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Factors Influencing Youth Farmers' Use of Soil and Water Conservation Technologies In Drylands of Machakos County, Kenya

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Land degradation presents a serious threat to sustainable soil and water resources, primarily through erosion, declining soil fertility, and extreme weather events. Addressing these challenges involves selecting appropriate Soil and Water Conservation (SWC) technologies to mitigate soil quality decline and enhance agricultural productivity. Soil and water conservation technologies have been promoted across various regions, especially in dryland areas for several decades with mixed outcomes. Despite their positive impacts, the utilization intensity of these technologies at farm level remains low. Furthermore, there is limited information on use and use intensity of the technologies among youth farmers, who are key to driving agricultural transformation. This study investigates the socio-economic factors influencing the use and use intensity of SWC technologies among youth farmers. A cross-sectional survey was employed to gather data from 396 youth farmers selected through a multi-stage sampling procedure. The data were analyzed using descriptive statistics and the Cragg's Double Hurdle (DH) model. The findings revealed that among 12 independent variables included in regression analysis education level, farm income, and farming experience significantly determined the choice of using SWC technologies. Additionally, access to credit, marital status, education level, farming experience, land size, technical knowledge, training participation, farm income, and land ownership had significant effects on the intensity of use. These findings highlight the need for targeted interventions, such as strengthening credit access, enhancing technical training, and expanding educational opportunities to promote broader adoption and effective utilization of SWC technologies. Integrating these factors into policy and planning is essential to enhancing agricultural productivity, resilience and sustainability among youth farmers in dryland regions.
Keywords: Youth farmers, Cragg's Double Hurdle model, climate variability, land use, resilience.

INTRODUCTION

Land degradation poses a significant threat to global agricultural productivity and food security, impacting millions of livelihoods (Slayi *et al*., 2024). It has resulted in increased vulnerability to climate variability and loss of biodiversity, impacting soil health and agricultural sustainability (Bhattacharyya *et al*., 2023). Approximately 52% of the world's productive land has experienced degradation, with nearly 80% of terrestrial areas affected by water erosion (Yousuf *et al*., 2019). In particular, declining soil fertility, often caused by continued extractive farming practices, poses a significant threat to crop production in many developing countries (Ndegwa *et al*., 2023). Each year, approximately 12 million hectares of farmland are lost worldwide due to soil degradation, with water erosion accounting for an estimated 28-36 petagrams of soil loss annually (Rotich *et al*., 2024). In response, the international community through United Nations Convention to Combat Desertification (UNCCD) has urged nations to take collective action to reduce land degradation and restore degraded lands and more particularly farmlands that support millions of resource constraint communities (Yan *et al*., 2024).

In Sub-Saharan Africa (SSA), poor land management and unsustainable farming methods are key drivers of food and nutrition insecurity (Kathula, 2023). An estimated 40% of

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SSA soils are classified as having insufficient soil nutrients, posing a significant barrier to food production needed to support a population projected to reach 2.7 billion by 2060 (Kiprotich *et al*., 2024; Tefera *et al*., 2024). Declining fertility of soils, combined with rising population pressure, is a major factor contributing to the gap between the demand for and supply of food in Africa (Asnake, 2024). As land degradation continues to affect human society, its negative impacts are expected to become more widespread, with SSA likely to be among the hardest hit regions (Tadesse and Hailu, 2024). Therefore , it is essential to implement SWC practices in African agricultural lands to safeguard food security and enhance productivity (Diop *et al*., 2022).

Kenya's population is anticipated to grow to 65 million by 2050, driving a substantial increase in food demand (Njoroge, 2020). However, this demand is threatened by challenges like land degradation, climate change, and low farming efficiency (Wang, 2022). For instance, approximately 80% of Kenya's land area is impacted by degradation AbdelRahman (2023), with severe soil erosion resulting in losses of up to 72 tonnes per hectare annually (Rotich and Csorba, 2022). This degradation is particularly pronounced in the Arid and Semi-Arid Lands (ASALs), where 30-40% of land area is rapidly deteriorating, and an additional 2% has already been completely lost (Nadir *et al*., 2024). The use of unsustainable farming methods has led to soil degradation, increased erosion rates, and reduced soil organic matter content, negatively affecting soil aggregate stability (Watene *et al*., 2021). Further, smallholder farmers in dryland regions of Kenya face altered livelihoods due to increased vulnerability to drought, erratic rainfall, floods, and food insecurity, highlighting the need for targeted interventions (Emoit and Gaynor, 2023). Climate-related challenges in these regions, have caused severe water stress, reducing soil moisture and fertility, constraining agricultural productivity, and exacerbating food insecurity (Tofu and Wolka, 2023). The combination of poor water retention and seepage losses further limits the productivity of these areas (Naorem *et al*., 2023).

Despite these challenges, there is considerable potential for agricultural development particularly through scaling up and out SWC measures. Techniques such as cover cropping, mulching, terracing, agroforestry, and intercropping improve soil conditions, moisture retention, and promote carbon sequestration capacity (Karuku, 2018). In regions like Machakos County, these technologies are widely practiced yet their utilization intensity at farm level remains low (Orumo and Mwangi, 2023). This highlights the need for broader implementation of these technologies to meet growing food demand while combating land degradation and climate change impacts. Previous studies in Kenya have also considered determinants of utilization of SWC technologies (Njenga *et al*., 2021; Nyirahabimana *et al*., 2021). Notably, household income, education status, gender, age, and household size influence uptake of SWC practices (Sherka, 2023). Factors such as marital status, age, access to alternative jobs, education level, access to land, occupation and market accessibility influence participation of youth in agricultural practices (Sennuga *et al*., 2023). Study by Muriithi *et al*. (2021) showed that the uptake of adaptation strategies was significantly influenced by gender (0.9%) and education level (9.2%). Using endogenous switch regression model, Ojo *et al*. (2021), indicated single farmers are more inclined to utilize technologies than their married counterparts, due to fewer responsibilities.

Limited evidence exists regarding the socio-economic determinants that influence use and intensity of use of SWC technologies among youth farmers in Kenya's dry zones. This study uniquely focuses on youth farmers, a demographic often overlooked in agricultural research despite their pivotal role in agricultural transformation as well as improving food and nutrition security. Integrating young people into smallholder farming is a key factor in advancing agricultural sector due to energy, enthusiasm, innovation, dynamism and openness to novel ideas and technologies (Mukwedeya, 2018). Moreover, youth farmers who are engaged in agricultural activities should be included in transforming food systems agenda (Rana and Bisht, 2023). Effective engagement of the youth in agricultural transformation agenda requires that they be equipped with appropriate tools, knowledge and skills (Mawia, 2023). In Kenya, where the informal sector contributes around 34% of the GDP and employs over 77% of the workforce Mogo *et al*. (2021), there is an increasing need to foster youth participation in agriculture. This highlights the importance of exploring how agricultural technologies can shape the decisions of youth to pursue farming as a career in Machakos County (Mwendwa, 2016). Addressing the adoption of SWC technologies is critical not only for enhancing food security and agricultural productivity at the local level but also for contributing to global initiatives aimed at promoting sustainable land use and mitigating land degradation. Participation of youth farmers in realizing this is thus critical as a change of technology adoption by this energetic and informed sector of the population. These initiatives are integral to achieving the United Nations Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger), SDG 13 (Climate Action), and SDG 15 (Life on Land). By promoting uptake of SWC technologies among youth farmers in the drylands of Kenya, this study supports these global goals by fostering sustainable farming methods and alleviating adverse impacts of climate change. This study, therefore, seeks to identify the socio-economic characteristics of youth farmers utilizing SWC technologies, analyze the socio-economic determinants influencing the adoption and use intensity of these technologies and provide policy recommendations to enhance the adoption of SWC technologies among youth farmers.

***Theoretical framework*:** This study was guided by Diffusion of Innovations Theory**,** the Theory of Planned Behaviour (TPB)**,** and the Push and Pull Theory**.** Diffusion of Innovations Theory by Rogers (2003), examined how specific attributes of SWC technologies such as perceived benefits, ease of use, and compatibility with existing practices influenced adoption decisions. The theory categorizes adopters into innovators, early adopters, early majority, late majority, and laggards. This theory would help to explain the varying rates of adoption among youth farmers based on their perceptions and willingness to try new innovations. The TPB, was also used to explore how attitudes, subjective norms, and perceived control influenced the youth farmers' intentions to adopt SWC technologies. These factors determine the likelihood of engaging in SWC measures, with stronger intentions leading to higher probabilities of adoption. The Push and Pull Theory Identifies the socio-economic drivers that either motivate or deter youth farmers from adopting SWC technologies (Norton and Alwang, 2020). Pull factors include access to critical resources like land, credit and agricultural training which encourage adoption. These factors attract youth to adopt new technologies by providing necessary support and enabling them to overcome barriers. On the other hand, push factors such as limited resources, lack of support and economic constraints act as barriers, discouraging youth farmers from adopting SWC technologies. Together, these theories offer a comprehensive framework for understanding the socio-economic factors influencing the decision-making process and use intensity of SWC technology among youth farmers in Machakos County.

MATERIALS AND METHODS

***Study Area*:** This study was conducted in Yatta Sub County located in Machakos County within dryland regions of lower Eastern Kenya. The Sub County has five wards (Ndalani, Kithimani, Matuu, Katangi and Ikombe). It occupies an area of 1062 square kilometers and its total population is approximately 172,583 (KNBS, 2019). The area lies between 1°37′S and 1°45′S latitude and 37°15′E and 37°23′E longitude. The rainfall pattern is bimodal with long rains commencing between March and May (about 400mm), while short rains are experienced from October to December (about 500mm). It has one permanent river and many seasonal rivers that dry up quickly after the rains. The Sub-county lies on a plateau at an altitude of 1700m. Located in agro-climatic zone IV, characterized as a semi-arid zone, the main economic activity is subsistence farming. Majority of residents are small-scale farmers practicing agricultural activities such as crop production and livestock keeping. Common crops grown are maize, beans, millet, sorghum, and cassava (Onyango, 2021).

***Research design, sample size and sampling technique*:** A cross-sectional survey design was employed in this study, targeting youth farmers in Yatta Sub County, Machakos County. The sample size was estimated to be 396 youth farmers based on Watson formula (Watson, 2001). A multistage sampling approach was employed to determine the sample size for data collection. In initial stage, Machakos County was selected as a representative of lower Eastern Kenya on justification that SWC technologies have been promoted in that County (Mwadalu *et al*., 2023). Further Machakos County is characterized by semi-arid conditions that are representative of the broader lower Eastern Kenya region. The County experiences variable rainfall patterns and frequent dry spells, making it an ideal location to study effectiveness of SWC technologies in mitigating negative effects of climate variability and enhancing agricultural productivity. In the second stage, out of eight Sub Counties of Machakos, Yatta Sub County was preferred due to its vulnerability to extreme weather events, yet majority of population depends on subsistence farming as the primary source of livelihood. Further, the Sub County has a significant population of youth engaged in agriculture. For instance 75% of youth population is engaged in agricultural activities in full time basis (Mwendwa, 2016). In third stage three wards of Yatta Sub County (Kithimani, Matuu, Ndalani) were randomly selected. In fourth step, two sub-locations were randomly selected from the three wards consisting of a total of six sub-locations including Kithimani, Matuu, Ndalani, Kaluluini, Kithendu and Mavoloni. Lastly, proportionate to size formula was used where the number of farmers in the selected sub-location was divided by number of farmers in the six sub-locations and multiplied by sample size.

***Data collection instruments*:** The study adopted a semi-structured questionnaire to collect information from respondents. The questionnaire addressed the utilization of twelve SWC technologies, farmer and farm characteristics, and socio-economic factors influencing use intensity of the technologies. The SWC technologies included terracing, cover cropping, buffer strips, mulching, contour farming, intercropping, ridging, construction of check dams, conservation tillage, live bands, trash lines, and cut-off drains.

***Model specification*:** In recent studies, the Double Hurdle model has become widely used for assessing both the choice to use agricultural technologies and extent to which they are utilized (Workie and Tasew, 2023). Therefore, the Double-Hurdle model, originally developed by Cragg is deemed suitable for this study (Cragg, 1971). The DH model assumes that farmers make agricultural decisions in two steps, an adoption decision followed by use intensity (Mahoussi *et al*., 2021). This model incorporates both probit and truncated regression at separate stages. In the initial stage, farmers made a binary choice to adopt SWC technologies and a probit regression was run to identify the factors influencing farmer's decision to adopt technologies. In the second stage, truncated regression was employed to examine intensity of adoption among individuals who passed the first hurdle. The model is specified as follows.

$Y_{i1} = \alpha A_i + \mu_i$ (probability of utilization)
$Y_{i2} = \beta X_i + \mu_i$ (Intensity of use)
$Y_i = \beta X_i + \mu_i$ if { $Y_{i1} > 0$ and $Y_{i2} > 0$
Where Y_{i1} indicates whether or not a youth farmer decides to use a technology or not, Y_{i2} is intensification of utilization, Y_i is proportion of land area under SWC technologies, A_i and X_i are explanatory variables, β are coefficients to be estimated and μ_i are error terms.

RESULTS

***Socio-economic characteristics of youth farmers*:** Table 1 displays summary statistics of the youth farmers who were part of the study sample. The data highlights the characteristics of these farmers with respect to their use of SWC technologies.

Table 1. Descriptive statistics of continuous variables.

Variable	Mean	Std. Dev.	Min	Max
Age	29.54	4.499	16	35
Household size	7.47	1.291	4	11
Experience	3.28	1.535	1	8
Land size (acres)	3.74	1.081	1	6
Farm size under cultivation	1.81	1.037	0.2	4

Source: Field data, 2024

The findings indicate that the mean age of youth farmers is 29.5 years, implying that respondents involved fit the prescribed age of definition of youth and thus their inclusion in the study was valid. The mean household size of 7.47 indicates that households in area of study are relatively large. This suggests that larger families may provide more labor for farming activities, potentially supporting the adoption of SWC technologies. With an average of 3.3 years of farming experience, most farmers are relatively new to farming, highlighting the need for targeted training and support for effective SWC technology use. The average land size per household is 3.74 acres, while youth farmers are cultivating an average of 1.81 acres. This indicates that youth farmers are using less than half of total available land for cultivation, suggesting potential for greater land utilization and more intensive agricultural practices.
Table 2 displays descriptive statistics for categorical variables used in the analysis. Pearson's Chi-square (χ^2) test and Fisher's exact test were used to assess the relationship between socio-economic factors and the adoption of SWC technologies at a 5% significance level ($\alpha = 0.05$). Specifically, Fisher's exact test was applied for categorical variables with expected frequencies below 5 as argued by Bazrafshan and Sayehmiri (2024) and also following the recommendations of Howitt and Cramer (2003).

Table 2. descriptive statistics for binary and categorical variables (chi2-test and Fisher exact).

Variables	Categories	Frequencies (percentages)			P-value
		Overall	Users (N=379)	Non-Users (N=17)	
Gender	Male	254(64.14)	244(64.38)	10(58.82)	0.640
	Female	142(35.86)	135(35.62)	7(41.18)	
Marital status	Single	196(49.49)	195(51.45)	1(5.88)	0.001***
	Married	192(48.48)	176(46.44)	16(94.12)	
	Widowed	4(1.01)	4(1.06)		
	Divorced	4(1.01)	4(1.06)		
Education level	None	36(9.09)	29(7.65)	7(41.18)	0.000***
	Primary	70(17.68)	61(16.09)	9(52.94)	
	Secondary	138(17.68)	137(36.15)	1(5.88)	
	College	110(27.78)	110(29.02)		
	University	42(10.61)	42(11.08)		
Occupation	Farming	284(71.72)	269(70.98)	15(88.24)	0.403
	Self-employed	50(12.63)	48(12.66)	2(11.76)	
	Government employee	11(2.78)	11(2.90)		
	Pension wages	51(12.88)	51(13.46)		
Landownership	Leased	61(15.4)	61(16.09)		0.118
	Own	71(17.93)	69(18.21)	2(11.76)	
	Family	264(66.67)	249(65.7)	15(88.24)	
Technical know-how	Yes	201(50.76	199(52.51)	2(11.76)	0.001***
	No	195(49.24)	180(47.49)	15(11.76)	
Participation in trainings	Yes	188(47.47)	187(49.34)	1(5.88)	0.000***
	No	208(52.53)	192(50.66)	16(94.12)	
Credit access	Yes	58(14.65)	57(15.04)	1(5.88)	0.486
	No	338(85.35	322(84.96)	16(94.12)	

Note: *** represents significance at 1%.

The findings from table 2 indicate that approximately 95.7% of the sampled farmers had utilized at least one of SWC technologies in the area of study. Gender distribution showed that a larger proportion of users (64.38%) were male, indicating that men farmers are mostly involved in implementing the technologies than female farmers. This disparity could be due to cultural factors, where traditional roles may limit women's engagement with technologies. Additionally, men may be more aggressive in adopting new practices, which could also contribute to their higher adoption rate. Findings indicate significant association between marital status and utilization of SWC technologies. Non-users were predominantly married (94.12%), while users had a more varied distribution, with singles (51.45%) and married individuals (46.44%) making up most of the group. This suggests that marital commitments may have an influence on technology usage. Education level shows a statistically significant relationship, with users more likely to have secondary (36.15%) or college (29.02%) education, while non-users are predominantly at the primary level (52.94%). This suggests that higher educational attainment is linked to greater utilization of SWC technologies, likely due to improved understanding and capability to engage with such practices. The findings reveal that most of both users (70.98%) and non-users (88.24%) were farmers, indicating that farming is the dominant occupation in both groups. However, youth farmers (70.98% of users) are more inclined to utilize SWC measures than non-farmers. Among users, 12.66% were self-employed, 2.90% were government employees, and 13.46% were pension wage earners. In contrast, among non-users, 11.76% were self-employed, and none were government employees or pension wage earners. This suggests that non-farming occupations have a lower adoption rate of SWC technologies. The land ownership data revealed that a higher proportion of users (18.21%) owned land compared to non-users (11.76%).

Among the users, most owned family land (65.7%), while others leased land (16.09%) or owned individual land (18.21%). The findings suggest that land ownership is a key factor in the adoption of SWC technologies. Technical know-how was more prevalent among users (52.51%) compared to non-users (11.76%), highlighting the importance of knowledge in adopting SWC technologies. Participation in training programs was statistically significant at the 1% level, with 49.34% of users participating compared to only 5.88% of non-users. This implies that access to training serves a vital role in adoption, as it equips farmers with the necessary knowledge and skills to adopt SWC technologies successfully. Credit access was observed more among users (15.04%) compared to non-users (5.88%), suggesting that financial support could help facilitate the adoption of SWC technologies.

DISCUSSION

***Use and use intensity of SWC technologies*:** The findings of the determinants of use and intensity of use of SWC technologies are presented in Table 3 and 4 respectively. The findings of the first hurdle indicate that level of education, farm income and experience in farming, were statistically significant variables influencing the probability of uptake of SWC technologies in area of study. The marginal effects

Table 3. Probit model.

Use	Coef.	St.Err.	dx/dy	t-value	p-value	[95% Conf	Interval]	Sig
Gender	-.06880	.40232	-0.0315	-0.17	.864	-.8573	.7197	
Marital status	-.57568	.55585	-0.0250	-1.04	.300	-1.6651	.5138	
Education level	.76263	.23610	.03491	3.23	.001	.2998	1.2253	***
Occupation	.48435	.35472	.02217	1.37	.172	-.2108	1.179	
Farm income	.00002	.000009	8.1e-07	2.09	.037	.000001	0.00003	**
Off-farm income	-.58557	.46713	-0268	-1.25	.210	-1.501	.33000	
Experience	.67974	.23339	.0311	2.91	.004	.2212	1.1382	***
Land size (acres)	-.03076	.18234	0.0014	-0.17	.866	-.3881	.3266	
Landownership	-.67409	.55520	0.0308	-1.21	.225	-1.762	.41409	
Technical knowhow	.73429	.50193	.03362	1.46	.143	-.24948	1.7180	
Participation in trainings	.58348	.61126	.0267	0.95	.340	-.6145	1.7815	
Credit access	.65680	.76500	0.0301	0.86	.391	-.8425	2.1561	
Constant	.90307	2.5515		0.35	.723	-4.0979	5.9040	

Mean dependent var	0.957	SD dependent var	0.203
Pseudo r-squared	0.535	Number of obs	396
Chi-square	75.125	Prob > chi2	0.000
Akaike crit. (AIC)	91.173	Bayesian crit. (BIC)	142.931

**** p<.01, ** p<.05, * p<.1*

estimates show how the probability of adopting SWC technologies changes with a one-unit increase in the explanatory variables. Conversely, the truncated results indicated that access to credit, marital status, level of education, experience, land size in acres, technical knowledge, participation in training programs, farm income, and land ownership significantly influenced the intensity of use of SWC technologies.

Results showed that education level influenced both choice of use and use intensity of SWC technologies. The finding suggests that a higher education level positively influences the probability of adopting SWC technologies, indicating that as a farmer's education level rises, the likelihood of adoption becomes much greater. This underscores the fact that the capacity to understand information through education can be the basis of deciding on utilizing or not utilizing a new technology that promises returns on investment. In the second stage, education level significantly influences the degree to which adopters use technologies. The findings imply that better-educated farmers not only adopt SWC technologies more frequently but also use them more intensively. Education thus helps change the perspectives from traditional to modern farming techniques among the youth farmers. This results corroborate findings of Belachew *et al*. (2020) that educated farmers possess greater knowledge and aware of soil and water conservation methods, enabling them to recognize and mitigate risks like soil erosion. The plausible justification was that educated farmers are more likely to seek information from development agents, embrace new technologies, and invest in SWC measures. This thus calls for enhanced extension service provision via all possible platforms so that the farmers remain constantly informed and updated on emerging and appropriate technology application to their areas of jurisdiction.

Farmer's experience significantly and positively affects the intensity and likelihood of adoption of the technologies. The marginal effects of this variable showed that as farming experience increases, the likelihood of utilizing SWC technologies and intensity of use also rise. This can be attributed to the fact that more experienced farmers are more inclined to adopt these practices and do so more intensively compared to less experienced farmers. The results are in tandem with previous research by Adesina and Favour (2016) who found that farming experience significantly influenced youth participation in agricultural programs. Also Ejaz *et al*. (2022);Wordofa *et al*. (2020) asserted that farming experience influences adoption of SWC technologies.

Farm income influenced the choice of use and intensity of use of SWC technologies. The study attributed this finding to the notion that higher farm income enhances the capacity of youth farmers to invest in agricultural innovations and sustainable practices, such as SWC technologies. Increased income provides the financial flexibility needed to cover the initial costs and potential risks associated with adopting new technologies This agrees with Osabohien (2023), that income strongly associates with adoption of information and technology among youth reducing post-harvest losses.

In terms of marital status, the findings showed a negative and statistically significant effect, showing that single farmers were more likely to use SWC practices compared to married farmers. This could be ascribed to single farmers generally having fewer responsibilities, allowing them to allocate more time and financial resources towards implementing SWC practices. On the other hand, the findings imply that married

Table 4. Truncated regression model.

Use intensity	Coef.	dy/dx	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Gender	1.772	1.77	1.091	1.62	.104	-.366	3.911	
Marital status	-3.42	-3.42	1.016	-3.37	.001	-5.411	-1.429	***
Education level	2.42	2.42	.542	4.47	0.000	1.358	3.482	***
Occupation	1.592	1.59	.542	2.94	.003	.530	2.654	***
Farm income	0. 0002	0.002	0.00001	14.31	0.000	0.0002	0.0002	***
Off-farm income	.744	.74	1.189	0.63	.531	-1.585	3.074	
Experience	.966	.97	.367	2.63	.009	.246	1.686	***
Land size (acres)	3.898	3.90	.555	7.02	0.000	2.809	4.987	***
Landownership	-2.332	-2.33	.739	-3.16	.002	-3.78	-.884	***
Technical knowhow	2.782	2.78	1.148	2.42	.015	.533	5.031	**
Participation in trainings	3.058	3.06	1.169	2.62	.009	.768	5.349	***
Credit access	3.126	3.12	1.471	2.13	.034	.244	6.009	**
Constant	4.433		3.969	1.12	.264	-3.346	12.213	
Sigma	9.853		.358	27.53	0	9.152	10.555	***

Number of obs	379	Chi-square	967.626
Prob > chi2	0.000	Akaike crit. (AIC)	2837.718

*** *p*<.01, ** *p*<.05, * *p*<.1

farmers are less inclined to engage in SWC measures. This could be attributed to marriage often leading to larger family sizes, which constrain financial resources and limit their ability to hire labor for SWC efforts. This outcome corresponds with results of Ojo *et al*. (2021) who posited that single farmers have higher likelihood of utilizing SWC technologies than married ones. The results however refute Afolabi *et al*. (2022); Sennuga *et al*. (2023) claim that youth engagement in agricultural activities is positively influenced by marital status. The implication was that marriage increases the economic responsibilities of youth farmers, prompting them to engage in income-generating activities to provide for their families. This necessity drives the adoption of sustainable practices like SWC technologies to enhance farm productivity and income stability.

Occupation positively influences the intensity of SWC technologies. The study attributes this to the fact that youth farmers whose primary occupation is farming are more likely to intensively adopt SWC technologies. This implies that full-time farmers have a greater vested interest in improving farm productivity and sustainability, leading to implementation of these technologies more thoroughly to enhance their income and long-term agricultural viability. Similarly a study by Sindakis and Showkat (2024) showed a positive correlation between occupation and utilization of innovations in agriculture. Further, farming as a primary occupation significantly contributes to the adoption of agricultural technologies, as farmers seek to boost productivity in response to declining arable land and a growing population's demand for more food (Shang *et al*., 2021).

The results also demonstrated a positive correlation between farm size and the adoption of SWC technologies because there is enough space to spare for trying and adopting them. This implies that the larger the farm the more likelihood of adopting these technologies. Additionally, owners of larger farms may perceive greater long-term benefits from improving water efficiency and land management, prompting them to adopt technologies that enhance productivity and sustainability. The results are consistent with those of Betela and Wolka (2021) and Mujeyi *et al.* (2020) who reported farm size to positively influence use of agricultural innovations.

Land ownership was negatively and significantly associated with the use of SWC measures. This suggests that youth farmers who lease land have a higher probability of utilizing technologies compared to those who either own land or use family land. This may be due to the investment made on leasing and desire to leap the most within the lease period by adopting the new appropriate technologies for maximum benefits. Correspondingly, Jha *et al*. (2021) asserted that a farmer who leased land was most able to engage in soil conservation and long-term beneficial practices, such as agroforestry. Further, the results are consistent with Xie and Huang (2021) findings who found that land leasing significantly influences adoption of agricultural technologies. The study however contradicted Chuang *et al*. (2020) and Dimelu *et al*. (2020) who found that land ownership did not influence young farmers intention to adopt innovative agricultural technologies.

Farmers' access to agricultural credit positively and significantly affected the intensity of use of SWC technologies. Farmers with access to credit are more inclined to utilize and intensify SWC technologies, as they can afford the necessary materials, tools, and labor to implement practices such as terracing or mulching. The credit facility needs to be repaid, hence the motivation to invest in the new and promising SWC technologies that guarantee best returns on investment. Furthermore, credit access enables farmers to make long-term investments in improving soil health and water management, which they might not be able to afford otherwise. Our finding was in agreement with those of Daudu *et al*. (2023); Ng'atigwa *et al*. (2020) who posited that access to credit influence youth participation in agricultural activities. Moreover, access to credit is crucial element for adoption of agricultural technology among smallholder farmers as it enables households to acquire necessary agricultural inputs and enhance long-term investment in their farms (Haryanto *et al*., 2023) .

The estimated coefficient for the dummy variable indicating youth farmer's participation in training programs showed a positive and significant influence on use intensity of SWC technologies. The study attributed this finding to the fact that participation in training programs equips youth farmers with the necessary knowledge and skills, thereby enhancing their capability and motivation to intensify the use of SWC technologies. The study agrees with Amadu *et al*. (2020), Hoang and Nguyen 2022 and Nguyen-Thi-Kim *et al*. (2024) who reported training programs to positively influence adoption of innovations in agriculture.

It was also found that technical know-how influences use intensity of SWC technologies. The study attributed this to fact that youth farmers with greater technical knowledge are more capable of effectively implementing and managing soil and water conservation practices. Technical know-how enables farmers to understand the benefits and proper application of these technologies, leading to better adaptation to local environmental conditions. The results resonates with those of Rotich and Csorba (2022) who found that skills and technical know-how influence adoption of SWC technologies. Further Bahari *et al*. (2024) reported that technical know-how had a positive influence on uptake of Internet of Things (IoT) in smart farming.

***Conclusion*:** The objective of this study was to determine factors influencing use and use intensity of SWC technologies among youth farmers in the drylands of Machakos County. The results, derived from DH model, highlighted that out of 12 independent variables analyzed, level of education, farm income, and farming experience were statistically significant in determining the likelihood of SWC technology adoption. Additionally, the truncated regression results indicated that variables such as access to credit, marital status, education level, farming experience, land size, technical knowledge, participation in training programs, farm income, and land ownership significantly influenced the intensity of SWC technology use. These results emphasize the need for targeted measures to promote adoption and utilization, such as expanding educational opportunities, improving access to credit, and providing technical training. Further, Policymakers and development practitioners should foster collaboration between government bodies, agricultural services, and necessary stakeholders to deliver community-based training and incentives for the adoption and use of SWC technologies. By addressing these factors, policymakers can empower youth farmers with the necessary knowledge, skills, and resources to enhance their engagement in agriculture and contribute to sustainable food security and livelihoods in Machakos County.

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REFERENCES

AbdelRahman, M.A.E. 2023. An overview of land degradation, desertification and sustainable land management using GIS and remote sensing applications. Rendiconti Lincei. Scienze Fisiche e Naturali 34:767-808.

Adesina, T.K. and E. Favour. 2016. Determinants of participation in youth in agriculture programme in Ondo State, Nigeria. Journal of Agricultural Extension 20:104-107.

Afolabi, B., J.D. Danladi and S. Ilugbusi. 2022. Determinants of youth engagement in agribusiness: Implication for sustainable agricultural practices in Southest, Nigeria. Fuoye Journal of Management, Innovation and Entrepreneurship 1:18-43.

Amadu, F.O., P.E. McNamara and D.C. Miller. 2020. Understanding the adoption of climate-smart agriculture: A farm-level typology with empirical evidence from southern Malawi. World Development 126:104692.

Asnake, B. 2024. Land degradation and possible mitigation measures in Ethiopia: A review 16:23-29

Bahari, M., I. Arpaci, O. Der, F. Akkoyun and A. Ercetin. 2024. Driving agricultural transformation: unraveling key factors shaping iot adoption in smart farming with empirical insights. Sustainability 16:2129.

Bazrafshan, M. and K. Sayehmiri. 2024. Predicting suicidal behavior outcomes: An analysis of key factors and machine learning models. BioMed Central Psychiatry 24:841.

Belachew, A., W. Mekuria and K. Nachimuthu. 2020. Factors influencing adoption of soil and water conservation practices in the northwest Ethiopian highlands. International Soil and Water Conservation Research 8:80-89.

Betela, B. and K. Wolka. 2021. Evaluating soil erosion and factors determining farmers' adoption and management of physical soil and water conservation measures in Bachire watershed, southwest Ethiopia. Environmental Challenges 5:100348.

Bhattacharyya, R., A. Bhatia, B.N. Ghosh, P. Santra, D. Mandal, G. Kumar, R.J Singh, M. Madhu, A. Ghosh and A.K. Mandal. 2023. Soil degradation and mitigation in agricultural lands in the Indian Anthropocene. European Journal of Soil Science 74:e13388.

Chuang, J.-H., J.-H. Wang and C. Liang. 2020. Implementation of internet of things depends on intention: young farmers' willingness to accept innovative technology 23:253-266.

Cragg, J.G. 1971. Some statistical models for limited dependent variables with application to the demand for durable goods. Econometrica: Journal of the Econometric Society 39:829-844.

Daudu, A.K., T. Abdoulaye, Z. Bamba, S.B. Shuaib and B.A. Awotide. 2023. Does youth participation in the farming program impact farm productivity and household welfare? Evidence from Nigeria. Heliyon 9:e15313.

Dimelu, M.U., A.M. Umoren and J.M. Chah. 2020. Determinants of youth farmers' participation in agricultural activities in akwa ibom state, nigeria. journal of agricultural science 12:201-202.

Diop, M., N. Chirinda, A. Beniaich, M. EI Gharous and K. EI Mejahed. 2022. Soil and water conservation in Africa: State of play and potential role in tackling soil degradation and building soil health in agricultural lands. Sustainability 20:13425.

Ejaz, R., K.M. Chaudhary, I. Ashraf and M. Tahir. 2022. Determinants of adoption of soil and water conservation practices in rainfed agriculture: a case study in Pothohar region, Pakistan. Journal of Arable Crops and Marketing 4:11-19.

Emoit, P.I. and N. Gaynor. 2023. Challenges faced by smallholder farmers in the implementation of adaptation strategies to climate variability in the arid and semi-arid areas in Kenya 13:45-56.

Haryanto, T., W.W. Wardana, I.R. Jamil, A.R.D. Brintanti and K.H. Ibrahim. 2023. Impact of credit access on farm performance: Does source of credit matter? Heliyon 9:e19720.

Hoang, H.G. and D.T. Nguyen. 2022. Factors influencing the adoption of improved rice varieties: A case of smallholder farmers in Quang Dien district of Vietnam. International Journal of Social Economics 50:227-241.

Howitt, D. and D. Cramer. 2003. A guide to computing statistics with SPSS 11 for windows—Revised edition. Harlow: Pearson Education Limited.

Jha, S., H. Kaechele and S. Sieber. 2021. Factors influencing the adoption of agroforestry by smallholder farmer households in Tanzania: Case studies from Morogoro and Dodoma. Land Use Policy 103:105308.

Karuku, G.N. 2018. Soil and water conservation measures and challenges in Kenya; A review 12:116-145.

Kathula, D.N. 2023. Factors Impacting agricultural production and the role of agricultural extension services in Kenya. Journal of Agriculture 7:22-44.

Kiprotich, S., H. Mogaka, S.N. Ndirangu and C.N. Onyari. 2024. Determinants of adoption and adoption intensity of integrated soil fertility management technologies among sorghum farmers in Upper Eastern Kenya. Soil Use and Management 40:e12958.

Mahoussi, F.E., P.Y. Adegbola, A.K.N. Aoudji, B. Kouton-Bognon and G. Biaou. 2021. Modeling the adoption and use intensity of improved maize seeds in Benin West-Africa: Double-hurdle approach. African Journal of Food, Agriculture, Nutrition and Development, 21:17931-17951.

Mawia, F.K. 2023. Factors influencing youth participation in agricultural cooperatives in the semi-arid areas of Kenya a case study of Mwingi, Kitui County. [PhD Thesis, Strathmore University].

Mogo, E.R.I., J.M. Wesonga, L.N. Gichuyia and E. Shuckburgh. 2021. COP26 Futures we want—Kenya country profile. Cambridge Open Engage.

Mujeyi, A., M. Mudhara and M.J. Mutenje. 2020. Adoption determinants of multiple climate smart agricultural technologies in Zimbabwe: Considerations for scaling-up and out. African Journal of Science, Technology, Innovation and Development 12:735-746.

Mukwedeya, B.T. 2018. The role of rural youth in the smallholder farming sector: Challenges and opportunies in Okhahlamba local municipality, South Africa. Engineering and Science.

Muriithi, L.N., C.N. Onyari, H.R. Mogaka, B.M. Gichimu, G.N. Gatumo and K. Kwena. 2021. Adoption determinants of adapted climate smart agriculture technologies among smallholder farmers in Machakos, Makueni, and Kitui Counties of Kenya. Journal of Agricultural Extension 25:75-85.

Mwadalu, R., A. Kisiwa, M. Elema and M. Gathara. 2023. Potential of soil and water conservation technologies for dryland agriculture and forestry. Journal of Applied Biosciences 181:18925-18939.

Mwendwa, J., 2016. Influence of social economic factors on youth engagement in agricultural project Activities in Yatta Sub-County, Machakos County Kenya [Thesis, University of Nairobi].

Nadir, S., R. Kaushal, A. Kumar, J. Durai, S. Reza, J. Ndufa, E. Ronoh, M. Elema, J. Thiga and M. Kumar. 2024. Hydrological response of bamboo plantations on soil–water dynamics in humid and semi-arid coastal region of Kenya. Water 16:1894.

Naorem, A., S. Jayaraman, Y.P. Dang, R.C. Dalal, N.K. Sinha, C.S. Rao and A.K. Patra. 2023. Soil constraints in an arid environment—Challenges, prospects, and implications. Agronomy 13:220.

Ndegwa, J.K., B.M. Gichimu, J.N. Mugwe, M. Mucheru-Muna and D.M. Njiru. 2023. Integrated soil fertility and water management practices for enhanced agricultural productivity. International Journal of Agronomy 2023:8890794.

Ng'atigwa, A.A., A. Hepelwa, M. Yami and V. Manyong. 2020. Assessment of factors influencing youth involvement in horticulture agribusiness in Tanzania: A case study of Njombe region. Agriculture 10:287.

Nguyen-Thi-Kim, N., N. To-The, T. Nguyen-Anh, P. Nguyen-The, T. Nguyen-Phuong, H. Lai-Minh, and T. Pham-Anh. 2024. Adoption of sustainable farming practices in Vietnam: A discourse of the determining factors. Heliyon 10:e31792.

Njenga, M.W., J.N. Mugwe, H. Mogaka, G. Nyabuga, M. Kiboi, F. Ngetich, M. Mucheru-Muna, I. Sijali and D. Mugendi. 2021. Communication factors influencing adoption of soil and water conservation technologies in the dry zones of Tharaka-Nithi County, Kenya. Heliyon 7:e08236.

Njoroge, W.W. 2020. Growth in energy demand and supply and its implications for achieving an inclusive green economy in Kenya [Thesis, University of Nairobi]. http://erepository.uonbi.ac.ke/handle/11295/154702

Norton, G.W. and J. Alwang. 2020. Changes in agricultural extension and implications for farmer adoption of new practices. Applied Economic Perspectives and Policy 42:8-20.

Nyirahabimana, H., A. Turinawe, J. Lederer, J. Karungi and M. Herrnegger. 2021. What influences farmer's adoption lag for soil and water conservation practices? Evidence from Sio-Malaba Malakisi River Basin of Kenya and Uganda borders. Agronomy 11:1985.

Ojo, T.O., L.J.S. Baiyegunhi, A.A. Adetoro and A.A Ogundeji. 2021. Adoption of soil and water conservation technology and its effect on the productivity of smallholder rice farmers in Southwest Nigeria. Heliyon 7:e06433.

Onyango, D.A. 2021. Climate change adaptation information for improved agricultural productivity among smallholder farmers in lower eastern Kenya [Thesis, University of Embu]. http://repository.embuni.ac.ke/handle/embuni/3878

Orumo, B.M. and J. Mwangi. 2023. Contribution of climate-smart agricultural activities to household livelihoods in masii ward, Machakos County, Kenya. African Journal of Empirical Research 4:182-198.

Osabohien, R., 2023. ICT adoption and youth employment in Nigeria's agricultural sector. African Journal of Economic and Management Studies 15:177-194.

Rana, J.C. and I.S. Bisht. 2023. Reviving Smallholder Hill Farming by Involving Rural Youth in Food System Transformation and Promoting Community-Based Agri-Ecotourism: A Case of Uttarakhand State in North-Western India. Sustainability 15:8816.

Rogers, E., 2003. Diffusions of Innovations 5th ed Free Press. New York.

Rotich, B. and A. Csorba. 2022. Soil and water conservation in Kenya; Practices, Challenges and Prospects. Proceedings of the 5th ISCW, Szarvas, Hungary pp 22-24.

Rotich, B., I. Maket, H. Kipkulei, C.M. Ocansey, P.N. Justine, M.A. MohammedZein, A. Csorba and E. Michéli. 2024. Determinants of soil and water conservation practices adoption by smallholder farmers in the central highlands of Kenya. Farming System 2:100081.

Sennuga, O., F. Alabuja, J. Bamidele, S. Maisule, S. Maisule and S. Sennuga. 2023. Rural youth participation in agriculture-based livelihood activities in Abuja, Nigeria. International Journal of Postharvest Technology and Innovation 10:45-62.

Shang, L., T. Heckelei, M.K. Gerullis, J. Börner and S.Rasch. 2021. Adoption and diffusion of digital farming technologies—Integrating farm-level evidence and system interaction. Agricultural Systems 190:103074.

Sherka, T.D. 2023. Factors affecting women's participation in soil & water conservation in abeshege district Southern Ethiopia. Cogent Economics and Finance 11:2192455.

Sindakis, S. and G. Showkat. 2024. The digital revolution in India: Bridging the gap in rural technology adoption. Journal of Innovation and Entrepreneurship 13:29.

Slayi, M., L. Zhou, A.R. Dzvene and Z. Mpanyaro. 2024. Drivers and consequences of land degradation on livestock productivity in sub-saharan Africa: a systematic literature review. Land 13:1402.

Tadesse, B. and M. Ahmed. 2023. Impact of adoption of climate smart agricultural practices to minimize production risk in Ethiopia: A systematic review. Journal of Agriculture and Food Research 13:100655.

Tefera, M.L., A. Carletti, L. Altea, M. Rizzu, Q. Migheli and G. Seddaiu. 2024. Land degradation and the upper hand of sustainable agricultural intensification in sub-Saharan Africa—A systematic review 125:63-83.

Tofu, D.A. and K. Wolka 2023. Transforming food insecure farmers from climate variability and land degradation susceptibility to resilient livelihoods. Research in Globalization 7:100168.

Wang, X., 2022. Managing land carrying capacity: key to achieving sustainable production systems for food security. Land 11:484.

Watene, G., L. Yu, Y. Nie, J. Zhu, T. Ngigi, J.de. D Nambajimana and B. Kenduiywo. 2021. Water erosion risk assessment in the Kenya Great rift valley region. Sustainability 13:844.

Watson, G. 2001. A study of CTLA formula values. Journal of Arboriculture 27:289-297.

Wordofa, M.G., E.N. Okoyo and E. Erkalo. 2020. Factors influencing adoption of improved structural soil and water conservation measures in Eastern Ethiopia. Environmental Systems Research 9:13.

Workie, D.M. and W. Tasew. 2023. Adoption and intensity use of malt barley technology package by smallholder farmers in Ethiopia: A double hurdle model approach. Heliyon 9:e18477.

Xie, H. and Y. Huang. 2021. Influencing factors of farmers' adoption of pro-environmental agricultural technologies in China: Meta-analysis. Land Use Policy 109:105622.

Yan, Z., Y. Guo, B. Sun, Z. Gao, P. Qin, Y. Li, W. Yue, W. and H. Cui. 2024. Combating land degradation through human efforts: Ongoing challenges for sustainable development of global drylands. Journal of Environmental Management 354:120254.

Yousuf, A., J. Lenz and E.A. Dar. 2019. Measures to control soil erosion. in watershed hydrology, management and modeling. pp. 77-97.