AGRA VBA Evaluation Phase 2 Report: Farmer-Level Impacts

August 29, 2023

Kim Siegal, Ali Akram, Abbie Turiansky, Esteban Quiñones, Maarten Froeling, Evan Christo, Naomi Dorsey, Anabela Mabota, Tabitha Nduku, and Lilian Treasure

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Acronyms

AEZ	Agro-Ecological Zone
ARSSI	Ability to Recover from Shocks and Stresses Index
ATE	Average Treatment Effect
CAPI	Computer-Assisted Personal Interview
CEM	Coarsened Exact Matching
FIES	Food Insecurity Experience Scale
GAP	Good Agricultural Practices
GPS	Global Positioning System
HDDS	Household Dietary Diversity Score
LGA	Local Government Area
NDVI	Normalized Difference Vegetation Index
PICS	Purdue Improved Crop Storage
PSM	Propensity Score Matching
ROI	Return on Investment
SERS	Subjectively Evaluated Resilience Score
ToC	Theory of Change
VBA	Village-Based Advisor

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Executive summary

AGRA is an African-led institution at the forefront of developing models to improve seed, fertilizer, extension, and last mile input distribution systems, policies, markets and finance access to transform smallholder agriculture on the continent. A key AGRA investment is the Village-Based Advisors (VBA) program, which aims to enhance farmers' access to extension services and markets. To evaluate the impacts of the program, AGRA and the Bill & Melinda Gates Foundation asked Mathematica to conduct a comprehensive evaluation of the program. This report focuses on Phase 2 of the evaluation.

Methods

We used a matched comparison group design to compare outcomes among farmers in communities served by the VBA program to those among farmers in communities not served by the program. The evaluation began at the end of the implementation timeline—approximately four years after program implementation began—therefore did not include a baseline survey. Consequently, the evaluation has a retrospective approach. We used coarsened exact matching (CEM) to identify a group of non-VBA farmers with which to compare VBA farmers. CEM is an intuitive and transparent matching technique, that introduces less bias than another popular matching technique, namely PSM. Using CEM, We matched farmers on observable characteristics to establish statistical balance between VBA farmers and similar farmers in a comparison group who did not receive the program. This procedure resulted in a well-balanced counterfactual in each country.

Findings

Leveraging this design, we were able to develop cross-cutting and country-specific insights:

- We found modest impacts on application of good agricultural practices and input adoption for VBA trained farmers in all three countries and yields per hectare did not increase. However, we found that **VBA farmers were cultivating larger areas of land than non-VBA farmers and that total production of focus crops was greater for VBA-trained farmers.** This suggests that VBA farmers might be focusing on extensification rather than intensification of their agricultural enterprises.
- 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**. This may be driven by a combination of factors including productive investments by VBA farmers in the early years of the VBA program, larger land area under cultivation and devoted to focus crops, and greater access to markets, increasing the revenue farmers receive from crop sales.
- **Among VBA farmers, those with higher levels of engagement with VBAs experienced higher yields and household-level outcomes.** Farmers who engaged with VBAs at least

three times per year saw higher maize yields in Kenya, higher soy yields in Nigeria, and higher yields for maize and rice in Mozambique. The difference between farmers with higher and lower intervention levels is most striking in Mozambique, where farmers with more VBA engagement saw substantially farm output values, farm profit, and household income than those who engaged with VBAs less frequently.

- We also found **VBA farmers had worse dietary diversity in all three countries**—an unexpected finding which warrants attention. While improving dietary diversity was not an explicit goal of the VBA program, this is worth noting since AGRA's next strategy focuses attention on crop diversification, food systems and nutrition.
- Broadly, **women and young farmers did not have substantively different results** to the full sample. However, in Kenya, women saw worse dietary diversity and resilience scores, while young farmers did experience greater dietary diversity in Kenya and Mozambique. Additionally, we found that young farmers in the VBA program saw relatively smaller yields in Nigeria and, downstream from this, they saw reduced farm profit, as compared to older farmers in the VBA program.
- Finally, we found that **AGRA's investment has a positive return**. Using our estimated impact on household total income, we estimate a portfolio-level return—across all three countries—of $59 for each $1 invested. This is driven by positive returns in Mozambique, which saw $99 of income impact for each $1 invested. However, given the large confidence interval around the estimated income benefits the portfolio-level return may be as low as $4 or as high as $114, and the return on investment calculated here should be treated as directional and not as a precise estimate of returns.
- **In Kenya,** the VBA program led to the strongest impacts on practices in any country, particularly regenerative agriculture practices, but these did not translate into impacts on yields and income. VBA farmers were significantly more likely to use herbicides and pesticides on their crops. We also found evidence of VBA farmers planting more trees, engaging in crop rotation, and being less likely to dust their harvest with pesticides—all pointing to the recent focus on regenerative agriculture in the country. However, the lack of detectable impacts on yields and market access mean that we were also unable to detect downstream impacts on farm profit, household income, resilience, and food security.
- **In Mozambique,** VBA farmers had greater access to output markets and higher household income than non-VBA farmers. We found mixed results in terms of practice adoption with some improvements in correct row spacing and spraying for crop protection, but no real improvement in terms of input use, which remained very low for both VBA and non-VBA farmers probably due to high input costs following the disturbance of input supply system attributed to COVID-19 and Ukraine-Russian war. These practice improvements did not translate into any statistically significant differences in yields per hectare. However, we found

improvements in market sales due to the VBA program, and this greater access to markets translated into improvements in household income.

- **In Nigeria,** the VBA program had relatively low impact on practice adoption, but we found that cash income increased for farmers served by the VBA program, likely due to improved access to output markets. We found no improvement in row spacing, crop protection, or post-harvest practices. Similarly, we did not detect any differences in the adoption of inputs by VBA farmers compared to non-VBA farmers. Given this, it is not that surprising that we did not find any statistically significant positive impact on yields in Nigeria. VBA farmers did sell more into the market and earn more farm profit than non-VBA farmers, but this did not translate into higher overall *household* income including value of unsold harvests.

Recommendations

These results suggest two broad sets of recommendations. First, in designing agricultural extension programming, AGRA may want to:

Conduct a full assessment in each country to tailor the VBA program to their specific needs and impact pathways. We found very different results, and likely impact pathways, in the three countries. Customizing the VBA program might therefore make more sense than administering one uniform program. We also recommend including baseline surveys in the assessments to measure pre-intervention conditions, which are critical for identifying valid counterfactuals and changes over time.

Devise an explicit strategy to address the unique barriers for women and youth. Earlier qualitative work found that there were specific cultural barriers to reaching women in Nigeria and economic barriers to reaching youth in Kenya. AGRA will need to investigate better avenues for reaching and serving women and youth in contexts in which serving such populations is challenging, given their goals for reaching these subgroups.

Focus more attention on access to inputs. The lack of impact on input use, such as fertilizer and improved seeds, points to a larger issue: even with increased information and access to inputs, farmers lack the cash and credit to purchase enough inputs. It is worth noting that the high costs of fertilizer in 2022 was likely a major barrier to its use by both VBA and Non-VBA farmers.

Second, to improve AGRA programming in the long run, AGRA may want to:

Investigate barriers to practice adoption and devise behavior change incentives. Training is a key component of the VBA program; consequently, it is important for AGRA to more deeply investigate why farmers do not adopt certain practices and what can encourage practice adoption.

Understand the optimal role of digital extension in generating impact. As AGRA considers digitalizing their offerings, especially VBA, we recommend studying which digital extension training and models are most likely to have an impact and in which contexts.

Integrate nutrition training into programming. While nutrition was not an explicit goal of the VBA program in the last AGRA strategy, it was surprising that dietary diversity (a leading indicator of nutrition outcomes) worsened among VBA farmers.

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1. Introduction

1.1. Background

AGRA is an African-led institution at the forefront of strengthening seed, fertilize, extension and input distribution systems, modernizing policies, and improving markets to drive smallholder agricultural transformation on the continent. Core aspects of AGRA's model include system-level investments and fostering collaboration with public, private, and nonprofit stakeholders to achieve impact for smallholders. One of AGRA's key investments is the Village-Based Advisors (VBA) program, which aims to enhance farmers' access to extension services and markets.

The VBA program was designed to address a significant gap in agricultural extension services in Sub-Saharan Africa, where national extension programs often fail to reach most rural smallholder farmers. Due to the limited availability of extension officers, the ratio of officers to farmers frequently exceeds 1:1,000, making extension support inaccessible for many smallholders (TASAI 2023). To bridge this gap, AGRA introduced the VBA program in eight countries in 2017. The program strategically recruits skilled farmers held in high regard within their communities as VBAs. AGRA, through its implementing partners, collaborates closely with public extension authorities to train these VBAs on good agricultural practices through mother and baby demonstration plots and with additional training modules tailored to specific country needs based on assessments by program partners. Subsequently, the VBAs train fellow farmers in their villages throughout the agricultural season. Beyond providing agricultural knowledge, the VBAs serve as a link to input and output markets, connecting farmers with suppliers of seeds, fertilizers, mechanization services, and potential buyers. Notably, the VBA program presents opportunities for VBAs to generate income and establish their own agro-enterprises, thereby promoting their sustainability and enabling them to continue offering valuable services to farmers within their communities. By 2022, the program had trained a total of 39,950 VBAs across eight countries.

1.2. Evaluation rationale

As AGRA progresses to the next phase of implementation, it is crucial to understand the effects of the VBA program on farmers, including their adoption of practices and impacts on yields, profitability, food security, and resilience. Equally important is understanding the program's influence on the practices and financial situations of the VBAs themselves, as well as their contribution to the broader last-mile delivery systems in which they operate. To evaluate these impacts, AGRA and the Bill & Melinda Gates Foundation have enlisted the expertise of Mathematica to conduct a comprehensive assessment in two phases. Phase 1 of the evaluation, completed in 2022, evaluated the impact of the program on VBAs themselves, the public and private systems in which they are embedded, and prospects for the sustainability of the program. Phase 2, the focus of this report, assesses the reach of the program, farmer-level impacts, and program cost and benefits.

1.3. Theory of Change

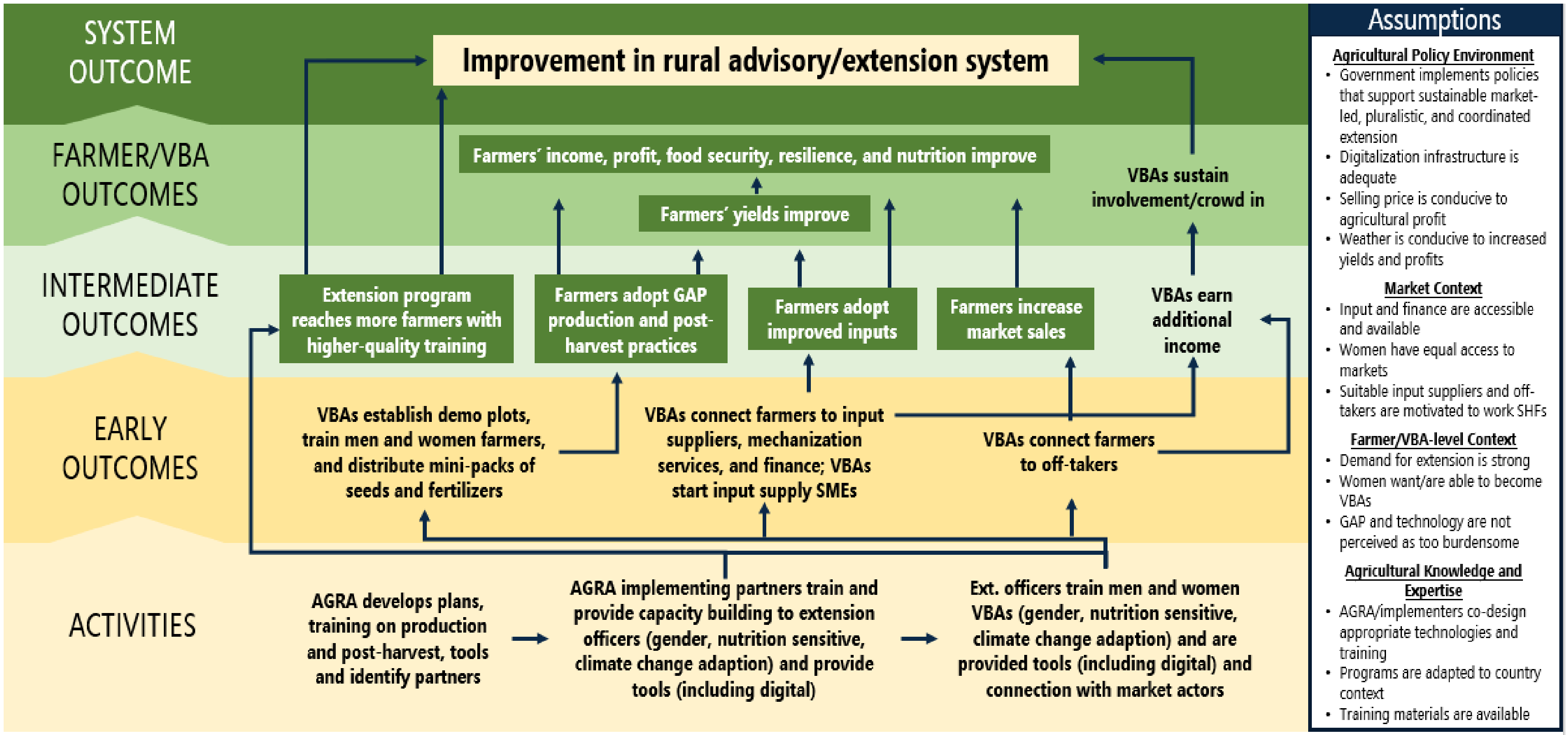
In collaboration with AGRA program staff, Mathematica documented the Theory of Change (ToC) for the VBA program (Figure 1) which was used to inform the evaluation framework for both phases. This involved elaborating on the causal pathways that span from the design and implementation of VBA training to the resulting impacts at the levels of VBAs, farmers, and agricultural systems. The ToC highlights the anticipated outcomes of the VBA program, including an increased number of farmers benefiting from extension services and improved linkages between farmers and input and output markets. Ultimately, these improvements should lead to higher yields, increased income, and enhanced resilience among farmers.

The ToC also outlines key assumptions that must be present in the supporting environment for these linkages to operate as envisioned. For instance, there should be sufficient yield-enhancing inputs available for VBAs to sell to farmers at accessible prices in their area of responsibility. Furthermore, a strong demand for extension services is essential for the success of the program.

The interaction between the VBA program and public extension services is expected to reinforce the impact of these public services. Additionally, linkages with market actors, such as input suppliers and aggregators, are projected to expand market access for farmers. As the central pillar of these crucial connections, VBAs are expected to experience improved livelihood opportunities. These aspects were assessed in the Phase 1 evaluation.

The Phase 2 evaluation focuses on the intermediate and farmer-level outcomes, marked by dark green boxes with white text in Figure 1. Specifically, we evaluated the reach of the extension program and the degree to which VBA-trained farmers had better farming practices and input adoption, more market interaction, and higher yields, farm profit, household income, food security, and resilience.

Figure 1. VBA program Theory of Change



GAP= good agricultural practice, SHF= small holder farmer, SME= small and medium enterprise, VBA= village based advisor

1.4. Evaluation research questions

This report focuses on the impacts of the VBA program at the farmer level, as well as impacts on extension program reach and the return on investment of the program. **Table 1** presents the research questions.

Table 1. Phase 2 research questions

Program reach	
1	**Extension program reach.** What impact has the VBA approach had on the reach effectiveness of the extension program? (For example, do the extension services reach more farmers than would otherwise be reached? Does the program reach those farmers more frequently?)
Impact	
2	**Adoption and market access**. What impact has the VBA approach had on the adoption of good agricultural practices, input use, and market access? How do these impacts differ between men and women and younger (<age 35) and older (≥ age 35) farmers?
3	**Impacts**. What impact has the VBA approach had on farmer-level outcomes, including productivity, income, profitability, resilience, nutrition, and food security? What were the primary pathways for that impact (for example, through higher yields, more market access, greater frequency of VBA visits, and so on)? How do those impacts differ between men and women farmers and younger and older farmers?
4	**Unintended consequences**. What positive and negative spillover effects have occurred due to the VBA model at the farmer level? For example, has the intervention had unintended negative impacts on the environment or the workload of women?
5	**Impacts across countries**. What are the differential farmer-level impacts of the VBA model across countries? What are the likely factors of success per country?
Cost and benefits	
6	**Return on investment.** What is the return on investment (ROI) or cost-benefit of the model from the farmer and VBA perspectives? That is, how much total monetary benefit does the program generate relative to its costs?

2. Evaluation design

To answer these questions, we used a quasi-experimental impact evaluation approach known as a matched comparison group design. Specifically, we used a matching procedure called coarsened exact matching (CEM) to identify a group of non-VBA farmers with which to compare VBA farmers approximately four years after program implementation began.

2.1. Retrospective, quasi-experimental (matched comparison), clustered empirical design

The evaluation was initiated at the end of the implementation timeline, so it is retrospective in nature and did not include baseline data collection. The VBA program had operated for approximately four years when we began the evaluation. As such, we could not collect any farmer-level or program-area-level baseline data, which would have allowed us to assess changes over the duration of the program or to statistically control for baseline characteristics and outcomes. Instead, we collected and used retrospective data, consisting of geospatial data at program start from Google Earth Engine, OpenStreet Maps (both described in more detail in Section 2.2), and self-reported farmer responses collected via in-person surveys. Two limitations of this approach are that (1) it does not allow us to document changes over time and (2) it relies on retrospective farmer responses, which may be less accurate.

Given the non-random rollout of the VBA program, we relied on a quasi-experimental strategy known as a matched comparison group design to identify a valid counterfactual to estimate the impacts of the program. This approach involves matching on observable characteristics to establish (statistical) balance between farmers receiving the program in the treatment group (VBA farmers) and similar farmers in a comparison group (non-VBA farmers) who do not receive the program. To ensure comparability of the VBA and non-VBA groups, we executed CEM (Ho et al. 2007; Iacus et al. 2011; King and Nielson 2019), drawing on a combination of (1) pre-intervention remotely-sensed geo-spatial data on climatic, agroecological, natural land, and contextual characteristics; and (2) survey responses referring to the pre-intervention period—such as farming and land use at the time—and other characteristics that are unaffected by the program, like age and gender.

As described in Section 2.2, the matching process included two steps: (1) first-stage matching on area-level characteristics to select communities, and (2) second-stage matching on farmer-level characteristics. We chose CEM over propensity score matching (PSM), another common approach, because it is a more intuitive and transparent strategy that introduces less bias than PSM (Iacus et al. 2012; Iacus et al. 2019; King and Nielsen 2019).

2.2. Two-stage matching and sampling approach

Before we sampled any farmers, we executed a first stage of matching at the area level to identify non-VBA areas that were as similar as possible to the known VBA areas. VBA areas include villages or wards (administrative level 3) to which the VBA delivered the program and non-VBA areas include villages or wards that did not receive the program. In Nigeria, we had clear information on which communities were served by VBAs, their global positioning system (GPS) coordinates (latitude and longitude), and the locations of communities not served by VBAs (from OpenStreet Maps), which allowed us to match at the village level.[1] In Kenya and Mozambique, we did not have comprehensive information on the locations of VBA-served communities and potential comparison communities. As a result, in these countries we matched at the ward level, which is spatially much larger than the village level.[2]

We matched areas based on agroecological, natural land, climatic, and contextual characteristics. This matching information included the most prominent agroecological zone (AEZ) from 1981 to 2010, an important program targeting factor, as well as average annual rainfall, average annual temperature, and maximum normalized difference vegetation index

[1] In Nigeria, this resulted in matching 1 square kilometer polygons.

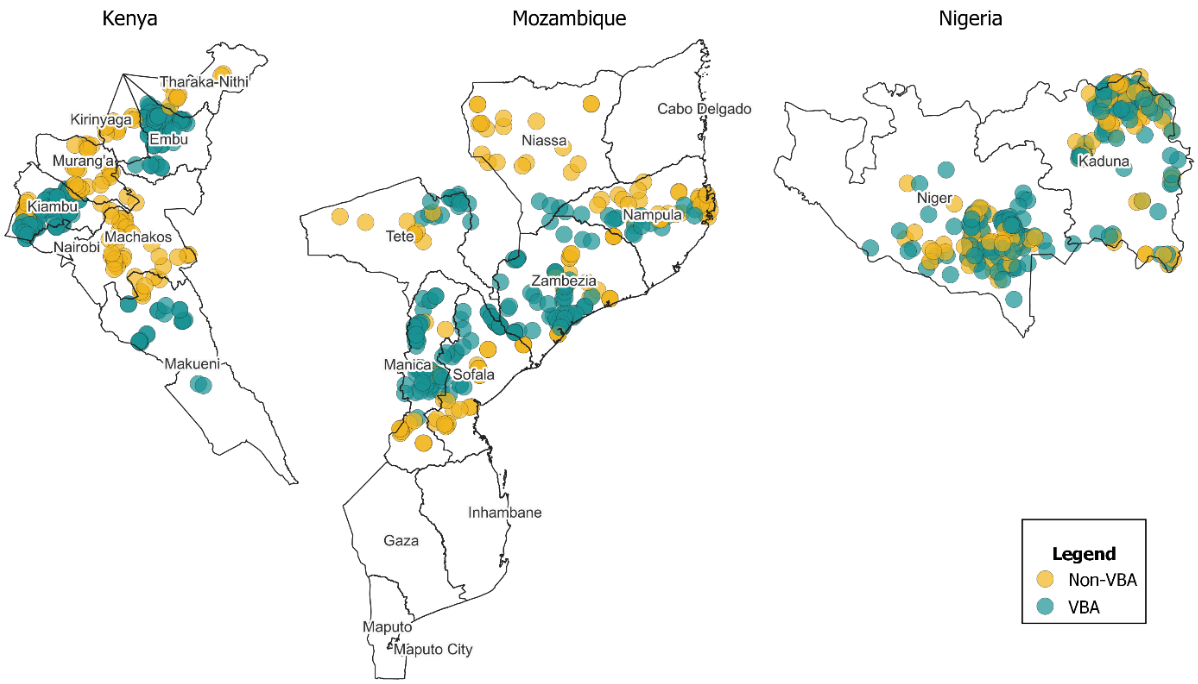
[2] In Kenya and Mozambique, the resulting area-level matches varied in area depending on the size of each ward.

(NDVI) from 1989 to 2018. (NDVI is commonly used to assess levels of healthy vegetation based on geospatial satellite data.) These agroecological, natural land, and climatic characteristics are all measured over the historical, 30-year *climate normal* period preceding project implementation. We also matched on the average nighttime radiance—commonly referred to as night lights—in the program start year as a proxy for economic activity, and population, which was sourced from High Resolution Population Density Maps and Demographic Estimates from Data for Good at Meta for 2019.[3] Remotely sensed, geospatial data were sourced via Google Earth Engine, FAO's GAEZ Data Portal, and the Humanitarian Data Exchange. All of these data were processed using Google Earth Engine. We additionally matched on either the state or district (administrative level 1) within which communities are located to ensure that area-level matches were spatially proximate.

Figure 2 displays the geographic spread of VBA and non-VBA communities in all three countries. In Nigeria, VBA communities are quite interspersed with non-VBA communities; thus, the area-level characteristics (like rainfall and agroecological zone) in these communities are quite similar. In Kenya and Mozambique, VBA and non-VBA communities tend to be geographically farther apart. This is because: (1) VBA program implementation saturated target areas in Kenya and Mozambique, requiring comparison communities to be located farther away; and (2) the first stage of matching took place at a much finer level in Nigeria (the village) than in Kenya and Mozambique (the ward). As such, in Kenya and Mozambique, each ward solely contains VBA or non-VBA communities, not both; this is not necessarily the case in Nigeria at the comparable administrative level (the local government area, or LGA). There are two key implications of these spatial patterns: (1) in Nigeria, village-level matches tend to be more similar, but the increased proximity may mean that there could be information spillovers, that is, farmers in comparison villages that did not receive the VBA program may have learned from farmers in nearby VBA communities; and (2) in Kenya and Mozambique, village-level matches tend to be less similar, but spillovers are less likely to influence the impact estimates.

[3] The population data are not available for the period immediately prior to implementation (i.e., 2017), but it is extremely unlikely that the VBA program impacted population in the first few months of its implementation.

Figure 2. Locations of VBA and non-VBA communities in the evaluation sample



Source: Mathematica VBA farmer survey, 2023.

Once we selected non-VBA areas that looked as similar as possible to VBA areas, we randomly sampled farmers from both areas. We sampled more non-VBA villages and farmers than VBA villages and farmers to ensure there was a larger pool of non-VBA villages and farmers from which to find good matches with VBA farmers. In Nigeria and Mozambique, we randomly sampled 200 and 184 VBA communities, respectively, and randomly sampled 125 and 119 non-VBA communities, respectively. In Kenya, we randomly sampled 100 VBA communities and 125 non-VBA communities.[4] This resulted in a *clustered* evaluation design that is less susceptible to bias due to information spillovers because spillovers are less likely across larger geographic areas, which could be likely if VBA and comparison farmers were selected from within the same communities.

We stratified farmer-level sampling based on gender and age group to reflect the focus of the VBA program on both women and men farmers, as well as youth (younger than age 35) and non-youth (age 35 and older). Once we selected non-VBA areas that looked as similar as possible to VBA areas, we randomly sampled farmers from both areas. In each community, we drew a random sample of 8 to 9 farmers for the survey, stratifying on gender and age group to ensure adequate representation of both women and men farmers and youth and non-youth farmers. Because farmers in study areas tend to be men and non-youth, we oversampled women

[4] This study was initially intended as a baseline for a prospective study assessing the additional impact of the digitalization program. That is why we purposively selected additional VBA areas in Mozambique and Nigeria that had implemented a digital VBA component.

and youth farmers in all three countries at the village level to ensure that the data would adequately reflect their experiences and the sample sizes for sub-groups would be sufficient to draw conclusions. We present the farmer sampling approach in each country, and the resulting number of observations, in more detail below:

- **Kenya.** The goal was to randomly sample 9 farmers per village, with an approximately equal distribution among women and men. It was not possible to fully stratify by youth and non-youth in Kenya because the farmer lists did not consistently include age. The final sample included 800 VBA farmers and 929 non-VBA farmers.
- **Mozambique.** The goal was to randomly sample 8 farmers per village, with an equal distribution among women and men, as well as youth and non-youth. The final sample included 1,653 VBA farmers and 1,176 non-VBA farmers.
- **Nigeria.** The goal was to randomly sample 9 farmers per village, with an equal distribution among women and men, as well as youth and non-youth. The final sample included 1,554 VBA farmers and 1,398 non-VBA farmers.

The second stage of matching took place at the farmer level after the farmer survey was conducted, as this matching drew on farmer- and household-level characteristics gathered through the survey. We matched on characteristics that were most likely to be time invariant and unaffected by VBA program participation. These included gender, age, education (completed primary school), if the household was cultivating their land prior to 2018, and if the land they cultivate was previously forested. We also incorporated all of the factors in the first stage of matching to ensure that the farmer-level matches would still be similar on the previously established area-level agroecological zones, rainfall, temperature, NDVI, night lights, population, and state or district administrative level.[5] Leaving these area-level characteristics out of the farmer match would result in farmers with similar farmer characteristics being matched across different agroecological zones and climates, which would result in a poor comparison and likely generate biased impact estimates. We conducted farmer-level matching on gender, age, education, cultivating land prior to 2019, cultivated land was previously forested, agroecological zones, rainfall, temperature, NDVI, night lights, population, and administrative level to identify a valid counterfactual. CEM allows for multiple matches and scales the resulting weights to account for how many matches are associated with each farmer match. We did not match on characteristics like land size, wealth, or family size because these may have been affected by the VBA program.

We succeeded in matching nearly all VBA farmers to similar non-VBA farmers. In Nigeria, we were able to match 1,405 of 1,554 VBA farmers to 1,211 of 1,398 non-VBA farmers. In Kenya,

[5] In the case of Nigeria, the same 1-kilometer squared polygons are considered. In Kenya and Mozambique, the area-level values were refined to comparable 1-kilometer squared polygons based on the GPS coordinates collected during the farmer survey.

we were able to match 738 of 800 VBA farmers to 698 of 929 non-VBA farmers. In Mozambique, we were able to match 1,578 of 1,653 VBA farmers to 1,147 of 1,176 non-VBA farmers.

The final analytical weights incorporated CEM weights to maximize balance and post-stratification weights to maximize representativeness. The CEM matching process generated CEM weights that we incorporated into our analyses to minimize the difference between observations in the VBA and non-VBA groups. Further, we incorporated post-stratification weights that adjust for the oversampling of women and youth (DeBell and Krosnick 2009). This process ensured that the results from our analysis would be representative of the population identified in the VBA farmer lists. We combined these weights into a final analytical weight that we applied throughout our analysis.

2.3. Results of the matching

Conducting CEM matching resulted in groups of VBA and non-VBA farmers that were similar, on average (Table 2). After matching, which prunes some observations, and applying CEM weights, we found that the number of statistically significant differences between the VBA and non-VBA groups decreased in each country-level analytical sample. For example, in Kenya, 8 out of 15 characteristics were statistically significantly different between the VBA and non-VBA groups before matching and weighting; there were only 3 statistically significant differences after.[6] In other words, the matched and weighted data were considerably more similar. Some characteristics did remain statistically significantly different, but there was balance along most dimensions. In our final regressions, we controlled for any characteristics for which there were significant differences after matching. This confirmed the validity of the matched comparison design approach using CEM because we were able to identify a strong counterfactual group in each country.

[6] Note that the number of observations does not change from the unweighted to weighted columns for each country, as this balance check is conducted strictly for each analytical sample. Including the pruned observations in the unweighted (unmatched) columns would result in more and larger differences prior to matching and weighting.

Table 2. Differences between VBA and non-VBA farmers in the analytical sample

	Kenya		Mozambique		Nigeria	
	Unweighted (unmatched)	Weighted (matched)	Unweighted (unmatched)	Weighted (matched)	Unweighted (unmatched)	Weighted (matched)
Farmer and household characteristics						
Age of decision maker	**5.5** ***	-0.1	**1.3** **	0.0	**0.8** *	-0.1
Youth decision maker (binary)	**-12.1%** ***	1.2%	**-3.8%** *	1.4%	**-3.4%** **	0.3%
Female farmer (binary)	**4.4%** **	1.1%	**-2.5%** *	-1.5%	**7.2%** ***	**7.0%** ***
Decision maker completed primary education or above (binary)	-3.4%	3.6%	-1.0%	1.0%	**4.9%** *	**5.2%** *
Female household head (binary)	**-7.7%** ***	**-11.5%** ***	-2.5%	0.4%	1.5%	1.6%
Number of household members (persons)	**0.4** ***	0.2	**0.4** ***	0.3	0.1	0.1
Cultivating land before 2018 (binary)	1.7%	-1.4%	**13.9%** ***	**12.9%** ***	1.2%	1.0%
Cultivates old forest land (binary)	-2.4%	-0.3%	-3.6%	-2.9%	0.8%	3.7%
Village characteristics (remotely sensed)						
Village population, 2019	974.5	787.1	560.6	1098.8	-102.5	-1998.1
Annual rainfall, 1989-2018 (mm)	8.531	-17.616	2.162	16.175	-3.438	3.583
Average daily temperature, 1989-2018 (deg C])	-18.060	-17.982	**-18.833** ***	**-18.427** ***	-17.861	-17.798
NDVI, 1989-2018 (-1,1)	**0.012** *	0.011	0.010	0.001	**-0.007** *	-0.001
Night lights, 2019 (nW/sr/cm^2)	0.148	0.128	-0.006	0.029	0.188	-0.062
Dominant agroecological zone (AEZ), binary						
Tropics, highland, humid, with slope/ terrain limitations	**-10.8%** *	**-13.0%** *	-	-	-	
Tropics, highland, sub-humid, with slope/ terrain limitations	**14.4%** **	**12.9%** *	-			
Tropics, lowland, sub-humid, with slope/ terrain limitations	-0.7%	5.1%			-5.3%	-6.2%
Severe slope/terrain limitations			0.4%	0.1%	2.2%	2.4%
Tropics, lowland, humid			2.3%	1.1%		
Tropics, lowland, semi-arid			-4.8%	-3.1%		
Tropics lowland, semi-arid, with slope/terrain limitations			2.2%	2.1%	**-3.6%** *	-2.5%

	Kenya		Mozambique		Nigeria	
	Unweighted (unmatched)	Weighted (matched)	Unweighted (unmatched)	Weighted (matched)	Unweighted (unmatched)	Weighted (matched)
Tropics, lowland, semi-arid, minor slope/ terrain limitations					4.4%	2.0%
Tropics, lowland, sub-humid, minor slope/ terrain limitations					5.4%	**9.4% ** **
Urban/built-up land					0.9%	-0.2%
Statistically significant differences	**8**	**3**	**6**	**2**	**5**	**3**
Number of obs.	1,436		2,725		2,616	

Source: Mathematica VBA farmer survey, 2023.

Notes: The differences in means between VBA and non-VBA farmers are restricted to the analytical sample. Sample sizes are smaller for some outcomes due to missing responses.

*/**/*** on difference indicates that it is statistically significant at the p = 0.10/0.05/0.01 level.

Our matching process identified a well-balanced counterfactual in each country; nevertheless, we chose to include several control variables in our weighted regression analysis.[7] First, we included characteristics used in matching that remain significantly different when weighted, including farmer gender, whether they completed primary education or above, whether the head of the household is female, whether they cultivated land before 2018 (historical), and AEZ. Second, we controlled for temperature and precipitation outcomes during the growing seasons of interest. Third, we controlled for household size at the time of the survey to account for economies of scale and labor availability; we could not include household size at the time of the survey in the matching because it may have been affected by the program. Fourth, given that the program focuses on both women and men farmers, as well as youth and non-youth farmers, we controlled for those categories, which also allowed us to explore potential heterogenous program impacts. Fifth, given the agricultural focus of the program we controlled for historical NDVI to ensure that differences in production were not a function of longstanding vegetation differentials. Finally, we controlled for the distance from a village to the nearest VBA village to account for potential information spillovers related to the program—this means that all treatment communities received a value of zero for this control.

2.4. Farmer survey data

The evaluation relied on primary data collected by the research team through a computer-assisted personal interview (CAPI)-based multimodule household survey. We refer to the survey as the Mathematica VBA farmer survey (2023). The survey took place in April and May 2023 and was conducted by Ipsos, a data collection and research firm contracted by the

[7] We conducted weighted regression analyses using ordinary least squares (OLS). We computed standard errors clustered at the village level that are robust to heteroscedasticity.

research team. The primary focus of the survey was the household's agricultural activities in the most recently completed calendar year, 2022. To capture a complete picture of agricultural activities, data collection encompassed both the long and short rain seasons where applicable. This approach ensured the inclusion of a complete year's worth of agricultural data in the analysis.

Randomly sampled VBA and non-VBA farmers were screened prior to being surveyed to ensure that they met the study criteria. In particular, farmers were included if (1) the VBA farmer did, in fact, receive training from a VBA and (2) the non-VBA farmer did not receive training from a VBA, and (3) the respondent was the member of the household most likely to receive agricultural training because they manage agricultural activities. This ensured that respondents were knowledgeable and the VBA respondents could reflect their experiences in the VBA program, and it minimized the chances that outcomes for the non-VBA group were influenced by VBAs. Nonresponse in the field was extremely uncommon, with response rates higher than 99 percent in all three countries.

The data collection tool encompassed several modules to capture various aspects of the evaluation. These modules included (1) household and farmer characteristics; (2) knowledge of agricultural practices; (3) implementation of agricultural practices; (4) farm plots, crops, harvests, and revenue; (5) farm input costs; (6) market access; (7) extension services; (8) household resilience; and (9) food security and nutrition. To ensure accurate and consistent wording and messaging, the instrument was translated and back-translated in eight languages. This rigorous process was implemented to uphold the integrity and reliability of the data collection instrument across the different contexts.

The data collection instrument was specifically designed to assess the impact of the VBA approach on the adoption of good agricultural practices (GAP) promoted by the VBA program, such as planting in rows and proper spacing, use of certified seeds, input usage, market access, and various farmer-level outcomes such as productivity, profitability, income, resilience, nutrition, and food security. To ensure the instrument's reliability and validity to capture outcomes and adoption, we carefully referenced and adapted questions from established data collection tools and resources. Notably, these included the World Bank's guidebook for designing household surveys (Sagesaka et al. 2021), the World Bank's Living Standard Measurement Study sample survey (Dillon et al. 2021), the World Bank's Findex questionnaire (World Bank 2021), and FAO's Resilience Index Measurement and Analysis questionnaire (FAO 2020).

To comprehensively measure concepts such as resilience, nutrition, and food security, the survey incorporated well-established tools. Feed the Future's Ability to Recover from Shocks and Stresses Index (ARSSI) was incorporated to measure a household's ability to rebound from shocks, while a condensed version of the Subjectively Evaluated Resilience Score (SERS) was included to evaluate respondents' perceived resilience (Feed the Future 2019; Jones 2019). The

ARSSI asks respondents about their exposure to and the severity of a series of shocks and stresses that might have occurred during the previous year. As part of the SERS, respondents were asked to what extent they agreed or disagreed with several statements pertaining to their household's situation in times of hardship. Both measures focus on the respondent's perception of their own ability but differ in that the SERS considers adaptability, social cohesion, and other support mechanisms that are not captured in the ARSSI. A household's food security was evaluated using FAO's Food Insecurity Experience Scale (FIES), while the Household Dietary Diversity Score (HDDS) was used to understand the household's ability to access a variety of foods. By using standardized indicators, the survey ensured a consistent and uniform approach to measurement, facilitating comparisons across different populations and geographic areas and enhancing the contextualization and validation of the evaluation findings.

With the overall evaluation objectives in mind, the design of the data collection tool sought an optimal balance between the level of detail required and the potential burden on respondents. For example, respondents were asked to recall farm-level labor data for the entire year rather than per season, and questions on input were asked at the crop level rather than individual plot level. These considerations aimed to ensure that the data collection process was efficient and manageable for the respondents, while providing the necessary information to meet the evaluation's objectives. Table 3 provides an overview of the reference period and the level (farm/crop) at which the study collected key data.

Table 3. Selected outcome measures in the farmer survey, level, and reference period

Outcome	Level	Reference period in 2022
Crops cultivated	Farm	"Long" rainy season and, if applicable, "short" rainy season
Land area cultivated	Crop	"Long" rainy season and, if applicable, "short" rainy season
Harvest quantity	Crop	"Long" rainy season and, if applicable, "short" rainy season
Harvest uses (e.g., quantity sold or consumed)	Crop	Calendar year
Harvest value (in local currency)	Crop	Calendar year
Seed input quantity and costs	Crop	"Long" rainy season and, if applicable, "short" rainy season
Fertilizer input quantity and costs	Farm	"Long" rainy season and, if applicable, "short" rainy season
Herbicide and pesticide quantity and costs	Farm	"Long" rainy season and, if applicable, "short" rainy season
Rent	Farm	"Long" rainy season and, if applicable, "short" rainy season
Irrigation	Farm	"Long" rainy season and, if applicable, "short" rainy season
Labor costs	Farm	Calendar year
Agricultural practices (focus crops only)	Crop	"Long" rainy season or, when no crops were planted during the main agricultural time period, the "short" rainy season
Market access	Farm	Calendar year
Extension services	Farm	Calendar year

The timing of an agricultural survey can significantly impact the accuracy and reliability of its data. For example, conducting farmer interviews right after harvest completion will likely yield better data on harvest quantities than if interviews took place some months later, say, during the early stages of the subsequent planting season. Data collection for this study took place in April and May 2023, capturing the period shortly after planting for the "long" rainy season in Kenya (around 8 months after farmers would have last harvested in September 2022) , towards the end of the sole season in Mozambique (during, but not before completion, of the 2023 harvest (a year after the last completed harvest in 2022)), and just prior to the commencement of the main season in Nigeria (around 4 months after the commencement of the 2022 harvest in December). The survey design employed specific measures to mitigate potential biases, including careful consideration of the order of sections and question formulations. Nonetheless, there may be potential recall inaccuracies that reflect the temporal relationship between data collection and the respective agricultural seasons.

We took several steps to address potentially inaccurate reports and missing information. First, we applied a correction to responses that were outliers (and therefore potentially erroneous). All outliers were identified at the crop and country level, and normalized at the unit level (input quantities were examined at the kg/ha level, and input prices at the price/kg level). We replaced outliers with the median, separately by country and crop, to approximate a normal distribution. In line with a normal distribution, in all cases, fewer than 5 percent of observations were identified as outliers and replaced with the median. Second, we imputed missing values (except quantities of input and output), most of which result from "don't know" responses from respondents or units that we were unable to convert to standard units; in these cases, we replaced missing values with the median values, separately by country and crop.

2.5. Analytical sample

The farmer surveys resulted in available samples of 1,436 farmers in Kenya, 2,725 farmers in Mozambique, and 2,616 farmers in Nigeria.[8] Although we attempted to locate an equal number of female and male and youth and non-youth farmers through stratification (over-sampling), this was not possible in practice (Table 4). For example, it was particularly challenging to locate youth in Kenya (20 percent for the VBA group and 32 percent for the non-VBA group) and women in Nigeria (45 percent in the VBA group and 38 percent in the non-VBA group). In Mozambique and Nigeria, a small number of respondents (61 and 28, respectively) were categorized as missing age instead of youth or non-youth because they did not report this information with enumerators.

Table 4. Analytical sample and key sub-groups by VBA status

	Kenya		Mozambique		Nigeria	
	Non-VBA	VBA	Non-VBA	VBA	Non-VBA	VBA
Total sample size						
Number of farmer observations	698	738	1,147	1,578	1,211	1,405

[8] Prior to pruning as part of matching, the farmer surveys resulted in available samples of 1,729 farmers in Kenya, 2,829 farmers in Mozambique, and 2,952 farmers in Nigeria.

	Kenya		Mozambique		Nigeria	
	Non-VBA	VBA	Non-VBA	VBA	Non-VBA	VBA
Subgroup sample sizes						
Female observations	413	469	586	766	463	639
Male observations	285	269	561	812	748	766
Youth observations	221	144	569	736	655	711
Non-youth observations	477	594	542	817	556	691
Missing age observations	-	-	36	25	25	3
Subgroup percentages						
Female observations	59%	64%	51%	49%	38%	45%
Male observations	41%	36%	49%	51%	62%	55%
Youth observations	32%	20%	50%	47%	54%	51%
Non-youth observations	68%	80%	47%	52%	46%	49%
Missing age observations	-	-	3%	2%	2%	0%

Source: Mathematica VBA farmer survey, 2023.

Notes: Estimates are weighted to adjust for differences in sampling probabilities and for differences between the VBA and non-VBA samples.

2.6. Limitations

Although we employed the most rigorous design possible for a retrospective study, the evaluation has several limitations. Because we were unable to collect baseline data, we could not control for pre-intervention differences or changes over time between VBA and non-VBA farmers, potentially biasing our impact estimates. Furthermore, our strategy—combining remotely sensed geospatial data and matching—attempts to account for a rich set of area-level factors, but it is still possible that there are unobserved area-level characteristics, including soil quality or pest conditions, that we are not able to account for. Therefore, the impact estimates may be biased if other correlated characteristics that we do control for do not adequately account for omitted area-level factors. This is of particular concern in Kenya and Mozambique, where a combination of a high degree of saturation in program implementation and incomplete village-level GPS information resulted in non-VBA communities that were less proximate. Moreover, we relied on self-reported data for some important outcomes like yields, land area cultivated, and income, which farmers are not always able to report accurately for previous seasons. This will not bias the results of the evaluation as long as there is not systematic bias in how VBA and non-VBA farmers respond to these types of questions; however, it may make the data less precise, which could make it more difficult to identify statistically significant differences between VBA and non-VBA farmers.

3. Findings

The evaluation assessed impacts on a range of farmer outcomes. Below, we first present demographic characteristics, followed by a discussion of farmers' engagement with extension services. Next, we present estimated impacts of the VBA program on practice adoption, market access, profit, income, and household outcomes such as resilience and food security. Finally, we discuss differential impacts by gender and youth status, unintended consequences of the program, and the estimated return on investment of the program.

3.1. Farmer demographic characteristics

There are several country-level differences in demographic characteristics (Table 5). In Kenya, farmers tend to be older, be more educated, have smaller households, and be more likely to have off-farm income. In Mozambique, farmers are younger and are less likely to have off-farm income or to be members of community groups. In Nigeria, farmers are less likely to be female and to earn off-farm income, and household sizes tend to be considerably larger.

Table 5. Demographic characteristics

	Kenya		Mozambique		Nigeria	
	Non-VBA (N=698)	VBA (N=738)	Non-VBA (N=1,147)	VBA (N=1,578)	Non-VBA (N=1,211)	VBA (N=1,405)
Female farmer	59.2%	63.6%	51.1%	48.5%	38.2%	45.5%
Age of decision maker	44.9	50.4	33.4	36.8	36.8	37.3
Household head completed primary school	85.8%	80.6%	48.7%	49.5%	50.0%	58.8%
Household size	3.9	4.3	5.4	5.8	8.7	8.7
Off-farm income-generating activity	79.2%	72.0%	46.6%	41.1%	37.7%	43.6%
Member of community group	65.2%	88.8%	36.3%	51.5%	43.7%	53.7%
Farmer-to-VBA ratio	160		346		134	

Source: Mathematica VBA farmer survey, 2023.

Notes: Estimates are weighted to adjust for differences in sampling probabilities and for differences between the VBA and non-VBA samples.

Farmer-to-VBA ratio is based on AGRA provided administrative data.

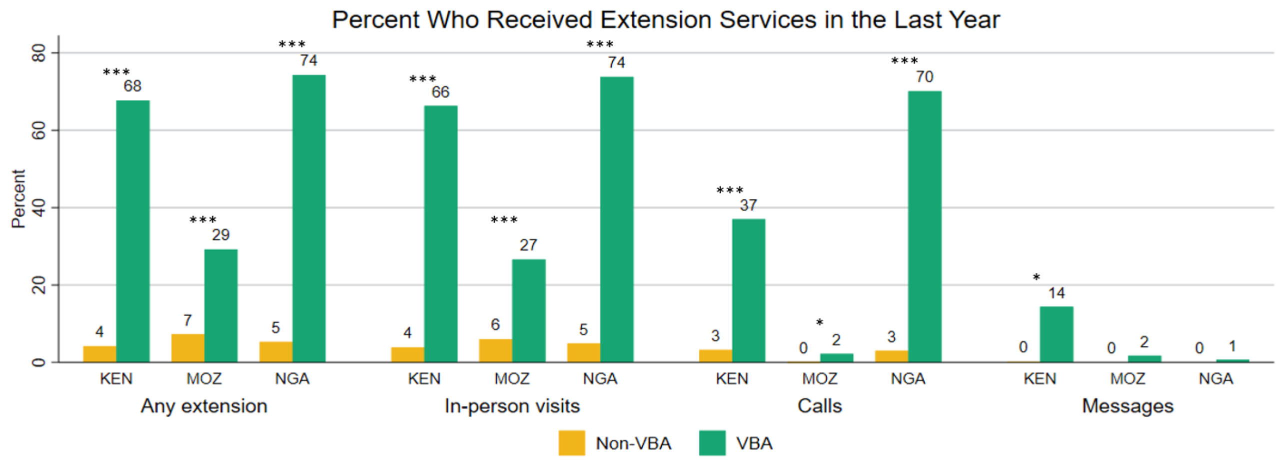
3.2. Extension reach

Key findings:

- The VBA program has substantially deepened the reach of agricultural extension in all three countries.
- Contamination of the non-VBA group due to receipt of VBA extension is unlikely and is not a major concern for this evaluation, though this does not rule out the possibility of information spillovers.◢

Receipt of any extension and extension calls in the last year are considerably more likely among VBA farmers in the last year. VBA farmers were substantially more likely to receive any extension services, including in-person visits and extension calls (**Figure 3**). Extension messages sent via SMS were also more common among VBA farmers in Kenya, though the proportion of VBA farmers received messages was small. Among farmers who did receive extension services, the number of visits was roughly the same for VBA and non-VBA farmers in Kenya and Mozambique, at around 3 to 4 visits in the past year, but VBA farmers in Nigeria received an average of 7.6 visits per year, compared with only 4.5 among non-VBA farmers (not shown); in other words, the VBA program does not appear to increase the intensity of interaction with extension agents for those who have such interactions, but rather the reach of extension. The number of visits received in the last year in Mozambique is likely lower because the program ended its activities earlier in 2022 in Mozambique than in the other two countries.

Figure 3. Farmer reach



Source: Mathematica VBA farmer survey, 2023

Notes: Estimates are weighted to adjust for differences in sampling probabilities and for differences between the VBA and non-VBA samples.

*/**/*** indicates difference is statistically significant at the p < 0.10/0.05/0.01 level.

3.3. Impacts on practice adoption and market access

Key findings:

- VBA farmers reported higher rates of some of the improved practices the VBAs promoted, including planting in rows, correctly spacing rows, crop rotation, and post-harvest storage in protective bags.
- Compared to non-VBA farmers, VBA farmers in Nigeria were more likely to use organic fertilizer and to combine organic and synthetic fertilizer, and VBA farmers in Kenya were more likely to use herbicide and pesticide, but we found no significant differences in the use of certified or hybrid seeds. Input use varied widely across countries, with high rates of certified seed use in Kenya, high rates of herbicide use in Nigeria, and relatively low use of all purchased inputs in Mozambique.
- There were only minor differences in input and output markets between VBA and non-VBA farmers. VBA farmers in Kenya were less likely to sell directly to consumers and more likely to sell to middlemen or a trading company, while VBA farmers in Mozambique were more likely to sell to a wholesaler.◢

The VBA program aimed to increase farmers' productivity through several pathways, including improved agricultural practices and increased access to inputs such as certified and hybrid seeds, fertilizer, pesticides, and herbicides. The program also aimed to increase market access for output sales, with the goal of increasing agricultural sales and allowing farmers to access better prices for their produce. Below we present the differences between VBA and non-VBA farmers on each of those intermediate outcomes.

Farmers in the VBA program were more likely to practice some of the improved practices highlighted in the training materials, including planting in rows, correctly spacing rows, and crop rotation. One improved planting practice promoted by the program was planting in rows, and we found that a higher share of VBA farmers than non-VBA farmers planted both maize and soy in rows, but only in Mozambique (Table 6). In Kenya and Nigeria, nearly all farmers in both groups planted in rows, indicating that this is already a common practice and there was little room for improvement through the program. The VBA program also promoted a specific row spacing for each crop to maximize productivity, and we observed that the share of VBA farmers using the recommended spacing for maize was substantially higher in both Kenya and Mozambique.

We also observed an increased share of farmers practicing crop rotation in all countries, with more VBA farmers practicing crop rotation for maize in Kenya and for all three target crops in Nigeria. In Mozambique, we did not observe higher rates of crop rotation overall, but we did observe higher rates of crop rotation with maize and pulses combined (not shown).

Table 6. Practice adoption: planting practices for focus crops[9]

	Kenya			Mozambique			Nigeria		
	Non-VBA	VBA	Difference	Non-VBA	VBA	Difference	Non-VBA	VBA	Difference
Planted in rows									
Maize	97.6%	98.9%	1.3%	66.4%	76.2%	9.8% *	98.5%	98.9%	0.4%
Rice				18.9%	20.9%	2.0%	89.7%	94.7%	5.0%
Soy				56.4%	97.2%	40.8% **	96.2%	98.6%	2.4%
Used recommended row spacing									
Maize	30.4%	44.3%	13.9% **	31.2%	65.7%	34.5% ***	60.6%	57.9%	-2.7%
Rice				3.1%	2.1%	-1.0%	36.6%	34.2%	-2.4%
Soy				6.4%	17.7%	11.3%	55.8%	57.5%	1.7%
Average time planting after rains (days)									
Maize	1.5	1.5	-0.1	3.3	3.0	-0.2	7.7	8.7	1.0
Rice				6.0	4.3	-1.7	18.4	21.6	3.2
Soy				11.4	11.1	-0.3	15.0	15.9	1.0
Practiced crop rotation									
Maize	43.0%	64.9%	21.9% **	32.4%	33.8%	1.4%	32.6%	43.7%	11.1% **
Rice				35.9%	29.4%	-6.5%	20.3%	30.6%	10.3% *
Soy				27.9%	38.6%	10.7%	30.2%	42.6%	12.4% *

Source: Mathematica VBA farmer survey, 2023.

*/**/*** indicates difference is statistically significant at the p < 0.10/0.05/0.01 level

[9] The survey posed questions to all farmers in all countries about any crops they planted, but crop-specific findings are only presented for focus crops.

Notes: Estimates are weighted to adjust for differences in sampling probabilities and for differences between the VBA and non-VBA samples.
Missing values are replaced with median values, separately by country and crop.
Sample sizes for crop-level estimates are presented in Appendix Table 1.

The largest improvement in post-harvest storage among VBA farmers occurred in Kenya, driven by increases in PICS bag adoption. PICS bags contain two liner layers fitted inside the third layer, a woven sack, allowing farmers to store crops without using chemicals to combat insects and pests. In Kenya, 48.4 percent of VBA farmers reported storing in PICS or a metallic silo, compared to 27.7 percent of non-VBA farmers, a statistically significant difference (Table 7). Access to PICS bags or metallic silos is likely limited in Nigeria and Mozambique, reflected in the low uptake of these crop storage methods among VBA and non-VBA farmers in both countries.

Table 7. Practice adoption: crop storage

	Kenya			Mozambique			Nigeria		
	Non-VBA	VBA	Difference	Non-VBA	VBA	Difference	Non-VBA	VBA	Difference
Stored in PICS or metallic silo									
Maize	**27.7%**	**48.4%**	**20.7% *****	0.6%	2.1%	1.5%	3.9%	2.8%	-1.1%
Rice				2.7%	-0.3%	-3.0%	5.0%	1.2%	-3.8%
Soy				0.0%	-1.1%	-1.1%	4.1%	2.5%	-1.6%

Source: Mathematica VBA farmer survey, 2023.
Notes: Estimates are weighted to adjust for differences in sampling probabilities and for differences between the VBA and non-VBA samples.
Sample sizes for crop-level estimates are presented in Appendix Table 1.
*/**/*** indicates difference is statistically significant at the p < 0.10/0.05/0.01 level.

VBA farmers in Kenya were less likely to dust with pesticides for crop protection in storage, while VBA farmers in Mozambique were more likely to spray crops as a storage protection method. GAP recommendations for protecting all focus crops in storage are the same: nothing beyond dry conditions for crops stored for one year or less, with some pesticide use needed for crops stored for more than one year. The reduction in pesticide use for protecting stored crops in Kenya may be a result of the program's focus on regenerative agriculture and subsequent avoidance of pesticides among farmers. There was no difference in post-harvest crop protection in storage between VBA and non-VBA farmers in Nigeria (Table 8).

Table 8. Practice adoption: crop protection in storage

	Kenya			Mozambique			Nigeria		
	Non-VBA	VBA	Difference	Non-VBA	VBA	Difference	Non-VBA	VBA	Difference
Stored crop protection: nothing									
Maize	69.1%	79.0%	9.9%	**60.3%**	**45.2%**	**-15.1% *****	35.6%	30.1%	-5.5%
Rice				90.1%	94.1%	4.0%	68.2%	69.1%	0.9%
Soy				78.4%	59.3%	-19.1%	80.1%	77.3%	-2.8%

	Kenya			Mozambique			Nigeria		
	Non-VBA	VBA	Difference	Non-VBA	VBA	Difference	Non-VBA	VBA	Difference
Stored crop protection: dusting with pesticides									
Maize	**25.9%**	**12.1%**	**-13.8% ****	10.3%	10.2%	-0.1%	36.6%	42.5%	5.9%
Rice				3.2%	1.0%	-2.2%	13.0%	10.0%	-3.0%
Soy				2.2%	0.7%	-1.5%	8.8%	6.6%	-2.2%
Stored crop protection: smoking									
Maize	0.1%	0.4%	0.3%	11.0%	12.8%	1.8%	1.7%	1.2%	-0.5%
Rice				0.9%	0.8%	-0.1%	0.1%	1.0%	0.9%
Soy				4.5%	-3.3%	-7.8%	0.0%	0.2%	0.2%
Stored crop protection: spraying									
Maize	2.5%	4.3%	1.8%	**19.2%**	**31.8%**	**12.6% *****	22.1%	22.4%	0.3%
Rice				2.7%	1.3%	-1.4%	18.0%	19.8%	1.8%
Soy				**15.0%**	**44.7%**	**29.7% ***	10.8%	14.4%	3.6%

Source: Mathematica VBA farmer survey, 2023.

Notes: Estimates are weighted to adjust for differences in sampling probabilities and for differences between the VBA and non-VBA samples.

Sample sizes for crop-level estimates are presented in Appendix Table 1.

*/**/*** indicates difference is statistically significant at the $p < 0.10/0.05/0.01$ level.

We observed some differences in input use between VBA and non-VBA farmers, with higher fertilizer use among VBA farmers in Nigeria and higher herbicide and pesticide use among VBA farmers in Kenya. VBAs aim to play a key role in providing improved access to inputs such as seeds and fertilizer by connecting farmers with markets. However, we did not find dramatic differences in input use. Organic fertilizer use was higher for VBA farmers than non-VBA farmers in Nigeria, as was the share of farmers who used a combination of synthetic and organic fertilizer, which was recommended by the VBA program (Table 9). In Mozambique, VBA farmers were less likely to use organic fertilizer, and use of either type of fertilizer was very low in Mozambique for both groups. We did not observe any statistically significant differences in the quantity of fertilizer used between VBA and non-VBA farmers.

Use of certified hybrid seeds was similar for VBA and non-VBA farmers. In Kenya, the share of farmers who used certified seeds was very high for both groups, suggesting little room for improvement, but certified seed use remained low for both Mozambique and Nigeria. VBA farmers in Nigeria were 10 percentage points more likely than non-VBA farmers to use hybrid maize seeds (including certified and non-certified), but less likely to use hybrid soy seeds (not shown).

Herbicide and pesticide use was higher for VBA farmers in Kenya, but rates of both were very low in Mozambique for both groups of farmers. In Nigeria, herbicide use was very high for both groups, but we did not observe a difference between VBA and non-VBA farmers.

Table 9. Practice adoption: input use

	Kenya			Mozambique			Nigeria		
	Non-VBA	VBA	Difference	Non-VBA	VBA	Difference	Non-VBA	VBA	Difference
Used fertilizer									
Synthetic	78.0%	72.4%	-5.6%	2.8%	3.8%	1.0%	88.8%	87.3%	-1.5%
Organic	69.6%	72.3%	2.7%	**7.0%**	**2.2%**	**-4.8% ****	**53.1%**	**60.8%**	**7.7% ***
Both	50.0%	48.3%	-1.7%	0.4%	0.4%	0.0%	**46.3%**	**54.3%**	**8.0% ****
Fertilizer use (kg/ha)									
Synthetic	53.7	46.6	-7.1	40.5	57.9	17.5	133.8	129.0	-4.9
Organic	1219.6	1239.9	20.3	199.7	503.9	304.2	733.8	836.4	102.6
Used certified seeds									
Maize	89.0%	89.9%	0.9%	18.4%	22.9%	4.5%	22.8%	29.0%	6.2%
Rice				5.2%	4.7%	-0.5%	25.6%	30.5%	4.9%
Soy				32.1%	4.3%	-27.8%	36.8%	44.0%	7.2%
Used herbicide/pesticide									
Herbicide	**12.6%**	**21.0%**	**8.4% ***	4.3%	2.0%	-2.3%	81.0%	80.4%	-0.6%
Pesticide	**34.1%**	**46.8%**	**12.7% ***	4.1%	1.9%	-2.2%	42.7%	43.4%	0.7%

Source: Mathematica VBA farmer survey, 2023.

Notes: Estimates are weighted to adjust for differences in sampling probabilities and for differences between the VBA and non-VBA samples.

Missing values and outliers (greater than 3 standard deviations for land area, 2 standard deviations for other variables) are replaced with median values, separately by country and crop.

Sample sizes for crop-level estimates are presented in Appendix Table 1.

*/**/*** indicates difference is statistically significant at the p < 0.10/0.05/0.01 level.

Fertilizer prices hit record high levels in 2022 around the world, due in large part to the disruption in global supply chains following the Russian invasion of Ukraine, with prices in 2022 rising more than three times higher than 2020 prices (World Bank 2023). The World Food Programme (2023) estimates that the increased prices are associated with approximately a 50 percent drop in fertilizer use in eastern Africa. Because of high fertilizer prices during the reference year for our survey, it is likely that prices dampened adoption, making it more difficult to detect any potential impacts of the program on fertilizer use.

There is some evidence that, among VBA farmers, those that received more extension visits were more likely to adopt the recommended practices (Table 10). Farmers in the VBA group who received three or more visits from their VBA in the past year were more likely than those who received fewer visits to report planting in rows, planting with recommended row spacing, and using fertilizer and herbicides in Nigeria; using certified seeds in Kenya; practicing crop rotation in Kenya and Mozambique, and using pesticides in all three countries. These differences may be correlations rather than caused by VBA interactions, as farmers more likely to be willing to adopt new practices may also be the types of farmers who reach out for more support from VBAs, but it is also possible that a higher level of engagement with VBAs leads to higher adoption of the recommended practices.

Table 10. Practice adoption among high- and low-intervention VBA farmers

Number of in-person VBA visits:	Kenya			Mozambique			Nigeria		
	Low (<3)	High (>=3)	Difference	Low	High	Difference	Low	High	Difference
Planted in rows	97.9%	98.9%	1.0%	69.7%	75.7%	6.0%	**97.0%**	**99.0%**	**2.0%****
Used recommended row spacing	39.7%	34.7%	-5.0%	36.1%	32.1%	-4.0%	**48.8%**	**61.8%**	**13.0%*****
Practiced crop rotation	**61.4%**	**73.4%**	**12.0%*****	**42.4%**	**54.4%**	**12.0%***	42.9%	44.9%	2.0%
Used fertilizer	96.6%	96.6%	0.0%	15.7%	21.7%	6.0%	**90.6%**	**98.6%**	**8.0%*****
Used certified seeds	**88.3%**	**92.3%**	**4.0%***	33.6%	37.6%	4.0%	57.6%	61.6%	4.0%
Used herbicide	21.4%	19.4%	-2.0%	5.3%	9.3%	4.0%	**77.6%**	**85.6%**	**8.0%*****
Used pesticide	**49.9%**	**59.9%**	**10.0%****	**3.3%**	**11.3%**	**8.0%****	**45.5%**	**54.5%**	**9.0%****

Source: Mathematica VBA farmer survey, 2023.

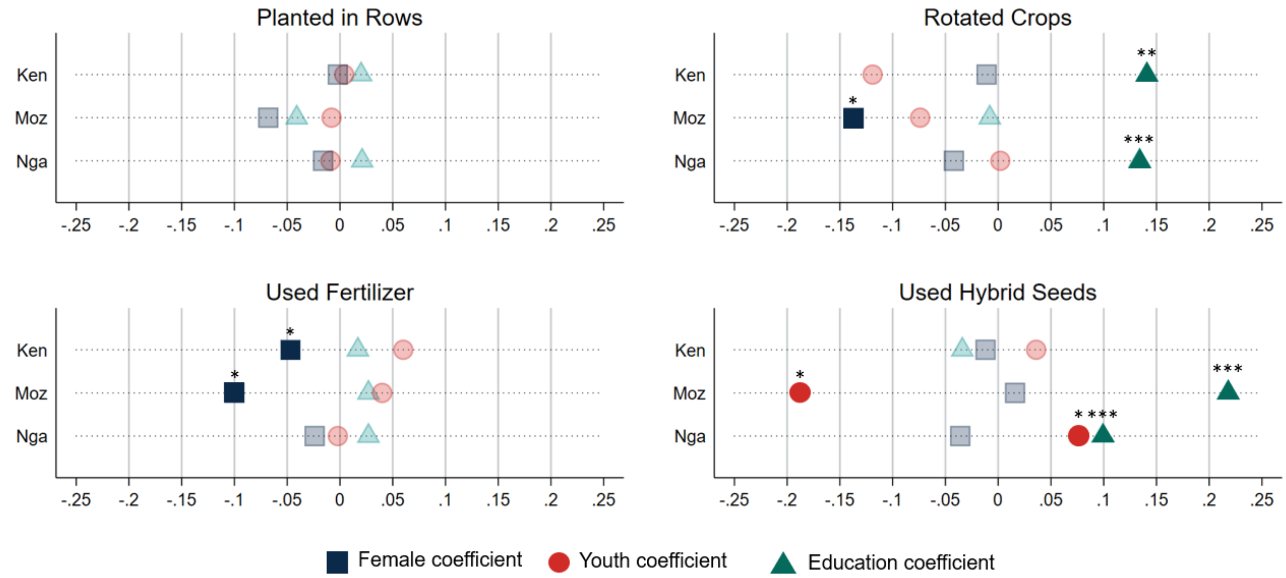
Notes: Estimates are weighted to adjust for differences in sampling probabilities and for differences between the VBA and non-VBA samples.

Missing values and outliers (greater than 3 standard deviations for land area, 2 standard deviations for other variables) are replaced with median values, separately by country and crop.

*/**/*** indicates difference is statistically significant at the $p < 0.10/0.05/0.01$ level.

Women farmers were less likely to adopt some GAPs than male farmers, few differences were observed for youth farmers (Figure 4). The figure below shows the difference in GAP adoption among various subgroups: female (blue squares), youth (red circles), or having at least primary education (green triangles). The icon (triangle, square, circle) indicates the difference in the share adopting a given practice between that subgroup and the rest of the population; e.g. an icon at the 0.10 level for *female* indicates that female farmers are 10 percentage points more likely to adopt that practice than male farmers. Statistically significant differences appear in bold with asterisks above the relevant shape. Female farmers are less likely to use fertilizer in Kenya and Mozambique, and less likely to practice crop rotation in Mozambique. We observe higher rates of both crop rotation and hybrid seed use among more educated farmers (other household characteristics, such as household size and proximity to markets, did not correlate with GAP adoption and are not shown). Youth farmers show few differences, with higher rates of hybrid seed use than non-youth farmers in Nigeria and the opposite in Mozambique.

Figure 4. Good agricultural practice adoption among subgroups



Source: Mathematica VBA farmer survey, 2023.

Notes: Estimates are weighted to adjust for differences in sampling probabilities and for differences between the VBA and non-VBA samples.

Youth = under 35 years of age

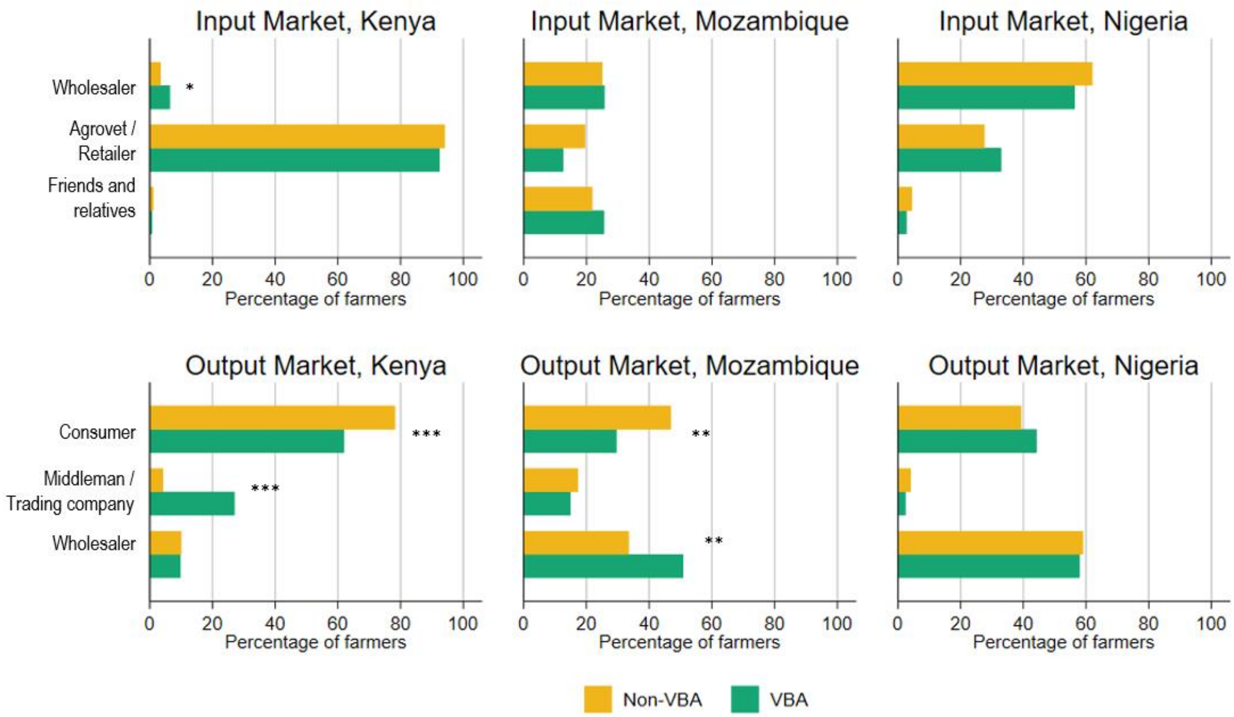
Education = has completed primary school or greater

*/**/*** indicates difference is statistically significant at the p < 0.10/0.05/0.01 level.

There were few differences in where VBA and non-VBA farmers bought from (input markets) or sold to (output markets). The VBA program aimed to increase market access to farmers though VBAs, by directly connecting farmers to input suppliers and off-takers and/or by VBAs setting up their own input/off-taking operations. In the Phase 1 evaluation, we found that about 50 percent of VBAs reported making some money from these types of market linkage activities during their time as VBAs. However, in the survey of farmers, we found relatively less strong evidence of market connectivity. There were some differences, however. In Kenya, for example, VBA farmers were less likely than non-VBA farmers to sell directly to consumers and were more likely to sell to middlemen or a trading company (Figure 5)[10]. In Mozambique, VBA farmers were more likely to sell to a wholesaler than non-VBA farmers. We did not find any meaningful differences in the time traveled to either input or output markets in any country (not shown).

[10] GAP documentation does not include recommendations on where farmers should sell their produce, so selling to middlemen or trading companies was not necessarily a practice that was promoted by the VBAs.

Figure 5. Input and output markets



Source: Mathematica VBA farmer survey, 2023.

Notes: Estimates are weighted to adjust for differences in sampling probabilities and for differences between the VBA and non-VBA samples.

Sample sizes are as follows: Input market: Kenya non-VBA (688), VBA (733); Mozambique non-VBA (808), VBA (1,149); Nigeria non-VBA (1,210), VBA (1,403). Output market: Kenya non-VBA (234), VBA (327); Mozambique non-VBA (394), VBA (682); Nigeria non-VBA (1,159), VBA (1346).

*/**/*** indicates difference is statistically significant at the p < 0.10/0.05/0.01 level.

3.4. Impacts on farm households

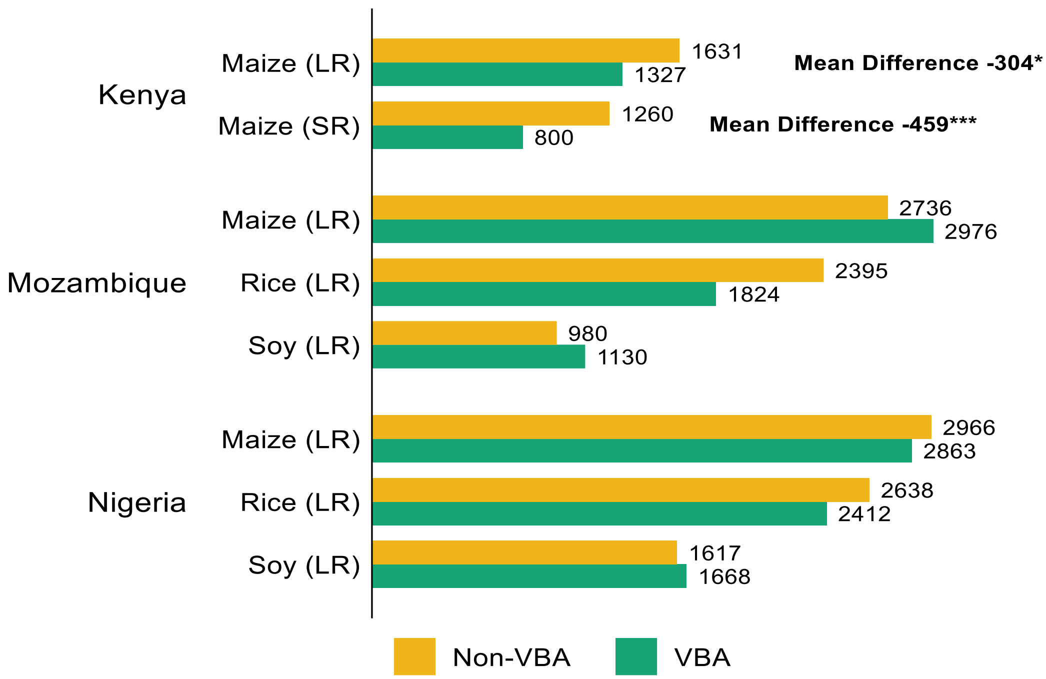
Key findings:

- The VBA program does not appear to have increased focus crop yields in the year of the survey.
- The amount of land dedicated to cultivating focus crops was higher among VBA farmers, with more land dedicated to maize in Kenya and Nigeria and to rice in Mozambique.
- Cash revenue from farming was higher for VBA farmers in Mozambique, and household cash income was higher for VBA farmers in Mozambique and Nigeria.
- We did not find evidence that the program significantly improved resilience or food security, and dietary diversity was lower among VBA farmers than non-VBA farmers.◢

The objective of the VBA program at a farmer level was to improve outcomes for farmers by increasing farm productivity and access to markets, leading to higher farm profits and, ultimately, higher incomes. In this section, we assess outcomes including farm yields, sales, profit, income, household food security and diversity, and resilience.

We did not find evidence that the VBA program increased yields for focus crops. The VBA program aimed to improve yields, particularly for focus crops, through improved practices and increased use of improved inputs. We did not find evidence of increased yields for any of the crops targeted by the program (Figure 6). Unexpectedly, we found that maize yields were lower among VBA farmers than among non-VBA farmers in Kenya. This unusual finding might be because we were not able to perfectly match at the area level in Kenya, so there may have been some exogenous factors that dampened yields in VBA program areas. In fact, we did find that twice as many VBA farmers reported having a shock of diseases or pests than non-VBA farmers (38 percent versus 19 percent, not shown). Another possibility is that the greater focus on regenerative agriculture in recent years might have some negative effects on yields in the earlier years of the program, despite the fact that these practices are beneficial for longer-term soil health and resilience. As we would expect, given the lack of impact on yields, we did not see an impact on revenue per hectare (not shown).

Figure 6. Yields of program focus crops (kg/ha)



Source: Mathematica VBA farmer survey, 2023.

Notes: Estimates are weighted to adjust for differences in sampling probabilities and for differences between the VBA and non-VBA samples.

Missing values and outliers (greater than 3 standard deviations for land area, 2 standard deviations for other variables) are replaced with median values, separately by country and crop.

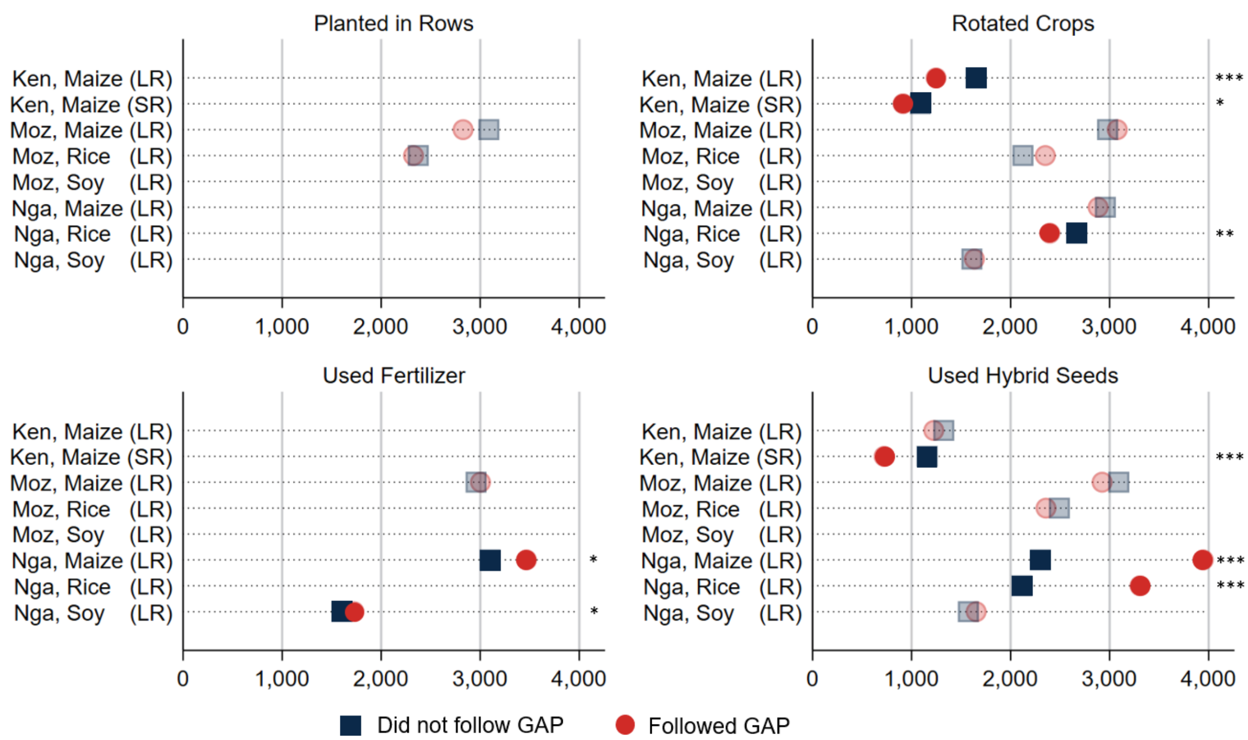
Sample sizes for crop-level estimates are presented in Appendix Table 1.

*/**/*** indicates difference is statistically significant at the p < 0.10/0.05/0.01 level.

SR = short rainy season; LR = long rainy season.

Among VBA farmers, there is mixed evidence of a link between GAPs and yields (Figure 7). The analysis of the link between GAPs and yields shows yields among those who practice a certain GAP (orange circles) and those who do not (grey squares). Statistically significant differences appear in bold with asterisks to the right. Hybrid seed use is associated with higher yields for some crops in Mozambique and Nigeria. Crop rotation and planting in rows do not appear to be correlated with higher yields in any country, although we are not able to fully assess the impact of the latter as the share of people planting in rows is so high in Kenya and Nigeria that there are not enough non-adopters to serve as a comparison. Fertilizer does correlate with higher yields in Nigeria, but we do not observe the same correlation in Mozambique, which has very low overall fertilizer use, and we are not able to assess the correlation in Kenya due to high rates of fertilizer use. These findings come from farmers in real conditions, rather than experiments in controlled settings, so the lack of correlation between recommended practices and yields could be due to those practices being applied imperfectly or other conditions on the ground affecting yields that we are not able to control for our study. For example, it is possible that farmers with poorer soil quality are more likely to adopt fertilizer, leading those farmers to have similar yields to those who do not apply fertilizer on higher-quality soil.

Figure 7. Correlations between good agricultural practices (GAPs) and yields



Source: Mathematica VBA farmer survey, 2023.

Notes: Estimates are weighted to adjust for differences in sampling probabilities and for differences between the VBA and non-VBA samples.

Missing values and outliers (greater than 3 standard deviations for land area, 2 standard deviations for other variables) are replaced with median values, separately by country and crop.

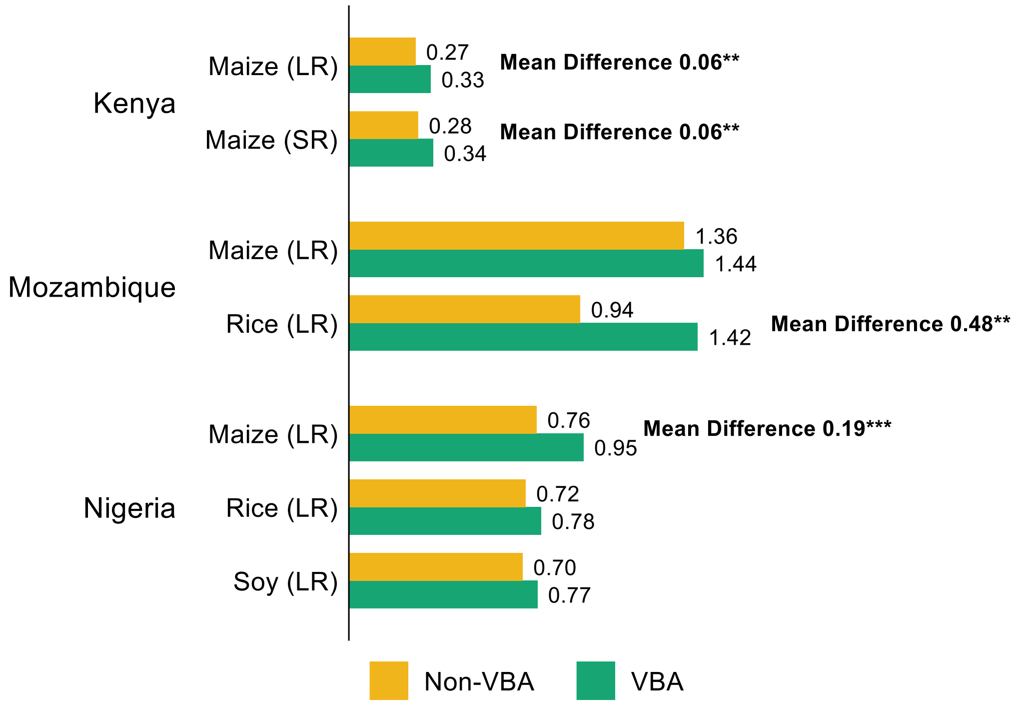
Some crops or GAPs are not presented because sample sizes are too small to allow for a comparison, either because too few farmers grow that crop in that season, or because the share of farmers practicing that GAP is very high or very low, making the sample size of adopters or non-adopters too small for a comparison.

*/**/*** indicates difference is statistically significant at the p < 0.10/0.05/0.01 level.

SR = short rainy season; LR = long rainy season.

VBA farmers cultivated more land associated with focus crops than non-VBA farmers. While we did not observe an increase in yield per hectare for target crops, we did observe some evidence of extensification, with VBA farmers cultivating more land in maize in Kenya and Nigeria and in rice in Mozambique (**Error! Reference source not found.**). The increase in land dedicated to target crops appears to be a result of shifting land from other crops in Mozambique, where total land area farmed was similar for VBA and non-VBA farmers, but the share of land dedicated to target crops was higher among VBA farmers (not shown). In Kenya and Nigeria, the reverse is true: VBA farmers cultivated more total land, but the share of land dedicated to target crops was the same for VBA and non-VBA farmers (not shown).

Figure 8. Land area cultivated in focus crops (hectares)



Source: Mathematica VBA farmer survey, 2023.

Notes: Estimates are weighted to adjust for differences in sampling probabilities and for differences between the VBA and non-VBA samples.

Missing values and outliers (greater than 3 standard deviations for land area, 2 standard deviations for other variables) are replaced with median values, separately by country and crop.

Sample sizes for crop-level estimates are presented in Appendix Table 1.

*/**/*** indicates difference is statistically significant at the p < 0.10/0.05/0.01 level.

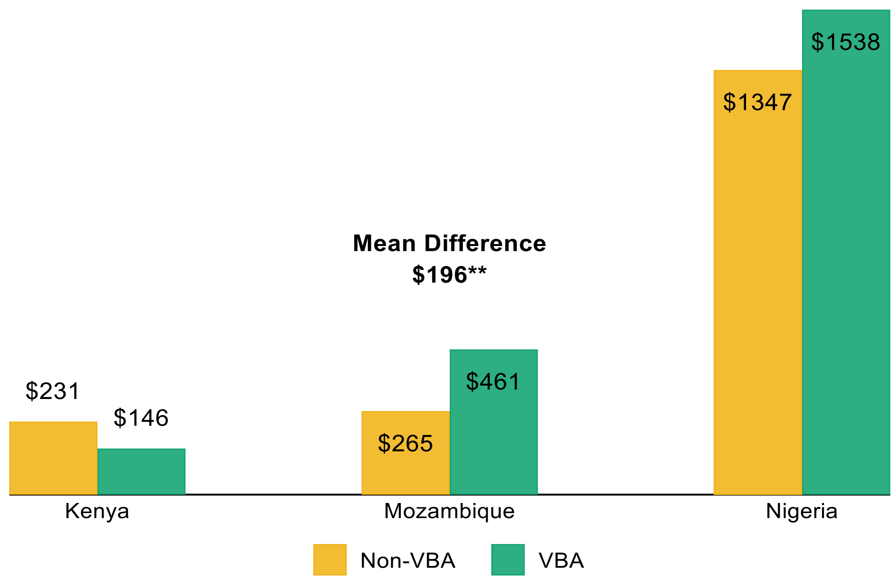
SR = short rainy season; LR = long rainy season.

The increased land dedicated to focus crops led to higher focus crop production for VBA-trained farmers. Despite per-hectare yields not being higher, the total quantity of focus crops harvested was higher for VBA farmers. In Nigeria, VBA farmers harvested more than 20 percent more total maize than non-VBA farmers, due to dedicating more overall land to maize. Similarly, in other countries and for other crops, we observe higher total yields for VBA farmers, but these differences are not statistically significant (Figure 9).

Figure 9. Total quantity (kg) produced for each focus crop

Farm sales were higher for VBA farmers in Mozambique. The VBA program aimed to improve farmers' access to markets, and one measure of increased market access is increased farm sales. In Mozambique, we found that VBA farmers earned nearly $200 more per year from farm sales than non-VBA farmers (Figure). While there was suggestive evidence of a similar increase in Nigeria, it was not statistically significant. In Kenya, there was no evidence of higher sales among VBA farmers than non-VBA farmers.

Figure 10. Annual farm sales from agriculture (USD)



Source: Mathematica VBA farmer survey, 2023.

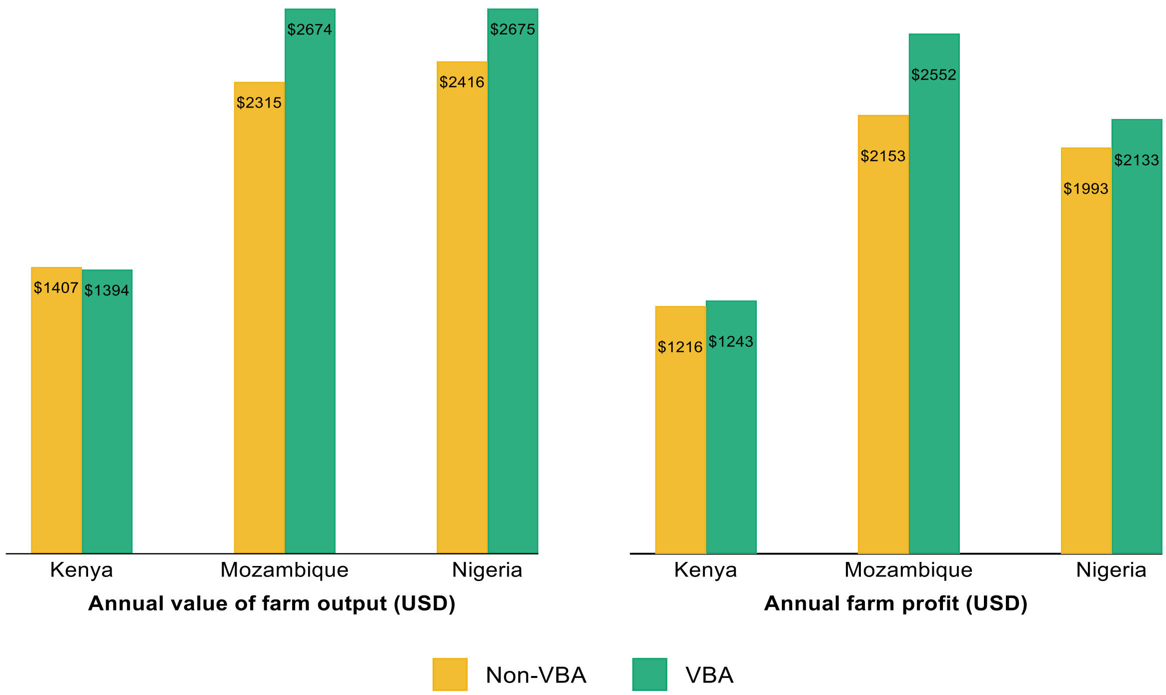
Notes: Estimates are weighted to adjust for differences in sampling probabilities and for differences between the VBA and non-VBA samples.

Missing values and outliers (greater than 3 standard deviations for land area, 2 standard deviations for other variables) are replaced with median values, separately by country and crop.

*/**/*** indicates difference is statistically significant at the $p < 0.10/0.05/0.01$ level.

The total values of farm output and total profit were not statistically significantly higher for VBA farmers. The total value of farm output includes everything harvested, including what is sold and what is consumed or used for other purposes, all valued at the reported sales price. We calculated total farm profit using this measure rather than only farm sales, to capture the full value of the farm enterprise regardless of whether the output was sold. We found suggestive evidence that VBA farmers in Mozambique and Nigeria reported higher levels of both total output value and total farm profit than non-VBA farmers **(**Figure **).** However, none of these differences are statistically significant, and we did not observe any differences between VBA and non-VBA farmers in Kenya.

Figure 11. Annual farm output and profit (USD)



Source: Mathematica VBA farmer survey, 2023.

Notes: Estimates are weighted to adjust for differences in sampling probabilities and for differences between the VBA and non-VBA samples.

Missing values and outliers (greater than 3 standard deviations for land area, 2 standard deviations for other variables) are replaced with median values, separately by country and crop.

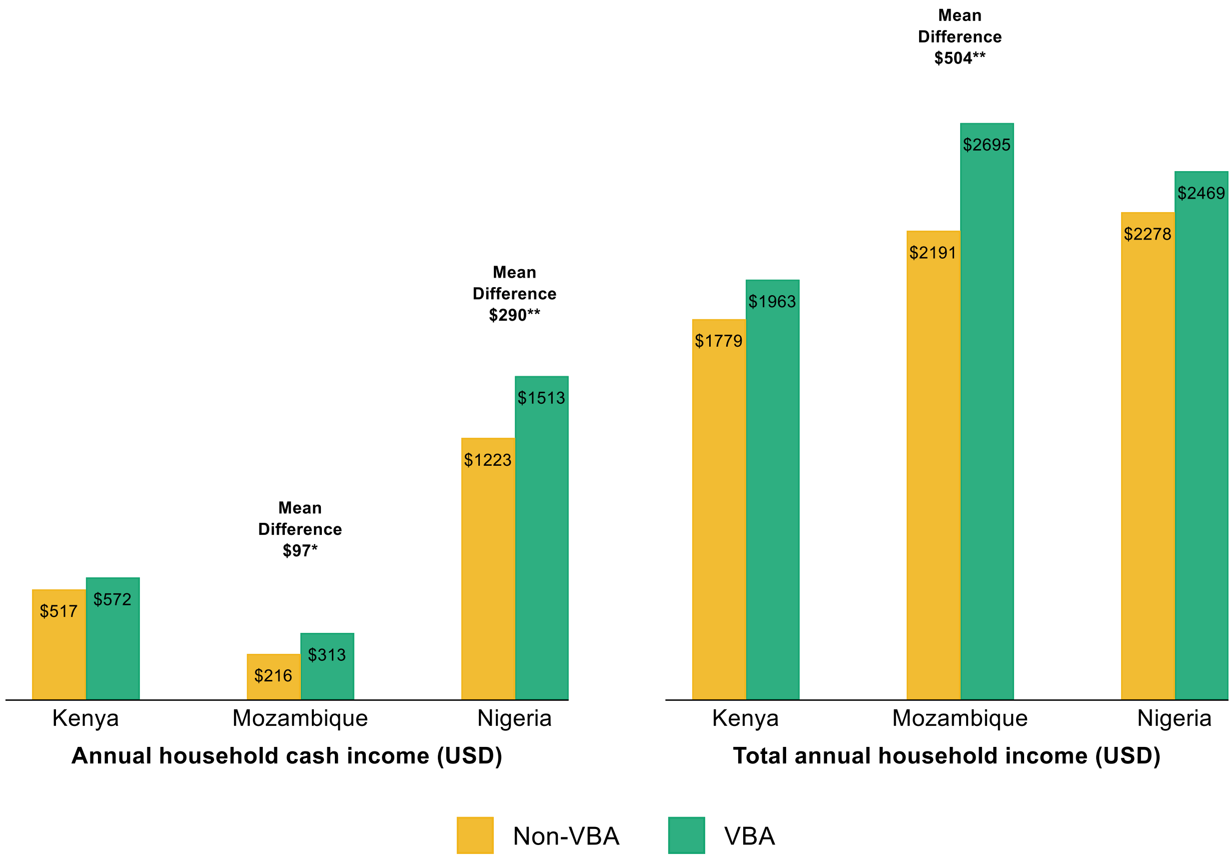
*/**/*** indicates difference is statistically significant at the p < 0.10/0.05/0.01 level.

Annual value of farm output is the total of all crops harvested, valued at the sales price for that crop.

Annual farm profit is the total value of farm output minus annual farm costs.

VBA farmers in Mozambique reported higher household incomes than non-VBA farmers. We report two measures of household income: (1) cash income, which includes revenue from farm sales minus farm costs, along with non-farm income sources, and (2) total income, which is total farm profit (including the value of sold and non-sold farm produce minus farm costs) plus non-farm income. Both measures of household income were higher for VBA farmers in Mozambique than non-VBA farmers, while cash income was higher for Nigerian VBA farmers (Figure). There is suggestive evidence of differences in Kenya and of higher total income in Nigeria, but these differences are not statistically significant. Non-farm income was higher for VBA farmers in Nigeria, but lower for VBA farmers in Mozambique (not shown). The links between agricultural activities and off-farm activities and how each could be impacted by participation in the VBA program warrant further exploration. For example, farmers could be shifting resources away from off-farm activities to more farming; conversely, they could be using additional earnings from the VBA program to invest in other income-generating activities. Better understanding these linkages would help capture the full impact of the program on agricultural households.

Figure 12. Annual household cash and total income (USD)



Source: Mathematica VBA farmer survey, 2023.

*/**/*** indicates difference is statistically significant at the p < 0.10/0.05/0.01 level.

Notes: Estimates are weighted to adjust for differences in sampling probabilities and for differences between the VBA and non-VBA samples.

Missing values and outliers (greater than 3 standard deviations for land area, 2 standard deviations for other variables) are replaced with median values, separately by country and crop.

Annual household cash income is the total of all farm sales and cash income from non-farm sources, minus farm costs.

Total annual household income is the total farm profit plus cash income from non-farm sources.

Among VBA farmers, those with higher levels of engagement with VBAs experienced higher yields and household-level outcomes (Table 11). Farmers who engaged with VBAs at least three times per year saw higher maize yields in Kenya, higher soy yields in Nigeria, and higher yields for maize and rice in Mozambique. The difference between farmers with higher and lower intervention levels is most striking in Mozambique, where farmers with more VBA engagement saw substantially farm output values, farm profit, and household income than those who engaged with VBAs less frequently. As noted previously, these differences may be correlations rather than evidence of causal impact, as more well-off farmers may be more connected to VBAs or more likely to reach out for VBA support VBAs, but it is also possible that a higher level of engagement with VBAs leads to higher yields and, as a result, higher profit and income.

Table 11. Yields and farm-level outcomes among high- and low-intervention VBA farmers

Number of in-person VBA visits:	Kenya			Mozambique			Nigeria		
	Low (less than 3)	High (3 or more)	Difference	Low	High	Difference	Low	High	Difference
Yields (kg/ha)									
Maize (LR)	1,383	1,629	237*	2,934	3,030	401*	2,881	3,056	156
Maize (SR)	969	1,226	107	2,959	3,607	915***	.	.	.
Rice (LR)	.	.	.	2,180	2,903	772**	2,412	2,546	43
Soy (LR)	.	.	.	.	.	.	1,583	1,680	88**
Farm-level outcomes (USD)									
Farm output value	1,440	2,096	183	**2,779**	**5,633**	**2,675*** **	2,799	3,047	217
Farm profit value	1,282	1,936	196	**2,696**	**4,655**	**1,841*** **	2,330	2,549	191
Household income	1,984	2,570	135	**2,719**	**4,791**	**1,824*** **	2,682	2,916	196

Source: Mathematica VBA farmer survey, 2023.

Notes: Estimates are weighted to adjust for differences in sampling probabilities and for differences between the VBA and non-VBA samples.

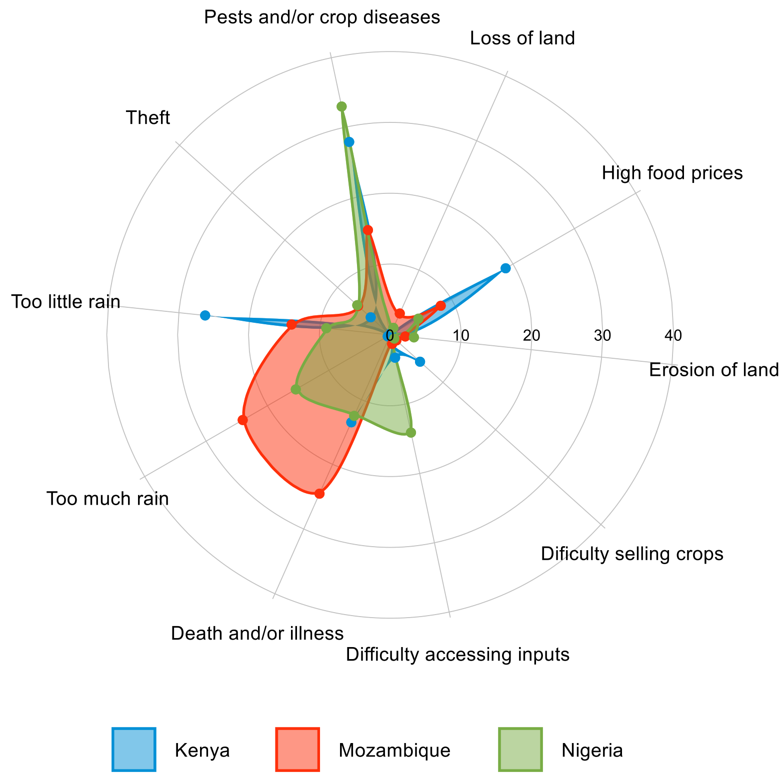
Missing values and outliers (greater than 3 standard deviations for land area, 2 standard deviations for other variables) are replaced with median values, separately by country and crop.

Sample sizes for crop-level estimates are presented in Appendix Table 1.

*/**/*** indicates difference is statistically significant at the p < 0.10/0.05/0.01 level.

Farmers in study areas exhibited a range of shocks (Figure 13). The prevalent shocks and pressures documented in the three nations include pests and/or plant ailments, insufficient rainfall, too much rainfall, elevated food costs, and the passing and/or illness of a family member. In Kenya and Nigeria, many farmers reported having been affected by pests and/or diseases that affect crops and/or livestock. In Mozambique, the primary shocks/stresses were the death or illness of a family member and too much rain. The strong cyclones that hit Mozambique in 2022 are likely the cause of the reported rain surplus.

Figure 13. Percentage of farmers affected by different shocks and stresses



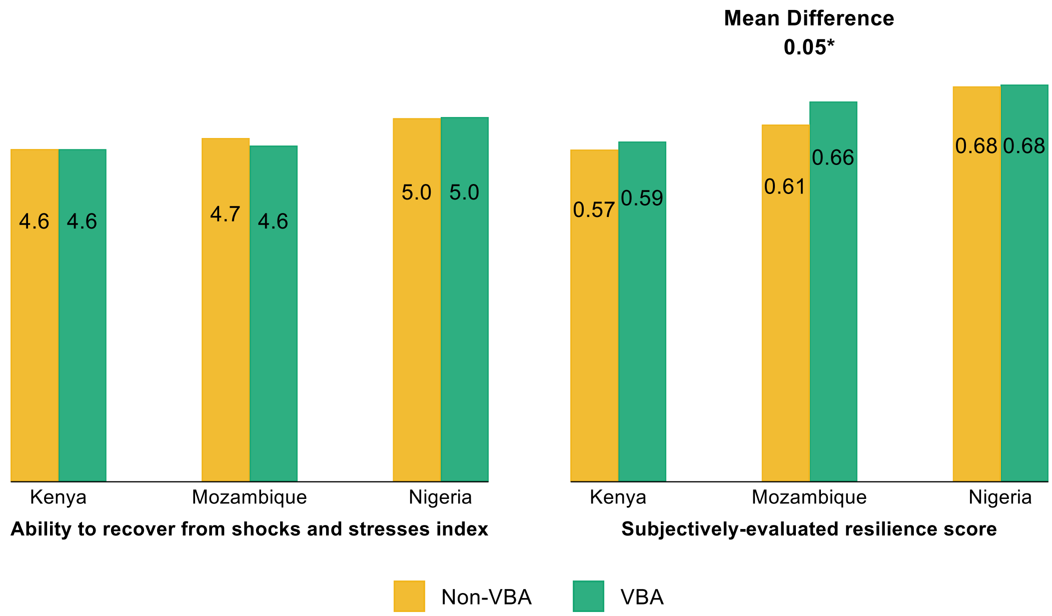
Source: Mathematica VBA farmer survey, 2023.

Notes: Estimates are weighted to adjust for differences in sampling probabilities and for differences between the VBA and non-VBA samples.

*/**/*** indicates difference is statistically significant at the p < 0.10/0.05/0.01 level.

The VBA program had a modest positive impact on perceived resilience in Mozambique but did not change treated farmers' self-reported ability to recover from shocks and stresses. The small insignificant differences between VBA and non-VBA farmers in ARSSI scores (Figure 14, left panel) do not suggest that VBA program had an impact on reported resilience. Results in the subjective resilience tool, the SERS (**Figure 14.** Reported resilience (ARSSI) and subjectively evaluated resilienceFigure 14, right panel), suggest a small improvement in perceived resilience in Mozambique but this should be interpreted with caution given the relatively weak level of significance.

Figure 14. Reported resilience (ARSSI) and subjectively evaluated resilience



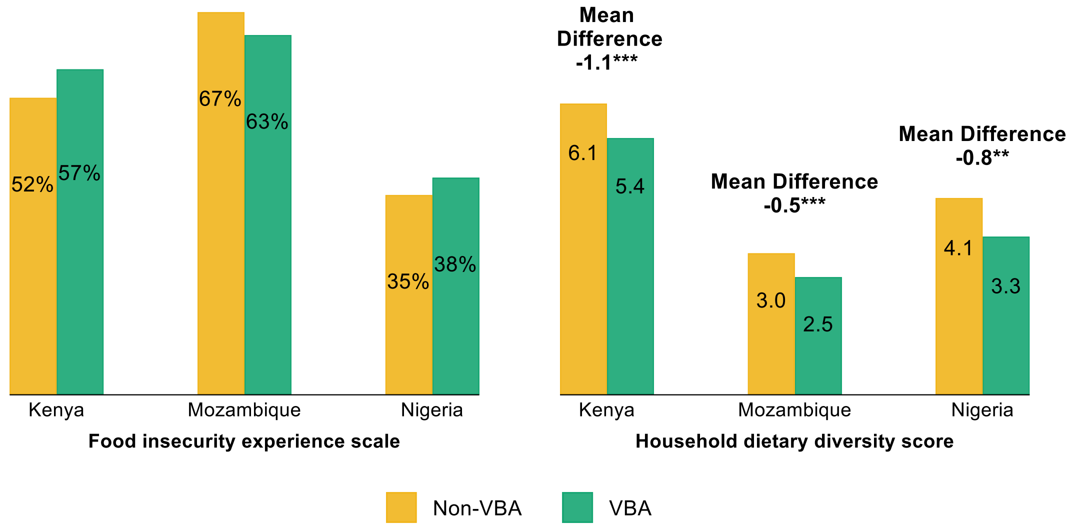
Source: Mathematica VBA farmer survey, 2023.

*/**/*** indicates difference is statistically significant at the p < 0.10/0.05/0.01 level.

Notes: Estimates are weighted to adjust for differences in sampling probabilities and for differences between the VBA and non-VBA samples.

The program did not impact food security, and dietary diversity was higher among comparison households. Based on FAO's FIES (Figure 15, left panel), food insecurity is highest for non-VBA households in Mozambique (at 67 percent insecure) and lowest for non-VBA farmers in Nigeria (at 35 percent insecure). However, there is no evidence that the VBA program impacted food security because none of the differences between VBA and non-VBA households are statistically significant. The earlier discussion on the lack of program impact on yields offers a plausible explanation for the corresponding absence of any consequential impact on food security. The results on dietary diversity, measured using FAO's HDDS, suggest non-VBA households have slightly higher dietary diversity score (Figure 15, right panel). Further research is recommended, but it is possible that a shift away from crops such as vegetables to focus crops has had an impact on what VBA farmers are eating at home.

Figure 15. Food insecurity and household dietary diversity



Source: Mathematica VBA farmer survey, 2023.

Notes: Estimates are weighted to adjust for differences in sampling probabilities and for differences between the VBA and non-VBA samples.

*/**/*** indicates difference is statistically significant at the p < 0.10/0.05/0.01 level.

3.5. Heterogeneous impacts

Key Takeaways:

- The effects of the VBA program on women farmers' yields and household total income were similar across countries, but in Kenya, women saw worse dietary diversity and resilience scores.
- We found that young farmers in the VBA program saw relatively smaller yields in Nigeria and, downstream from this, they saw reduced farm profit, as compared to older farmers in the VBA program; however, young farmers did experience greater dietary diversity in Kenya and Mozambique. ◢

Next, we explore program impacts for women (Figure 16) and for youth in our sample (Figure **16**16). The key question we answer is whether program impacts for women and youth farmers in VBA communities were different compared to those of men and non-youth farmers in VBA communities, respectively. Each outcome is shown in a group with all three countries; statistically significant differences appear in bold with asterisks to the right. The analysis for women farmers (Figure 15) shows the treatment effects on women farmers (red circles) and on men farmers (black squares). Similarly, the analysis for youth (Figure 16) shows the treatment effects on young farmers (red circles) and on older farmers (black squares).

Broadly, we found limited evidence of differential impacts for these subgroups, though we did note some important differences. Because we analyzed the results from smaller subsamples (resulting in reduced statistical power), we focus on the direction of significant differences rather than their magnitude.

We found that the impact of the program on women farmers' resilience (using ARSSI) and dietary diversity in Kenya was relatively lower. This suggests that—at least for dietary diversity—women farmers may be driving the lower overall dietary diversity in VBA communities in Kenya. By contrast, impacts on women farmers in Mozambique and Nigeria were no worse than those of their VBA male counterparts on measures of resilience and dietary diversity. In fact, the estimated differences in dietary diversity and resilience were higher for women farmers in Mozambique and Nigeria, though only statistically significantly so in the case of dietary diversity in Mozambique.

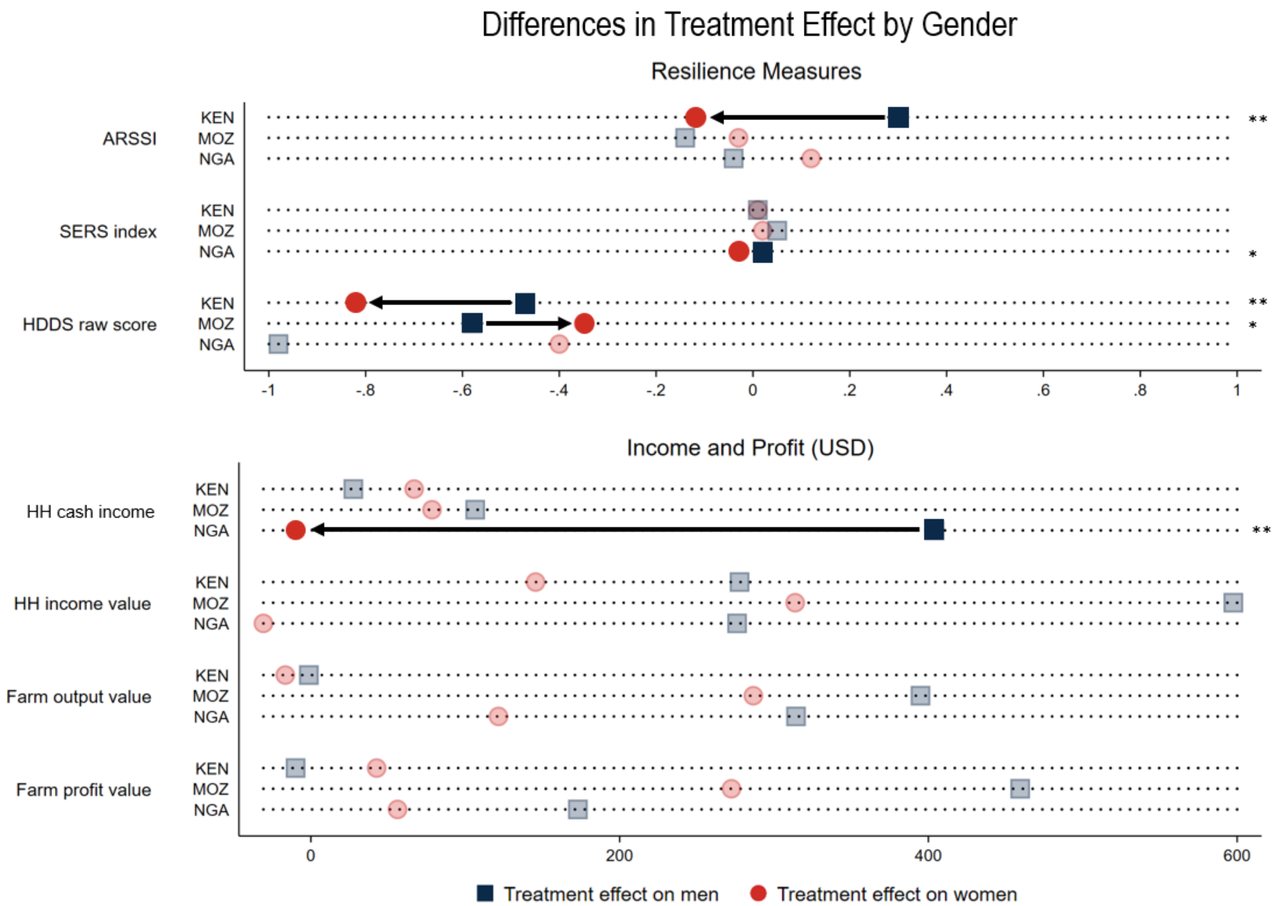
We found that program impacts on women farmers' yields and household total income were similar across countries (Figure 16)**.** Starting with yields, we found that women farmers in the VBA program performed on par with men farmers in the VBA program in terms of maize, rice, and soy yields across the three countries; that is, women's productivity was the same as that of men farmers in VBA communities. However, women farmers in VBA communities in Nigeria saw lower cash revenue from crops sold and lower overall household cash income. We do note that household total income (including the value of non-sold farm produce) was not statistically significantly different for women farmers across all three countries, though the sign of the estimate is negative. Even though these estimates are not statistically precise, they do suggest that there is some probability that women farmers in the VBA program had lower total household income than men farmers in the VBA program, and this should be noted for program design.

Next, we found that young farmers in the VBA program saw relatively smaller yields in Nigeria and, downstream from this, they saw reduced farm profit, compared to older farmers in the VBA program (lower panel, Figure 17). Furthermore, young VBA farmers in Nigeria had relatively lower total household income, while household total income for young farmers in Kenya and Mozambique was no different compared to that of older farmers. In contrast to young farmers in Nigeria, yield estimates for young farmers in Kenya and Mozambique were not statistically significantly different compared to that of older farmers; downstream from this, farm profit and household total income were also not different.

While measures of resilience were no different for young farmers in the VBA program compared to older farmers in the VBA program, young farmers did see improvements to their dietary diversity in Kenya and Mozambique.

As noted earlier, the VBA program struggled to reach young farmers. Therefore, our ability to find a sufficiently large sample of young farmers was hampered by the fact that there were few young farmers in VBA villages.

Figure 16. Program impacts for women



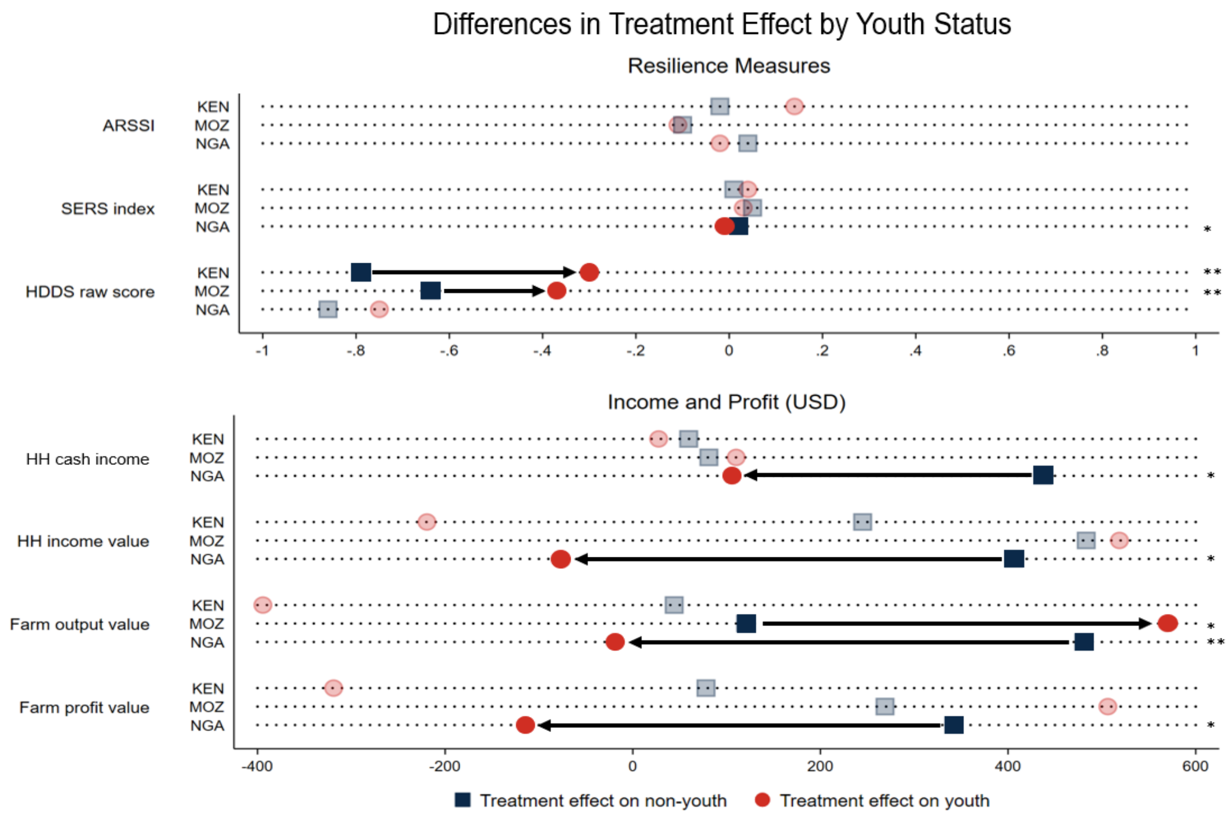
Source: Mathematica VBA farmer survey, 2023.

Notes: Estimates are weighted to adjust for differences in sampling probabilities and for differences between the VBA and non-VBA samples.

Missing values and outliers (greater than 3 standard deviations for land area, 2 standard deviations for other variables) are replaced with median values, separately by country and crop.

*/**/*** indicates difference is statistically significant at the p < 0.10/0.05/0.01 level.

Figure 17. Program impacts for youth



Source: Mathematica VBA farmer survey, 2023.

Notes: Estimates are weighted to adjust for differences in sampling probabilities and for differences between the VBA and non-VBA samples.

Missing values and outliers (greater than 3 standard deviations for land area, 2 standard deviations for other variables) are replaced with median values, separately by country and crop.

*/**/*** indicates difference is statistically significant at the p < 0.10/0.05/0.01 level.

3.6. Unintended consequences

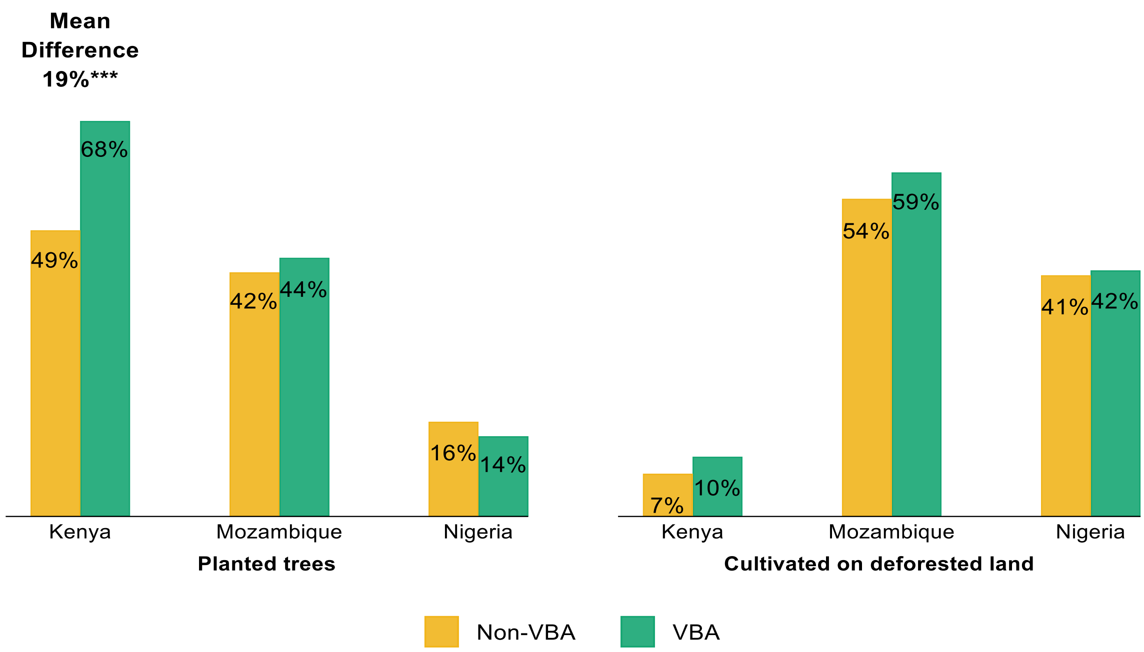
Key Takeaways:

- VBA farmers in Kenya showed a greater likelihood of planting trees in the last 12 months, while no significant results for environmental impacts were found in Mozambique or Nigeria.
- While deforestation and farming on deforested land occur at varying rates across the study countries, there is no evidence that participation in the VBA program affected deforestation.
- While there was no impact of the VBA program on gender labor dynamics in Kenya and Mozambique, in Nigeria the share of agricultural labor conducted by women increased for VBA farmers.

In addition to assessing anticipated impacts of the VBA program that were described in the ToC, we also examined unintended spillover effects, both negative and positive. Assessing unintended program consequences is challenging because data collection instruments might not be able to capture a wide array of outcomes (since many unintended consequences are also likely to be unanticipated). Drawing on the results of the Phase 1 evaluation, we identified several potential unintended consequences of the program—such as changes in land allocation and labor investments—and thus included questions in the farm survey to capture the potential impacts on those outcomes.

The impact of the VBA program on tree planting behavior was evident in Kenya (where VBA farmers were more likely to have planted trees in the last 12 months), but we found no significant impact on tree planting in Mozambique or Nigeria. To assess the unintended environmental consequence, we inquired whether farmers planted trees in 2022. The integration of trees into farming systems offers significant benefits to both the environment and farmers. They provide essential shade, safeguard crops from extreme weather, and their roots prevent erosion and stabilize the soil. Moreover, trees can serve as valuable sources of additional income, and when they yield edible fruits or nuts, they contribute to improved dietary diversity and nutrition. Figure 18 reveals that 68 percent of Kenyan VBA farmers embraced tree planting, likely due to the recent VBA focus on regenerative agriculture, but only 49 percent of non-VBA farmers did so (a statistically significant difference). In Mozambique and Nigeria the results did not suggest a difference between VBA and non-VBA farmers on tree planting.

Figure 18. Share of farmers who planted trees and share of farmers who cultivated on deforested land



Source: Mathematica VBA farmer survey, 2023.

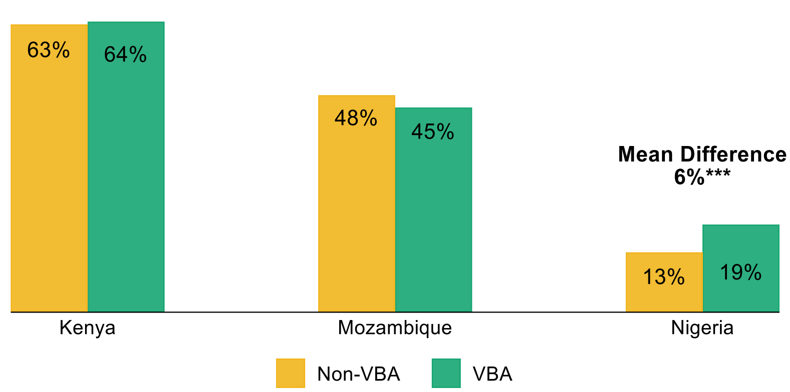
Notes: Estimates are weighted to adjust for differences in sampling probabilities and for differences between the VBA and non-VBA samples.

*/**/*** indicates difference is statistically significant at the p < 0.10/0.05/0.01 level.

The VBA program did not impact the deforestation of land for the purpose of expanding crop cultivation. Deforestation carried out by smallholder farmers to expand agriculture raises significant concerns, as it may lead to loss of biodiversity, soil degradation, increased carbon emissions, disruption of the ecosystem, and destruction of wildlife habitats. Farmers were surveyed regarding their current crop cultivation on land that was forested just five years ago. The data presented in Figure **18** reveal that over half of VBA and non-VBA farmers in Mozambique have engaged in farming on former forest land, but there is no evidence that the program increased cultivation on deforested land. Fewer farmers in Nigeria and Kenya cultivated on deforested land. As in Mozambique, there is no evidence that participation in the VBA program affected deforestation.

While the VBA program had no impact on gender labor dynamics in Kenya and Mozambique, it led to a significant increase in the share of agricultural labor conducted by women in Nigeria. Differences in the distribution of labor within agricultural activities are a noteworthy concern in Sub-Saharan Africa, where women often face gender-based disparities in workload allocation. Figure 19 reveals that women in Kenya do more than half of the agricultural labor, which is more than in both Mozambique and Nigeria. The notable differences between countries are likely the result of various factors beyond the scope of this study, including cultural, social, and economic factors. A comparison of VBA and non-VBA households within the countries reveals that Kenyan and Mozambican women's contribution to agricultural activities is roughly equal to that of their male counterparts across the two groups. However, in Nigeria, the significant difference suggests that women in VBA households conduct a bit more agricultural labor than their non-VBA counterparts. Additional research in Nigeria could investigate whether the increased share of labor among women is a result of a positive outcome such as enhanced decision-making power within the agricultural process or merely the allocation of more work to women due to differences in agricultural practices.

Figure 19. Percentage of agricultural labor conducted by women



Source: Mathematica VBA farmer survey, 2023.

Notes: Estimates are weighted to adjust for differences in sampling probabilities and for differences between the VBA and non-VBA samples.

Missing values and outliers (greater than 2 standard deviations) are replaced with median values, separately by country.

*/**/*** indicates difference is statistically significant at the p < 0.10/0.05/0.01 level.

3.7. Return on investment

Key Takeaways:

- Using the estimated impact on farmer household income, we calculated a positive return on investment (ROI) ranging between 4 and 114 for the three-country portfolio.
- This result should be treated as directional rather than as a precise estimate of returns.◢

The VBA program likely generates returns that exceed costs, though country-level ROI estimates vary substantially, and positive returns are driven by Mozambique. We calculated an ROI based on our estimates of impact and cost for each country and for the investment across all three countries. Our goal was to understand if AGRA's investment in the VBA program across the three study countries generated a positive economic return. We used our estimate of total household income (reported in the righthand panel of Figure and discussed in Section 3.4) as a measure of program returns. We used estimates of program costs over the four years of the program as a measure of investment. Program costs had two major components: (1) AGRA program management costs and (2) transfers to local implementation partners. We interviewed AGRA staff to understand AGRA program management costs and used budget documents to acquire information on transfers to local implementation partners. We note that the program has very low costs per farmer, as the total number of farmers reached by the program is in the millions.

To calculate the ROI, we set up a simple model of returns and investment costs with the following key characteristics:

- **<u>Economic benefits</u>: To estimate economic benefits, we used the estimated difference between non-VBA and VBA farmers in household total income in 2022, which is the last (fourth or fifth) year of the VBA program.** We believe this is the most complete measure of sustained gains for farmers from the VBA program as it accounts for all household income sources. Agricultural profit is likely more precisely measured as it relies on self-reports from fewer sources, but it does not fully account for the broader benefits to other income-generating activities farming households engage in. We estimated total household income by summing total agricultural profits (value of all agricultural produce minus costs) and income from various other sources including salaries, remittances, business income, livestock, and rent. However, we were unable to subtract out all costs associated with non-agricultural income; for example, farmers may run non-agricultural enterprises that generate income but they may incur costs for these enterprises for which we do not have data. Because we have not accounted for all costs, therefore, we term this simply household income and note that it may represent an overestimate of economic benefits.
- **The impact of the VBA program on household income was positive and statistically significant in Mozambique (with an estimated difference of $503). In Kenya and Nigeria, the impact was positive not significant, thus we treat those as having zero return.** For

Mozambique, since we do not have exact benefit estimates for each year of the program (our estimate is from Year 5 of the program), we use this estimate conservatively. In our ROI model, the income gain appears gradually and decays gradually. The gain in income appears gradually, that is, starting at zero and increasing by 25% each year to reach the maximum of $503 in the final year of program implementation (Year 5). This difference then decays—25 percentage points a year—to zero within four years of program closeout (by 2021 in Mozambique; for Kenya and Nigeria this is inconsequential as they did not demonstrate statistically significant impact on household total income). We choose to increase and to decay household total income because: the effect of AGRA programming will have taken time to kick in i.e., gradual increase; and, as AGRA oversight ended, the program's effect may not be as strong i.e., decay in benefits.

- **<u>Costs</u>: We calculated total costs for each country based on two components: AGRA management costs and transfers to local implementing partners.** The AGRA management costs were put together after detailed bilateral communication with AGRA staff and included AGRA headquarters administrative overhead, headquarters technical officers, country officers, and country managers. Transfers to local implementing partners were acquired from summary budget documents. Since these did not provide the exact year of transfer, we divided and applied costs evenly over the project implementation period for each country. Thus, our calculated cost in Kenya was $265,878 per year for four years; in Mozambique it was $1,148,082 per year for five years (the program ran from 2017–2021); and in Nigeria it was $665,840 per year for four years.
- <u>Number of farmers</u>: The estimated number of farmers impacted by the program was different for each country: Kenya reached 66,175 farmers, Mozambique reached 484,163, and Nigeria reached 806,620. We used these numbers to scale up returns; that is, we multiplied our estimate of household total income by these impacted farmer population numbers. Since we did not find income impacts for Kenya and Nigeria, this was effectively only done for Mozambique.
- <u>Timeframe</u>: We assumed an investment period (the active program implementation period in which costs were incurred) of four years each for Kenya and Nigeria (2018–2021), and five years for Mozambique (2017–2021).
- <u>Discount rate</u>: We used a 10 percent discount rate for future benefits for the analysis. This is based on current practice at multilateral development banks.

Based on this simple model, we found a portfolio-level ROI of $59 for each AGRA dollar invested across all three countries driven by positive returns in Mozambique. Mozambique saw a return of $99, while Kenya and Nigeria had zero measurable returns to investment. Both the portfolio-level ROI and the Mozambique-specific ROI are high. By way of reference, the literature does find a large range in ROI. McGill and Turner (2020) suggest a return of $8.6 for private sector facilitation funds for Rwandan agribusinesseses, while investments in agricultural research and development result in returns ranging from $10 (Alston et al. 2020) to $33 (Rosegrant et al. 2023).

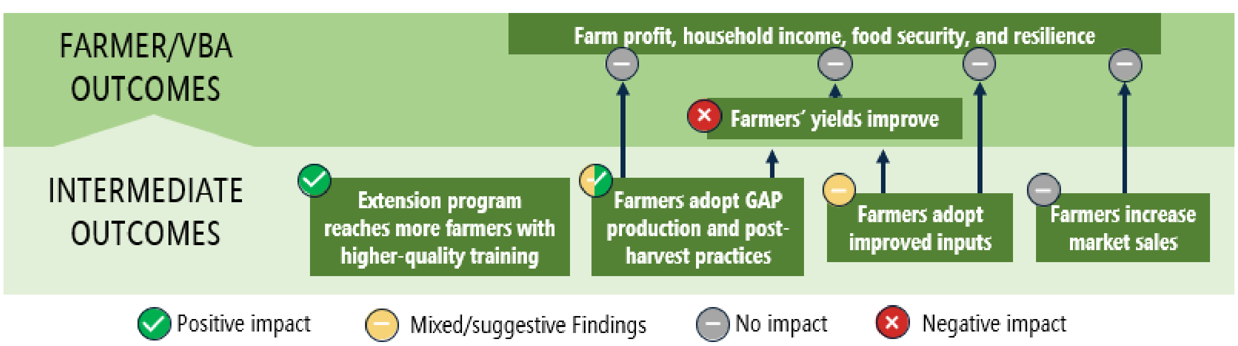
This result should be treated as directional and not as a precise estimate of returns. Given the limitations of our methodology, we hesitate to focus on the point estimate. Rather, we suggest that it is seen as indicative of the potential for positive returns to this program. As noted earlier, there are some limitations to the evaluation design (particularly due to its retrospective nature). More measurements, such as baseline data, and less reliance on retrospective measurement could potentially have improved the quality and precision of our estimates. While we have used the mean difference estimate for total household income in our calculation, the 95-percent confidence interval for the impact estimate is wide, with a lower bound of $36 and an upper bound of $971. This suggests that the return could be as low as $4 or as high as $114, that is, there is a wide range of possible returns. Thus, it is best to treat this as indicative of a positive return on investment.

4. Discussion

To synthesize these findings, we first map the evidence from each country to the ToC. This allows us to better understand the change pathways and how they differ in various country contexts. Then, we discuss cross-cutting trends.

4.1. Program impacts in Kenya

Figure 20. Intermediate and farmer outcomes of the VBA program in Kenya



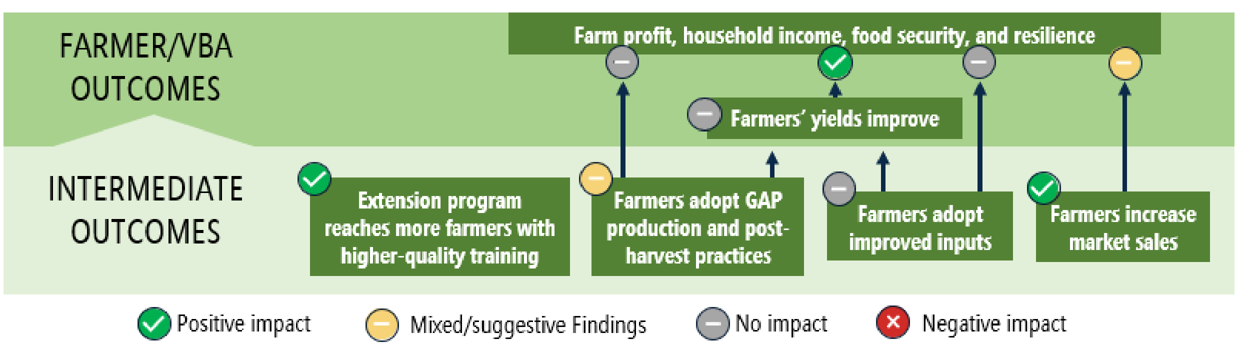
Kenya saw the strongest practice changes of the three countries, particularly regenerative agriculture practices, but these did not translate into impacts on yields and income (Figure 20**).** In Kenya, VBA extension reach was strong, with a high percentage of farmers in VBA areas reporting having received extension services (68 percent) and having received more than three visits in the last year, on average, despite the fact that AGRA was no longer supporting the VBA program in some areas of Kenya. In addition, in Kenya we found the greatest impact on farmer practices, with statistically significant differences seen in row spacing, crop rotation, and adoption of PICS bags. Fertilizer and certified seed adoption was already quite high in Kenya, and there were no differences in the percentage of farmers who adopted these inputs in the year of the survey; furthermore, the amounts of fertilizer and seed applied per hectare did not increase. However, herbicide and pesticide use was relatively low in Kenya and VBA farmers were more likely to use both. Interestingly, we also found evidence of the recent focus on regenerative agriculture, with VBA farmers planting more trees, being much more likely to engage in crop rotation, and being less likely to dust their harvest with pesticides.

However, these practice improvements failed to translate into improved yields in the year of the survey. In fact, in Kenya, VBA farmers had statistically significantly lower yields than comparison farmers. As noted in Chapter 2, we tried to match VBA program areas to areas that were similar in terms of agroecological conditions. However, because the VBA program saturated districts in Kenya, we often had to identify non-VBA communities in neighboring districts or areas, which were still somewhat different in terms of their agroecological conditions. Therefore, it is possible that differences in yields reflect location-specific differences (such as prevalence of pests or disease) that we were unable to perfectly match. Another hypothesis is that the greater focus on regenerative agriculture in recent years might have some negative effects on yields in the earlier years of the program, despite the fact that these practices are beneficial for longer-term soil health and resilience.

Finally, in Kenya we did not find any increase in cash sales or selling price. This accords with findings from Phase 1 of the evaluation showing that VBAs struggled to connect farmers to selling markets in Kenya. The lack of detectable impact on yields and market access means that impacts further up the ToC—in farm profit, household income, resilience, and food security—failed to materialize.

4.2. Program impacts in Mozambique

Figure 21. Intermediate and farmer outcomes of the VBA program in Mozambique



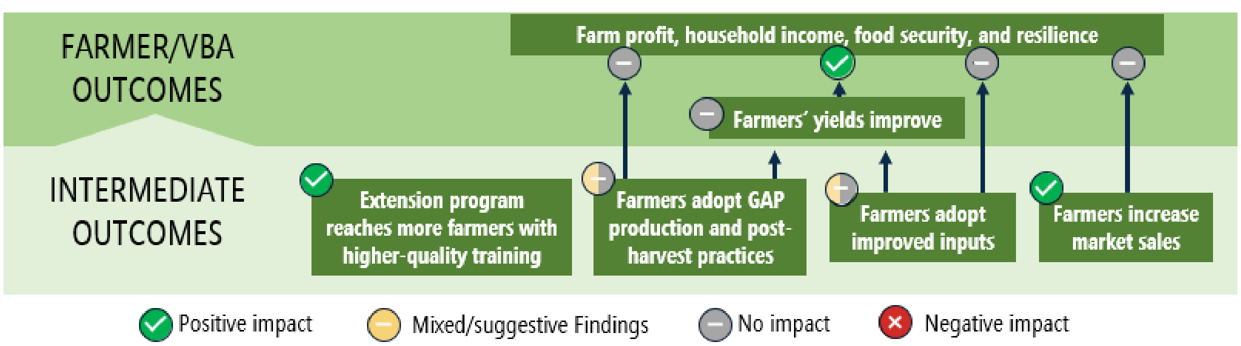
VBA farmers in Mozambique had better access to output markets and higher household income (Figure 21)**.** In Mozambique, we found a much different pattern than in Kenya. The VBA extension reach was lower than in other countries, likely due to the fact that AGRA had stopped supporting the program years earlier and potentially because the VBAs had to cover greater distances to reach farmers in Mozambique given the lower population density. We found mixed results in terms of practice adoption, with some improvements in correct row spacing and spraying for crop protection, but no real improvement in terms of input adoption, which remained very low in Mozambique. The improvements in practices that *were* observed did not translate into differences in yields. Compared to non-VBA farmers, VBA farmers had higher maize yields and lower rice yields, on average, but these differences were not statistically significant.

However, we found improvements in market sales, with VBA farmers making an additional $196 in revenue from cash sales annually compared to non-VBA farmers. This finding aligns with what we found in Phase 1, which concluded that VBAs in Mozambique had much stronger links to off-taking markets than VBAs in the other four countries in the review, which enabled them to connect farmers to markets effectively. These links were facilitated by high integration between input suppliers and off-takers and pre-existing warehouse infrastructure in the areas where VBAs worked. Perhaps most importantly, the Phase 1 evaluation found that farmers in Mozambique were dispersed and underserved by market actors in general, so there was an opportunity for VBAs to expand market access.

This improvement in cash sales and market access translated to higher levels of household income (a difference of $504). Mozambique was the only country in which VBA farmers reported higher levels of resilience (an impact on the SERS of 5 percentage points).

4.3. Program impacts in Nigeria

Figure 22. Intermediate and farmer outcomes of the VBA program in Nigeria



Practice adoption was relatively poor in Nigeria, but we found that cash income increased, likely due to improved access to output markets (Figure 22)**.** Similar to Kenya, most farmers (74 percent) reported receiving extension services over the past year and an average of 7.5 visits. However, this intensity of interaction did not appear to have influenced practice and input adoption. We found no improvement in row spacing, crop protection, or post-harvest practices. The only statistically significant practice change was for crop rotation, for which we saw higher levels among VBA farmers compared to non-VBA farmers across all three crops. Similarly, there were no differences in the adoption of any inputs for VBA farmers. Given this, it is not that surprising that we did not find statistically significant impacts on yields in Nigeria.

VBA farmers in Nigeria did sell more into the market and earn more farm profit than non-VBA farmers, but neither of these differences was statistically significant. When we assessed impacts on total household *cash* income from all sources, VBA farmers did make an additional $290 annually. However, looking at total household income including the value of non-sold harvest, there was no statistically significant difference between VBA and non-VBA farmers in Nigeria. As noted above, self-reported household income generally has very wide distribution and so it can be difficult to find statistically significant results. Therefore, we would view these impacts as "suggestive" but not definitive. Additionally, while VBA farmers did not have more income than non-VBA farmers, on average, younger VBA farmers in Nigeria saw relatively smaller yields and farm profits, resulting in lower total household income. VBA programming does not seem to have suited younger farmers as well as older farmers in Nigeria.

4.4. Cross-cutting trends

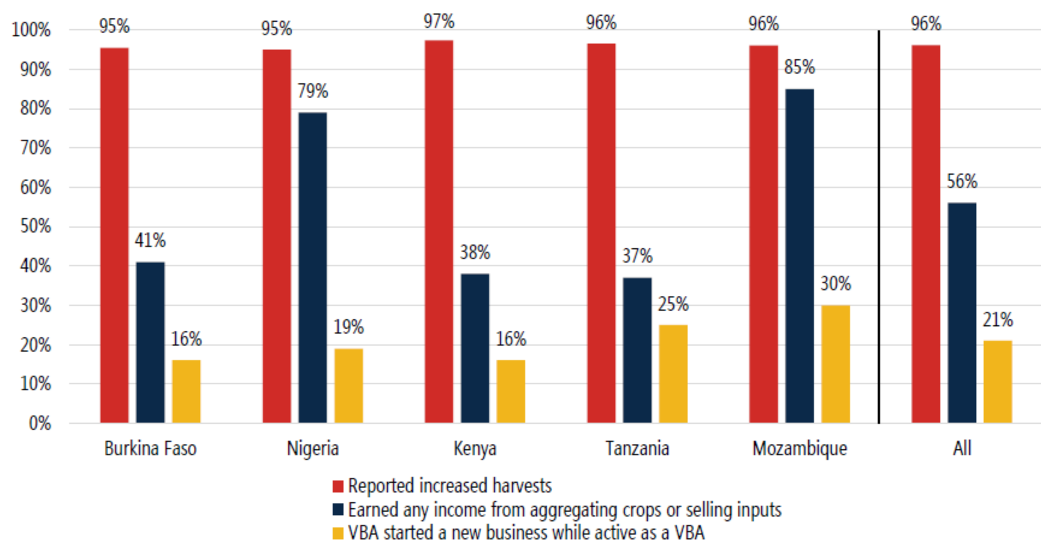
While VBA and non-VBA farmers had similar yields, VBA farmers cultivated larger land areas, which suggests that VBA farmers might be focusing on extensification rather than intensification. In both Kenya and Nigeria, VBA farmers cultivated larger areas of maize and, moreover, cultivated more land overall (across all groups). Farmers in Mozambique dedicated a larger percentage of their land to focus crops. This extensification might be especially important in a year in which fertilizer prices were abnormally high. While this was not an explicit component of the ToC—which focuses mainly on yield per hectare increases and market access—it is worth considering how the program might affect land use. We plan on conducting some qualitative follow-up work to better understand this trend as well as other unanticipated findings.

VBA farmers had lower levels of dietary diversity in all countries, an unexpected finding which warrants attention. Improving dietary diversity was not an explicit goal of the VBA program in AGRA 2.0, and there were no interventions specifically intended to improve dietary diversity. However, AGRA is focusing attention on food systems and nutrition in its next strategy. Therefore, we measured household dietary diversity as a leading indicator of improved nutrition. Unexpectedly, we found that dietary diversity was actually worse among VBA farmers in all three countries, although the magnitude of those differences was relatively small (between 0.5 and 1.1 fewer food groups). It is possible that the greater emphasis on focus crops may have come at the expense of crop diversity, though we know that in AGRA 3.0 there will be an emphasis on increasing crop diversity.

Interestingly, we found that the practice that improved the most consistently across all three countries was crop rotation, despite the fact that this was not a practice that appeared to be highlighted prominently in any of the VBA training materials. This somewhat unexpected finding likely requires further investigation, and we intend to ask farmers about this during our follow-up qualitative work

Despite the relatively minimal increases in input use and lack of statistically significant impacts on yields, we did find a strong impact on household income in Mozambique and suggestive trends in Nigeria. We believe that these income differences are driven by three potential pathways. First, the VBA program has been in operation for four years and it is possible that in earlier years, in which input prices were lower, farmers did increase their use and realize greater harvest gains. These may have in turn led to productive investments which meant that VBA farmers had greater incomes in Year 4 of the program. Second, we found evidence that VBA farmers had more land allocated for focus crops and more land under cultivation overall. Assuming that focus crops are relatively more profitable and that any additional land planted is profitable, this should improve household incomes over time. Finally, VBAs may have facilitated greater access to better markets, increasing the revenue farmers receive from crop sales. We have direct evidence that this is happening in Mozambique and suggestive evidence for this in Nigeria. These trends align with our findings from the Phase 1 evaluation, which found that VBAs in Mozambique and Nigeria were more than twice as likely as VBAs in three other countries to report some income from connecting farmers by aggregating crops or selling them inputs (Figure 23). We intend to further investigate the most likely impact pathways for VBA-trained farmers in our follow-on qualitative work.

Figure 23. VBA-reported impacts on their livelihood



Source: VBA phone survey, December 2022.
N = 1,032.

5. Recommendations

We suggest two sets of recommendations: the first set is immediately relevant to AGRA's agricultural extension programming, and the second set speaks to areas that AGRA may want to consider exploring further to better inform its programming in the long run.

Key recommendations that are immediately relevant to AGRA's agricultural extension programming include:

Conduct a full pre-intervention assessment of each country in order to tailor the VBA program to specific needs and likely impact pathways. We found very different results, and likely impact pathways, in the three countries in this evaluation; we noted similar differences in the focus of the VBA program in each country in the Phase 1 evaluation.

- In Mozambique, we found that output market access is a key focus of VBAs and a positive impact pathway for farmers to generate income, so it makes sense to continue focusing on output market access.
- In Kenya, we found that VBAs are not as successful in connecting farmers to markets because market access is already quite strong. Practices (such as row spacing) are already commonly followed and input adoption is already high, so the focus on regenerative agriculture is well placed and appears to be bearing fruit in terms of farmer practice changes, such as planting more trees.
- In Nigeria, despite the high rate of interaction between VBAs and farmers, meaningful practice changes did not occur; however, there is suggestive evidence of improved market access. It is worth assessing how to encourage farmers to change their practices and adopt more inputs.
- Ex-ante, pre-intervention assessments also position programs to be evaluated from their outset. Incorporating baseline surveys is important because they improve measurement of pre-intervention conditions, which are critical for identifying valid counterfactuals, and changes over time for treatment and comparison groups.

Therefore, administering a uniform VBA program across countries will not make sense. To take one example, despite the fact that well over 90 percent of farmers plant in rows in Kenya, row planting remained a key component of farmer training that appears somewhat redundant—at least many years into the program, it no longer seems relevant. Rather, it may be best to tailor training to the specific agroecological conditions and to focus on underutilized practices that might have the biggest impact. In addition, we recommend tailoring the program as a whole to specific country conditions. If the most promising impact pathway is through access to off-taking markets, as is the case in Mozambique, it may make sense to focus on that.

Devise an explicit strategy to address the unique barriers for women and youth, especially in Nigeria. The Phase 1 evaluation found that it was particularly challenging to recruit women VBAs in Nigeria and young VBAs in Kenya. This pattern extends also to the types of farmers VBAs are reaching and benefiting in those countries. Our qualitative work from Phase 1 found that there were specific cultural barriers to reaching women in Nigeria and economic barriers to reaching youth in Kenya. However, women VBAs reached more women and young

VBAs reached more men. So, a good starting point to address these disparities is in the VBA recruitment strategy. AGRA may want to investigate other avenues for better reaching and serving women and youth in contexts in which serving such populations is challenging, particularly given their goals for reaching those subgroups.

Focus more attention on improving uptake of inputs. Increasing access to agricultural inputs through improved connections to markets is a key function of the VBAs. We know from the Phase 1 evaluation that just over 30 percent of VBAs reported earning income from selling inputs and that 21 percent started a new business associated with their role as a VBA. Despite that, in the year of our Phase 2 farmer survey, VBA farmers did not improve their input use relative to non-VBA farmers, perhaps because fertilizer prices were unusually high in the period of interest (2022), which may have dampened use. However, the lack of impact on input use points to a larger issue: even with increased information and access to inputs, farmers lack the cash and credit to purchase enough inputs. This lack of access to credit was also highlighted as a key challenge in focus groups with farmers and interviews with VBAs in the Phase 1 evaluation. Because a primary hinderance to closing the yield gap is input use (Dzanku et al. 2015; Larson and Frisvold 1996), AGRA may want to explore approaches to increase access to input financing.

Next, we propose three areas that merit further exploration to better calibrate AGRA's future programming:

Investigate barriers to practice adoption and devise strategies for behavior change. While there were some meaningful improvements in row spacing for some crops and improvements in crop rotation across all countries, many practices did not change as a result of the program (such as use of certified seeds and synthetic fertilizer and timing of planting). Furthermore, Nigerian farmers did not meaningfully change most of their practices. Because training is a key component of the VBA program, it is important for AGRA to further investigate why farmers in VBA areas do not adopt certain practices and what can encourage practice adoption. This investigation should follow the country-level assessment and be tailored to program configurations to focus on the most promising, yet underutilized, practices.

Understand the optimal role for digital extension going forward in generating impact. As noted in the methods section (Section 2), the Phase 2 evaluation was initially planned to be a prospective study of AGRA's digitalization program in Mozambique and Nigeria; however, due to implementation challenges, this was determined to be an inefficient use of research funds. In our Phase 1 report, we recommended that AGRA conduct formative research to assess implementation challenges and suggest course corrections. The findings in this report (showing that it was difficult to affect practices and yields with the current in-person training) underline the importance of identifying the optimal change pathways for digital extension (for example, whether it is through targeted training, follow-up reminders, market access, etc.). AGRA may want to study which digital extension training and models are most likely to have an impact and in which contexts.

Integrate nutrition training into programming. While nutrition was not an explicit goal of the VBA program in the last AGRA strategy, it was still surprising that dietary diversity (a leading indicator of nutrition outcomes) worsened among VBA farmers. This finding supports research indicating that simply improving harvest or household income may not lead to improvements in nutrition (Berti et al. 2004; Masset et al. 2012). As improving nutrition is a goal of the next AGRA strategy and the VBA program is a key avenue for reaching farmers, AGRA may want to develop an explicit strategy for improving nutrition through the VBA program.

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Appendix A

Table A.1. Sample sizes for crop-level outcomes

	Kenya		Mozambique		Nigeria	
	Non-VBA	VBA	Non-VBA	VBA	Non-VBA	VBA
Long Rain						
Maize	641	677	598	689	849	985
Rice	0	0	139	261	538	607
Soybean	0	7	16	42	304	455
Short Rain						
Maize	605	664	442	703	63	64
Rice	0	0	85	107	9	31
Soybean	0	9	12	76	34	31

Table A.2. Farmer Costs (USD / kg)

	Kenya					Mozambique					N	
	Sample size		Mean			Sample size		Mean			Sample size	
	Non-VBA	VBA	Non-VBA	VBA	Diff	Non-VBA	VBA	Non-VBA	VBA	Diff	Non-VBA	VBA
Seed cost (USD/kg) – hybrid	698	735	20.9	16.7	-4.1	1146	1578	8.8	11.5	2.7	1211	1404
Seed cost (USD/kg) – recycled	698	738	22.5	26.7	4.2	1147	1578	13.2	13.4	0.2	1211	1405
Fertilizer cost (USD/kg) – synthetic	500	478	1.4	0.9	-0.4	14	153	1.4	-1.0	-2.4	993	1154
Fertilizer cost (USD/kg) – organic	264	203	0.1	0.0	-0.1 **	15	16	1.5	-2.9	-4.3	311	361
Farm cost (total)	669	675	165.9	178.3	12.4	1081	1486	78.0	73.1	-5.0	1149	1348

Table A.3. Reasons for selecting input markets

	Kenya			Mozambique			
	Non-VBA (N=688)	VBA (N=728)	Diff.	Non-VBA (N=726)	VBA (N=1072)	Diff.	Non-V (N=12
I get the best price at this source	32.6%	26.9%	-5.7%	55.6%	64.2%	8.6%	72
I do not have access to transport from other sources markets	2.0%	3.9%	1.9% *	10.5%	12.0%	1.5%	5
Poor road conditions to other sources	0.2%	0.9%	0.7% *	5.2%	6.3%	1.1%	6
I am not aware of prices at other sources	4.9%	7.1%	2.2%	5.6%	3.9%	-1.7%	6
The seller offers the best quality of inputs	29.9%	35.6%	5.7%	8.3%	7.6%	-0.7%	12
It is close to my farm	46.7%	31.3%	-15.4% **	20.8%	12.6%	-8.2% *	15
Reliable stock availability	25.2%	27.1%	1.9%	9.8%	7.5%	-2.3%	31

	Kenya			Mozambique			
	Non-VBA (N=688)	VBA (N=728)	Diff.	Non-VBA (N=726)	VBA (N=1072)	Diff.	Non-V (N=12
After-sales services (e.g., free advice on farming practices)	5.4%	10.0%	4.6% **	1.1%	0.3%	-0.8%	1
Other	5.1%	14.9%	9.8% ***	8.2%	4.2%	-4.0%	2

Table A.4. Reasons for selecting output markets

	Kenya			Mozambique			
	Non-VBA (N=688)	VBA (N=728)	Diff.	Non-VBA (N=726)	VBA (N=1072)	Diff.	No (N=
I get the best price at this market	55.9%	47.0%	-8.9%	54.8%	55.1%	0.3%	85
I do not have access to transport to other markets	12.5%	19.8%	7.3% *	34.4%	36.9%	2.5%	7
Poor road conditions to other markets	2.9%	6.0%	3.1% **	15.2%	21.6%	6.4%	8
I am not aware of prices at other markets	9.9%	12.7%	2.8%	11.6%	12.0%	0.4%	8
I don't produce enough to transport to bigger market	21.2%	27.5%	6.3%	13.6%	13.9%	0.3%	15
It is close to my farm	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0
Other	22.2%	28.6%	6.4%	4.5%	-0.7%	-5.2%	2

Table A.5. Selling price (USD / kg) for priority crops

	Kenya					Mozambique					Nigeria				
	Sample size		Mean			Sample size		Mean			Sample size		Mean		
	Non-VBA	VBA	Non-VBA	VBA	Diff	Non-VBA	VBA	Non-VBA	VBA	Diff	Non-VBA	VBA	Non-VBA	VBA	Diff
Maize, long rains	106	133	0.8	0.8	0.0	155	260	0.4	0.4	-0.0	631	786	1.5	1.7	0.2
Maize, short rains	69	105	0.8	0.7	-0.0	89	234	0.4	0.5	0.1	21	33	1.3	4.3	3.0
Rice, long rains						35	59	0.3	0.4	0.0	431	510	3.0	4.4	1.4
Rice, short rains						17	25	0.5	0.5	0.1	8	25	19.3	-29.2	-48.5
Soy, long rains						9	36	2.3	1.1	-1.1	283	417	3.2	5.6	2.3
Soy, short rains						6	55	0.8	2.8	2.1 *	34	29	18.9	14.8	-4.1

Table A.6. Sources of net household income (USD/year)

	Kenya					Mozambique						
	Sample size		Mean			Sample size		Mean			Sample size	
	Non-VBA	VBA	Non-VBA	VBA	Diff	Non-VBA	VBA	Non-VBA	VBA	Diff	Non-VBA	VBA
Wages or salary from regular job	680	734	100.3	111.8	11.5	1,106	1,543	42.6	-8.5	-51.1 **	1,211	1,400
Wages or salary from occasional job	680	723	122.4	71.7	-50.8 *	1,091	1,526	26.3	4.6	-21.8 **	1,201	1,399
Running own business in retail, manufacturing, or providing services	688	724	0.0	2.5	2.5	1,082	1,472	0.0	0.2	0.2	1,179	1,369
Grant, pension, stipend/allowance, or subsidy of some sort	695	734	23.1	69.6	46.6 *	1,144	1,577	2.8	1.2	-1.7	1,211	1,405
Receiving money from family or friends/remittances from abroad	693	731	35.4	46.3	10.9	1,133	1,574	0.6	2.0	1.4	1,206	1,404
Growing fruits and vegetables	695	734	15.1	15.6	0.5	1,123	1,560	1.2	13.5	12.3 ***	1,210	1,405
Rearing livestock, poultry, fish, or bees and selling it or its byproduct	691	725	98.4	131.0	32.6	1,131	1,567	1.1	5.9	4.8 **	1,210	1,398
Rental income	697	736	3.0	53.9	50.9 *	1,145	1,571	2.6	-0.2	-2.8	1,211	1,404
Other	696	736	7.7	31.5	23.8 *	1,136	1,573	7.0	10.6	3.6	1,209	1,401