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Communication technologies for sustainable agriculture and food security among smallholder farmers in Nyatike and Suna East, Kenya

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Abstract: Communication technologies enhance information sharing among agricultural stakeholders and farmers, improving food production and security. Despite the availability of indigenous knowledge and digital technologies, many rural smallholder farmers lack adequate agricultural information, leading to food insecurity. This study aimed to explore the communication technologies for information and knowledge sharing among smallholder farmers in Migori County, Kenya. Despite its favourable agricultural climate, Migori County faces significant food insecurity. The study used a qualitative descriptive design and semi-structured focus group discussions to obtain farmers' perspectives on the communication technologies they use. The study purposively sampled 86 smallholder farmers from farmer groups in Nyatike and Suna East sub-counties, who participated in seven focus group discussions. Qualitative data were audio-recorded, organised, and analysed using thematic analysis. Reliability was obtained through member checking. Findings revealed that smallholder farmers in Suna East and Nyatike predominantly rely on interpersonal oral communication, agribusiness personnel, and the radio to obtain information on sustainable agriculture and food security. Few farmers used digital technology, while extension officers and NGOs were rare. The study concluded that communication of agricultural information among smallholder farmers is heterogeneously multiplex. While interpersonal communication promotes the sharing of indigenous knowledge, few sources, limited expertise, a lack of practical demonstrations on the radio, and limited digital access hinder effective knowledge sharing on sustainable agriculture and food security. The study recommends an integrated approach to communicating sustainable agriculture and food security, using digital storytelling tools to document and share both indigenous knowledge and new farming techniques.

Keywords – Communication technologies, Information sharing, Food security, Knowledge sharing, Smallholder farmers, Sustainable agriculture

1. INTRODUCTION

The goal of sustainable farming is to combat hunger, ensure food security, achieve SDG 2, and enhance environmental sustainability. Food security refers to the availability, accessibility, utilization, and stable supply of food within a population (Food and Agriculture Organisation (FAO et al., 2020)). Food insecurity arises from unpredictable weather conditions, unsuitable farming practices, low soil fertility, inadequate use of farm inputs, and limited access to agricultural information among farmers. Africa bears the biggest burden of food insecurity, with 20.2% of the African population being food-insecure (FAO et al., 2022; FAO et al., 2023). In 2022, the proportion of

the population in Africa that faced food insecurity reached 61%, a figure twice that of the global 29-6% (FAO et al., 2023). Despite this, 54% of the world's food losses occur upstream during post-production, postharvest handling, and storage. These losses are caused by pests and diseases, flooding, and contamination- factors that can be mitigated by adequate knowledge and information sharing among farmers.

According to FAO et al. (2020), achieving food security heavily relies on saving smallholder farmers from climate variability and extremes and providing them with information. In Kenya, smallholder farmers, especially those in rural areas, account for a large share of the agricultural value chain and are the primary suppliers of horticultural produce, serving the urban population with fresh, nutritious food and contributing significantly to food security. Smallholder farmers comprise about 75% of total agricultural production in Kenya. Therefore, providing farmers with timely and sufficient information on sustainable farming practices, such as smart agriculture, vertical farming, greenhouse and cyber farming, and postharvest handling, can contribute significantly to food security.

Kenyan farmers have traditionally benefited from Indigenous Agricultural Knowledge (IAK) and agricultural extension services. IAK comprises skills, beliefs, and insights about the environment, agriculture, health, spirituality, and social organization that are deeply entrenched in the cultures and traditions of a people and are transferred from one generation to another (Ajani et al., 2024). IAK, including weather patterns, seed selection and storage, weed and pest control, and food preservation, has been recognized as an invaluable source of information for sustainable agriculture and food security.

Kenyan farmers also rely on public extension services for agricultural information. However, the government employs a few extension officers, creating an information gap among farmers (Ireri, 2021; Phiri et al., 2019). Besides extension officers, farmers can connect with fellow farmers, producers, and markets at the local level through face-to-face interactions and digital technologies, thereby increasing agricultural knowledge sharing on sustainable farming practices (Hanson & Heeks, 2020). Digital technologies can be used to document indigenous knowledge and preserve information such as medicinal plants, pest and disease control, and ecological knowledge for the benefit of the current society and future generations and contribute to the cultural heritage of a people (Adam et al., 2022).

Despite their affordances, the adoption of digital technologies in agriculture faces several challenges. Studies highlight limited access, socioeconomic constraints, limited digital literacy, technical complexity, and incompatibility between norms and scientific discourse, including misinformation on the internet (Lubell & McRoberts, 2018). Literature shows that both indigenous knowledge and digital communication are valuable yet readily inaccessible to smallholder farmers who serve the majority of the population with food and enhance food security. Despite this, few studies examine how rural smallholder farmers can optimize different communication technologies to enhance sustainable agriculture and food security.

2. LITERATURE SURVEY

Communication technologies comprise systems, platforms, and tools used for sharing information by individuals and organizations. Communication technologies have lasted throughout human existence and transformed over time from traditional oral to print, mediated, and digital communication. In the information age, communication technologies have transformed how people create and share information, operate, and connect locally and globally. Agricultural communication provides information to farmers, agricultural stakeholders, and markets, enabling production, processing, and distribution of agricultural products. The advent of AI, including autonomous technologies, is also improving dairy production and indoor production, such as pig and poultry farming (van Hilten & Wolfert, 2022). Moreover, AI is now applicable to farmers with different capacities, including those with limited digital literacy, through short messaging and WhatsApp, using native vernacular (Godwin & Johnson, 2025).

2.1. Oral communication

Rural farmers rely heavily on oral communication of Indigenous Agricultural Knowledge (IAK) to improve agricultural production. Indigenous agricultural knowledge (IAK) is deeply entrenched in the cultures and traditions and is orally transferred from one generation to another (Ajani et al., 2024). Indigenous knowledge, such as seed selection and smoke-based storage, traditional pest control using ash, weather patterns, weed control, and food preservation, has been recognised as an invaluable source of information for sustainable agriculture and food security (Melash et al., 2023). IAK promotes sustainable farming and environmental conservation, which contributes significantly to food security (Berkes, 2017; Melash et al., 2023; Musyoka & Omosa, 2024). The use of Zai pit technologies and integrated soil fertility management, an indigenous knowledge system to reduce soil moisture, was found to improve crop productivity in arid and semi-arid regions of sub-Saharan Africa (Kebenei et al., 2023). Despite its potential in enhancing food production and security, IAK relies on elders' memories and cultural transmission and lacks adequate documentation; thus, it risks being lost (Lwoga et al., 2010; Melash et al., 2023). Other studies show that IAK has been ignored due to modernity and the commercialization of food (Mamati & Omare, 2024).

2.2. Agricultural extension services

Agricultural extension services provide reliable agricultural information to smallholder farmers. In the nineteen nineties, the Kenyan government implemented the National Agriculture and Livestock Extension Program (NALEP) to support crop and livestock production. Extension officers provided impressive results in food production, but were later criticized for poor results, being top-down, one-size-fits-all, and marginalizing resource-poor farmers with financial constraints (Muyanga & Jayne, 2006). Though extension services provide reliable agricultural information to smallholder farmers, the number of extension staff employed by the government has decreased over the years, creating a gap in agricultural knowledge dissemination, which limits farmers from sourcing useful agricultural information, such as adaptive farming practices (Ireri, 2021; Phiri et al., 2019). Further, public confidence in extension services continues to wane, especially among rural farmers who need them most.

Studies show variable results on the effectiveness of extension services. A study on extension services in Kenya opined that extension agents deliberately positioned themselves to serve economically well-off households (Damonte et al., 2019). Other studies show that while farmer-to-farmer extension within social networks is effective, extension contact does not guarantee technology adoption because of factors such as the farmer-to-agent ratio and logistical constraints (Apantaku et al., 2016; Morrison et al., 2025). In central Ghana, an assessment of how well extension systems support Farmer-Based Organisations (FBO) through training, market access, inputs, research links, participation, productivity and technology adoption found that a market-oriented extension system, which had weak research-extension links, limited credit and input support, and low technology adoption, was ineffective and resulted in little improvement in yields. On the other hand, the commodity-based approach, Training and Visit system, outgrower scheme, and Farmer Field Fora were considered effective because they improved farmer participation, technology adoption, productivity, and, in some cases, access to inputs, credit, and markets. The study indicates that since smallholder farmers have different needs, siloed extension services are more effective in meeting specific farmer needs. In addition, the FBOs enabled effective farmer participation (Akomaning, et al., 2017). A recent study in Bumula sub-county in Kenya found that farmers relied on extension services for technically complex agricultural practices that require expert advice, as opposed to simple practices such as intercropping, which they obtained from fellow farmers (Saenyi et al., 2025). These varied findings call for further research on how best governments and smallholder farmers can maximise the benefits of extension services.

2.3 Digital communication

The application of digital communication, such as computers, cloud computing, computer networks, wired and wireless networks, blockchain, and AI (Artificial Intelligence) and machine learning, has transformed agricultural production in livestock farming, machinery, crop production, and marketing. Farmers can obtain information on sustainable agricultural practices, such as substituting herbicides and fertilizers with weeding robots and organic fertilizers. Digital communication also has the potential to improve farmers' access to information, agricultural productivity, environmental sustainability, and food security (Ireri, 2021; Ngulube, 2025). Besides the application tools, individual farmers, consumers, and organizations use radio, Television, mobile phones, tablets, social media, and online platforms for networking and sharing agricultural information, thereby increasing agricultural knowledge and sustainable farming practices. Online access to agricultural information, such as land preparation, weather forecasts, and pest control, provides real-time solutions to agricultural challenges

Recent trends in the use of digital technologies in agriculture include the use of software platforms to capture soil and climatic conditions, disease control and management, and remote sensing diagnostic tools, enabling the gathering of data, including soil moisture, weed occurrence, crop biomass and disease occurrence, which can help in early mitigation and improve productivity (Finger, 2023). Globally, other ICT services include the use of websites and mobile applications like Nokia Life and IFFCO Airtel (India), Z-Kilimo (Tanzania) (Ireri, 2021). Automated systems like Farmerchat deliver advice through text, voice, and images in multiple Kiswahili, Odia, and Hausa languages, which can help tailor crop management considering soil conditions, pest presence, and crop development (Michael, 2024). ICT also offers support for easier and cheaper communication between farmers and buyers (Hanson & Heeks, 2020). Recent studies show that digital systems can be used by rural farmers with low digital literacy through short messaging and WhatsApp using native vernacular (Godwin & Johnson, 2025).

Despite their digital affordances, adoption of digital technologies in agriculture faces several challenges. Barriers to adoption of ICT include digital access, socioeconomic constraints, limited digital literacy, technical complexity and incompatibility between norms and scientific discourse, including misinformation on the internet (Lubell & McRoberts, 2018). Studies have also cited an oversupply of apps and a mismatch between scientific experts developing tools and local farmers, affordability, low priority, the type of knowledge being shared, as well as lack of trust due to previous failures (Krell et al., 2021; Mallory et al., 2022; Manzoor et al., 2025). Poor quality information, literacy levels, information-seeking behaviour, poorly designed information channels, and high cost of information access also pose challenges to digital agricultural communication (Muhanguzi & Ngubiri, n.d.).

Because of these challenges, digital technologies hardly reach and benefit populations, especially rural women with low literacy and limited digital skills, compounding the digital asymmetry (Krell et al., 2021). Educated individuals are more likely to access and use information from a variety of sources than their less literate counterparts. Poorer farmers may lack digital tools and infrastructure to access digital information, thereby exacerbating the digital divide. Additionally, the ease of noticing results of adoption, financial budgets, farmers' philosophies and beliefs regarding the technology, level of inspiration, and perceived significance of the new technology can act as impediments to acceptance of agricultural technologies. Studies observe that information seekers may choose to use the most convenient and cheapest sources (Muhanguzi & Ngubiri, n.d.; Haruna, 2024).

A study on the adoption of ICT among extension professionals examined the benefits and risks of ICT use based on attributes such as innovation, compatibility, complexity, observability, and friability. The study found that extension professionals recognized the advantage of ICT for quickly communicating with a more diverse and distant audience. However, they considered ICT less potentially reliable for coordinating on-the-ground activities. Barriers to adoption of ICT were time constraints, technical complexity and incompatibility between norms and scientific

discourse, including misinformation on the internet (Lubell & McRoberts, 2018). Unfortunately, rural women, who are the largest source of agricultural labour have limited education and digital literacy skills, which affects their adoption of digital technology.

The use of radio for agricultural communication has been extensively researched, with most studies showing that it is effective in creating awareness among farmers (Attuh &Kamkam, 2024; Saenyi et al., 2025). However, a study in Tanzania showed that radio was ineffective in promoting climate-smart agriculture among the youth due to its passivity (George, 2025). A similar study in Bumula, Kenya, found that a one-size-fits-all communication approach is ineffective in involving youth in climate-smart agriculture (Saenyi et al., 2025). Nonetheless, Anya et al. (2026) argue that smart agriculture can strengthen food security and rural resilience, but only when inclusive policies, institutions, infrastructure, and local capacity support the technology.

While agricultural communication plays a significant role in promoting sustainable agriculture and enhancing food security, communication with hard-to-reach smallholder farmers, who comprise the majority of food producers, remains a challenge. Smallholder farmers are disadvantaged by economies of scale; limited access to appropriate information may inadvertently compromise their productivity and worsen food insecurity.

2.3 Theoretical framework

This study was anchored on the Diffusion of Innovation Theory (DoI) by Everett Rogers, espoused in 1962 (Rogers et al., 2019), and the Knowledge Management (KM) theory. DoI theory traces its origin in agriculture and posits that an idea, regarded as an innovation or new practice, spreads within a social system over time through certain channels. The target group adopts the innovation over time, following a pattern influenced by the innovation's characteristics, the nature of the social system, and the communication channels used to spread it. According to Diffusion of Innovation theory, diffusion is a special type of communication in which participants create and share information to reach a common understanding. The theory considers face-to-face communication to be more suitable than mass media for spreading innovation. In addition, the theory categorizes adopters as innovators, early adopters, early majority, late majority, and laggards, based on their adoption speed.

Knowledge Management theory focuses on how knowledge is generated, exchanged, and applied across different communities and organisations. It provides a framework for comprehending the mechanisms of knowledge creation, distribution, and implementation, particularly within the intricate and information-rich sphere of agriculture. In agriculture, KM accentuates the conversion of information into practical knowledge that improves farming outcomes. The KM framework is organized around three interconnected dimensions: Knowledge acquisition, which entails the systematic gathering of information from varied sources, including Indigenous knowledge, empirical research, stakeholder networks, extension services, and traditional knowledge systems. Knowledge sharing, which refers to the dissemination of knowledge among stakeholders such as smallholder farmers, researchers, and agricultural extension agents, is crucial for promoting collaboration, the diffusion of innovation, and improved decision-making capabilities (Small & Sage, 2006). Knowledge application pertains to the pragmatic use of knowledge in agricultural practices, facilitating evidence-based decision-making and adaptation to specific challenges faced in various locales (Sudha, 2015). Efficient acquisition guarantees that agricultural knowledge encompasses both global advancements and localized realities (Tumwebaze et al., 2025).

Recent studies have shown that the application of Knowledge Management (KM) theory must consider stakeholder heterogeneity, which posits that the agricultural knowledge ecosystem consists of participants with differing levels of expertise, objectives, and access to information. This diversity necessitates contextually aware KM strategies that

cater to the informational requirements of marginalized demographics, especially smallholder farmers (Tumwebaze et al., 2025).

Additionally, the informality of knowledge exchange presents a significant challenge, as much of knowledge transfer in rural contexts transpires through informal channels such as interpersonal communication, peer learning, and oral traditions. Although these methods are readily accessible, they frequently lack the rigour and consistency characteristic of formal systems, creating obstacles for knowledge validation and scalability (Tumwebaze et al., 2025). Furthermore, the integration of indigenous knowledge acknowledges and incorporates traditional knowledge systems into KM processes, thereby enhancing the relevance, acceptance, and sustainability of agricultural initiatives. This integration helps to bridge epistemological divides and fosters culturally appropriate innovations (Tumwebaze et al., 2025).

Notwithstanding its potential, KM in agriculture faces constraints due to tensions stemming from conflicting stakeholder interests, unequal access to digital platforms, and the enduring informality of communication in rural settings. These complexities highlight the necessity for adaptive KM frameworks that are both inclusive and responsive to specific contexts. This is the context upon which this study is founded and thus emphasizes the collaborative development of KM systems that utilize digital communication tools while preserving the integrity of indigenous knowledge structures.

3. PROBLEM STATEMENT

It is estimated that 40% of food loss occurs at postharvest and processing levels in developing countries (Gustavsson et al., 2011). 51% of the Kenyan population lacks sufficient food, yet the country loses up to 50 per cent of its horticultural harvests as a result of poor storage and handling practices (Kenya News Agency, April 25, 2020). The proportion of the population experiencing severe food insecurity increased from 15% in 2016 to 28% in 2023(Agricultural-Marketing-Strategy-2023-2032, n.d.). Smallholder farmers play a significant role in ensuring food security; however, they often lack access to farm inputs, food storage facilities, access to markets, and agricultural information. In Migori County, Kenya, over 80 % of the population lives in rural areas and depends on agriculture for their livelihoods. However, the county faces challenges with food insecurity (County Government of Migori, 2023). Nyatike and Suna East sub-counties in Migori County, characterized by erratic rainfall patterns, frequent droughts, and floods, are most vulnerable to food insecurity. The farmers rely heavily on seasonal rainfall, leading to poor crop yields and food shortages. Therefore, the availability of agricultural information to farmers in this region can ameliorate the agricultural challenges in the region and improve food security.

The objective of this study was to explore communication technologies used by smallholder farmers in sharing agricultural information and food security among smallholder farmers in Nyatike and Suna East sub-counties in Migori County.

Research questions

The study set out to answer the following questions:

i. What are the communication technologies for sharing information on sustainable agriculture and food security among smallholder farmers?
ii. What are the farmers' perceptions of the communication technologies they use for sharing information on sustainable agriculture and food security?

4. RESEARCH METHODOLOGY

4.1. Study area

The study was carried out in Nyatike and Suna East, Sub-counties in Migori County, located in the southwest of Kenya. Over 80 % of the population in Migori County lives in rural areas and depends on agriculture for their livelihoods. However, the county faces food insecurity, with the most vulnerable being Nyatike and Suna East Sub-Counties (Migori County CIDP, 2023-2027). The region faces erratic rainfall patterns, frequent droughts and floods, which impact agriculture. Farmers heavily rely on seasonal rainfall, leading to poor crop yields and food shortages. Smallholder farmers in the area hold small parcels of less than two acres of land, have limited access to capital and farm equipment, and are highly impacted by climatic variability. Due to these factors, they embrace collective sustainable farming approaches such as agroforestry, irrigation, intercropping, organic and mixed farming, fishing, livestock, and poultry farming. They plant crops like maize, kales, cassava, millet, beans, groundnuts, tomatoes, vegetables, and bananas mainly for domestic consumption and small-scale trade. The farmer groups were suitable for understanding how communication technologies enable smallholder farmers to cope with such challenges amidst food insecurity.

4.2. Data collection

The study was conducted using a qualitative descriptive research design. It was suitable for this study since it would unearth participants' perspectives on the communication technologies for agricultural information transfer among smallholder farmers. The study purposively sampled four smallholder farmer groups: *Nyanam Ratek Tich* and *Oywa Ngori* from Nyatike and *Aminyasa*, and *Suna Pamoja* cooperative groups from Suna East sub-county. Unlike other groups in the study area, these four groups met the inclusion criteria; they have a fairly formal structure with clearly identified members and leadership, which made it easy to identify participants for the study. Some farmer groups were unstructured, had inconsistent membership, and rarely held group meetings, which would make it difficult to understand the communication dynamics. Before data collection, permission was obtained from the area chiefs, and farmers' consent to participate in the study was sought. Only farmers willing to participate voluntarily participated in the study. A total of 86 farmers comprising men, women, and youth from the four farmer groups participated in the study. There were more men (45) than women (30) and youth (11).

The researcher collected qualitative data through semi-structured focus group discussions held in the participants' localities. The researcher held seven (7) focus group discussions in two sessions: one in Nyatike and another in Suna East sub-county. The focus groups comprised twelve participants, drawn from the same farmer group to ensure homogeneity and self-expression, except one, which had thirteen participants. During the group discussions, data were collected using audio recording. The audio recordings were later shared with the study participants for member checking and confirmability during a meeting for the Food Learning and Growing (FLOW) project held in Karungu.

5. DATA ANALYSIS AND DISCUSSIONS

The researcher conducted a step-by-step qualitative data analysis, beginning by studying the data to understand the meanings of words and expressions of the farmers. The researcher manually transcribed the audio-recorded data, then organised it based on the questions used in the focus group discussion guide. Participants' verbatim records were kept as original as possible to reflect nuances of meaning. Using a deductive approach, the researcher identified codes from the data, paying close attention to any new codes that emerged from the data. Similar codes were grouped into themes, which formed the units of analysis.

5.1. Results

5.1.1. Communication technologies for sharing information on sustainable agriculture and food security

The study sought to establish how farmers obtain information on sustainable agriculture and food security. Farmers were asked to describe where they obtain information about land preparation, crop selection, planting, seed selection, planting techniques, pest and disease management, food security, storage and marketing. Findings on sources of information are summarized in Table 1.

Table 1: Summary of Communication Technologies for agricultural information sharing

Communication Technology	Who participates	Characteristics	Limitations
Oral communication	Farmer-to-farmer	Individual Farmers who plant similar crops seek views of others. Information is readily available Enhances Knowledge transfer	Lack of expertise among local farmers. Lack of scalability
	Farmer groups	Farmers with varied knowledge and experience on various crops; Groups act as access to NGOs and government bodies. Heterogeneity in information sharing and knowledge management (IAK and Digital information) Acts as knowledge hubs.	Overgeneralization of knowledge shared in groups; lack of sensitivity to different soil types
	Local provincial administration in barazas	Predominantly used for awareness creation. Generalised communication e.g. announcements from the government	Limited attendance by smallholder farmers, especially women and youth.
	Agribusiness personnel	Personnel operating agrovets provide advisory information on how to plant crops, control disease and use pesticides.	Communication is business-driven. Insufficient information.
	Agricultural Extension Officers	Farmer engagement is limited to events and critical government information, or upon requests by farmers. Hold expert knowledge	Limited access by smallholder farmers
Radio	Vernacular radio stations air agricultural programs in the local language	Farmers participate in talk shows. Sometimes radio hosts agricultural experts	Information from radio studios lacks practical demonstration, posing a challenge to mastery. Missing radio segments due to other personal engagements
Field demonstrations	Agricultural organizations &NGOs	Practical learning on the farm Reaches groups of farmers Expert knowledge transfer.	NGOs focus on specific crops of interest like maize and beans, thus may exclude other farmers; Demonstrations are rare
Digital Communication Technologies	Youth use phones to access information on YouTube and share with older farmers	Digital information sharing Intergenerational knowledge management.	Limited technical skills, internet access and costs.

Interpersonal oral communication with fellow farmers

The study found that farmers use personal experiences and obtain agricultural knowledge from fellow farmers who either planted similar crops or had experience with those crops. These types of sources were regarded as familiar, free, and readily available, making information access easy. Study participants also obtained indigenous agricultural information, such as seed selection, storage and consumption, and disease and pest management, from elderly experienced farmers.

> *If a farmer has produced good quality, we visit their farms; we visit one another and share information.*
>
> *I used to plant maize and beans, but they were not doing well, so I went to a fellow farmer who I asked why hers were doing well but mine had limited production; she told me how to plant beans and maize together.*
>
> *We look at our neighbour, whose crops usually do well. When he begins to prepare his land, I also start preparing my land.*

The study participants observed that though information from fellow farmers is readily available, its application is challenging due to generalization, a lack of expertise, and insincerity among some farmers. Sometimes farmers generalize the shared techniques, ignoring differences in soil types, which may lead to poor harvests and losses.

> *Due to differences in soil type, one practice may not apply to all other farms; one may therefore try some farming practices and fail.*
>
> *Some farmers are not sincere, and out of jealousy, they may mislead their fellow farmers. This can lead to losses.*

The data show that some knowledge is accessible to smallholder farmers; however, farmer-to-farmer knowledge transfer lacks rigour in verification and may compromise scalability. The findings confirm the challenge of scalability of knowledge from informal systems as espoused by knowledge management theory (Tumwebaze et al., 2025). Some smallholder farmers may assume differences in their soil types and apply unverified knowledge, exposing them to further risks.

Oral communication in farmer groups

The study found that farmer groups consisting of farmers in the same neighbourhood growing similar crops such as vegetables, maize, millet and bananas acted as information hubs. The farmer groups hold regular meetings where both young and older farmers discuss their experiences and support each other with general farming practices, new knowledge, markets, and finances. Farmers with indigenous knowledge share information on practices such as using ash and cow dung for pest and disease management, seed selection, drying and storage, planting time, and post-harvesting techniques such as smoke drying. Other studies show similar findings on reliance on indigenous agricultural knowledge (Berkes, 2017; Kebenei et al., 2023; Melash et al., 2023; Musyoka & Omosa, 2024).

The farmer groups also serve as entry points for Non-governmental Organizations (NGOs) that provide agricultural information, farm inputs, and field demonstrations.

> *The NGOs mobilize farmers through farmer groups, after which farmers become key agents. They help in recruiting other farmers who come to successive meetings.*
>
> *Agricultural tours by IFAD- we were trained on grafting and keeping goats. From there, I learnt how to improve farming.*

Oral communication by the local provincial administration

This study found that local government leaders share agricultural information from the government, such as access to subsidized fertilizers, new seed varieties, new farming techniques, disease outbreaks, and government policies, in chiefs' barazas, churches, and funerals. Fish farmers from *Oywa Ngori* farmer group in Nyatike sub-county, near

Lake Victoria, obtain government directives regulating fishing in Lake Victoria from the area chiefs and clan elders. Communication in the gatherings was predominantly for awareness. The study found that most farmers, especially women and the youth, do not attend the chief's baraza. This finding is similar to other studies that showed poor attendance of chiefs' barazas among women and youth in Migori County (Atieno, 2021). Moreover, provincial administration shared general agricultural information, unable to address specific farmer needs.

Oral communication with Agribusiness Personnel

Smallholder farmers obtain information about seed selection and planting techniques, poultry management and disease control, and livestock farming from agribusiness personnel operating agrovets in the locality. These were advisory information on planting, controlling diseases and using pesticides and other farm chemicals; they sell to the local smallholder farmers.

> *There is an Agrovet in Sori town. When I see some symptoms in my chicken, I go there and ask what disease my chicken has. He gives me drugs and explains to me what I can do to prevent the disease in my poultry from spreading. They also explain how to use fertilizers and other chemicals on animals. But Sori is far, and sometimes I cannot get there in time.*

The study participants observed that agrovet personnel are driven by business and may not provide sufficient information to farmers. Some poultry farmers reported losing their flocks due to inadequate guidance on how to contain poultry diseases.

> *My neighbour's chicken started to have diarrhoea, then the disease got to mine. I tried using a kienyeji (indigenous herb) mixture of Aloe vera and pepper to contain the disease. But some died.*

Agricultural extension officers

Most smallholder farmers in Nyatike and Suna East Sub-counties do not access information from agricultural extension officers; the majority state they do not know any extension officers. While some farmers said that extension service officers exist, they hardly visit farms or engage farmers unless they have critical information or when government officers plan to visit the area. Farmers from *Nyanam Ratek Tich* and *Aminyasa* groups stated that extension officers come to the field at the request of specific farmers. Similar studies show that extension service agents deliberately position themselves further from poorer households and are ineffective (Apantaku et al., 2016; Muhanguzi & Ngubiri, n.d.).

However, contradictory findings in Bumula sub-county in Kenya showed that extension services were the most dominant communication pathway for technically complex agricultural practices such as agroforestry, crop rotation, and drainage (Saenyi et al., 2025). Other sources were farmers' friends and mass media. Although participants in this study lack access to extension officers, they observed that extension service officers are more reliable and their expertise can be applied in different contexts.

Use of Radio

This study found that farmers obtained agricultural information from radios, especially vernacular radio stations which air agricultural programs in the local language. Radio Ramogi, Onagi and Milambo hold discussions on food production, markets and food consumption in their programs. The radio stations host farmers and agricultural experts- though rarely- in their talk shows, during which farmers call in and contribute to the topics of discussion, making the learning participatory.

I listen to information on farming on the radio. Particularly in vegetable farming. Radio Ramogi, a program called Farming Entrepreneurship. This led to an improvement in my farm produce. However, I just bumped into the program. I'm not sure when the program will be aired.

Radio announces new technologies such as the use of herbicides in weeding, new seeds with high yields and suitable seeds.

While the radio is a useful communication technology for obtaining agricultural information, study participants cited a lack of practical field demonstrations as a weakness of the radio, and the possibility of missing some segments of the program due to personal commitments, which could affect their ability to understand and apply the agricultural knowledge acquired from the radio.

Several farmers were discussing farming with pesticides, farming of vegetables, and the pesticides to be used.

Radio gives suitable information; however, if you forget one step while trying to apply the knowledge, you can get lost.

Due to power outages or a lack of battery cells, one might miss the program

Women, for example, observed that house chores and domestic duties may prevent them from fully listening to the radio. Poor mastery by farmers, especially the elderly and semi-literate farmers, was also cited as a challenge to the replicability of the knowledge obtained by listening to the radio.

Sometimes I am cooking, and the program is on; I may not listen to the radio program and miss the teaching.

Radio does not repeat; a practical field demonstration involving experts presents better opportunities for participatory learning.

Another challenge of relying on radio to get agricultural information is when the batteries go off, or there is a power outage, and that is the day you were waiting for to listen to the program. That day will go just like that without you listening to the radio.

These findings mirror findings of Mwaniki et al. (2017), who observed that program timing may impede obtaining agricultural information from the radio. Smallholder farmers observed that radio broadcasts of agricultural information lack practical demonstration. While Ngulube (2025) argues that community radio and mobile phones are significant channels of agricultural communication in rural Africa, their effectiveness remains a challenge. Radio presents itself as a suitable source of information for smallholder farmers, but program timing and the reliance on personal recollection pose challenges to memorability since information is absorbed through listening (Mwaniki et al., 2017). According to Haruna (2024), Farmers' level of comprehension may hamper the effective use of technology. Rural farmers who are semi-literate may lack the capability to master and apply radio content without practical demonstrations. In this study, participants cited an inability to master and apply information sought through listening, and a lack of access to electricity to power the radio.

Field demonstrations by agricultural organizations

This study found that NGOs such as One Acre Fund and IFAD provided live farm demonstrations, enabling practical information sharing on farming practices such as early land preparation, spacing and fertiliser application. The NGOs collaborate with farmer groups to mobilize farmers to attend field demonstrations. Members of the farmer groups become key agents and recruit other farmers to attend successive training. The study found that field demonstrations are not all-inclusive because NGOs focus on specific crops of interest such as maize and beans, thus may exclude other farmers. This finding is similar to others showing that private extension services focus on specific crops (Swinnen & Barrett, 2025). Information sharing by NGOs was very rare; however, smallholder farmers prefer NGOs due to their practical demonstrations.

One acre fund….. one year ago. They demonstrated how to space maize and how to apply fertilisers at different stages of plant growth.

Agricultural tours by IFAD- we were trained on grafting and keeping goats. From there, I learnt how to improve farming.

Comparing Radio and One Acre Fund, I prefer One Acre Fund because radio will not demonstrate to you which seed you should plant, but One Acre Fund will come and demonstrate for you and tell you which soil to use on what kind of soil.

Digital communication technologies

This study found that few smallholder farmers in Nyatike and Suna East sub-counties used their mobile phones to obtain information from the internet. The information includes farming practices, symptoms of disease and control, crop varieties, and fertilizer application. Some farmers accessed videos on sustainable farming from YouTube and showed them to other farmers during farmer group meetings.

I use my phone. I follow experts on the internet and get information on how to produce my own fertilizer. I learn about new farm machinery.

Using a smartphone, I type any keyword in agriculture then pop-ups will appear. I choose what I want, where I watch videos and follow. I stopped farming, but since I started following the internet, I'm back to farming. This is the second season where I now use technology in maize farming. It was good, and now I expect it to be better.

My son planted tomatoes and, using the internet, he prepared fertilizer and used it on his farm. It is very good (an elderly farmer).

These findings show limited adoption of digital technologies for agricultural information sharing. In this study, participants who obtained information from the internet were younger farmers. The study found that age, a lack of digital phones, limited technical skills, and costs were impediments to the use of digital tools by smallholders. These findings are similar to other studies, which showed limited use of digital technologies among smallholder farmers due to levels of education, costs, and technical skills (Lubell & McRoberts, 2018; Muhanguzi & Ngubiri, n.d.). Poor rural roads and low connectivity have also been cited as impediments to technology access and, by extension, limiting access to agricultural information (Anya et al., 2026). Nyatike sub-county is characterised by poor rural roads and connectivity that may hamper digital adoption.

This study found a multiplex information-sharing ecosystem. The study established that most of the farmers did not have smartphones and had not accessed agricultural information using digital technologies. However, they were eager to obtain information using digital smartphones and expressed the desire to know how to access digital agricultural information. One farmer said;

These days, we obtain information about everything on our phones. Everything is in our phones, including KCPE results. The majority of us use WhatsApp and Facebook, so if we are shown how to get that knowledge, we will benefit a lot.

This finding showed that despite limited access to technology, smallholder farmers in the study area believe that digital technologies are significant in improving agricultural production. Previous studies have shown that membership of farmer groups influences the use of mobile services (Krell et al., 2021), and farmers' beliefs and the significance of digital technologies impact adoption (Haruna, 2024). Moreover, recent studies show that rural farmers with low digital literacy can use digital technologies through short messaging and WhatsApp using native vernacular (Godwin & Johnson, 2025). The positive attitude towards the use of digital technology among the study

participants indicates that, if supported, smallholder farmers in Nyatike and Suna East may use the digital tools accessible to them to access information on sustainable agriculture and food security.

5.1.2. Farmers' perceptions on the effectiveness of communication technologies for sustainable agriculture and food security

This study found a multiplex communication ecosystem for sustainable agriculture and food security. Oral communication among farmers, agribusiness personnel, and in farmer groups was predominant. Some farmers obtained information from the radio, while digital technologies were minimally used. Despite the existence of multiple communication techniques, the study found that smallholder farmers in Suna East and Nyatike lack adequate information on sustainable agriculture and food security. The study sought their perspectives on the effectiveness of the communication technologies. The study sought smallholder farmers' perceptions of communication technologies used for sustainable agriculture and food security.

Perceived efficacy

Smallholder farmers felt that oral communication with fellow farmers was accessible, but had limited perceived efficacy. They acknowledged that overreliance on fellow farmers with limited expertise may perpetuate limited knowledge on sustainable agriculture and contribute to losses and cyclic food poverty. Due to differences in soil types, the knowledge shared by fellow farmers may not be replicated in other farms. These findings are comparable to arguments by Tumwebaze et al. (2025), who opine that though knowledge shared through peer learning is easily accessible, they lack rigorous validation and scalability.

Lack of perceived efficacy was also attributed to limited field demonstrations by the radio. Smallholder farmers preferred practical demonstrations as opposed to a radio broadcast. They felt that communication for sustainable farming and food security should be accompanied by practical demonstrations, making information easier to interpret and replicate.

> *Radio gives suitable information; however, if you forget one step while trying to apply the knowledge, you can get lost. Radio lacks demonstrations; Agrovet do not come to the field. We need something that you can see and understand how it works. If I see a video, I can try following it. Similarly, if an older farmer demonstrates how they prevent diseases, I can learn from that and try it at home.*
>
> *Comparing Radio and One Acre Fund, I prefer One Acre Fund because radio will not demonstrate to you which seed you should plant, but One Acre Fund will come and demonstrate for you and tell you which soil to use on what kind of soil.*

Farmers felt that digital technologies can promote information transfer by recording practical demonstrations on the farm, which can be stored and shared with many people at any time. Nonetheless, study participants felt that since technology is transforming all aspects of life, they were determined to change as well. In one of the FGDs, a farmer observed as follows;

> *majority of us use WhatsApp and Facebook, so if we are shown how to get that knowledge, we will benefit a lot.*

IoT-based technology systems enable farmers to use short messaging and WhatsApp using native vernacular (Godwin & Johnson, 2025). Farmers in this study use WhatsApp. They can therefore share video content from YouTube on WhatsApp, thereby improving information sharing. Study participants observed that rural farmers must embrace new technologies to cope with the changing world. These findings agree with propositions of

knowledge management theory that efficient agricultural knowledge acquisition encompasses both global advancements and localized realities (Tumwebaze et al., 2025).

We must also change the way the world changes; we can no longer use older methods used in the olden days.

Compatibility

This study found compatibility between indigenous knowledge and traditional value systems of smallholder farmers. Smallholder farmers in Nyatike believe that some indigenous agricultural practices, such as intercropping, fallow farming, indigenous seed sharing, seed smoking, use of farmyard manure, and indigenous seeds, contribute to good health, cultural and environmental preservation, and are better than new techniques. They therefore practice them more often. These findings are supported by the DOI theory, which posits that individuals are likely to adopt innovations compatible with their value systems (Rogers et al., 2019). Several farmers in Nyatike sub-county believe that the land is still fertile and they do not use agrochemicals such as commercial fertilisers and herbicides. However, study respondents felt that few community members have knowledge of these indigenous practices and the information is not adequately communicated to the next generation.

Our land is very rich. We should be able to produce more food than we currently do. Fertilisers from the shop will kill the fertility, and we shall suffer like some other parts of this country. What we need is continuous education on how to maintain this natural fertility. The old men and women with knowledge on timing for planting and food preparation, like smoking, should share it with us. We need to preserve it.

The study found inconsistencies in farmers' beliefs in farming technology. While some farmers detest the use of agrochemicals and promote indigenous techniques, some smallholder farmers also observed that some farming techniques are no longer sustainable and that they should embrace new technologies. These inconsistencies may impact knowledge transfer.

Some of the old farming techniques, like broadcasting, are not very productive. Though this is also good. We rely on what we already know. It is not enough. (FGD, Nyatike).

Our land has lost its fertility, and the weather keeps changing, so we must grow crops that will eradicate hunger. But our people fail to get good yields because we lack information on which crops to plant, seed variety, timing for planting and how to control pests. (Farmer from Suna East).

This finding reflects the multiplicity of the smallholder farmers' ecosystem and shows that a multiple approach to information sharing and technology adoption is more suitable. This finding aligns with knowledge management theory, which calls for a pragmatic approach to the use of knowledge encompassing both global and local realities (Tumwebaze et al., 2025). It is also supported by views of Saenyi et al. (2025), who concluded that adoption of smart climate agriculture does not require a one-size-fits-all approach.

Inadequate information

Farmers also felt that inadequate agricultural information contributes to losses from pests and diseases, poor crop yields, and food insecurity.

We incur a lot of losses because we do not know where to sell the produce. Most of us rely on schools around where we take our maize, but they don't pay. Sometimes we sell the produce at a throwaway price.

Vegetables and tomatoes are very perishable; without enough information on where I can sell them, they just rot at home because we cannot eat all of them.

We do not have adequate information on some of the new farming practices and the market for our crops. The extension officers do not reach us, and the radio talks about these things once in a while. It affects our food production, and the little we produce gets wasted again.

5.2. Discussions

This study found that smallholder farmers in Nyatike and Suna East sub-counties predominantly obtain agricultural information from oral communication with fellow farmers in their social circles and farmer groups. This finding reflects the argument of DOI theory that face-to-face communication is more suitable than mass media in the diffusion of innovation (Rogers et al., 2019). However, since most farmers lack expertise, this study argues that overreliance on oral communication with non-experts limits farmers' access to adequate and useful information on sustainable agriculture and food security.

Oral communication provides easy access to and sharing of agricultural information and Indigenous Agricultural Knowledge (IAK)among farmers. This finding adds impetus to a court ruling by the High Court of Kenya that declared seed sharing as a fundamental element of peasants' identity and contribution to the food systems (Samuel Wathome & 14 others v. Kenya Plant Health Inspectorate Service & another, 2025). However, due to a lack of documentation, IAK risks extinction. The study also found that inadequate access to expert information on production, suitable markets, and prices contributes to production losses, food wastage and may exacerbate food insecurity. Some farmers sell maize they produce immediately after harvesting at throwaway prices, then later face hunger. This results from poor physical infrastructure that limits market access, a lack of information and expert advice on storage, markets and food prices. This finding confirms observations by the National Food and Security Policy, which notes that a significant proportion of food produced is lost due to post-harvest spoilage or waste. Against this backdrop, the National Cereals Board's grain storage capacity of 28million bags of maize remains largely underutilised (Republic of Kenya, 2011). To mitigate this challenge and ensure food security, this study echoes FAO (2020), which proposes providing smallholder farmers with adequate information.

Findings in this study are similar to previous studies, which show that extension services strategically position themselves to serve economically well-off households, leaving smallholder farmers unattended (Damonte et al., 2019). A poultry farmer in this study lost her chicken due to inadequate knowledge of disease control and management. The lack of interaction between farmers and extension officers hampers effective knowledge management, especially on complex agricultural practices, thereby exposing smallholder farmers to losses and exacerbating food insecurity. Although smallholder farmers in this study do not have access to extension services, they believe information from extension services is more reliable compared to information from local farmers. This view reflects findings from a recent study in Kenya showing that farmers relied predominantly on extension services for complex information and agricultural knowledge such as agroforestry, use of inorganic fertilisers, and crop rotation, and on friends and neighbours for practices such as intercropping and irrigation (Wekesa et al.,2025). Nyatike sub-county is a vast area characterised by poor road networks and harsh climatic conditions, which pose transport and communication challenges and may hamper adequate provision of extension services. Smallholder farmers rely more on fellow farmers and agribusiness personnel to obtain information.

Smallholder farmers in Nyatike and Suna East sub-counties are heterogeneous, comprising youth, middle-aged individuals, the older generation, educated, literate and semi-literate individuals with relatively low socio-economic income. Whereas recent studies opine that improved digital technologies enable farmers to access information easily in their native language (Godwin & Johnson, 2025), this has yet to trickle down to smallholder farmers in rural areas. This study found limited technology adoption among smallholder farmers. Few younger farmers access agricultural information on YouTube. The study, however, noted that those few farmers share digital information with fellow

farmers in farmer groups. While in the UK, technology adoption is supported by extension services and institutional policies (Anya et al., 2026), this study found limited support for digital adoption among smallholder farmers in Nyatike and Suna East. A study in Australia found that extension service personnel lag behind their customers in adopting technology due to a lack of professional and institutional support and technical complexity (Lubell & McRoberts, 2018). Similar studies show that extension services do not guarantee technology adoption due to the farmer-to-agent ratio and logistical challenges (Apantaku et al., 2016; Morrison et al., 2025).

National Agroecology Policy of Kenya (2024-2023) encourages cooperation among knowledge-generating institutions and agencies (Ministry of Agriculture and Livestock Development, 2024). This study argues that though extension services do not guarantee digital adoption, as shown in previous studies, policy support can promote collaboration between extension officers in Nyatike and younger farmers and leverage current limited technology adoption to improve farmers' access to accurate agricultural information. This argument is supported by the knowledge management framework, which posits that information sharing must take cognisance of local realities and challenges and promote networks and collaboration.

This study found that smallholders prefer practical knowledge sharing through farm demonstrations. However, field NGOs rarely conducted demonstrations, and radio broadcasts lack practical demonstrations. These limit practical application by smallholder farmers. Further, digital communication applications like YouTube, TikTok and WhatsApp, which have humanised communication, can be incorporated into oral communication and enhance information sharing. Integrating digital technology and oral communication can bridge the digital divide and promote practical demonstrations, documentation, and knowledge sharing among farmers with diverse needs. It can also promote intergenerational transfer of indigenous knowledge from older to the younger generation and enhance sustainable agriculture and food security.

According to Diffusion of Innovation theory, adopters of innovation are categorised as early adopters and laggards. This study, however, deconstructs this binary categorisation by presenting a fusion of both early adopters and laggards. The early adopters of digital innovation- the younger generation- used digital technology to access and use agricultural information; however, they were considered laggards in the adoption of indigenous agricultural innovation (IAK). Some late adopters of digital technology, constrained by limited digital access, however, have indigenous innovation. These findings show that in an ecosystem with diverse innovations, adoption of both indigenous and digital technologies occurs concurrently, blurring the binary categorisation of levels and stages of innovation adoption. Therefore, both innovations can be effectively utilized to support each other.

Similarly, Knowledge Management (KM) theory argues that information sharing must consider stakeholder heterogeneity. Therefore, KM strategies should consider the informational requirements of marginalized demographics, especially smallholder farmers (Tumwebaze et al., 2025). Further, FAO et al. (2023) observe that a number of technological innovations exist, but no single bullet technology or innovation will meet all needs in all contexts across the rural-urban continuum. By integrating digital technology into their oral communication system, the smallholder farmers in Suna East and Nyatike can use their phones to record and share both indigenous knowledge and new farming techniques, thereby enhancing knowledge on sustainable agriculture and food security.

6. RESEARCH IMPLICATIONS

This study contributes to scholarly debate and the practice of agricultural communication, particularly among rural smallholder farmers. The study area faces economic and climatic variability; thus, farmers require timely and sufficient information to adopt their farming techniques. Previous studies emphasised the adoption of technology in agriculture to promote food production with a focus on the digital divide. This study found that smallholder farmers are diverse groups with different agricultural needs; they have limited access to resources and information, and are

also technologically deprived. This requires a multiplex approach to agricultural communication, where farmers and other stakeholders use both traditional and new technologies to collaboratively generate and share information.

The study findings show that extension officers do not reach most rural smallholders to provide the much-needed information and support. To close this information gap, digital technology can be integrated with oral communication. The few digital devices available can record indigenous knowledge, new farming techniques, and farmers' experiences to improve knowledge sharing. According to Knowledge Management Theory, agricultural knowledge acquisition should encompass both global advancements and localized realities (Tumwebaze et al., 2025). While digital technologies promote new farming technologies across global platforms, oral communication of indigenous knowledge addresses local needs. The farmers say it is easy to access fellow farmers who are also familiar. Communication for sustainable agriculture should thus be contextualized to local needs.

The study shows that Knowledge management among smallholder farmers is intricately intertwined with indigenous knowledge, oral and digital communication technologies and farmer characteristics such as age, education, and skills. The findings align with Knowledge Management theory, which holds that the agricultural knowledge ecosystem comprises participants with varied levels of expertise and access to information (Tumwebaze et al., 2025). Communication and knowledge management for smallholder farmers should accommodate both the informality and the technological and indigenous systems.

The study also contributes to understanding innovation adoption in a heterogeneous ecosystem. Whereas DoI categorises innovation adopters as early adopters and laggards, this study shows that technology adoption in agriculture is non-linear and multiplex; the older generation with indigenous knowledge are early adopters of IAK but have limited digital knowledge and thus are late adopters of digital knowledge. On the other hand, the younger generation are later adopters of IAK but early adopters of digital technology. This intricacy requires a multiplex approach whereby farmers can harmoniously and concurrently apply both innovations- indigenous and digital- to enhance production and improve food security.

7. CONTRIBUTIONS TO SCIENTIFIC COMMUNITY AND FUTURE RESEARCH

This study adds knowledge to agricultural information sharing among rural smallholder farmers in technologically deprived regions. Previous studies on the use of ICT for agricultural communication depict optimism amidst a wide socio-economic and digital divide. Consequently, smallholder farmers are left without a clear solution, thereby hindering the attainment of food security and the achievement of SDG2. Similarly, previous studies on indigenous agricultural knowledge show that valuable information resides with the elderly but is threatened by a lack of documentation. This study fills the communication gap by showing that, with limited digital access, young smallholder farmers with access to indigenous knowledge can use digital technology to document indigenous knowledge on sustainable farming and food security and share it during meetings in farmers' groups. This can promote documentation of endangered indigenous agricultural knowledge (IAK), improve farming practices, and enhance food security.

This study also shows that Knowledge management among smallholders is intricately intertwined with indigenous knowledge, oral communication, and farmer characteristics such as age, education, and skills. While smallholder farmers predominantly share information using interpersonal oral communication, overreliance on a monolithic communication approach may perpetuate limited access to useful agricultural information. The study findings, however, show that digital oratory tools like WhatsApp and YouTube can support communication among smallholder farmers.

This study adds insight to criticisms of Diffusion of Innovation theory by showing that in a multiplex ecosystem with diverse innovations, adoption of innovation can occur concurrently, blurring the binary categorisation of

adopters. In this study, the older generation are early adopters of indigenous innovation but appear as laggards in digital adoption. The younger generation are early adopters of digital technology; they appear as laggards in adopting indigenous innovation. This study confirms that adoption patterns vary and that anyone can be an innovator.

The study also contributes to communities of practice by focusing on building the digital capacities of smallholder farmers in digitally deprived areas, enabling them to integrate indigenous agricultural knowledge and digital communication technologies for sharing information on sustainable agriculture and food security. This study was purely qualitative, focusing on the communication technologies smallholder farmers use in obtaining agricultural information. It was limited to selected rural areas of Kenya with unique characteristics. The study recommends further research on technology adoption among extension service personnel in Kenya and the integration of both indigenous and digital technologies for sharing agricultural information.

8. CONCLUSION

The study found that smallholder farmers in rural communities are deeply culturally and orally oriented, predominantly using oral and face-to-face communication of indigenous knowledge, but are pragmatic and open to using new technologies. However, few elderly people possess IAK, posing a threat to IAK. Similarly, limited access to extension services and digital technologies hampers access to adequate and expert information on sustainable agriculture among smallholder farmers, leading to losses and food insecurity. The study concludes that both indigenous knowledge and digital farming techniques should co-exist to ameliorate the challenges experienced by smallholder farmers.

This study recommends building the digital capacities of smallholder farmers by integrating indigenous peoples' knowledge, agricultural experts, and oral and digital communication technologies in sharing information on sustainable agriculture and food security. The county governments should build the capacities of extension service personnel and empower them to provide services to smallholder farmers. The Department of Agriculture should collaborate with extension officers and farmers' groups to leverage technology and enhance agricultural communication. They can use farmer groups as communication hubs for creating and sharing both digital and traditional agricultural information.

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Declaration of Generative AI and AI-Assisted technologies in the writing process

While preparing this work, the author utilised Grammarly for grammar refinement, language enhancement, formatting support, and structural organization of the manuscript. After using this AI tool, the authors carefully reviewed and edited the content as necessary and assume full responsibility for the publication's content.

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