Adoption of Technology Enabled Agricultural Extension Services by Kenya's Youthful Farmers

Abstract

Agricultural extension services are vital for ending hunger, achieving food security, and improving nutrition. The adoption of Information and Communication Technologies (ICTs) enhances the reach and effectiveness of these services. This study examined the factors influencing the adoption of technology-enabled agricultural extension services (TEAES) among youthful farmers in Kenya, using the Technology Acceptance Model (TAM) as a guiding framework. A cross-sectional survey design was employed, collecting data from 325 young women and 243 young men through structured questionnaires. Data analysis involved descriptive statistics and Chi-square tests. The findings revealed that gender, education level, access to digital devices, and internet connectivity were all significantly associated with the adoption of TEAES, with education level being the most influential factor. Youth farmers showed a strong preference for blended (face-to-face and online) delivery models, indicating openness to digital platforms when infrastructural and socio-demographic conditions are favorable. The study concludes that adoption of TEAES is shaped not just by technological availability but also by digital literacy, access barriers, and inclusive design. It recommends targeted digital literacy programs, improved digital infrastructure, provision of affordable devices, and the development of inclusive, mobile-friendly content, particularly tailored to the needs of young women and underserved rural communities.

Keywords: Technology, Agriculture, Extension Services, Youthful Farmers and Mobile Learning

Introduction

Global efforts to create a world free of hunger by 2030 through increased agricultural productivity are well entrenched in the Sustainable Development Goals (SDG) of the United Nations. United Nations (n.d.) SDG Goal 2 aims to end hunger, achieve food security, improve nutrition, and promote sustainable agriculture. Achievement of this goal is pegged on increased agricultural production. Agricultural extension programmes have been the key channel for disseminating information to farmers on new farming innovations (Danso et al., 2018).

Agricultural extension and advisory services promote agricultural productivity, increasing food security and rural livelihoods (FAO, 2025 and FAO, 2017). However, agricultural extension services have been limited in their reach, particularly in Kenya's rural areas (Milu & Jayne, 2006; Awour & Rambim, 2022), and hence Kenyan farmers were not accessing new agricultural technologies. Online provision of agricultural extension service would go a long way in addressing this gap.

The use of online training as a means of delivering agricultural extension services has grown in popularity due to the increased availability and affordability of internet-based technologies. FAO (2017) observes that Information Communication Technologies (ICTs) are vital in providing agricultural extension and advisory services to farmers, especially in remote and poorly-endowed regions. Some technologies (radio, television, videos, and mobile phones) were being applied in extension services (FAO, 2017).

Internet penetration in Kenya stood at 32.7%, while smartphone penetration was estimated to reach 58.3% by July 2023 (Digital, 2023; Communication Authority of Kenya, 2017). Kenya Bureau of Statistics [KNBS] (2023) reports that 43.0% of boys and 57.0% of girls owned mobile phones, while the proportions for women and men were 50.0% and 53.0%, respectively. This indicates near-equal mobile phone penetration across genders, which is a game-changer for online agricultural extension services.

Based on ICT affordances, online agricultural extension services offer advantages such as flexible schedules, accessibility from anywhere, anytime, and reduced costs (School Education, 2022). Flexibility allows youthful farmers to participate at convenient times, while distance is no barrier. Online training also facilitates large-scale learning networks, enabling knowledge-sharing and best practices.

The potential of online delivery extension servicesas a substitute for traditional extension services is still underutilized in Kenya, especially among youthful farmers. Talukder (2012) indicates that understanding potential adopters and influencing factors is crucial for innovation adoption. This study aims to determine context-related factors influencing youthful farmers' adoption of online agricultural extension services in Kenya.

Objectives of the Study

To identify factors influencing adoption of online agricultural extension services among youthful farmers in Kenya.

Research Hypotheses

1. There is no relationship between gender and adoption of online agricultural extension services among youthful farmers in Kenya.
2. There is no relationship between education level and adoption among youthful farmers in Kenya.
3. There is no relationship between access to digital devices and adoption among youthful farmers in Kenya.
4. There is no relationship between internet access and adoption among youthful farmers in Kenya.

Literature Review

this literature review covers online agricultural extension services as alternative to traditional services, current state of agricultural extension services in kenya, factors affecting adoption of online extension services and benefits and drawbacks of online extension services

Online Agricultural Extension Services as Alternative to Traditional Services

Studies show that agricultural extension services can be provided online through digital devices. Rajkhowa (2021) asserts that increased internet access and smartphone ownership led to new digital extension approaches, driven by cloud services, open-source software, and big data analytics.

In Bangladesh, ICT was used to train farmers via floating centers with internet-linked laptops and multimedia equipment (Shidhulai Swanirvar Sangstha, 2023), proving online extension's feasibility. Gichuki & Wechuli (2020) observe that online extension fills gaps caused by limited conventional services while Langat (2020) notes past adoptions of digital learning in agriculture, where farmers used mobile texts to contact experts. Traditional agricultural extension services involved platforms like farmer study groups and demonstration farms (Rahman, 2017). Gichuki & Wechuli (2020) indicate ICT is an enabler for food security solutions. Hence the need to consider

how traditional extension services can be delivered digitally. Bates (2022) has identified affordances of distance-based online learning. These affordances can be harnessed to improve traditional extension services and benefit youthful farmers. Extension officers can create virtual platforms, organize farmer groups, and simulate innovations agricultural technologies via ICT.

Current State of Agricultural Extension Services in Kenya

Extension officers bridge research and farmers. NGOs, universities, and training centers have historically educated farmers on new and emerging agricultural technologies (Chandra Shekhar Prasad, 2012). Traditional extension provided one-on-one mentorship, crucial for modernizing agriculture (Danso et al., 2018). However, challenges including underfunding, weak farmer-research links, and limited officer have been a barrier to accessing this crucial services (Gichuki & Wechuli, 2020).

Extension officers' roles include propagating new methods, researching food and animal products, treating diseases, and farm planning (Langat, 2020). These services remain valuable, necessitating alternative delivery methods.

Factors Affecting Adoption of Online Extension Services

Technology (smartphones, computers, internet) access and digital literacy and training are essential for adoption technology-enabled agricultural extension services (TEAES) (Mugambi et al., 2018 and Adesoji & Olatokun, 2016). Youthful farmers are more likely to adopt TEAES if it is perceived to be beneficial (Kabbiri et al., 2018), aligning with Davis (1989) Technology Acceptance Model (Venkatesh & Davis, 2000; Taylor & Todd, 1995).

High technology costs may be impediment to adoption TEAES according to Minten et al. (2019) while Kabbiri et al. (2018) notes that peer influence may also matters when it comes to adoption of TEAES. Government policies, subsidies, and incentives promote adoption of new technologies like TEAES (Habtewold & Heshmati, 2023). Tailored information about new technologies increases their adoption (Rajkhowa & Qaim, 2021). Hence tailored advocacy message about TEAES would go a long way in increasing the likelihood of its adoption.

In Kenya, a narrow gender digital divide exists (KNBS, 2023) while Mugambi et al. (2018) notes that female farmers face unique challenges. These two factors may compound adoption of TEAES by youthful women. The other factors that may influence adoption of TEAES are related to trust of agricultural information sources (Geza et al., 2021). Adoption of TEAES will be embraced by many youthful farmers if they are involvement in decision-making to fosters ownership (Awotide et al., 2016).

Benefits and Drawbacks of Online Extension Services

TEAES will involve online learning to overcomes distance, time, and trainer limitations (Ranjan, 2021; Inegbedion, 2021). Strengths of TEAES include flexibility, wide reach, and immediate feedback (Rochina & Tabuena, 2022). However, TEAES is likely to face drawbacks in the context of, lack of social interaction, digital literacy gaps, and technical challenges (Joshi et al., 2022).

TEAES offers virtual training opportunities (Langat, 2020) via text, audio, video, or Learning Management Systems. It enables collaborative learning (Joshi et al., 2022). However, time management, technological barriers, and emotional frustrations are some of the anticipated weaknesses with TEAES (Rochina & Tabuena, 2022). Internet connectivity, device access and educator methodologies should also be anticipated as threats to TEAES. Addressing these challenges is crucial for effective adoption of TEAES.

Theoretical Framework

The study was underpinned by the Technology Acceptance Model (TAM), proposed by Davis (1989). The theory suggests that perceived usefulness and perceived ease of use are key determinants of user acceptance of technology like adoption of online delivery of agricultural extension services. Venkatesh and Davis (2000) extended the TAM and discussed it in the context of various technologies and incorporating social influence, facilitating conditions, and cognitive instrumental processes to predict user acceptance of a variety of information technologies. Taylor and Todd (1995) conducted a study on the Technology Acceptance Model and emphasised the importance of perceived usefulness and perceived ease of use as factors that influenced technology adoption.

The TAM is a widely recognized framework that is used to understand and predict how users adopt and accept new technologies or systems. In the context of the current study, TAM helped to analyse the factors that influence the adoption of online delivery of agricultural extension services among youth farmers in Kenya. The components of TAM that influenced adoption of technology include: perceived usefulness, perceived ease of use, external variables, behavioural intention and actual use. TAM further acknowledges that other than these factors, there were external factors that influenced adoption of technology such as demographic characteristics and individual differences. The conceptual framework is presented in figure 1.

Methods

A cross-sectional survey design was used to collect data from samples of youths who were actively involved in agriculture. Cross-sectional survey design collects data from specific points in time, allowing researchers to analyse the data to identify common patterns and trends among participants (Mugenda & Mugenda, 2013). This type of survey is well-suited to this study because it allowed the researcher to collect data that enabled determination of factors that would influence adoption of online delivery of agricultural extension services.

Sampling and Sampling Techniques

Purposive sampling techniques were used to select preformed Community Based Organization that were actively engaged in farming activities across 10 counties (Baringo, Nakuru, Narok, Marsabit, Kilifi, Tana River, Kakamega, Makueni, Meru and Taita Taveta) in Kenya. Stratified random sampling technique was further used to select 325 women and 243 men. Mugenda & Mugenda (2013) opines that purpose sampling is a non-probability sampling technique where the researcher chooses participants based on specific criteria or characteristics that are relevant to the research study while stratified proportionate random sampling techniques are appropriate in studies where there is comparison of various sub-groups.

Data Collection Procedure

KoBoCollect is an open-source mobile data collection tool that simplifies the process of gathering and managing data in the field, particularly in research and survey projects and allows users to create customized data collection forms, collect data using Android devices, and transmit the data

to a central server for analysis and reporting (KoBoToolbox, n.d.). The researcher created data collection forms using the KoBo Toolbox, a web-based form designer. The created forms included open and closed ended questions.

Data Analysis, Results and Discussions

Collected data was analysed using descriptive statistics (frequencies and percentages) and *Chi*^{2} *test* was used to test the null hypotheses. According to Mugenda & Mugenda (2013) a *Chi-square test is* used to determine whether there is a significant relationship between the observed frequencies in a sample and expected frequencies in a population. In the current study, the relationship between independence (gender, level of education, access to digital devices and access to internet) and adoption of online delivery of agricultural extension services were tested.

Relationship Between Gender and Adoption of Preferred Mode of Delivering Agricultural Extension Services

The first hypothesis tested the relationship between gender and mode of delivering agricultural extension services. The results are shown in table 1 and 2.

Table 1: Relationship Between Gender and Mode of Delivery of Agricultural Extension Services (n=569)

		GENDER					
		Female		Male		Total	
		n	%	n	%	n	%
MODE OF DELIVERY	Blended	103	18.1%	107	18.8%	210	36.9%

	Face-to-Face	192	33.7%	100	17.6%	292	51.3%
	Online	33	5.8%	33	5.8%	66	11.6%
	Total	329	57.8%	240	42.18%	569	100%

The results revealed that the majority (51.3%) of the respondents (female 33.7% and male 17.6%) preferred face-to-face mode of delivery while 36.9% preferred blended mode of delivering agricultural extension services. A *Chi² test* was further performed to establish if there was a relationship between gender and online delivery of agricultural extension services. The results are shown in Table 2.

Table 2*:* Relationship Between Gender and Adoption of Online Delivery of Agricultural extension services

Chi^2	15.81
df	2
p	<.001

The results of the chi-square test reveal a statistically significant association between gender and adoption of online delivery of agricultural extension services, $\chi^2(2) = 15.81$, $p < .001$. Although the relationship is statistically significant, the effect represented by Cramér's V = 0.17 is weak, indicating that gender influences adoption to a limited extent.

This suggests that while gender plays a role in shaping preferences for delivery modes, it is likely not the sole or dominant factor. Other variables, such as education level, access to digital devices, and digital literacy, may exert a stronger influence on adoption behavior. The results echo findings by OECD (2018), which reported that women are less likely than men to use the internet not due to lack of access alone, but often due to perceived irrelevance or lack of perceived usefulness.

These perceptions are directly linked to the Technology Acceptance Model (TAM), where perceived usefulness and ease of use are key determinants of technology adoption (Davis, 1989; Venkatesh & Davis, 2000; Taylor & Todd, 1995). If women do not perceive online extension services as useful or accessible, their likelihood of adoption decreases.

Moreover, OECD emphasizes that digital access, usage, and ownership are not gender-neutral, with women facing greater barriers due to affordability, social norms, and technical skills gaps. Therefore, a uniform approach to delivering agricultural extension services may inadvertently reinforce gender disparities. The implication is that gender-responsive strategies such as inclusive design, targeted outreach, and digital literacy training for women are necessary to ensure equitable access and adoption of online extension platforms.

Relationship Between Level of Education and Adoption of Preferred Mode of Delivery of Agricultural Extension Services

The second hypothesis tested if there was a relationship between level of education and mode of delivering agricultural extension services. Results are shown in table 3 and 4.

Table 3: Level of Education and Mode of Delivering Agricultural Extension Services (n=569)

		LEVEL OF EDUCATION						
		Certificate	Diploma	PRIMARY	SECONDARY	None	Degree	Total

MODE OF DELIVERY	BLENDED	6.5%	6.3%	8.4%	13.2%	0.4%	2.1%	36.9%
	Face-to-face	3.3%	1.1%	22.0%	17.1%	7.7%	0.2%	51.3%
	ONLINE	1.2%	1.2%	3.3%	3.87%	0.9%	1.1%	11.6%
	Total	11.1%	8.6%	33.7%	34.1%	9.1%	3.3%	100%

The results revealed that the majority (51.3%) of the respondents across all the levels of education preferred face-to-face mode of delivery. This implies that youth farmers preferred face-to-face and blended (face-to-face and online) mode of delivery of agricultural extension services. A Chi^2 test was further performed to establish if there was a relationship between level of education and online mode of delivery of agricultural extension services. The results are shown in Table 4.

Table 4*:* Relationship Between Level of Education and Online Delivery of Agricultural Extension Services

Chi^2	106.55
df	10

p	<.001

The chi-square test results reveal a statistically significant association between level of education and the adoption of online delivery of agricultural extension services, $\chi^2(10) = 106.55$, $p < .001$. The p-value, being far below the 0.05 threshold, provides strong evidence to reject the null hypothesis. With a Cramér's V of 0.31, the strength of the association is moderate, indicating that educational attainment has a meaningful influence on the likelihood of adopting online agricultural extension platforms.

These findings affirm that education plays a pivotal role in shaping youth farmers' readiness and ability to engage with digital extension services. Higher levels of education are often associated with improved digital literacy, better understanding of the perceived usefulness of technology, and greater confidence in navigating online platforms. As noted by OECD (2018), digital illiteracy particularly among individuals with lower education levels can hinder the ability to use digital tools effectively, reducing their likelihood of adoption.

This result aligns with the Technology Acceptance Model (Davis, 1989; Venkatesh & Davis, 2000; Taylor & Todd, 1995), where external variables such as education level influence perceived ease of use and perceived usefulness, two central factors driving technology acceptance. Youthful farmers with higher education are more likely to perceive digital agricultural services as both useful and manageable, increasing their behavioral intention to adopt these technologies.

The findings underscore the need for differentiated strategies in the design and delivery of online extension services. For populations with lower education levels, simplified interfaces, local language support, and targeted digital skills training may enhance adoption rates. For more educated groups, advanced content and self-paced learning tools may be more effective.

Following this, the study further explored whether youth farmers' interest in agriculture influences their likelihood of adopting online delivery of agricultural extension services.

Relationship Between Access to a Digital Device and Adoption of Online Delivery of Agricultural Extension Services

The third hypothesis tested the relationship between access to digital devices and adoption of online delivery of agricultural extension services. Table 5 and 6 show the results.

Table 5 Access to a Digital Device and Mode of Online Delivery of Agricultural Extension Services n=565

		MODE OF DELIVERY							
		BLENDED		Face-to-face		ONLINE		Total	
		n	%	n	%	n	%	n	%
ACCESS	Digital Devices	173	30.4%	168	29.5%	49	8.6%	390	68.5%
	NONE	35	6.2%	123	21.6%	17	3.0%	175	30.9%
	Total	208	36.6%	291	51.1%	66	11.6%	565	100%

The results revealed the majority (68.5%) of the youth farmers had access to a digital device. Face-to-face mode of delivering agricultural extension services was preferred by the majority (51.1%) of the respondents. This was followed by blended mode of delivery (36.6%) and online mode (11.6%). A Chi^2 test was further performed to establish the relationship between access to digital devices and adoption of online delivery of agricultural extension services. The results are shown in table 6.

Table 6*:* Relationship Between Access to Digital Devices and Online Delivery of Agricultural Extension Services

Chi^2	37.67
df	2
p	<.001

The chi-square test indicates a statistically significant association between access to digital devices and adoption of online agricultural extension services, $\chi^2(2) = 37.67$, $p < .001$. With a p-value well below the 0.05 threshold, the null hypothesis is rejected, affirming that access to digital devices has a significant effect on adoption behavior. The strength of this relationship is moderate, as indicated by Cramér's V = 0.26, suggesting that digital device availability is a key factor influencing engagement with online agricultural extension platforms.

This finding highlights the pivotal role of digital infrastructure in facilitating equitable access to agricultural knowledge. Youthful farmers who possess or can access smartphones, tablets, or computers are better positioned to benefit from digital extension services, as these tools serve as the primary gateways for accessing information, participating in virtual learning, and communicating with extension agents. These results corroborate Mugambi et al. (2018), who found that mobile device ownership among Kenyan youth significantly enhances access to agricultural information and services.

Although recent data show that 99.7% of Kenyans aged 16–64 own a smartphone (Connecting Africa, 2021), device ownership alone does not ensure meaningful or sustained use. Without adequate digital literacy and contextually relevant content, even well-equipped users may fail to fully utilize online platforms. Therefore, agricultural extension programs must adopt a holistic approach beyond merely providing devices by incorporating mobile-responsive content, intuitive interfaces, and user training initiatives tailored to the needs of young farmers.

These findings are consistent with the Technology Acceptance Model (TAM), particularly the "facilitating conditions" construct, which emphasizes the importance of access to necessary resources and support in influencing both perceived ease of use and behavioral intention. Improving digital infrastructure, coupled with targeted support mechanisms, can significantly

enhance the adoption and impact of online agricultural extension services among Kenya's youthful farming population.

Relationship Between Access to Internet and Adoption of Online Delivery of Agricultural Extension Services

The fourth hypothesis tested the relationship between accessing the internet and adoption of online delivery of agricultural extension services. The results are shown in table 7 and 8.

Table 7: Access to Internet and Mode of Online Delivery of Agricultural Extension Services n=568

		ACCESS TO INTERNET					
		Very Easy	Easy	Not sure	Difficult	Very difficult	Total
MODE OF DELIVERY	Blended	3.5%	27.8%	2.6%	2.5%	0.5%	210
	Face-to-face	3.7%	25.3%	10.0%	10.2%	2.1%	292
	Online	2.7%	6.2%	1.2%	1.8%	0.2%	66
	Total	9.5%	59.2%	14.1%	14.4%	2.8%	100%

Overall, 68.7% of the youths indicated accessing the internet was easy while 17.2% indicated it was difficult. A *Chi^2 test* was used to analyse the relationship between access to the internet and online delivery of agricultural extension services. The results are shown in Table 8.

Table 8*:* Relationship Between Access to Internet and Online Delivery of Agricultural Extension Services

Chi^2	55.56
df	8
p	<.001

The chi-square test revealed a statistically significant association between access to the internet and adoption of online agricultural extension services, $\chi^2(8) = 55.56$, $p < .001$. The p-value is well below the 0.05 threshold, providing sufficient evidence to reject the null hypothesis. With a Cramér's V of 0.22, the relationship is of moderate strength, indicating that access to the internet is a meaningful determinant of adoption.

This finding suggests that youthful farmers with reliable internet access are more likely to engage with online agricultural extension platforms. Internet connectivity serves as a foundational requirement for accessing digital content, participating in virtual training, and communicating with extension agents. The result reinforces earlier findings by Rajkhowa (2021), who emphasized that access to the internet enables farmers in remote or underserved areas to receive timely agricultural information, improving their capacity to make informed farming decisions.

Although increasing internet penetration across Kenya has improved access to online platforms, disparities in connectivity particularly in rural or economically disadvantaged regions continue to limit equitable adoption. Thus, while internet access is necessary, it is not solely sufficient. Extension programs must also address digital literacy, affordability, and content relevance.

The findings support the Technology Acceptance Model (TAM), particularly the role of facilitating conditions and external variables such as infrastructure, which shape perceived ease of use and intention to adopt. Enhancing internet access through policy and investment, especially in underserved areas, is therefore crucial to promoting widespread uptake of online agricultural extension services.

Conclusion

This study investigated the factors influencing the adoption of online agricultural extension services among youthful farmers in Kenya. Drawing on the Technology Acceptance Model (TAM), the study examined the role of gender, education level, access to digital devices, and access to the internet in shaping adoption behavior.

The findings reveal that all four factors (gender, education, access to digital devices, and internet connectivity) are significantly associated with the likelihood of adopting online extension services. However, the strength of association varied across the variables. Education level exhibited the strongest influence, suggesting that digital literacy and prior educational attainment play a critical role in enhancing farmers' capacity to navigate and benefit from online platforms. Access to digital devices and internet connectivity also showed moderate associations with adoption, confirming that infrastructural readiness is an essential enabler of digital engagement in agricultural contexts. Gender differences were statistically significant but comparatively weaker in strength. This points to the need for gender-responsive approaches that address digital access and perception gaps among male and female youth farmers. Women, in particular, may face compounded challenges due to social, economic, and technological barriers that limit their engagement with online services.

Overall, the study affirms that adoption of online agricultural extension services is not merely a matter of technological availability but is influenced by socio-demographic and infrastructural conditions. Interventions aimed at increasing adoption must therefore be multifaceted. Strategies should include expanding digital infrastructure, improving affordability and accessibility of devices, offering targeted digital literacy programs, and designing inclusive content delivery mechanisms that cater to users with varying levels of education and access.

The Technology Acceptance Model (TAM) remains a valuable framework for understanding these dynamics, particularly the influence of external variables on perceived usefulness, ease of use, and behavioral intention. By addressing the identified barriers and leveraging the enabling factors, stakeholders including policymakers, agricultural extension officers, and development partners can enhance the reach, equity, and impact of digital extension services among Kenya's youthful farming population.

Recommendations

i. In light of the study's findings on the factors influencing the adoption of online agricultural extension services among youthful farmers in Kenya, the following recommendations are proposed:

ii. Given the association between education level and adoption, government agencies, NGOs, and agricultural institutions should design and implement digital literacy programs tailored to youthful farmers with low formal education.

iii. Stakeholders should collaborate with private sector actors to subsidize or provide affordable digital devices to youth farmers, particularly in underserved and rural regions.

iv. The government and its partners should prioritize investment in affordable and reliable internet connectivity in rural and remote areas.

v. Extension programs should adopt inclusive design approaches that address barriers faced by young women farmers.

vi. Extension content should be accessible, mobile-friendly, and available in local languages.

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