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RESEARCH ARTICLE

CHALLENGES AND CAPACITY GAPS IN SMALLHOLDER ACCESS TO DIGITAL EXTENSION AND ADVISORY SERVICES IN KENYA AND UGANDA

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KEYWORDS

advisory service, agricultural extension, digital extension, digital literacy

HIGHLIGHTS

- Seventy-eight percent of farmers accessed extension and advisory services from electronic sources dominated by radio.
- Low digital literacy and high cost of internet and digital devices were key barriers to digital extension and advisory services use.
- Farmers need information to make decisions, e.g., fertilizers, seeds or pesticides to use.
- Integrating digital and face-to-face methods can enhance inclusive scaling of extension activities.

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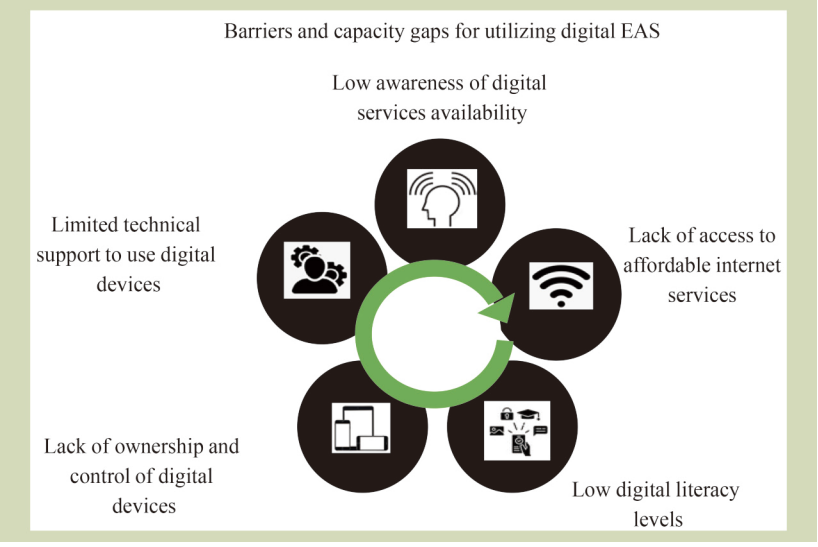
GRAPHICAL ABSTRACT



ABSTRACT

An assessment of the challenges and capacity gaps in smallholder access to digital extension and advisory services (EAS) was made by surveying 197 female and 239 male farmers in Kenya and Uganda. Non-digital extension approaches remain dominant but at least 78% of farmers accessed EAS from electronic sources dominated by radio. This is attributed to the fact that ownership of radios was more widespread than of other digital devices. Challenges that particularly limit the use of digital services included low digital literacy and prohibitive cost of internet and mobile devices. Female and elderly farmers were more likely to report these challenges than their counterparts. Logistic regression model results show that ownership of digital devices, participation in post-production activities, and access to extension were

enablers of digital EAS use. Farmers mentioned gaps in obtaining information on crop pest/disease diagnosis and management, fertilizer application, pesticide safety and quality seed. Given the diversity in smallholder technological capabilities and information needs, the recommendations made include integration of digital communication within multimode advisory services that use different but linked communication channels, continued farmer digital innovation capacity enhancement, and participatory design approaches that deliver relevant and actionable information for inclusive scaling of extension activities.

1 INTRODUCTION

Agricultural extension and advisory services (EAS) facilitate the access of farmers to knowledge, information, financial services and technologies necessary for improving farm performance[1]. However, access to EAS remains a critical issue in many rural settings[2]. This is in part due to insufficient funds for supporting public extension, lack of appropriate strategies for effective research, and limited coverage of extension services[3]. Public advisory services in particular have been criticized for their inability to provide satisfactory services to farmers due to the fact that they are generally supply-driven and do not consider the actual farmer needs[4]. On the demand size, small land holdings, lack of education and low incomes are some of the key barriers that restrict farmer access to EAS[5–7]. Also, empirical studies have shown that extension services have not equally benefited female and male farmers due to differentials in access to and control of production resources and participation in training programs and decision making[8]. Farmers are experiencing new and emerging farming challenges such as climate change and related extreme events and transboundary invasive insect pests and diseases. Many argue that agricultural extension services need transformation through tested and proven decision-support devices and digital revolution to improve production, reduce crop losses and increase productivity.

Digitally-enabled EAS using single or a combination of devices can potentially ameliorate the inadequate technical assistance to farmers occasioned by a lean extension staff and provide information to marginalized and hard-to-reach areas[9,10]. Digital options include radio programs using add-on features, television shows, videos shared online, mobile mediated value-added services or agricultural value-added services, digital decision-support devices, digital learning devices and the internet. Evaluation studies have shown considerable cost-effectiveness of digital EAS in the long run and the potential to deliver timely, relevant and actionable information to farmers even in remote locations, increasing the adoption of technology. Tambo et al.[11] showed that participation in the information and communication technology (ICT)-based extension campaigns significantly increased farmer knowledge about fall armyworm and stimulated the adoption of agricultural technologies and practices for the management of the pest. Silvestri et al.[12] and Hudson et al.[13] showed significant positive effects on knowledge scores and agricultural technology adoption by farmers who listened to promotional radio programs compared to those who did not. The information provided via digital platforms is also becoming diverse, ranging from specific technologies, market access, price information, weather information, application of inputs and early warning of drought, floods, and pests/diseases, allowing farmers to make more informed decisions on how to improve their agricultural practices. Other changes facilitating increased use of digital devices include the growth of mobile phone ownership among the rural population in some developing countries[14]. Increased radio coverage presents further opportunities to deliver much-needed agricultural services to smallholders using digital technology[15].

The call for effective use of digital solutions became even more pronounced during the 2020 global economic shutdown as a result of the COVID-19 pandemic[16,17]. The lockdowns across countries entailed a rise in the use of information systems and networks, with massive changes in usage patterns and behavior[16]. In a study of ICT for improving the investment readiness of small and medium agribusinesses, Valverde[18] reports that 58% of agricultural value-added service providers interviewed reported an increase in demand for their services since the beginning of the COVID-19 crisis, in particular, for their roles in facilitating cash flows and access to credit. Recently, various studies have focused on understanding farmer socio-psychological behavior and institutional services that support access to knowledge and use of improved agricultural technologies in different parts of the world[19–22]. However, challenges and capacity gaps in smallholder access and utilization of digital EAS as well as the success of digital EAS in promoting behavioral change among farmers in Kenya

and Uganda has yet to be explored. There are also concerns that infrastructure weaknesses (particularly in remote areas), costs of accessing digital services and digital illiteracy of already marginalized groups can exacerbate inequities.

This study aimed to assess challenges and capacity gaps in smallholder access to digital extension and advisory services. Specifically, the objectives were to (1) assess farmer access to extension and advisory services and factors affecting the likelihood of adoption of digital EAS; (2) assess farmer information and advisory services needs that could be met by digital technology; (3) assess barriers and required skills and knowledge for farmers to use digital EAS effectively; and (4) make recommendations on appropriate use of digital EAS by smallholders in Africa. The study is based on primary data gathered through household interviews in Uganda and Kenya.

The results show that over 88% of farmers (96% in Kenya and 79% in Uganda) received extension advice from any source in the previous year mainly from family and friends, the local community, and extension workers. Significantly more households in Kenya (92%) than in Uganda (63%) reported that they received agricultural advice through digital devices dominated by radio. Lack of access to affordable internet services, low digital literacy levels, lack of ownership and control of devices, limited technical support to use digital devices, and low awareness of digital services availability were among the key factors limiting the use of digital EAS.

2 MATERIALS AND METHODS

2.1 Study areas, populations and samples

The study was conducted in Uganda and Kenya. Four local government areas were selected in each country that represent diversity in biophysical characteristics and production activities which may influence farmer agricultural knowledge seeking behaviors (Table 1). In each area the local administration helped to select at least two sub-counties that were considered to have contrasts in terms of ICT

Table 1 Main biophysical characteristics and production activities of study locations and sample sizes

Local government area and enumeration sub-counties	Biophysical characteristics	Production activities	Sampled households
Kenya			
Baringo County - Eldama Ravin (rural) - Koibatek (peri-urban)	Semiarid, receiving an average of 745 mm of rainfall per year	Livestock farming is dominant and crop farming under irrigation schemes	56
Kirinyaga county - Kirinyaga East, West (rural) - Mwea (peri-urban)	The annual rainfall is 996 mm	Rice production at Mwea irrigation scheme. Coffee and tea grown in the cooler areas	55
Nakuru county - Mangu (rural) - Rongai (peri-urban)	The rainfall is around 762 mm per year	Main crops include: maize, beans, potato and wheat. Horticultural crops are fruits, vegetables and flowers	64
Tharaka Nithi county - Igamba ngombe (rural) - Tharaka (peri-urban)	Rainfall is around 853 mm per year, and poorly distributed on lower areas	Cultivation of tea, coffee, maize, cowpeas, pigeon peas, tobacco and other food crops	53
Uganda			
Kiryandongo district - Kigumba (rural) - Kiryandongo town council (peri-urban)	Average rainfall of 1259 mm with high variability	Smallholder agriculture mainly cereal crops and sunflower. About 6.2% of the total farmland is under large scale commercial farming	53
Luwero district - Butuntumula (rural) - Luwero (peri-urban)	Average rainfall of 1,270 mm	Small to large scale farming but majority are smallholders. Banana-coffee farming system	49
Lyantonde district - Mpumude (rural) - Lyantonde town council (peri-urban)	Average rainfall range of 915 mm	Mainly smallholders with agro-pastoral practices	54
Tororo district - Merikit (rural), - Tororo Municipality (peri-urban)	Average rainfall range of 1215–1328 mm	Small-scale subsistence mainly annual crops	52
Total			436

infrastructure, signal strength and accessibility (e.g., rural/remote or peri-urban/urban areas). Rural/remote locations were those more than 30 km from the main district/county town and lacking an all-weather road, or as defined by the local administration based on their accessibility indicators. From each of the selected sub-counties at least two villages were selected from where the respondents were drawn. The study population comprised all the farm households in the enumeration area, though particular attention was placed on segmenting responses from contrasting categories of farmers including those known to be already excluded such as female, older and subsistence (as opposed to commercially oriented) farmers. At the end of the exercise a total of 436 households, 228 in Kenya and 208 in Uganda, were interviewed. Table 1 shows the main biophysical characteristics and production activities of the study locations and sample sizes.

2.2 Data collection

Data collection was done by structured questionnaire. The questionnaire was coded in Open Data Kit (ODK collect), an open-source Android application, and data collected using tablet computers by trained enumerators. Farmer interviews sought information on the extent of utilization of digital EAS; ownership of digital devices (radio, TV, mobile phone or computer); awareness and access to digital EAS; unmet needs for information, advice and decision support that could be met by digital devices; and barriers to accessing digital EAS.

2.3 Empirical model

Logistic regression analysis was done to identify drivers of digital EAS access. The dependent variable was designated as access to digital EAS, having a value of zero if a farmer did not receive any agricultural advice via digital devices (e.g., radio, SMS, TV and video), and one if a farmer received agricultural advice through any of the devices. However, this did not consider the frequency of receipt of information or whether the messages led to adoption of practices. The following explanatory variables were included in the model taken from the household survey: (1) ownership of digital devices (radio, TV or mobile phone); (2) farm size, viz., areas of land under production and fallow, in hectares, during the October–December 2020 growing season; (3) livestock assets, viz., the count of the number of livestock owned by the household from a list of common animals including cattle, goats and sheep, converted to tropical livestock units[23]; (4) education, viz., highest level of education completed by the respondent with the following categories, none (reference), primary, secondary and tertiary level; (5) location which was coded as zero for rural/remote areas and one for those in peri-urban areas or near townships (as defined in the methodology section); (6) gender, viz., women were the reference category (coded as 0); (7) farm orientation, viz., farmers who sold more than 60% of their farm produce were categorized as commercial and those with lower produce sale as subsistence (coded as 0); (8) age- chronological age of respondent in years; and (9) other household socioeconomic characteristics - age of respondent in years, household size, access to extension services and farmer engages in non-farm production activities. These variables are hypothesized to affect the dependent variable based on empirical evidence from other studies[24–26].

2.4 Data analysis

The final data sets from the household survey were downloaded from the Open Data Kit aggregate server as CSV files and exported to STATA 16 software for analysis. Descriptive analysis was done by calculating frequencies, means and percentages to understand farmer awareness and access to digital extension services, information and knowledge gaps, and barriers to utilization of digital EAS by farmers.

3 RESULTS

3.1 Respondent household characteristics

The majority of respondents were male with an average age of 45 years and an average household size of six people (Table 2). At least 55% of the respondents had secondary and tertiary level education. About 4% indicated that they had not received any formal education. At least 77% of the respondents owned a radio (92% in Kenya and 62% in Uganda), 77% owned a feature phone (69% in Kenya and 86% in Uganda), while TV and smartphone ownership was mentioned by 51% and 43%, respectively. Significantly more households in Kenya owned digital devices (radio, TV and smartphone) than in Uganda. In particular, ownership of TVs and smartphones in Uganda was limited at 30% and 19%, respectively.

The majority of farmers (90%) engaged in farm production and were categorized as subsistence (> 60% of food grown for home consumption). Significantly more farmers in Kenya than Uganda were categorized as commercial despite the fact that they had significantly smaller farm sizes compared to Uganda. Maize and beans were mostly grown in the sample counties in Kenya, while crop farming in Uganda was more diversified with maize, sorghum, banana, beans and coffee mentioned as key food and cash crops. Livestock production was represented

Table 2 Socio-economic and demographic characteristics of respondents in Kenya and Uganda

Descriptive	Kenya		Uganda		Overall	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Respondent sex (male = 1)	0.56	0.50	0.54	0.50	0.55	0.50
Respondent age (years)	44.89	15.52	45.04	15.36	44.96	15.43
Household size	5.16	2.14	7.21***	3.28	6.14	2.93
Location (peri-urban = 1)	0.48	0.50	0.56**	0.50	0.52	0.50
Farm size (ha)	1.19	1.36	2.36***	5.35	1.75	3.86
Tropical livestock units	2.52	0.48	2.28***	0.26	2.39	0.27
Education level						
Primary	0.36	0.48	0.47**	0.50	0.41	0.49
Secondary/vocational	0.41	0.49	0.38	0.49	0.39	0.49
Tertiary	0.22	0.41	0.09***	0.29	0.16	0.37
None	0.02	0.13	0.06**	0.24	0.04	0.19
Ownership of digital devices (yes = 1)						
Radio	0.92	0.28	0.62***	0.49	0.77	0.42
TV	0.70	0.46	0.30***	0.46	0.51	0.50
Feature phone	0.69	0.46	0.86***	0.35	0.77	0.42
Smart phone	0.64	0.48	0.19***	0.39	0.43	0.50
Farm orientation (commercial = 1)	0.17	0.37	0.05***	0.21	0.11	0.31
Primary activity						
Farming	0.91	0.29	0.90	0.30	0.90	0.30
Business	0.02	0.13	0.02	0.15	0.02	0.14
Salaried employment	0.05	0.21	0.06	0.24	0.06	0.23
Other	0.03	0.16	0.01	0.12	0.02	0.12
Agribusiness activities (yes = 1)						
Produce aggregation/transportation	0.43	0.47	0.10***	0.23	0.29	0.40
Produce selling	0.78	0.42	0.25***	0.43	0.52	0.50
Value addition and processing	0.03	0.16	0.04	0.20	0.03	0.18
Service delivery	0.06	0.23	0.07	0.25	0.06	0.24
Input sales	0.03	0.17	0.00**	0.00	0.02	0.13

Note: ***, **, indicate 1% and 5% levels of significance, respectively, between Kenya and Uganda.

in small proportions averaging 2.4 tropical livestock units. Poultry was the most common (81% in Kenya and 74% in Uganda). Cattle farming, especially dairy cattle, was more pronounced in Kenya than in Uganda, while small ruminants were represented in similar proportions across Kenya and Uganda (44% in Kenya and 43% in Uganda). Produce selling (78% in Kenya and 25% in Uganda), produce transportation (32% in Kenya and 6% in Uganda) and produce aggregation (11% in Kenya and 10% in Uganda) were the most commonly mentioned off-farm agribusiness activities. Significantly more farmers in Kenya than Uganda engaged in produce aggregation and selling, and transportation.

3.2 Farmer access to extension and advisory services

Farmers were asked if they had received extension advice in the last 12 months considering both non-digital and digital approaches (Table 3). Over 88% (96% in Kenya and 79% in Uganda) received extension advice from any source, while 12% did not receive any advice irrespective of the source. At least 67% (75% in Kenya and 60% in Uganda) received extension from conventional extension approaches dominated by family and friends, local community, extension workers or plant doctors, agricultural input dealers and farmer groups/

Table 3 Sources of agricultural advice as mentioned by farmers in Kenya and Uganda (%)

Variable	Kenya	Uganda	Total
Farmer accessed extension services	96	79***	88
Farmer did not access any extension advice	4	21***	12
Source of extension advice			
Digital extension	92	63***	78
Conventional extension	75	60***	67
Both digital and conventional	96	79***	88
Conventional extension			
Friends/family	52	48	50
Local community	41	36	39
Extension	26	54***	38
Agricultural input dealer	43	23***	35
Farmer cooperative	16	20	18
Worship places	10	2**	6
Print materials	4	4	4
Digital extension and devices			
Radio	84	76***	80
Television	58	36***	47
Smartphone	23	5***	14
Feature phone	9	5	7
Computer	5	1**	3
Community radio	1	3	2

Note: ***, **, indicate 1% and 5% levels of significance, respectively, between Uganda and Kenya.

cooperatives. There were significant differences in farmer access to advice from extension services, agricultural input dealers and places of worship between Kenya and Uganda. A higher proportion of farmers in Uganda mentioned receiving information from extension workers compared to Kenya, while the reverse was true for Kenya in terms of accessing information from agricultural input dealers and through places of worship.

At least 78% (92% in Kenya and 63% in Uganda) reported that they also accessed agricultural advice through digital devices. Radio was the prevalent digital platform used by farmers to access agricultural advice in both Kenya (84%) and Uganda (76%), followed by television (58% in Kenya and 36% in Uganda) and mobile phones (32% in Kenya and 10% in Uganda) (Table 3). Use of computers and community radio were less popular and were reported by 5% and 1% in Kenya and 1% and 3% in Uganda, respectively.

Female and male farmer access to digital EAS differed between the two countries (Table 4). In Kenya there was no significant difference in the proportion of female (90%) and male farmers (93%) receiving agricultural advice via digital devices. In Uganda there was a significant difference between female (46%) and male (77%) farmers receiving information via digital devices. In terms of location of farmer, the data did not reveal significant differences in access to information via digital devices by farmers in very remote areas and those close to towns. Male farmers, irrespective of location, were more likely to access digital EAS than their female counterparts. When subdivided by digital device used, significantly more male farmers than female farmers in Kenya were likely to use TV and mobile phone to received agricultural advice, while use of radio was not significantly different across gender (Table 4).

Farmers receiving information through digital devices indicated that they received information mainly on crop/livestock pest and disease management, weather information, markets for inputs and products and market price information. The trend of information flow was very similar across Kenya and Uganda, with a focus on advisory. These messages are simple and can be easily transmitted through digital devices (Table 5; Table 6).

At least 65%, 59% and 47% of the farmers using radio, TV and mobile phone, respectively, rated them better than conventional face-to-face extension methods. The main reasons given for their rating were: ease of access, ease of understanding the advice, information is considered relevant to farming activities, information is of good quality and is time-saving. However, those who did not use any digital devices indicated that they were not aware of the digital services (52%) and as such relied on other sources of information (Table 7). Other reasons given were that services are expensive, lack of knowledge on how to use the services and lack of ownership of digital devices. There were also issues related to ability to read and comprehend the messages sent especially via mobile phones, language barriers and information relevance. These challenges were more pronounced in Uganda than in Kenya.

3.3 Logistic regression results

We used a binary logistic generalized linear model to test the likelihood that a respondent adopts digital EAS. We estimated the odds ratio the dichotomous dependent variable: access to information via digital devices (Table 8). Ownership of a radio, TV or mobile phone was associated with a higher likelihood of accessing digital EAS in Kenya. In fact, radio, TV or phone ownership was associated with 23, 58 and seven times as likely

Table 4 Access to digital EAS by female and male farmers by country and location (%)

Variable	Kenya		Uganda		Remote areas		Townships/peri-urban	
	Female	Male	Female	Male	Female	Male	Female	Male
Access to digital EAS	90	93	46	77***	69	85***	76	91***
Digital devices used to access EAS								
TV	46	60**	20	25	31	40	42	55*
Radio	76	78	32	61***	56	72**	58	71**
Mobile phone	22	35**	2	9**	14	22	13	30***

Note: ***, **, indicate 1% and 5% levels of significance, respectively, between male and female farmers by country and location.

Table 5 Information accessed from digital devices by farmers in Kenya (%)

Information type	TV	Radio	Feature phone	Smart phone
Managing crop pests and diseases	59	54	17	47
Managing livestock vectors and diseases	57	57	39	45
Weather information	53	48	28	30
Livestock production	36	31	0	9
Where to buy seed, fertilizers, pesticides etc.	29	37	11	30
What type of seed to use	27	34	17	28
Market pricing information	22	21	22	17
Crop agronomy (GAPs)	19	17	6	6
Credit services	9	15	0	6
Alerts on agricultural activities e.g., time of planting	8	12	17	11
Purchase and sale of produce	8	6	6	17
Processing and value addition	2	2	0	6

Table 6 Information accessed from digital devices by farmers in Uganda (%)

Information type	TV	Radio	Feature phone	Smart phone
Managing crop pests and diseases	72	63	40	50
Managing livestock pests and diseases	46	27	20	67
What type of seed to use	46	42	40	0
Alerts on agricultural activities e.g., time of planting	41	38	20	0
Crop agronomy (GAPs)	35	22	60	0
Livestock production	33	18	20	33
Where to buy seed, fertilizers, pesticides etc.	24	42	0	50
Weather information	22	43	0	17
Market pricing information	20	20	0	33
Processing and value addition	13	8	20	0
Purchase and sale of produce	11	9	0	0
Credit services	2	2	0	0

Table 7 Reasons for not using digital extension devices (%)

Reason	Kenya	Uganda	Total
I am not aware of these services	21	59	52
The services are too expensive	37	42	41
I do not know how to use these types of services	16	44	38
I do not own a phone/radio to access these services	16	42	37
These types of services are not available in my area	16	24	23
I do not have the time to use them	16	23	22
I have trouble reading the content	26	18	20
The services are not available on my phone network	11	18	16
There is no network coverage in my area	0	17	13
The content is not in a language I understand	11	10	10
The content is not relevant to me	16	1	4

Table 8 Logistic regression results of access to digital EAS by farmers

Explanatory variable	Kenya		Uganda	
	Odds ratio	Std. Err.	Odds ratio	Std. Err.
Location (remote = 0)	2.06	1.60	0.99	0.40
Respondent gender (female = 0)	0.60	0.53	3.19**	1.42
Respondent age (chronological are in years)	1.00	0.03	0.98	0.01
Education level: primary	132**	321	0.64	0.48
Education level: secondary/vocational	11.53	27.11	1.21	1.00
Education level: tertiary	3.73	8.94	1.50	1.88
Household size (# of household members)	0.95	0.24	1.08	0.08
Radio ownership (yes = 1)	5.34	62.9	8.55	3.68
TV ownership (yes = 1)	23.1***	23.4	5.55***	3.10
Feature phone ownership (yes = 1)	58.4**	4.79	0.72	0.44
Smart phone ownership (yes = 1)	7.26**	7.44	1.48	1.00
Farm size (hectares)	0.98	0.13	1.01	0.04
Tropical livestock units	1.25	0.34	0.94	0.05
Farm orientation (commercial = 1)	0.92	0.90	1.00	–
Farmer engages in non-farm production (yes = 1)	0.06**	0.08	1.16	0.57
Extension service access (other sources)	7.05**	5.76	2.48**	1.04
Constant	0.01**	0.02	0.22**	0.31
Observations	228		208	
Chi-square	67.03		91.55	
Probability	0.000		0.000	
Pseudo R^2	0.512		0.344	

Note: ***, **, indicate 1% and 5% levels of significance, respectively.

as non-owners to use digital EAS. In Uganda, only TV ownership was significantly associated with the likelihood of using digital EAS, almost six times more likely than non-owners. Farmer engagement in non-farm production activities

(post-production), e.g., transportation and service delivery, was associated with a higher likelihood of adopting digital EAS compared to farmers engaged only in farm production activities in Kenya. In both countries, access to extension services was associated with a high likelihood of adopting EAS. The coefficient on being a male respondent was positive in both Kenya and Uganda but showed significant effects in Uganda. Males were 3.2 times more likely to use digital EAS in Uganda than their female counterparts.

3.4 Farmer information and advisory service needs that could be met by digital technology

Respondents were asked the type of information and advice they would need but found difficult to obtain. The highest proportion of respondents (46% in Kenya and 25% in Uganda) mentioned crop pest and disease management (Fig. 1). Farmers indicated that the most commonly shared information was in crop/livestock pest and disease management but they also expressed information gaps especially in pest/disease identification, prevention, control practices and products. In particular, farmers require information on how to identify and diagnose pests and diseases, how to distinguish diseases with similar symptoms, how to use biological pest and disease control methods, and the appropriate stage at which to control pests and diseases. Similarly, farmers expressed information gaps in recommended pesticides, when and how to spray, where to get quality pesticides, and safe handling of pesticides. In terms of livestock production, the knowledge gaps were reported on general animal husbandry, diagnosis of livestock diseases, feeding dairy cattle, proper breeding, recommended vaccines (especially for poultry), control of livestock diseases, and how to maximize profits from livestock production. Other reported information gaps were as follows.

• Markets: information on market prices, how to access markets and where to get good markets.

• Fertilizer use: safe use of fertilizers, where to get affordable fertilizers, application rates, effective/recommended fertilizers, how to obtain subsidized fertilizers, how to make organic fertilizers and the types of fertilizer to use on different crops.

• Credit facilities: how/where to access credit facilities.

• Quality seed: best type of seed to grow in their area, where to obtain quality/certified seed, information on quality/certified seed, how to distinguish quality seed from 'fake' seed and best cultivars to plant.

• Soil fertility management: soil pH testing services, how to increase soil fertility, best soils for different crops and advice on soil conservation.

• Value addition: how to do value addition and processing of milk and fruits and postharvest storage.

• Water management: who can help in installation of piped water and how to deal with too much rainwater

• General information on farming: landscaping, how to

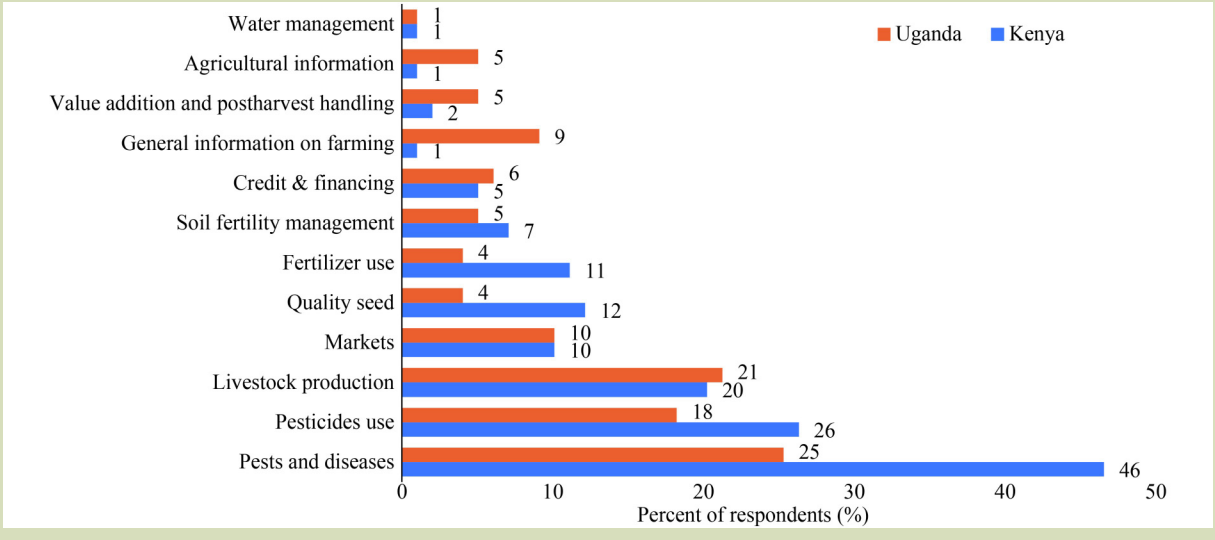


Fig. 1 Information that is difficult for smallholders to access in Kenya and Uganda.

practice crop rotation, how to do organic farming, increasing production, spacing, how to increase yields, and weather.

Factors that contribute to difficulty in obtaining the information needed by smallholders included: limited access to extension services, and limited farmer resources to proactively search for this information, e.g., when travel is required. Farmers also reported that government extension officers are few and not easy to access, while private ones are expensive to hire. There were also perceptions that the available cadre of government extension officers are not interested/willing to train farmers, do not have adequate technical skills and are unable to help farmers, especially during pest/disease outbreaks. However, the study noted current efforts in Uganda to recruit more extension workers to bridge this gap. Farmers also mentioned that the recommendations extension officers give to them sometimes do not work and extension worker have preference for large scale farmers who can pay for their services. Other challenges mentioned by farmers include a lack of resources to acquire recommended inputs, poor availability of inputs such as quality seed and lack of access to soil testing services.

3.5 Barriers and required skills and knowledge for farmers to use digital EAS effectively

Smallholders faced various barriers in accessing digital devices and this differed by gender and age category of farmers. Sixty-one percent of respondents (43% in Kenya and 81% in Uganda) indicated that older farmers faced barriers in accessing mobile phones, followed by female farmers: 42% of respondents (21% in Kenya and 66% in Uganda). The main reasons given for limited access to mobile phone services included: low literacy levels, lack of ownership and control of digital devices, calling prohibitively expensive, and subscription fees for some services unacceptably high. The difference between Kenya and Uganda was statistically significant ($P < 0.001$). In particular respondents in Kenya were more likely to mention higher calling and subscription rates than those in Uganda, while those in Uganda were more likely to report not owning digital devices.

For radio access the majority of respondents did not perceive barriers across gender and age category. However, 37% of respondents (18% in Kenya and 58% in Uganda) indicated that women faced barriers in accessing radio compared to men 33% (12% in Kenya and 56% in Uganda). The difference between the two countries was statistically significant ($P < 0.001$) as more farmers in Uganda were more likely to report facing barriers with respect to accessing radio than those in Kenya. The main reasons given were a lack of time to tune into suitable programs, timing of programs coinciding with other activities, lack of ownership and control of digital devices. Data also show significant differences with respect to specific barriers faced between farmers in Kenya and Uganda. Farmers in Uganda were more likely to report lack of ownership of digital devices (80%) compared to Kenya (28%) while more farmers in Kenya were more likely to report lack of time (73%) compared to Uganda (40%). For video screenings and computer access, all categories of farmers faced barriers, particularly attributed to low literacy levels, lack of ownership of digital devices and lack of awareness. This is also related to the fact that those who actually used or accessed these sources of information were relatively few compared to other means, namely radio, TV and phone in particular.

Based on the barriers faced, more than 50% of the respondents mentioned they would like skills on how to access digital devices, how to use these devices to access the agricultural information of interest to them, and how to subscribe to receive information on SMS, including subscription codes. They would also like access to hotlines and the internet, as well as knowledge on applications that give farming information and training. A few farmers mentioned that they needed information on where to access affordable digital devices, awareness on which radio or TV stations run programs on agriculture and the timing of these programs. They would also like the information to be communicated in local languages and via multiple means.

4 DISCUSSION

This study shows that farmers accessed extension advice from various sources including both traditional and digital ones. Family and friends, extension workers, local community/neighbors, agribusinesses, and farmer groups were important face-to-face sources of information, while radio was the most prevalent digital device used by farmers to access agricultural advice, followed by television and mobile phones. Dominance of radio as the main mass media source may be attributed to the fact that ownership of radios was more widespread than other ICT devices such as phones. Other factors mentioned by farmers as limiting the use of digital devices in this study include: lack of ownership and control of digital devices, limited technical support to use digital platforms/devices, and low awareness of digital services availability. Female and elderly farmers were more likely to report these barriers than men and younger people. This is consistent with Aker at al.[27]. who note that access to mobile phones, as well as other ICT, is often unequally distributed, which may aggravate information

asymmetries between men and women, or older and younger farmers. Kansiime et al.[28] also noted a digital divide in access to extension services in Tanzania as men were more familiar with digital approaches such as radio, than women. The differences between female and male access to digital EAS are related to differences in socioeconomic and cultural factors that may affect ownership of ICT devices or participation in extension activities. In addition, lower levels of literacy, household duties and workloads, social norms and limited disposable income, all intersect to reduce female participation in extension programs but more so mobile phone or mobile internet use for agricultural advice[8].

In relation to specific digital devices, several overarching challenges were found. For example, while radio was the most prevalent source of digital EAS, farmers reported a lack of time to tune into aired programs which potentially limits the use of radio or TV to access extension services. This limitation has also been highlighted in other studies attributed to the fact that programs on radio or TV are often aired at the time when farmers are busy with farm work or household chores limiting their participation in such programs[27,29]. For mobile phones, lack of ownership of digital devices, high cost of internet access and low digital literacy were the main challenges. Consequently, the use of different but linked communication channels, including digital and analog ones would ensure more farmers are reached in a way that maximizes accountability and increases impact[12,19].

The logistic regression model results show that ownership of digital devices (radio, TV or mobile phone), farmer engagement in post-production activities, and access to extension services were associated with a high likelihood of using digital EAS. The correlation between ownership of digital devices and likelihood of accessing digital EAS is fairly obvious, as ownership of the digital devices facilitates easy access to information including agricultural advice, and ensures connectivity with extension and fellow farmers[24]. Post-production activities included service delivery, produce marketing and value addition. It is assumed that farmers engaged in such activities are more exposed and more likely to know and use digital devices to access advice. Farmers who have access to extension services know the value and are always seeking better ways to remain connected to technical personnel, and are thus more likely to adopt digital EAS devices. Contrary to expectation, farmer location (whether a farmer is in a remote or peri-urban area) did not show significant effects on the likelihood of them using digital EAS, and was also not mentioned by farmers as a key barrier. This may imply that the study areas were fairly equally connected to radio or TV, the most commonly mentioned digital devices, or it may reflect the general lack of awareness and access to services that have limited location bearing.

Though the relative importance of and demand for different types of information varied across the farmers surveyed, there was a consistent demand for information on crop pest and disease diagnosis and management, types of fertilizers for a given soil type, pesticide use and safety, type of seed for a given agroecology, new crop cultivars, credit and market information, weather advisories and livestock production (pest control products, pest and disease management, breeding). This is consistent with literature on farmer information needs[30,31]. These information types also represent areas where information needs to be context-specific to support farmer decision-making. Participatory design methodologies need to be used that consider new insights about local information needs, user preferences and capacities[32]. This process ensures that both the digital platform and content are adapted for end-users that are often of different genders, ages, wealth groups, literacy, languages and agroecological zones.

5 CONCLUSION AND RECOMMENDATIONS

We investigated challenges and capacity gaps in smallholder access to digital EAS using household survey data from Kenya and Uganda. Farmers accessed EAS from various long-established extension services and digital sources dominated by radio. Dominance of radio as the main mass media source is attributed to the majority of the respondents owning a radio in comparison to other digital devices. In relation to specific digital devices, several overarching challenges were found. Lack of time to listen to aired programs was the major limitation for accessing EAS on radio or TV, while low or lack of ownership of digital devices, high cost of internet access, and low digital literacy were the key challenges for use of digital services in general. Our results further highlight that ownership of digital devices, participation in post-production activities, and access to extension are key drivers of digital EAS use. These factors reflect differences in smallholder technological capabilities, farming objectives and exposure, which should be taken into consideration in the design of innovations to aid appropriate use of digital EAS by farmers. Across farmers surveyed there was a consistent demand for information on crop pest and disease diagnosis and management, fertilizer application, pesticide use and safety, quality seed, new cultivars, market information, weather advisories and livestock production. These subjects represent areas where farmers need to make decisions based on agroecology and farmer asset base. We

therefore make the following recommendations for policy and practice.

Recommendations for policy: (1) farmer profiling to understand the different needs of smallholders to provide targeted information and advisory services; (2) enhancing farmer digital innovation capacity and creating farmer awareness of available digital EAS to help agricultural extension services to tap the full potential of the digital revolution; and (3) enhancing physical infrastructure development for digital access and reducing costs associated with access to internet and digital devices to enhance inclusion by smallholders.

Recommendations for practice: (1) continued development, testing and evaluation of ICT for various farmer categories and suitability to pass on information on promoted technologies; (2) integration of digital communication within multimode advisory services that use different but linked communication channels, for inclusive scaling of extension activities; (3) inclusion of bundled agricultural production services (e.g., insurance, credit and inputs) in digital EAS delivery to inspire participation of smallholders; and (4) content development that addresses farmer-identified information needs, and which is adaptable to various digital devices to enhance dissemination.

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Compliance with ethics guidelines

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