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What Influences Farmer's Adoption Lag for Soil and Water Conservation Practices? Evidence from Sio-Malaba Malakisi River Basin of Kenya and Uganda Borders

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Abstract: Agricultural intensification and expansion efforts aimed at feeding increasing populations have led to soil degradation globally. Due to their suitability for resource-constrained farmers, and potential positive impacts on agricultural land improvement, Soil and Water Conservation Practices (SWCPs) are recommended as a solution to soil degradation in Sub Saharan Africa (SSA). However, the adoption rates of SWCPs are low and farmers who adopt them do not adopt on time. There is a lag between the time when farmers first learn about SWCPs and the time of adoption. This study examines the factors influencing adoption lag for Soil and Water Conservation Practices among smallholder farmers in the Sio-Malaba Malakisi River Basin border region of Kenya and Uganda. We utilize data collected from 506 randomly selected households and use the duration analysis model to analyze the data. Results show that the average adoption lag of SWCPs in the study area was about 10 years. Further, reduction in adoption lag is associated with household size, number of accessible markets, access to credit, age of the household head, farm size owned, and tropical livestock units. On the other hand, access to off-farm income and household location in Uganda are associated with increased adoption lag of SWCPs. Participation in social groups, households being male-headed, and education of the household head showed mixed effects on adoption lag, depending on the SWCP of focus. Strengthening farmer social networks and access to credit and markets are recommended as possible interventions to promote the timely adoption of SWCPs.

Keywords: soil and water conservation practices; adoption lag; soil loss; erosion; duration model

1. Introduction

The world population growth rate is higher than the growth rate of food production. For Sub-Saharan Africa (SSA), the population is expected to more than double between 2019 and 2050 [1]. Efforts to increase food production to match the needs of the growing population have been mainly through agricultural expansion and intensification, which have increased soil degradation rates [2]. In SSA, 70% of farmland is already degraded [3], which traps farmers in a cycle of land degradation effects.

Enormous quantities of soils are lost inconspicuously but leave devastating effects on land quality and the environment; soil erosion may pass unseen in onetime rain yet the associated soil loss ranges between 35 to 75 t/ha/year [4,5]. In the catchment of the Lake Victoria basin, in the Eastern African Plateau of South-Eastern Uganda and Western

Kenya, soil loss due to erosion in annual cropland use was estimated at 93–140 t/ha/year in 2002 [6,7]. Some counties in Kenya have experienced floods and severe drought stress with USD 11 billion lost to land degradation between 2001 and 2009 [8,9]. In Uganda, the highest portion of land degradation is due to erosion, causing a reduction in crop yield due to a lack of soil conservation [10–14].

Food production on limited land necessitates efficient use of the resources to ensure sustainable productivity and food security for growing populations. SWCPs contribute to the reversal and reduction of erosion and land and soil degradation rates and increase soil and crop productivity [5]. There have been recommendations to adopt SWCPs in Africa to ensure improved crop productivity and conservation of land resources [15]. Both Uganda and Kenya have policies that address and streamline the dissemination of SWCPs: on the part of Uganda, efforts to promote better land management practices including soils and water conservation practices, are embedded in the National Agricultural Extension Strategy and the National development plans II and III (NDPIII and NDPIII) [16]. Dissemination efforts are supplemented by other agencies (environmental conservation programs, forestry offices, Non-Governmental Organizations (NGOs), and farmer-based organizations. Kenya has a National Agriculture Policy (2019) and the National Agricultural Soil Management Policy (NASMP). These emphasize efforts to address the problems associated with declining soil productivity. Kenya has extension agents spread throughout the counties in Kenya [17]. Despite these efforts and farmers' exposure to different SWCPs, the adoption rates are still low, especially in SSA [18,19]. In addition, even with exposure and awareness of the SWCPs and their benefits among farmers, they still take long to adopt the practices. Delayed adoption is costly both in terms of lost value of production and soil quality. To control the decline in the quality of soils and improve agricultural land productivity in developing countries, SWCPs need to be adopted on time and at a reasonable rate.

There is limited empirical evidence on determinants of adoption lag (time between exposure to/awareness of a technology and its adoption) of SWCPs and its influencing factors. Even though many studies have been conducted on adoption, adoption intensity, and the influencing factors for SWCPs adoption [19–29], little is known about the specific extent to which farming households delay using the recommended SWCPs. Factors that influence how long the farmers take between exposure to SWCPs and adoption are also not clear.

Soil and Water Conservation Practices in East Africa

Over time from traditional society to now, farmers have been practicing different agricultural technologies as means of improving or sustaining their productivity, enhancing soil moisture, conserving rainwater, and controlling erosion. Both traditional and modern knowledge about SWCPs has been transmitted across generations. Indigenous agricultural knowledge can be roughly described as the knowledge that an indigenous (local) community accumulates over generations living in a particular ecological setting [30,31]. New and improved technologies were born from improvements of traditional ones [32]. Both traditional and modern SWCPs are practiced in SSA. Traditional practices include compost, mulching, trash lines, terraces, crop rotation, intercropping, minimum tillage, fallowing, cover crops, alley cropping, and contour plowing. While modern/improved practices include *fanya-chini* terraces, *fanya juu* terraces, trenches/diversion channels, grass trips, agro-forestry, improved trash lines, and bench-terraces [25,33–35]. Adoption of SWCPs depends on a number of factors including but not limited to physical, socioeconomic, and institutional factors [36–39].

In this study, we determined the adoption lag (delay time to adopt) and factors influencing the adoption lag of SWCPs being utilized by farmers in the Sio-Malaba Malakisi River Basin (SMMRB) border region between Kenya and Uganda.

2. Materials and Methods

2.1. The Study Area

This study was carried out in the Sio-Malaba Malakisi River Basin (SMMRB), located at the border between Kenya (Eastern side of the border) and Uganda (Western side of the border) (Figure 1). Kenya and Uganda were purposively selected because they are major food producers for neighboring countries such as Somalia, South Sudan, and Congo. The SMMRB has numerous natural resources for farming, which are being unsustainably exploited and result in land and soil degradation. The major economic activity in SMMRB is subsistence agriculture, which employs 85% of the population [40,41]. Busia and Bungoma counties in Kenya were selected while in Uganda, the study covered Tororo, Namisindwa, and Busia districts.

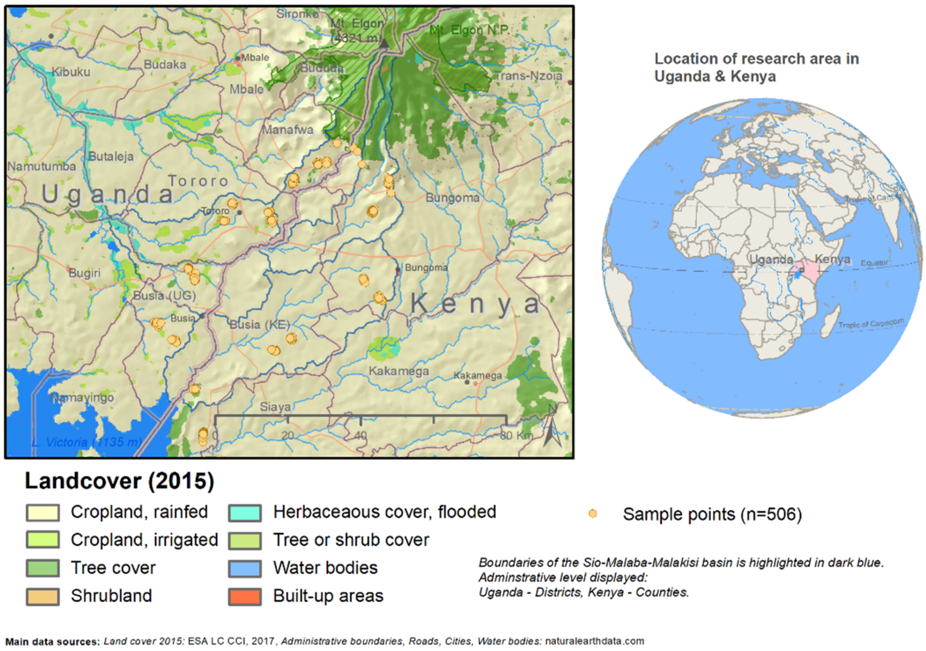

Figure 1. Land cover and location of the study area in the border region of Kenya and Uganda between Lake Victoria in the South and Mt. Elgon in the North. The distribution of sample points, where farmers were interviewed, is shown as points [42]. Another map containing other parameters than land use (e.g., geography, population density) can be found in [43].

2.2. Sampling and Data Collection

The study used a multi-stage purposive random sampling technique to select 506 households for the study in the SMMRB. A Ugandan district comprises smaller administrative units namely county, sub-county, parish, and village, in order of their level of importance. A Kenyan county on the other hand comprises the constituency, ward, and village. Only sub-counties and constituencies near the border and within the SMMRB were purposively selected. In Uganda, two sub-counties were randomly selected from each district, giving a total of six sub-counties from the three districts. From each sub-county, two villages were randomly selected to give a list of 12 villages considered in the study on the Uganda side. In Kenya, two constituencies were randomly selected from each county, giving a total of four constituencies of the two counties. From each constituency, two villages were randomly selected to give a list of eight villages considered in the study for Kenya. A sampling frame that had all the names of households living in the selected villages was retrieved from the village chairpersons. The sampling frame was used to randomly select 253 households from each country, this made a total of 506 farming households interviewed. A semi-structured questionnaire was used to interview farmers between May and June 2018 through face-to-face interviews. The data collected from farmers included socio-economic characteristics, farm production systems, soil and water conservation practices and adoption behavior, household assets, access to training, extension, credit and markets, and membership to groups, among others.

2.3. Analytical Methods

The duration analysis model (also known as survival analysis) is the most commonly used model to determine the time (duration) elapsed until a certain event occurs [44,45]. This time is defined as adoption lag (AL) in adoption studies [46–49]. Ref [50] argues that when studying the time difference between two mutually exclusive events (which are adoption and non-adoption of SWCPs in this case), the time difference between the two time points must be calculated. Therefore, to determine AL of a certain SWCP k, the difference between the year when the practice k was adopted by the household h and the year when it was made available/awareness to the household h was taken. In some cases, farmers were aware of SWCPs but had not yet adopted them by the time this study was conducted (2018). Therefore, their adoption time is unknown. However, it may take place in the future. To know how far such farmers (non-adopters who are aware) have lagged, the statistical procedure to determine AL was right-censored to establish the year of exit by the time when the study was conducted [50,51]. Thus, to get adoption lag for such farmers by 2018, the year of exit was replaced by the year when the survey was done (2018) to give their adoption lag by 2018.

Following [44,45,50], the empirical model of adoption lag conditional on having full knowledge about SWCPs is as follows:

$$(AL_{hki}|A_i = 1) = T_{hki} - T_{kh} \quad (1)$$

where by AL_{hki} is the adoption lag for household h conditional on awareness of an SWCP k on any plot i measured in years, T_{hki} is the year when household h adopted an SWCP k on any plot i (or 2018 for non-adopters who are aware), and T_{kh} is the year when the household h became aware of SWCP k. Following [36,46,50,51], adoption lag (AL) was determined and defined as the time in years between the year when a farmer learned about a specific soil and water practice and the year when they adopted the practice or the year of the survey (2018) for non-adopters. This means that non-adopters of SWCPs but who are aware of practice were still lagging behind till the time of the survey (2018), although there was a possibility that they may adopt the practice sooner or later in the future.

Duration analysis estimates, the effect of covariates on the duration/time elapsed until a certain event occurs. According to [46], recent duration analyses used hazard functions to estimate the probability of exiting the initial state (non-adoption). In cases where duration data are available, such that the dependent variable is in the form of duration (such as the number of years, weeks, or days), hazard functions have been the most suitable for modeling such duration data. In such cases, Ordinary Least Squares cannot be used because of its assumption of normality of the outcome variable [51]. Parametric, non-parametric, and semi-parametric models have been widely used in cases when the event is associated with influential factors [52,53]. Parametric models are the most preferred since they do not lead to rejection of what happens to covariates at the time of adoption. Weibull and exponential distribution are the most common [51]. Other functional forms that have been used include Gompertz, logistic normal, and log logistic probability distribution [54]. In this study, Weibull distribution was used. Therefore, the households' decision to adopt SWCP was modeled using lognormal hazard functions with Weibull distribution, by estimating the probability of exiting the non-adoption state via maximum likelihood estimation. The interpretation of the estimates is based on their signs that show the direction of effect and their probabilities that indicate the significance of the estimate. The empirical model according to [46] is as follows:

$$Log(AL) = \gamma P + \mu \quad (2)$$

where AL is the adoption lag, γ is a parameter to be estimated, P is a vector of household characteristics that influence AL, and μ is the error term.

Farm size was transformed into Inverse Hyperbolic Sine (IHS) form before being put into the duration model. HIS is a variable transformation form that accounts for variable skewness without a need to set zero values to 1 or another value needed to ensure normal distribution [55]. Means and percentages were used to summarize socio-economic variables. In addition, t-tests and Chi2 tests were used to test the significance of differences in socio-economic variables among male- and female-headed households.

3. Results and Discussion

3.1. Socio-Economic and Demographic Characteristics of the Respondents

Results in Table 1 show that the majority (80%) of the surveyed households were male-headed. There were statistically significant differences in some socio-economic characteristics between male and female-headed households in the study areas. Female-headed households had more farming experience, household heads were older, and had a higher dependency ratio than their male-headed counterparts. Male-headed households were significantly more educated, accessed more markets, and had comparatively bigger household sizes. An average household owned about 2 acres of land, while the average household head had 6.8 years of formal education. On average, each household had about six individuals, with a dependency ratio of 1.45 (Table 1). In addition, the awareness about any organizations that run sustainable land management, soil and water conservation, and natural resource was below average in the study area (33.8%). More so, participation in natural resource management was below average with 24% of households reported participation

Table 1. Socio-economic and demographic characteristics by gender.

Characteristic	Pooled (n = 506)	Female Headed (n = 100)	Male Headed (n = 406)	T-Statistics/Chi2
	Mean (SD)	Mean (SD)	Mean (SD)	
Education level of household head (years)	6.78 (3.89)	4.53 (3.88)	7.34 (3.68)	−6.76 ***
Farming experience of household head (years)	35.54 (15.67)	42.05 (16.71)	33.94 (14.99)	4.74 ***
Farm size (acres)	2.07 (3.05)	1.67 (2.47)	2.17 (3.17)	−1.46
Household size	6.19 (2.54)	5.38 (2.58)	6.38 (2.50)	−3.58 ***
Age of household head	49.31 (15.15)	55.41 (15.71)	47.82 (14.64)	4.58 ***
Number of accessible markets	1.99 (1.06)	1.8 (0.99)	2.03 (1.07)	−1.98 **
Tropical Livestock Units (TLU)	1.72 (2.71)	1.56 (1.88)	1.75 (2.87)	−0.6
Dependency ratio	1.45 (1.03)	1.62 (1.20)	1.41 (0.99)	1.78 *
Number of plots operated	5.77 (3.06)	5.34 (2.81)	5.88 (3.12)	−1.58
Number of parcels operated	1.72 (0.94)	1.6 (0.79)	1.75 (0.97)	−1.47
Male-headed household (0/1)	0.80 (0.40)	- (-)	- (-)	-
Participation in natural resource management trainings (0/1)	0.24 (0.42)	0.18 (0.39)	0.25 (0.43)	−1.45
Participation in extension services (0/1)	0.13 (0.33)	0.09 (0.29)	0.14 (0.34)	−1.24
Participating in social groups (0/1)	0.48 (0.50)	0.44 (0.50)	0.49 (0.50)	−0.90
Access to off-farm income (0/1)	0.72 (0.45)	0.67 (0.47)	0.73 (0.45)	−1.12
Households with access to credit (0/1)	0.32 (0.47)	0.32 (0.47)	0.32 (0.47)	0.09
Household owning livestock (0/1)	0.89 (0.31)	0.91 (0.29)	0.89 (0.31)	0.27
Awareness on land management/SWCP providers (0/1)	0.33.8 (0.21)	0.31 (0.5)	0.35 (0.24)	−0.67

Figures in parentheses are standard deviations. ***, **, * represents significance at 1%, 5%, and 10% level, respectively.

Farmers reported about 17 SWPCs that are being used in the SMMRB. Table 2 presents the SWCPs found in Kenya and Uganda. In addition, Figure 2 shows the number of farmers who adopted combinations of SWCPs (0 and 17) and their frequency.

Table 2. Soil and water conservation practices adopted in the study area.

Reported SWCPs	Number and Percentage of Adopters		
	Overall (*n* = 506)	**Kenya (*n* = 253)**	**Uganda (*n* = 253)**
Trenches/Diversion channels	304 (60.08)	168 (66.40)	136 (53.75)
Trash lines	183 (36.17)	114 (45.06)	69 (27.27)
Contour ploughing	163 (32.21)	110 (43.48)	53 (20.95)
Mulching	245 (48.42)	137 (54.15)	108 (42.69)
Fallow	233 (46.05)	121 (47.63)	112 (44.27)
Fanya chini	73 (14.43)	54 (21.34)	19 (7.5)
Minimum tillage	63 (12.45)	32 (12.64)	31 (12.25)
Intercropping	456 (90.12)	216 (85.37)	240 (94.86)
Hedges	63 (12.45)	42 (16.60)	21 (8.300)
Grass strips	189 (37.35)	123 (48.62)	66 (26.08)
Fanya juu	75 (14.82)	59 (23.32)	16 (6.23)
Fresh and decomposed manure	330 (65.22)	187 (73.91)	143 (56.52)
Alley cropping	26 (5.14)	16 (6.32)	10 (3.95)
Agro-forestry	180 (35.57)	100 (39.52)	80 (31.62)
Cover crops	285 (56.32)	146 (57.70)	139 (54.94)
Crop Rotation	420 (83.00)	208 (82.21)	212 (83.79)
Stones/soil bands	72 (14.23)	47 (18.58)	25 (9.88)

Note: The figures in parentheses are percentages while those outside parentheses are frequencies. Detailed descriptions of the SWCPs can be found in the literature [20,56–60].

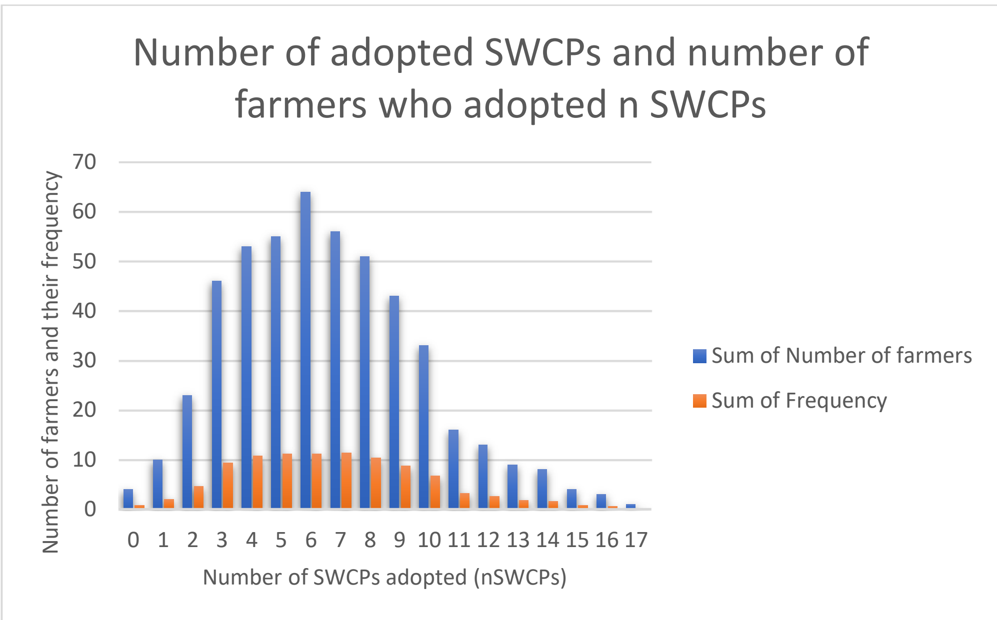

Figure 2. Number of SWCPs combinations adopted by farmers and farmer frequency.

3.2. *Adoption Lag and Its Determinants*

3.2.1. Adoption Lag of Soil and Water Conservation Practices

Results in Table 3 show adoption lags (AL) of the SWPCs present in the study area. The average household level adoption lag was estimated by averaging adoption lags for all SWCPs adopted by a given household, to estimate how long on average, a household waits to adopt any SWCP after becoming aware of it. The results show that the average adoption lag was 9.3 years. This means that an average household in SMMRB waits for about 10 years to adopt any of the 17 SWCPs. The earliest adopted SWCP was intercropping (AL = 4 years), while the tardiest adopted SWCP was stone/soil bands (AL = 15 years)**.**

Table 3. Adoption lag (in years) of soil and water conservation practices in SMMRB.

Soil and Water Conservation Practices (Pooled Sample *n* = 506)	**Mean Adoption Lag in Years**	**Standard Error**
Fanya Chini (*n* = 193)	12.35	0.93
Minimum tillage (*n* = 267)	9.09	0.65
Trenches/Diversion channels (*n* = 445)	9.76	0.57
Contour plowing (*n* = 311)	12.09	0.74
Trash lines (*n* = 315)	9.97	0.68
Fallow (*n* = 445)	12.08	0.58
Alley cropping (*n* = 96)	11.32	1.1
Crop Rotation (*n* = 448)	4.35	0.34
Hedges (*n* = 174)	13.21	1.01
Intercropping (*n* = 469)	3.95	0.32
Grass strips (*n* = 319)	10.92	0.65
Fanya juu (*n* = 197)	12.55	0.96
Agro-forestry (*n* = 312)	8.91	0.56
Stones/soil bands (*n* = 227)	14.16	0.89
Mulching (*n* = 392)	10.28	0.65
Cover crops (*n* = 336)	5.34	0.42
Use of fresh and decomposed manure (*n* = 425)	8.77	0.51
Household lag (average lag) (*n* = 506)	9.32	0.30

3.2.2. Factors Influencing Adoption Lag of Soil and Water Conservation Practices

Results from the duration analysis models used to estimate determinants of adoption lag for individual SWCPs under study are presented in Tables 4 and 5. Interpretation of the results is done simultaneously for both tables. All the models run to determine factors influencing the adoption lag of each of the 17 SWCPs were significant at a 1% level of significance. To interpret the results in Tables 4 and 5, the coefficient is multiplied by 100 to obtain the semi-elasticity of the covariate. The sign of the coefficient shows the direction of the effect of the covariate on the adoption lag of SWCPs while the corresponding probability shows the significance level. A positive coefficient means a longer waiting time to adopt SWCPs and a negative sign means a shorter waiting time to adopt SWCPs. In addition, a negative coefficient means higher chances/probability of adopting SWCPs early (discontinuing waiting time) while a positive coefficient means lower chances/probability of adopting SWCPs early.

Table 4. Factors influencing adoption lag of individual SWCPs.

	Mulching	Trenches/Diversion Channels	Trash-Lines	Fallow	Contour Ploughing	Grass Strips	*Fanya Chini*	*Fanya Juu*	Minimum Tillage
Independent Variable	**b/se**	**b/se**	**b/se**	**b/se**	**b/se**	**b/se**	**b/se**	**b/se**	**b/se**
Male-headed households (1 = Male)	0.229 (0.202)	0.475 ** (0.235)	0.273 (0.229)	0.239 (0.165)	0.023 (0.209)	−0.572 ** (0.270)	−0.524 ** (0.248)	−0.633 ** (0.258)	0.022 (0.235)
Household size	−0.031 (0.031)	−0.040 (0.031)	−0.050 (0.035)	−0.020 (0.027)	0.008 (0.036)	−0.058 (0.038)	−0.033 (0.035)	−0.020 (0.037)	−0.016 (0.032)
Education level of household head (years)	−0.035 * (0.021)	0.047 ** (0.022)	0.046 * (0.025)	0.000 (0.019)	0.036 * (0.019)	0.067 *** (0.026)	0.039 (0.028)	0.053 * (0.029)	0.045 ** (0.018)
Number of accessible markets	−0.080 (0.064)	−0.291 *** (0.078)	−0.089 (0.075)	−0.164 *** (0.053)	−0.084 (0.079)	−0.276 *** (0.084)	−0.141 * (0.077)	−0.175 ** (0.078)	−0.051 (0.057)
Access to credit (1 = Yes)	0.028 (0.152)	−0.245 (0.158)	−0.180 (0.167)	−0.302 ** (0.125)	−0.212 (0.138)	−0.035 (0.198)	−0.039 (0.169)	−0.141 (0.200)	−0.284 **(0.142)
Age of household head	−0.046 *** (0.008)	−0.039 *** (0.009)	−0.057 *** (0.008)	−0.067 *** (0.007)	−0.040 *** (0.010)	−0.076 *** (0.011)	−0.035 *** (0.008)	−0.034 *** (0.008)	−0.016 ***(0.006)
Farm size(IHS-acres)	−0.187 ** (0.095)	−0.322 *** (0.114)	−0.018 (0.148)	−0.219 * (0.113)	−0.219 ** (0.098)	−0.046 (0.134)	0.006 (0.155)	−0.046 (0.155)	−0.338 *** (0.108)
Access to extension services (1 = Yes)	−0.047 (0.264)	−0.198 (0.192)	−0.105 (0.239)	0.198 (0.177)	−0.209 (0.210)	0.050 (0.251)	0.268 (0.206)	0.076 (0.268)	0.057 (0.202)
Group participation (1 = Yes)	0.125 (0.155)	0.013 (0.162)	−0.052 (0.177)	0.129 (0.140)	0.064 (0.144)	−0.149 (0.163)	0.034 (0.209)	0.017 (0.193)	0.156 (0.151)
Household being from Uganda (1 = Yes)	0.164 (0.163)	0.433 ** (0.180)	−0.144 (0.150)	0.037 (0.141)	0.251 (0.179)	−0.015 (0.180)	0.336 (0.213)	0.352 * (0.208)	0.224 (0.138)
TLU	−0.036 (0.026)	0.011 (0.027)	−0.003 (0.034)	−0.003 (0.020)	0.022 (0.025)	−0.081 ** (0.035)	−0.016 (0.011)	−0.020 (0.018)	−0.016 (0.019)
Access to off-farm income (1 = Yes)	0.587 ** (0.255)	0.188 (0.243)	−0.099 (0.205)	0.231 (0.166)	−0.022 (0.208)	−0.283 (0.206)	0.192 (0.236)	0.124 (0.225)	−0.288 (0.195)
Constant	−2.927 *** (0.580)	−3.900 *** (0.693)	−3.089 *** (0.723)	−3.270 *** (0.582)	−4.217 *** (0.732)	−1.065 (0.720)	−3.147 *** (0.791)	−2.777 *** (0.745)	−1.739 *** (0.434)
ln_*p* Constant	0.533 *** (0.077)	0.621 *** (0.084)	0.687 *** (0.079)	0.790 *** (0.069)	0.694 *** (0.084)	0.691 *** (0.096)	0.553 *** (0.093)	0.498 *** (0.088)	0.145 *** (0.049)
Log-likelihood	−217.7 ***	−204.2 ***	−158.9 ***	−235.4 ***	−167.4 ***	−176.8 ***	−134.1 ***	−141.7 ***	−306.9 ***
n	283	322	245	360	248	253	143	146	233

Figures in parentheses are standard errors. ***, **, * represents significance at 1%, 5%, and 10% level, respectively.

The results in Tables 4 and 5 indicate that household size, number of accessible markets, access to credit, age of the household head, farm size, and Tropical Livestock Units (TLU) were generally associated with a reduction in the adoption lag of SWCPs. On the other hand, access to off-farm income and the household being located in Uganda were associated with an increase in the adoption lag of SWCPs. Participation in social groups, household being male-headed, and years of formal education of the household head had mixed effects on adoption lag of different SWCPs.

The coefficient on gender is negative and significant for most SWCPs (Tables 4 and 5), which indicates that when a household is male-headed, the adoption lag is likely to reduce. This is true for Grass strips, *fanya chini*, *fanya juu* ($p < 0.05$), and alley cropping ($p < 0.1$) with −0.572, −0.524, −0.633, and −0.535 coefficients for Grass strips, *fanya juu*, *fanya chini*, and alley cropping, respectively. These results mean that holding other factors fixed, the probability of adopting those practices early is higher by 57%, 52%, 63% and 54%, respectively when the household head is male compared to when it is a female-headed household.

Table 5. Factors influencing adoption lag of individual SWCPs.

	Hedges	Alley-Cropping	Agro-Forestry	Cover-Crop	Stones/Soil Bands	Inter-Cropping	Fresh Manure/Decomposed	Crop Rotation
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
Independent variable								
Male-headed households (1 = Yes)	0.096 (0.213)	−0.535 * (0.289)	0.300 (0.291)	−0.417 (0.325)	0.108 (0.207)	−0.135 (0.237)	0.316 (0.213)	0.313 (0.744)
Household size	−0.056 (0.041)	−0.010 (0.068)	−0.055 (0.042)	−0.025 (0.067)	−0.057 * (0.029)	−0.047 (0.030)	−0.123 *** (0.043)	−0.101 (0.108)
Education level of household head (years)	−0.012 (0.027)	0.006 (0.031)	0.038 * (0.022)	−0.058 (0.046)	0.030 (0.023)	0.021 (0.028)	0.019 (0.025)	−0.056 (0.054)
Number of accessible markets	−0.097 (0.076)	0.099 (0.094)	0.067 (0.077)	0.004 (0.150)	−0.110 (0.069)	−0.056 (0.073)	−0.407 *** (0.106)	−0.448 *** (0.170)
Access to credit (1 = Yes)	−0.146 (0.178)	−0.309 (0.221)	−0.080 (0.182)	0.235 (0.389)	−0.146 (0.148)	−0.246 (0.204)	0.204 (0.206)	0.336 (0.618)
Age of household head	−0.058 *** (0.008)	−0.050 *** (0.015)	−0.056 *** (0.008)	−0.056 *** (0.013)	−0.049 *** (0.008)	−0.030 *** (0.007)	−0.066 *** (0.010)	−0.054 *** (0.015)
Farm size(IHS-acres)	0.112 (0.128)	0.100 (0.177)	−0.055 (0.115)	−0.129 (0.229)	0.095 (0.110)	−0.032 (0.151)	−0.491 *** (0.187)	−0.228 (0.397)
Access to extension services (1 = Yes)	0.404 (0.266)	−0.280 (0.350)	0.217 (0.279)	−0.302 (0.482)	0.163 (0.185)	−0.289 (0.301)	0.263 (0.506)	0.987 (0.689)
Group participation (1 = Yes)	−0.198 (0.193)	0.384 * (0.217)	−0.368 ** (0.186)	0.081 (0.343)	−0.027 (0.164)	−0.354 * (0.210)	−0.341 * (0.203)	0.447 (0.640)
Household being from Uganda (1 = Yes)	−0.150 (0.205)	−0.364 (0.243)	−0.224 (0.182)	−0.438 (0.309)	0.021 (0.167)	0.017 (0.203)	0.345 (0.230)	0.762 (0.541)
TLU	−0.068 (0.048)	0.024 (0.063)	0.012 (0.037)	−0.006 (0.072)	−0.018 (0.025)	−0.022 (0.031)	−0.056 (0.049)	−0.092 (0.092)
Access to off-farm income(1 = Yes)	−0.250 (0.214)	0.079 (0.296)	−0.126 (0.202)	0.571 (0.404)	0.242 (0.185)	0.314 (0.224)	0.128 (0.232)	−0.481 (0.791)
Constant	−1.743 ***	−2.486 ***	−3.001 ***	−4.328 ***	−3.092 ***	−1.030 *	−2.688 ***	−3.657 **
	(0.649)	(0.943)	(0.607)	(1.151)	(0.675)	(0.549)	(0.754)	(1.839)
ln_*p* Constant	0.618 ***	0.588 ***	0.683 ***	0.919 ***	0.621 ***	0.175 ***	0.822 ***	0.808 ***
Log-likelihood	−126.8 ***	−76.4 ***	−170.3 ***	−65.1 ***	−174.0 ***	−260.5 ***	−139.5 ***	−56.3 **
n	147	82	237	200	197	230	311	235

Note: Figures in parentheses are standard errors. ***, **, * are significance levels at 1%, 5%, and 10%, respectively.

The results are comparable to those of [60–63] who argue that male-headed households are more likely to adopt agricultural technologies than female-headed households. Contrary to this, the authors of [24] found a higher likelihood of adoption of conservation technologies in female-headed households compared to male-headed households. The above results, therefore, suggest that male-headed households are not only more likely to adopt these SWCPs, but they are also likely to adopt them comparatively early as well.

Results (Tables 4 and 5) indicate that number of accessible markets to the household is significantly associated with reduced waiting time to adopt trenches/diversion channels ($p < 0.01$), fallow ($p < 0.01$), grass strips ($p < 0.01$), *fanya chini* ($p < 0.05$), *fanya juu* ($p < 0.05$), fresh/decomposed manure ($p < 0.01$), and crop rotation ($p < 0.01$) by 29%, 16%, 28%, 14%, 18%, 41%, and 45%, respectively. That is, it is associated with an increase in the probability of adopting those practices early holding other factors fixed. The number of accessible markets may be an incentive to invest in land management because of an assured outlet for the sale of crop produce. The authors of [64] argue that markets are very important because farmers only derive full benefit from investing in improved technologies if prices are high enough to warrant the investment. The results thus imply that a reasonable number of accessible markets can motivate farmers to control land degradation through timely adoption of SWCPs to increase in crop yield because of the expectation of better prices in different accessible markets.

The results in Table 4 further indicate that access to credit is significantly associated with reduced adoption lag for fallowing ($p < 0.5$) and minimum tillage ($p < 0.5$). This result suggests that access to credit increases the chance of early adoption of fallowing and minimum tillage by 30% and 28%, respectively, holding other factors constant. Credit may be used to invest in the adoption of technologies by facilitating the purchase or hiring of required resources. The authors of [65] also argue that access to credit enhances agricultural production and the adoption of agricultural technologies. Another possible explanation could be because credit may be used to buy food or to compensate for what would have been harvested from the land under the fallow. Similarly, credit can be used to hire more land from outside to grow different crops for household food security.

The results in Tables 4 and 5 indicate negative and significant (1% to 10%) coefficients on Inverse Hyperbolic Sine (HIS) transformed acres of total farm size by the household for mulching (−0.187), trenches (−0.322), fallow (−0.219) contour plowing (−0.219), minimum tillage (−0.338), and use of fresh/decomposed manure (−0.491). This means that a unit increase in the HIS transformed acres of farm size owned by the household is associated with reduced adoption lag of some SWCPs. That is, it increases the probability of early adoption of mulching, trenches, fallow contour plowing, minimum tillage, and use of fresh/decomposed manure by 19%, 32%, 22%, 22%, 34%, and 49%, respectively when other factors are held constant. Land ownership has been considered as a sign of stock of capital and a measure of wealth [66]. Thus, the more the land owned by the household, the easier it is to invest in various SWCPs early. In addition, farmers with large acreages can afford to leave part of their land under fallow since there is enough land to grow crops every season. Also, farmers with large acreages can easily adopt minimum tillage early because they can grow monocrops or limited intercrops on their larger land available. Similarly, for practices such as mulching and fresh manure, farmers with larger land are likely to produce the raw materials used from their own land, and thus the likelihood of adopting those practices earlier than those with smaller land. These results are consistent with those in Ref. [52] which found that land operation speeds up the probability of adopting agricultural technology. The authors [67] also found that large-scale farmers adopted agricultural inputs rapidly than small-scale farmers in Kenya. This implies that farmers who own large farm sizes are more likely to adopt SWCPs earlier than those without or with small farm size.

Table 5 indicates negative and statistically significant (5% to 10%) coefficients on group participation for agro-forestry (−0.384), intercropping (−0.354), and use of decomposed/fresh manure (−0.341). This means that farmer group participation reduces the adoption lag of agro-forestry, intercropping, and use of manure by 37%, 35%, and 34%, respectively. In other words, the farmer group participation is associated with the increased probability of adopting these SWCPs early, when other factors are held constant. The results are similar to those of Ref. [52], which found that farmer group participation reduces the adoption lag of agricultural technologies. In addition, participation in social groups does not only help farmers to socialize and access information, but it also helps to reduce weather risks and improve farm productivity [52,68]. Farmers in groups can also learn from demonstration plots that are common as a learning tool in farmer groups. Thus, farmer groups help in the transfer of information about agricultural technologies for yield improvement or land management, stimulating early adoption of SWCPs.

However, this study finds a positive (0.384) and significant (10%) coefficient on farmer group participation for alley cropping. This means that group participation increases the adoption lag of alley cropping by 38% *ceteris paribus*. In other words, it is associated with a reduced probability of adopting alley cropping early, holding other factors constant. It is thus evident that the effect of farmer group participation on adoption lag differs by technology or it depends on the main purpose of the groups because some groups may not be focusing on land conservation.

4. Conclusions

This study estimated adoption lag for soil and water conservation practices and highlighted factors influencing this delay in smallholder farmers of Sio-Malaba Malakisi River Basin of Kenya and Uganda. Cross-sectional data collected from 506 farmers in 2018 were used. Duration analysis with hazard model was used to determine factors influencing adoption lag for 17 soil and water conservation practices found in the study area. The average adoption lag was 9.3 years in the study area. Econometric results from the duration analysis model indicated that a unit increase in household size, number of accessible markets, access to credit, age of the household head, farm size, and tropical livestock units were generally associated with reduced adoption lag of SWCPs. On the other hand, access to off-farm income and the household being located in Uganda are associated with an increase in the adoption lag of SWCPs. Participation in social groups, the household being male-headed and years of education of the household head had mixed effects on adoption lag of different SWCPs. In conclusion, the study highlights the importance of having improved access to services such as markets and credit; ownership of resources such as bigger farm sizes and livestock (as indicated by Tropical Livestock Units); participation in social groups; and education of household heads for reducing adoption lag of SWCPs. Strengthening sustainable farmer social networks, access to credit and markets are recommended as part of interventions to promote timely adoption of soil and water conservation practices, as foreseen by national regulations and required for sustainable socioeconomic growth in East Africa [69,70]. In addition, further studies on the adoption lag of SWCPs should assess what happens to lags and their factors if combinations of SWCPs are adopted. Also, they should assess lags since the last SWCP is adopted.

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