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Agricultural Extension Services and Use Intensity of Soil and Water Conservation Technologies among Youth Farmers in Drylands of Machakos County, Kenya

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ABSTRACT

Background: Effective extension services have the potential to bridge adoption gaps in soil and water conservation (SWC) technologies and ultimately minimize farmers' vulnerability to climate-related risks in agricultural production. However, information on the effectiveness of agricultural extension services (AES) in supporting the adoption of sustainable practices such as SWC technologies, remains limited in many parts of Kenya, despite being provided to farmers for decades. The aim of this research was to determine youth farmers' perceptions regarding the effectiveness of extension services and the factors that influence their use and use intensity of SWC technologies. The effectiveness of AES was measured using eleven variables.

Methods: Data were collected from 396 youth farmers using a semi-structured questionnaire through a cross-sectional survey with a multistage stratified sampling procedure. We used descriptive statistics and Tobit regression model for data analysis.

Result: The study found that AES among youth farmers in drylands of Machakos County were perceived as ineffective. The frequency of receiving extension services, the main source of information, tools used in delivering AES and the level of extension education influenced use and use intensity of SWC technologies. The results underscore the need for targeted interventions that increase the frequency of extension services, diversify information sources and improve the tools and training provided to youth farmers.

Key words: Agricultural extension services, Climate-smart agricultural practices, Effectiveness, Resilience.

INTRODUCTION

The agri-food sector is currently facing significant challenges, as the global population is projected to surpass 9 billion by 2050, necessitating a 70% increase in agricultural and food production to meet the growing demand (Ben Ayed and Hanana, 2021; Selvakumar and Sivakumar, 2021). Sub-Saharan Africa (SSA) has a young and rapidly growing population, with an annual growth rate of 2.6%, notably surpassing the global average of 1.5% (Byaro *et al.,* 2023). The industry does not appeal to the younger generation, who frequently move to cities in pursuit of better opportunities (Girdziute *et al.,* 2022). Climate-related challenges in Kenya's drylands, including drought, erratic rainfall and floods have intensified water stress, reduced soil fertility and constrained agricultural productivity (Mutungi *et al.,* 2025).

In response to these challenges, many developing economies, including Kenya, the government and development partners are promoting climate-smart agricultural practices and one of the main components of these practices are SWC measures (Abegaz *et al.,* 2024; Saraswati *et al.,* 2022). In Machakos County, terracing, mixed cropping, cover cropping and agroforestry are widely practiced (Mwadalu *et al.,* 2023). However, these measures will only be fully effective when they are consistently integrated into the household's farming operations where the youth actively participate. Despite the promotion of SWC, a smaller proportion of farmers' cultivated pieces of land are being treated with appropriate SWC practices (Belayneh, 2023). Numerous studies on the use of agricultural technologies have found that, alongside other demographic and socioeconomic factors, institutional constraints and incomplete information hinder the use of agrarian technologies (Kyalo *et al.,* 2025)

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Agricultural extension services influence farmers' attitudes, facilitate access to markets and support sustainable resource management (Prajapati *et al.,* 2025). However, in Kenya, AES are provided by the government through a top-down approach that is widely criticized for being inflexible and non-participatory and their effectiveness has further declined over the years due to low budgetary allocations, dwindling public sector resources and decentralization to county governments (Kyambo *et al.,* 2021). Moreover, ineffective extension linkages, insufficient and inappropriate agricultural technologies for farmers and inadequate extension agents hinder agricultural extension systems from delivering high-quality advisory services that are crucial for promoting sustainable development (Kassem *et al.,* 2021).

Youth engagement in agriculture holds the potential for driving innovation, integrating technology and promoting sustainable practices that could transform traditional farming landscapes. Engaging and empowering youth in agricultural extension programs is crucial for the long-term growth of rural communities and the overall development of the agricultural sector (Geza *et al.,* 2021). The aging population of African farmers in general and Kenya in particular undermines food security and the transfer of agricultural productivity enhancement knowledge and technologies, as they are less inclined and slower to adopt new technologies compared to younger farmers (Dave, 2020). In contrast, youth are argued to possess traits such as energy, resilience, innovation, adaptability and willingness to embrace new ideas, which are essential for adopting agricultural management practices and technologies (Devkota *et al.,* 2023). Therefore, this study seeks to assess the effectiveness of agricultural extension services and effectiveness determinants supporting use and use intensity of SWC technologies among youth farmers aged from fifteen to thirty-five years.

MATERIALS AND METHODS

Study area

The study was carried out in Yatta Sub-County, located in Machakos County within the arid and semi-arid lands (ASALs) of lower Eastern Kenya, an area with limited information on effectiveness of AES despite these services being offered for decades. The area is positioned on a plateau at an altitude of 1,700 meters above sea level and falls under agro-climatic zone IV, classified as a semi-arid zone. It covers an area of 1,062 square kilometers and has an estimated population of 172,583 people (KNBS, 2019). Geographically, Yatta Sub-County lies between latitudes 1°37′S and 1°45′S and longitudes 37°15′E and 37°23′E. Administratively, the Sub-County comprises five Wards: Ndalani, Kithimani, Matuu, Katangi and Ikombe. The region experiences a bimodal rainfall pattern, with long rains occurring from March to May (approximately 400 mm) and short rains from October to December (around 500 mm). Subsistence farming is the primary economic activity and means of livelihood, with most residents engaging in small-scale agricultural practices such as crop cultivation and livestock rearing. In addition, the region's food system is characterized by frequent crop failure occasioned with more frequent and severer climate extremes particularly droughts (Mutuku, 2020). Field data were collected during 2024 cropping season as part of academic research undertaken at the University of Embu.

Research design, sample size and sampling technique

This study employed a cross-sectional survey design focusing on youth farmers in Yatta Sub-County, Machakos County. A sample of 396 youth farmers aged from 15 to 35 years was taken based on Watson formula (Watson, 2001). A multistage sampling strategy was employed to choose youth respondents to participate in the study. In the first stage, Machakos County was purposively selected to represent lower Eastern Kenya due to the promotion of SWC technologies in the County (Mwadalu *et al.,* 2023). Additionally, AES have been provided to farmers in the area for a long period by the government, private sector, non-governmental organizations, as well as producer and farmer organizations. In second stage, Yatta Sub-County was purposively selected due to its vulnerability to extreme weather and heavy reliance on subsistence farming, highlighting the critical need to assess the effectiveness of agricultural extension services in enhancing farmers' resilience and productivity. The sub-county also has a substantial youth population engaged in agriculture, with approximately 75% of youth involved in farming on full-time basis (Mwendwa, 2016). In the third stage, three Wards: Kithimani, Matuu and Ndalani were randomly selected from the five Wards in Yatta Sub County. Subsequently, two sub-locations were randomly selected from each of these Wards, resulting in six sub-locations: Kithimani, Matuu, Ndalani, Kaluluini, Kithendu and Mavoloni. Finally, proportionate to size formula was applied by dividing the number of youth farmers in each selected sub-location by the total number of youth farmers across all six sub-locations and multiplying the result by total sample size to determine the number of youth farmers to be sampled from each sub-location.

Data collection instruments

The study utilized semi-structured questionnaire programmed in Kobo Toolbox to gather data from youth farmers. The questionnaire focused on utilization of twelve SWC technologies and effectiveness of AES in supporting use intensity of the technologies. The perceived effectiveness of AES was assessed using various variables based on the recommendations of Maake and Antwi (2022) which align with established standards for extension and advisory services in agriculture. Questions on AES measurements were presented on a five-point Likert scale: where, 1 = Very ineffective, 2 = Ineffective, 3 = Average, 4 = Effective and 5 = Very effective (Table 1). The proportions of very ineffective and ineffective were combined to be

classified as ineffective, while the average responses were categorized as moderately effective. Additionally, the proportions of effective and very effective were merged and classified as effective.

Model specification

Tobit regression model was used to analyse determinants of use and use intensity of SWC technologies among youth farmers. Tobit model consists of both discrete and continuous components, making it suitable for simultaneously analyzing the decision to use agricultural practices and the extent of their utilization. The dependent variable that was used in Tobit model is the proportion of land area under SWC technologies. The respondents were assigned 1 if users and zero for non-users. Where a user is a youth farmer who has utilized at least one of the technologies whereas non-users did not implement any of the technologies. Model specification is as follows:

$$Y_i = \beta_0 + \beta X_1 + \beta_2 X_2 + ... + \beta_n X_n + \varepsilon$$

Where,
Y_i = Utilization intensity.
X_1, X_2,..., X_n = Explanatory variables.
β_1, β_2...β_n = Coefficients of independent variables.
ε = Error term.

RESULTS AND DISCUSSION

Effectiveness of agricultural extension services

There were variations in responses on effectiveness of AES, among youth farmers (Table 2). The services were perceived as ineffective in 7 out of 11 variables as shown by proportion of respondents, exceeding 50%, who rated these services as either ineffective or very ineffective. For instance, with a mean of 1.82 (SD = 1.02) majority of respondents (77.53%) considered equity in service delivery to different groups, including youth farmers, as ineffective. Similarly, mean score of 2.25 (SD = 1.19) indicates that (67.93%) viewed the availability of AES on demand as ineffective highlighting the difficulty youth farmers faced in accessing these services when they were needed most. Additionally, flexibility in responding to youth farmers' ever-changing needs was seen as ineffective by 67.42% of youth farmers suggesting a lack of flexibility in adapting to the rapidly evolving challenges faced by youth in agriculture. In terms of providing and facilitating access to advice on sustainable agricultural production including conservation of natural resources, the mean score of 2.64 (SD = 1.29) indicates that over half of the respondents (51.01%) found the services ineffective in addressing these critical concerns. The impact on changes in productivity was rated

Table 1: Description of explanatory indicators in the regression model.

Explanatory indicators	Measurement description
Frequency of receiving AES	1= Weekly, 2= Monthly, 3= Annually, 4= Rarely
Main source of extension services	1=government extension officers, 2= farmer groups, 3=Social media (*i.e.* WhatsApp and Facebook)
Tools AES providers used	1= Printed materials, 2= Digital tools, 3= Demonstration kits
Access to AES	1= Yes, 0= No
Extension education	1= Yes, 0= No
AES received	1= Training workshops on SWC technologies, 2= Information through SMS or mobile apps, 3= Testing technologies, 4= Phone messages for farmers, 5= Radio and TV programs targeted to farmers, 6= Linking farmer to markets, 7= Linking farmer to input supplies, 8= Linking farmer to advisory services.
· Equity in service delivery. · Availability of AES on demand. · Is flexible in responding to farmers' ever-changing needs. · Alignment with farmer priorities. · Focuses on human and social capital development. · Provides and facilitates access to agricultural information for improved planning and decision-making. · Facilitates access to technology and where possible, provides such technologies · Provides and facilitates access to advice on sustainable agricultural production (including conservation of natural resources). · Impacts on changes in productivity. · Quality extension services. · Uses approaches relevant to beneficiaries.	1=Very ineffective, 2= ineffective, 3=Average, 4=effective, 5=very effective

with a mean of 2.40 (SD = 1.29), signaling that AES were not particularly successful in directly enhancing farm productivity, with 59.85% of respondents perceiving them as ineffective in this regard. Approximately 83.59% of youth farmers considered the approaches used by extension services to be relevant, suggesting that, although there are areas for improvement, many youth farmers found the methods employed in delivering extension services to be closely aligned with their needs and farming practices. In general, the effectiveness of AES was perceived as effective in 2 variables, as shown by the combined proportion of respondents who rated the services as effective and very effective and ineffective in 7 variables, based on the combined proportion of respondents who rated them as ineffective and very ineffective.

Use and use intensity of SWC technologies

The results on the determinants of the effectiveness AES influencing utilization rate of SWC technologies are presented in Table 3. The findings of this study indicate that the frequency of receiving agricultural extension services significantly influences the use of SWC technologies among youth farmers. Specifically, there was a negative relationship suggesting that as the frequency of receiving extension services decreases, for instance when services are provided less frequently such as annually or rarely, the likelihood of utilizing the technologies also declines. Conversely more frequent access to extension services for instance weekly or monthly visits is associated with higher usage levels. This implies that consistent and timely provision of extension services plays a critical role in encouraging youth farmers to use the technologies. Results of this study are in congruence with those of Khumalo *et al.* (2025) and Tamiru *et al.* (2023) who found that regular access to extension services facilitated the adoption of climate-smart agricultural practices by providing continuous technical support, which in turn enhanced productivity and contributed to improved food and nutrition security.

The main source of information was found to positively correlate with the use of SWC measures among youth farmers. The results showed that youth farmers who rely on digital social media were more likely to adopt and implement soil and water conservation technologies. These platforms provide timely, accessible and interactive content that empowers farmers with knowledge, skills and practical advice on sustainable agricultural practices. This suggests the growing role of digital platforms in extension. The finding aligns with that of Eze *et al.* (2021) who found that the use of mobile apps such as WhatsApp and Facebook for delivering extension services facilitated significant increases in agricultural productivity, including lowland rice production, vegetable production and upland rice production.

The use of visual and hands on tools by extension service providers influenced utilization of SWC measures among youth farmers. Tools such as demonstration kits which include practical tools and materials for showcasing agricultural technologies, significantly enhance farmers' understanding and confidence in implementing new practices. By providing tangible evidence of effectiveness, these demonstration kits bridge the gap between research

Table 2: Perceived effectiveness of agricultural extension services.

Variables	Frequencies (percentages)						
	Very ineffective	Ineffective	Average	Effective	Very effective	Mean	SD
Equity in service delivery	202(51.01)	105(26.52)	55(13.89)	28(7.07)	6(1.52)	1.82	1.02
Availability of AES on demand	122(30.81)	147(37.12)	64(16.16)	33(8.33)	30(7.58)	2.25	1.19
Is flexible in responding to farmers' ever-changing needs	136(34.34)	131(33.08)	80(20.20)	31(7.83)	18(4.55)	2.15	1.12
Provides and facilitates access to advice on sustainable agricultural production	94(23.74)	108(27.27)	78(19.70)	80(20.20)	36(9.09)	2.64	1.29
Focuses on human and social capital development	172(43.43)	111(28.08)	68(17.17)	25(6.31)	20(5.05)	2.02	1.15
Provides and facilitates access to agricultural information for improved planning and decision-making	119(30.05)	37(9.34)	74(18.69)	112(28.28)	54(13.64)	2.86	1.45
Facilitates access to technology and where possible, provides such technologies	106(26.77)	117(29.55)	4912.37)	105(26.52)	19(4.80)	2.53	1.27
Alignment with farmer priorities	22(5.56)	130(32.83)	89(22.47)	114(28.79)	41(10.35)	3.05	1.12
Impacts on changes in productivity	122(30.81)	159(29.04)	70(17.68)	54(13.64)	35(8.84)	2.40	1.29
Quality extension services	43(10.86)	31(7.83)	16(4.04)	236(59.60)	70(17.68)	3.65	1.18
Uses approaches relevant to beneficiaries	18(4.550)	20(5.05)	27(6.82)	190(47.98)	141(35.61)	4.05	1.02

and practical application, fostering a more engaging and educational experience for farmers. This emphasizes the importance of experiential learning. This corroborates findings of Hussain and Maharjan (2025) who found that on-farm demonstrations significantly influences adoption of agricultural technologies.

Equity in service delivery of AES was positively correlated with uptake of SWC technologies among youth farmers. This suggests that when AES are delivered equitably, ensuring that all youth farmers regardless of their socio-economic background have access to information, resources and support, they are more likely to utilize SWC technologies. This finding corroborates the results of Sattar *et al.* (2024) who found that equitable access to agricultural services significantly enhances technology adoption among smallholder farmers. It further indicated that when services are tailored and made accessible to underserved groups, such as youth farmers, adoption rates for agricultural innovations increase, leading to improved productivity and sustainability in farming.

Alignment of AES with farmer's priorities and needs was found to significantly influence utilization of SWC techniques among youth farmers. When AES programs are tailored to address the needs, challenges and goals of farmers, they are more likely to be adopted. This alignment ensures that services offered are relevant increasing their willingness to implement the technologies. This findings agrees with those of Hameed and Sawicka (2023) who reported that aligning extension services to farmers needs promoted adoption of sustainable practices and emphasizes the importance of understanding farmers perceptions and priorities to design extension programs that are relevant and effective. The relevance includes the extent to which the SWC technologies solve the farmers' immediate concerns such as food security and increased income besides ease of use and low investment costs.

Facilitation of access to technology, including the provision of such technologies where possible, was found to be a significant measure of the effectiveness of AES which significantly influences the utilization of SWC measures among youth farmers. This implies that enhancing AES to focus not only on disseminating knowledge but also on ensuring the availability and accessibility of relevant technologies can drive utilization of SWC technologies. Correspondingly, Danso-Abbeam (2022) reported that access to extension services plays a pivotal role in bridging the gap in the use of SWC measures, ultimately enhancing productivity and sustainability among farmers. Learning about extension education positively impacted youth farmers' adoption and use of SWC measures. Youth farmers who participated in extension education programs demonstrated a greater likelihood of implementing effective soil and water conservation practices, highlighting the importance of agricultural extension services in enhancing the adoption of sustainable farming techniques. This showed that capacity-building has a long-term effect. The study was in line with that of Kipkogei *et al.* (2025) who indicated that extension

Table 3: Parameter estimates of Tobit regression model.

Use intensity	Coef.	St. err.	t-value	p-value	[95% Conf	Interval]	Sig
Frequency of AES	-.136	.022	-6.34	.000	-.179	-.094	***
Main source information	.139	.028	4.88	.000	.083	.195	***
Tools providers used	.081	.030	2.67	.008	.021	.141	***
Alignment with farmer priorities	.047	.018	2.58	.010	.011	.083	**
Access to AES	.117	.080	1.46	.145	-.041	.275	
Quality services	.003	.015	0.19	.847	-.027	.033	
Relevant approaches	.012	.022	0.53	.597	-.032	.056	
Sustainable advice	-.018	.021	-0.89	.374	-.059	.022	
Equity in service delivery	.052	.023	2.28	.023	.007	.097	**
Access to technology	.066	.022	3.04	.003	.023	.109	***
Impact on productivity	-.023	.025	-0.90	.369	-.072	.027	
Human and social capital development	.041	.023	1.74	.082	-.005	.087	*
Extension education	.107	.057	1.87	.062	-.006	.22	*
Availability on demand	.049	.025	1.93	.054	-.001	.098	*
Information access for planning and decisions	.008	.017	0.45	.655	-.026	.041	
Flexibility to farmer needs	-.008	.025	-0.32	.752	-.058	.042	
Constant	2.895	.156	18.56	.000	2.589	3.202	***
var(use intensity)	.121	.009			.105	.139	
Mean dependent var	3.524		SD dependent var		0.460		
Pseudo r-squared	0.435		Number of obs		396		
Chi-square	211.287		Prob > chi2		0.000		

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

education positively influenced microcredit access and agricultural technology adoption, which in turn contributed to increased income for maize farmers in Kenya.

CONCLUSION

In general, AES were perceived as ineffective among youth farmers in drylands of Machakos County, as indicated by effectiveness measures such as equity in service delivery, availability of AES on demand, flexibility in responding to farmers' ever-changing needs, providing and facilitating access to advice on sustainable agricultural production, focus on human and social capital development, facilitating access to technology and impact on changes in productivity. This suggests that AES were not fully meeting the needs of youth farmers in terms of accessibility, relevance and flexibility. However, agricultural extension services were deemed effective in two aspects; quality of extension services and use of approaches relevant to beneficiaries. Through the Tobit regression model, the study identified key indicators that influencing use and use intensity of SWC technologies. These indicators include the frequency of receiving extension services, the main source of information, the tools used in delivering AES and the level of extension education. The results underscore the need for targeted interventions that increase the frequency of extension services, diversify information sources and improve the tools and training provided to youth farmers.

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Disclaimers

The authors' views and conclusions in this work are not associated with their linked institutions. The authors are responsible for the accuracy and completeness of their information. Similarly, authors remain committed to addressing any potential errors that may still be present, but they are not liable for any direct or indirect damage.

Informed consent

There was no coercive requirement for the respondents to participate and their responses were entirely optional.

Conflict of interest

The authors claim no conflicts of interest exist to publish this work. Research design, data collection, analysis, publication decision and production were independent of funding or assistance.

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