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Farmer Groups as ICT Hubs

Findings from a Cluster-Randomized Controlled Trial in Malawi

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Abstract

Many rural producer groups face poor management practices, low productivity, and weak market linkages. An information and communication technology (ICT)-based intervention bundle was provided to producer groups to transform them into ICT hubs, where members learn about and adopt improved management practices and increase their productivity and incomes. The intervention bundle includes phone messages and videos, promotion of the call center/hotline, and facilitation of radio listening clubs and collective marketing. The study, a cluster-randomized controlled trial, randomly assigned 59 groups into treatment groups and 59 into control groups. After 18 months of interventions, results show positive but small impact on crop sales (USD65 per household) and no impact on productivity. The income effect was mainly from Kasungu and Nkhota-kota, which experienced increased production and sales of rice, soybean, and groundnut and received higher prices due to collective marketing. Farmers in Kasungu and Nkhota-kota improved a few agricultural management practices, while farmers in other districts did not improve their management practices. Results show more farmers accessing phone messaging on agriculture and markets, greater awareness and use of the call center, more listening groups established, and more farmers—especially women—joining these groups. Nevertheless, coverage and uptake remain very low, which are likely reasons for the limited impact.

Keywords: ICT, digital agriculture, digital extension, group-based approaches, impact evaluation

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1. Introduction

Digital tools can transform economic activity, make markets more efficient, and improve livelihoods and incomes in low- and middle-income countries (Abate et al. 2023; Aker, Ghosh, and Burrell 2016; Nakasone, Torero, and Minten 2014). Despite skyrocketing access to mobile phones in recent years and rapidly growing mobile penetration in rural areas, adoption of digital tools and their scaling to a wider population have been limited and their development impacts rarely evaluated (Abate et al. 2023). In Malawi, among the poorest and most food insecure countries in Africa, 50 to 60 percent of the population had access to mobile phones and 18 to 28 percent had internet access in the last five years (GSMA 2024; Handforth and Wilson 2019). According to national rural surveys (Ragasa and Niu 2017), about 50 percent of rural households own mobile phones, and about 75 percent of men and 55 percent of women use mobile phones every day. While these mobile phones are still primarily basic feature phones operated on 2G networks, the use of smartphones operated on 3G and 4G networks is increasing, even in Malawi's rural areas.

However, the use of mobile phones for agricultural information is limited; radio programs and government extension services still dominate as the main sources of agricultural information. While radio programs have been effective (see Ragasa et al. 2021; Ragasa, Mzungu, et al. 2022), mobile apps can contribute by providing user-friendly apps, videos, reminders, and the latest market information. Low-cost provision of information via mobile apps and call centers can complement government extension services. Examples of digital extension services in Malawi include Access Agriculture's focus on video-based extension, Viamo's agriculture extension support through a mobile phone service called 3–2–1, and a call center/hotline operated by Farm Ratio Trust–Malawi (FRT) for agriculture and rural development issues (Ragasa et al. 2021; Tauzie et al. 2024). In national surveys, however, less than 3 percent of rural households report using these digital tools and services.

To address this issue, FRT and its partners are implementing the Scaling up Radio and Information and Communication Technologies (ICTs) for Enhanced Extension Delivery (SRIEED) II project[1] in five districts in Malawi from 2020 to 2025. A major component involves strengthening existing community-based producer groups as ICT hubs, targeting them as centers for providing demand-driven extension and models for early adopters of agricultural and marketing innovations in rural communities. These groups are being supported in the form of a bundled package of services including short message service (SMS), video-based extension, promotion of the call center and hotline, facilitation of group learning and listening clubs, and assistance in collective marketing and aggregation. This paper presents the evaluation of the intervention bundle provided to ICT hubs after 18 months of implementation.

[1] See Annex Figure A1 and Ragasa, Carrillo, et al. (2022) for more details of the project.

2. Literature review

This study on transforming producer groups into ICT hubs is rooted in different concepts and strands of the literature. Lessons from past studies can suggest adjustments in the design and implementation of the intervention bundles for the producer groups. We review prior work from both the conceptual and empirical literature below.

2.1. Group-based learning

In the literature on group-based learning as a mechanism for disseminating and promoting agricultural technologies, approaches include farmer field schools (FFSs), farmer business schools (FBSs), farmer clusters, and radio forums. Scholars have documented many benefits of learning groups, such as helping farmers to innovate, facilitate solutions to their own concerns, and even change their behaviors (Bergevoet and Woerkum 2006; Owen and Williams 2012; Pasiona et al. 2021; Roling and de Jong 1998). Learning groups offer a site for the fast spread of knowledge (Bergevoet and Woerkum 2006). However, few studies examine learning context and approaches, and fewer scrutinize the behavior of learners while learning (see Sewell et al. 2017 for exception; see Pasiona et al. 2021 for a review).

The most studied among these group-based learning approaches are FFSs, which facilitators implement using participatory "discovery-based" learning grounded in adult education principles (see reviews by van den Berg et al. 2020 and Waddington et al. 2014). FFSs' objectives include tackling overuse of pesticides and other harmful practices, improving agricultural and environmental outcomes, and empowering disadvantaged farmers such as women. Waddington et al. (2014) reviewed 92 impact evaluations, 15 of which were of sufficient quality for policy-oriented findings, and 20 qualitative studies. They conclude that FFSs improved farmers' knowledge and adoption of beneficial practices, reduced overuse of pesticides, and led to a 13 percent increase in agricultural yields as well as a 20 percent increase in income on average. However, the evidence for these outcomes comes from short-term evaluations of pilot programs, and no studies with a low risk of bias are available. In programs delivered at a national scale, studies conducted more than two years after implementation did not show any positive program outcomes and showed no effect on non-participants in neighboring communities. Large-scale programs had problems recruiting and training appropriate facilitators.

Other critiques of FFSs, FBSs, and similar group-based learning models highlight the costs of intensive facilitation and engagement, and the limited effect of these learning groups on non-participants (Waddington et al. 2014). Such critiques suggest using low-cost alternative approaches like ICT tools, but few studies look at the combination or integration of low-cost ICT tools in group-based approaches or how they enhance and optimize the tools' effects in rural communities.

2.2. ICT-based extension

ICT tools—including radio programs, mobile apps, SMS, interactive voice response (IVR), video-based extension, television, and the internet—can offer low-cost, wide-coverage, and high-impact platforms for disseminating information, linking producers to markets, and facilitating transactions and value chain coordination. Empirical evidence to date, however, shows mixed findings of these tools' impact on productivity, incomes, and nutrition security and mixed results on women's inclusion and empowerment (see reviews by Aker, Ghosh, and Burrell 2016; Aker and Ksoll 2016; de Brauw and Bulte 2021; Ezeomah and Duncombe 2019; Nakasone, Torero, and Minten 2014). Many ICT or digital tools remain in the pilot phase and have never reached a wider scale (Abate et al. 2023).

Radio has been used for decades to disseminate information and provide education on agricultural practices (Chapman et al. 2003; Lwoga 2010; Odame and Kassam 2002; Pasiona et al. 2021). Its use is widespread in developing countries: more than 55 percent of sub-Saharan African households listen to the radio weekly (Aker 2011). In Malawi, more than 60 percent of households listen to the radio at least once a week and 41 percent at least once a day (Ragasa and Niu 2017); 52 percent of women reported listening to the radio at least once a week (Ragasa et al. 2021). Despite radio's advantages—affordability and accessibility even in remote areas and to poor women—earlier radio programs promoting agricultural information were criticized for their limited range of information and the one-way communication radio offers (Aker 2011). By comparison, face-to-face visits are expensive but can offer intensive training and learning, and mobile phone and SMS—also more expensive—can offer much more varied information and enable an interactive process (Aker 2011). Combining radio programing, group-based approaches, and more advanced digital tools to optimize effects for rural communities remains an innovation challenge.

Projects in several countries have promoted radio listening clubs, which combine elements of group learning and radio programming (Pasiona et al. 2021), although impacts of these clubs have rarely been evaluated. In the Philippines, a modified listening group enabled farmers to learn technical concepts, as evidenced by their knowledge gain, and afforded them the opportunity to collectively forward their agenda to the government (Pasiona et al. 2021). Adding creative or innovative games to listening groups is reported to effectively facilitate and enhance knowledge absorption (Manalo et al. 2016; Pasiona et al. 2021).

Rural telecenters—often comprising computers, printers, scanners, telephones and the internet—have been studied and evaluated but show limited accessibility and sustainability (Lwoga 2010; Lwoga and Chigona 2020). Although such centers can benefit and empower some women, many women cannot access them (Lwoga 2010; Lwoga and Chigona 2020). Telecenters in Bangladesh fared well overall in improving rural people's livelihoods but largely benefited the emerging middle class, with limited impact on the very poor (Rahman and Bhuiyan 2016).

Using experimental or quasi-experimental research methods, recent studies of mobile-based and video-based extension find mixed results (see reviews by Aker and Ksoll 2016; Ezeomah and Duncombe 2019; Nakasone, Torero, and Minten 2014). In Mali, Dzanku, Osei, and Osei-Akoto (2021) used a randomized-controlled trial (RCT) to evaluate whether mobile phone voice messages reinforced the recommendations provided in face-to-face trainings. They find that reminders significantly induced timely harvesting, reduced on-farm cereal losses, increased uptake of improved grain storage technology, and increased the likelihood of preharvest sales contracting; however, they find no overwhelming evidence that reminders increased yields and no evidence of impact on revenues.

In northern Nigeria, Oyinbo et al. (2021) used an RCT and panel data to estimate immediate and longer-term effects of site-specific extension recommendations with and without complementary information about variability in output prices and expected returns through mobile-based extension. They find that site-specific nutrient management recommendations improved fertilizer management practices and maize yields but did not increase fertilizer use. In addition, they find that recommendations accompanied by additional information about variability in expected returns induced larger fertilizer investments that persisted beyond the first year, but the magnitudes of these effects were small.

In India, Cole and Fernando (2021) conducted an RCT of a program that sends voice messages to farmers with information on weather and crop conditions and provides a hotline for specific agricultural consulting. They find a weak impact on farming practices, which they argue may be due to spillovers from the treatment to the control group. In Uganda, van Campenhout et al. (2017) show that watching agricultural extension videos significantly increased farmers' knowledge and that video-based extension is most effective when farmers already have some idea about techniques explained in the video. Similarly, van Campenhout et al. (2021) show that providing information to farmers in eastern Uganda through a short video significantly increased farmers' knowledge about improved agricultural input use and recommended management practices, whereas IVR and SMS had insignificant incremental effects.

An important lesson emerging from these studies is that ICT tools alone are often not enough to change rural producers' behavior or outcomes. Relevance and quality of the message content are important, as is the need to provide intensive training and engagement with rural producers for multi-dimensional technology packages. Programs should consider providing complementary services to address the many constraints facing intended users.

2.3. Innovations in linking small-scale producers to markets

Using ICT to link farmers to markets is becoming increasingly popular. Although mobile money networks facilitate market transactions, limited research exists on other market platforms that improve access to

markets or buyers. Earlier studies show mixed results of ICT-based market platforms and market information services (see reviews by Aker, Ghosh, and Burrell 2016; Aker and Ksoll 2016; de Brauw and Bulte 2021; Ezeomah and Duncombe 2019; Nakasone, Torero, and Minten 2014). In Kenya, an ICT-based market information services project had positive and significant impact on the use of seeds, fertilizers, and land and on labor productivity but a negative impact on labor usage (Ogutu et al. 2014). More recently, COVID-19 led to an explosion of online or digital platforms for marketing. Empirical evidence on their impacts and inclusiveness has started to emerge but is mostly concentrated in developed countries (see O'Hara and Low 2020; Abate et al. 2023).

Women's access to ICT-based market information services is also shown to be more challenging (Lwoga and Chigona 2020; Malanga and Banda 2021), with evaluations of approaches and interventions showing mixed results. Several factors prevent some women from accessing and benefiting from ICT-based market information: institutional factors (inadequate computers, space and personnel, unreliable electrical power, and slow internet connectivity) and individual factors (multiple responsibilities, status, low level of education, language barrier, lack of digital literacy skills and technology efficacy, and inability to afford ICT short courses) (Lwoga and Chigona 2020; Malanga and Banda 2021).

FRT-Malawi is piloting an intervention bundle that integrates group-based learning via radio listening groups, phone messaging, video-based extension, promotion of the call center, and facilitation of collective marketing to transform existing producer groups into ICT hubs that become centers of demand-driven extension and models for technology adoption and improved productivity and incomes in rural communities.

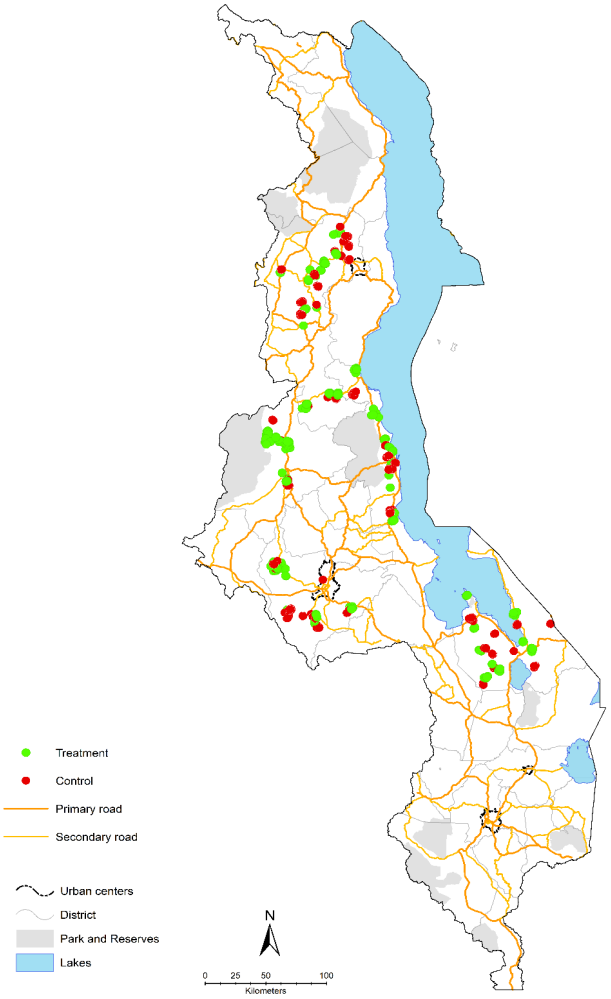
3. Methodology

This section provides details on the study sites, intervention being evaluated, research design, estimation method, and descriptive statistics. This study is registered in and approved by the American Economic Association's registry for Randomized Controlled Trials (#AEARCTR-0008467); IFPRI Institutional Review Board (DSGD-21-0514, IRB #00007490, FWA #00005121); and the Malawi National Committee on Research Ethics in the Social Sciences and Humanities (NCST/RTT/2/6) on May 26, 2021, and July 26, 2023.

3.1. Study site

The study focused on five districts: Kasungu, Lilongwe, Mzimba, Nkhota-kota, and Mangochi (see Figure 1 for location of the focus groups and their assignment as treatment and control ICT hubs).

Figure 1. Map of Malawi and the location of the treatment and control ICT hubs



Source: IFPRI/Wadonda household survey (2021).
Note: ICT = information and communication technology.

3.2. Intervention and outcomes

Many producer groups in Malawi are small and are engaged in farming and marketing of agricultural commodities. Their members face many constraints, including poor management practices, low productivity, limited surplus, and poor market linkages. Even for the more formal groups like cooperatives, many have low management capacity and fail to provide clear or reliable benefits for their member-farmers through their commercial activities (Davis et al. 2022). FRT-Malawi aimed to support grassroot groups with low-cost and wide-coverage ICT tools to improve their group's information system and their members' access to agricultural and market information and facilitate group learning and collective marketing.

FRT-Malawi identified between 18 and 20 existing groups per district,[2] for a total of 118 groups, as having the capacity and commitment to be transformed into ICT hubs. These groups have diverse membership sizes (9–128 members). Most are general groups/clubs; some are producer/marketing cooperatives, youth groups, water user groups, and village savings and loans groups. Most are mixed-gender groups; some are women's groups. On average, 69 percent of members are women, and 31 percent are men; 28 percent of members are youth (18–35 years of age), and 72 percent are non-youth. Most groups formed 5 to 10 years ago, some with external support during formation (74 percent), some that continue to receive external support (40 percent), and some that formed organically without external support (about 26 percent). On average, 67 percent of group members own cell phones; only 17 percent have smartphones (to enable app use). See Ragasa, Balakasi, et al. (2022) for more details on the sample producer groups.

The intervention is a bundled package of services to existing producer groups, including SMS messaging, video-based extension, facilitation of radio listening clubs and group learning, promotion of the call center/hotline, and assistance in collective marketing and aggregation. These services aim to complement the popular agricultural radio programming in Malawi (Ragasa et al. 2021; Ragasa, Mzungu, et al. 2022).[3] Annex 1 provides examples of messages provided via SMS push and video-based extension.

The intervention bundle is expected to transform these existing groups into ICT hubs, with members experiencing improved adoption of agricultural and marketing innovations, improved production, and increased incomes. These impact ICT hubs are then expected to induce other households in the community to demand and access information and improve adoption of agricultural innovations. FRT is intentional on reaching and benefiting women and therefore included women-only and mixed groups in the group selection and ensures that interventions reach women and men group members and member-households equally.

For the impact evaluation, primary outcome indicators include crop productivity (MWK/ha) and sales income (MWK, MWK/ha). Secondary outcome indicators measured are Household Dietary Diversity Score (HDDS), Women's Dietary Diversity Score (WDDS), Women's Empowerment in Agriculture Index (WEAI), and gender parity. To address potential bias from multiple hypothesis testing, we adjusted the standard errors using Anderson Q-values (Anderson 2008). We also estimated heterogenous effects by gender of respondent and by district. To describe the impact pathways and mechanisms, we studied the

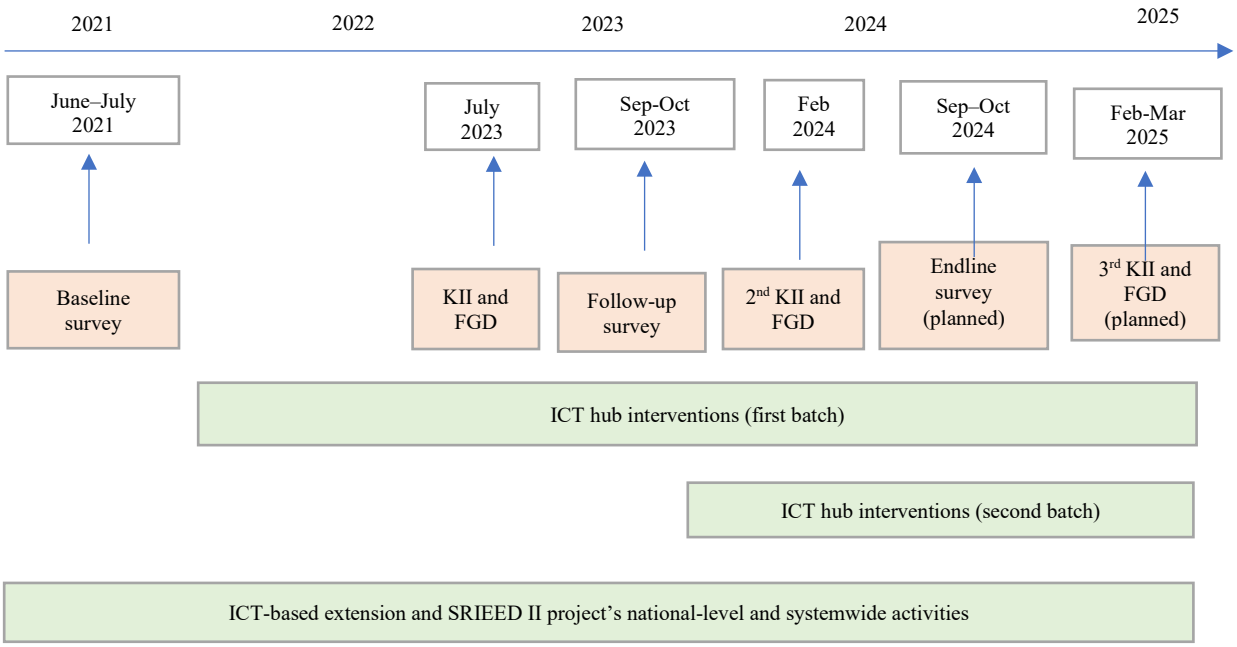
[2] FRT-Malawi breaks down Mzimba, the largest district, into two subdistricts: Mzimba North and Mzimba South. A total of 20 groups were listed in Mzimba North, and another 20 groups were listed in Mzimba South. The other five districts have a listing of 18 to 20 groups, for a total of 118 focus groups for this study. We adopted similar stratification and breakdown into six districts/subdistricts in our analysis.

[3] All rural communities have access to agricultural radio programming, and this is not an experimental factor in the study design.

types of messages embedded in the ICT tools and measured the changes in group members' exposure and receipt of SMS advice or video on agriculture, nutrition, or markets; awareness and use of the call center/hotline; participation in listening clubs; and the number of promoted management practices that sample households are aware of and have adopted. These management practices were identified via the district-level technology prioritization activity by FRT-Malawi, inputs from FRT-Malawi, literature review, and key informant interviews. Annexes 2 and 3 provide definitions and measurements of the indicators; Annex Table A1 presents the list of 48 promoted and tracked management practices.

This paper is largely based on the baseline survey implemented in 2021 and midline survey, key informant interviews, and focus group discussions implemented in 2023 and early 2024 (see Figure 2 for timeline).

Figure 2. Study timeline



Source: Authors' illustration. KII = key informant interview; FGD = focus group discussion; ICT = information and communication technology.

3.3. Evaluation design

The evaluation design used a cluster-randomized controlled trial (cRCT), with producer groups as the unit of randomization and households as the unit of analysis. Of the 118 producer groups identified, half were randomly assigned as treatment group and half as control group (using the Stata statistical software program). For the interventions, we took advantage of the phased implementation approach to set up a cRCT, with the treatment group serving as the first batch and the control group as the second batch.

All members of the treatment groups are eligible to receive the intervention package; the control group receives no intervention package. All groups have access to radio programming and a call center, which are national or districtwide in coverage and difficult to control or assign to different groups. Therefore, the treatments being evaluated are the promotion of the call center (not the call center itself), promotion and setup of listening clubs (not the radio program), SMS, video-based extension, and facilitation of group marketing.

For the baseline and midline surveys, we randomly selected between 9 and 40 members from each group (depending on group size) and analyzed the outcomes and impacts on these sample members. We used sampling weight, which is the inverse of the probability of selection in the survey. We also interviewed another decision-maker of the opposite sex in each household for indicators on WEAI and gender parity within the household. We also surveyed leaders of the 118 groups and conducted key informant interviews and focus group discussions (FGDs) with them. Key insights from these interviews and FGDs are presented in section 4.

3.4. Estimation model

Given random assignment to the treatment, we estimated intent-to-treat effects, where the variable of interest is the indicator variable equal to 1 if the ICT hub was assigned to a treatment group. We estimated treatment effects based on the midline survey data using single-difference estimation:

$$Y_{1ij} = \alpha_0 + \beta_{1,SD} T_v + \gamma_x X_{1ij} + \varepsilon_{1ij} \qquad (1)$$

where Y is the outcome indicator at time 0 (baseline) or time 1 (midline); i is the individual or household; j is the group; a is the intercept; β_1 measures the average effects of the treatment T; X is a vector of control variables; and ε is the error term, which is clustered at the group level. We test the null hypothesis $\beta_1 = 0$. If rejected, we conclude that the treatment has significant effect to the magnitude of β_1. Annex Table A2 provides the results of the test for balance. Almost all baseline and midline characteristics are similar between treatment and control households.

To check for robustness, we complemented the single-difference estimates with difference-in-difference estimation, using a subsample of the midline survey data. Fewer households had both baseline and midline data than had midline survey data, for several reasons. The midline survey sample size was larger because of an increased number of group members. Some group members exited the sample groups, and some included in the baseline survey could not be tracked. Moreover, we detected contamination of some groups and replaced them with freshly randomized groups; new groups did not have baseline data.

We made several design adjustments in response to identified challenges in the implementation of the experiment (see Annex Figure A1 for summary). Because several activities were not fully implemented

at midline, the midline results should be interpreted as impacts of the following interventions: SMS push, promotion of the call center/hotline, and facilitation of listening groups and collective marketing. The most relevant challenge in implementation was contamination of the control groups. As noted earlier, we replaced a few contaminated groups with freshly randomized groups, using the original list of eligible groups. We detected a few more contaminated control groups in the midline survey and removed them as well. Adaptive measures were undertaken to minimize bias in the estimates. Triangulating data and analysis from single-difference regression model, difference-in-difference, and qualitative data from interviews and focus group discussions ensure the credibility of the results and their implications.

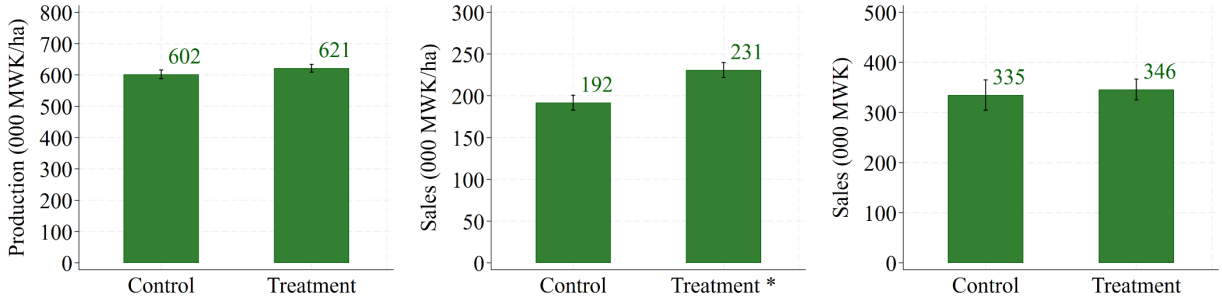
4. Results

4.1. Primary outcomes

We found significant impact of the intervention bundle on crop income, although the magnitude is small, and no impact on productivity (Figure 3a–c and Table 1), The impact on crop income was MWK75,000 or USD65[4] per household and MWK51,000 or USD43 per hectare (ha) on average. Disaggregating by district shows that overall impacts are mainly driven by impacts in Kasungu and Nkhota-kota (Figure 4a–c). In Kasungu, the impacts were larger: MWK450,000 or USD387 per household and MWK130,000/ha or USD111/ha on average, and this is mainly due to more soybean and groundnuts produced and sold and higher prices received due to collective marketing. While we did not find significant impact on crop productivity overall, treatment households in Kasungu experienced small improvements in crop productivity; the intervention bundle led to MWK90,000/ha or USD77/ha impact on productivity. In Nkhota-kota, the income effect was MWK210,000 or USD180 per household and MWK160,000/ha or USD140/ha on average, mainly due to more rice and soybean produced and sold and higher prices received due to collective marketing. In Nkhota-kota, crop productivity increased slightly; the intervention bundle led to MWK230,000 or USD198/ha impact on crop productivity.

[4] USD 1 = MWK 1,162 in September 2023.

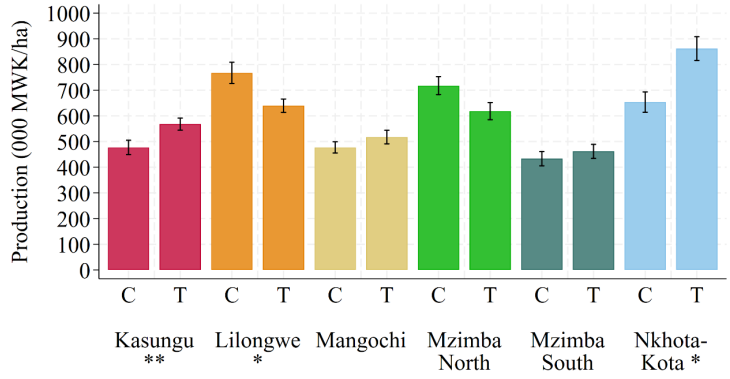
Figure 3. Difference in average crop productivity and income between treatment and control groups



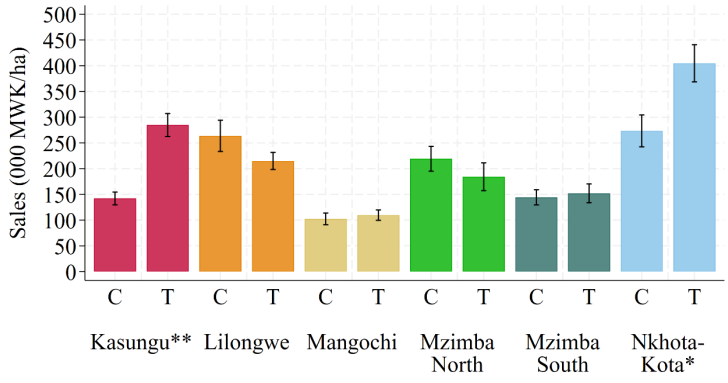
(a) Crop productivity (000 MWK/ha) (b) Crop income (000 MWK/ha) (c) Crop income (000MWK)

Note: Statistically different at †0.15, *0.10, ** 0.05, and *** 0.01 level. Bars show the averages, and the vertical lines represent the standard errors, clustered at ICT hub level.

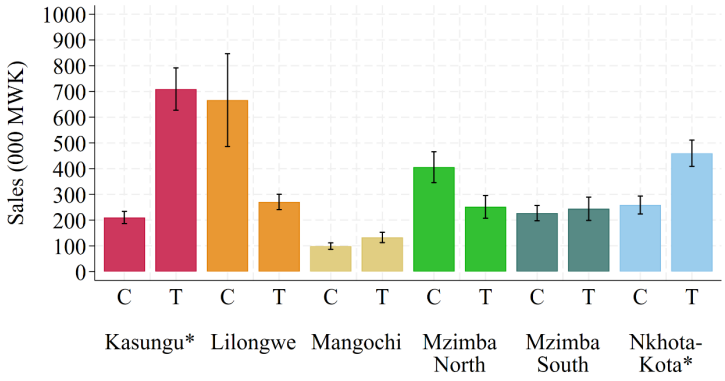
Figure 4. Difference in average crop productivity and income between treatment (T) and control (C) groups, by district



(a) Crop productivity (000 MWK/ha), by district



(b) Crop income (000 MWK/ha), by district



(c) Crop income (000 MWK), by district

Note: Statistically different at †0.15, *0.10, ** 0.05, and *** 0.01 level. Bars show the averages, and the vertical lines represent the standard errors, clustered at ICT hub level.

Table 1. Treatment effects of ICT hub intervention bundle on crop productivity and income

Outcome indicator	Crop productivity (000 MWK/ha)		Crop income (000 MWK)		Crop income (000 MWK/ha)	
Model 1						
Treatment	35.44	41.27	61.49	74.93	45.52*	51.06*
	(38.21)	(37.85)	(83.86)	(80.48)	(26.69)	(25.97)
Model 2						
Treatment	47.07	51.03	33.76	43.38	7.03	9.36
	(64.01)	(64.80)	(42.07)	(44.33)	(26.93)	(28.33)
District interactions (base=Mangochi)						
Treatment x Kasungu	34.08	34.87	387.42*	382.09*	114.58*	118.92**
	(72.63)	(73.21)	(208.33)	(205.22)	(59.32)	(58.21)
Treatment x Lilongwe	-189.79**	-178.55**	-377.12	-357.27	-48.20	-32.13
	(93.74)	(93.23)	(344.14)	(337.02)	(69.96)	(68.85)
Treatment x Mzimba North	-70.35	-68.22	-83.15	-75.45	5.59	7.75
	(101.64)	(100.14)	(126.04)	(123.99)	(73.31)	(73.03)
Treatment x Mzimba South	-10.42	-10.14	-10.11	-10.45	4.64	4.90
	(78.80)	(82.03)	(64.99)	(62.79)	(35.89)	(36.51)
Treatment x Nkhota-Kota	178.98	176.40	176.80*	174.44*	162.20*	159.84*
	(126.46)	(127.56)	(105.93)	(103.85)	(89.32)	(89.28)
Controls	No	Yes	No	Yes	No	Yes
Control Mean	601.73	601.73	334.85	334.85	191.81	191.81
N	1597	1597	1612	1612	1612	1612

Note: ICT = information and communication technology. Standard errors are in parenthesis and cluster at ICT hub level. Statistically significant at †0.15, *0.10, ** 0.05, and *** 0.01 level. Controls are unbalanced household head characteristics (gender, age, and marital status). Model 1 and Model 2 are two separate estimation models.

Collective marketing is significantly correlated to higher crop prices received. Across all focus districts, soybean farmers selling in groups received 6 percent higher prices: MWK479/kg sold as group compared to MWK450/kg sold individually. Groundnut farmers selling in groups received 22 percent

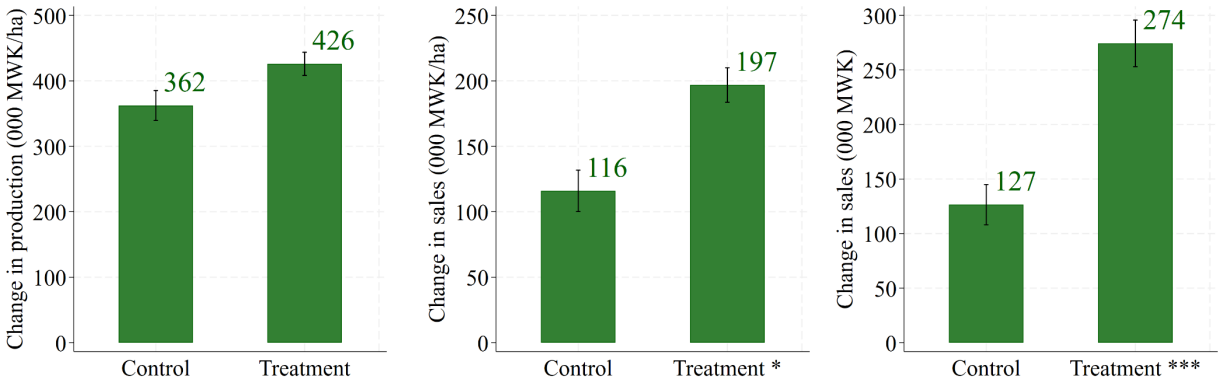
higher prices: MWK437/kg sold as group compared to MWK357/kg sold individually. In Kasungu, groundnuts sold collectively at MWK506/kg compared to MWK315/kg sold individually, or a 61 percent increase.

Across all focus districts, rice farmers selling in groups received 3 percent higher prices: MWK 573/kg sold as group compared to MWK558/kg sold individually. In Nkhota-kota, leaders in an ICT hub reported at least MWK35,000/50-kg of rice received by members selling as group, compared to MWK20,000–30,000/50-kg when selling individually; or a roughly 28 percent increase.

Across all districts, maize farmers selling in groups received 3 percent higher prices: MWK461/kg sold as group compared to MWK446/kg sold individually. In Nkhota-kota, leaders in an ICT hub reported about MWK30,000/50-kg of maize received when sold by the members as group, compared to MWK20,000/50-kg when sold individually, or a roughly 17 percent increase.

Using the subsamples surveyed at both baseline and midline, and comparing before and after the interventions, we find that results consistently show significant impact on crop income and no significant impact on productivity (Figure 5). Improvements in crop income were significantly higher among treatment groups than among control groups in Kasungu and Nkhota-kota, consistent with results shown in Figure 4 and Table 1. We also find greater improvements in treatment groups than control groups in Lilongwe and Mzimba South (Figure 6). Improvements from 2021 to 2023 were mainly driven by increases in crop prices: retail prices increased by 290 percent from 2021 to 2023, according to FAO and IFPRI price monitoring (FAO 2023; IFPRI 2024).

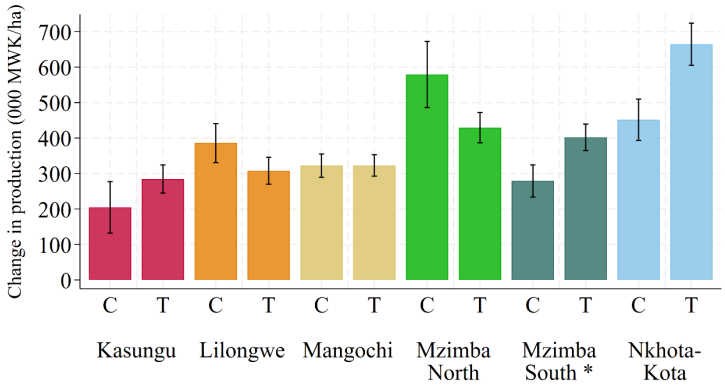
Figure 5. Difference in difference of crop productivity and income between 2023 and 2021 and between treatment (T) and control (C) groups



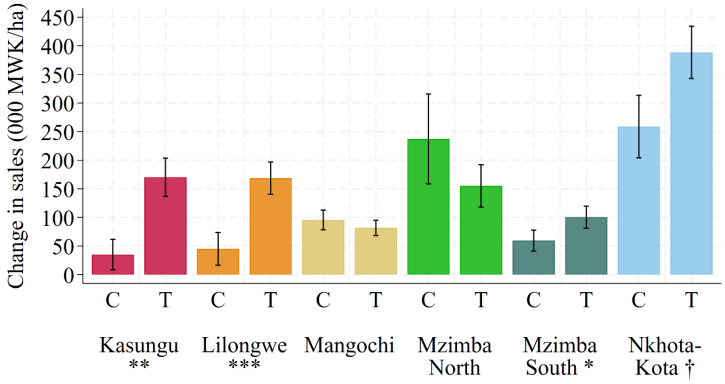
(a) Crop productivity (000 MWK/ha) (b) Crop income (000 MWK/ha) (c) Crop income (000 MWK)

Note: Statistically different at †0.15, *0.10, ** 0.05, and *** 0.01 level of significance. Bars show the averages, and the vertical lines represent the standard errors, clustered at ICT hub level.

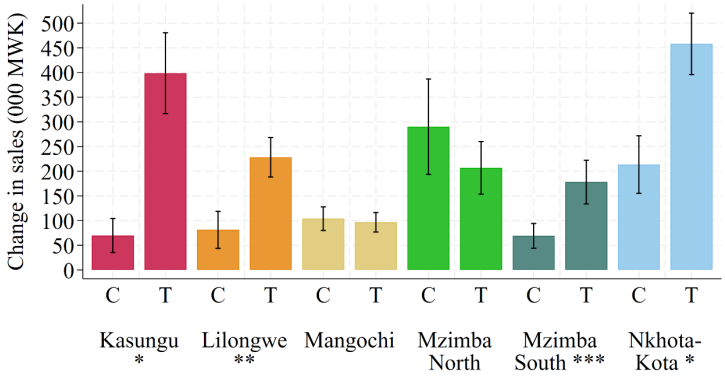
Figure 6. Difference in difference of crop productivity and income between 2023 and 2021 and between treatment (T) and control (C) groups, by district



(a) Crop productivity (000MWK/ha), by district



(b) Crop income (000MWK/ha), by district



(c) Crop income (000MWK), by district

Note: Statistically different at †0.15, *0.10, ** 0.05, and *** 0.01 level of significance. Bars show the averages, and the vertical lines represent the standard errors, clustered at ICT hub level.

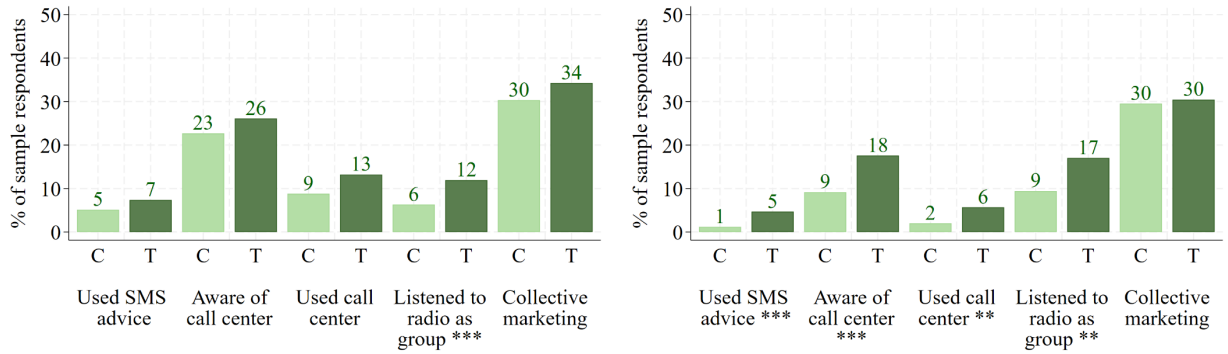
4.2. Impact pathways

4.2.1. Access to digital tools and information

The interventions have reached only a small proportion of the intended beneficiaries after 18 months of implementation (Figure 7). Among the treatment groups, only 7 percent of men and 5 percent of women

received SMS on agriculture, health, or markets; 13 percent of men and 6 percent of women used the call center/hotline; 12 percent of men and 17 of women participated in radio listening groups, and 34 percent of men and 30 percent of women practiced collective marketing (Figure 7).

Figure 7. Percentage of men and women respondents and receipt of interventions



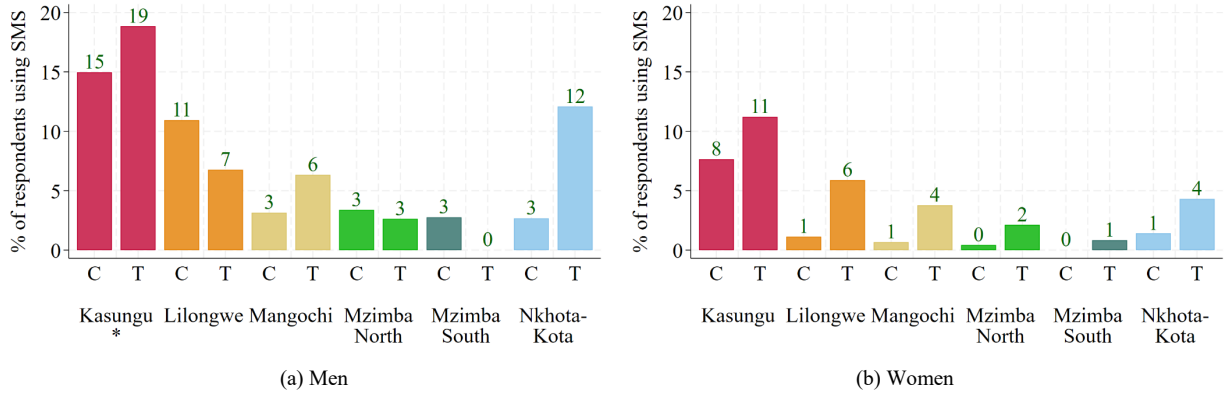
(a) Men (b) Women

Note: SMS = short message service. Statistically different at †0.15, *0.10, ** 0.05, and *** 0.01 level of significance.

As expected, treatment groups were significantly more exposed to the interventions compared with the control groups. Men and women in the treatment groups received more agriculture-related SMS, had more awareness and use of the call center/hotline, and were more likely to join a radio listening group (Figures 7–11) overall. More women in treatment groups than in control groups were reached by SMS, used call center, and joined radio listening clubs. Women experienced consistently positive effects on all these indicators, but men showed effects only on listening group participation (Table 2).

There are differences by district. The SMS texts reached 19 percent of men in Kasungu and 12 percent in Nkhota-kota (Figure 8). These are higher than other districts, and this is among the reasons we observed impacts in crop income and small impact in crop productivity in these districts. We found a strong correlation between receipt of SMS and increased crop productivity and income. However, the promotion of SMS push in these districts can be improved further, as many more members of these groups who have cellphones did not get the SMS and need to be reached. Reach to women respondents was weaker in these districts, with only 11 percent of women in Kasungu and 4 percent in Nkhota-kota receiving SMS; and this needs major improvement and close attention. SMS push was particularly very weak in other districts with only 0 to 7 percent of men and women respondents reported receiving SMS texts. Major SMS push is needed in these districts.

Figure 8. Percentage of respondents who have received agricultural advice through SMS

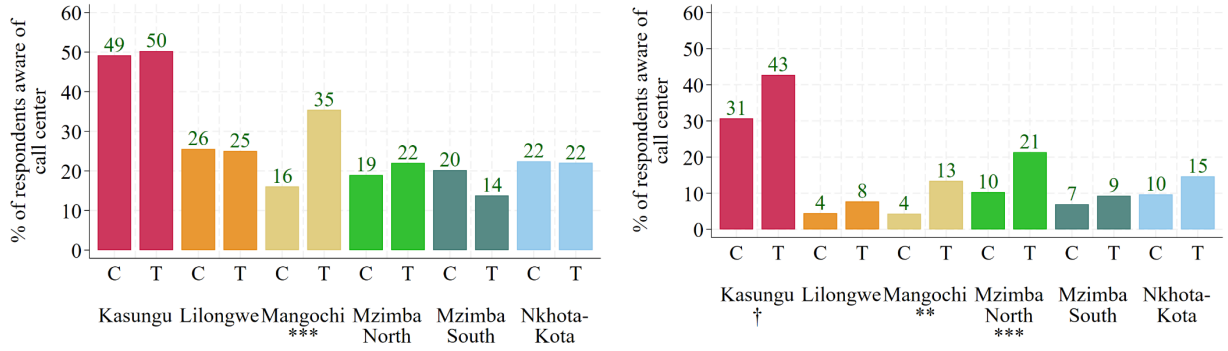


(a) Men (b) Women

Note: SMS = short message service. Statistically different at †0.15, *0.10, ** 0.05, and *** 0.01 level of significance.

In Kasungu, half of men respondents in the treatment group were aware of the call center, and 30 percent used the call center to call for queries and advice on agriculture and markets (Figures 9–10). This is higher than other districts and is another reason there are more visible impacts on crop income in Kasungu than in other districts. In Nkhota-kota, slightly more men in the treatment group compared to the control group used the call center, and this may have contributed to greater impacts on crop income. We found a significant correlation between using the call center and increased crop productivity and income. It is worth noting that in Mangochi, call center awareness was higher for both women and men in the treatment group than in the control group, and call center use was higher for male farmers. We did not find a significant association between call center use and higher productivity and incomes in Mangochi, but we found a strong association between call center use and household dietary diversity (see section on secondary outcomes). This may be related to more queries to call centers on nutrition and health from farmers in this district.

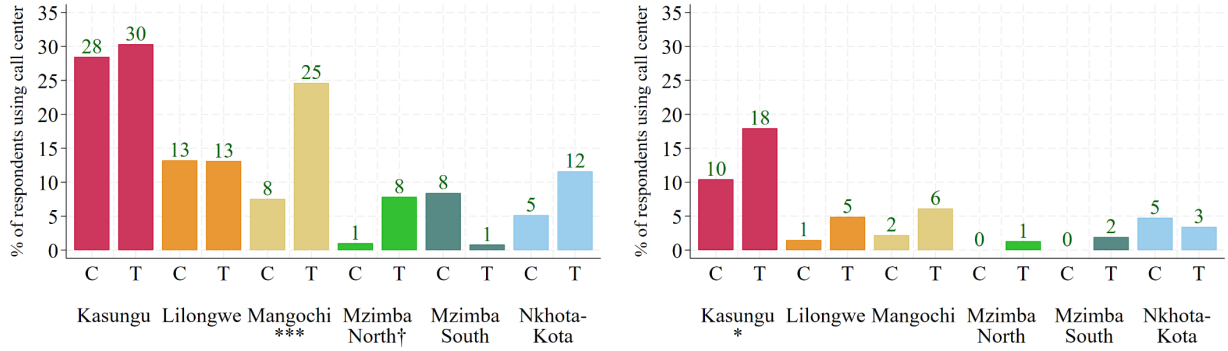
Figure 9. Percentage of respondents who are aware of Mlimi call center/hotline



(a) Men (b) Women

Note: Statistically different at †0.15, *0.10, ** 0.05, and *** 0.01 level of significance.

Figure 10. Percentage of respondents who have ever used Mlimi call center/ hotline

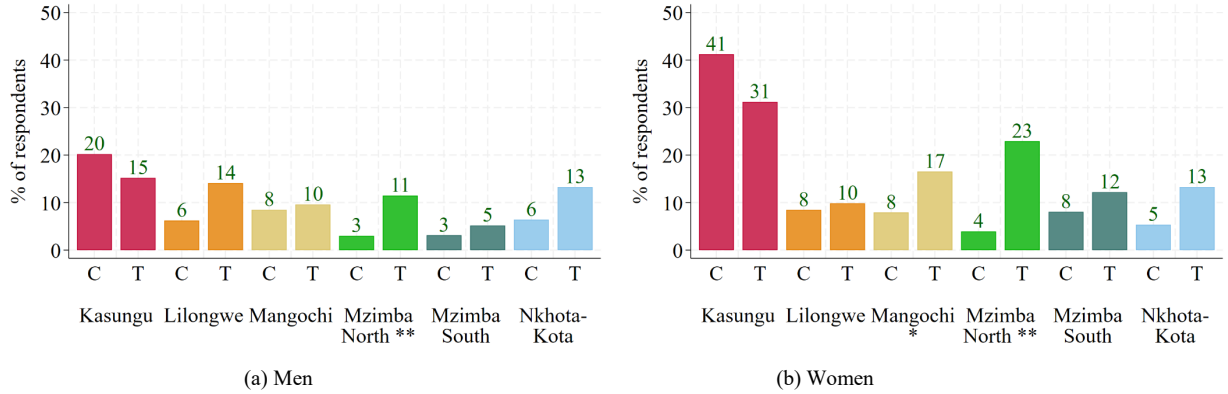


(a) Men (b) Women

Note: Statistically different at †0.15, *0.10, ** 0.05, and *** 0.01 level of significance.

Across all focus districts, participation of men in radio listening clubs was low: only 5 to 15 percent of men in the treatment group joined these listening clubs. Women's participation was much higher: 10 to 31 percent of women in the treatment group participated in the radio listening clubs. Kasungu had the highest participation of men and women in these listening clubs; and the participation was similar in both the control group and the treatment group. This lack of difference between the treatment and control groups indicates that the higher participation in listening clubs may not be associated with the intervention bundle in this experiment. It is worth noting that significantly more women and men in the treatment group than in the control group were participating in these listening clubs in Mzimba North; and more women in the treatment group than in the control group were participating in Mangochi. We did not find a significant association between radio listening clubs and higher productivity or income, but we found some associations between radio listening clubs and household dietary diversity in these districts.

Figure 11. Percentage of respondents joining radio listening clubs

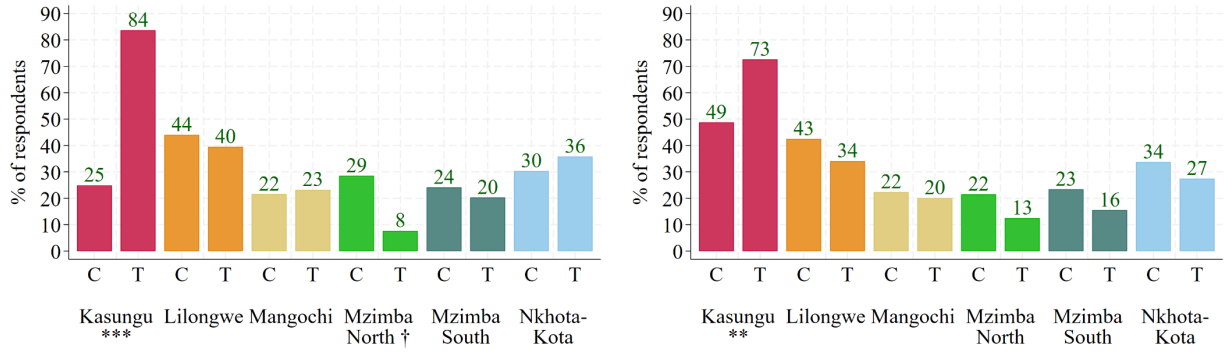


(a) Men (b) Women

Note: Statistically different at †0.15, *0.10, ** 0.05, and *** 0.01 level of significance.

Collective marketing was widely adopted by the treatment groups in Kasungu: 84 percent of men and 73 percent of women in the treatment group reported selling in groups, compared to 25 percent of men and 49 percent of women in the control group (Figure 12). This indicates visible impact of the promotion of collective marketing in Kasungu. We found a very strong correlation between collective marketing and crop income. Collective marketing has the strongest correlation with crop income compared to SMS, call center use, or radio listening club.

Figure 12. Percentage of respondents adopting collective marketing



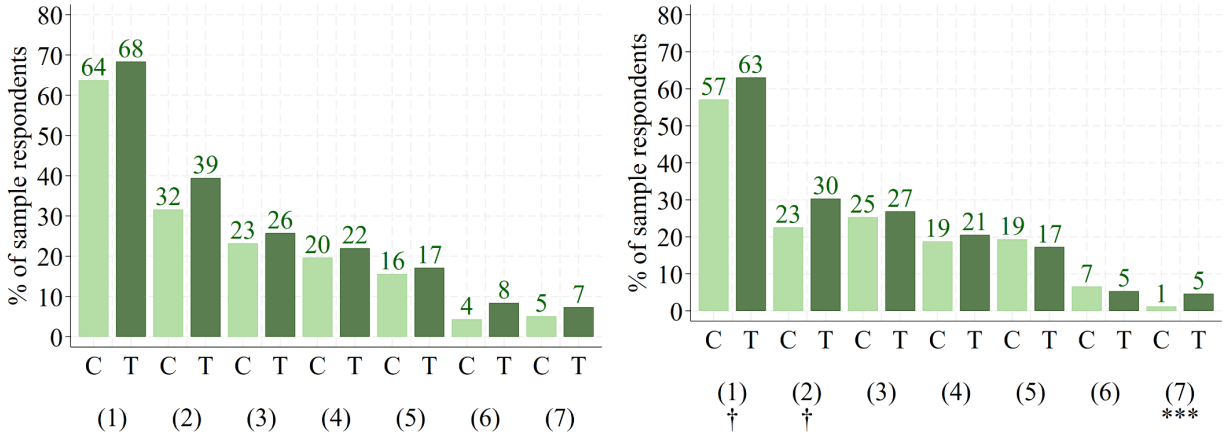
(a) Men (b) Women

Note: Statistically different at †0.15, *0.10, ** 0.05, and *** 0.01 level of significance.

Government extension agents were the main direct source of advice, followed by radio programming, and village or group meeting was the most popular method of receiving agricultural information, followed by radio (Figure 13a–b). Treatment and control groups showed similar access to agricultural information; however, more women in the treatment group than in the control group accessed government extension services, radio programming, and SMS (Figure 13a). Similarly, more women in the

treatment group accessed group and village meetings, face-to-face visits, and SMS (Figure 13b), indicating the positive effect of the ICT hub intervention bundles on women's access to these extension services.

Figure 13a. Access to extension services in the last 12 months, by main source (percentage of rural men and women respondents)

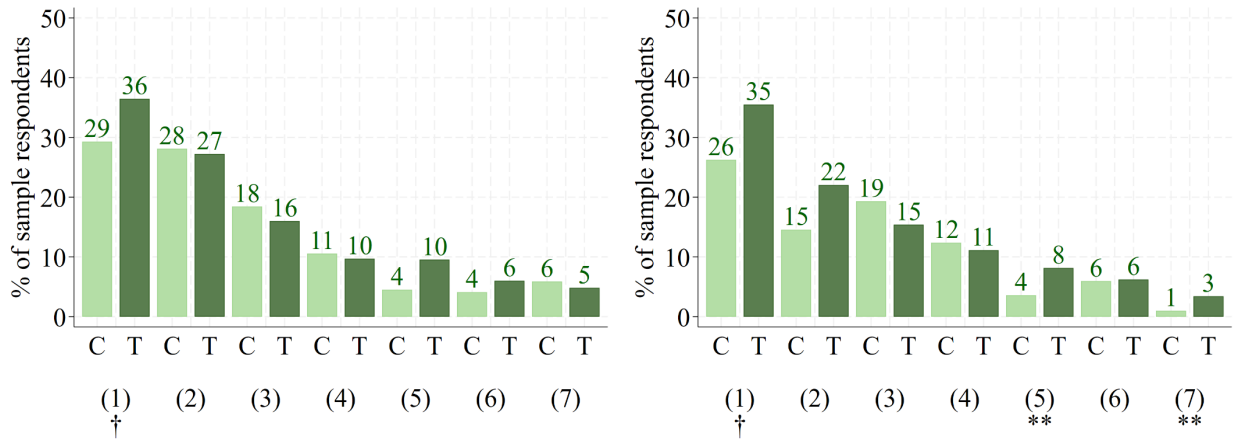


(a) Men (b) Women

Source: IFPRI/Wadonda household survey (2023).

Note: Statistically significant at †0.15, *0.10, ** 0.05, and *** 0.01 level. Respondents received agricultural extension services from (1) government agriculture extension workers, (2) radio, (3) other farmers/neighbor/friends, (4) extension worker from NGO, (5) lead farmer, (6) extension worker from community-based organizations, and (7) phone/SMS. Resources used by less than 5 percent of the respondents are not shown, including FFS, private sector, call center/hotline TV, video, and internet.

Figure 13b. Delivery method of receiving advice on agricultural production (percentage of rural men and women respondents)



(a) Men (b) Women

Source: IFPRI/Wadonda household survey (2023).

Note: Statistically significant at †0.15, *0.10, ** 0.05, and *** 0.01 level. Respondents received agricultural advice from (1) village/group meeting, (2) radio, (3) short-term training, (4) friends, neighbor, other farmers, (5) face-to-face, individual visit, (6) farmer demos, and (7) SMS/mobile phone. Delivery methods used by less than 5 percent of the respondents are not shown, including FFS, TV, print, farmer field day, cluster, and video.

Table 2. Treatment effects of the ICT hub intervention bundle on awareness and use of digital tools and information

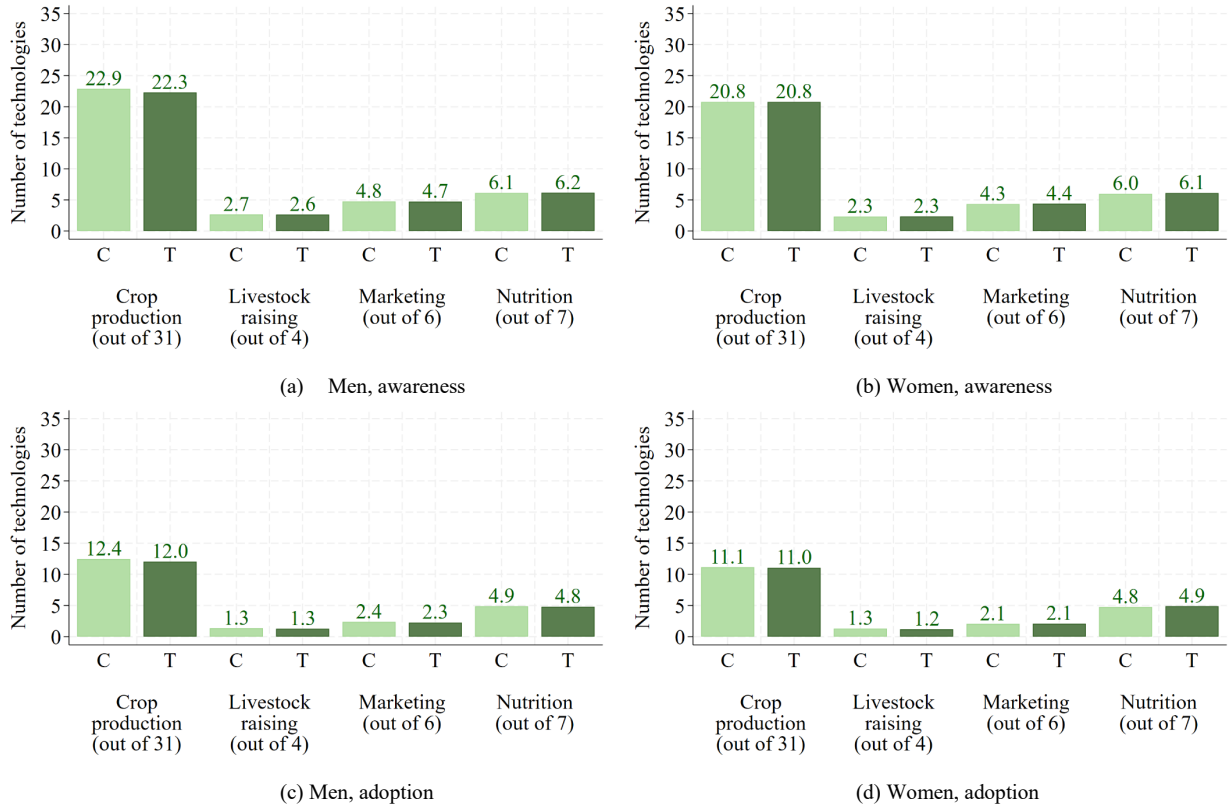
	Men								Women							
Outcome indicator	**Received SMS on agriculture**		**Aware of Mlimi hotline/call center**		**Used Mlimi hotline/call center**		**Have listened to the radio as a group**		**Received SMS on agriculture**		**Aware of Mlimi hotline/call center**		**Used Mlimi hotline/call center**		**Have listened to the radio as a group**	
Model 1																
Treatment	0.02	0.03	0.05	0.06	0.05*	0.06*	0.04†	0.04*	0.04**	0.04**	0.09***	0.09***	0.05**	0.04**	0.08**	0.07**
	(0.02)	(0.02)	(0.04)	(0.04)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)	(0.02)	(0.03)	(0.03)
Model 2																
Treatment	0.05	0.05	0.21**	0.19**	0.16***	0.15***	0.01	0.01	0.03	0.05	0.14**	0.13**	0.04†	0.04†	0.10**	0.10*
	(0.05)	(0.05)	(0.08)	(0.08)	(0.05)	(0.05)	(0.04)	(0.04)	(0.03)	(0.04)	(0.06)	(0.06)	(0.02)	(0.03)	(0.05)	(0.05)
District interactions (base=Mangochi)																
Treatment x Kasungu	0.00	0.02	-0.14	-0.07	-0.12**	-0.09†	-0.05	-0.04	-0.00	-0.04	-0.08	-0.07	0.06	-0.01	-0.10	-0.09
	(0.07)	(0.06)	(0.12)	(0.11)	(0.06)	(0.06)	(0.06)	(0.06)	(0.05)	(0.04)	(0.08)	(0.08)	(0.06)	(0.03)	(0.08)	(0.08)
Treatment x Lilongwe	-0.09	-0.07	-0.20*	-0.13	-0.14**	-0.10†	0.05	0.06	0.00	-0.00	-0.05	-0.04	-0.00	0.02	-0.10	-0.10
	(0.07)	(0.06)	(0.11)	(0.11)	(0.07)	(0.07)	(0.07)	(0.07)	(0.03)	(0.04)	(0.13)	(0.12)	(0.03)	(0.05)	(0.09)	(0.09)
Treatment x Mzimba North	-0.06	-0.06	-0.18†	-0.16	0.01	0.03	0.11†	0.12*	-0.02	-0.03	-0.01	-0.02	-0.02	0.54***	0.07	0.05
	(0.07)	(0.07)	(0.12)	(0.11)	(0.13)	(0.13)	(0.07)	(0.07)	(0.03)	(0.05)	(0.07)	(0.07)	(0.03)	(0.07)	(0.09)	(0.09)
Treatment x Mzimba South	0.00	0.00	-0.25**	-0.23**	-0.34***	-0.33***	0.06	0.06	-0.03	0.33***	-0.10	-0.10	-0.01	0.57***	-0.04	-0.04
	(.)	(.)	(0.11)	(0.11)	(0.13)	(0.12)	(0.08)	(0.08)	(0.03)	(0.07)	(0.09)	(0.09)	(0.03)	(0.08)	(0.09)	(0.09)
Treatment x Nkhota-Kota	-0.02	-0.02	-0.30**	-0.29**	-0.19**	-0.18**	0.00	0.00	0.00	-0.01	-0.10	-0.10	-0.04	-0.05	-0.02	-0.02
	(0.07)	(0.07)	(0.13)	(0.13)	(0.09)	(0.09)	(0.06)	(0.05)	(0.04)	(0.05)	(0.08)	(0.08)	(0.04)	(0.04)	(0.07)	(0.08)
Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Control Mean	0.06	0.06	0.23	0.23	0.09	0.09	0.07	0.07	0.01	0.01	0.09	0.09	0.02	0.02	0.10	0.10
N	1237	1237	709	709	709	709	1237	1237	1577	1577	1430	1430	1430	1430	1577	1577

Note: ICT = information and communication technology; SMS = short message service. Standard errors are in parenthesis and cluster at ICT hub level. Statistically significant at †0.15, *0.10, ** 0.05, and *** 0.01 level. Controls include household head characteristics (gender, age, literacy in Chichewa or English, marital status, and education level), household asset quintiles, household's ownership of cellphones, size of the ICT hub, and district. Model 1 and Model 2 are two separate estimation models.

4.2.2. Awareness and adoption of management practices promoted

We tracked 48 agricultural management, marketing, and nutrition practices and compared awareness and adoption of these practices. We found no significant difference between treatment and control groups overall in the number of practices respondents were aware of or adopted (Figures 14 and 16 and Table 3). However, we found small positive effects on men's adoption in Kasungu when we aggregated by district level (Figure 15).

Figure 14. Number of management practices that respondents were aware of or adopted



(a) Men, awareness

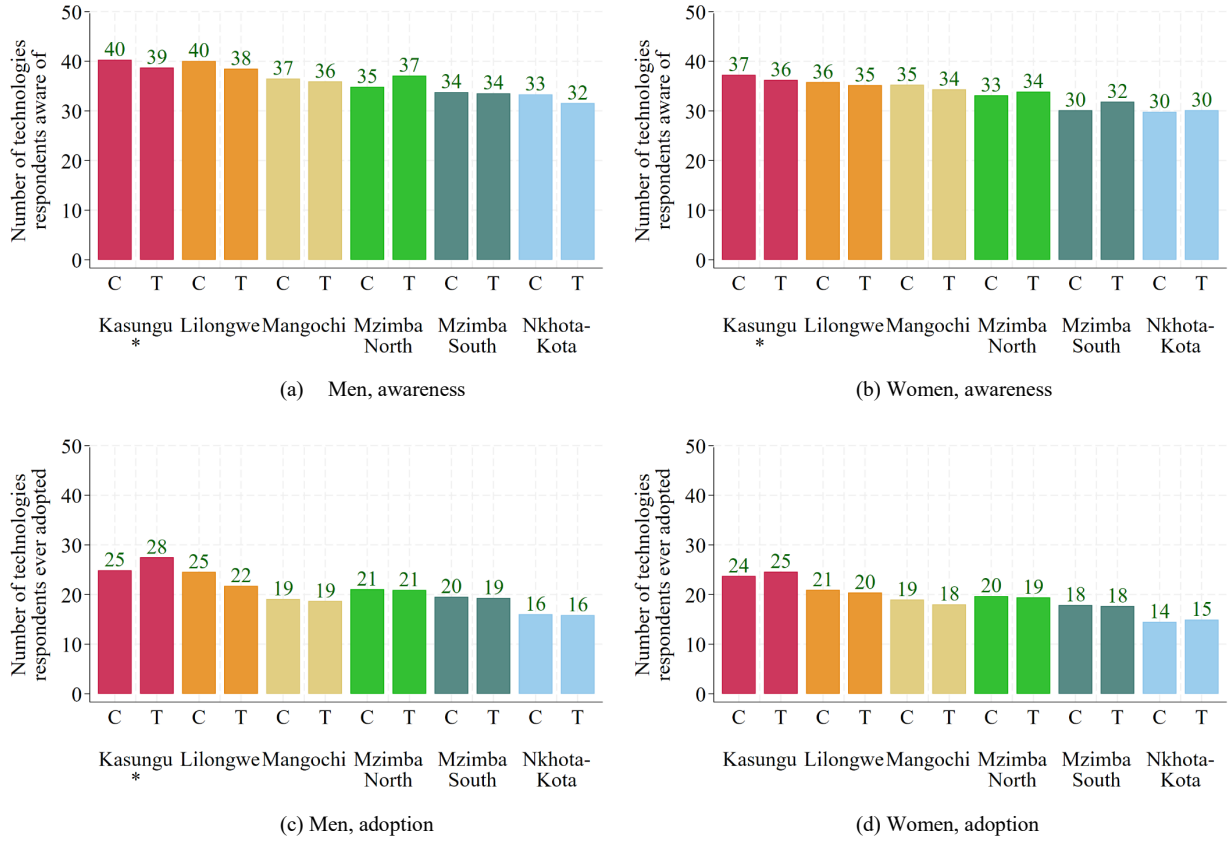
(b) Women, awareness

(c) Men, adoption

(d) Women, adoption

Note: Statistically different at †0.15, *0.10, ** 0.05, and *** 0.01 level of significance.

Figure 15. Number of management practices that respondents were aware of and have adopted



(a) Men, awareness

(b) Women, awareness

(c) Men, adoption

(d) Women, adoption

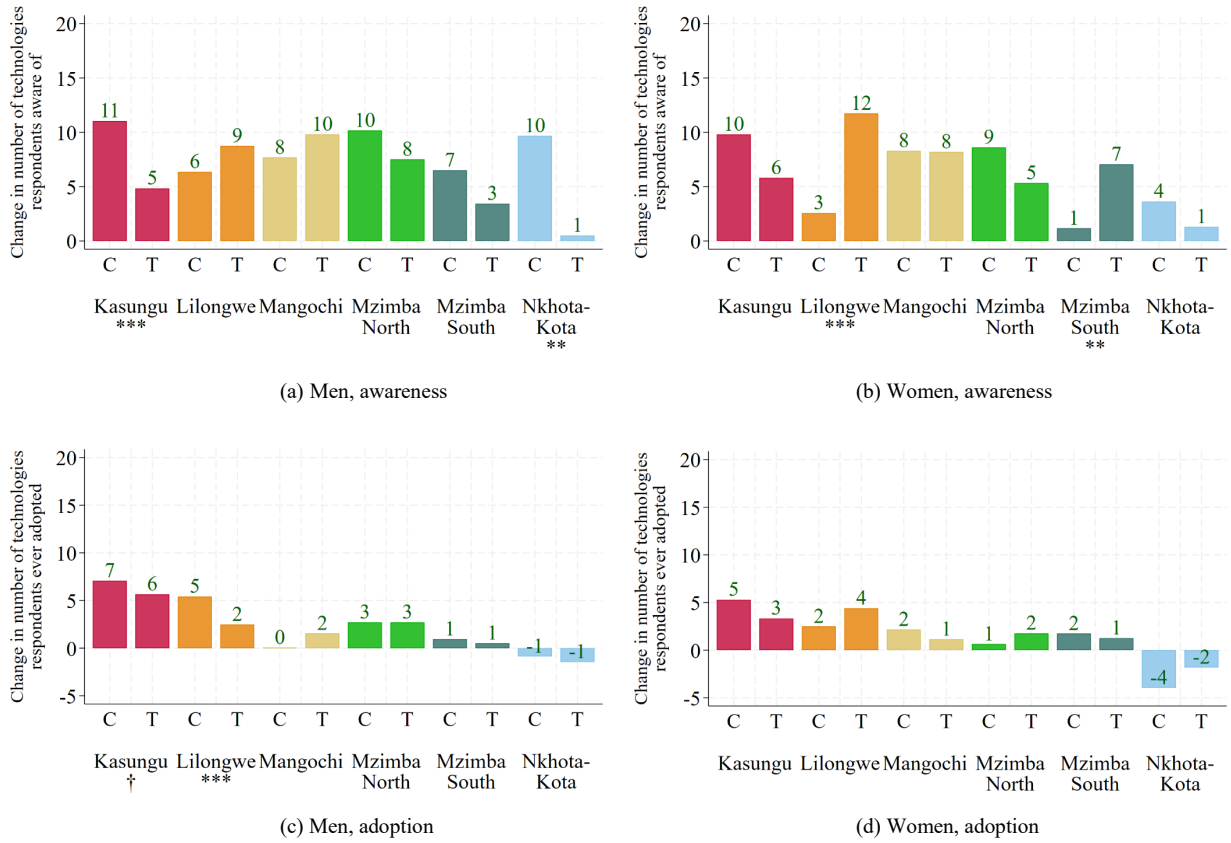
Note: Statistically different at †0.15, *0.10, ** 0.05, and *** 0.01 level of significance.

Table 3. Regression results on the impact of treatment on technology awareness and adoption

Outcome indicator	Men's technology awareness (number of technologies)		Men's technology adoption (number of technologies)		Women's technology awareness (number of technologies)		Women's technology adoption (number of technologies)	
Model 1								
Treatment	0.03	0.02	0.15	0.13	0.82	0.68	0.82	0.76
	(1.10)	(1.08)	(1.15)	(1.12)	(0.82)	(0.79)	(0.88)	(0.85)
Model 2								
Treatment	-0.92	-0.76	-0.77	-0.55	-0.50	-0.59	-0.92	-0.97
	(1.55)	(1.50)	(1.80)	(1.74)	(1.47)	(1.48)	(1.60)	(1.59)
District interactions (base=Mangochi)								
Treatment x Kasungu	1.06	0.52	4.29†	3.55	-0.03	-0.02	2.84	2.76
	(2.52)	(2.37)	(2.63)	(2.54)	(1.64)	(1.65)	(2.31)	(2.28)
Treatment x Lilongwe	-0.05	-0.56	-0.72	-1.39	0.87	0.64	1.60	1.33
	(2.23)	(2.18)	(3.00)	(2.91)	(2.37)	(2.37)	(3.02)	(2.98)
Treatment x Mzimba North	3.02	3.29	0.92	1.19	1.57	1.48	1.37	1.43
	(2.32)	(2.33)	(2.39)	(2.32)	(1.90)	(1.94)	(1.98)	(1.96)
Treatment x Mzimba South	0.84	0.89	0.77	0.80	2.54	2.61	1.00	1.14
	(3.77)	(3.70)	(3.40)	(3.29)	(2.74)	(2.69)	(2.53)	(2.46)
Treatment x Nkhota-Kota	-0.41	-0.43	-0.93	-0.99	0.80	0.91	0.99	1.10
	(2.10)	(2.09)	(2.58)	(2.53)	(1.64)	(1.66)	(1.91)	(1.91)
Controls	No	Yes	No	Yes	No	Yes	No	Yes
Control Mean	35.95	35.95	20.35	20.35	33.29	33.29	18.77	18.77
N	714	714	714	714	1431	1431	1431	1431

Note: Standard errors are in parenthesis and cluster at ICT hub level. Statistically significant at †0.15, *0.10, ** 0.05, and *** 0.01 level. Controls are unbalanced household head characteristics (gender, age, and marital status).

Figure 16. Difference in the number of management practices that respondents were aware of and have adopted between 2023 and 2021



In Kasungu, major improvements in marketing practices are achieved, including use of hermetic bags for storage, collective marketing, warehouse receipt system, and commodity aggregation; and some improvements in a few farm production practices are observed, including herbicide use, compost manure, general manure, soil testing, planting vetiver, and integrated pest management (Annex Table A1b). Similarly, among women, we see major improvements in marketing practices, including greater use of hermetic bag, collective marketing, and warehouse receipt system; and some improvements in zero or minimum tillage, herbicide use, pit planting, fertilizer tree crops, soil testing, and double row soybean planting. Greater adoption of these management practices helps explain the more visible impact on crop income in Kasungu.

In Nkhota-kota, there are limited visible improvements in management practices (Annex Table A1c). Significantly more women in treatment groups than in control groups used herbicide and adopted composting toilets and integrated pest management practices. More men in treatment groups than in control groups practices grading or sorting out produce. Slightly more women in the treatment group than in the

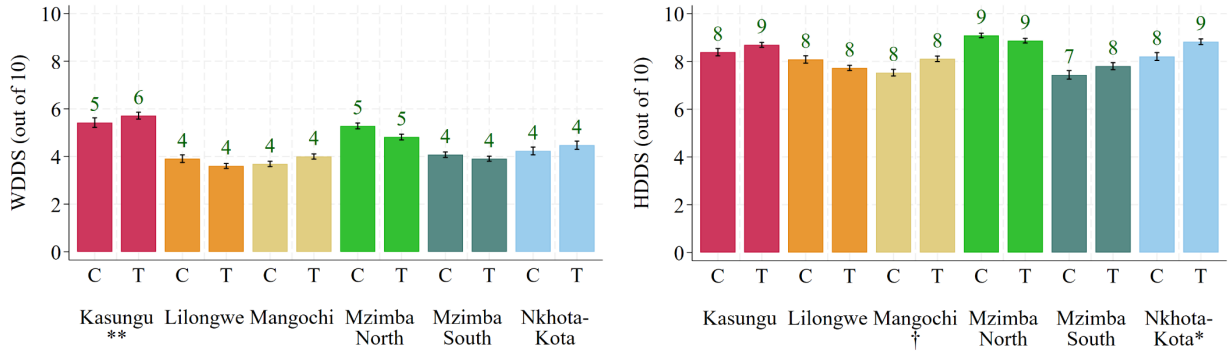
control group adopted rice intensification, maize-legume rotation, and double up legume intercropping. There is an increase from 2021 to 2023 on the use of hermetic bags and collective marketing, and these improvements were slightly higher in treatment groups than in control groups. ICT leaders interviewed confirmed the improvement in herbicide use and rice intensification, and they also highlighted that because of the ICT hub intervention bundles, their members became more aware of good agricultural management practices including optimal planting spacing and timing, integrated pest management, maize-legume intercropping and rotation, and collective marketing. These survey results and ICT leader interviews on some improvements in the management practices adopted help explain the more visible impact on crop income in Nkhota-kota.

4.3. Secondary outcomes

Overall, we did not find positive impacts on WDDS, HDDS, gender parity, and women's empowerment, but we observed some impacts in some districts (Figures 17 and 18; Tables 4 and 5). We found a small positive impact on WDDS in Kasungu, Mangochi, and Nkhota-kota (Figure 17a), although their statistical significance disappears and is inconsistent across estimations (Figure 18a; Table 4). The intervention bundle led to an increase of 0.16 to 0.42 out of 10-point WDDS and 3 to 7 percent more women achieving adequacy in dietary diversity (Table 4). The SMS and call center use seem to have contributed to the small improvement in women's dietary diversity in Kasungu; SMS and radio listening club may have contributed in Nkhota-kota; and the call center use and radio listening club may have contributed in Mangochi.

Similarly, we also found a small positive impact on household dietary diversity in Mangochi and Nkhota-kota (Figure 17b). The intervention bundle led to an increase of 0.63 to 0.72 out of 10-point WDDS and 4 to 18 percent more households achieving adequacy in dietary diversity (Table 5). These results generally hold even when we account for multiple hypothesis testing and adjust the standard errors conservatively (see Annex Table A3 for the Q values, which are largely below 0.10 significance).

Figure 17. Difference in dietary diversity between treatment group (T) and control group (C)



(a) Women's Dietary Diversity Score (b) Household Dietary Diversity Score

Note: Statistically different at †0.15, *0.10, ** 0.05, and *** 0.01 level of significance.

Table 4. Treatment effects of the ICT hub intervention bundle on WDDS

Outcome indicator	WDDS		Adequate WDDS (> = 5 food groups)		All 6 food groups consumed	
Model 1						
Treatment	0.05	0.06	0.01	0.01	-0.01	-0.01
	(0.20)	(0.20)	(0.05)	(0.05)	(0.03)	(0.03)
Model 2						
Treatment	0.36	0.35	0.07	0.07	0.03	0.03
	(0.31)	(0.31)	(0.08)	(0.08)	(0.06)	(0.06)
District interactions (base=Mangochi)						
Treatment x Kasungu	0.02	0.07	-0.02	-0.00	0.00	0.01
	(0.38)	(0.37)	(0.11)	(0.11)	(0.07)	(0.07)
Treatment x Lilongwe	-0.66*	-0.60†	-0.12	-0.10	-0.19***	-0.18**
	(0.38)	(0.38)	(0.10)	(0.10)	(0.07)	(0.08)
Treatment x Mzimba North	-0.68*	-0.71*	-0.16	-0.17†	-0.12*	-0.13*
	(0.40)	(0.39)	(0.11)	(0.11)	(0.07)	(0.07)
Treatment x Mzimba South	-0.59	-0.59	-0.11	-0.11	-0.12†	-0.12†
	(0.41)	(0.41)	(0.11)	(0.11)	(0.08)	(0.08)
Treatment x Nkhota-Kota	-0.17	-0.19	-0.02	-0.03	0.03	0.03
	(0.52)	(0.52)	(0.13)	(0.13)	(0.09)	(0.09)
Controls	No	Yes	No	Yes	No	Yes
Control Mean	4.32	4.32	0.45	0.45	0.17	0.17
N	1629	1629	1629	1629	1629	1629

Note: ICT = information and communication technology; WDDS = Women's Dietary Diversity Score. Standard errors are in parenthesis and cluster at ICT hub level. Statistically significant at †0.15, *0.10, ** 0.05, and *** 0.01 level. Controls are unbalanced household head characteristics (gender, age, and education level). Model 1 and Model 2 are two separate estimation models.

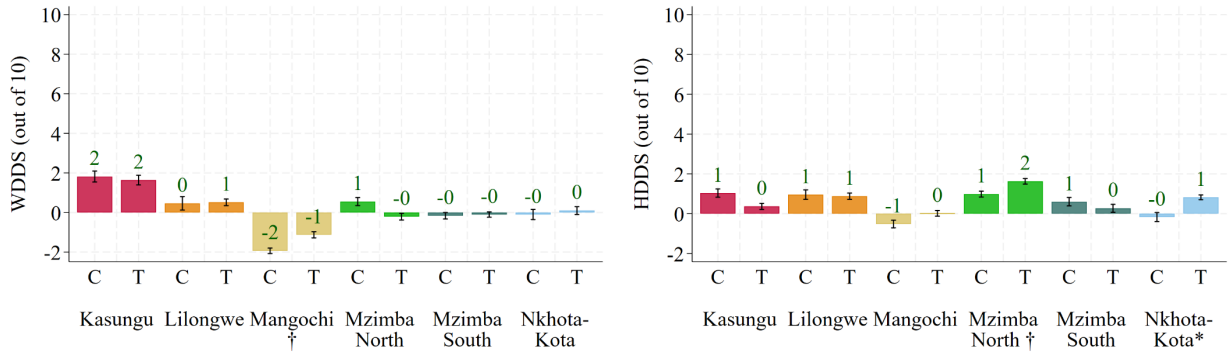
Table 5. Treatment effect of the ICT hub intervention bundle on HDDS

Outcome indicator	HDDS		Adequate HDDS (> = 5 food groups)		All 6 food groups consumed	
Model 1						
Treatment	0.22	0.23	0.02	0.02	0.04	0.04
	(0.20)	(0.20)	(0.02)	(0.02)	(0.05)	(0.05)
Model 2						
Treatment	0.63†	0.64*	0.04†	0.05†	0.15*	0.15**
	(0.38)	(0.38)	(0.03)	(0.03)	(0.08)	(0.08)
District interactions (base=Mangochi)						
Treatment x Kasungu	-0.51	-0.48	-0.04	-0.04	-0.11	-0.10
	(0.47)	(0.47)	(0.06)	(0.06)	(0.11)	(0.11)
Treatment x Lilongwe	-1.05**	-1.00**	-0.07*	-0.06†	-0.27***	-0.25**
	(0.47)	(0.47)	(0.04)	(0.04)	(0.10)	(0.10)
Treatment x Mzimba North	-0.68†	-0.71*	0.00	0.00	-0.24**	-0.25**
	(0.43)	(0.42)	(.)	(.)	(0.11)	(0.11)
Treatment x Mzimba South	-0.30	-0.30	-0.01	-0.01	-0.03	-0.03
	(0.65)	(0.66)	(0.04)	(0.04)	(0.12)	(0.12)
Treatment x Nkhota-Kota	0.09	0.07	0.00	0.00	0.03	0.02
	(0.50)	(0.50)	(0.05)	(0.05)	(0.10)	(0.10)
Controls	No	Yes	No	Yes	No	Yes
Control Mean	8.05	8.05	0.96	0.96	0.57	0.57
N	1620	1620	1620	1620	1620	1620

Note: ICT = information and communication technology; HDDS = Household Dietary Diversity Score. Standard errors are in parenthesis and cluster at ICT hub level. Statistically significant at †0.15, *0.10, ** 0.05, and *** 0.01 level. Controls are unbalanced household head characteristics (gender, age, and education level).

From 2021 to 2023 (before and after intervention), WDDS and HDDS showed little change across districts and among treatment and control groups, although treatment groups in Mangochi and Nkhota-kota have slightly and consistently improved WDDs and HDDS status than in control groups (Figure 18). In Mangochi, we see a worsening of WDDS and HDDS during the period, but they worsened consistently less among treatment groups than control groups. This implies a consistent yet small positive impact of the intervention package in Mangochi.

Figure 18. Difference between treatment group (T) and control group (C) in the change in dietary diversity from 2021 to 2023



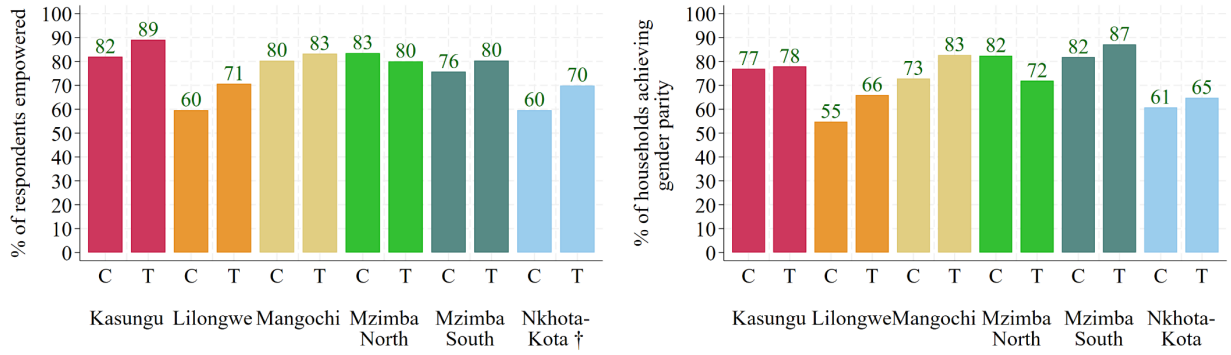
(a) Women's Dietary Diversity Score

(b) Household Dietary Diversity Score

Note: Statistically different at †0.15, *0.10, ** 0.05, and *** 0.01 level. Bars show the averages, and the vertical lines represent the standard errors, clustered at ICT hub level.

We saw no overall impact on women's empowerment and gender parity, but disaggregating by district and WEAI dimension shows small impacts on women's empowerment in Nkhota-kota (Figure 19; Table 6). More women in Nkhota-kota were empowered and had higher empowerment scores in treatment groups than in control groups. There are also more women empowered in the treatment group than in the control group in Kasungu, although the difference is not significant in all models. Disaggregating by WEAI dimensions, the overall improvement in women's empowerment seems to be driven by improved access to and control over financial resources in Nkhota-kota and improved group membership in Kasungu (Figure 20). However, work balance may also have decreased (Figure 20), and time burden may have also increased, for women in all districts, and this requires close monitoring to ensure that women achieve work balance.

Figure 19. Difference in gender parity, and women's empowerment between treatment group (T) and control group (C)

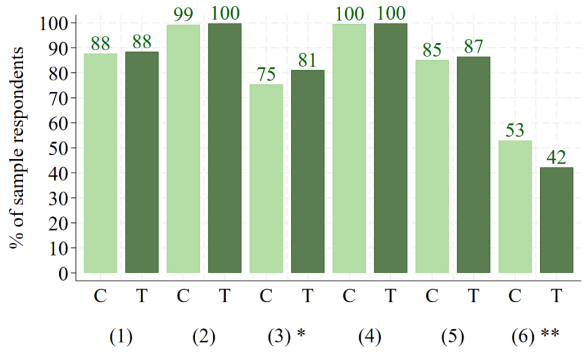


(a) Percent of women empowered

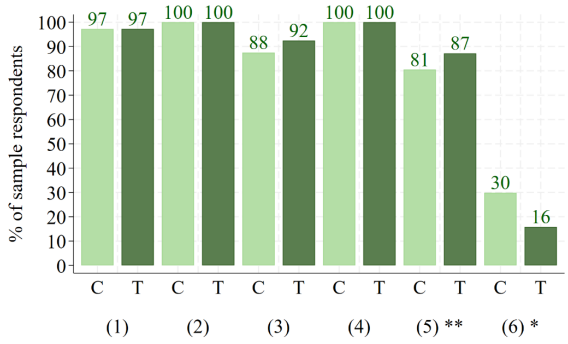
(b) Percent of households achieved gender parity

Note: Statistically different at †0.15, *0.10, ** 0.05, and *** 0.01 level.

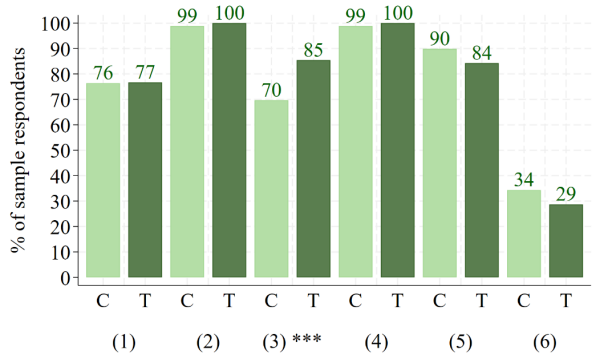
Figure 20. WEAI dimensions



(a) Women, all



(b) Women, Kasungu only



(c) Women, Nhkota-kota only

Note: WEAI = Women's Empowerment in Agriculture Index. Statistically significant at †0.15, *0.10, ** 0.05, and *** 0.01 level. A-WEAI indicators are (1) input in productive decisions, (2) ownership of assets, (3) access to and decision on credit, (4) control over use of income, (5) group membership, (6) work balance.

Table 6. Treatment effect of the ICT hub intervention bundle on gender parity and women's empowerment

Outcome indicator	Women's empowerment score (0-1)		Women's empowerment status (1 = empowered)		Household achieved gender parity	
Model 1						
Treatment	-0.01	-0.02	0.04	0.04	0.03	0.04
	(0.01)	(0.01)	(0.03)	(0.03)	(0.05)	(0.05)
Model 2						
Treatment	0.00	0.00	0.03	0.03	0.10	0.09
	(0.02)	(0.02)	(0.08)	(0.08)	(0.11)	(0.11)
District interactions (base=Mangochi)						
Treatment x Kasungu	-0.01	-0.01	0.07	0.07	-0.07	-0.06
	(0.02)	(0.02)	(0.10)	(0.10)	(0.16)	(0.16)
Treatment x Lilongwe	0.04	0.04	0.05	0.04	0.02	0.03
	(0.03)	(0.03)	(0.10)	(0.09)	(0.15)	(0.14)
Treatment x Mzimba North	-0.02	-0.03	-0.07	-0.08	-0.18	-0.18
	(0.02)	(0.02)	(0.09)	(0.09)	(0.14)	(0.14)
Treatment x Mzimba South	-0.02	-0.02	0.01	0.02	-0.02	-0.02
	(0.03)	(0.03)	(0.10)	(0.10)	(0.17)	(0.18)
Treatment x Nkhota-Kota	-0.01	-0.01	0.04	0.05	-0.10	-0.10
	(0.02)	(0.02)	(0.09)	(0.09)	(0.14)	(0.14)
Controls	No	Yes	No	Yes	No	Yes
Control Mean	0.84	0.84	0.74	0.74	0.71	0.71
N	1597	1597	1431	1431	498	498

Note: ICT = information and communication technology. Standard errors are in parenthesis and cluster at ICT hub level. Statistically significant at †0.15, *0.10, ** 0.05, and *** 0.01 level. Controls are unbalanced household head characteristics (gender, age, and education level).

The results reported above suggest that the program had positive effects on some outcomes but not others. Annex Table A4 summarizes the treatment effects of the intervention. The single-difference and difference-in-difference estimations were largely consistent. Access to SMS, call center use, and listening group setup and participation improved, but the coverage remained low. Greater coverage and implementation of the interventions, especially SMS, call center, and collective marketing promotion in Kasungu and Nkhota-kota, led to greater impacts in crop income in those districts but not in other districts. Crop income improved mainly because of the shift to higher-value crops, including rice, soybean, and groundnuts in Kasungu and Nkhota-kota. We saw small positive impacts in crop productivity and greater adoption of a few production practices, including herbicide use and maize-legume intercropping/rotation in Nkhota-kota and fertilizer tree crops, manure, and soil testing in Kasungu. The major improvements visible in Kasungu and to some extent in Nkhota-kota are the marketing practices, including greater practice of collective marketing, hermetic bags, and aggregation.

Overall dietary diversity did not improve, although some improvements were observed in the consumption of legumes and nuts, fats and oils, egg, and other fruits, especially in Mangochi and Nkhota-kota. Women's empowerment score or status did not improve, but specific dimensions such as access to and control over credit and group membership did. Effects are heterogeneous, mostly driven by more intensive implementation and consistent effects in Kasungu and Nkhota-kota. Greater effects are observed among women than men in access to SMS, call center use, and listening group setup and participation, although the coverage and reach remain very low and must be improved.

Overall, the ICT hub intervention bundle, if implemented intensively and properly, is proven to be effective in increasing crop incomes and can be promoted and scaled out to other producer groups in Malawi. SMS and call center were complementary: SMS text was used to promote the call center, and the call center was useful to get more advice in addition to the short phone messages. SMS and call centers were also used to promote collective marketing. SMS can be easily replicated to other contexts, while the call center can also be set up and promoted in other contexts. The radio listening clubs were not correlated to productivity and income increases in Kasungu and Nkhota-kota, although they may have contributed slightly to the small dietary diversity impacts in Mangochi. Only a few members of the ICT hubs join radio listening clubs, which may be the likely reason for their limited impact.

4.4. Qualitative insights

The qualitative interviews, FGDs, and open-ended questions in the household survey provide useful insights on areas that are working well. First, many treatment groups had growing membership and a broader range of activities than at baseline. The prospect of the producer group being transformed into an ICT hub and the potential activities and interventions associated with it made more people in the community interested

in joining the group. Second, they had greater use of radios, set up more listening clubs, and participated more in group listening sessions. Respondents find the radio listening clubs useful for them:

> *"15 of the 20 members join the listening group. The group discusses immediately after listening. We meet every Wednesday and discuss topics and issues we have heard about. Yes, it is positive experience and useful for me personally and for the group."* Leader of treatment group in Kasungu

Third, there was greater awareness and use of the call center and hotline because of the interventions. ICT hub members were finding the responses from call centers very useful:

> *"In this ICT hub, many of them know about call center, and we remind each other during meetings that we can call for free. The last time I called, I wanted to learn about groundnuts farming. It worked, I learned how to dry groundnuts, specifically, how to dry after 3 days. Tried and actually works."* Leader of treatment group in Kasungu

Fourth, SMS push has been implemented successfully, and farmers found the messages useful:

> *"SMS messages were useful. The messages encourage the farmers and the group to apply best farming practices."* Leader of treatment group in Kasungu

> *"Last time, the message was how to take care of maize and groundnut after harvesting (Protect your harvest by storing it in sacks). We have been following the advice."* Leader of treatment group in Kasungu

Fifth, video screening has started in four ICT hubs (three in Kasungu, one in Nkhota-kota), although less than 1 percent of the sample farmers in the midline survey reported accessing videos for agriculture advice. Those who viewed the videos on agriculture production and marketing found them very useful:

> *"They only showed the videos, and sometimes, they post on WhatsApp group various videos on many issues. One on raising poultry, one on how to do soya farming from land prep to harvesting and how to make soil more productive. We have been applying various messages on farming rom videos."* Leader of treatment group in Kasungu

Sixth, FRT's WhatsApp group started and was reported by one ICT hub. Those who have used the WhatsApp group found the messages and videos in them very useful:

> *"Around 15 members with smartphones (of 200 total members) are part of the WhatsApp group. The WhatsApp group is useful for us members. We get videos and messages and exchange information on best farming practices."* Leader of treatment group in Kasungu

Despite these early signs of successes, coverage remains low, as noted earlier. The following areas need improvement based on the qualitative interviews, FGDs, and open-ended questions in the household

survey. First is limited accessibility (cell phone, smartphone, network, data plan): although 67 percent of sample group members have cellphones, only 17 percent have smartphones, and this is a major barrier for individual video screening. In a few ICT hubs, less than 20 percent of the membership has a cellphone. Respondents suggested increasing phone/network coverage, expanding radio programs, and considering group-based video screening:

> *"They should talk to service providers to improve phone networks because accessing extension services using phone is difficult because of poor network in the area."* Survey respondent

> "*Members need to get video screenings with everyone watching, which would improve the current setup where they were on individual phones."* Survey respondent

Second, SMS messages did not reach every member with a phone. For some farmers who got the SMS texts, they found the messages infrequent and too general:

> *"SMS message only went to the group chair; other members did not get."* Two ICT hub officials

> *"SMS message should be shared to all members… update the list and send to all members with phones."* Three ICT hub officials

> *"It would be more productive if not general, but specific to crops (maize, soya, maize, potatoes, Irish potato). How to take care once they have it before planting, what does it need once harvested, even on tomatoes, how to plan, what pesticides…."* Survey respondent

> *"There should be more features and more interactions: Not just receiving information, but also sending feedback via message and sending photos timely via photos to providers."* Survey respondent

Third, messages and videos need to consider the literacy status and language of the target audience. SMS and video screening should be delivered in different languages, including Tumbuka and Yao, which are commonly used in other districts, not just in Chichewa. Fourth, respondents indicated the need to complement SMS with physical visits and demonstrations:

> *"There are supposed to be frequent visits to clubs by providers of the extension services through ICT.… They should spare some time to visit the different clubs to see the impact of the information about farming they get through ICT."* ICT hub officials

> *"They should explain how to do the practice instead of just sending SMS because one can read the message and fail to apply."* ICT hub officials

Fifth, respondents also suggested providing more radio sets and training on how to fix them as well as improving radio programming through more timely and more regular programming and by mobilizing drama groups in the communities:

> *"Radios are not functioning well….. They should be sending people to fix these radios cause once they are unfunctional it means we no longer have access to these programs, and it seems they can't just be fixed by anyone…. The authorities should respond quickly when clubs report that the radio is not functioning because radio listening is the easiest way to get extension services since not many club members have phones."* ICT hub official

> *"Those that prepare such programmes should personally go to communities and mobilize drama groups as a way of disseminating information. Some people do not have radios and they can get the messages from the drama."* ICT hub official

> *"Provide radio programs regularly and in a timely manner (during growing season)."* ICT hub official

Last, issues in terms of the inaccessibility of the call center/hotline need to be fixed. Implementation challenges may blur the benefits of the interventions:

> *"They have been promoting call centers. They should pick up all calls at the call center. Members of this club have been calling but they have never been answered*." Two ICT hub officials

> *"We are getting the same SMS message: 'if you have a certain crop, take care of it, and call 711 on airtel network, or 811 tnm network to listen to more.' However, when they call the numbers, there is no response."* Survey respondent

5. Conclusions

The study provided 59 randomly selected producer groups in five districts in Malawi with SMS on improved agriculture, marketing, and nutrition practices; exposed and encouraged group members to use the call center/hotline; and facilitated their participation in radio listening clubs and in collective marketing. These interventions aim to transform these groups into ICT hubs, where members use and promote digital tools; are aware of and adopt improved agricultural, marketing, and nutrition practices; and improve agricultural productivity and incomes, with spillover effects into the community. Roughly 1.5 years after the interventions, we evaluated the early impacts and identified areas for adjustment and improvements. We compare primary outcomes (crop productivity and income) and secondary outcomes of the randomly selected members of the 59 treatment groups with outcomes of those members of the 59 control groups. Our main findings are as follows.

First, the ICT-based intervention bundle has led to a significant but small increase in crop income, with greater increases achieved in Kasungu and Nkhota-kota. Kasungu had increased production and sales of soybean and groundnuts, and Nkhota-kota had increased production and sales of rice and soybean. Second, in terms of impact pathways, results show greater use of phone messaging on agriculture and markets and use of call center/hotline, which contributed to the increase in crop income in Kasungu and Nkhota-kota. Collective marketing improved significantly in Kasungu and to some extent in Nkhota-kota, which is the major contributor of the increase in crop income in these districts. There are strong correlations between crop income and collective marketing, SMS receipt, and call center use. Other focus districts have low implementation and coverage of SMS, call center, and collective marketing promotion. which explain limited impact on technology adoption, productivity, and income in those districts. Participation in radio listening clubs slightly increased among women, although it is very low overall. More women in treatment groups than in control groups were reached by the interventions, and this is helping narrow the gender gaps in access and use of ICT tools and group-based approaches. Coverage and service provision remain very low, however, and must be expanded.

Third, in productivity and technology adoption, we saw small positive impacts in Kasungu and Nkhota-kota, not in other districts. This is also associated with greater implementation and coverage of the interventions in Kasungu and Nkhota-kota. Of the 48 management practices on production, marketing, livestock, and nutrition, we found only a few practices that improved in Kasungu and Nkhota-kota. The few production practices that improved include herbicide use and maize-legume intercropping/rotation in Nkhota-kota and herbicide use, fertilizer tree crops, manure, and soil testing in Kasungu. The major improvements visible in Kasungu and to some extent in Nkhota-kota are the marketing practices, including greater adoption of collective marketing, hermetic bags, and aggregation. Promotion and improvements in livestock practices were not mentioned in the interviews with ICT hub leaders and were also not visible in the survey results.

Fourth, in secondary outcomes, we did not find overall impacts on dietary diversity, gender parity, and women's empowerment. Some positive impacts, however, were observed in specific districts. In Mangochi, we found positive impact of the interventions on household dietary diversity, which could potentially be explained by higher call center awareness and use, and greater participation in radio listening clubs by women and men farmers in treatment groups than in control groups. In Kasungu and Nkhota-kota, some positive impacts of the interventions on women's group membership and access to and control over financial resources, which are sources of empowerment, may be related to more receipt of SMS, greater use of the call center/hotline, collective marketing, and greater adoption of a few improved practices and

technologies in treatment groups than in control groups. However, these activities may have increased the workload and time burden for women and need to be closely monitored.

Overall, these midline impact evaluation results provide useful lessons for making program adjustments. Not all digital tools and mobile apps will be scaled or have impact; our evaluation results show which interventions are working, their potential for scalability, and where an ICT-based intervention bundle can optimize its impact. They also show that interventions are reaching women, with some indications of women's empowerment. We will need to closely monitor this impact in the endline survey, especially on women's workload. The results identified several bottlenecks in program implementation, requiring programming adjustments—such as regularly updating and auditing member phone lists; providing group-based video screening, SMS, and video screening in languages other than Chichewa, including Tumbuka and Yao; training groups to fix radio sets and having them pitch in for radio set replacement or repair; incorporating dramas into radio programs; and fixing issues with the call center and hotline. Last, and most important, the program needs to accelerate the implementation of its interventions and expand its coverage and reach to intended beneficiaries. The interventions implemented more intensively and widely in Kasungu and Nkhota-kota are leading to positive impacts in crop productivity and incomes. There are strong correlations between crop productivity and income and SMS receipt, call center use, and collective marketing. The ICT hub intervention bundle, if implemented intensively and properly, is proven to be effective and can be promoted and scaled out to other producer groups in Malawi.

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ANNEXES

Annex 1. Thematic areas and examples of short messages in the FRT-SRIEED II Project

1. **Timing of Planting:**
   "Make sure that your soya has been planted before 15 January to avoid pests and diseases in the field. Call for free on 7111 TNM, 8111 on Airtel"

2. **Pest and Disease Management:**
   "Visit the crop field regularly to check for pests or diseases. Call for free on 7111 TNM, 8111 Airtel for more information."
   "Termites destroy soybeans, groundnuts and maize at any age, especially when it's hot, spray chlorpyrifos to kill termites, call 7111 TNM, 8111 Airtel"
   "Farmers Apply an approved insecticide if 20 out of 100 seeds are found with signs of caterpillars. Find out more by calling 7111 TNM, 8111 Airtel"
   "Lice damage Soybeans, peanuts and beans by shriveling the leaves and preventing the leaves from growing properly, spray with Dimethoate. Call 7111 TNM, 8111 Airtel"
   "Farmers, if you find green eggs and droppings of black-headed caterpillars, know that the crops have been attacked by caterpillars. Call 7111 TNM or 8111 Airtel."

3. **Weed Management:**
   "Weed the maize field at least twice, use herbicides to reduce the competition between weeds and crops. Call 7111 TNM, 8111 Airtel."

4. **Soil Fertility Management:**
   "Sow soybeans in two rows at a distance of 25–30cm, one seed per row at a distance of 5cm. For more information call 7111 TNM, 8111 on Airtel"

5. **Livestock/Animal Feed Management:**
   "Farmers, fix the animal lodging/cages when they have been damaged so that the animals don't lodge in a wet place, and rebuild where the lodging has fallen. Call for free on 7111 TNM or 8111 Airtel"
   "Farmers give vaccinations to animals for different diseases such as distemper and foot and mouth sores. Call toll free on 7111 TNM, 8111Airtel"
   "Farmers finish drying the animal food that was stored in the winter (hay) so that it does not spoil, Call 8111 Airtel, 7111 TNM for more information."
   "Farmers keep the animal feed in the sacks and follow the proper procedure for stacking the sacks. Call toll free on 7111TNM/8111 AIRTEL"
   "Farmers vaccinate your animals to protect them from various diseases such as: distemper, skin sores and stomach worms. CALL FREE ON 7111TNM/8111 AIRTEL"

6. **Harvest and Storage:**
   "Farmers harvest soybeans by cutting the stem of the tree using a scythe or sickle so that the roots of the soybean remain in the soil to increase fertility."
   "Farmers, keep your harvest in modern PICS bags to protect them from insects and other harmful insects. Call 8111airtel, 7111TNM for more information."

"You can tell if the groundnuts are ripe by the days when the groundnuts ripen and when pods have dark lines. Call 8111 Airtel, 7111TNM"
"Ripe potatoes that have matured after 4 to 6 months depending on the type so that they are not damaged by pests. Call 8111 Airtel, 7111 TNM for more information"
"Farmers should be careful when digging, packing and transporting potatoes from the field so that they do not rot and spoil. Call 8111 Airtel, 7111TNM for more information"
"Farmers, keep potatoes in a one-meter-deep hole to keep them for a long time, pour sand from the marsh on the ground to prevent them from sprouting. Call 8111 Airtel, 7111 TNM."

7. **Marketing:**
"Farmers sell your grains based on the minimum prices of grains so that you don't get ripped off, Call toll free on 8111 Airtel, 7111TNM for more information"
"Farmers sell your crops as groups in order to meet the demand of consumers and fetch a good price, Call toll free on 8111 Airtel, 7111TNM for more information"
"Selling your harvest in a group helps us farmers to have the power to negotiate the price of selling crops with buyers so that we can sell them at a good price"
"Farmers buy modern storage sacks (PICS sacks) from reputable agrodealers to avoid being sold fake storage sacks, call toll free on 8111 Airtel, 7111TNM"
"Listen to 'Tipindule ndi Ulimi' (Benefit from Agriculture) program on Zodiak Broadcasting Station on Monday at 2:05 pm, Call toll free on 7111 TNM or 8111 airtel for more information"

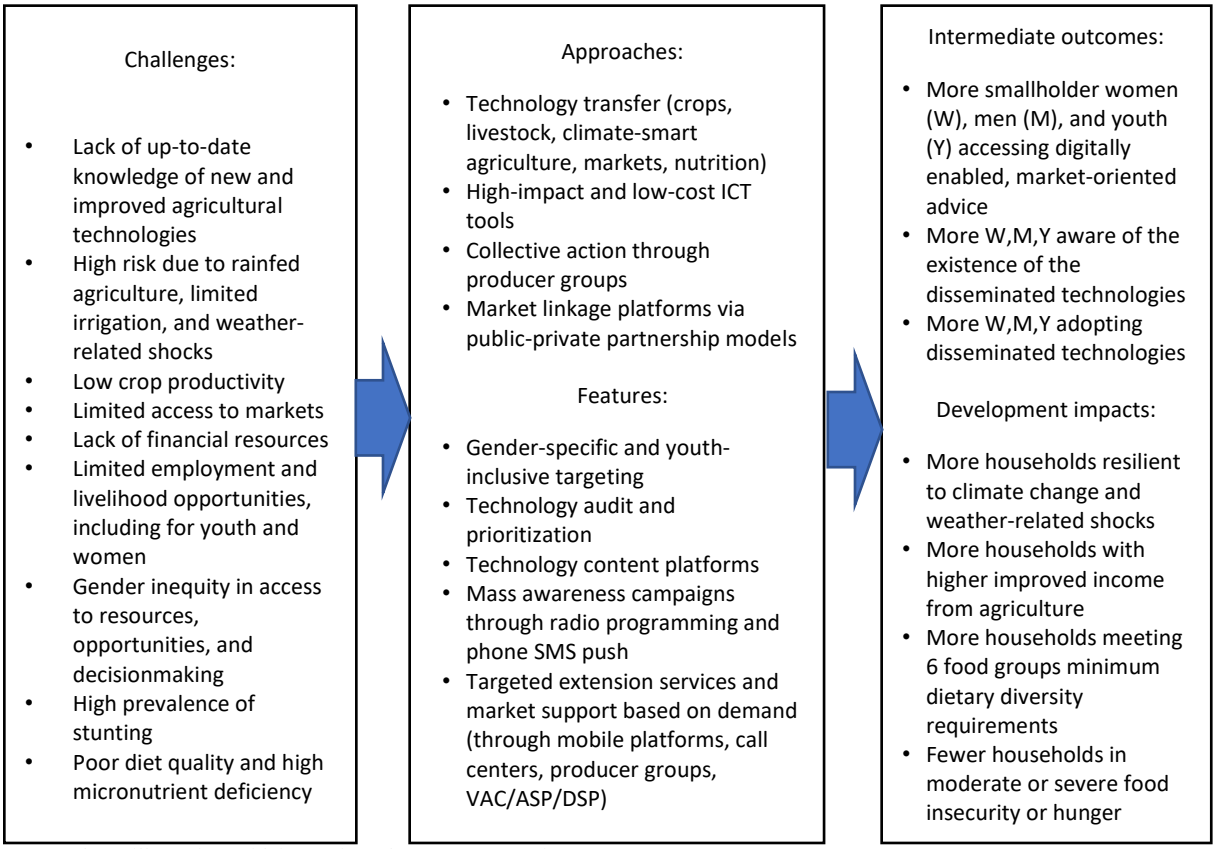
8. **Nutrition:**
"Farmers keep small animals so that you don't have to worry about getting proteins from the animals to keep you healthy. Call for free on 8111 Airtel, 7111 TNM"
"Farmers know how much food your family can eat throughout the year so you know what foods to save after harvest. Call 8111 Airtel, 7111TNM"

9. **Gender:**
"Farmers, both men and women, have the responsibility to ensure that the field work of caring for groundnuts and soybeans is done together to get more profit."
"Farmers, both men and women, are responsible for taking part in field work, make sure you help each other so that the work is done quickly and efficiently."

Videos prepared and planned for implementation:

- Drip irrigation for tomato
- Reviving soils with Mucuna
- Feeding dairy goats
- Managing nematodes in vegetables
- The onion nursery
- Managing onion diseases
- Making a business from home-raised chicks
- Making a raised platform for sheep and goats
- Fattening sheep and goats
- Natural ways to keep children healthy
- Crop rotation with legumes
- Making cassava snacks

Annex Figure A1. Theory of change adopted for the SRIEED II project



Source: Authors' illustration, with inputs from the SRIEED II project team.

Annex 2. Measurement of dietary diversity

We adopt two measures of dietary diversity—household level and individual level.

Household level

The Household Dietary Diversity Score (HDDS),[5] described as the number of food groups consumed by a household over a given reference period, is a population-level indicator of household food access. It is an important indicator of food security for many reasons. A more diversified household diet is correlated with caloric and protein adequacy, percentage of protein from animal sources, and household income (Swindale and Bilinsky 2006). The HDDS indicates a household's ability to access food as well as its socioeconomic status, based on consumption over the previous 24 hours (Kennedy et al. 2011). The HDDS includes the following 11 food groups:

1. Cereals
2. Roots, tubers, and plantains
3. Legumes and nuts
4. Vegetables
5. Meat, fish, and animal products
6. Dairy
7. Fruits
8. Vegetables
9. Sugar, sugar products, and honey
10. Fats and oil
11. Spices and condiments

In addition to these standard food security and dietary diversity indicators, we add the percentage of households consuming all six required food groups being promoted in Malawi—cereals and roots, legumes and nuts, meat and fish, vegetables, fruits, and fats and oils.

Individual level

We also include measures at the individual level, particularly for women. We sample the primary woman decision-maker within the household. Evidence suggests that women are more likely to be food insecure within the household; at the same time, mothers' nutrition is highly correlated with children's nutrition. We used the standard measure of women's dietary diversity score (WDDS) and expanded it to provide a proxy measure of the proportion of the sample women who eat the minimum nutritious diet. The Minimum Dietary Diversity for Women (MDD-W) is an internationally validated proxy indicator for the probability of micronutrient adequacy, such that the population of women ages 15 to 49 years is more likely to have achieved micronutrient adequacy if on average at least 5 out of 10 healthy food groups are consumed in a 24-hour period (FAO and FHI360 2016; Martin-Prével et al. 2015). There is no validated cutoff for other age groups. This study considers adult women the primary decision-makers, including those above 49 years, and adopts the MDD-W threshold of five food groups as an indication of improved probability of adequate dietary diversity and micronutrient adequacy. In the baseline survey, 77 percent of women in the households and women respondents are ages 15 to 49 in both project and comparison districts. Interviews followed the good-practice recommendations on food groupings for the 24-hour

[5] https://inddex.nutrition.tufts.edu/data4diets/indicator/household-dietary-diversity-score-hdds

recall period and interview processes highlighted in FAO and FHI360 (2016). The specific women's dietary diversity outcomes monitored are (1) WDDS measured by the number of healthy food groups consumed (0–10), (2) inadequate dietary diversity (<5 food groups), and (3) consumption of each food group. The following 10 food groups are used to estimate WDDS, based on MDD-W food groupings:

1. Cereals
2. Pulses
3. Nuts and seeds
4. Dairy
5. Meat and fish
6. Eggs
7. Dark green leafy vegetables
8. Vitamin A–rich fruits and vegetables
9. Other vegetables
10. Other fruits

We also include an indicator aligned with the six required and promoted food groups in Malawi: staples, legumes and nuts, meat and fish, vegetables, fruits, and fats and oils. We added an indicator on the percent of women respondents consuming all six food groups.

Annex 3. Measurement of women's empowerment

We adopt the Abbreviated Women's Empowerment in Agriculture Index (A-WEAI) as the measure of women's empowerment and to calculate gender parity (see Malapit et al. 2017 for details). A woman is considered "empowered" if the A-WEAI score is at least 0.8, following the A-WEAI cutoff. Gender parity is achieved if the sample woman is at least as empowered as the sample man within the household, following the same definition and criteria as A-WEAI.

Annex Table A1a. Adoption rate of promoted management practices, all households

Technology	Reported by men			Reported by women		
	Baseline	Midline control	Midline treatment	Baseline	Midline control	Midline treatment
Crop production technologies						
Permanent soil cover	18	22	23	17	19	19
Zero or minimum tillage	28	28	23	23	20	20
Herbicide	19	18	24	14	13	18
Mulching	63	51	50	52	50	45
Crop residue incorporation	82	77	78	78	75	75
Pit planting	24	26	20	21	21	18
Crop rotation (cereal-legume rotation)	64	80	86	59	81	84
Cereal-legume intercropping	63	65	57	58	67	63
Double up legume intercropping	27	34	36	24	36	37
Agroforestry (fertilizer) trees in crop plots	58	47	46	47	39	42
Fallow	28	18	23	23	20	21
Mixed cropping	70	58	49	66	60	58
Compost manure	56	59	63	49	51	57
Mbeya manure	26	24	32	22	25	32†
General manure from domestic rubbish pits	48	46	52	41	38	47†
Pelletized tobacco waste/manure	7	13	9	6	6	7
Soil testing	3	4	9	2	5	6
One-one maize planting (Sasakawa)	67	73	77	61	73	74
Double row soybean planting	24	50	51	21	47	54
Rice intensification system	3	12	9	3	10	11
Composting toilets	8	7	7	6	5	7
Box ridges	58	39	40	48	26	29
Contour bunds	62	53	56	56	42	48
Planting Vetivar grass to control for soil erosion	48	55	64	43	56	60
Water harvesting in pits or swales	12	13	11	9	9	10
Proper ridge spacing	57	73	72	44	62	63
Reduced use of pesticide (integrated pest management)	16	36	38	11	25	24
Biological control	22	14	10	18	10	11
Mechanical control	63	58	58	57	53	52
Consulted a plant clinic or plant doctor	7	22	23	5	15	14
Inoculant	7	19	20	4	12	17
Livestock-related practices						
Fodder trees in crop plots	9	8	9	6	5	8
Livestock/animal manure	75	78	75	71	81	76†
Hay/silage making	5	5	9	2	4	4
Improved livestock housing	28	41	35	21	36	33
Marketing and agroprocessing practices						
Grading or sorting out produce	62	72	65	58	63	62
Use of hermetic bags for storage	14	30	37	9	27	33
Collective marketing	nd	26	34	nd	28	32
Warehouse receipt system	nd	19	19	nd	13	17

Technology	Reported by men			Reported by women		
	Baseline	Midline control	Midline treatment	Baseline	Midline control	Midline treatment
Commodity aggregation	nd	24	22	nd	21	21
Use of Mandela cock drying for aflatoxin management	nd	45	55	nd	44	53
Nutrition and health–related practices						
Food budgeting/food calendar	36	52	45**	33	48	49
Including multiple food groups (dietary diversity) in each meal	64	80	80	60	80	82
Consuming iron-rich foods	48	71	67	43	73	73
Using iodized salt in food preparation	88	84	86	85	82	85†
Washing hands before preparing and consuming food	96	96	97	96	97	99**
Backyard gardening	55	59	53	51	56	55
Orange-fleshed sweet potato	54	51	51	49	47	52

Note: Statistically significant at †0.15, *0.10, ** 0.05, and *** 0.01 level between midline control and treatment groups. Nd = no data (it was not asked in the computer-assisted personal interviewing).

Annex Table A1b. Adoption rate of promoted management practices, households in Kasungu

Technology	Reported by men			Reported by women		
	Baseline	Midline control	Midline treatment	Baseline	Midline control	Midline treatment
Crop production technologies						
Permanent soil cover	4	22	26	2	15	21
Zero or minimum tillage	19	11	21	17	6	10*
Herbicide	16	7	36***	13	7	23*
Mulching	67	44	64	64	61	58
Crop residue incorporation	92	96	89*	90	93	88
Pit planting	14	7	17	14	6	19**
Crop rotation (cereal-legume rotation)	89	96	92	84	90	94
Cereal-legume intercropping	44	78	62	46	79	76
Double up legume intercropping	38	44	47	38	44	49
Agroforestry (fertilizer) trees in crop plots	53	59	60	50	50	65**
Fallow	26	30	30	19	19	23
Mixed cropping	59	63	66	53	64	69
Compost manure	66	63	81**	64	54	62
Mbeya manure	44	48	57	51	46	44
General manure from domestic rubbish pits	59	33	55**	50	43	40
Pelletized tobacco waste/manure	15	11	13	8	13	8
Soil testing	5	4	21**	1	4	10*
One-one maize planting (Sasakawa)	78	78	79	77	76	80
Double row soybean planting	60	81	87	58	79	88*
Rice intensification system	0	4	4	0	1	0
Composting toilets	8	7	9	5	10	8
Box ridges	68	67	81	54	69	76
Contour bunds	65	78	87	52	78	76
Planting Vetivar grass to control for soil erosion	61	67	91***	57	58	70
Water harvesting in pits or swales	3	11	11	2	4	3
Proper ridge spacing	64	78	83	44	69	75
Reduced use of pesticide (integrated pest management)	28	19	42***	11	25	27
Biological control	27	26	21	26	14	19
Mechanical control	60	78	77	55	76	71
Consulted a plant clinic or plant doctor	6	33	36	2	15	16
Inoculant	23	52	70	20	38	47
Livestock-related practices						
Fodder trees in crop plots	20	15	13	13	8	14
Livestock/animal manure	88	93	87	87	88	79
Hay/silage making	0	7	17	1	10	5†
Improved livestock housing	26	52	64	20	43	48
Marketing and agroprocessing practices						
Grading or sorting out produce	61	81	72	55	65	58†
Use of hermetic bags for storage	11	22	43*	7	24	40*
Collective marketing	nd	30	81***	nd	44	69**
Warehouse receipt system	nd	11	64***	nd	14	48**

Technology	Reported by men			Reported by women		
	Baseline	Midline control	Midline treatment	Baseline	Midline control	Midline treatment
Commodity aggregation	nd	7	47***	nd	25	37
Use of Mandela cock drying for aflatoxin management	nd	81	89	nd	82	82
Nutrition and health–related practices						
Food budgeting/food calendar	33	59	45**	29	56	49
Including multiple food groups (dietary diversity) in each meal	53	100	85***	58	90	88
Consuming iron-rich foods	37	63	72	39	68	77*
Using iodized salt in food preparation	95	96	91	94	83	85
Washing hands before preparing and consuming food	98	100	96	98	99	100
Backyard gardening	59	74	75	56	68	80
Orange-fleshed sweet potato	48	81	66*	49	67	62

Note: Statistically significant at †0.15, *0.10, ** 0.05, and *** 0.01 level between midline control and treatment groups. Nd = no data (it was not asked in the computer-assisted personal interviewing).

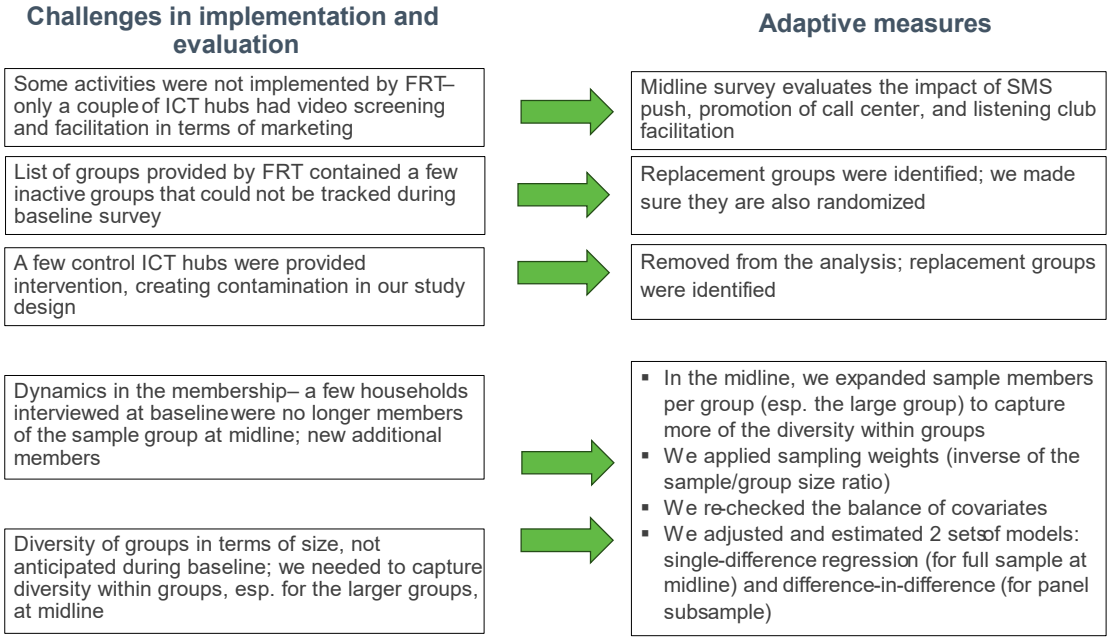
Annex Table A1c. Adoption rate of promoted management practices, in Nkhota-kota

Technology	Reported by men			Reported by women		
	Baseline	Midline control	Midline treatment	Baseline	Midline control	Midline treatment
Crop production technologies						
Permanent soil cover	18	23	15	16	15	17
Zero or minimum tillage	44	36	29	40	27	33
Herbicide	34	19	29	29	16	27†
Mulching	55	11	3	46	17	14
Crop residue incorporation	89	62	49	93	48	47
Pit planting	21	26	12**	20	13	15
Crop rotation (cereal-legume rotation)	74	74	75	70	71	82
Cereal-legume intercropping	37	34	34	43	27	30
Double up legume intercropping	26	17	10	30	11	18
Agroforestry (fertilizer) trees in crop plots	55	47	29	52	27	30
Fallow	51	15	15	48	17	19
Mixed cropping	51	11	7	54	26	31
Compost manure	50	66	39**	48	40	29
Mbeya manure	18	11	10	16	7	13
General manure from domestic rubbish pits	56	51	31**	52	34	26
Pelletized tobacco waste/manure	1	2	3	1	2	1
Soil testing	4	6	2	2	8	2
One-one maize planting (Sasakawa)	66	55	68	70	60	61
Double row soybean planting	11	23	24	12	12	18
Rice intensification system	19	43	34	20	29	40
Composting toilets	6	6	7	2	1	6*
Box ridges	55	23	17	50	12	6
Contour bunds	66	34	29	67	31	19
Planting Vetivar grass to control for soil erosion	57	74	68	50	67	55
Water harvesting in pits or swales	4	11	3	2	3	6
Proper ridge spacing	72	70	71	53	57	56
Reduced use of pesticide (integrated pest management)	11	32	37	15	13	23†
Biological control	26	17	8	27	4	8
Mechanical control	76	62	53	78	55	51
Consulted a plant clinic or plant doctor	8	17	22	9	16	17
Inoculant	1	15	15	1	3	5
Livestock-related practices						
Fodder trees in crop plots	4	15	0**	6	3	2
Livestock/animal manure	77	70	54**	80	71	61
Hay/silage making	3	2	3	1	1	0
Improved livestock housing	37	36	31	37	36	27
Marketing and agroprocessing practices						
Grading or sorting out produce	77	55	68†	72	48	53
Use of hermetic bags for storage	6	23	24	6	12	19
Collective marketing	nd	30	39	nd	29	27
Warehouse receipt system	nd	21	17	nd	11	9

Technology	Reported by men			Reported by women		
	Baseline	Midline control	Midline treatment	Baseline	Midline control	Midline treatment
Commodity aggregation	nd	28	25	nd	24	24
Use of Mandela cock drying for aflatoxin management	nd	26	27	nd	18	19
Nutrition and health–related practices						
Food budgeting/food calendar	36	55	51	34	51	50
Including multiple food groups (dietary diversity) in each meal	66	72	83†	63	80	81
Consuming iron-rich foods	34	66	66	27	71	60
Using iodized salt in food preparation	86	81	90	78	80	87
Washing hands before preparing and consuming food	93	96	93	91	99	99
Backyard gardening	61	60	47	60	58	46*
Orange-fleshed sweet potato	64	55	49	52	52	50

Note: Statistically significant at †0.15, *0.10, ** 0.05, and *** 0.01 level between midline control and treatment groups. Nd = no data (it was not asked in the computer-assisted personal interviewing).

Annex Figure A1. Summary of challenges and adaptive measures in cRCT implementation



Source: Authors' illustrations.

Annex Table A2. Test of balance in midline characteristics between treatment and control households

	Mean [SD]		
Variable	**Treatment**	**Control**	***P* value**
Household characteristics			
HH with youth (=1)	0.445	0.425	0.743
	[0.497]	[0.495]	
Female-headed HH (=1)	0.267	0.360	0.046**
	[0.443]	[0.480]	
Youth-headed HH (=1)	0.196	0.164	0.323
	[0.398]	[0.370]	
Dual-headed HH (=1)	0.824	0.800	0.626
	[0.381]	[0.401]	
HH with women only (=1)	0.160	0.180	0.730
	[0.367]	[0.385]	
HH with men only (=1)	0.016	0.020	0.507
	[0.127]	[0.140]	
Livestock unit	12.368	13.205	0.673
	[32.558]	[27.931]	
Asset quintile 1 (=1)	0.211	0.191	0.508
	[0.409]	[0.394]	
Asset quintile 2 (=1)	0.209	0.196	0.590
	[0.407]	[0.397]	
Asset quintile 3 (=1)	0.203	0.194	0.589
	[0.403]	[0.395]	
Asset quintile 4 (=1)	0.197	0.200	0.883
	[0.398]	[0.400]	
Asset quintile 5 (=1)	0.180	0.219	0.213
	[0.384]	[0.414]	
Household head characteristics			
Age	48.011	49.185	0.491
	[14.740]	[13.838]	
Male (=1)	0.731	0.641	0.048**
	[0.444]	[0.480]	
Ever a lead farmer (=1)	0.144	0.160	0.277
	[0.352]	[0.367]	
Active lead farmer (=1)	0.075	0.091	0.424
	[0.263]	[0.288]	
Married (=1)	0.837	0.761	0.053*
	[0.370]	[0.427]	
Reads/writes in Chichewa (=1)	0.802	0.783	0.941
	[0.399]	[0.413]	
Reads/writes in English (=1)	0.526	0.478	0.706
	[0.500]	[0.500]	
Education level			
No formal schooling	0.064	0.080	0.854
	[0.245]	[0.271]	
Some years in elementary	0.425	0.416	0.579

Variable	Mean [SD] Treatment	Control	*P* value
	[0.495]	[0.493]	
Graduated in elementary	0.208	0.231	0.268
	[0.406]	[0.422]	
At least some years in high school	0.302	0.274	0.716
	[0.460]	[0.446]	
Men decision-makers within the household			
Age	44.428	45.178	0.899
	[16.316]	[16.730]	
Ever a lead farmer (=1)	0.118	0.130	0.379
	[0.323]	[0.337]	
Active lead farmer (=1)	0.054	0.074	0.353
	[0.226]	[0.262]	
Married (=1)	0.866	0.832	0.047**
	[0.341]	[0.374]	
Reads/writes in Chichewa (=1)	0.851	0.845	0.761
	[0.356]	[0.362]	
Reads/writes in English (=1)	0.587	0.565	0.952
	[0.493]	[0.496]	
Education level			
No formal schooling	0.032	0.052	0.427
	[0.176]	[0.221]	
Some years in elementary	0.390	0.363	0.330
	[0.488]	[0.481]	
Graduated in elementary	0.211	0.227	0.408
	[0.409]	[0.419]	
At least some years in high school	0.366	0.358	0.928
	[0.482]	[0.480]	
Women decision-makers within the household			
Age	41.332	43.369	0.056*
	[14.562]	[14.148]	
Ever a lead farmer (=)	0.076	0.088	0.550
	[0.265]	[0.283]	
Active lead farmer (=1)	0.046	0.054	0.593
	[0.209]	[0.226]	
Married (=1)	0.795	0.742	0.060*
	[0.404]	[0.438]	
Reads/writes in Chichewa (=1)	0.705	0.720	0.733
	[0.456]	[0.449]	
Reads/writes in English (=1)	0.391	0.384	0.857
	[0.488]	[0.487]	
Education level			
No formal schooling	0.121	0.107	0.641
	[0.326]	[0.309]	

Variable	Mean [SD] Treatment	Control	*P* value
Some years in elementary	0.510	0.506	0.875
	[0.500]	[0.500]	
Graduated in elementary	0.177	0.180	0.917
	[0.382]	[0.384]	
At least some years in high school	0.192	0.208	0.564
	[0.394]	[0.406]	

Source: IFPRI/Wadonda household survey (2023).

Note: HH = household. Standard errors are clustered at ICT hub level. Statistically significant at †0.15, *0.10, ** 0.05, and *** 0.01 level.

Annex Table A3. Anderson's Q-values for secondary outcomes

	All		Kasungu		Lilongwe		Mangochi		Mzimba North		Mzimba South		Nkhota-Kota	
	M	W	M	W	M	W	M	W	M	W	M	W	M	W
Household Dietary Diversity Score							0.665						0.668	
p							0.100						0.055	
q							0.115						0.091	
Women's Dietary Diversity Score			0.450											
P			0.030											
Q			0.063											
A-WEAI														
Empowerment score	-0.019						-0.032							
P	0.074						0.144							
Q	0.109						0.115							
Empowerment status (1 = empowered)									-0.141					0.105
P									0.133					0.117
Q									0.105					0.106
Access to and decisions on financial services		0.056	0.215						-0.164	-0.085				0.155
p		0.077	0.018						0.025	0.049				0.008
q		0.109	0.063						0.086	0.105				0.068
Work balance		-0.109		-0.140									-0.154	
p		0.042		0.063									0.109	
q		0.109		0.072									0.106	
Group membership			0.090	0.082					-0.346					
p			0.058	0.006					0.003					
q			0.072	0.060					0.025					

Annex Table A4. Treatment effects of ICT hub intervention bundle from single-difference regression model and difference-in-difference

Outcomes	Level	Total	Kasungu		Lilongwe		Mangochi		Mzimba North		Mzimba South		Nkhota-Kota	
			M	W	M	W	M	W	M	W	M	W	M	W
SMS access (=1)	Individual	*	*			†								
Call center use (=1)	Individual	**/*	***	*			***/*		†/**	***	*			
Radio listening group (=1)	Individual	**					***	*	**	**	†			
Technology adoption (count, out of 48)	Individual		*			**								**
Crop productivity (MWK/ha) /a	Household		**		*(-)						*		*	
Crop sales (MWK) /a	Household	***	*/*		**						***		*/*	
Crop sales per ha (MWK/ha) /a	Household	*/*	**/**		***						*		*/†	
HDDS (score)	Household						†/†						*/*	
HDDS (cutoff)	Household						*						**	
- Legumes and nuts	Household	*/**			†								*/***	
- Fat and oil	Household	**/***					*/***			†		*	**/†	
WDDS (score)	Household		**				†							
WDDS (cutoff)	Household													
- Egg	Household	*	†				†/†					**		
- Other fruits	Household	†(-)	*						*** (-)/**(-)				†	
A-WEAI (cutoff)/a	Individual								† (-)					†
- Access to and control over credit	Individual	†/†	**/***						** (-)	** (-)				***
- Group membership	Individual	†	*/***	***		†(-)			*** (-)					*

Note: Statistically significant at †0.15, *0.10, ** 0.05, and *** 0.01 level. Results of difference-in-difference models are in larger fonts and in red. Negative effects are marked with (-). /a Increased in value are largely due to high inflation or a jump in prices from 2021 to 2023.

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