

Communication pathways and youth engagement in climate-smart agriculture in Bumula Sub-County, Kenya

David Wekesa Saenyi¹
Vitalis Ogemah²
Teddy Amge³
John Caleb Dimo⁴

¹saenyidavid2009@yahoo.com

^{1,2,3,4} Masinde Muliro University of Science and Technology, ⁴Egerton University, ^{1,2,3,4}Kenya

<https://doi.org/10.51867/ajernet.6.4.67>

ABSTRACT

Climate-Smart Agriculture (CSA) is essential for developing climate change resilience in susceptible areas such as Kenya's semi-arid regions. The involvement of youths is crucial for the transformation of agriculture, but uptake remains low. While the successful delivery of information is an established driver of CSA, the best communication channels for various CSA practices are unknown. This research, guided by the Diffusion of Innovations, Social Learning, and Channel Complementarity theories, aimed to evaluate the impacts of different information communication channels on young people's involvement in CSA in Bumula Sub-County, Kenya. A correlational research design was employed. A structured questionnaire was administered to a simple random sample of 120 youth farmers (18-35 years), drawn from a target population of 10,888 in the Siboti and Khasoko wards. Data was analysed using descriptive statistics and binary logistic regression in SPSS to estimate the relationship between communication sources (extensions, media, and social networks) and the uptake of different CSA practices. The analysis revealed a strong association between information sources and involvement in CSA (Cramer's $V = 1.0$). Pathways to involvement were practice-specific: extension agents predominated for knowledge-based practices (agroforestry, 47.7%), social networks for visible practices (intercropping, 43.0%), and mass media for market-related inputs (improved seeds, 41.2%). The findings demonstrate that a one-size-fits-all communication approach is ineffective. A multi-channel, segmented strategy that aligns the communication channel with the distinctive characteristics of each CSA practice is imperative to bridge the information gap efficiently and strengthen youth-led climate adaptation. The results provide an evidence-informed path for policymakers and practitioners to upgrade extension services by integrating digital platforms, strengthening peer networks, and adopting tailored communication strategies to enhance youth engagement in CSA.

Keywords: Climate-Smart Agriculture, Information Communication Pathway, Youths in Agriculture, Youth Unemployment

I. INTRODUCTION

In recent years, there have been studies that analyzed how communication channels affect the uptake of farming innovations among rural farmers in developing countries (Atser et al., 2023; Mahama et al., 2024). For instance, Mulungu et al. (2025) found that text message notifications significantly increased farmers' uptake of new practices, highlighting the transformative potential of information and communication technologies (ICTs). Similarly, studies in Kenya have identified the role of both formal extension and social networks in passing on information (Morrison et al., 2025). But there is one major constraint. Much of the research lumps communication channels together into a single, undifferentiated category and does not often elucidate which specific pathways work best to improve different types of Climate-Smart Agriculture (CSA) practices, especially among the young population. This gap is most urgent in sub-Saharan Africa, where the involvement of youth in agriculture is both a demographic imperative and a development issue.

The urgency of this question is intensified by the expanding climate crisis. In Kenya, and across Eastern Africa, climate change manifests itself as increasingly erratic rainfall, increasing droughts, and rising temperatures, which poses an immediate danger to farm production and food security (Allen et al., 2025). Climate Smart Agriculture has now become an important paradigm in building resilience and increasing productivity in a sustainable manner while also trying to mitigate greenhouse gas emissions (Kabato et al., 2025). However, the adoption of CSA practices is frustratingly low, often below 25% in Bumula Sub-County considered risk-prone (Mwanzia et al., 2025). The challenge of adoption is further compounded by an allied crisis. Youth unemployment and the aging farmer population. Though the youth between 18-35 years represent 38% of Bumula's population (Onyango et al., 2025) and are a strong force for agricultural transformation, their participation is hindered by an array of institutional, economic, and social barriers, including limited access to credit, land, and most importantly, relevant information (Deiningner et al., 2022).

Existing literature indicates that the relationship between communication, youth, and Climate-Smart Agriculture (CSA) is not well understood. While the worth of information undoubtedly is an international phenomenon, studies have reported mixed findings. For example, some studies, such as that of Morrison et al. (2025) and (Mulungu et al., 2025). Onyango et al. (2025) found a weak association (Cramer's $V = 0.3-0.5$) between adoption of technology and extension contact, citing logistics and relevance issues. Other studies, by contrast, praise digital platforms as the magic bullet for harnessing technology-savvy youth (Haddock et al., 2022). This raises a vital shortcoming in the lack of a fine-grained, practice-by-practice communication model. The typical "one-size-fits-all" approach to dissemination does not anticipate that the technical level, visibility, and resource requirements of different CSA practices may call for specialized communication channels. Is a WhatsApp group as useful for transferring the subtleties of agroforestry as it is for selling new varieties of seeds? The literature is quiet on this key differentiation, making it so that policymakers and extension officers lack an overt, evidence-based framework by which to segment their communication approaches.

In response to this gap that has been identified, this study formulates the following core research inquiry: How do various information communication channels affect youth engagement in particular Climate-Smart Agriculture practices in Bumula Sub-County, Kenya? This query is expanded to explore: 1) Through which of the above-mentioned channels of communication (extension officers, media, social networks) do different CSA practices find their major sources of information? 2) Is there a statistically significant relationship between these channels of communication and youth adoption of CSA? 3) How do the particular attributes of a CSA practice (technical expertise, observability) influence which mode of communication best advertises it?

1.1 Statement of the Problem and Research Gap

The empirical literature confirms that communication is a critical driver of agricultural innovation adoption. However, a critical limitation persists since much of the existing research treats communication channels as a monolithic category, often reporting on their generalized effectiveness or ineffectiveness without linking specific channels to the distinct attributes of specific agricultural practices (Onyango et al., 2025; Molala & Makhubele, 2021). This has resulted in a body of work with mixed and sometimes contradictory findings, as seen in the stark contrast between studies that report a strong link between extension and adoption and those that find a weak association.

This generalized approach has created a significant gap in both theory and practice. Policymakers and extension officers lack an evidence-based, fine-grained framework to guide their communication strategies. It remains unclear, for instance, whether a WhatsApp group is as effective for transferring the complex knowledge required for agroforestry as it is for promoting the use of improved seeds. Therefore, a practice-by-practice analysis is urgently needed. This study sought to fill this gap by moving beyond a generic assessment of communication channels. It investigated how the effectiveness of extension officers, mass media, and social networks is contingent upon the technical complexity and observability of specific CSA practices among the youth population in Bumula Sub-County, Kenya. By doing so, it provided a segmented communication model that can enhance the efficiency and impact of youth engagement in climate-smart agriculture.

1.2 Research Objectives

The general objective of this study was to evaluate the impact of information communication channels on youth engagement in Climate-Smart Agriculture practices in Bumula Sub-County, Kenya.

The specific objectives were:

- i. To identify the primary communication channels (extension officers, mass media, and social networks) through which youth access information for different CSA practices.
- ii. To determine the existence and strength of the statistical relationship between these communication channels and the adoption of CSA practices among the youth.
- iii. To evaluate how the specific attributes of a CSA practice (such as technical complexity and observability) influence the effectiveness of different communication channels.

II. LITERATURE REVIEW

2.1 Theoretical Review

The study is anchored on three interconnected theoretical frameworks that explain the adoption of innovations and the role of communication.

2.1.1 Diffusion of Innovations (DOI) Theory

The Diffusion of Innovations (DOI) theory by Kapoor et al. (2014) provides a foundational framework for understanding how new ideas and technologies, such as CSA practices, spread through social systems over time. The theory posits that the rate of adoption of an innovation is influenced by its perceived attributes: relative advantage, compatibility, complexity, trialability, and observability. This study directly applies the DOI framework by

hypothesizing that the complexity (technical knowledge needed for agroforestry) and observability (visible results from intercropping) of different CSA practices determine the most effective communication channel for their dissemination. The theory suggests that complex, less observable practices require interpersonal, credible channels like extension agents, while simple, highly observable practices can diffuse effectively through peer networks, a premise this research tests empirically.

2.1.2 Social Learning Theory (SLT)

Social Learning Theory (Deaton, 2015) emphasizes that individuals learn and adopt new behaviors by observing others within their social environment and the consequences of those behaviors. This theory is crucial for understanding the role of informal communication pathways, such as neighbors and friends, in the adoption of CSA. When youth farmers observe their peers successfully implementing a visible practice like intercropping or rainwater harvesting, they are more likely to adopt it themselves. SLT thus explains the efficacy of social networks for practices where vicarious learning and social validation are powerful motivators, complementing the DOI framework by focusing on the mechanism of peer-to-peer influence.

2.1.3 Channel Complementarity Theory

Channel Complementarity Theory (Rains & Ruppel, 2016) argues that individuals use multiple information channels in a complementary, rather than mutually exclusive, manner to fulfill different information needs. This theory challenges the notion of a single "best" channel and instead supports a segmented, multi-channel strategy. It posits that audiences actively seek out different media for different purposes for instance, using mass media for awareness and extension services for in-depth knowledge. This theory provides the theoretical justification for this study's core argument against a one-size-fits-all communication approach and for a strategy that aligns specific channels with specific CSA practice characteristics.

2.2 Empirical Review

Empirical studies on communication channels and agricultural adoption reveal significant but often contradictory findings, underscoring the need for a more nuanced, practice-specific analysis.

2.2.1 The Role of Extension Services

Several studies highlight the importance of extension services, but their reported effectiveness varies greatly. Morrison et al. (2025) conducted research in the Kenyan dairy sector and reported that farmer-to-farmer extension within social networks was highly effective for sharing knowledge on common practices. In contrast, Gao et al. (2020) in a study in China, found only a weak to moderate association (Cramer's $V \approx 0.3-0.5$) between extension contact and technology adoption, citing logistical challenges and high farmer-to-agent ratios as major constraints. This contrast suggests that the effectiveness of extension is highly context-dependent, influenced by local infrastructure and the nature of the practice being promoted.

2.2.2 The Efficacy of Social and Digital Networks

The rise of digital platforms has been hailed as a transformative tool for youth engagement. Larochelle et al. (2019) found that text message notifications in Tanzania significantly increased farmers' uptake of new practices, highlighting the potential of low-cost ICTs. Similarly, Singh et al. (2023) in a study in South India, demonstrated that mobile-based agricultural extension services significantly boosted adoption rates. However, other studies offer a more cautious perspective. George (2025), researching agricultural data sharing in Tanzania, concluded that conventional extension and radio were broadly ineffective for youth, citing low digital literacy and the passive nature of such platforms. This creates a clear contrast: while some studies champion digital tools as a "magic bullet," others point to significant barriers to their effectiveness, particularly among certain demographics.

2.2.3 The Function of Mass Media

Mass media has been identified as playing a specific, rather than general, role in information dissemination. Mahama et al. (2024), in a study in the Savannah Region of Ghana, found that mass media was highly effective for disseminating information about commercial inputs like seeds and fertilizers, which are often promoted through advertisements. This aligns with findings from other regions where media serves as a key channel for market-linked information. However, its limitation is also evident. Danso-Abbeam et al. (2018), in Northern Ghana, noted that media was less effective for complex land management practices that require hands-on, experiential learning, a constraint that underscores the channel's inability to deliver rich, interactive communication.

III. METHODOLOGY

3.1 Study Location and Context

This investigation was conducted in Bumula Sub-County (0°34'N, 34°23'E), a semi-arid locality within Bungoma County, western Kenya (KNBS, 2015). The sub-county was strategically chosen as a research site due to its representative characteristics for studying information dissemination patterns related to Climate-Smart Agriculture among youth populations. Characterized by increasingly unpredictable bimodal rainfall regimes (800-1,200 mm annually) attributed to climate change (Bouteska et al., 2024), the 396 km² territory presents a compelling case for investigating CSA communication dynamics.

Demographic composition reveals a predominantly rural population of 156,000 residents, with youth aged 18-35 years constituting 38% of the inhabitants (Kenya National Bureau of Statistics (KNBS, 2022), creating a substantial cohort for examining agricultural information pathways. The economic foundation rests primarily on smallholder maize-bean production systems, engaging approximately 62% of the youth population (Kiriimi et al., 2023). However, agricultural sustainability faces severe challenges from multiple environmental stressors, including prolonged seasonal droughts, erratic precipitation patterns, and documented temperature increases of 1.5°C since the millennium, collectively contributing to 30-40% yield reductions over the past decade (Nying'uro et al., 2023). These climatic stresses are compounded by soil erosion and limited irrigation infrastructure, which covers less than 5% of arable land (Bouteska et al., 2024).

The institutional landscape further compounds these challenges, creating an information-poor environment that necessitates diverse communication strategies. Critical barriers include limited financial inclusion, with only 18% of youth farmers accessing formal credit (Morrison et al., 2025), and constrained extension reach, with merely 32% of farmers receiving formal advisory services (Ministry of Agriculture, Livestock and Fisheries (Kabato et al., 2025). These institutional gaps are exacerbated by significant gender disparities, where 68% of young women report land ownership constraints that potentially limit their access to formal information channels (Federation of Women Lawyers (Atser et al., 2023).

The convergence of climate vulnerability, demographic pressure, institutional limitations, and high dependence on informal networks creates a critical research context where effective information communication becomes paramount for CSA adoption (Morrison et al., 2025). This complex socio-ecological setting provides an ideal natural laboratory for investigating how communication channels mediate youth engagement with climate-resilient agricultural practices, addressing a crucial knowledge gap in agricultural extension literature. See the study map in figure 1.

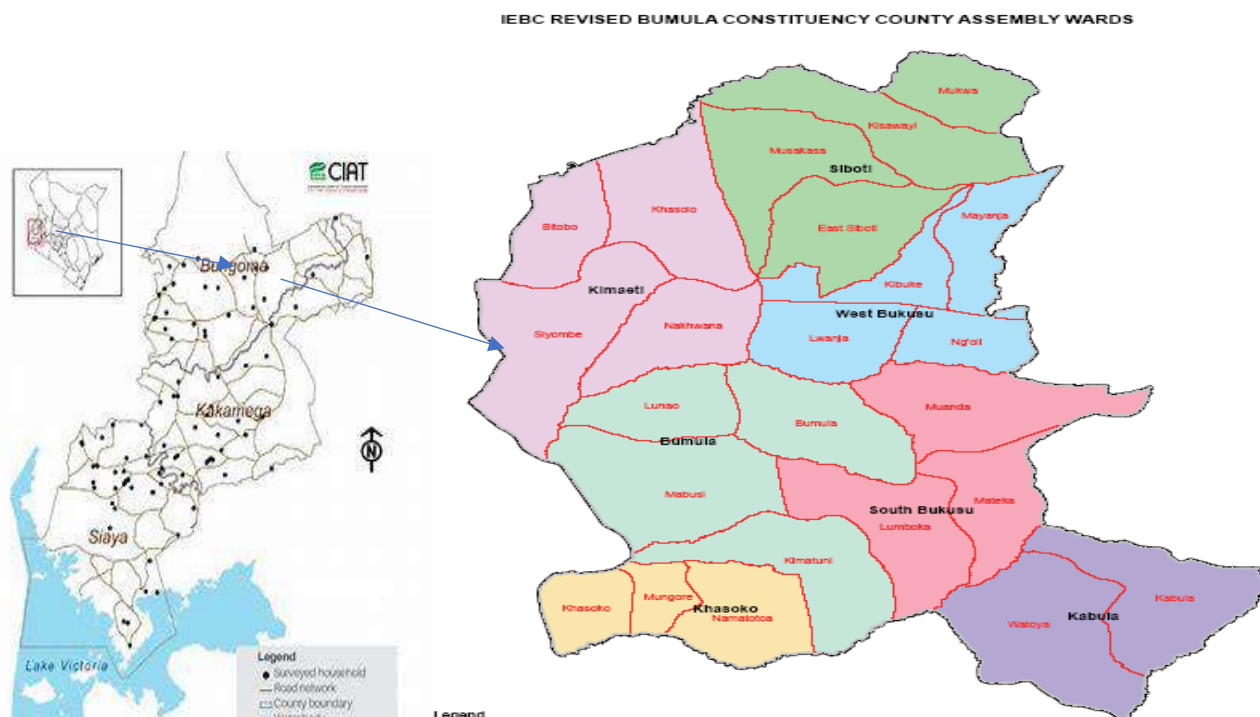


Figure 1
Map of Study Location

3.2 Research Design

This study adopted an explanatory, correlational research design grounded in the Diffusion of Innovations (DOI) theory (Turner, 2007). This framework was selected to move beyond merely describing relationships and instead to explain how the perceived attributes of different Climate-Smart Agriculture (CSA) practices influence which communication channels become most effective for their adoption among youth. A cross-sectional survey served as the primary data collection method to operationalize this design, providing the quantitative data necessary to test the postulated relationships within the theoretical model at a specific point in time.

The design was particularly appropriate as it enabled the investigation of whether the effectiveness of a communication channel (extension agents, mass media, and social networks) is contingent upon the nature of the CSA practice being promoted. For instance, the DOI theory suggests that practices high in complexity are more effectively disseminated through interactive channels like extension services, while easily observable practices may diffuse more rapidly through social networks. This study specifically tested this nuanced relationship, which is often overlooked in broader communication studies. By applying binary logistic regression, the research was able to model the probability of a youth adopting a specific CSA practice based on their primary information source, thereby providing a predictive and explanatory understanding of communication pathway efficacy (Omeiza Bashiru et al., 2022). This approach provided a more granular and theoretically informed analysis than a standard descriptive survey, directly addressing the research objective of identifying practice-specific communication pathways.

3.3 Target Population

The study focused on 18-35 years youth farmers in Bumula Sub-County, with the youth population being 51,641 (Njenga et al., 2024). The target population at hand was 10,888 youths from Siboti (6,602) and Khasoko (4,286) wards, selected due to their youth farmer concentration, agricultural intensity, and high vulnerability to climate risks, making them an appropriate group for exploring CSA information channels (Debates, 2023).

3.4 Sampling Procedure and Sample Size

A multi-stage cluster sampling design was employed to select a representative cohort of youth farmers. This approach was deemed appropriate for efficiently sampling a population distributed across a wide geographical area while maintaining statistical robustness (Ahmed, 2024).

In the first stage, two administrative wards, Siboti and Khasoko, were purposively selected as primary sampling units. This selection was based on their high agronomic significance, accounting for approximately 83% of the sub-county's agricultural activity, a pronounced climate risk index (7.2/10), and a high density of youth populations (62%), making them critical loci for investigating CSA communication channels (Li et al., 2024). The sample size was calculated using Nassiuma, (2001) coefficient of variation formula, which is designed for finite populations where the variance is not directly known. The formula is expressed as:

$$n = \frac{NC^2}{C^2 + (N-1)e^2},$$

where N is the population size (10,888), C is the coefficient of variation (set at 0.5), and e is

the margin of error (set at 0.05). This calculation yielded a base sample of 109 respondents. To account for potential non-response and ensure data robustness, this figure was rounded up to a final sample of 120 youth farmers.

In the final stage, a simple random sampling technique was applied within each selected ward with proportional allocation to ensure representativeness. This resulted in the selection of 73 respondents from Siboti ward and 47 from Khasoko ward, as detailed in Table 1.

Table 1

Proportion of Sample Size per Ward

Ward	Number of youth Farmers	Proportion	Sample size
Siboti	6,602	61	73
Khasoko	4,286	39	47
Total	10,888	100	120

3.5 Instrumentation

Data collection was conducted using a structured survey questionnaire, meticulously designed to capture the study's core variables. To ensure the tool's robustness, a multi-step validation process was employed. Content validity was established through a thorough review by a panel of agricultural extension specialists, who assessed the relevance, clarity, and comprehensiveness of the items. Furthermore, a pilot study was administered to 30 youth in Bumula ward, which served to refine question phrasing, estimate the time required for completion, and identify any potential ambiguities in a field setting. The internal consistency of the scales, particularly for the institutional factors construct, was confirmed via reliability analysis, yielding a Cronbach's alpha coefficient of 0.82, which is considered a good level of reliability (Karimian & Chahartangi, 2024).

3.6 Data Collection Procedure

The data collection process was executed through a structured, multi-phase procedure designed to ensure the integrity and quality of the field data. Prior to commencing fieldwork, research assistants were recruited and participated in a comprehensive two-day training session. This training covered the study's objectives, the precise meaning of each questionnaire item, ethical protocols for engaging respondents, and techniques for conducting neutral, non-leading interviews.

The primary data were subsequently gathered through face-to-face interviews conducted at the homes or farms of the sampled youth farmers using the structured questionnaire. Each interaction began with the researcher introducing themselves, explaining the study's purpose, and obtaining verbal informed consent before proceeding. To maintain high data quality, a rigorous, multi-layered verification protocol was implemented concurrently with data collection. This involved daily audits of completed questionnaires for consistency and completeness, followed by systematic back-checking where a random selection of 20% of respondents were contacted via phone to verify the consistency of key responses. Furthermore, the GPS coordinates of each interview location were electronically captured to document the spatial distribution of the survey. This meticulous, stepwise approach ensured the collection of robust, verifiable, and high-fidelity data for subsequent analysis.

3.7 Data Analysis

The data analysis was conducted using SPSS version 26, following a two-stage analytical procedure. Initially, descriptive statistics, including frequencies, percentages, and means, were employed to systematically characterize the study sample and summarize the predominant patterns in communication channel usage for different Climate-Smart Agriculture (CSA) practices. Subsequently, inferential analysis was performed using binary logistic regression. This technique was specifically selected to model the probability of CSA practice adoption and to test the statistical influence of the various information communication channels on youth engagement, thereby addressing the core research objective of identifying significant predictive pathways.

IV. FINDINGS & DISCUSSION

4.1 Information Communication Pathways for Climate-Smart Agriculture

The analysis of information sources in Table 2 reveals distinct and purposeful patterns in how youth in Bumula sub-county access knowledge on different Climate-Smart Agriculture (CSA) practices, moving beyond a monolithic view of information dissemination.

Table 2

Frequencies of CSA Use Arising from different Information Communication Pathways

Information of CSA practices	Extension officer		Mass Media		Neighbors and Friends	
	F	%	F	%	F	%
Composting	37	36.3	28	27.5	37	36.3
Rainwater harvesting and storage	30	25.6	42	35.9	45	38.5
Crop rotation	53	46.9	27	23.9	33	29.2
Mulching	43	41.3	25	24.0	36	34.6
Drainage	50	47.6	22	21.0	33	31.4
Irrigation	30	31.6	26	27.4	39	41.1
Furrow/ ridge planting	41	42.7	29	30.2	26	27.1
Minimum tillage	41	41.4	27	27.3	31	31.3
Improved crop varieties	37	38.1	40	41.2	20	20.6
Agroforestry	51	47.7	25	23.4	31	29.0
Terracing	46	43.8	30	28.6	29	27.6
Intercropping	41	36.0	24	21.0	49	43.0
Inorganic fertilizers	50	43.9	38	33.3	26	22.8

F – Frequency; % - Percent; N/F – Neighbors and friends; Ext Off – Extension officers

A clear delineation emerges based on the technical complexity and observability of the practices. Extension officers were the dominant information source for knowledge-intensive and permanent land management techniques. Practices such as agroforestry (47.7%), drainage (47.6%), and crop rotation (46.9%) relied most heavily on formal extension. This aligns with the findings of Morrison et al. (2025), who noted that farmers depend on extension agents for technically complex practices that require expert guidance for correct implementation. The high reliance on extension for these practices in Bumula suggests they are perceived as demanding specialized knowledge that is less easily transmitted through informal channels.

Conversely, informal social networks, including neighbors and friends, were the primary pathway for practices that are highly visible, easily replicable, or managed communally. This was most evident for intercropping (43.0%), irrigation (41.1%), and rainwater harvesting (38.5%). This pattern strongly supports social learning theory (Deaton, 2015), where individuals adopt behaviors observed and validated within their immediate social circles. The prominence of peer-to-peer learning for these practices, also observed in rural Kenya by Haddock et al. (2022), underscores their low perceived risk and the critical role of community-based demonstration in their adoption, particularly for techniques like rainwater harvesting which may involve shared resource management.

Mass media (radio, television) played a significant but specific role, acting as a key conduit for information on market-linked inputs. Media was the leading source of information for improved crop varieties (41.2%) and a major source for inorganic fertilizers (33.3%). This finding corroborates research by Mahama et al. (2024), which found that mass media is highly effective for disseminating information about commercial inputs like seeds and fertilizers, which are often promoted through advertisements and sponsored programs. However, media's lower influence on complex land management practices like terracing (28.6%) and minimum tillage (27.3%) highlights its limitation in delivering the hands-on, experiential learning these methods require, a constraint noted by Danso-Abbeam et al. (2018).

These findings present a nuanced picture that both confirms and challenges broader narratives. The robust role of extension in Bumula contrasts with studies from regions like Northern Ghana, where extension services were found to be ineffective due to logistical constraints and high farmer-to-agent ratios (Apantaku et al., 2016). This discrepancy suggests that Bumula may benefit from a relatively more functional extension infrastructure or targeted youth programs. Furthermore, the practice-specific effectiveness of media underscores the "digital divide" in agricultural extension (Singh et al., 2023). While digital and broadcast media are powerful for simple messages, they cannot replace demonstration for complex techniques. Ultimately, the data argue against a one-size-fits-all communication strategy and instead advocate for a segmented approach that matches the communication channel to the inherent characteristics of the CSA practice being promoted.

4.2 Effect of Information Communication Pathways on Youth's CSA Practice

The quantitative analysis (Table 3) reveals a statistically profound relationship between information communication channels and the adoption of CSA practices among youth in Bumula Sub-County. A chi-square test of independence confirmed a significant association, $\chi^2 (2, N = 120) = 100.12, p < .001$. The strength of this association was found to be perfect, as measured by Cramer's V ($V = 1.0$). This indicates that the specific source of information is a primary determinant of youth participation in CSA, moving beyond a mere correlation to suggest a near-categorical relationship within this sample.

Table 3

Effect of Information Communication Pathways on Youth's CSA Practice

Statistical Measure	Value	Interpretation
Chi-square (χ^2)	100.12139	A significant association between variables.
Degrees of freedom (df)	2	Number of categories minus one for the chi-square test.
p-value	< 0.05	Statistically significant at the 5% level (rejects the null hypothesis).
Cramer's V	1.0	Very strong association between information sources and CSA participation.
Conclusion		Information communication channels significantly influence youths' CSA adoption.

The strength of this relationship offers a powerful confirmation of the enabling potential of information and communication technologies (ICTs) documented in emerging agricultural literature. For instance, Cerjak et al. (2025) demonstrated that mobile phone-based advisories in India significantly increased farmers' adoption of new methods, underscoring the power of accessible, real-time information. Similarly, Ntsoane et al. (2025) found that SMS notifications led to a marked uptick in the uptake of agricultural innovations among Tanzanian smallholders. Our findings from Bumula corroborate this paradigm, suggesting that for a digitally engaged youth population, the very accessibility of information through modern channels is a potent catalyst for change.

However, the perfect association (Cramer's $V = 1.0$) found in this study stands in stark contrast to several other empirical studies, raising critical questions about contextual factors. For example, research by Wang et al. (2020) in China found only a weak to moderate association (Cramer's $V \approx 0.3-0.5$) between extension contact and technology adoption, attributing this to logistical challenges, high farmer-to-agent ratios, and the limited relevance of information provided. This stark discrepancy suggests that the quality, local applicability, and delivery mechanism of information in Bumula's dominant channels may be uniquely effective. The divergence could be attributed to Bumula's relatively higher mobile phone penetration or the targeted use of interactive, youth-specific digital platforms (e.g., dedicated WhatsApp groups, YouTube tutorials) which create a more engaging information ecosystem than the passive, one-way communication noted in less effective studies (Gazi et al., 2024).

Furthermore, our results, which champion a practice-specific efficacy of channels, directly challenge the findings of studies that have dismissed certain dissemination methods in a generalized manner. For example, Mwinami et al. (2023) concluded that conventional extension and radio were broadly ineffective for youth, citing low digital literacy and the passive nature of such platforms. Our study, conversely, found that mass media was the leading source for market-linked inputs like improved seeds (41.2%), while extension agents were crucial for complex practices like agroforestry (47.7%). This divergence underscores a critical insight: a channel deemed "ineffective" in a generalized sense may be highly effective for a specific type of practice. The failure in some contexts may not be inherent to the channel itself, but in its misapplication. This aligns with the contingency theory of communication, which posits that communication effectiveness is dependent on matching the medium's richness to the complexity of the message (Singh et al., 2023). Complex practices like agroforestry require the rich, interactive communication of extension agents, while simple messages about seed availability are effectively broadcast via media.

The strong link between information channels and adoption in Bumula strengthens the imperative for policymakers to prioritize ICT-integrated, multi-channel extension systems. ICT-based platforms, particularly those already popular with youth like social media and SMS advisories, are essential for scaling information dissemination (Morrison et al., 2025). However, this technological push must be tempered with the caution offered by Molala and Makhubele (2021), who warns that technology-centric policies can exacerbate exclusion in marginalized communities with limited connectivity or digital skills. Therefore, a hybrid or blended approach is paramount. The proven efficacy of social networks for visible practices like intercropping (43.0%) suggests that the most resilient strategy combines the reach of digital tools with the trust and demonstrability of community-level peer learning, creating an information safety net that is both broad and deep.

V. CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

It is evident that information communication channels are a key determining factor of youths' engagement with Climate-Smart Agriculture in Bumula Sub-County. Although formal extension services were a prominent source of knowledge, and a strong statistical relationship (Cramer's $V = 1.0$) was established between communication channels and CSA uptake, efforts have not yet translated into high adoption as evidenced by the small percentage (14.3%) of high adopters. This underlying disconnect underscores the fact that effective information dissemination, critical as it is, is insufficient on its own. The evidence compellingly argues that achievable youth involvement in CSA at scale requires not only segmented communication strategies but also a parallel addressing of the underlying institutional and socio-economic limitations such as poor access to credit, land, and inputs limiting the knowledge-to-sustained-practice transition.

5.2 Recommendations

To effectively bridge the gap from awareness to the widespread adoption of Climate-Smart Agriculture (CSA) among youth, a multi-pronged strategy is essential. First, it is imperative for the Ministry of Agriculture and relevant stakeholders to modernize public extension services. This should be achieved by strategically integrating conventional methods with digital platforms such as targeted SMS alerts and dedicated mobile applications, thereby effectively reaching and engaging technology-literate youth. Second, institutional support should be directed towards reinforcing peer-to-peer knowledge sharing. Scaling up initiatives like youth champion farmer programs can formally leverage the proven power of social learning for practices that are easily observable within communities. Finally, and most critically, a segmented communication strategy must be adopted. This approach entails deliberately matching the promotion channel to the specific characteristics of each CSA practice: utilizing extension agents for knowledge-intensive techniques, mass media for disseminating information on market-linked inputs, and social networks for promoting highly visible practices. Such a diversified and targeted strategy, when implemented in tandem with efforts to address foundational constraints like credit and land access, is paramount for converting youth awareness into sustained, high-level CSA adoption.

REFERENCES

- Ahmed, S. K. (2024). How to choose a sampling technique and determine sample size for research: A simplified guide for researchers. *Oral Oncology Reports*, 12, 100662. <https://doi.org/10.1016/j.oor.2024.100662>
- Allen, E. M., Munala, L., Frederick, A. J., Quito, C., Enayat, A., & Ngunjiri, A. S. W. (2025). Climate change and health: Impacts across social determinants in Kenyan agrarian communities. *Climate*, 13(8), 169–180. <https://doi.org/10.3390/cli13080169>

- Apantaku, S. O., Aromolaran, A. K., Shobowale, A. A., & Sijuwola, K. O. (2016). Farmers and extension personnel view of constraints to effective agricultural extension services delivery in Oyo State, Nigeria. *Journal of Agricultural Extension*, 20(2), 202–214. <https://doi.org/10.4314/jae.v20i2.15>
- Atser, G. L., Dixon, A., Ekeleme, F., Hauser, S., Fadairo, O., Adekoya, A., Ayanwale, A. B., Agada, M., Oladokun, I., Akpu, P., Sanni, L., Pypers, P., Ampadu-Boakye, T., & Vanlauwe, B. (2023). The effect of communication media on the uptake of agricultural innovations in selected states of Nigeria. *The Journal of Agricultural Education and Extension*, 29(5), 583–604. <https://doi.org/10.1080/1389224X.2022.2120026>
- Bouteska, A., Sharif, T., Bhuiyan, F., & Abedin, M. Z. (2024). Impacts of the changing climate on agricultural productivity and food security: Evidence from Ethiopia. *Journal of Cleaner Production*, 449, 141793. <https://doi.org/10.1016/j.jclepro.2024.141793>
- Cerjak, M., Medici, M., Faletar, I., Sundeeep, J. V., & Canavari, M. (2025). Adoption of mobile-based agricultural extension services: Evidence from South India. *Journal of Rural Studies*, 120, 103851. <https://doi.org/10.1016/j.jrurstud.2025.103851>
- Danso-Abbeam, G., Ehiakpor, D. S., & Aidoo, R. (2018). Agricultural extension and its effects on farm productivity and income: Insights from Northern Ghana. *Agriculture & Food Security*, 7(1), 74–89. <https://doi.org/10.1186/s40066-018-0225-x>
- Deaton, S. (2015). Social learning theory in the age of social media: Implications for educational practitioners. *I-Manager's Journal of Educational Technology*, 12(1), 1–6. <https://doi.org/10.26634/jet.12.1.3430>
- Debates, C. A. (2023). County government of Bungoma County assembly debates the daily Hansard. 183(204), 1–32.
- Deininger, K., Jin, S., & Ma, M. (2022). Structural transformation of the agricultural sector in low- and middle-income economies. *Annual Review of Resource Economics*, 14(1), 221–241. <https://doi.org/10.1146/annurev-resource-111820-033252>
- Gao, Y., Zhao, D., Yu, L., & Yang, H. (2020). Influence of a new agricultural technology extension mode on farmers' technology adoption behavior in China. *Journal of Rural Studies*, 76, 159–173.
- Gazi, M. A. I., Rahaman, M. A., Rabbi, M. F., Masum, M., Nabi, M. N., & Senathirajah, M. R. B. S. (2024). The role of social media in enhancing communication among individuals: Prospects and problems. *Environment and Social Psychology*, 9(11), 74–90. <https://doi.org/10.59429/esp.v9i11.2979>
- George, V. (2025). Social sciences & humanities open: Harnessing digital dividends: A systematic review of ICT initiatives for transformation in Tanzanian agriculture. *Social Sciences & Humanities Open*, 12, 101716. <https://doi.org/10.1016/j.ssaho.2025.101716>
- Haddock, A., Ward, N., Yu, R., & O'Dea, N. (2022). Positive effects of digital technology use by adolescents: A scoping review of the literature. *International Journal of Environmental Research and Public Health*, 19(21), 14009. <https://doi.org/10.3390/ijerph192114009>
- Kabato, W., Getnet, G. T., Sinore, T., Nemeth, A., & Molnár, Z. (2025). Towards climate-smart agriculture: Strategies for sustainable agricultural production, food security, and greenhouse gas reduction. *Agronomy*, 15(3), 565–678. <https://doi.org/10.3390/agronomy15030565>
- Kapoor, K. K., Dwivedi, Y. K., & Williams, M. D. (2014). Rogers' innovation adoption attributes: A systematic review and synthesis of existing research. *Information Systems Management*, 31(1), 74–91. <https://doi.org/10.1080/10580530.2014.854103>
- Karimian, Z., & Chahartangi, F. (2024). Development and validation of a questionnaire to measure educational agility: A psychometric assessment using exploratory factor analysis. *BMC Medical Education*, 24(1), 1284. <https://doi.org/10.1186/s12909-024-06307-z>
- Kenya National Bureau of Statistics. (2015). Bungoma County. *World Bank Microdata Library*. <https://doi.org/10.2499/p15738coll2.134464>
- Kenya National Bureau of Statistics. (2022). *Economic survey 2022*. <https://www.knbs.or.ke/wp-content/uploads/2023/09/2022-Economic-Survey.pdf>
- Kirimi, L., Olwande, J., Langat, J., Njagi, T., Kamau, M., & Obare, G. (2023). Agricultural inputs in Kenya: Demand, supply, and the policy environment (pp. 201–230). *International Food Policy Research Institute*. https://doi.org/10.2499/9780896294561_08
- Larochelle, C., Alwang, J., Travis, E., Barrera, V. H., Manuel, J., & Andrade, D. (2019). Did you really get the message? Using text reminders to stimulate adoption of agricultural technologies. *The Journal of Development Studies*, 55(4), 548–564. <https://doi.org/10.1080/00220388.2017.1393522>
- Li, Q., Shan, H., Tang, Y., & Yao, V. (2024). Corporate climate risk: Measurements and responses. *The Review of Financial Studies*, 37(6), 1778–1830. <https://doi.org/10.1093/rfs/hhad094>
- Mahama, S. W., Abudu, J. I., Damwah, A. K., & Arhin, E. T. (2024). Influence of communication on smallholder farmers' adoption of agricultural innovations in Damongo of the Savannah Region of Ghana. *African Journal of Empirical Research*, 5(4), 1278–1295. <https://doi.org/10.51867/ajernet.5.4.105>

- Molala, T. S., & Makhubele, J. C. (2021). The connection between digital divide and social exclusion: Implications for social work. *Humanities & Social Sciences Reviews*, 9(4), 194–201. <https://doi.org/10.18510/hssr.2021.9427>
- Morrison, R., Cassar, X., Duncan, A. J., Rao, E. J. O., & Barnes, A. P. (2025). Information flows within farmer networks and the implications for farmer-to-farmer extension: Evidence from the Kenyan dairy sector. *The Journal of Agricultural Education and Extension*, 31(5), 785–809. <https://doi.org/10.1080/1389224X.2025.2461455>
- Mulungu, K., Kassie, M., & Tschopp, M. (2025). The role of ICT-based extension in agriculture: Application, opportunities, and challenges. *Information Technology for Development*, 91(126), 1–30. <https://doi.org/10.1080/02681102.2025.2456232>
- Mwanzia, D. K., Mbala, S., & Akuja, T. E. (2025). Assessment of the level of awareness of climate-smart agricultural practices among smallholder farmers in Mwingi West Sub-County, Kitui County, Kenya. *African Journal of Climate Change and Resource Sustainability*, 4(2), 107–116. <https://doi.org/10.37284/ajccrs.4.2.3537>
- Mwinami, N., Dulle, F. W., & Mtega, W. P. (2023). Communication channels and their potential applicability in enhancing agricultural research data sharing among agricultural researchers in Tanzania. *LIBER Quarterly: The Journal of the Association of European Research Libraries*, 33(1), 103–121. <https://doi.org/10.53377/lq.12931>
- Nassiuma, D. K. (2000). *Survey sampling: Theory and methods*. Nairobi University Press.
- Njenga, N. N., Oywaya-Nkurumwa, A., & Munyua, C. N. (2024). Perceptions on influence of membership in young farmers clubs on career interest and participation in agricultural activities among secondary school students in Nakuru North Sub-County, Nakuru County, Kenya. *Journal of the Kenya National Commission for UNESCO*, 4(2), 1–9. <https://www.ajol.info/index.php/jkncu/article/view/281876>
- Ntsoane, M. M., Ndoro, J. T., & Wayi-Mgwebi, N. (2025). Multivariate probit model analysis of the factors influencing smallholder farmers' choice of ICT tools: A case study of Mpumalanga, South Africa. *Agriculture*, 15(17), 1817. <https://doi.org/10.3390/agriculture15171817>
- Nying'uro, P., Kimutai, J., & Kiptum, C. (2023). State of the climate Kenya. <http://196.202.217.199>
- Omeiza Bashiru, S., Ibrahim, A., Modu Isa, A., & Ismaila Itofa, I. (2022). Binary logistic regression model with application in students' G.P.A performance. *Arid Zone Journal of Basic and Applied Research*, 1(4), 62–69. <https://doi.org/10.55639/607mlkji>
- Onyango, R., Nzengya, D., & Lihasi, L. (2025). Engendering climate-smart agriculture in Mt. Kenya East: How farmer demographics shape smallholder adoption. *11*(2), 115–132.
- Rains, S. A., & Ruppel, E. K. (2016). Channel complementarity theory and the health information-seeking process: Further investigating the implications of source characteristic complementarity. *Journal of Communication*, 66(4), 635–656. <https://doi.org/10.1177/0093650213510939>
- Singh, N. K., Sunitha, N. H., Tripathi, G., Saikanth, D. R. K., Sharma, A., Jose, A. E., & Mary, M. V. K. J. (2023). Impact of digital technologies in agricultural extension. *Asian Journal of Agricultural Extension, Economics & Sociology*, 41(9), 963–970. <https://doi.org/10.9734/ajaees/2023/v41i92127>
- Singh, R., Slotznick, W., & Stein, D. (2023). Digital tools for rural agriculture extension: Impacts of mobile-based advisories on agricultural practices in southern India. *Journal of the Agricultural and Applied Economics Association*, 2(1), 4–19. <https://doi.org/10.1002/jaa2.42>
- Turner, R. J. (2007). Book review. *Journal of Minimally Invasive Gynecology*, 14(6), 776–783. <https://doi.org/10.1016/j.jmig.2007.07.001>
- Wang, G., Lu, Q., & Capareda, S. C. (2020). Social network and extension service in farmers' agricultural technology adoption efficiency. *PLOS ONE*, 15(7), e0235927. <https://doi.org/10.1371/journal.pone.0235927>