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

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Abstract

Agricultural extension services are vital for ending hunger, achieving food security, and improving nutrition. The integration of Information and Communication Technologies has enhanced the reach, efficiency and effectiveness of these services. This study examined the factors influencing the adoption of Technology-Enabled Agricultural Extension Services (TEAES) among youth farmers in Kenya, guided by the Technology Acceptance Model. A cross-sectional survey design was employed, involving 325 young women and 243 young men who provided data through structured questionnaires. Descriptive statistics and Chi-square tests were used for analysis. The findings revealed that gender, education level, access to digital devices, and internet connectivity influenced TEAES adoption, with education level emerging as the most critical determinant. Youth farmers expressed a strong preference for blended delivery models, indicating a willingness to engage with digital platforms when infrastructural and socio-demographic conditions are favorable. The study concludes that TEAS adoption is shaped not only by technological availability but also by digital literacy, access barriers, and inclusivity in design. It recommends targeted digital literacy initiatives, improved digital infrastructure, provision of affordable devices, and the development of inclusive, mobile-friendly content tailored to the needs of young women and underserved rural communities.

Keywords: Technology, Agriculture, Extension Services, Youth Farmers

Introduction

Global efforts to eliminate hunger by 2030 are firmly embedded in the United Nations Sustainable Development Goals (SDGs). Specifically, SDG 2 seeks to end hunger, achieve food security, improve nutrition, and promote sustainable agriculture (United Nations, 2015). Achieving this goal depends heavily on improved agricultural production, which in turn requires effective dissemination of innovations. Agricultural extension programmes have long served as vital channels for transferring knowledge and technologies to farmers, thereby enhancing productivity and supporting rural livelihoods (Danso et al., 2018; FAO, 2017; FAO, 2025).

Despite their importance, conventional extension services in many developing countries, including Kenya, remain limited in reach. Coverage is often restricted in remote and resource-poor areas, hindering farmers' access to timely and relevant information (Kimani & Rao, 2025; Awour & Rambim, 2022; Milu & Jayne, 2006). These limitations underscore the need for innovative approaches that can broaden access and ensure equitable delivery of agricultural knowledge.

Information and communication technologies (ICTs) have emerged as powerful tools to overcome these constraints. Mobile applications, SMS services, videos, and voice-based platforms have been shown to enhance farmers' awareness, adoption of improved practices, yields, and incomes across sub-Saharan Africa (Mulungu et al., 2025; FAO, 2017). Collectively, these innovations form the foundation of Technology-Enabled Agricultural Extension Services (TEAES), which improve information dissemination even in hard-to-reach regions. Evidence from Kenya indicates that ICT-based extension, though still limited, has significantly boosted productivity where adopted (Gwademba et al., 2019). Kenya's digital landscape demonstrates strong potential for TEAES: as of January 2025, the country had 27.4 million internet users, representing a 48 percent penetration rate (Mutheu, 2025). Mobile phone ownership shows near gender parity, with 54.5 percent of men and 52.9 percent of women owning phones (KICTANET, 2025). Among youth aged 18–34, ownership rates are even higher, with 82.4 percent of men and 80.7 percent of women owning mobile phones (SCRIBD, 2023). These trends suggest that mobile-based platforms could effectively reach youth farmers and provide inclusive, gender-responsive extension services.

Despite these opportunities, adoption of TEAES in Kenya remains uneven, particularly among youth who constitute a significant portion of the agricultural workforce. While ICT-based tools offer flexibility, accessibility, and reduced costs (School Education, 2022), barriers such as limited digital literacy, poor connectivity, and lack of trust in digital platforms persist. Adoption depends not only on availability but also on user characteristics and perceived benefits (Talukder, 2012). Although youthf farmers are generally more receptive to technology (Mittal & Mehar, 2016), their engagement with TEAES is not fully understood.

Statement of the Problem

Despite the growing digital infrastructure and widespread mobile phone ownership among Kenya's youth, the adoption of Technology-Enabled Agricultural Extension Services remains uneven. Understanding the factors that influence this adoption is therefore critical for designing inclusive and effective digital extension programmes that can accelerate progress toward food security and rural transformation. This

study investigates how information and communication technologies (ICTs) can be leveraged to deliver timely, inclusive, and effective TEAES to Kenya's youth farmers.

Purpose of the Study

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

Research Hypotheses

H_{01}: There is no statistically significant relationship between socio-demographic and technological factors and the adoption of Technology-Enabled Agricultural Extension Services among youth farmers in Kenya.

Literature Review

This literature review covers transition from traditional to technology enabled extension services, growing feasibility and promise of online agricultural extension services, constrained affecting adoption of technology enabled agricultural extension services and benefits and drawbacks of online extension services.

Transition from Traditional to Technology-Enabled Extension Services

Conventional agricultural extension systems in Kenya have historically relied on platforms such as farmer study groups and demonstration farms (Rahman, 2017). Extension officers have played a central role in bridging research findings and farmers, providing one-on-one mentorship, propagating new methods, treating diseases, and supporting farm planning (Langat, 2020; Danso et al., 2018). NGOs, universities, and training centers have also contributed to educating farmers on new technologies (Chandra Shekhar Prasad, 2012).

However, persistent challenges including underfunding, inadequate staffing, weak farmer–research linkages, and limited coverage have restricted access to these services, particularly for rural and youth farmers (Gichuki & Wechuli, 2020; Danso et al., 2018; Langat, 2020). These constraints underscore the urgent need to digitize extension services to enhance scalability, timeliness, and interactivity. For Kenya's youth farmers, who are increasingly digitally connected, adopting TEAES offers a viable pathway to complement and extend traditional approaches, ensuring timely access to agricultural knowledge and enhancing productivity.

Growing Feasibility and Promise of Online Agricultural Extension Services (TEAES)

Studies show that agricultural extension services can be effectively delivered online through digital devices. Bates (2022) identified affordances of distance-based online learning that can be leveraged for agricultural extension. Rajkhowa (2021) asserts that increased internet access and smartphone ownership have driven new digital extension approaches, supported by cloud services, open-source software, and big data analytics. In Bangladesh, ICT was used to train farmers via floating centers equipped with internet-linked laptops and multimedia tools (Shidhulai Swanirvar Sangstha, 2023), demonstrating the feasibility of online extension.

In Kenya, 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, such as farmers using mobile texts to contact experts. These studies collectively show that online agricultural

extension services are feasible and impactful, offering scalable, interactive, and data-driven solutions that complement or even substitute traditional methods. With Kenya's youth farmers already exhibiting high levels of mobile phone ownership and increasing internet access, the adoption of TEAES holds significant promise. By leveraging digital platforms, mobile communication, and advanced tools such as cloud services and big data analytics, youth farmers can overcome the limitations of conventional extension and actively contribute to enhancing agricultural productivity and national food security.

Constraints Affecting Adoption of Technology-Enabled Agricultural Extension Services

Despite high mobile ownership and internet penetration, adoption of TEAES in Kenya remains uneven due to multiple barriers. Access-related challenges include limited connectivity, high costs of digital devices, and poor rural infrastructure (Minten et al., 2019). Knowledge-related barriers involve digital literacy gaps, lack of technical support, and limited ICT training (Mugambi et al., 2018; Adesoji & Olatokun, 2016). Socio-cultural factors such as gender inequalities, trust issues, and peer influence also play a role (Kabbiri et al., 2018; Geza et al., 2021). Institutional constraints include weak policy support, limited incentives, and fragmented coordination among stakeholders (Habtewold & Heshmati, 2023).

Youth farmers are more likely to adopt TEAES if they perceive it as beneficial, consistent with Davis' (1989) Technology Acceptance Model (Venkatesh & Davis, 2000; Taylor & Todd, 1995). Peer influence can further shape adoption decisions (Kabbiri et al., 2018). Supportive government policies, subsidies, and incentives have been shown to promote uptake (Habtewold & Heshmati, 2023), while access to tailored information enhances adoption (Rajkhowa & Qaim, 2021). In Kenya, a narrow gender digital divide exists (KNBS, 2023), and female farmers face unique challenges (Mugambi et al., 2018), compounding adoption barriers. Trust in agricultural information sources is also critical (Geza et al., 2021). Adoption is more likely when youth farmers are involved in decision-making, fostering ownership and empowerment (Awotide et al., 2016).

These findings highlight that adoption of TEAES is not only a technological issue but also a socio-economic and institutional challenge requiring multidimensional solutions.

Benefits and Drawbacks of Online Extension Services

Technology-Enabled Agricultural Extension Services (TEAES) offer multiple benefits. They overcome distance, time, and trainer limitations (Ranjan, 2021; Inegbedion, 2021), provide flexibility, wide reach, immediate feedback (Rochina & Tabuena, 2022), and enable virtual training opportunities through multiple modes of engagement such as text, audio, video, and Learning Management Systems (CAST, 2024; Langat, 2020). TEAES also fosters collaborative learning among farmers and extension agents (Joshi et al., 2022).

Despite these strengths, drawbacks exist. Challenges include limited social interaction, digital literacy gaps, technical difficulties, and frustration with navigating online platforms (Joshi et al., 2022; Rochina & Tabuena, 2022). Other weaknesses include difficulties with time management, connectivity issues, limited device access, and trainers' methodologies.

Overall, while TEAES offers flexibility, broad reach, and innovative learning opportunities well-suited to the digital orientation of Kenya's youth farmers, its effective adoption will depend on addressing challenges such as digital literacy gaps, connectivity barriers, and limited access to devices. Success will require balancing technological innovation with human-centered design and support mechanisms.

Theoretical Framework

Understanding adoption behavior requires a strong theoretical grounding to explain how perceptions, attitudes, and contextual factors influence technology use. This study is anchored in the Technology Acceptance Model (TAM), developed by Davis (1989), which provides a foundational framework for analyzing how individuals adopt and use new technologies. TAM posits that two key beliefs underpin technology adoption: perceived usefulness (the extent to which a person believes that using a system will enhance their performance) and perceived ease of use: the degree to which the system is perceived as free of effort.

Venkatesh and Davis (2000) extended TAM by incorporating constructs such as social influence, facilitating conditions, and cognitive instrumental processes. These extensions are particularly relevant in complex environments like agriculture, where external factors such as infrastructure, peer networks, and institutional support strongly shape adoption behavior.

In the context of this study, TAM is applied to examine how youth farmers perceive and respond to TEAES**.** The model provides an analytical lens to interpret the relationship between individual beliefs and external variables such as gender, education level, access to digital devices, and internet connectivity. These external variables are critical in shaping behavioral intention and actual use, especially in rural and underserved regions. For example, education level influences digital literacy and the ability to navigate online platforms, thereby affecting perceived ease of use. Rani and Kumar (2023) emphasize that digital literacy is a key enabler of agricultural innovation among youth, particularly when supported by structured training and access to relevant tools. Similarly, gender may shape perceptions of usefulness and trust in digital systems, as women often face social and economic barriers to technology adoption. Qazi et al. (2022) provide a meta-analysis of gender differences in ICT use and skills, highlighting persistent gaps in access and capability, while Mifuko Trust (2025) documents how digital tools empower women in rural Kenya, enhancing their participation in regenerative farming and digital agriculture.

Access to digital devices and internet connectivity also serve as enabling conditions without which adoption is unlikely, regardless of perceived benefits. Research by CGIAR (2022) highlights how mobile internet and digital innovations are transforming rural agricultural practices across Africa, especially when supported by inclusive infrastructure and policy frameworks. Additionally, the International Labour Organization (ILO, 2023) underscores the importance of market-driven digital skills in empowering youth in Kenya's agricultural sector, linking digital inclusion to economic opportunity and innovation.

By applying TAM, this study recognizes that adoption of TEAES is not solely a function of technological availability but is deeply influenced by socio-demographic factors and contextual realities. The framework thus offers an analytical lens to interpret adoption patterns and identify leverage points for intervention, ensuring the design of inclusive, effective, and scalable digital extension services that resonate with the needs and capacities of Kenya's youth farmers.

Methods

Research Design

A cross-sectional survey design was used to collect data from youth farmers actively engaged in agriculture. This design allows researchers to gather information at a single point in time, enabling the identification of patterns and trends among participants (Creswell & Creswell, 2018; Mugenda & Mugenda, 2013). It also permits data collection from a wide range of participants simultaneously, thereby increasing representativeness (Bryman, 2016). The design was appropriate for this study as it facilitated the determination of factors influencing the adoption of online delivery of agricultural extension services.

Sampling Techniques

The sampling procedure involved a two-stage approach to ensure representativeness and enable subgroup comparisons. First, purposive sampling was used to select community-based organizations (CBOs) actively engaged with youth farmers across ten counties in Kenya. This ensured that the sample included organizations relevant to the study objectives (Creswell & Creswell, 2018).

Following the selection of CBOs, a stratified random sampling technique was employed to ensure sufficient numbers are sampled from the population sub-groups. The sample was stratified by gender to allow comparative analysis between young men and women farmers. Within each stratum, participants were randomly selected proportionally to their representation in the population, resulting in a sample of 325 young women and 243 young men. Stratified sampling method reduces sampling bias and enhances the precision of subgroup estimates (Etikan et al., 2016; Kothari, 2004). The approach aligns with established sampling principles for subgroup analysis (Mugenda & Mugenda, 2013).

Data Collection Procedure

Data were collected between May and August 2023 across ten counties representing diverse agro-ecological zones in Kenya. KoBoCollect**,** an open-source mobile data collection tool administered via Android devices, was used. KoBoCollect enabled the electronic administration of structured questionnaires and secure transmission of responses to a central server (Bhardwaj et al., 2021; KoBoToolbox, 2023).

The questionnaire was designed to capture information on socio-demographic characteristics (age, gender, education level), technology access (digital devices and internet connectivity), and perceptions of Technology-Enabled Agricultural Extension Services (TEAES), including perceived usefulness and ease of use. The instrument was developed based on constructs from the Technology Acceptance Model and adapted to the agricultural extension context.

To ensure validity and reliability, the questionnaire was pretested with a pilot group of 30 youth farmers from one county not included in the main study. Feedback informed revisions to wording and structure. Internal consistency of perception measures was assessed using Cronbach's alpha, with coefficients above 0.70 indicating acceptable reliability.

Data Analysis

Data was analyzed using IBM SPSS Statistics Version 29 (2023). Prior to analysis, all responses were checked for completeness and consistency, and incomplete questions were excluded. Descriptive statistics

(frequencies and percentages) were used to summarize socio-demographic characteristics and technology access variables.

Inferential analysis (Chi-square test of independence) was used to examine relationships between variables. Specifically, the relationship between independent variables (socio-demographic characteristics) and the dependent variable (adoption of technology-enabled agricultural extension services) was tested. The chi-square test determines whether there is a significant association between observed and expected frequencies in categorical data (Agresti, 2018; McHugh, 2013; Mugenda & Mugenda, 2013; Sharpe, 2015). A significance level of $p < .05$ was used to determine statistical significance.

Ethical Considerations

Ethical considerations were strictly observed. Ethical approval was obtained from the relevant Institutional Review Board**,** and informed consent was secured from all participants. Respondents were assured of confidentiality, voluntary participation, and the right to withdraw at any stage without penalty.

Results and Discussion

This section presents the findings and interprets them within the lens of the Technology Acceptance Model (TAM). The findings are organized into two main parts, reflecting the socio-demographic and technological determinants of Technology-Enabled Agricultural Extension Services (TEAES). The first part examines how gender and education level influence adoption and delivery TEAES while the second part focuses on technological conditions, specifically access to digital devices and internet connectivity, showing how these factors act as critical enablers in farmers' engagement with TEAES. TAM constructs (perceived usefulness, perceived ease of use) and external variables are used to frame the discussion.

Socio-Demographic Factors and Adoption of Technology Enabled Agricultural Extension Services

Socio-demographic factors, particularly gender and education level, play a critical role in shaping the adoption and delivery of Technology-Enabled Agricultural Extension Services (TEAES).

Gender and Adoption of Technology Enabled Agricultural Extension Services

Gender significantly shapes access to and utilization of agricultural extension services, as demonstrated in both prior literature and the current study. The finding that over half (51.3%) of respondents preferred face-to-face delivery, with a higher proportion of females (33.7%) than males (17.6%) favoring this mode, reflects gendered differences in access, confidence, and trust in technology platforms (Awour & Rambim, 2022; OECD, 2018). This aligns with literature that documents how social and cultural norms, as well as practical barriers such as digital literacy and mobility constraints, limit women's use of technology-enabled extension services (Mugambi et al., 2018; Geza et al., 2021; Mifuko Trust, 2025).

The preference for blended delivery models in the study signals an important transitional phase for Kenya's youth farmers, where the acceptance of digital tools grows alongside enduring appreciation for interpersonal interactions (Langat, 2020; Joshi et al., 2022). The Technology Acceptance Model (TAM) theoretical framework applied in the study helps explain this phenomenon by emphasizing perceived ease of use and perceived usefulness as key determinants of technology adoption (Davis, 1989; Venkatesh & Davis, 2000). Female youth farmers' greater preference for face-to-face extension may indicate lower perceived ease of use or trust in digital services compared to male counterparts.

Moreover, prior literature highlights the need for gender-responsive approaches in extension service design and delivery, including targeted digital literacy programs, inclusive platform design, and recruitment of female extension agents to enhance trust and accessibility for women (Müller et al., 2022; Awotide et al., 2016). Such strategies are essential to close gender gaps in digital adoption and empower women as active participants in agricultural innovation (Qazi et al., 2022; Mittal & Mehar, 2016).

To this end, gender-sensitive, blended extension delivery models that address digital literacy, trust, and social norms are critical to ensuring equitable adoption of TEAES services among Kenyan youth farmers (Rajkhowa, 2021; Mugambi et al., 2018; Awour & Rambim, 2022). The results are presented in table 1.

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%

To further examine whether gender influences the adoption of online delivery of agricultural extension services, a Chi-square test was conducted to determine the significance of the relationship. The results are presented in table 2.

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

Chi^2	15.81
df	2
p	<.05

The chi-square test showed a significant association between gender and adoption of online agricultural extension services, χ^2 (2) = 15.81, $p < .05$. However, the weak effect (Cramér's V = 0.17) suggests that while gender influences delivery mode preferences, it is not the main determinant. Factors such as education, device access, and digital literacy likely play stronger roles (Awour & Rambim, 2022; Mugambi et al., 2018).

Consistent with OECD (2018), women are less likely than men to use the internet, not only due to access barriers but also perceptions of irrelevance or low usefulness which are core constructs of the Technology Acceptance Model (TAM) (Davis, 1989; Venkatesh & Davis, 2000). When online services are not seen as useful or easy to use, women's adoption decreases (Mugambi et al., 2018).

Gender disparities in digital access and use persist, driven by affordability, social norms, and skills gaps (Geza et al., 2021; Müller et al., 2022). This study confirms the need for gender-responsive strategies such as inclusive design, targeted outreach, and digital literacy training for women to ensure equitable adoption (Müller et al., 2022; Awotide et al., 2016).

The findings reinforce the TAM framework by showing how socio-demographic factors interact with perceived usefulness and ease of use to shape behavioral intentions. The weak but significant gender effect highlights the need for integrated interventions addressing gender gaps alongside education and digital infrastructure (Rajkhowa, 2021; Mugambi et al., 2018). Multi-faceted, gender-sensitive policies that enhance digital literacy, affordability, and culturally appropriate delivery modes are essential to empower women youth farmers (Müller et al., 2022; Mittal & Mehar, 2016). Secondly, relationship between level of education and adoption of online delivery of agricultural extension services was investigated.

Level of Education and Adoption of Technology Enable Agricultural Extension Services

Education level is often linked to digital literacy, openness to innovation, and ability to interpret extension information. This sub-section discusses the extent to which youth farmers' education influences their adoption of preferred modes of delivery of agricultural extension services. Results are shown in table 3.

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%

Youth farmers with primary (22.0%) and secondary education (17.1%) education mainly favored face-to-face interactions, while those with certificate (6.5%), diploma (6.3%), and secondary education (13.2%) preferred blended approaches, indicating greater openness to technology when combined with direct engagement. Fully online services were least preferred (11.6%), reflecting barriers such as digital literacy, trust and internet access. These findings suggest that higher education promotes adoption of blended methods, whereas lower education reinforces reliance on traditional face-to-face delivery.

This aligns with the Technology Acceptance Model (TAM), which emphasizes that perceived ease of use and perceived usefulness influence technology adoption behavior (Davis, 1989; Venkatesh & Davis, 2000). The literature review supports that education level is a significant external variable affecting digital literacy and the ability to navigate online platforms, which influence perceived ease of use and usefulness of TEAES (Mugambi et al., 2018; Rajkhowa, 2021).

The preference patterns observed in the study are consistent with prior evidence that farmers with higher education levels are more likely to adopt digital tools and blended learning modes, while those with lower education levels tend to prefer traditional extension services due to limited digital skills and trust issues (Mugambi et al., 2018; Rajkhowa, 2021). Thus, targeted interventions such as simplified digital content, local language support, and digital skills training are critical for enhancing adoption among less educated farmers. To determine whether there is a significant association between level of education and the adoption of online delivery of agricultural extension services, a Chi-square (χ^2) test of independence was conducted. The results are shown in Table 4.

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

Chi²	106.55
df	10
p	<.05

The chi-square test revealed a significant association between education level and adoption of online agricultural extension services, χ^2 (10) = 106.55, p < .05. The low p-value (< 0.05) rejects the null hypothesis and a Cramér's V of 0.31 indicates a moderate association. This confirms that educational attainment strongly influences adoption of online agricultural platforms.

Education shapes youth farmers' readiness and ability to use digital services. Higher education correlates with stronger digital literacy, higher perceived usefulness, and greater confidence in navigating online platforms. OECD (2018) notes low education levels hinder digital tool use, limiting adoption. This aligns with the Technology Acceptance Model, which posits that education affects perceived ease of use and usefulness (Davis, 1989; Venkatesh & Davis, 2000; Taylor & Todd, 1995).

The findings highlight the need for differentiated design and delivery. For less educated farmers, simplified interfaces, local language support and targeted digital training can boost adoption. Studies in Kenya and similar contexts confirm that education and digital literacy are key enablers of digital agriculture adoption and improved practices (Mugambi et al., 2018; Rajkhowa, 2021; Jumanne, 2024).

Capacity-building focused on education and digital skills is therefore essential for inclusive adoption of online extension services among youth farmers in Kenya.Next relationship between access to digital devices and adoption of online delivery of agricultural extension services was determined.

Technological Factors and Adoption of Technology Enabled Agricultural Extension Services

Access to digital devices and internet connectivity is a central technological factor influencing the adoption of agricultural extension services. Inequalities in affordability, availability, and quality of these resources shape farmers' ability to engage with and benefit equitably from digital platforms.

Access to a Digital Device and Adoption of Online Delivery of Technology Enabled Agricultural Extension Services

Access to digital devices such as smartphones, tablets, or computers is a prerequisite for TEAES. This section analyzes how possession of these devices affects youth farmers' adoption of online knowledge delivery methods. Results are shown in table 5.

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%

Access to digital devices influences the preferred mode of agricultural extension delivery. Farmers who possessed digital devices largely favored blended (30.4%) and face-to-face (29.5%) modes, whereas online delivery alone was least preferred (8.6%). Conversely, farmers without devices predominantly chose face-to-face delivery (21.6%), with minimal preference for blended (6.2%) or online (3.0%) approaches. These findings highlight that availability of digital devices is critical for TEAES.

This observation aligns well with the TAM, which posits that external factors, such as access to technology are key determinants of perceived ease of use and, consequently, technology adoption (Davis, 1989; Venkatesh & Davis, 2000). The presence of devices enhances perceived ease of use by reducing access barriers and facilitating interaction with digital platforms, thus supporting positive behavioral intention toward adoption. Studies have found that device ownership and the quality of user interfaces significantly influence farmers' acceptance of mobile-based agricultural extension services (Jimenez et al., 2020; Ninsiima, 2018).

Therefore, addressing infrastructural factors such as access to affordable digital devices is imperative for enhancing TEAES uptake among youth farmers, within the Kenyan context (Mugambi et al., 2018; Rajkhowa, 2021; Awour & Rambim, 2022). To assess whether access to digital devices is significantly associated with the adoption of online delivery of agricultural extension services, a Chi-square (χ^2) test of independence was conducted. Results are shown in table 6.

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

Chi²	37.67
df	2
p	<.05

The chi-square test revealed a significant association between access to digital devices and adoption of online agricultural extension services, χ^2 (2) = 37.67, $p < .05$. The low p-value (< 0.05) confirms rejection of the null hypothesis, indicating that device access significantly influences adoption. With a Cramér's V of 0.26, the moderate association underscores the importance of device availability in engaging with online agricultural platforms.

Digital infrastructure plays a vital role in ensuring equitable access to agricultural knowledge. Youth farmers with smartphones, tablets, or computers are better positioned to access information, join virtual learning, and communicate with extension officers. This supports Mugambi et al. (2018), who found that mobile device ownership enhances access to agricultural information among Kenyan youth.

Although 99.7% of Kenyans aged 16–64 own smartphones (Connecting Africa, 2021), ownership alone does not ensure meaningful use. Without digital literacy, relevant content, and user-friendly platforms, engagement remains limited. Therefore, extension programs must go beyond access, offering mobile-responsive content, intuitive designs, and targeted digital training for young farmers.

These results align with TAM, where "facilitating conditions" such as access to resources and support influence perceived ease of use and behavioral intention (Davis, 1989; Venkatesh & Davis, 2000). Strengthening digital infrastructure and providing tailored support can enhance adoption and impact of

online agricultural extension services among Kenya's youth farmers. Finally, relationship between access to internet and adoption of online delivery of agricultural extension services was assessed.

Access to Internet and Adoption of Online Delivery of Technology Enabled Agricultural Extension Services

Reliable internet access is central to the effectiveness of TEAES. This section discusses the relationship between youth farmers' internet connectivity and their adoption of online delivery of extension services. The results are shown in table 7.

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%	2.5%	0.5%	210
	Face-to-face		25.3%	3.7%	2.1%	292
	Online	2.7%	6.2%	1.8%	0.2%	66
	Total	9.5%	59.2%	14.4%	2.8%	100%

Ease of internet access influenced farmers' preferred modes of agricultural extension delivery. Those with easy or very easy access favored blended (31.3%) and face-to-face (29.0%) modes, while fully online uptake remained low (2.7%–6.2%). Farmers with poor or uncertain access mainly preferred face-to-face delivery, showing limited adoption of blended or online approaches. These findings highlight that reliable internet connectivity is vital for adopting TEAES.

Consistent with the TAM, connectivity acts as an external factor shaping perceived ease of use and technology adoption (Davis, 1989; Venkatesh & Davis, 2000). Stable internet enhances users' confidence and engagement with digital platforms. The study's framework positions infrastructure as a facilitating condition influencing behavioral intention and technology use.

Supporting studies (Mugambi et al., 2018; Rajkhowa, 2021; Awour & Rambim, 2022) similarly stress that improving digital infrastructure is essential to close adoption gaps and ensure equitable access to agricultural knowledge among youth farmers. Without reliable connectivity, the potential of TEAES cannot be fully realized, underscoring the need for investments and support systems to promote widespread adoption. A Chi-square (χ^2) test confirmed that internet access significantly affects adoption of online extension services (see Table 8).

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

Chi^2	55.56
df	8
p	<.05

The chi-square test showed a significant association between internet access and adoption of online agricultural extension services, $\chi^2(8) = 55.56$, $p < .05$. The low p-value (< .05) confirms rejection of the null hypothesis. With a Cramér's V of 0.22, this moderate association indicates that internet access meaningfully influences adoption behavior.

Youth farmers with reliable internet are therefore more likely to use online agricultural platforms to access virtual training and communication with extension agents. This supports Rajkhowa (2021) who found that internet access helps farmers obtain timely information for better decision-making.

Despite growing internet penetration in Kenya, disparities in rural and low-income areas still hinder equitable adoption. Internet access, while necessary, is not sufficient. Digital literacy, affordability and relevant content are also vital. These findings align with TAM, emphasizing that facilitating conditions like infrastructure shape perceived ease of use and adoption intent (Davis, 1989; Venkatesh & Davis, 2000). Strengthening internet access in underserved areas remains essential for wider uptake of online extension services.

Conclusion

The study confirmed that socio-demographic (gender and education) and technological (access to digital devices and internet connectivity) factors influence adoption of TEAES among youth farmers. Education was the strongest predictor, highlighting the role of digital literacy and prior learning. Access to devices and reliable internet also proved critical, showing that equitable infrastructure underpins meaningful adoption. Although gender differences were significant, their effect size was smaller, pointing to the need for gender-sensitive strategies that address women's access barriers.

Recommendations

- Ministry of Agriculture should enact policies that support online agricultural extension services.
- Agricultural Extension Service Providers should adopt blended face-to-face and digital models, promote gender inclusion and offer ongoing digital literacy training for youth farmers.
- Development Partners and NGOs should collaborate with government and private sectors to fund digital programs, create locally relevant multilingual content and support community-driven technology adoption.
- Private Sector Technology Providers should develop affordable, user-friendly mobile applications, co-design tools with extension providers, and use farmer feedback to improve usability and relevance.
- Government should expand digital infrastructure by providing affordable internet and electricity in rural areas.

References

Adedoyin, O. B., & Soykan, E. (2020). Covid-19 pandemic and online learning: The challenges and opportunities. *Interactive Learning Environments*, 1–13. https://doi.org/10.1080/10494820.2020.1813180

Adesoji, S. A., & Olatokun, W. M. (2016). Factors influencing youth participation in agricultural information dissemination through mobile phones in Oyo State, Nigeria. *Information Development, 32*(3), 587–595. https://edepot.wur.nl/638878

Agresti, A. (2018). *Statistical methods for the social sciences* (5th ed.). Pearson.

Awotide, B. A., Karimov, A. A., & Diagne, A. (2016). Agricultural technology adoption, commercialization, and smallholder rice farmers' welfare in rural Nigeria. *Agricultural and Food Economics, 4*(3). https://doi.org/10.1186/s40100-016-0047-8

Bates, T. (2022). *Teaching in a digital age: Third edition – General*. https://inee.org/sites/default/files/resources/Teaching-in-a-Digital-Age-Third-Edition-General-1669733778.pdf

Bhardwaj, A., Chauhan, R., & Singh, S. (2021). Mobile-based data collection using KoBoToolbox in field surveys. *Journal of Advances in Social Science and Humanities, 7*(2), 178–184. https://doi.org/10.15520/jassh.v7i2.549

CAST. (2024). *Universal design for learning guidelines version 3.0*. http://udlguidelines.cast.org

CGIAR. (2022). *Digital innovations and agricultural transformation in Africa: Lessons from Kenya*. CGIAR Research Repository. https://cgspace.cgiar.org/server/api/core/bitstreams/413e2dc2-7627-4036-bc75-d6aa1efce102/content

Chandra Shekhar Prasad. (2012). *Agriculture and sustainable development in India*. New Century Publications.

Communication Authority of Kenya. (2023). *Sector statistics report Q3 2022–2023*. https://www.ca.go.ke/sites/default/files/2023-06/Sector%20Statistics%20Report%20Q3%202022-2023.pdf

Connecting Africa. (2021, April 14). *Kenya internet usage lags mobile penetration*. https://www.connectingafrica.com/author.asp?section_id=761&doc_id=768744

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications. https://writingcenter.westcliff.edu/wp-content/uploads/2022/06/Creswell-Creswell-2018.pdf

Danso, G., Ehiakpor, D. S., & Aidoo, R. (2018). Agricultural extension and its effects on farm productivity and income: Insight from Northern Ghana. *Agriculture & Food Security, 7*, 74. https://doi.org/10.1186/s40066-018-0225-x

DataReportal. (2023, February 13). *Digital 2023: Kenya*. https://datareportal.com/reports/digital-2023-kenya

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319–340. https://doi.org/10.2307/249008

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics, 5*(1), 1–4. https://doi.org/10.11648/j.ajtas.20160501.11

Food and Agriculture Organization (FAO). (2017, February 21). *ICT and agriculture extension services*. https://www.fao.org/e-agriculture/blog/icts-and-agricultural-extension-services

Food and Agriculture Organization (FAO). (2025). *The status of youth in agrifood systems*. https://openknowledge.fao.org/server/api/core/bitstreams/8dd3c274-da6f-46f5-b6c3-dbc84432a93d/content

Geza, W., Ngidi, M., Ojo, T., Adetoro, A. A., Slotow, R., & Mabhaudhi, T. (2021). Youth participation in agriculture: A scoping review. *Sustainability, 13*(16), 9120. https://doi.org/10.3390/su13169120

Gichuki, D. K., & Wechuli, A. N. (2020). Online agricultural extension based on internet communication principles. *International Journal of Scientific Research in Science, Engineering and Technology, 7*(3). https://doi.org/10.32628/IJSRSET207384

Gwademba, G. K., Muthee, D. W., & Masinde, J. M. (2019). Application of ICTs in transforming agricultural extension. *Regional Journal of Information and Knowledge Management, 4*(2), 12–21. https://rjikm.org/index.php/rjikm/article/view/23/17

Habtewold, T. M., & Heshmati, A. (2023). Impacts of improved agricultural technology adoption on welfare in Africa: A meta-analysis. *Heliyon, 9*(7), e17463. https://doi.org/10.1016/j.heliyon.2023.e17463

Inegbedion, J. O. (2021). *The concept of online learning* [MOOC]. https://www.mooc4dev.org/course/nounmooc/#/home#

Jordan, K., David, R., Phillips, T., & Pellini, A. (2021). Education during the COVID-19: Crisis opportunities and constraints of using EdTech in low-income countries. *Revista de Educación a Distancia (RED), 21*(65).

Joshi, O., Chapagain, B., Kharel, G., Poudyal, N. C., Murray, B. D., & Mehmood, S. R. (2022). Benefits and challenges of online instruction in agriculture and natural resource education. *Interactive Learning Environments, 30*(8), 1402–1413. https://doi.org/10.1080/10494820.2020.1725896

Kabbiri, R., Dora, M., Kumar, V., Elepu, G., & Gellynck, X. (2018). Mobile phone adoption in agri-food sector: Are farmers in Sub-Saharan Africa connected? *Technological Forecasting and Social Change, 131*, 253–261. https://doi.org/10.1016/j.techfore.2017.12.010

Kante, M., Oboko, R., & Chepken, C. (2017). An e-agriculture based model for sustainable crop production in developing countries: Case of Mali. *Telematics and Informatics, 34*(7), 1678–1692. https://doi.org/10.1016/j.tele.2017.07.009

Kenya Bureau of Statistics. (2023). *Kenya preliminary report SDG5b1*. https://data.unwomen.org/sites/default/files/documents/Publications/Kenya_Preliminary-Report_SDG5b1.pdf

KICTANET. (2025, January 16). *Digital divide in Kenya: ICT access and usage data reveals disparities*. https://www.kictanet.or.ke/digital-divide-in-kenya-ict-access-and-usage-data-reveals-disparities

Kimani, J., & Rao, E. J. O. (2025). Farmer-to-farmer approach offers solutions to improve the efficiency of agricultural extension services in Kenya. *International Livestock Research*

Institute. https://www.ilri.org/news/farmer-farmer-approach-offers-solutions-improve-efficiency-agricultural-extension-services

KoBoToolbox. (2023). *KoBoCollect: Mobile data collection for Android devices*. Harvard Humanitarian Initiative. https://www.kobotoolbox.org

Kothari, C. R. (2004). *Research methodology: Methods and techniques* (2nd ed.). New Age International Publishers. http://dl.saintgits.org/jspui/bitstream/123456789/1133/1/Research%20Methodology%20C%20R%20Kothari%20(Eng)%201.81%20MB.pdf

Langat, A. (2020, March 11). *Partnerships aim to rebuild Kenya's agriculture extension services*. Devex. https://www.devex.com/news/partnerships-aim-to-rebuild-kenya-s-agriculture-extension-services-96716

McHugh, M. L. (2013). The chi-square test of independence. *Biochemia Medica, 23*(2), 143–149. https://doi.org/10.11613/BM.2013.018

Mifuko Trust. (2025). *Digital tools empower women and regenerative farming in rural Kenya*. Mifuko Trust Blog. https://mifuko.com/blogs/mifuko-trust/digital-tools-empower-women-and-regenerative-farming-in-rural-kenya

Milu, M., & Jayne, T. S. (2006). *Agricultural extension in Kenya: Practice and policy lessons* (Tegemeo Working Paper 21/2006). Egerton University, Tegemeo Institute.

Minten, B., Koru, B., Stifel, D., & Tamru, S. (2019). The last mile(s) in modern input distribution: Pricing, profitability, and adoption. *World Development, 123*, 104609. https://doi.org/10.1016/j.worlddev.2019.104609

Mittal, S., & Mehar, M. (2016). Socio-economic factors affecting adoption of modern information and communication technology by farmers in India: Analysis using multivariate probit model. *The Journal of Agricultural Education and Extension, 22*(2), 199–212. https://doi.org/10.1080/1389224X.2014.997255

Mugambi, I., Kimani, E., Ondiek, G., & Gathenya, J. (2018). Role of mobile phone-based technologies in linking smallholder farmers to agricultural information: The case of agricultural call centres in Kenya. *Agriculture & Food Security, 7*(1), 37. https://dos.chuka.ac.ke/public/uploads/pdf/pdf-26.pdf

Mugenda, O. M., & Mugenda, A. G. (2013). *Research methods: Quantitative and qualitative approaches*. https://www.sciepub.com/reference/323951

Müller, A., Ortiz-Crespo, B., & Steinke, J. (2022). *Designing gender-inclusive digital solutions for agricultural development: An introductory guide and toolkit*. Alliance of Bioversity International and CIAT. https://cgspace.cgiar.org/items/15c8f3f1-6bd9-486b-b483-99db2b9acdc8

Mulungu, K., Kassie, M., & Tschopp, M. (2025). The role of information and communication technologies-based extension in agriculture: Application, opportunities and challenges. *Information Technology for Development*, 1–30. https://doi.org/10.1080/02681102.2025.2456232

Mutheu, D. (2025, March 4). *Kenya's digital surge in early 2025: 68.8M mobile connections, 27.4M internet users, 15.1M social media accounts*. TechJournal. https://techjournal.co.ke/2025/03/04/kenyas-

digital-surge-in-early-2025-68-8m-mobile-connections-27-4m-internet-users-15-1m-social-media-accounts/?noamp=mobile

Muthomi, E. (2017). *Challenges and opportunities for youth engaged in agribusiness in Kenya* [Unpublished research project]. United States International University. http://erepo.usiu.ac.ke/bitstream/handle/11732/3273/ERIC%20MUTHOMI%20GEMBA%20%202017.pdf?sequence=1&isAllowed=y

Organization for Economic Co-operation and Development (OECD). (2018). *Bridging the digital gender divide*. https://www.oecd.org/digital/bridging-the-digital-gender-divide.pdf

Rahman, M. A. (2017, October 27). *Role of agriculture extension officers* [Blog post]. https://aridagriculture.com/2017/10/28/role-agriculture-extension-office

Rajkhowa, P. (2021, March 17). *Using personalized digital extension services to improve agriculture performance – An example from India*. Rural 21. https://www.rural21.com/english/current-issue/detail/article/using-personalised-digital-extension-services-to-improve-agriculture-performance-an-example-from-india.html

Rajkhowa, P., & Qaim, M. (2021). Personalized digital extension services and agricultural performance: Evidence from smallholder farmers in India. *PLOS ONE, 16*(10), e0259319. https://doi.org/10.1371/journal.pone.0259319

Rani, S., & Kumar, A. (2023). Digital literacy and technology adoption in agriculture: A systematic review. *Digital Agriculture, 7*(9), 296. https://www.mdpi.com/2624-7402/7/9/296

Ranjan, M. P. (2021). *Concept of ODL and the changing nature* [MOOC]. https://www.mooc4dev.org/AC4ODL3

Rochina, A. G., & Tabuena, A. C. (2022). Online learning as an alternative learning modality in Ecuador's education institutions amidst crises and outbreaks: A SWOT analysis. *Journal of Learning for Development (JL4D), 9*(3), 475–491.

School of Education. (2022, March 24). *The 10 benefits of online learning*. Drexel University. https://drexel.edu/soe/resources/student-teaching/advice/benefits-of-online-and-virtual-learning

SCRIBD. (2023). *Fact sheet on ICT analytical report based on Kenya housing survey 2023–2024: Final web version*. https://www.scribd.com/document/900574177/Fact-Sheet-on-ICT-Analytical-Report-Based-on-Kenya-Housing-Survey-2023-2024-Final-WEB-Version

Sharpe, D. (2015). Chi-square test is statistically significant: Now what? *Practical Assessment, Research, and Evaluation, 20*(1), 8. https://doi.org/10.7275/tbfa-x148

Shidhulai Swanirvar Sangstha. (2023). *Operating school-boat since 2002*. https://shidhulai.org/our-work.html

Talukder, M. (2012). Factors affecting the adoption of technological innovation by individual employees: An Australian study. *Procedia – Social and Behavioral Sciences, 40*, 52–57. https://www.sciencedirect.com

Taylor, S., & Todd, P. A. (1995). Understanding information technology usage: A test of competing models. *Information Systems Research, 6*(2), 144–176. https://doi.org/10.1287/isre.6.2.144

United Nations. (2015). *The 17 Sustainable Development Goals*. https://sdgs.un.org/goals

United Nations. (n.d.). *Agenda for sustainable development*. https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science, 46*(2), 186–204. https://doi.org/10.1287/