the rates of soil and nutrient loss. Farmers in the Muyembe sub-county rotated cotton with millet or maize and finally beans or ground nuts. This conforms with Ailincai et al., (2009), who measured and found that on 16% slope fields, the use of peas-wheat-maize rotated with perennial grasses, reduced erosion by 40.2% (1.291 t/ha) in the mean annual losses of eroded soil.

Factors influencing the adoption of sustainable soil and water conservation practices by small-holder farmers in Muyembe sub-county

The adoption rate of soil and water conservation practices in Muyembe was more among female farmers than it was among male farmers, a finding that contradicts one of Alufah et al., (2012). This contradiction is mainly due to differences in cultural values. In Uganda, females are more food providers as opposed to males who are financial providers. Also, more females joined merrygo-round groups where they accessed soil and water conservation practices information than their male counterparts.

Smaller family sizes were associated with the highest adoption rate with the majority adopting contour and mixed cropping practices. Conversely, large families registered the lowest adoption rate with farmers concentrating on labour-intensive practices like contour and crop. This clearly shows that large families adopted practices that required the use of smaller pieces of land. This disagrees with many studies (Apata et al., 2009, Alufah et al., 2012), which had earlier indicated that, the larger the family, the higher the adoption rate. In the current study, larger families were associated with land fragmentation which limited the permanence of soil and water conservation practices on farms as opposed to small families. This study, therefore, aligns with Yohannes (2001), who maintained that family size is not a deciding factor for the adoption of soil conservation practice.

There was a close association between age and farmers' adoption rate of soil and water conservation practices. The older the farmers grew, the higher the rate of adoption of soil conservation practices. This is because as the farmers grew old, they attained experiences in conserving soil and water. It is this experience, therefore, that encouraged adoption, an argument similar to the one held by Belete (2017), who indicated that older farmers who have experienced soil erosion are always cautious about soil conservation.

Farmers' income levels play a big role in the adoption of capital-intensive soil conservation practices. The more the annual incomes farmers earned, the more they adopted the soil and water conservation practices. This is because some practices require initial capital input such as buying seedlings for agro-forestry and improved seeds for crop rotation as well as paying the labour force for mulching and developing contour bands. This is in line with Alufah et al., (2012) who noted that farmers who have access to credit have a higher probability of adopting soil and water conservation (SWC) technologies.

Education has a negative contribution when it comes to decision-making about the adoption of soil and water conservation practices. The current study revealed that the least adoption rate was associated with farmers who had attained tertiary and secondary education levels, while the uneducated farmers registered the highest adoption rate of all soil and water conservation n practices. This is because the un-educated have no other economic fall-back position, they have gone into farming whole-heartedly unlike the educated that tend to run back to their professions and are less committed to what it takes to have the best out of arable farming. This is similar to the notion advanced by Long (2003), that, the level of education negatively influenced the adoption of soil and water conservation practices.

Small land size owned by farmers was found to be a hindrance to the adoption rate of soil and water conservation practices. This is because it limited the farmers' liberty to choose and exercise several conservation technologies. For example, crop rotation required large land to change crops over time but this was not possible for some farmers due to the small sizes of land. Conversely, farmers with large farm sizes had all the liberty to choose and practice and retain soil and water conservation structures on farms, hence a higher rate of adoption. This explanation is similar to the one given by Amsalu and DeGraff (2006), who indicated that large farm holding had a higher probability of adoption of SWC practices because farmers can retain conservation structures since they are labour-intensive to install.

Farmers on steep slopes adopted soil and water conservation practices more than those in lowland areas. This is because farms on steep slopes were more occasionally affected by soil erosion than those in low lands. Accordingly, planting crops without any soil and water conservation practice rendered farming unproductive and caused more losses to farmers. This finding is similar to the one by Amsalu and DeGraff (2006) who observed that farmers on steep slopes adopted soil and SWC practices more than those on gentle slopes.

Land tenure arrangements are important in influencing the adoption rate of soil and water conservation practices. Farmers who owned land permanently adopted more soil and water conservation practices than those who were renting the land for a short time. Those who owned land had an assurance that they would use the same land and so established permanent soil and water conservation structures, while those who were renting adopted fewer soil conservation practices and others did not adopt any at all because they were not sure whether they would use the same lands later. This does not differ from the idea of Tesfaye (2011), that a more secure tenure system provides the incentives for farmers to decide on the adoption of SWC measures on their farm plots.

The provision of extension services increases the rate of adoption of soil and water conservation practices. More farmers adopted soil and water conservation practices as a result of their interaction with agricultural experts as compared to those farmers who had no interaction with such experts. The interaction increased awareness of the importance of a variety of soil and water conservation practices aimed at improving farm yields. This is in line with the findings of Mugonola et al. (2013), that contact with extension service providers was found to have a positive effect on the adoption of SWC measures in the Rwizi catchment of South-western Uganda.

Conclusion and policy implications

This study was carried out to establish the factors affecting the adoption of sustainable soil and water conservation practices by small-holder farmers in the Muyembe sub-county, Eastern Uganda. Based on the study findings, the following conclusions were made:

Eight soil and water conservation practices were being employed by farmers in the Muyembe sub-county. The dominant ones were contour cropping, mixed cropping, and crop rotation. The least popular practices were retention ditches and agro-forestry. Others that were moderately adopted included vegetative stripping, cover cropping, and mulching. Adoption of these practices was associated with levels of education, age of the farmers, the size of the land farmers held, farmers' income, and social capital.

Based on how these factors were associated with the adoption of soil and water conservation practices in the study area, we concluded that policy leaders need to attend to the factors about the adoption of soil and water conservation practices. Stakeholders who work on soil and water conservation programs and projects should use those farmers with relatively larger farm plots as points of entry to acquaint the practice more with small farm owners. Such model farmers can be used as proponents of improved structural soil and water conservation practices measures.

The study also concluded that no soil and water conservation practice can single-handedly and effectively conserve water and soil because of the physical characteristics of the area in terms of relief. Consequently, farmers need to be effectively trained in how to use the different soil and water conservation practices and the importance of investing in more than one practice, especially if one practice cannot effectively work on their farms.

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