Digital tools for Village-Based Advisors

A formative research study and follow-up to prior impact evaluation

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Kim Siegal, Jacqueline Shieh, Naomi Dorsey, Deirdre Duquette, Lilian Treasure, and Anabela Mabota

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Executive Summary

VBA program

AGRA's village-based advisor (VBA) program recruits respected lead farmers from local communities to train them on good agricultural practices (GAPs) so they can disseminate the practices in their local communities. Implementing partners also connect VBAs to input providers and off-takers so farmers can access improved inputs and find a market for their produce. In the process, VBAs have the opportunity to generate income and even start their own agri-enterprises. These profit-driven activities promote the sustainability of the VBAs and enable them to continue to offer services to farmers in their communities. AGRA has recently experimented with providing digital tools to VBAs to help enhance both their training to farmers and connection to market actors in a number of their focus countries, including Mozambique and Nigeria.

Study scope and methods

In this study, Mathematica assesses AGRA's early experiences training VBAs on digital applications, notably CropIn, and VBAs' use of and experience with those applications in Mozambique and Nigeria. To assess AGRA's early digitization efforts and recommend the most likely avenues of success, we relied on a mix of qualitative and quantitative data sources, including key informant interviews with program implementers, government officials, and market actors (including off-takers and input suppliers); focus groups of farmers and VBAs; and a survey of VBAs who have interacted with digital technology.

In addition, this study presented an opportunity to (1) discuss with farmers and VBAs their main constraints in applying GAP and how they perceive their interactions with VBAs and (2) investigate some anomalous finding from an earlier retrospective impact evaluation through deeper conversation with farmers. That evaluation, conducted by Mathematic in 2022, found that farmers trained by VBAs were not increasing their use of inputs relative to untrained farmers and that dietary diversity was actually worse for VBA-trained farmers. The study also found that income improved for VBA-trained farmers relative to non-VBA-trained farmers, but the impact pathway for that improvement was not clear, especially because we found no impact on yields per hectare.

We present the findings in three parts. Part1: Use of digital extension tools; Part 2: Farmer constraints and interactions with VBAs; and Part 3: Follow-up from unexpected findings in previous impact evaluation.

Part 1: Digital extension

⬜ Use of digital applications

Uptake and use of CropIn has been low in both countries. A total of 46 VBAs received training in Mozambique and 228 VBAs received training in Nigeria. Most VBAs we surveyed reported they did not regularly use the CropIn application. Weaknesses in CropIn implementation and training, lack of phone compatibility, and the complex design of the application itself were main contributors to low adoption of CropIn. Compared to VBAs in Nigeria, Mozambican VBAs were additionally challenged by the lack of access to smartphones, the cost of data to use the application, and language barriers.

Some VBAs had experiences with other digital applications, which included those intended to improve market connectivity and those meant to disseminate agricultural information. For example, VBAs in Nigeria used Plantix, an application to diagnose plant diseases, and Farmex, a market connection and extension application; VBAs in Nigeria used Kugulisa, a market and extension information-sharing platform. Regular use of all applications was relatively low among those trained on digital applications (Figure ES1), but we still discuss challenges and facilitators of success with those who received training on and used those digital applications.

Findings from our qualitative and quantitative data suggest that using digital applications expanded the frequency and quality of interactions of VBAs, but not necessarily the reach. Most VBAs who used digital agricultural applications regularly reported the tools increased their ability to interact with farmers more frequently and provide more accurate information, especially for identifying and treating pests and diseases. For example, the Plantix application enables users to take a picture of a plant to digitally diagnose a problem and recommend a solution. However, farmers, implementers, and VBAs pointed out that digital applications are most effective for providing reminders and targeted recommendations, but they cannot fully substitute for face-to-face training.

Figure ES1. Regular usage of applications among those trained on each application

Source: Geopoll phone survey (2024).

Note: Regular usage was considered using the application two to five times a week or most days.

CropIn (n = 53), Farmex (n = 57), Kobo Toolbox/ODK (n = 121), Plantix (n = 66), Kugulissa (n = 37).

Challenges

The main barriers to the use of digital tools include limited access to necessary devices and associated costs, weak digital infrastructure, limited training, and application design deficiencies. VBA respondents indicated these barriers limited their own ability to understand and properly use digital tools, as well as their ability to effectively communicate information about digital tools to farmers. Application design deficiencies appear to compound challenges of their use. In part, overcomplication is likely due to the design-reality gap, in which applications are informed by a strong technological rationale but are misinformed about users' interest and capability, and thus fail to connect with users on the ground.

Communication apps

Compared to digital applications, VBAs were more likely to use messaging platforms, such as WhatsApp. VBAs' preference for communication applications rather than digital platforms (Figure ES2) might be due to certain advantages, such as time savings and ease of communication with farmers, other VBAs, and extension agents. VBAs in Mozambique highlighted the importance of SMS in communicating with farmers, as they often live far from their farmers and messaging enables them to send reminders and advice despite the distance. Research has found that communication challenges are more easily surmounted by chat applications than they are by specialized agricultural applications (Coggins et al. 2022).
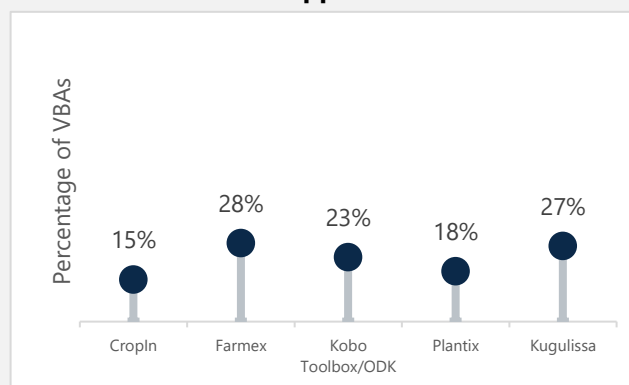
Figure ES2. Digital application and messaging platform usage and preference
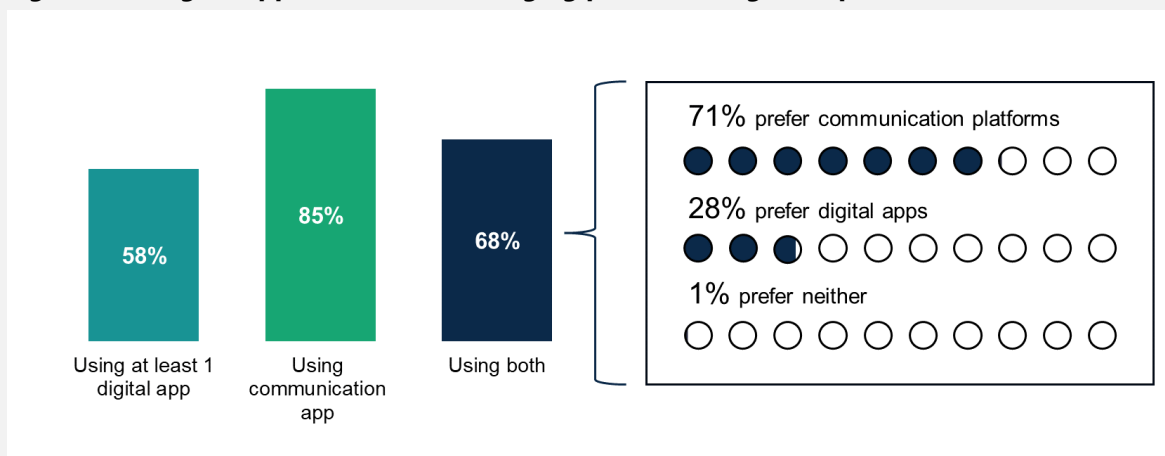
Source: Geopoll phone survey (2024).
N = 294; those using both digital applications and communication platforms (n = 201)

Facilitators of success

Strong onboarding to the application, thoughtful application design, positive early experience with the tools, and a hospitable digital landscape are facilitators of using digital tools. VBAs we surveyed highlighted refresher or repeated trainings, in addition to onboarding training, as particularly important in supporting their use of digital applications. Design simplicity was especially important. One representative of an information dissemination application in Nigeria noted that their team had to work for more than seven years on the language their application used, making sure the wording was not only in the local language but that the messaging was simple enough for farmers with low levels of literacy (both digital and nondigital) to easily understand.

Perceived impacts on farmers and VBAs

VBAs perceived that the use of digital applications had more impact on farmers' adoption of GAP and input use than they did on farmers' output market activities. Specifically, VBAs noted that applications that provide reminders help farmers at all experience levels increase their adherence to GAP and, therefore, increase their yields. However, relatively few VBAs cited market access-related impacts on farmers, likely because the most commonly used applications were information dissemination applications rather than market connection applications.

Digital applications support VBAs in their work by enabling them to work more efficiently and gain credibility in the eyes of their farmers. In Nigeria, some VBAs generated income from using digital applications. Seeking to engage extension agents as main users and promoters of applications is one of the most promising pathways for integrating digital tools with public systems, but we did not find strong integration among the applications we examined.

Interaction with public and private systems

We did not find any integration with public extension systems among the applications we examined. Engaging extension agents as main users and promoters of applications is one of the most promising pathways for integrating digital tools with public systems, but we found no strong integration among the applications we examined. Government extension capacity to absorb new digital tools is limited, as active extension agents often have limited capacity and are frequently older and less digitally literate.

Market connection applications had a unique set of challenges and struggled to reach a critical number of farmers and market actors. Market actors in Nigeria, such as input suppliers and off-takers, were interested in digital tools because they provided the possibility of reaching farmers who were previously unavailable. Although there was more private sector engagement in Nigeria compared to Mozambique, the market applications we reviewed had not reached much scale. These applications face a unique set of barriers, including establishing trust between farmers and market actors, access to credit, and drawing in a critical mass of input suppliers and off-takers.

Recommendations

- **Build applications with user-oriented design and include adequate time for iteration.** Those applications that failed to scale were often designed in advance and with little input from the field, whereas those that succeeded started by undertaking problem identification with farmers and working iteratively with them over a long time to find applications that targeted their biggest concerns and had messages that resonated with their needs. Any new application AGRA engages with should adhere firmly to user-centered design principles.

- **Focus on simplicity of messages and platform.** The complexity of the application was a main challenge hindering use, particularly with CropIn, and this was also something that comparator programs warned against. Applications that AGRA promotes should start with a simple design and simple messages and plan to iterate on those designs and messages when entering new regions or markets.

- **Deliver robust training with refreshers.** In rolling out any digital application, stakeholders emphasized the importance of upfront investment in training and in ensuring VBA program implementers are engaged with the digital application. Examples of helpful engagement include deputizing implementers as lead trainers and allowing them to access the data and interact with the digital application staff.

- **Leverage existing messaging applications.** Most VBAs use, and even prefer, messaging applications and platforms for communicating and sharing information among farmers and market actors. Compared to digital applications, messaging apps require less training, have less data and time costs, are user friendly, operate on basic smartphone models, and might have greater trust because groups are formed with mutual acquaintances. Given these advantages, when introducing a specialized digital application, AGRA should also consider how to integrate digital applications with messaging applications.

- **Continue to pursue a hybrid approach.** Digital applications cannot replace the in-person training and VBAs will have to continue to play the role of a trusted intermediary in any digital strategy. In-person, hands-on training is not possible to replicate with text messages and for many market applications, smallholders still depend on a trusted broker to act on any market information. AGRA should consider digital tools as a mechanism for enhancing the *quality* and *depth of interaction* rather than the *reach* of VBAs' work.

- **Match the application type (for example, market connection versus information dissemination) with the country priority needs, making adjustments depending on the level of digital infrastructure.** The digital tool of choice should solve a specific problem that is either (1) the most pressing problem or (2) a problem that is most immediately addressable through a digital solution. AGRA should also plan the roll-out in accordance with the various contexts and constraints of each country (such as poor access to phones and connectivity in Mozambique).

  - **Start small with a market-application pilot and purchase or subsidize smartphones for VBAs in Mozambique.** In Mozambique, farmers are most interested in finding a market for their produce. Market connectivity applications are more complicated and have a harder time scaling. However, it could be worth finding promising pilot areas (such as with stronger digital infrastructure and VBAs who have pre-existing market connections) to experiment with these applications, as this will meet the most pressing need. It is also important to acknowledge the lack of digital infrastructure and access to smartphones among VBAs and consider purchasing or subsidizing smartphones for VBAs. Although this is a costly investment, adequate digital infrastructure and access is a foundational piece of any digital extension strategy. AGRA could consider a partial subsidization scheme as a pilot and then expand from there. Without improved access to smartphones, a robust digital strategy is likely to face significant challenges.

  - **Build on current momentum in Nigeria by supporting the expansion of successful applications and work with developers to ensure tools evolve to be even more user friendly.** In Nigeria, it could be worth building on the momentum of digital applications that VBAs and farmers are most excited about and that provide an immediate benefit, such as Plantix and Farmex. This would enable AGRA to build on an existing foundation and add additional services as warranted and demanded by farmers. VBAs were relatively enthusiastic about tools, which many reported increased the respect that farmers paid them and enabled them to reach additional farmers. Younger VBAs were particularly excited about the technology, as they felt it elevated their credibility with older farmers. This suggests further investment in a digital strategy could increase AGRA's ability to recruit younger VBAs, which is an important strategic goal. It will be important to clearly identify a targeted number of applications to avoid spreading services across too many applications and diluting their value (for example, if there are too many market aggregation applications they could all fail to register a critical number of market actors).

Part 2: Content delivery and farmers' experience

This study presented an opportunity to gather more information about the barriers to farmers' adoption of VBA-recommended practices and input; how farmers perceive their interactions with VBAs; and any

benefits the experienced beyond improvements in practices, yields, and income. We highlight three key related findings:

1. Farmers faced multiple barriers to adopting GAPs, including a lack of cash or credit to purchase recommended inputs, the additional labor and time required to apply the practices, difficulty in reaching input suppliers, and a lack of hired help sufficiently trained in and/or interested in applying those practices. Similar to our recommendation in prior reports, we encourage AGRA to identify pathways to improve access to credit for inputs for farmers. In addition, it could be important in Nigeria to encourage laborers, not just farmers, to attend training or provide farmers with paper-based training tools to share with hired laborers.

2. Generally, farmers greatly preferred in-person, live demonstrations delivered before land preparation or planting rather than receiving information digitally or by phone. Farmers especially valued VBAs' visits to their farms so VBAs could make recommendations and confirm that farmers implemented practices correctly.

3. When we asked farmers what additional benefits they felt the VBA program had provided (in addition to training or yield and income improvements), they noted the program had encouraged a greater acceptance of a more prominent role for women in agriculture and increased financial literacy. AGRA should build on this early momentum in changing norms about women's roles in agriculture by working in concert with religious and community leaders and carving out a niche for women VBAs to focus attention on crops and value chain activities that are more traditionally considered female dominated, as this would face fewer cultural barriers. However, AGRA would have to take care that this focus does not simultaneously limit the income-generating opportunities for women by focusing on lower-value crops.

Part 3: Follow up on impact evaluation trends

We used this data collection exercise to investigate some anomalous finding from the retrospective impact evaluation. Table ES1 outlines the anomalous trends along with insights from focus group discussions with farmers.

Table ES1. Findings from the earlier impact evaluation and corresponding insights from focus group discussions with farmers

Earlier finding	Insights from focus groups
In our retrospective impact evaluation, we observed an increased share of VBA-trained farmers practicing crop rotation relative to matched non-VBA-trained farmers. Given the relatively smaller focus on crop rotation in VBA training, it was unexpected that we found such a consistent impact on the practice.	Farmers who implemented crop rotation on their land in Nigeria and Mozambique reported doing so to help with pest control, improve the nutrition of their land's soil, and increase yield. Training on crop rotation appears to be enhanced by a seeing is believing approach. A handful of farmers also reported they implemented crop rotation after training by their VBAs and were shown how it could increase yields in fields with side-by-side demonstrations
We found that although VBA-trained farmers did not necessarily increase their yields per hectare they did expand the land they dedicated to AGRA's focus crops. So, they appeared to engage in an extensification strategy rather than intensification strategy.	Farmers who expanded the land they cultivated in Mozambique did so thanks to income gains in prior years and/or due to the promise of greater yields with the benefit of improved practices they learned from or inputs they acquired from their VBAs.

Earlier finding	Insights from focus groups
The retrospective impact evaluation estimated the impact of the VBA program on practice adoption related to AGRA focus crops. However, we hypothesized that the farmers might apply some of those practices to adjacent nonfocus crops and have additional benefits on those fields.	Farmers' application of GAP to nonfocus crops was common among participants in the focus groups who reported that, having seen the benefits of GAP on their yield of focus crops (maize, soya, and rice), they wanted to carry those practices over to other crops they grew to hopefully yield the same results.
In our previous study we found no significant differences in the likelihood of using certified or hybrid seeds or fertilizer comparing VBA-trained farmers and matched comparison farmers. We hypothesized that the year of study, which saw record fertilizer prices due to the Ukraine conflict, might have dampened input use among trained farmers who would have otherwise invested.	Focus group discussions across Mozambique and Nigeria with VBAs and farmers revealed that price increases for chemical fertilizer was a primary contributing factor in any reduction in input use for these groups. Respondents across both countries reported altering their purchasing and usage of certified seed as a result of price increases.
In our previous study, despite the relatively minimal increases in input use and lack of statistically significant impacts on yields per hectare, we found a strong impact on household income in Mozambique and suggestive trends in Nigeria. Therefore, we explored which income pathways might be most prevalent among VBA-trained farmers outside additional income from yield improvements.	Farmers in Nigeria and Mozambique who reported an increase in income most commonly used their income gains to reinvest in farming, either purchasing farming inputs or y buying or renting more land to cultivate. Overall, they appear to have invested most of the prior year income boosts in productive assets, so it is possible the increase in income we found in our impact evaluation could have been the result of prior year investments.
In our previous study we unexpectedly found a slight, but statistically significant, dip in dietary diversity across all countries. We hypothesized that this might be due to a greater focus on a narrower set of crops and lack of training in dietary diversity.	Farmers we spoke with did not generally report a reduction in their dietary diversity, so it was difficult to explore this trend.

Introduction

AGRA is an African-led institution at the forefront of strengthening seed systems, modernizing policies, and linking markets to drive smallholder agricultural transformation. Core aspects of AGRA's model include system-level investments and collaboration with public, private, and nonprofit actors to generate outsized impact. As part of its investments, AGRA has implemented the village-based advisors (VBAs) program to improve farmers' access to extension, input markets, and output markets. The VBAs (referred to as CBAs, community-based advisors, in Nigeria) are a key part of AGRA's private sector-led extension provision for farmers.

AGRA designed the VBA program to address a glaring gap in agricultural extension services in sub-Saharan Africa in which most national extension programs reach only a fraction of rural smallholders. In 2017, AGRA introduced the VBA program in eight countries to address this gap. The program recruits VBAs—skilled farmers known to be respected in their community—and works closely with public extension authorities to train them on good agricultural practices (GAPs). The VBAs then train farmers in their villages throughout the agricultural season. VBAs also serve as a conduit to input and output markets by connecting farmers to seed and fertilizer suppliers, mechanization services, and off-takers. In the process, VBAs have the opportunity to generate income and even start their own agri-enterprises, which promotes the sustainability of the VBAs and enables them to continue to offer services to farmers in their communities.

In 2021, in the aftermath of the COVID-19 pandemic that curtailed VBAs' ability to meet regularly with farmers, AGRA sought a digital solution to expand the reach and quality of interactions between farmers and VBAs. To further those goals, AGRA partnered with CropIn, an agri-tech organization, to bring the CropIn digital application to VBAs and enhance extension services. The CropIn application was built to generate farmer scores based on the historical performance of their plots and other socioeconomic factors, enabling CropIn and AGRA to appropriately adjust their support. In addition, it was intended to enhance VBA linkages with other service providers to increase their capacity for the last-mile delivery of agricultural inputs and services.

As seen in **Figure 1**, the CropIn theory of change (developed in consultation with AGRA) posits that training will lead VBAs to use the application regularly in engaging with farmers who will receive better-quality training and improved access to input and off-taking markets. The application will also enable VBAs to reach more farmers. The improved access to inputs, training, and markets will lead to increased yields for farmers, income and food security, while also benefiting VBAs in their role as an intermediary and generating income. In aggregate, the greater reach and quality of these interactions should mean an overall improvement of extension services.

For this theory of change to work as articulated, a number of conditions need to hold. VBAs must have access to compatible technologies and there has to be sufficient digital infrastructure. In addition, other actors—such as farmers, input suppliers, and buyers—must have the ability to similarly engage with the tools and information disseminated through digital applications. It is also important that groups such as women and older farmers are not inadvertently disadvantaged by VBAs' greater reliance on digital tools by being left out of important messages, trainings, or market connections.

Figure 1. Theory of change for CropIn digital extension
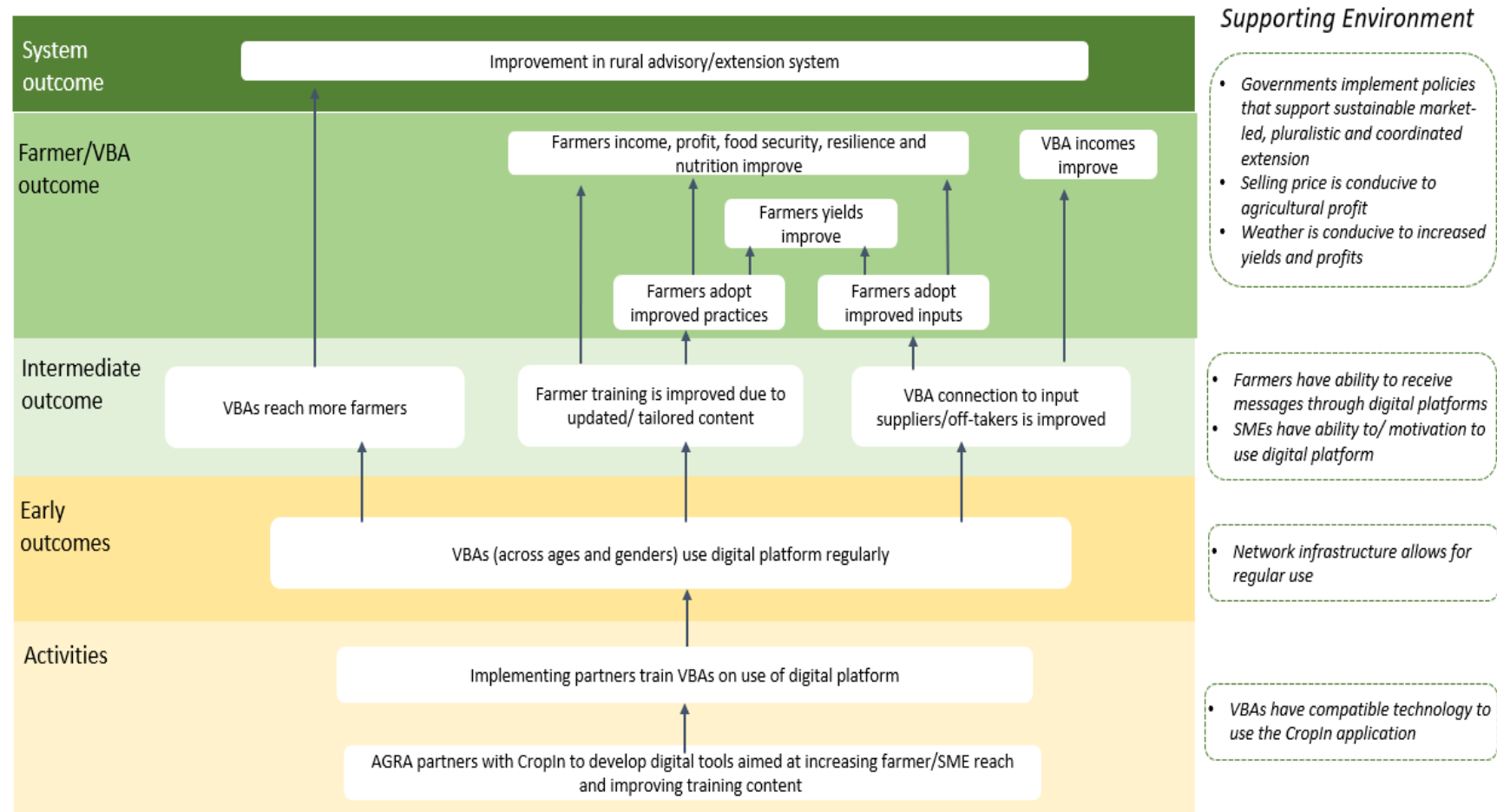
Study rationale and research questions

AGRA and the Bill & Melinda Gates Foundation (the foundation) initially contracted with Mathematica to conduct a series of evaluations of the VBA program. The first was an assessment of the VBA program on VBAs and private and public systems, which largely drew from qualitative sources. The second was an impact evaluation of VBA program in Kenya, Mozambique, and Nigeria. This evaluation sought to include (1) a retrospective matched comparison study conducted in each country to assess the impact of the program on farmers (for example, their yields, sales, profits, resilience, and food security) thus far; and (2) a prospective matched comparison study in Mozambique and Nigeria to assess any additional impact VBAs who use digital services have on farmers relative to the impact from VBAs who do not use digital services.

While conducting initial research, we learned that implementing partners have experienced some challenges training VBAs on the digital platform (CropIn, also referred to as SmartFarm) and that the roll-out of this program was more limited than anticipated. Because the evaluation stakeholders were concerned that less-than-full implementation would make it difficult to measure any impact at the farmer level within the evaluation period, AGRA, the Gates Foundation, and Mathematica, decided to repurpose the impact evaluation into a formative evaluation with the goal of informing future digital VBA programs.

In addition, this study presented an opportunity to (1) discuss with farmers and VBA their main constraints in applying GAPs and how they perceive their interactions with VBAs and (2) investigate some anomalous finding from the retrospective impact evaluation through deeper conversations with farmers. In particular, that evaluation found farmers trained by VBAs had not increased their use of inputs relative to untrained farmers and dietary diversity was actually worse for VBA-trained farmers. We also found income improved for VBA-trained farmers relative to non-VBA trained farmers, but the impact for that improvement was not clear, especially because we did not find an impact on yields per hectare.

To address these issues, we agreed on the following research questions:

   A. **Digital extension improvements**
      1. How does digitalization affect interaction between VBAs and farmers? (for example, can it increase the frequency of interactions? Improve farmers' behavior? What types of messages are more effectively conveyed digitally versus in person?
      2. How does AGRA's digital extension interventions increase efficiency, reach, and quality of content?
      3. What are the key drivers or barriers that drive or hider use of digital solutions, and how do these differ for women and youth?
      4. How can early challenges identified in places where AGRA's digital extension programs have been rolled out be mitigated to reach AGRA's goals?
      5. What are the perceived early impacts on VBAs and farmers of digital tool use?
      6. How do digital solutions fit with government digital platforms or interventions?
      7. How successful are various digital extension platforms and models' effectiveness in different contexts and what are the drivers of that success? What are the most promising change pathways for digitizing VBA services (that is, through knowledge acquisition, behavior change prompts, connection to input or output markets, and so on)?
      8. How can digitalization programs bring more service providers onboard (input and output market access)? How can digital investment catalyze other actors to onboard more onto this service? That is, how can it create demand beyond current investment?

B. **Content delivery and farmers' experience**
   1. What are the key barriers to practice adoption and input use and how can they be addressed? (For example, are farmers most constrained by inadequate information, access to inputs, access to credit, or other factors?)
   2. How do famers perceive information conveyed to them by VBAs? Which types of information and which delivery mechanisms lead to the most knowledge retention? What is the optimal time to receive messages so they are well understood and farmers are most likely to apply them?

C. **Follow-up to impact evaluation unexpected trends**
   1. Do farmers perceive benefits of the VBA program that are not in the form of key changes to practice, yield, or income?
   2. How have impacts varied in prior years with different conditions (such as weather and input price)?
   3. What are the main pathways to increased household income other than improved harvests?
   4. How have farmers invested or spent any income gains (current or prior years)?
   5. What accounts for the slight reduction in dietary diversity found across all countries?

This report is organized in four parts.

1) **Part 1.** In the first section, we describe the scope and methods of the study.
2) **Part 2.** In the second section, we discuss our findings related to digital extension use. In this section, we start with an overview of AGRA's experience with CropIn and then expand to examine the other tools that VBAs interacted with. We focus on how VBAs used these tools and how the tools affected their interactions with farmers, the challenges they experienced and the facilitators of success. We then look at the perceived impact of digital tool use on farmers and VBAs themselves, and we describe the interaction these digital tools have with public and private systems. We end this section with some recommendations for AGRA as it grows its digital extension program.
3) **Part 3.** In the third section, we draw mainly on farmer focus groups to better understand farmers' perspectives of VBA content delivery.
4) **Part 4.** In the fourth section, we follow up on some surprising findings from our impact evaluation, drawing on our focus group discussions (FGDs) to better understand patterns and trends.

1. Scope and Methods

To assess AGRA's early digitization efforts and recommend the most likely avenues of success, we relied on a mix of qualitative and quantitative data sources, including key informant interviews (KIIs) with program implementers, government officials, and market actors; FGDs with farmers; and a survey of VBAs who have interacted with digital technology.

Focus group discussions

We conducted 34 FGDs, 16 in Nigeria and 18 in Mozambique, with VBAs who had received training in digital applications and the farmers they worked with (**Table 1**). In both countries, we conducted FGDs with an equal number of men and women. We conducted two mixed-gender FGDs in each country during the pilot data collection. We conducted two additional focus groups in Mozambique (one for farmers and one for VBAs), as there was confusion among participants while recruiting, and participants in initial interviews after the pilot were not at all familiar with digital applications. With the two additional focus groups, our data collection partners worked closely with implementers to recruit participants who were familiar with the applications in Mozambique.

The study team stratified VBA selection at the district level and selected districts based on where digitization was implemented in both countries. We used a sampling frame provided by AGRA, which included all VBAs trained in using digital applications. For each focus group, we randomly selected one VBA from the sampling frame. We then used a snowball approach, recruiting other VBAs in close proximity to the randomly selected VBA. VBAs in each focus group provided contact information of their farmers, who we recruited for farmer FGDs to ensure that farmers interviewed had some familiarity with applications or worked with VBAs who had used applications. To recruit the remaining participants of each VBA FGD, we then asked those recruited VBAs for the contact information of their farmers to ensure farmers in FGDs would have some familiarity with the applications.

VBA FGDs covered topics such as early experiences with the digital application, including challenges, uses, training, benefits, changes in interactions with farmers, and recommendations for improvements. We had initially planned to focus on VBAs' experience with the CropIn program, but given the limited experience participants had with CropIn, we adapted the interview guide to cover other applications with which VBAs had some experience. These included Plantix and FarmEx in Nigeria and Kugulisa in Mozambique. The FGDS with farmers included questions on farming challenges, interactions with their VBAs via the digital tools, personal use of digital tools, experience with the digital infrastructure, and challenges they believe could be overcome with digital tools. All FGDs included a facilitator and a note-taker and were recorded (with the consent of respondents), transcribed, and translated.

Table 1. Number of focus groups conducted, by country

	Nigeria		Mozambique	
	Target (# all women)	**Achieved (# all women)**	**Target (# all women)**	**Achieved (# all women)**
Farmer focus groups	8 (4)	8 (3)	8 (4)	8 (4)
VBA focus groups	8 (4)	8 (3)	8 (4)	10 (5)
Total	**16 (8)**	**16 (6)**	**16 (8)**	**18 (9)**

Key informant interviews

We conducted 25 KIIs for this assessment (Table 3). In Mozambique and Nigeria, we interviewed program implementers including headquarters staff and training staff who interact most directly with VBAs and farmers. We also interviewed government extension officials and key market actors, such as input suppliers and off-takers who interacted with the digital applications VBAs had experience with. We also identified comparator digitization programs through a literature review, review of program documents, and recommendations from AGRA and foundation staff. We selected comparator programs that met the following criteria: (1) digital programs that had achieved some degree of scale and longevity, (2) programs operating in contexts similar to Nigeria or Mozambique (3) programs that promote digital applications designed to either improve market connection for smallholders or to improve extension and information services, and (4) programs promoting applications that can be used by an intermediary such as a VBA. In all interviews, we administered semistructured protocols with questions aligned with our research questions. For comparator programs, we gathered respondents' perspectives on scaling challenges, how they surmounted them, and key elements for their success.

Table 2. KIIs conducted

	Nigeria	Mozambique
Implementers	3	3
Government actors	2	3
Market actors	3	5
Comparator programs[a]	6	
Total KIIs	**25**	

[a] These programs covered multiple countries across Africa.

We used a systematic approach to analyze the qualitative data from the FGDs and KIIs. In a first step, we used notes and transcripts from meetings with AGRA and other interviews conducted to identify prominent themes and developed a coding system for each theme or key research question. Three analysts assigned codes to the transcripts or in-depth interview notes and coded transcripts until reaching thematic saturation or the point when no new themes, trends, or data emerged.

VBA survey

We supplemented information from the KIIs and FGDs with a short phone survey of VBAs to obtain more representative opinions on their use of and experiences with digital applications. This survey covered VBAs trained in digital tools in both Mozambique and Nigeria with a goal of 200 VBAs in each country. Our sampling frame included VBAs trained in CropIn and other tools promoted by AGRA (namely Farmex, Plantix, KoboToolbox/ODK, and Kugulissa).[1] We achieved 210 respondents in Nigeria and 85 in Mozambique (**Table 3**). During data collection, we faced difficulties recruiting enough participants in Mozambique because contact numbers were incorrect or Portuguese was not the primary language spoken. To address this, we translated the survey to an additional local language and added a survey question asking respondents to provide contact information of other VBAs they knew who had received training in digital apps. Even with these adjustments we could not meet our sampling targets given the relatively small number of VBAs trained in any digital applications in Mozambique. The survey consisted primarily of closed-ended questions focused on VBAs' experience with training on digital tools, frequency and type of use of digital tools, challenges they faced, and changes they would like to see, among other topics, and took respondents about 25 minutes to complete.

Table 3. VBAs surveyed

	VBAs		
	Surveyed	Percentage youth (= < 35)	Percentage women
Nigeria	210	56	21
Mozambique	85	26	12

Literature review. To contextualize our findings, we undertook a limited literature review focused on the meta-studies or reviews of the digital application in agricultural in Africa, drawing from both academic

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[1] Although we initially planned to survey only those VBAs trained in CropIn, we learned that the total number of those trained was too small to reach our sample targets, especially in Mozambique, where the program listed only 41 VBAs who attended CropIn training.

studies and the industry reports. We used this literature review to contextualize some of our findings, particularly about the challenges in scaling digital applications and the causes for those challenges. The reference section of this report lists those studies.

Limitations. There are several limitations to our findings. We could not definitely respond to the research question about how successful various digital extension platforms and models' effectiveness in different contexts are given the relatively minimal roll-out of most digital applications. We were also unable to fully respond to the degree to which digital solutions fit in with government platforms because governments we spoke to were very early in their digital application strategy. However, we were able to comment on these research questions based on the limited experience of key informants. In addition, we were unable to survey very many VBAs in Mozambique given the relatively low number of VBAs who received training on any digital application. Finally, we expect there was some degree of positive response bias in our phone surveys, as phone survey respondents claimed to use digital applications they were trained on more frequently than we were told was common in our face-to-face focus groups.

2. Digital extension tools

Digital infrastructure in Mozambique and Nigeria

This study took place in two countries that represent very different contexts in terms of digital infrastructure and agricultural needs. They thus provide insights on types of applications and models that might be best suited to different contexts.

Nigeria has more developed and established digital infrastructure relative to Mozambique. In Nigeria the cell phone penetration is 85 mobile phones per 100 people, whereas in Mozambique the penetration is nearly half that at 46 (CIA Fact Book 2020). The overall mobile connectivity in Mozambique is also weaker. GSMA ranks countries on a mobile connectivity scale assessing the infrastructure, affordability, consumer readiness, and content and services. Using these criteria, Mozambique has an index score of 34.5, compared to Nigeria's score of 52.1. In Nigeria, 90 percent of the population has mobile connections, whereas in Mozambique that number is 53 percent. In terms of smartphone penetration, Nigeria also outpaces Mozambique with an estimated 44 percent penetration of smartphones (compared to 29 percent in Mozambique), which is estimated to keep growing given the young population and influx of more affordable models from China (Alliance for Affordable Internet 2022).

The agricultural challenges that mobile applications can hope to solve also vary by country. In our earlier study of VBAs across five African countries, we found the biggest challenges VBAs-trained farmers faced in Mozambique related to output market access. Farmers used minimal inputs but farmed over relatively large land size, meaning they could often grow much of what they needed with extra to sell but struggled to access markets. In contrast, in Nigeria access to markets and use of inputs is much higher, but farmers are wary of counterfeit inputs interested in access to finance and professionalization of their farms.

Digital tools can help farmers though two main pathways: (1) information to help increase productivity and (2) connection to markets. The first works by helping farmers overcome information gaps by offering location-specific recommendations about input use, plant disease and remedies, and weather patterns, or offers reminders about best practices to encourage their adoption. Throughout this report, we refer to

digital applications that support this pathway as *information applications*. In the second pathway, digital tools link farmers to markets and provide input and buyer prices across a larger number of actors than they could access through traditional means. Improved access to price information can theoretically help farmers sell their products in markets with higher prices, reduce the need for middlemen, reduce waste of perishable crops and reduce price dispersion across markets. Ultimately, this can lead to higher revenue for farmers and lower average prices for consumers. We will refer to applications that support this pathway as *market applications*.

Key findings: digital extension tools

Uptake and use of CropIn has been low in both countries. Weaknesses in CropIn implementation, training and the complex design of the application itself were main contributors to the low adoption of CropIn. Across all digital applications that VBAs had experience with, they reported that using digital applications expanded the frequency and quality of interactions with farmers and that information applications were best suited to reminders and targeted recommendations but could not replace training on GAPs. VBAs reported several major barriers to the use of digital tools, including limited access to necessary devices and associated costs, weak digital infrastructure, limited training, and application design deficiencies. Market connectivity applications with the largest impediments were in generating trust from both buyers and sellers and access to credit. Compared to digital applications, more VBAs used and preferred communication platforms. Several broad themes emerged as facilitators of the use of digital tools, including strong onboarding to the application, thoughtful application design, the perceived and experienced benefits of applications, and a hospitable digital landscape.

CropIn/SmartFarm

Uptake and usage of CropIn has been low in both countries. A total of 46 VBAs received training in Mozambique and 228 VBAs received training in Nigeria (**Table 4**). According to qualitative interviews with implementers, CropIn use in Nigeria peaked in 2021 (toward the end of program funding) and declined when program funding ended. In Nigeria, about half of the VBAs survey respondents reported they currently used the application and their usage ranges from two to five times a month. In Mozambique, VBA use is even lower, with only one of seven VBAs trained on CropIn still currently using it.

Table 4. Number of VBAs trained on CropIn

	VBAs trained
Mozambique	**46**
Manica	23
Tete	18
Sofala	2
Zambezia	2
Nigeria	**228**
Kaduna	57
Niger	171

Weaknesses in CropIn implementation, training, and the complex design of the application itself were main contributors to the low adoption of CropIn. In Mozambique, CropIn was deployed close to the end of program funding, and implementers felt they did not have time to sufficiently train and roll out the application with the limited time and funding they had available. In Nigeria, the training and rollout for CropIn posed several challenges, including no follow-up trainings, limited involvement of implementing partners, and limited training on all application functionalities. The training was an intensive one-day in-person training. With limited time, VBAs were not trained on all functionalities of the application. One implementing partner said VBAs only received training on how to register farmers and not the other functions, including measuring plots; linking farmers to aggregators; and creating markets, accessing inputs, and providing extension information. Another implementing partner expressed concern about a lack of involvement in the implementation and training:

> *We have a lot of experience and advice that we can offer on how to succeed. But all they tell us to do is to just give them the list of the CBAs…. I had no role in the training. But I had hoped that they should have trained us first. Let us understand what it is, how interesting it is. And they should even ask us, how is the best way to implement it? We can tell them.* (Implementing partner, Nigeria)

Design challenges hindered rollout and uptake of CropIn among intended users. CropIn requires Android 12 to function and many VBAs and farmers did not have access to compatible devices to run the application. Users of the application also reported the interface was not user friendly and was difficult to navigate, especially for those with lower levels of digital literacy. VBAs reported that features that would have been helpful, such as viewing data VBAs entered (such as farm sizes of farmers), could be accessed only by AGRA and not by users of the application or implementing partners. Some VBAs reported the application stopped functioning, perhaps because of the compatibility issues with Android systems.

> *… working with some other farmers who have little or no access to technology I think CropIn has potential but in terms of localizing it to the Nigeria space, it still needs some work … for a CBA to go … collect some information when he doesn't have a lot of time to navigate the application, the interface needs to be quite user friendly…. The application wasn't that, it was [for the] tech savvy.* (AGRA, Nigeria)

In Mozambique, lack of access to smartphones, the cost of data to use the application, and language barriers were the biggest challenges to using CropIn. Implementers reported the largest barrier to uptake of CropIn was access to smartphones among trainees and intended users in Mozambique overall. Phone survey respondents also considered phone ownership the biggest challenge to using CropIn, reported by 43 percent of VBAs in Mozambique. During training, trainees shared phones (sometimes four or five VBAs clustered around the phone of one VBA with a smartphone) and those without smartphones did not interact with the application again. VBAs who owned smartphones had to use their own data to register farmers when using CropIn, incurring additional costs that discouraged VBAs from using the application. Trainees and those who had used CropIn also reported part of the application was in Portuguese and another part was in English (a language most VBAs in Mozambique do not speak) and was a further deterrent to its use among VBAs in Mozambique.

Overview of other digital applications

Because CropIn use was lower than anticipated, we asked VBAs about their use of other applications in our phone survey and in the qualitative interviews. Initial pilot interviews with VBAs and implementors revealed that VBAs had experience with other digital applications, such as Farmex, Kobo Toolbox/ODK, and Plantix in Nigeria and Kugulissa and iStock in Mozambique, which we describe in more detail in **Table 5**. Our findings around VBAs' experiences with digital tools therefore center on these digital applications. VBAs and implementors reported that usage of these digital applications was relatively low. As shown in **Figure 2**, fewer than 30 percent of VBAs regularly used even the most popular digital application.

Figure 2. Regular usage of applications by VBAs
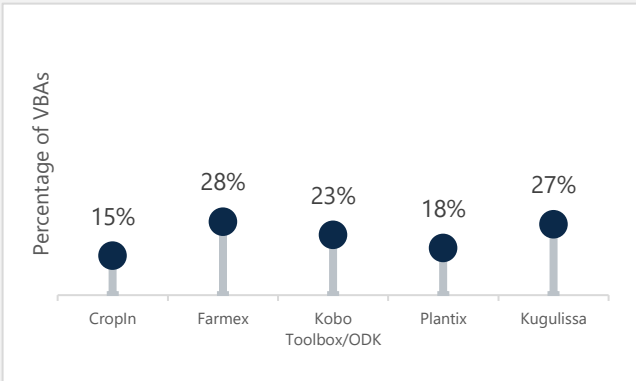
Source: Geopoll phone survey (2024).

Note: Regular usage was considered using the application two to five times a week or most days.

CropIn (n = 53), Farmex (n = 57), Kobo Toolbox/ODK (n = 121), Plantix (n = 66), Kugulissa (n = 37).

Although the digital agriculture application landscape in Mozambique is still in early development phases, Nigeria has a robust environment of agricultural applications used by extension advisors (including VBAs), farmers, input providers, and market actors. In addition to our focus digital applications, key informants noted a number of other applications that were in operation in their areas (**Appendix A**). We found a greater number of digital applications mentioned in Nigeria than in Mozambique, which makes sense given the greater development of digital infrastructure and smartphone penetration. Most applications in Mozambique were market connection applications, whereas the majority of applications in Nigeria were extension information applications.

Table 5. Digital applications used by VBAs in Nigeria and Mozambique

| Digital applications	Description	Information or market application
Farmex (Nigeria)	Launched in Nigeria in July 2023 by Extension Africa, Farmex is an agribusiness extension application that facilitates linkages between extension agents, farmers, and market actors to fulfill demand for farming inputs, tools, services, and markets. Extension Africa co-financed 100 Android phones to VBAs with the Farmex application pre-loaded onto the devices, as it was not publicly available in the Play Store. Many VBAs and farmers had phones that were not compatible with the application and attempts to install it on other models of phones failed. Users of Farmex stated that WhatsApp served as a good alternative to the application for facilitating market linkage.	Market and information

Digital applications	Description	Information or market application
Plantix (Nigeria)	Plantix is a mobile application that uses artificial intelligence and image recognition to help users of the application identify issues with crops—including plant diseases, pests, and nutrient deficiencies—with the overall goal of increasing crop yield and quality. Users take a photo of a plant and Plantix analyzes the photo against a database, then provides a diagnosis and next steps, such as applying pesticides or fertilizers, to address the issue. Plantix is publicly available in the Play Store and popular among VBAs and farmers interviewed in Nigeria who spoke very positively of the application.	Information
KoboCollect (Nigeria)	Associated with AGRA but not considered a digital extension application, KoboCollect enables VBAs to collect data on farmers' profiles, including yield data. Even though it does not offer extension advice or services like other applications in our scope, many VBAs in Nigeria reported using it in our qualitative interviews.	Neither
Kugulissa (Mozambique)	Kugulissa is a market and extension information-sharing platform with information on product demand, prices, and availability within communities and providing linkages between VBAs, farmers, input providers, and off-takers. VBAs interviewed in Mozambique who received training on the Kugulissa platform faced similar challenges as those trained in CropIn: not all trainees had smartphones, so trainees shared phones. The implementers did provide some phones to trainees, but some of those trainees interviewed reported that when the phones broke or were lost or stolen, they could not afford to replace them with a smartphone that had the application. Those without phones could not use the application again. For farmers to use the application, they had to be registered by VBAs, but VBAs noted that registration was difficult because they had a large number of farmers under their purview and as a result registered few farmers. VBAs and one input provider interviewed noted that the application had potential to make it easier for buyers to know the availability of products in communities and make prices more transparent, but there are not currently enough users to fully realize that usefulness. Implementation staff reported in interviews that registering farmers was a challenge but the ideal outcome would be to have more farmers as the end users of the application to remove extension agents as the intermediaries delivering messages.	Market
I-Stock (Mozambique)	I-Stock is an application to support agro-dealers' management of stocks and inputs. Some VBAs received training in iStock, but training took place close to the end of program funding and qualitative interviewees reported not using the application, which an implementer confirmed was no longer running at the time of the interview.	Market

Gender and age differences in usage

Women and young VBAs were just as likely to use digital applications as men and older VBAs, according to survey data (**Figure 3**). We found a similar number of female (20 percent) VBAs regularly used digital applications they were trained on compared to men (23 percent). Young VBAs were slightly more likely than older VBAs to e regularly using their digital application than older VBAs (25% vs. 20%). While there were not great differences between men and women, women are under-represented among VBAs overall and so the minority of women who became VBAs are likely to be somewhat atypical (e.g. more entrepreneurial, tech-savvy), and they were, on average, four years younger than male VBAs. Other research has found that when it comes to digital agricultural technology in Sub-Saharan Africa, women are generally disadvantaged, as are those who are less wealthy and poorly educated (Coggins et al., 2022, Steinke et al., 2021, Porciello et al., 2021).

Figure 3. Regular digital application users, by gender and age group
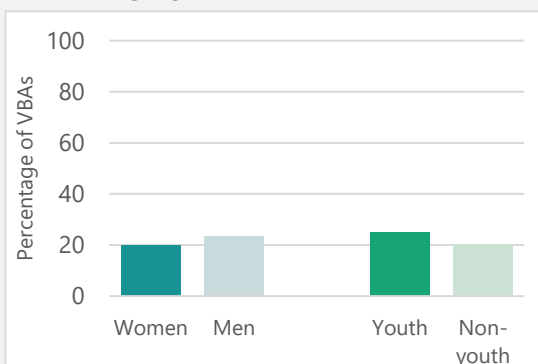
Source: Geopoll phone survey (2024).

Note: Regular usage is defined as two to five times a week or most days within a month.

N = 280.

Interaction with farmers

Research questions: How does digitalization affect interaction between VBAs and farmers? (e.g., can it increase frequency of interactions? What types of messages are more effectively conveyed over digital vs. in person). How does AGRA's digital extension interventions increase efficiency, reach, and quality of content?

Findings from our qualitative and quantitative data suggests that using digital applications expanded the frequency and quality of interactions of VBAs. Most VBAs who used digital agricultural applications regularly reported that use of these tools increased their ability to interact with farmers more frequently with more accurate information, especially with pest and disease identification and treatment. The biggest advantage that VBAs reported in providing extension services digitally, compared to in-person, was the efficiency and frequency of interactions with farmers (44 percent). In qualitative interviews, VBAs appreciated the efficiency of digital content, reporting they could reach more farmers at once by sending messages to farmers in groups (mainly through WhatsApp or short messaging service [SMS]), saving both time and money. FGD participants explained that applications have enabled VBAs to offer extension advice digitally without always necessitating an in-person visit to farms, which VBAs, in both our interviews and surveys, reported increasing the number of interactions they had with farmers. In Nigeria, VBAs frequently highlighted Plantix as an example of this, because farmers could send the VBA a picture of the pest or disease affecting their farm and VBAs could run it through Plantix, providing a diagnosis and recommendation through the phone.

Through Plantix I have received a lot of referrals from my farmers because they are impressed with the way the application works. (VBA, man, Nigeria)

Because you have the digital applications in your phone you can render support to your farmers at any time of time of the day. You don't have to necessarily be with them in person. By so doing, you can attend to many farmers in a day than (compared to) when you have to be with them in person to support them. Considering the fact that you may be busy as well or could have distance constraints you may not be able to attend to the number of farmers you would have like liked to attend to a given time. (VBA, woman, Nigeria)

Farmers and VBAs prefer in-person and digital interactions for different scenarios. Farmers and VBAs we spoke with agreed that in-person demonstrations make it easier for people to learn, and they especially highlighted the importance of in-person interactions when farmers had questions or required consultation from VBAs. In Mozambique, farmers with lower levels of literacy shared that in-person interactions were especially important to them, as they tended to not get much out of written content delivered digitally. Farmers without smartphones especially valued the prioritization of in-person interactions.

I prefer face-to-face because I get to enjoy ample time. I have enough time to ask questions and receive answers. Digital platforms have their shortcomings. It is not suitable for sharing certain knowledge. But in-person is suitable for all knowledge. Moreso, face-to-face helps the VBA to make more reliable decisions because he can physically view the challenge being faced. (Farmer, man Nigeria)

Many farmers and VBAs agreed that although certain trainings or farm visits to consult on challenges best occurred in person, arranging of logistics like meeting times, weather information, and information on inputs such as seeds, pesticides, and herbicides were easier to disseminate digitally. Similarly, phone survey respondents reported that the most useful information to provide digitally include information on improved seed varieties and other inputs, weather forecasts, crops diseases or pests, and answers to specific questions and answers (**Figure 4**).

Information about weather condition of a particular state or region can be shared digitally.… But when it involves challenges you are facing in your farmland, in-person would be preferable. (Farmer, woman, Nigeria)

I prefer to use digital tools to inform him to come and examine my farmland where the need arises. For instance, he can send me a picture of what to purchase on WhatsApp platform. (Farmer, man, Nigeria)

Farmers, implementers, and VBAs noted that digital applications are best suited to reminders and targeted recommendations but could not replace training on good agricultural practices. They found digital messages to be useful for specific information, such as weather predictions or disease outbreaks, or as reminders on when to plant and what seed varieties to use after farmers received training. One program representative noted they moved from simply relying on digitally disseminating training into in-person video training (short video trainings disseminated using a portable projector to groups of farmers) because they realized this in-person format was a much more effective medium for

training. The live training also enabled them to reach more women than relying solely on digital communication, given women's variable access to smartphones in Nigeria and Mozambique. VBA respondents in Nigeria preferred in-person engagement in order to relay certain types of information because VBAs can encourage farmers to ask clarifying questions and confirm their understanding.

> *Although, you can invite them for the training via WhatsApp, but you would need to train them face to face for them to have good comprehension of the knowledge. Moreso, some farmers don't know how to ask questions in writing format but in-person. They are more comfortable asking question via word of mouth. As a matter of fact, as a VBA you would understand what they are trying to say better when they communicate in this format."* (VBA, woman, Nigeria)

Figure 4. VBAs' perceptions of most useful information to provide farmers digitally
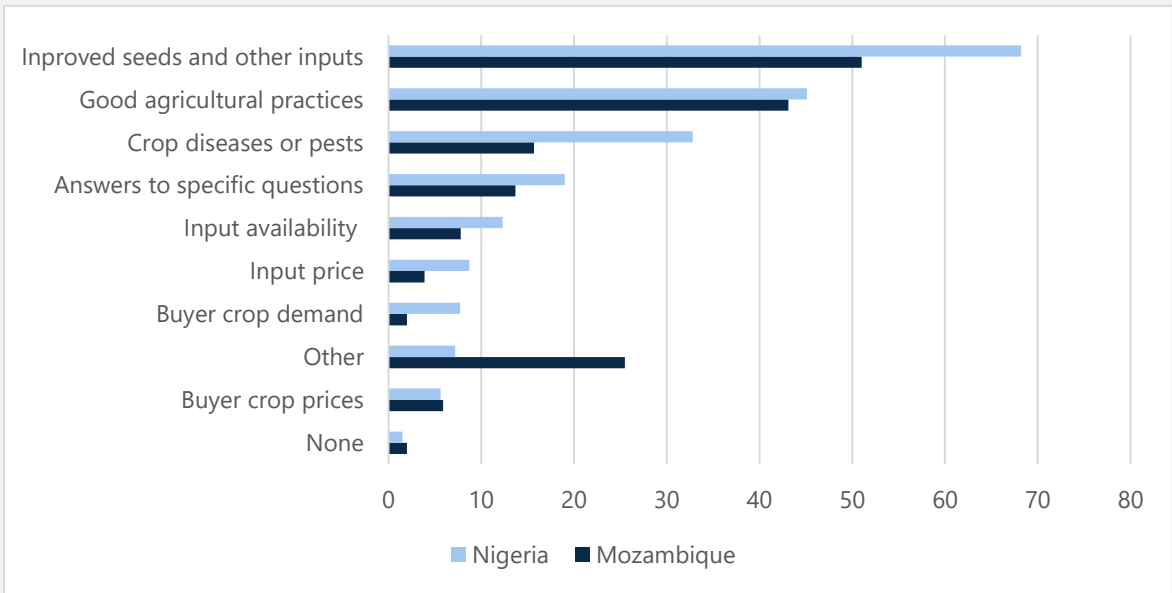
Source: Geopoll phone survey (2024).
Full sample (N = 246); disaggregated by Nigeria (n = 195) and Mozambique (n = 51).

Overall factors affecting digital tools usage

Research questions. What are the key drivers of barriers that drive or hinder use of digital solutions, and how to these differ for women and youth? How successful are various digital extension platforms and models' effectiveness in different contexts and what are the drivers of that success? What are the post promising change pathways for digitizing VBA services (that is, through knowledge acquisition, behavior change prompts, connection to input and output markets, and so on)?

The main factors contributing to effective and expanded use of digital tools include digital infrastructure, access to necessary devices and associated costs, application design, and level of training. In **Error! Reference source not found.**, we provide an overview of these challenges and facilitators, and the extent to which the VBAs in each country experienced them according to the phone survey. VBA respondents indicated weak digital infrastructure and complicated application designs limit

their ability to understand and properly use digital tools, but having adequate training and supports can help overcome these barriers. We discuss each of these factors in detail below.

Figure 5. Challenges and facilitators with using digital applications
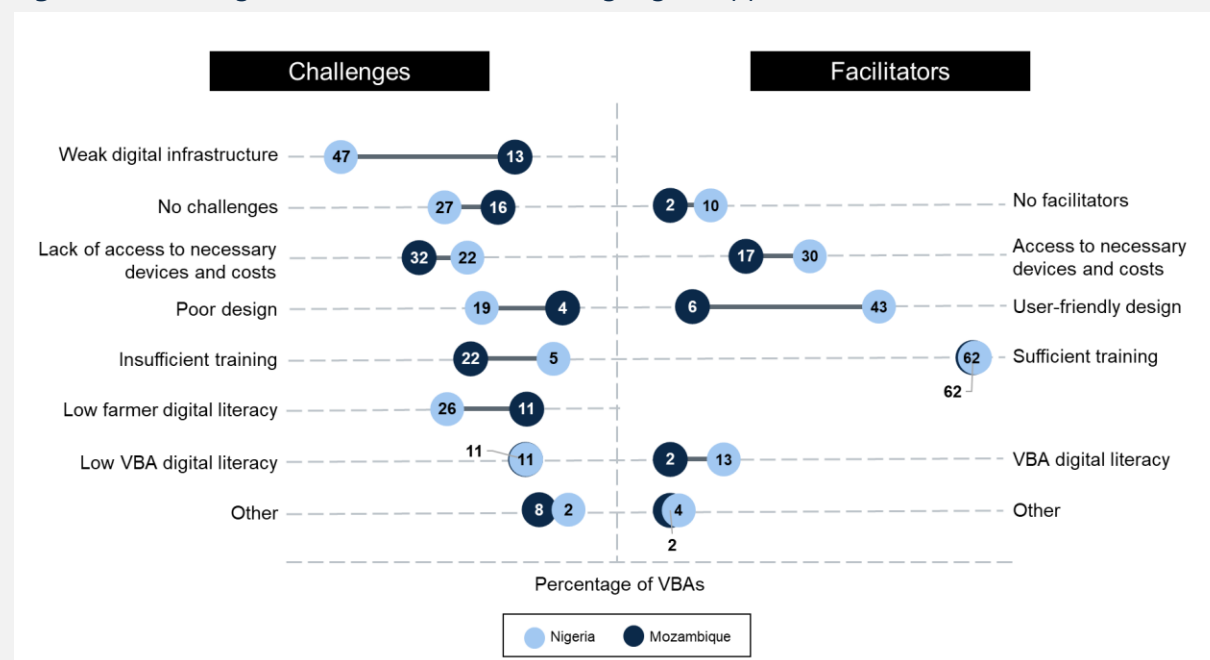
Source: Geopoll phone survey (2024).

Note: Access to necessary devices and costs includes phone ownership, mobile data costs, and phone compatibility. Digital infrastructure includes internet access and access to power or electricity. Application design deficiencies include digital application not working or only working sometimes, application not available in local language, application not interactive, and issues with registration. Farmers' digital literacy and acceptance includes farmers find application difficult to understand, farmers don't trust digital application, and farmers prefer in-person training.

Full sample (N = 280); respondents for challenges include nondigital application users (n = 34) and digital application users (n = 246). Respondents for facilitators only includes digital application users (n = 246).

Digital infrastructure

Respondents reported that unreliable network connection and electricity hindered digital application usage, effective training, and scaling. Network access was the biggest barrier among phone survey respondents, with 41 percent of VBAs reporting it as a challenge, a notable barrier among focus group participants as well. Respondents not only noted that poor network connection made it challenging to use their digital apps, but access to electricity was also a problem in using their smartphones, particularly in Mozambique. VBAs across Mozambique and Nigeria reported the lack of reliable network connection as a major challenge during trainings on digital applications, noting that they often could not use tools properly during training periods, which affected their level of understanding. The literature also identified a weak digital infrastructure as a priority challenge for scaling of digital applications (Deichmann et al. 2021; Fabregas et al. 2019; GSMA 2020).

> *The challenges is the network, whenever you want to download it will be difficult, maybe the application is heavy, I don't know even when we went to Minna, we went with some of our members here, even our facilitator there we had big problem, if we had been able to download it in our*

phones it would have been easy because we will get him to teach us but we couldn't download let alone having proper training on it. (VBA, man, Nigeria)

Access to necessary devices and associated costs

Another primary barrier to the use of digital applications was application-compatible smartphone ownership and associated costs. Smartphone ownership was supposed to be a prerequisite to digital application training, but this did not always happen in practice. In FGDs, respondents in both countries reported that some VBAs did not have access to devices compatible with digital tools, primarily because of the high cost of compatible smartphones. The primary challenge for VBAs in Mozambique was smartphone ownership, whereas VBAs in Nigeria expressed more challenges with compatibility between their smartphones and diverse digital tools. VBA respondents recounted multiple instances when they could not download or use digital applications because they were not compatible with a specific brand or model of smartphone. VBAs who reported being provided with phones or tablets with applications already downloaded and set up, however, had a more positive outlook on their ability to use the applications to improve communication with farmers.

> *I don't like the fact that Plantix functions only with certain android versions. (that is, Android version 7 and above).... Even during the training only participants who own smartphones with high android versions could practicalize it.* (VBA, man, Nigeria)

> *There is also limitation associated with the android versions of the Smart being used. The application does not on low end android versions but high-end android versions.* (VBA, woman, Nigeria)

VBAs also had to cover costs of using digital applications, such as data costs and potential application subscriptions fees. VBAs perceived that some applications, including CropIn, consume a costly amount of mobile data, leading users to limit their time using the application. Female FGD participants were especially vocal about the related cost barriers.

> *CropIn for instance requires heavy data to operate. This is not economically friendly, especially with the current cost of data services.* (VBA, woman, Nigeria)

> *The cost of data is gradually increasing, and a VBA needs data to upload information on a regular basis. I think AGRA should consider providing mobile data to VBAs. The fact is as much as we want to admit that applications have been useful, it has its own cost as well.* (VBA, woman, Nigeria)

Application design

VBAs were dissuaded from using applications with overly complicated designs. For example, applications that required a lengthy log-in and registration process were more difficult for VBAs and any participating farmers to adopt. The more information required for a given application, such as log-in information and verification codes, the more it appeared to VBAs that farmers were reluctant or unable to use the application. Applications that required an email address for registration also posed a challenge, as many participants might not have email accounts. In FGDs, participants discussed applications they perceived as complicated and not user friendly (like CropIn) far less than applications they perceived to be simple to operate (like Plantix).

Some of the source of this application overcomplication might be due to what some call the "design-reality gap" evidenced in many digital applications. The design reality gap is when applications are informed by a strong technological rationale but are misinformed about users' interest and capability so an application that works well under ideal conditions with technologically proficient users fails to connect with users on the ground. One study found that many digital information services in low- and middle-income countries were created by technology enthusiasts, often with international donor funding, which requires a fully planned application before rolling it out in the field. (Dodson et al. 2013) This inhibits the ability to do iterative user-focused designs. The lack of working directly with intended users to design the applications has limited the ability for scale up.

Applications that provide simple messaging in local languages, on the other hand, can help VBAs in using the application. Farmers with limited English or Portuguese proficiency reported content that was not in a local language was a greater challenge than it was for VBAs. Comparator programs and implementers therefore emphasized the importance of simple messaging in local languages that would resonate with farmers. One digital application representative told us it took them several years to come up with the right words that would resonate with farmers. They initially tried very precise, descriptive, and lengthy messages, but found these messages did not resonate with farmers. They had to iterate repeatedly to find the right messages in the local language. They even had to simplify messages that said "high chance" of rain. When they found the right simple language, adoption improved.

> *In Niger state you will meet people that cannot speak English and cannot speak Hausa they only speak their indigenous language so for them to make use of the application.* (Input provider, Nigeria)

Training

Alongside user-friendly application designs, VBAs could better use digital applications if they receive adequate training on how to use specific applications. As shown in Error! Reference source not found., phone survey respondents considered training the biggest facilitator of application usage, and was reported by more than 60% of VBAs in both countries. Conversely, respondents from qualitative interviews who expressed confusion or inability to understand and operate digital applications noted insufficient training as a contributing factor. VBAs spoke highly of the training for KoboCollect, a popular application in Nigeria. Implementers of the KoboCollect training highlighted their focus on interactive sessions with demonstrations,1:1 support for trainees and ensuring that all participants had their own phone to follow along. Moreover, focus group participants reported positive feedback on follow-up and refresher trainings (among those who received them), noting the sessions helped trainees feel more confident in using the application independently and training others on the applications. Several VBAs who did not receive refresher trainings, such as those trained in Farmex and CropIn, said refresher trainings would have been helpful for their understanding and use of the applications. A comparator program implementer noted that multiple, repeated trainings for their application was a key success factor in users successfully and confidently using the application and all its functions.

Differences in challenges based on age group and gender

All groups rated digital infrastructure as a top challenge, but there were some differences by gender and age. Both women and men VBAs reported that the weak digital infrastructure was the biggest challenge they faced in using digital applications (Error! Reference source not found.). However, more women VBAs reported facing no challenges, and a higher share of women VBAs also reported

challenges with application designs and digital literacy. This is a somewhat surprising finding as most studies have found that women have less access digital technology and are less prepared to interact with it. It is possible that the women who self-select as VBAs are more digitally savvy than typical women.

In terms of using digital applications for sharing farming knowledge, some women VBAs in Nigeria reported facing distrust and suspicion about information from digital tools from farmers, but several noted that when the opportunity arose to allow the farmer to use the application or tool themselves (either by having them look at a VBA's phone or installing it on a farmer's device when available) this distrust was often mitigated and farmers appeared more receptive to information.

> *They don't listen to us because we are women but if we give them the application and they go round their farmland by themselves and they got the measurement they will now believe us…. The farmer I used this for, I installed it in his phone. He went home and tried it, the result I got was exactly what he got. So, he believes me.* (VBA, woman, Nigeria)

Figure 6. Challenges with using digital applications, by gender

Source: Geopoll phone survey (2024).
Full sample (N = 246); disaggregated by women (n = 46) and men (n = 200).

Young VBAs were also more likely to report no challenges with using digital applications (Error! Reference source not found.) than older VBAs. This is not surprising given young people's greater fluency with digital technology. Implementers in both Nigeria and Mozambique pointed to recruiting a high number of young VBAs as a key driver of successful digital programs due to their higher levels of digital literacy. We also found that a higher share of youth reported challenges with reliable networks and electricity and application design deficiencies, which likely reflects their higher engagement with those applications.

Figure 7. Challenges with using digital applications, by age group
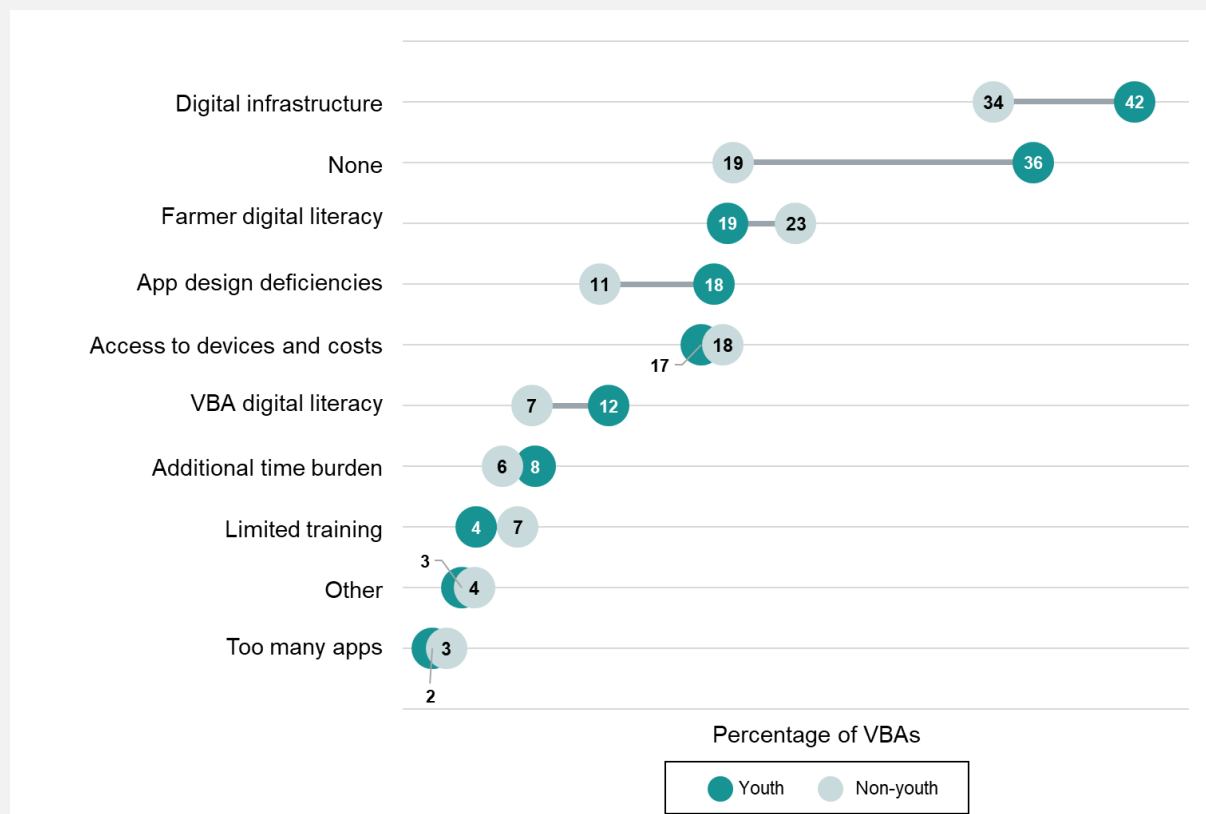
Source: Geopoll phone survey (2024).

Note: Access to necessary devices and costs includes phone ownership, mobile data costs, and phone compatibility. Digital infrastructure includes network reliability and access to power or electricity. Application design deficiencies include digital application not working or only working sometimes, application not available in local language, application not interactive, and issues with registration. Farmers' digital literacy and acceptance includes farmers find application difficult to understand, farmers don't trust digital application, and farmers prefer in-person training.

Full sample (N = 246); disaggregated by youth (n = 120) and non-youth (n = 126).

Messaging applications and platforms

Compared to digital applications, VBAs are more likely to use messaging platforms. Although a growing number of VBAs use digital applications, particularly in Nigeria, a higher percentage use messaging applications or platforms (**Figure 8**), such as WhatsApp, Facebook messenger, or SMS. Among those using both digital applications and messaging platforms, more than 70 percent of respondents from the phone survey preferred messaging platforms over digital applications.

Figure 8. Digital application and messaging platform usage and preference
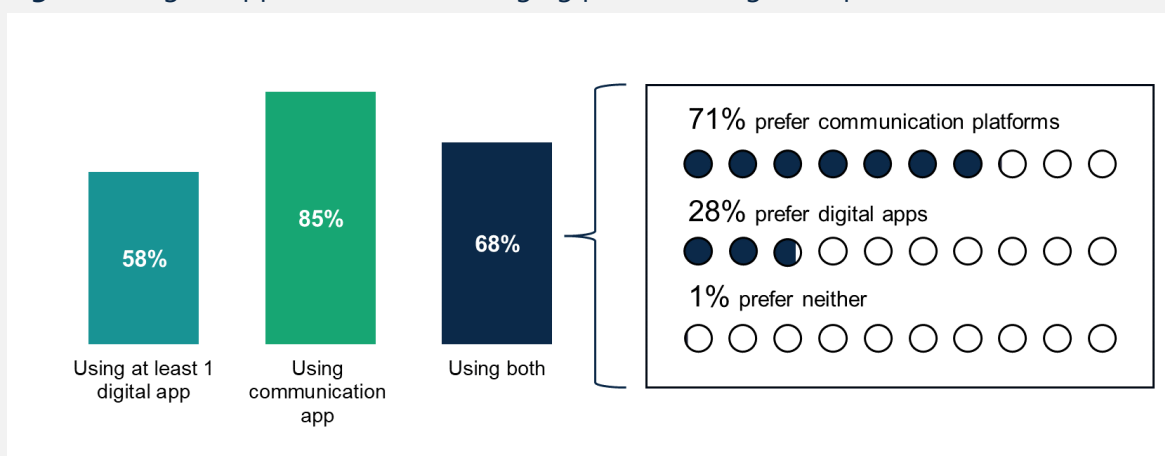
Source: Geopoll phone survey (2024).

Full sample (N = 294); sub-sample of those who used both digital applications and communication platforms (n = 201).

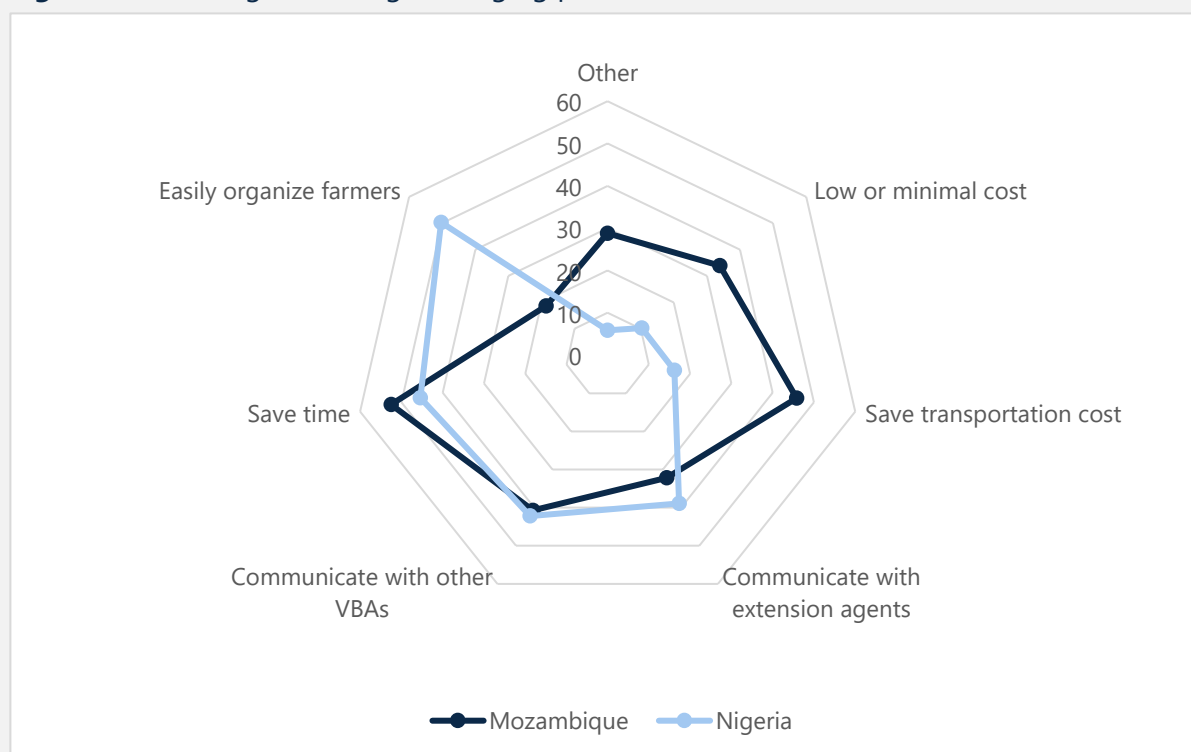**VBAs' preference for communication applications rather than digital platforms could be due to certain advantages, such as time savings and ease of communication with farmers, other VBAs, and extension agents.** In Nigeria, the ability to organize farmers easily was an important advantage of communication platforms over digital applications, with half of VBAs reporting this as an advantage compared to less than one-quarter in Mozambique. Many focus group participants also noted they communicated with other VBAs through WhatsApp and SMS, and with farmers through SMS or phone calls, because many farmers do not own smartphones. Farmer FGD participants who owned smartphones (mostly in Nigeria, but also some in Mozambique) found WhatsApp communication with VBAs especially useful for treating infestations or diseases in their fields because they could share photos and receive treatment recommendations from VBAs. VBAs in Nigeria found WhatsApp especially helpful for sharing training videos with their farmer groups, particularly those with visual reminders of GAPs (such as the correct distancing of rows for planting) and answering questions from farmers about the training videos they send. VBAs in Mozambique highlighted the importance of SMS in communicating with farmers, as they often lived far from their farmers and messaging enabled them to still send reminders and advice despite the distance.

> … when I want to organize a general training I can send [farmers] information about the time, date and venue via WhatsApp group or SMS. I can also ask to know the current situation of my farmers' farmland. I can give my farmers instructions on what variety of seed to plant, when to plant it, when to apply fertilizer, distance between stands and so on. All these messages can be sent digitally, and the farmers comprehend. (VBA, woman, Nigeria)

Costs savings appeared to be a bigger advantage for communication platforms in Mozambique. Compared to VBAs in Nigeria, a higher share of VBAs in Mozambique cited transportation cost savings and the low cost of communication platforms as advantages (**Figure 9**). Several VBAs noted purchasing data for WhatsApp was less costly than SMS, further increasing popularity of WhatsApp among many VBAs for communications.

Figure 9. Advantages of using messaging platforms

Source: Geopoll phone survey (2024).

Full sample (N = 250); disaggregated by Nigeria (n = 188) and Mozambique (n = 62).

Most VBAs used communication applications or platforms to share information with their farmers, with some differences in usage by country. Similar to digital applications, VBAs used communication applications or platforms to communicate, share information, organize, and provide market linkages to farmers (**Figure 10**). Nearly 90 percent of VBAs in both countries used communication platforms to share information with their farmers, including weather information, reminders on GAPs, and knowledge or extension information. About 10 percent more VBAs in Mozambique than in Nigeria reported using communication platforms for market connectivity. In our previous report, we found the long distances between farmers and market actors was a salient challenge for VBAs in Mozambique. This physical inaccessibility, paired with the reported advantages of communication platforms as low cost, time saving, and transportation cost saving (as discussed), might be why more VBAs in Mozambique used communication applications for market connectivity than those in Nigeria.

Figure 10. How VBAs use messaging platforms
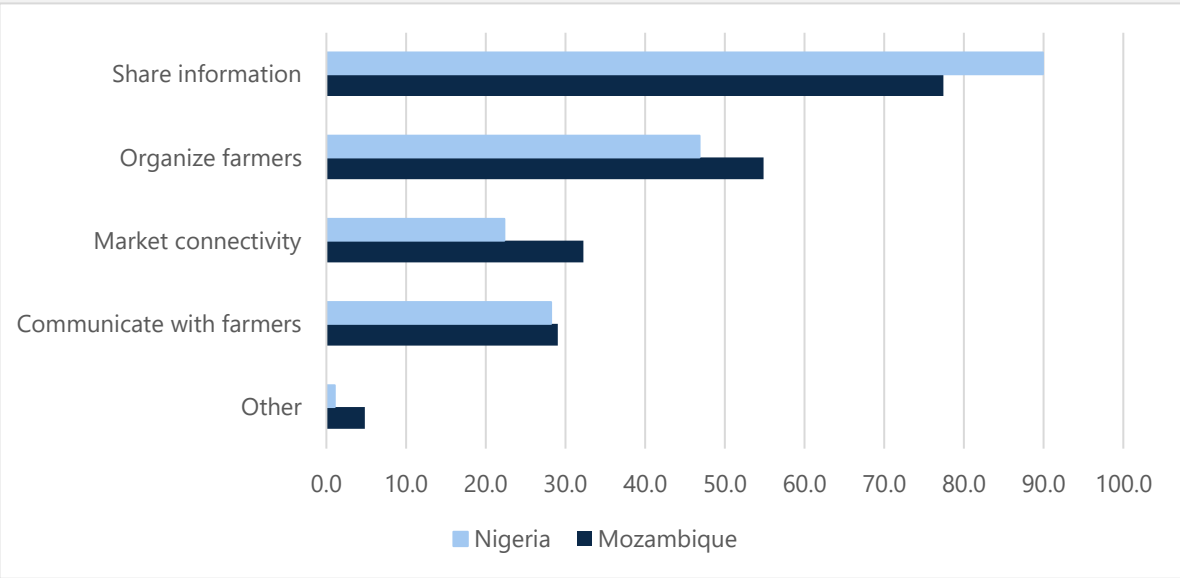
Source: Geopoll phone survey (2024).

Note: Sharing information includes sharing knowledge or extension information with farmers, sharing weather information, sending reminders about GAPs, sharing farmers' information and challenges with extension agents, and sharing pictures or videos. Market linkages include sharing input availability; sharing input prices; connecting farmers to input providers; sharing market prices; and connecting farmers to buyers, off-takers, and aggregators. Organize farmers includes organizing farmers for trainings or off-taking.

Full sample (N = 250); disaggregated by Nigeria (n = 188) and Mozambique (n = 62).

The ability of communication applications and tools to address common challenges in information dissemination is likely the reason for farmers' and VBAs' preference. One study that drew from interviews of digital extension tool developers across 40 countries and a systematic literature review, found 15 pitfalls typically constrained the use of digital applications (Coggins et al., 2022). These pitfalls include users' unawareness of tool, inaccessibility of the device, inaccessibility of electricity, inaccessibility of a mobile network, the application's insensitivity to digital illiteracy, insensitivity to illiteracy, messaging conducted in an unfamiliar language, application being slow to access and hard to interpret, unengaging, insensitivity to user's knowledge, insensitivity to farmer's priorities, insensitivity to socioeconomic constraints, irrelevancy to farm, and distrust. Nearly across the board, chat applications surmount each of these challenges more easily than specialized agricultural applications and can help explain why farmers and VBAs use such user-driven tools such as WhatsApp, more than externally driven digital applications (Table 6).

Table 6. Assessment of agricultural digital tools according to common challenges

		Chat application (such as Whatsapp)	Specialized agri-application
Access interface	Unaware of digital extension tools	Moderate	Hard to find or share
	Device inaccessible	Smartphone needed	Smartphone needed
	Electricity inaccessible	High	High requirements
	Mobile network inaccessible	Moderate	High requirements

		Chat application (such as Whatsapp)	Specialized agri-application
Access content	Insensitive to digital literacy	Moderate	Hard
	Insensitive to illiteracy	Moderate literacy needed	Moderate literacy needed
	Unfamiliar language	User-driven	Adaptable
	Slow to access	Fast	Moderate
	Hard to interpret	Moderate	Moderate
	Unengaging	Interactive	Moderate
Change behavior	Insensitive to knowledge	Two-way discussion	Adaptable
	Insensitive to priorities	User-driven	Maybe
	Insensitive to socioeconomic constraints	Two-way discussion	Maybe
	Irrelevant to farm	Two-way discussion	Adaptable
	Distrust	Uses social networks	Maybe

Source: Repurposed from Coggins et al. (2022).

Red = most difficult challenge; yellow = moderate or potential challenge; green = not a challenge.

Perceived impacts on farmers and VBAs

Research question: What are the perceived early impacts on VBAs and farmers of digital tool use?

Key findings. VBAs perceived that the use of digital applications had the biggest impacts on farmers' adoption of GAPs, as well as input use and practices; however, they saw less impact on farmers output market activities. Digital applications support VBAs in their work by providing easy access to farming knowledge and information, enabling them to work more efficiently and gain credibility in the eyes of their farmers. In Nigeria, some VBAs also generated income from using digital applications. Targeting extension agents as main users and promoters of applications is one of the most promising pathways for integrating digital tools with public systems, but we found no strong integration among the applications we examined. Market actors in Nigeria bought into digital tools because, with the extension services provided by VBAs also on the platform, they could reach markets of farmers that were previously unavailable.

Perceived impacts on farmers

Research on the use of mobile technologies in agriculture found some positive impacts on farmers but we urge caution in interpreting results. A meta-analyses of studies of digital extension tools found that the transmission of agricultural information through mobile technologies in sub-Saharan Africa and India increased yields by 4 percent and the odds of adopting recommended agrochemical inputs by 22 percent (Fabregas et al. 2019). However, other systematic reviews found more mixed results, with applications affecting farmer-level outcomes in some areas but not others. For example, one review found digital applications improved farmers' knowledge for those who used it; however, impacts in terms of input use, crop choice, farm-gate prices and yields were more mixed (Aker et al. 2016). This same study found digital tools were primarily successful when information asymmetries were high (for example, farmers lacked price data that input suppliers possessed) and when related markets, such as credit and infrastructure, performed well. Another review of the literature found a lack of rigorously conducted

studies, with some studies of the same digital tool coming to opposite conclusions (Baumüller 2018). This study did find that information applications appeared to provide some benefit to farmers in terms of production planning and better management of weather-related risks; however, market connect applications had less evidence for impact on trading patterns. Nearly all studies we reviewed encouraged caution when discussing farmer-level impacts, noting that digital applications were not a panacea, that they have to be coupled with analog technology, and that considerable barriers (as outlined earlier) remained in unlocking their full potential.

In our study, VBAs perceived that the use of digital applications had the biggest impacts on farmers' adoption of GAPs. According to the phone survey, VBAs thought farmers' adoption of GAP was the biggest impact of digital application usage (Error! Reference source not found.). This was consistent with VBAs' comments in the focus groups in Nigeria, in which VBAs reported the digital applications had improved farmers' knowledge of GAPs. In addition, applications that provide reminders helped farmers at all experience levels increase their adherence to GAP, and therefore increase their yields.

Figure 11. VBAs' perceptions of the impacts of VBA digital application usage on farmers, by country
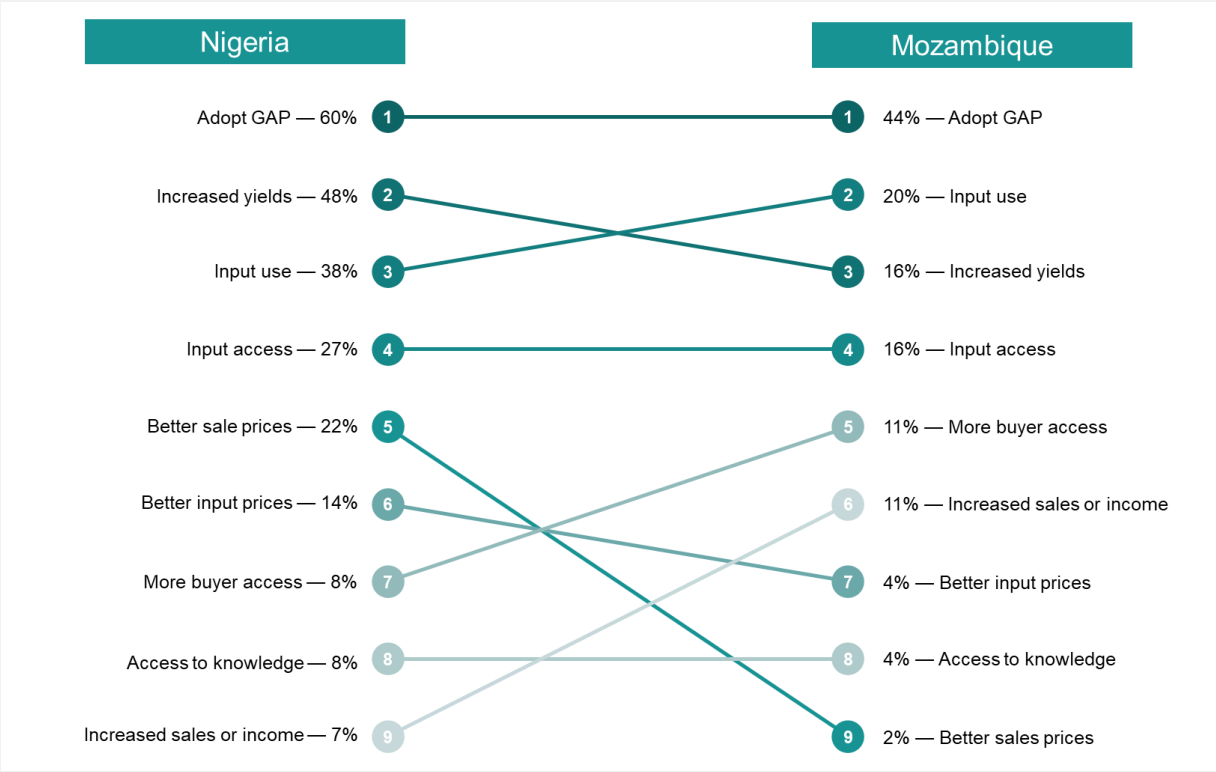
Source: Geopoll phone survey (2024).
Full sample (N = 246); disaggregated by Nigeria (n = 195) and Mozambique (n = 51).

The introduction of digital applications also had some perceived impacts on input use and access and farmers. Input use and input access were among the top five perceived impacts on farmers from VBAs' use of digital applications (Error! Reference source not found.). Not only did VBAs believe farmers used and accessed more inputs, but a handful of VBAs in Nigeria reported in FGDs that farmers had increased the accuracy of their input purchases using applications. Because the digital platforms improved the precision of estimates of farm sizes, farmers could calculate their input needs more precisely.

> *To be able to make a proper and reliable farming budget a farmer needs to establish the farm size. This would help to make a realistic budget. UTME application has helped in achieving that objective. This is paramount because a lot of farmers don't know the actual size of their farmlands. Hence, they make wrong estimate of fertilizer, seedlings, herbicides, and pesticides they require. This can result to poor harvest at the end of the season.* (VBA, woman, Nigeria)

> *The use of digital applications has made an impact on my farmers' adoption of GAP because the wastage they used to incur during planting or application of fertilizer has been reduced since GAP recommends one seed per hole and burying fertilizer instead of spreading. In other words, if they would need 50kg of seedlings hectare before, now it's 20kg per hectare because GAP recommended one see per hole as against 3-5 seeds per hole.* (VBA, woman, Nigeria)

Compared to adoption of GAP and input use, VBAs did not report impacts on output market activities. Namely, being able to negotiate better prices with buyers and access more buyers were among the bottom five farmer impacts by VBAs in the phone survey (Error! Reference source not found.). However, about 10 percent more of Nigerian VBAs could support farmers in negotiating better farmgate prices compared to Mozambican VBAs. Fewer than 10 percent of VBAs cited impacts on farmers' sales and income. This finding is likely due to the fact that the most commonly used applications were information dissemination applications rather than market connection applications.

Impacts on VBAs themselves

Overall, the VBAs perceived that the introduction of digital applications supported their work by providing access to more information, saving time and increasing efficiencies, building trust among farmers, and providing additional streams of income.

Digital applications support VBAs in their work by providing easy access to farming knowledge and information. According to the phone survey, VBAs from both countries reported access to more information as the top impact of using digital applications (Error! Reference source not found.). In particular, VBAs in Nigeria, mainly in reference to Plantix or Farmex, emphasized the importance of having near constant availability to farming knowledge and information in their work.

> *These applications have helped my interactions with farmers because I can easily make references to the application when I need to ensure better understanding. There are times when I would be confronted with a question that I don't have answers to immediately. But with the application I can conveniently get it and disseminate.* (VBA, woman, Nigeria)

Figure 12. Comparison of VBA perceptions of digital application impacts, by country
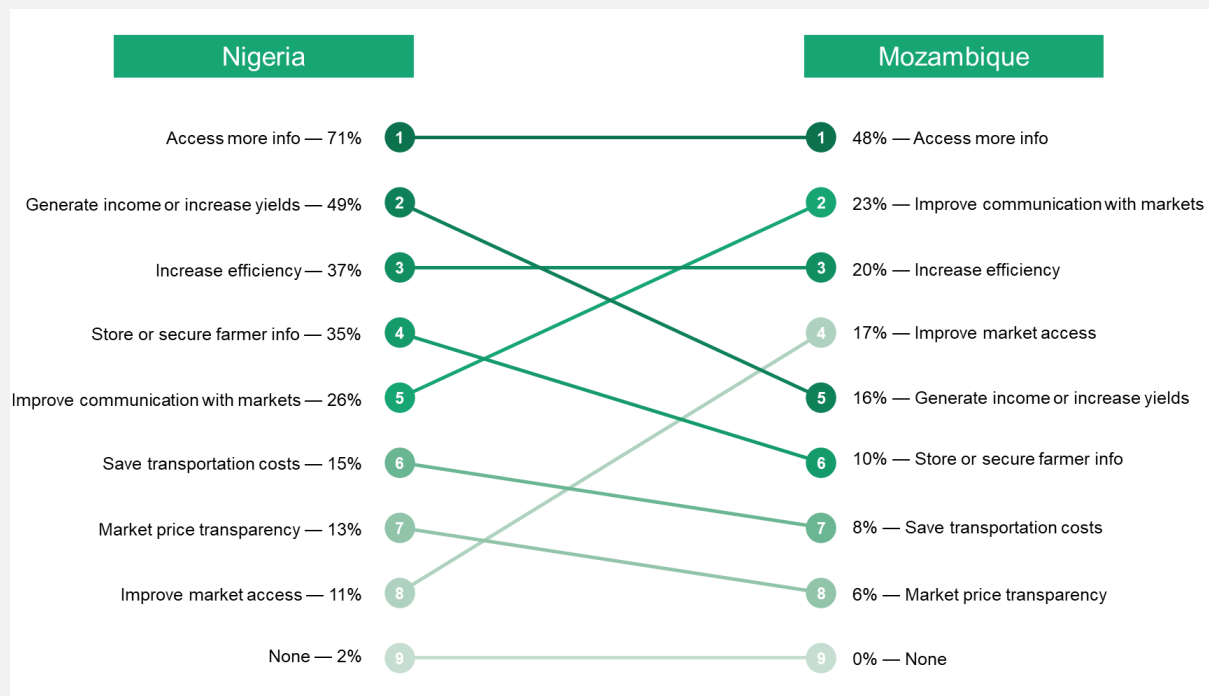
Source: Geopoll phone survey (2024).

Note: Generate income and increase yields includes income generated from commission and using digital applications for other farmers. Increase efficiency includes saving time, making farming easier, and facilitating work.

Full sample (N = 246); disaggregated by Nigeria (n = 195) and Mozambique (n = 51).

VBAs cited time savings and efficiencies as other important impacts of digital applications. Survey respondents considered efficiency and motivation among the top three impacts on their lives and work. Some VBAs in Nigeria explained that applications have increased the efficiency of their extension activities by reducing the time they spend both tracking farmers' activities and offering advice, services, and trainings to farmers. VBAs previously used paper and pen to collect and keep track of farmers' information, but applications such as Farmex, CropIn, and ODK enable VBAs to digitally track data such as crops and land size and send appropriate reminders to farmers. Some VBAs found their extension advice and services to be more efficient because of the immediate access to information and recommendations, and more accurate and efficient ways to measure farm size.

> *Before now, VBAs used a lot of words to explain information or knowledge to a farmer. But with the use of digital applications … the application does most of the work. For instance, to establish the cause and remedy to an unknown disease confronting a plant I would only need to log into the application and snap the leaves instead of using a lot of words to explain to the farmer the cause and remedy to the problem.* (VBA, man, Nigeria)

Gaining farmers' trust was an important impact of digital application usage. Several VBAs reported that farmers' trust in their extension advice increased when they used applications. VBAs' confidence in the information they disseminated also increased, as they could tap into and offer accurate advice in situations when they previously would not have had answers to farmers' questions or concerns.

The applications have helped a lot. To the best of my knowledge successful farming starts with selecting the right seedlings. Sometimes when I advise farmers on variety of seedlings to plant, they tend to be skeptical about it but with the use of application like CropIn the farmer is more convinced about my recommendation. (VBA, woman, Nigeria)

In the phone survey, nearly half of Nigerian VBAs reported generating income from using digital applications. FGD participants explained that farmers within or even outside their communities offered to pay VBAs a fee for their services and sometimes reimbursed VBAs' transportation costs spent traveling to farmers' land to measure the sizes of their plots or to diagnose plant pests or diseases via the digital applications. Several VBAs in Nigeria also reported that the extension information available to them through the applications was helpful in their own farming and led to improved harvests and an increase in income. VBAs in FGDs in Mozambique did not report using applications to generate income.

Digital tools and interactions with public and private systems

Research questions. How do digital solutions fit in with government digital platforms or interventions? How can digitization programs bring more service providers on board (input and market access)?

Public sector

Engaging extension agents as main users and promoters of applications is one of the most promising pathways for integrating digital tools with public systems, but we found no strong integration among the applications we examined. Based on KIIs with implementers and government representatives, Nigeria's extension policy favors integration of digital tools, but actual uptake and use of those tools lags far behind the private sector. Government representatives who participated in our KIIs were very aware of the agricultural digital landscape and named at least a dozen applications they found to be promising. They also indicated that they were experimenting with these applications in public extension work. The public sector does not currently directly support the implementation of AGRA digital tools in Nigeria or Mozambique; however, Nigeria is working with other applications that train extension agents on the use of other applications.

Government extension capacity to absorb new digital tools is limited. Government policy in Nigeria often focuses on expanding the number of extension agents, but typically falls short. As a result, active extension agents often have limited capacity and are frequently older and less digitally literate. Key informants in Mozambique described an extension system with some extension agents using applications in their work, but many others felt their capacity to learn new tools was low, often stretched thin with many hundreds of farmers under their extension oversight across a large geographic area. In combination with the other challenges facing digitization efforts in Mozambique (access to smartphones, network connectivity, cost, and so on), Mozambique's extension system has not yet deeply integrated digital tools among all extension agents, or in extension policy (and unlike Nigeria faces a deficit in functional, useful agricultural applications).

For digital applications to scale, they will need public or donor support. Comparator programs noted their biggest challenge in achieving scale was the lack of farmers' willingness to pay for the information. As such, these applications will likely not scale solely by commercial means, and many find there is a clear role for public or donor support for digital extension to reach as many farmers as might benefit (Fabregas et al. 2019; Deichmann et al. 2016; Steinke et al. 2021).

Private sector

Market actors in Nigeria were interested in digital tools because they provided the possibility of reaching of farmers who were previously unavailable. An input provider in Nigeria highlighted three crucial elements that were necessary for their buy-in to Farmex: access, extension, and earnings. Through Farmex, one input supplier noted he could get the pulse on farmers' demand across communities, receive orders from farmers, earn a commission through these sales, and provide the necessary GAP guidance to ensure successful use of inputs by farmers. The input provider did not have the capacity to do this extension work privately, but by offering commission to VBAs to sell their products in the VBA's community, they could increase their sales. Beyond Farmex, multiple applications in Nigeria found similar partnerships with the private sector, including herbicide, pesticide, seed, and fertilizer companies.

Nigeria had more private sector engagement compared to Mozambique and strong alignment of interests, but the market applications we reviewed had not reached much scale. These implementers still worked to onboard enough market actors and prove that connections through the application could be profitable and viable. One market application developer told us that often the commission that an agent could earn by connecting a farmer to a market was simply too small to provide a meaningful salary. Particularly on the output side, the issue of trust (that farmers would come with sufficient quantity and quality of produce and that buyers would pay a fair price) was a significant hurdle, as was the inability of digital applications to provide the convenience and immediacy of payment that middlemen can offer.

Mozambique had fewer examples of successful integration of digital tools with the private sector but highlighted the need for market connection tools. We interviewed one market connection application developer in Mozambique who highlighted the immense need for market access among Mozambican farmers as the strong rationale for developing their market connection application. However, they faced significant hurdles in ensuring payment to farmers, transporting goods, and ensuring confidence in the quantity and quality of produce, which hampered their ability to onboard enough market actors. The developer noted they were not 100 percent confident they would achieve success.

Market connection applications face a unique set of barriers, including establishing trust, access to credit, and drawing in a critical mass of market actors. Implementers of comparator programs noted the difficulty in scaling market connectivity applications largely due to challenges in generating trust from both buyers and sellers and access to credit. They noted traders might not trust that farmers will produce output at sufficient quality and the farmer might not trust that they will receive a good price. The only way to ensure that trust is to work through a trusted intermediary, such as known members of communities like VBAs. However, even in these cases, it can be difficult for an intermediary to ensure quality for a supplier and to convince a farmer to sell to a new buyer. Farmers will often instead revert to selling to a middleman who is familiar and who can buy at farmgate more immediately.

> *But it's hard to make a rural farmer trust the urban trader. This is a big challenge. The trader wants to affirm the quality, but the farmer doesn't trust they will be paid. The only way this works is to have an intermediary who can confirm trust. The trader trusts the NGO. The farmer trusts the NGO.* (Comparator program representative)

A VBA FGD participant echoed the importance of ensuring quality on the farmer end and ensuring price delivery on the buyer end as a big impediment to market applications:

> *Truly majority of them [farmers] don't like it [applications connecting farmers to dealers, buyers] because some of their farm produces are not very good some are bad and have infection our farmers will just mix them up and the company people will check if the crops are not healthy, they will not buy it with good price but in the market, they will buy it whether the crops are healthy or not.* (VBA, mixed, Nigeria)

However, even when trust is established through an intermediary, farmers can still lack credit to purchase inputs and/or get them delivered. Due to these challenges, most of the market connection programs we interviewed were not at the scale they had hoped. They struggled to onboard market actors and farmers and had not reached a critical mass that would entice others to join.

Challenges of scaling digital applications

Putting our findings into a broader context, we found that despite the proliferation of digital tools in sub-Saharan Africa, many have failed to scale. There has been a massive proliferation of digital applications for agriculture in the past several years and, despite the challenges in terms of digital infrastructure, smartphone penetration and digital literacy have grown in sub-Saharan Africa, outpacing the growth in other continents. For example. for digital financial services in agriculture, one review found that by 2020 there were 437 services in sub-Saharan Africa, 105 in South Asia, 99 in Southeast Asia, and 59 in Latin America and the Caribbean, with the growth in sub-Saharan Africa at least partly driven by the prevalence of mobile money across many markets (GSMA 2020). Despite the growth in the number of applications, many of them have failed to scale. One survey of digital service providers in the global South found that overall adoption has been low; their tools failed to reach even 1 percent of the intended population (Sida et al. 2023). Uptake among government and private sector actors of these tools remained minimal. The challenges we highlighted earlier (lack of infrastructure, literacy, overly complex tools, a mismatch with farmer needs, and a lack of trust) and the inability to engage policymakers or to develop into viable business models have led to the discontinuation of many services after initial funding ended (Qiang et al. 2012).

Many applications, once touted as promising, are no longer in operation. A number of digital platforms that were highlighted as promising in a 2020 profile of digital agricultural applications have shut down or changed their business model (GSMA 2020). For example, Wefarm's eFarm Shop in Kenya shut down barely a year after its inception because of difficult market conditions (internet source); Farm.ink, a peer-to-peer knowledge-sharing platform and chatbot appears to be defunct;[2] and Qualitrace, an application in Ghana that enabled farmers to trace the quality of their inputs has also appeared to be out of business.[3]

Implementors of comparator programs reported that the primary challenge to scaling was a lack of farmers' willingness to pay for information. Although the VBA program does not currently ask farmers to pay for information, the comparator programs we spoke with were mostly for-profit social ventures building a business case for digital information applications. They noted that farmers were generally unlikely to pay for extension information, but some strategies helped surmount this challenge. One was bundling the information in a package of other services, such as input financing. One seed company we interviewed in Nigeria told us it bundled the cost of weather information with seeds and other inputs.

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[2] The online presence and all related articles are older than 2018.

[3] The website is defunct and all social media references ended in 2021.

Another provided a free trial period in hopes that farmers would see the benefit and thereafter agree to pay for this, but that was not successful. Overall, implementors believe it is important that similar applications at least partially subsidize information applications for the foreseeable future.

Recommendations

Research question. How can early challenges identified in places where AGRA's digital extension programs have been rolled out be mitigated to reach AGRA's goals?

- **Build applications with user-oriented design with much time planned in for iteration.** The successful comparator programs and the studies of digital applications both found that user-centered design was absolutely essential when designing and rolling out digital applications. Those applications that failed to scale were often designed in advance and with little input from the field, and those that succeeded started by undertaking problem identification with farmers and working iteratively with them over a long period to find applications that targeted their biggest concerns and had messages that resonated with their needs. Any new application AGRA engages with should adhere firmly to user-centered design principles.

- **Focus on simplicity of messages and platform.** Somewhat related to the previous point, we found that complexity of the application was a main challenge hindering use, particularly with CropIn, and this was something that comparator programs warned against. Simplicity is especially important for applications that focus on information dissemination, as it is easy for farmers to ignore messages that are overly complicated or use language that is not comprehensible. Further, VBAs expressed frustration with applications that were unwieldy, difficult to log in to, and lacked a clear benefit and purpose. Applications that AGRA promotes should start with simple design and simple messages and plan to iterate on those designs and messages when entering new regions or markets.

- **Training has to be robust with refreshers.** The CropIn training was relatively minimal did not meaningfully involve the implementing partners and did not have any follow-up. This made it nearly impossible for many users to surmount any complexity challenges. In contrast, the KoboConnect training in Nigeria occurred over several days with fewer participants and focused on practical applications and practice. In rolling out any digital application, an upfront investment in training and in ensuring VBA program implementers are engaged with the digital application through deputizing them as lead trainers and enabling them to access the data and interact with the digital application staff will help ensure a smoother rollout of any digital application.

- **Continue to pursue a hybrid approach.** Digital applications cannot replace the in-person training and VBAs will have to continue to play the role of a trusted intermediary in any digital strategy. In-person, hands-on training is not possible to replicate with text messages and, for many market applications, smallholders still depend on a trusted broker to act on any market information. AGRA should consider digital tools as a mechanism for enhancing the *quality* and *depth of interaction* rather than the *reach* of VBAs' work. Some of the applications farmers were most excited about, such as Plantix and a tool to measure field size, have to be used in person rather than remotely. The literature we reviewed similarly emphasized the importance of coupling digital approaches with in-person analog approaches to achieve benefits for farmers. (Steinke et al. 2021; Deichman et al. 2021)

- **Use existing messaging applications.** Messaging applications and platforms are widely used, and most VBAs even prefer them for communicating and sharing information among farmers and market actors. Similarly, findings from a [report in South East Asia](#) showed that although many agriculture digital applications have emerged, farmers have been slow to adopt them, with many opting for messaging platforms instead. Compared to digital applications, messaging platforms require less training, have less data and time costs, are user friendly, operate on basic smartphone models, and farmers might trust them more, because they form groups with mutual acquaintances. Given these advantages, when introducing a specialized digital application, AGRA should consider what usage gaps of messaging platforms a digital application can fill. Specifically, VBAs already use messaging platforms to communicate, organize, and share market price information—introducing digital applications with these functions would be redundant. AGRA can also consider how to integrate digital applications with messaging applications. For example, digital applications that provide a virtual marketplace can have an option to share buyers' contact information or availability through WhatsApp, enabling the virtual marketplace to benefit from the wider reach of WhatsApp groups.

- **Match the application type with the country's priority needs, adjusting depending on the level of digital infrastructure.** The digital tool of choice should solve a specific problem that is either the most pressing problem or a problem that is most immediately addressable through a digital application with the goal of building momentum and trust. AGRA should also plan the roll-out in accordance with the various needs of each country (for example, poor access to phones and connectivity in Mozambique) (**Table 7**).

- **Start small with a market-application pilot and purchase or subsidize smartphones for VBAs in Mozambique.** Mozambique farmers are most interested in finding a market for their produce. Market connectivity applications are more complicated and have a harder time scaling, but it might be worth finding pilot areas (such as those with stronger digital infrastructure and VBAs who have existing market connections) to experiment with these applications, as this will meet the most pressing need. It is also important to acknowledge the real digital infrastructure constraints and lack of access to smartphones among VBAs and consider purchasing or subsidizing smartphones for VBAs. This is a costly investment, but it is a foundational piece of any digital extension strategy. AGRA could consider a partial subsidization scheme as a pilot and then expand from there. Without improved access to smartphones, a robust digital strategy is likely to face significant challenges.

- **Build on current momentum in Nigeria by supporting the expansion of successful applications and work with developers to ensure that tools evolve to be even more user friendly.** In Nigeria, it could be worth building on the momentum of digital applications that VBAs and farmers are most excited about and that provide an immediate benefit, such as Plantix and Farmex. This would enable AGRA to build on a strong foundation and add additional services as is warranted and demanded by farmers. VBAs were relatively enthusiastic about tools, which many reported increased the respect that farmers paid them and enabled them to reach additional farmers. Some VBAs even reported additional income generation from these tools. The younger VBAs were particularly enthusiastic about the technology, as they felt it elevated their credibility with older farmers. It is likely that further investing in a digital strategy will increase AGRA's ability to recruit younger VBAs, which is an important strategic goal. It will be important to clearly identify only a small number of applications to increase their likelihood of use and to avoid spreading services across too many applications and diluting their value.

For example, if there are too many market aggregation applications, they might all fail to register a critical number of market actors.

Table 7. Assessing conditions for application rollout by country

	Greatest needs	Enabling and inhibiting factors	Recommended priority tool type	Suggested roll-out
Mozambique	• Farmers are geographically dispersed, making extension visits difficult. • Input use and market access is low. • The most pressing request from farmers is market access to sell produce.	• Poor digital infrastructure • Inability to charge; • Low cell phone and smart phone penetration	Market connection application	• Start where there is the greatest likelihood of success in clusters where VBAs are already active as market connection actors. • VBAs need smartphones to benefit from market connection tool.
Nigeria	• Farmers have relatively higher input use and access to markets. • They are interested professionalizing their status as farmers.	• Relatively high cell phone and smart phone penetration; • Ffrequent use of Whatsapp	Expansion of Plantix and Farmex or similar tool that already has generated interested and showed some degree of success	• Confirm the applications that VBAs currently find the most success with. • Expand training and use among a wider number of VBAs and work with developers to ensure new versions are sensitive to the local user experience.

3. Content delivery and farmer experience

This study presented an opportunity to gather more information about the barriers to VBA-recommended practice and input adoption; how farmers perceive their interactions with VBAs; and any benefits the experienced beyond improvements in practices, yields, and income. We draw from the farmer and VBA FGDs to better understand the dynamics between VBAs and farmers and common challenges in AGRA VBA areas.

Key findings. Farmers faced multiple barriers to adopting GAP, including a lack of cash or credit to purchase recommended inputs, the difficulty of applying the more laborious practices, and difficulty in reaching input suppliers and hiring laborers who are untrained and/or uninterested in applying those practices. We encourage AGRA to identify pathways to improve access to credit for inputs for farmers. In addition, in Nigeria, it could be important to encourage laborers, not just farmers, to attend training or provide farmers with paper-based training tools to share with hired laborers. Generally, farmers greatly preferred in-person, live demonstrations delivered before land preparation or planting. When we asked farmers what additional benefits they felt the VBA program had provided (beyond training or yield and income improvements), they noted the program had prompted the start to changing some norms around women's greater role in agriculture and an increase in financial literacy. AGRA should build on this momentum and redouble efforts to include more women VBAs and reach out to more women farmers.

Key barriers to adoption and input use

Most farmers and VBAs we interviewed in Mozambique and Nigeria reported access to capital and labor were key barriers to practice adoption. Adoption of GAP is often a more expensive investment for farmers given the importance of buying inputs such as certified seed and fertilizer, and the greater labor (in terms of farmers' time or time for paid laborers) required for more intensive planting and weeding practices. Interviewees frequently noted that when farmers cannot afford to adopt these practices, they revert to their previous practices, which many noted are often deeply embedded in culture, passed down generationally, and can be slow to change, especially among older farmers.

> *The farm got bigger and I'm on my own, and following some procedures that the VBAs say is difficult, for example row planting is time-consuming to do on my own compared to the old practice.* (Farmer, woman, Mozambique)

> *… the biggest problem is money. When the time comes to implement, with the lack of money, sometimes they won't be able to…. The fertilizer costs a lot of money, so [when] they have nothing, the tendency is to go back to their previous method…. Sometimes when you teach them something, it's to move forward, … but if they don't have the conditions to be able to start with that thing, they end up going back.* (VBA, man, Mozambique)

This lack of capital for purchase of inputs has been exacerbated by the increasing price of inputs, which, as many farmers reported, caused them to reduce the amount of inputs, especially fertilizer, that they could purchase.

> *The major challenge I face is the constant increase in the prices of farming inputs like fertilizer, herbicides, and pesticides. This inadequacy has led me to apply a lower quantity of inputs on my farmland than what my VBA requested. For instance, due to the high cost of fertilizer, I decided to apply 2 bags of fertilizer instead of 5 bags. By implication, my harvest would be less than expected.* (Farmer, man, Nigeria)

In Nigeria, farmers were more likely to hire labor, and hired labor often has different incentives and capacities to apply GAP. Several interviewees in Nigeria pointed out that farmers often hire laborers to help with planting, and those laborers are often not trained in GAP, have little investment in implementing GAP, and prioritize the most time- and labor-efficient methods (which are often contrary to GAP).

> *One of the major challenges I face in adoption is related to labor. For instance, my VBA advised me that during planting I should ensure to bury the seeds and give 25cm gap between stands. The challenge in adopting this practice is that because I'm not the only one planting, the laborers may not apply the practice as I instructed them. This is because the practice tends to be time consuming. And the laborers are only after their wages. It's not easy to force them to apply the practice.* (Farmer, man, Nigeria)

Mozambican farmers faced the additional hurdle of having to travel long distances to access inputs. Farmers in Mozambique specifically highlighted their challenge of accessing quality inputs in their communities, reporting they often had to travel long distances and take on those transportation costs to find the needed inputs.

> *We face difficulties in terms of distance to find agricultural inputs recommended by the extensionist, and this causes a delay in the planting season.* (Farmer, woman, Mozambique)

Recommendation

Similar to our recommendations in prior reports, we encourage AGRA to identify pathways to improve access to credit for inputs for farmers. In addition, in Nigeria, it could be important to encourage laborers, not just farmers to attend training or to provide farmers with paper-based training tools to share with hired laborers.◢

Farmers' experience of VBA content

Farmers preferred to receive information from VBAs about implementing GAP via in-person, demonstrative trainings. Farmers often cited demonstration plots as a helpful way to see new teachings in practice and to see the real-world benefits of implementing those practices. Farmers especially valued VBA's visits to their farms so VBAs could make recommendations and confirm that farmers implemented practices correctly. Nearly all farmers interviewed noted they coordinated these trainings and visits via SMS or phone call with their VBA.

Farmers in Nigeria and Mozambique overwhelmingly preferred to receive training and agricultural information before land preparation and planting. Farmers noted that receiving these messages early, and before making significant investments in their land, would provide them adequate time to prepare to implement recommended practices.

> *I prefer to receive information and knowledge before planting. To ensure a successful farming season, a farmer needs to get all the information he requires. Such that when the season starts all he does is implementation and management…. Have you asked yourself why most trainings are being scheduled before the season starts? It's because the organizers know the importance of planning ahead of time.* (Farmer, man, Nigeria)

When farmers spoke about additional benefits of the VBA program (beyond training and yield and income improvements), they highlighted the inclusivity of women farmers. Other than practice, yield, or income changes, several farmers and VBAs in Nigeria felt the VBA program changed attitudes around women's involvement in farming, allowing more women to participate in areas where they were previously not engaged in farming activities. Women have traditionally rather circumscribed roles in farming in some areas of Nigeria, and participants noted that including women might have started to change some norms and expectations around their involvement.

> *Generally, in the North women don't engage in farming. But the AGRA program has influenced that notion. This is why you find more men willing to allow their wives to take part in active farming. The*

> *northern people are beginning to realize that women can make a positive impact in agriculture if given the chance. So … I would say, the program changed their perspective of women participation in agriculture.* (VBA, man, Nigeria)

> *AGRA's digitalization program has improved the knowledge and information female farmers in particular have on GAP. This is because it has made the knowledge more accessible to them since it's through a smartphone…. The impact can be seen in the numbers of females going into farming. Currently, females in farming are competing with men in farming. This is something that seemed impossible about a decade ago.* (VBA, woman, Nigeria)

Several farmers also noted that they had acquired more financial knowledge and literacy, about both the importance of diversifying their income streams through non-agricultural income and in managing their income and tracking their savings. These farmers reported VBAs encouraged them to track spending and income to better plan for farmers' needed expenses throughout seasons, whether for household uses or agricultural input purchases.

> *There are many benefits … because they also taught us to make plans…for money at the time of the sale, after the sale, with money, you have to make the plan first … because if you don't make the plan, you can end up just buying things anyway, the money runs out before it's time for another season. So, if you plan first with money, you'll already be able to balance that between now and this month I have to use this amount, between now and then I have to use this amount, this amount here I have to buy seed, and this was also an idea that, for me, was almost a benefit that I also learned about in this part.* (Farmer, man, Mozambique)

Recommendation

There is suggestive evidence that AGRA has begun changing norms about women's roles in agriculture. AGRA should build on this momentum and redouble efforts to include more women VBAs and reach out to more women farmers. Our first VBA report outlined some tactical recommendations on increasing inclusiveness of women, including building community-level acceptance of women as VBAs by working in concert with religious and community leaders and carving out a niche for women VBAs to focus attention on crops and value chain activities that are more traditionally considered woman-dominated, as this would face fewer cultural barriers. However, AGRA would have to take care that this focus does not simultaneously limit the income-generating opportunities for women.◄

4. Follow-up on impact evaluation trends

We used this data collection exercise to investigate some anomalous finding from the retrospective impact evaluation. In particular, the evaluation found that farmers trained by VBAs had not increased their use of inputs relative to untrained farmers and dietary diversity was actually worse for VBA-trained farmers. We also found income improved for VBA-trained farmers relative to non-VBA-trained farmers, but the impact for that improvement was not clear, especially because we found no impact on yields per hectare. To better understand these findings, we discussed them in our VBA and farmer FGDs.

Crop rotation

Earlier finding. In our retrospective impact evaluation, we observed an increased share of VBA-trained farmers practicing crop rotation relative to matched non-VBA-trained farmers in all three countries we studied: Kenya, Mozambique, and Nigeria. This was one of the most consistent statistically significant impacts on practice adoption, larger and more significant than other practices, such as planting in rows or adopting certified seed, practices that receive much more attention in training guides than crop rotation. Given the relatively smaller focus on crop rotation, it was therefore unexpected that we found such a consistent impact on the practice, and we asked FGD respondents what prompted their decision to engage in crop rotation.

Farmers who implemented crop rotation on their land in Nigeria and Mozambique reported doing so to help with pest control, to improve the nutrition of their land's soil, and to increase yields. Farmers reported that rotating their crops, either to different areas of their own land or by exchanging land with another farmer so they could each rotate their crops, controlled pests that would normally attack crops they had previously planted in the same area in successive seasons. An uptick in pests might have prompted more farmers to try to engage in this practice.

> *I received information on crop rotation. For instance, if this season I plant maize and pests attack it, the next season I would plant rice on it. Alternatively, I would get another farmer who is mainly farming rice to come and plant on my farmland, and I would farm her farmland. This is because if the pest doesn't find what to feed on the next season they would die. But if I plant maize again next season the pest would still attack it.* (Farmer, woman, Nigeria)

Farmers also mentioned improved soil health as a motivator behind crop rotation. They noted that nutrients left behind by certain plants, such as legumes, would be beneficial to new crops the next season,

such as maize. They appear to have absorbed the science behind this practice and VBAs' training had convinced them that crop rotation could improve soil health.

> *The reason for practicing crop rotation is that the decayed leaves and roots of certain crops tend to add nutrients to the farmland. This nutrient deposited could be helpful to the crop that would eventually be planted on it. For instance, the leaves and roots of soybean and groundnut deposited in the soil are useful to maize plants.* (Farmer, man, Nigeria)

> *… there are plants, that … at the time of harvesting … leaves something. There are other plants that, when they are removed, leave nothing, they leave the soil empty. So you have to rotate and sow those plants that leave something so the soil … recovers a little.* (Farmer, man, Mozambique)

Training on crop rotation appears to be enhanced by a "seeing is believing approach." A handful of farmers also reported that they implemented crop rotation after trainings by their VBAs and had shown how it could increase yields in fields with side-by-side demonstrations.

> *One of the ways the VBA convinced me was by clearly proving that [compared to] the old way of planting … [rotating crops] has more advantages and production is higher now.* (Farmer, woman, Mozambique)

> *The way I [used to] farm soyabean every year, I noticed I didn't get enough yield, so when I started to follow [the VBA's] training, I noticed that it was good.* (Farmer, man, Nigeria)

Land expansion

Earlier finding. In our earlier report, we found that although VBA-trained farmers did not necessarily increase their yields per hectare, they did expand the land they dedicated to AGRA's focus crops. So, they appeared to engage in an extensification strategy rather than intensification strategy. We hypothesized that the land increases might have come from earlier years of VBA program income impact that enabled them to cultivate more land.

Farmers who expanded the land they cultivated in Mozambique did so thanks to income gains in prior years and/or due to the promise of greater yields with the benefit of improved practices they learned from or inputs they acquired from their VBAs. Many farmers who did report land expansion noted that they bought or rented land using income gains from increased harvests in previous seasons. Other farmers who expanded their land felt more capable of managing larger farms after trainings by VBAs. One farmer noted that with new techniques taught by their VBA, they needed a larger field size, and another farmer had received seeds from his VBA that he could not grow on his single field, so he expanded to use those seeds.

> *Some of my farmers reinvested the profit in the farming business. In other words, they increased their farm size. Some decided to add to the number of crops they usually cultivate.* (VBA, man, Nigeria)

> *I have increased the size of land I apportion for farming my main crop. This is because with the help of the VBA, I have become more knowledgeable about the crop and farming activities generally.* (Farmer, man, Nigeria Sabon Gari)

Application of GAP to non-focus crops

Earlier finding. The retrospective impact evaluation estimated the impact of the VBA program on practice adoption related to AGRA focus crops. However, we hypothesized the farmers might apply some of those practices to adjacent non-focus crops and have additional benefits on those fields.

Farmers' application of GAP to non-focus crops was common among FGD participants who reported that, having seen the benefits of GAP on their yield of focus crops (maize, soya, and rice), they wanted to carry those practices over to other crops they grew to hopefully yield the same results. Farmers in Nigeria reported applying GAP to groundnuts, guinea corn, potatoes, beans, millet, and sorghum. Farmers interviewed in Mozambique applied GAP to cabbage, beans, groundnuts, sweet potatoes, oranges, tangerines, bananas, cassava, and sugar cane.

Low impact on inputs use

Earlier finding. Our previous study found no significant differences in the likelihood of using certified or hybrid seeds or fertilizer comparing VBA-trained farmers and matched comparison farmers. This contradicted an earlier study of the VBA program, which found some impact on input use for some crops and countries. We hypothesized that the year of study, which saw record fertilizer prices due to the Ukraine conflict, might have dampened input use. In addition, at the time of data collection the VBA program had ended—in some places more than a year ago—so seed packs were not distributed.

FGDs with VBAs and farmers across Mozambique and Nigeria revealed that price increases for chemical fertilizer were a primary contributing factor in any reduction in input use for these groups. Most respondents indicated they would have purchased more chemical fertilizer to use had the price not increased in 2022. In both Nigeria and Mozambique, farmers reported that amid the climate of higher prices, VBAs advised them on how to adapt to anticipated price increases in chemical fertilizers by combining it with organic fertilizer (primarily cow, chicken, and bat manure).

> *During the training of 2022, the AGRA trainer told us to consider local means of meeting our fertilizer needs because of the anticipated increases in the price of chemical fertilizer. In other words, they introduced us to various sources of alternative fertilizer like manure, animal waste, straws etc. These were the actions most farmers took to cope with the increase in chemical fertilizer. So, basically most farmers used a mixture of chemical fertilizer and local fertilizer.* (VBA, man, Nigeria)

> *In 2022 ... all the producers had to ... reduce their plot to be able to fertilize according to what they had in their pockets.* (Farmer, man, Mozambique)

Respondents across Nigeria and Mozambique reported altering their purchasing and usage of certified seed as a result of price increases. In Mozambique, group discussions with farmers revealed a variety of strategies to combat such price changes, including traveling to Malawi to purchase inputs at

more competitive prices or combining certified seed and old or regular seed. Some respondents described choosing between purchases of fertilizer and certified seed in response to price changes.

> *I didn't use the fertilize r... I just ... went to buy seed to put in that space I'd increased. In another space I used old seed. But I did not use the fertilizer ... because I couldn't afford to buy seed and fertilizer.* (Farmer, man, Mozambique)

The impact of input price changes appeared to be felt more profoundly in Mozambique than in Nigeria. In Mozambique more qualitative respondents reported using just grass clippings to fertilize—or using no fertilizer at all—than in Nigeria, where most reported mixing chemical and organic fertilizer. Respondents in Nigeria conveyed better access to alternative fertilizers (manure) and purchasing power or availability of limited chemical fertilizers than in Mozambique. VBAs and farmers in Nigeria appeared generally more resilient or less severely affected by price increases, expressing easier access and greater ability to purchase alternative forms of fertilizer.

In addition to the use of manure to supplement more expensive chemical fertilizer, VBAs suggested a variety of input-reducing strategies in response to input price changes. VBAs reported providing advice about best practices to preserve fertilizer—such as cutting plants to harvest instead of pulling the entire crop—so the remains would decompose and act as fertilizer. Another strategy to cope with price increase was strategically timing the application of chemical fertilizer to maximize its impact and extend its efficacy. In addition, some VBAs and farmers reported reacting to price increases by changing or shifting the proportions of the crops they grew toward those plants that required less fertilizer.

> *Unlike maize and soya beans, rice is a crop that needs chemical fertilizer and not manure. However, it doesn't require much fertilizer. For that reason, we stick with our rice farming regardless of the increase in price. We had no option. But I know a lot of farmers who switched to rice farming, but it requires less chemical fertilizer. Some reapportioned the lands among the crops they grow.* (Farmer, man, Nigeria)

Nigerian VBAs also mentioned that some farmers purchased certified seed and fertilizer input before cost increases and later benefited from selling their crops at a higher price. VBA respondents discussed advising their farmers on financing and timing strategies to minimize impact.

> *In the year 2021 I advised my farmers not to sell their farm products immediately after harvest. Rather they should wait till the beginning of next year when the prices are relatively high to make more profit from its sale. So, when the prices of fertilizer were high, the impact was minimal.* (VBA, woman, Nigeria)

Pathway to increased income

Earlier finding. In our previous study, despite the relatively minimal increases in input use and lack of statistically significant impacts on yields per hectare, we found a strong impact on household income in Mozambique and suggestive trends in Nigeria. Therefore, we explored which income pathways might be most prevalent among VBA-trained farmers outside additional income from yield improvements. These could include land extensification (already explored) and investments from agricultural yield and profit boosts from prior years.

Farmers in Nigeria and Mozambique who reported an increase in income most commonly used their income gains to reinvest in farming, either purchasing farming inputs or buying or renting more land to cultivate. Beyond productive farming investments, many farmers also reported investing in non-agricultural businesses and several female farmers in Nigeria used income gains to invest in furthering their own education. Farmers commonly reported familial uses of income gains, including paying children's school fees and general support of family members, such as purchasing food for their families. Some male farmers in Nigeria used their income gains to get married or to marry more wives (several VBAs in Nigeria noted they discouraged farmers from using income gains for this purpose and instead encouraged investment in agriculture).

Nearly all farmers in Nigeria and Mozambique who reported income gains from non-harvest pathways reported earning that income by rearing livestock, including poultry, goats, ox, and cattle. Several farmers started agricultural businesses to make and sell byproducts (including soy milk, soy cake, and corn flour). In addition, farmers in Nigeria noted that other non-VBA-trained farmers had invited them to come to their farms and offer advice as farmers who had received training from VBAs and earned some income through this. Overall, most of the prior year income boosts appear to have been invested in productive assets, so it is possible the increase in income we found in our impact evaluation could have been the result of prior year investments.

Dietary diversity

Earlier finding. In our previous study, we unexpectedly found a slight but statistically significant dip in dietary diversity across all countries. We hypothesized this might be due to a greater focus on a narrower set of crops and lack of dietary diversity training.

Despite finding a decline in dietary diversity in our previous study, when asked about changes in their dietary practices, farmers tended not to report a reduction in dietary diversity. Therefore, it was difficult to fully investigate this trend in our qualitative responses. Those farmers who did report such a reduction did not attribute this negative change to their participation in the VBA program. Respondents who reported experiencing a stagnation or decrease in access to and consumption of diverse food groups noted cost of living, reduced production, and general market and weather conditions as major limiting factors to dietary diversity.

> *Because of the high cost of living, we have reduced the consumption of protein foods like meat and fish. We replaced them with other protein foods like Soya bean, cowpea etc. To make it more interesting we have options of making various delicacies using soya beans and cowpea.* (Farmer, woman, Nigeria)

Farmers' responses were mixed about whether the VBA program improved understanding of and access to a diverse diet. Some respondents believed VBAs' advice enhanced their understanding of how to diversify their diet; however, many responses indicating an ability to diversify household diets seem to relate closely to the increased income and understanding of saving and budgeting best practices.

Respondents who reported increased dietary diversity expressed a developed understanding of producing both cash and subsistence crops to support household nutrition. Some farmers in Mozambique and Nigeria reported learning nutrition information and strategies from VBAs during

training, emphasizing the importance of rotating the nutrients consumed in the household by including a variety of food groups in each meal.

> *Still during the step-down training my VBA taught us how to improve the nutrients of our meals by mixing different crops to get a more balanced or nutritious meal. Like the mixture of soya beans and corn flour to get a more nutrients. It's a practice we have adopted in my family for quite some time now.* (Farmer, woman, Nigeria)

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Appendix A: Digital Applications Noted by Key Informants in Mozambique and Nigeria

Table A.1. Digital applications mentioned by interviewees

Application name	Country	Description	Market application	Information application
Epepa	Mozambique	Market application to connect buyers and sellers	X	
FAMEWS	Mozambique	FAO application to map and combat infestations of Fall Army Worms		X
Izyshop	Mozambique	Online supermarket with mission of supporting local producers	X	
M-Farm	Mozambique	Registration of VBAs and agro-dealers to register extension work and sales management of agro-dealers	X	
Plantwise	Mozambique	Plant disease and pest identification and solutions		X
Agropronto	Nigeria	Market connection application between farmers and market actors	X	
Feserwam	Nigeria	Provides site-specific recommendations for extension agents		
Fida	Nigeria	A farmer management application to manage input distribution and farmer information, including mapping, monitoring, and harvest	X	
Ignitia	Nigeria	Weather information with prompts on specific recommendations based on farmers' coordinates		X
Livestock247	Nigeria	Online livestock platform to create linkages in the livestock value chain	X	
NiMet Weather	Nigeria	Weather and climate information from the Nigerian Meteorological Agency		X
Nutrient Expert	Nigeria	Site-specific extension advice to farmers		X
PlantVillage	Nigeria	Extension advice		X
RiceAdvice	Nigeria	Extension advice for rice crop management		X
Seasonal Climate Prediction	Nigeria	Predictive climate data, including rainfall onset and cessation dates, rainfall amounts, length of growing season, temperature, dry spells, little dry season, and crop calendar		X