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Relative Roles and Limits of Extension Approaches in Promoting Sustainable Agricultural Management Practices

Analysis of Nationally Representative Panel Data from Malawi

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Notices

Abstract

Low-cost and sustainable agricultural management practices are being promoted in many countries but continue to face low adoption among farmers. We tracked the awareness and adoption among farmers of a number of practices—soil cover, minimum tillage, crop rotation, intercropping, crop diversification, crop residue incorporation, pit planting, water harvesting, and organic fertilizer—in two rounds of a nationally representative rural household survey in Malawi. Survey data and focus group discussions are used to understand the factors explaining the variations in farmers' awareness and adoption of these practices. Results show a strong positive effect of extension services receipt on farmers' awareness of these practices but no effect on farmers' adoption of most of the practices being promoted, except for crop residue incorporation and organic fertilizer use. Receipt of input subsidy does not influence the adoption of these practices. Both survey data and focus group discussions highlight the need for intensive and iterative engagement between service providers and farmers to fully communicate, learn, and adapt to these management practices.

Keywords: technology adoption, extension services, agricultural management practices, sustainable land management

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1. Introduction

Access to improved technologies and state-of-the-art knowledge is key to increasing agricultural productivity and incomes. These technologies are much needed in many developing agriculture-based economies, especially those in Africa south of the Sahara (SSA). There is much focus in the literature on inorganic fertilizer and, to a lesser extent, improved seed technologies (Duflo, Kremer, and Robinson 2008, 2011; Alene et al. 2009; Suri 2011; Ricker-Gilbert, Jayne, and Chirwa 2011; Jayne and Rashid 2013; Lunduka, Ricker-Gilbert, and Fisher 2013). Less is known about the knowledge creation, adoption, and suitability of agricultural management practices. With a changing and unpredictable climate, farmers also need to adopt practices that are productive and profitable and at the same time climate resilient and sustainable.

Low-cost, climate-smart, and sustainable agricultural management practices are being promoted in many countries in the subcontinent, but they continue to face low adoption among farmers. Conservation agriculture (CA), which has three main dimensions—use of soil cover, minimum tillage, and intercropping or crop rotation—has been promoted in many parts of the world since the early 2000s and has been well studied (for examples in Malawi alone, see Bell et al. 2018; Chinseu et al. 2019; Hermans et al. 2021; Holden et al. 2018; Ngwira et al. 2014; Thierfelder et al. 2016; Ward et al. 2016, 2018). Evidence highlights the persistently low adoption rates and cases of disadoption of CA (Brown et al. 2017; Chinseu et al. 2019). Studies have emphasized different ways of engaging with farmers, financial incentives, and external support to nudge farmers toward greater adoption of CA (Amadu, McNamara, and Miller 2020; Bell et al. 2018; Chinseu et al. 2019; Hermans et al. 2021; Ward et al. 2016, 2018). Others have highlighted the need to think differently about measurements of adoption and focus on farmers' contextualization and adaptation to management practices when analyzing a complex and multi-dimensional package of technologies such as CA (Brown et al. 2017; Chinseu et al. 2019; Hermans et al. 2021).

Other management practices that have been promoted include crop residue incorporation, pit planting, crop diversification, water harvesting, and organic fertilizer production and use (Malawi, MoAIWD, undated, 2019; Nzima and Warren 2021). These practices are less studied and also face low adoption among farmers (see Niu and Ragasa 2018; Ragasa and Comstock 2019). While several in-depth, qualitative case studies are available (mostly on CA), what seems to be missing in the literature is a broader assessment of the heterogeneity of locations and different types of farmers in order to identify factors that explain which farmers are adopting, not adopting, or disadopting these management practices and where and why they are doing so. The role of policies, subsidies, or other incentives to encourage adoption has also been investigated in the literature (Amadu, McNamara, and Miller 2020; Bell et al. 2018; Piñeiro et al. 2020; Ward et al. 2016, 2018), but more research on the types and nature of policies, subsidies, and incentives is needed (Arslan et al. 2014; Piñeiro et al. 2020). Many studies have also stressed the importance of technical assistance and extension services in promoting these management practices (see review by Piñeiro et al. 2020). Despite major investments and programs in agriculture extension (Davis, Babu, and Ragasa 2020) and the multitude of extension approaches being used, however, low adoption of and adaptation to these sustainable practices persist, begging for more research on what types and approaches can best be used in particular context to promote these practices and change the perception and behavior of different types of farmers. This paper aims to fill that gap by analyzing data from a large-sample nationally representative household survey, and juxtaposing those survey data with qualitative interviews and focus group discussions in Malawi.

As the primary objective, we hypothesize and test whether the intensity, quality, type, and medium of information provision and farmers' engagement contributed to greater awareness and adoption of these sustainable agricultural management practices. As a secondary objective, we hypothesize and test whether the receipt of a subsidy from the Farm Input Subsidy Program (FISP) (replaced by the Affordable Inputs Program starting in the 2020/21 cropping season) affects the adoption of these practices.

We use Malawi, which is highly vulnerable to drought and changing climate, and among the poorest and most food insecure countries in SSA (Davis-Reddy and Vincent 2017; UNDP-UNEP PEI 2016; Malawi, MoAIWD 2016). According to data from the Third Integrated Household Survey (IHS3) 2010/11 and Fourth Integrated Household Survey (IHS4) 2016/17, the national poverty rate remained steady at 51 percent in 2010/11 and 52 percent in 2016/17. Rural poverty, however, appears to have risen over the same period: from 57 percent in 2010/11 to 60 percent 2016/17. As of 2019, Malawi ranked low in the United Nations Development Programme's Human Development Index—172 out of 189 countries (UNDP 2019). Malawi faces limited market and economic opportunities and high levels of food and nutrition insecurity, compounded by issues of extreme weather events, increasing youth population and youth unemployment, and gender disparities. Malawi is among the countries with the lowest agricultural productivity, despite decades of major investments in farm input subsidies (Dorward and Chirwa 2011; Lunduka, Ricker-Gilbert, and Fisher 2013; Ragasa and Mazunda 2018; Ricker-Gilbert et al. 2011). In 2015/16, the country experienced major droughts marked by an El Niño event that affected a third of Malawi's population (Tembo-Nhlema, Vincent, and Malinga 2019). Most recently, severe floods associated with tropical cyclone Idai in March 2019 affected over a million people, of whom the majority were displaced but others lost their lives (Malawi, DoDMA 2019). It is within this background that productivity-enhancing as well as climate-smart or sustainable management practices, and diversification strategies, are considered possible options that households can employ in order to manage such climate-related risks and improve productivity and incomes over time.

This paper fills the gap in the literature in several ways. First, it focuses on understanding the knowledge creation, adoption, and suitability of agricultural management practices, an area less studied than inorganic fertilizer or improved seed. Such practices are becoming more important given the changing climate, more frequent droughts, and continuous depletion of soil fertility, particularly in most parts of SSA. The paper specifically models the role of information provision as a facilitator of or barrier to knowledge creation and adoption of these sustainable agricultural management practices. It compares and contrasts types and medium of extension provision and how they affect the adoption of different practices. We measure and model adoption not only as a binary variable but by its intensity (area covered); and we look at the specific practices within the multi-dimensional technology packages based on how farmers understand them. Second, it models the relationship of the receipt of subsidy from the FISP, a major program in Malawi and in many countries in the subcontinent, with the adoption of the sustainable management practices being promoted. Third, it utilizes unique nationally representative panel data that tell the status of the promotion of these technologies at the national level, complementing available in-depth case studies and small-sample analyses as well as addressing limitations in earlier cross-sectional studies on unobserved heterogeneity and estimation bias (Feder, Just, and Zilberman 1985; Ragasa and Mazunda 2018), and characterize a stepwise adoption of technologies and nonexposure bias (Brown et al. 2017; Diagne and Demont 2007; Kabunga, Dubois, and Qaim 2012). It uses a unique dataset that contains detailed information on the type, source, delivery methods, and intensity of extension services received by the farming households, linked to household- and plot-level information on awareness and adoption of technologies, and time series weather and soil data. It juxtaposes these large-sample nationally representative survey data with in-depth interviews and focus group discussions.

2. Data Sources and Empirical Strategy

2.1. Data sources

This paper uses various sources of data, both quantitative and qualitative. First, it uses nationally representative household data collected from August to October 2016 (wave 1) and from July to September 2018 (wave 2, covering, to the extent possible, the same households as wave 1) by the International Food Policy Research Institute (IFPRI) and Wadonda Consult. All districts (except Likoma) were covered in the surveys. Within each district, the probability-proportional-to-size sampling method was used to determine the number of communities and households to randomly select. Within each selected district, sections were randomly selected, and, within those, communities were randomly selected. Ten households were interviewed in each selected community. In total, the first wave covered 3,001 households and the second wave covered 2,880, with very small attrition (4 percent). We have a total of 5,542 pooled observations for the two periods with balanced and complete data for all the variables used in the paper. Ragasa and Niu (2017) have offered more details on the sampling method.

Complementing these household surveys were (1) community surveys, with two to four village leaders and opinion leaders responding, (2) key informant interviews of over 50 extension service providers and extension agents, and (3) focus group discussions (FGDs), made up of six to eight participant-farmers and conducted by personnel from IFPRI and graduate students from the Lilongwe University of Agriculture and Natural Resources.

A total of 22 gender-disaggregated FGDs were conducted in January–February 2017. In January 2019 these groups were revisited and others added, for a total of 30 FGDs in 2019. In total, the 52 FGDs covered 113 male and 141 female respondents, sampled from 11 communities in eight districts from the same geographic areas as the household and community surveys. The locations of these FGDs are illustrated in Figure 1. The eight FGD districts were sampled purposively using a maximum variation approach to capture different agroeconomic and social characteristics, such as soil type, main crops produced, and dominant tribal affiliation. Two communities from each of these districts were randomly sampled from the survey population, one very remote and one more central, because we hypothesized that the quality and frequency of service delivery might differ according to remoteness. Adults from households in these communities (six to eight per community) were purposively sampled based on different household headship and wealth characteristics. However, fewer men than women were willing to participate, decreasing somewhat the number and variation of the sample of men. These FGDs were led by local enumerators fluent in the local Chichewa, Chibandya, and Chinyika languages. Enumerators were experienced in qualitative data collection and were asked to encourage the active participation of all and the articulation of differing views among participants. Discussions were recorded, transcribed, and translated, and then thematically coded using NVivo 11.

Figure 1. Map of Malawi showing locations of the focus group discussions and the districts covered in the household and community surveys used in this paper

Source: International Food Policy Research Institute (IFPRI) household and community surveys (2016, 2018) covering all districts (except Likoma), and 52 focus group discussions conducted by IFPRI in January–February 2017 and January 2019 in 11 communities in eight districts.
Note: The areas shaded in blue are bodies of water.

2.2. Empirical model

The main goal of this paper is to model the contribution of access to agricultural advice in the decision to adopt sustainable agricultural management practices being promoted in Malawi. Papers on technology adoption have modeled the adoption decision as a stepwise process, starting with discovery, exposure, or awareness, and then moving on to trying out the technology (see Brown, Nuberg, and Llewellyn 2017;

Kabunga, Dubois, and Qaim 2012; Lambrecht et al. 2014). We analyze adoption by smallholder farmer *i* as a two-step process consisting of awareness and adoption. The model is specified as follows:

Awareness: $Y_{iAw} = 1[\beta'_{Aw}X_{ij} + \gamma_{Aw}EXT_i + \varepsilon_{iAw} > 1]$ (1)

= 0, otherwise

Adoption: $Y_{iAd} = 1[\beta'_{Ad}X_{ij} + \gamma_{Ad}EXT_i + \varepsilon_{iAd} > 1]$ if $Y_{iAw} = 1$ (2)

= 0, otherwise

We use the binary outcome variable Y_{iAw} for awareness and both binary and continuous variables for adoption of agricultural technologies or management practices during the current cropping season; EXT_i is the receipt of agricultural extension advice, and X_{ij} is a vector of explanatory variables. All of these are defined below, and the descriptive statistics are in Table A.1.

Technology (Y_{iAw} and Y_{iAd}): The outcome variables being measured are those on technology awareness and adoption. We define *awareness* as farmers' being aware of or having knowledge about a specific technology or management practice. The survey question was "Are you aware or do you have knowledge of the following technologies and practices?" For adoption, we used two measures: (1) self-reported adoption for at least two seasons from a list of predetermined technologies and practices (in the technology awareness module) and (2) self-reported management practices and input use in the particular plot for the current cropping season (in the plot-level production module). If a farmer practiced technology *x* in any of his or her plots, we considered it adopted. Both measures of adoption were largely consistent. We also computed the intensity of adoption, measured in terms of percentage of total acreage in which a particular technology or practice was adopted.

We chose technology packages and practices that are commonly promoted as low-cost and sustainable management practices (Malawi, MoAIWD 2019; Nzima and Warren 2021)—namely, soil cover or mulching; minimum tillage or minimum disturbance of the soil; crop residue incorporation; intercropping; crop rotation; crop diversification; pit planting; organic fertilizer production and use, including composting pits, composting toilets, and Mbeya method; planting vetiver grass; agroforestry; and water management, mainly via rainwater harvesting in box ridges, swales, pits, or tanks. These practices help manage soil fertility and moisture retention to adapt to climate change. The description of these practices is translated in Chichewa and complemented by photos of the actual plot or action illustrating these practices.

For crop diversification, instead of intensity of adoption, we used Simpson's Index of Crop Diversification, $SID_i = 1 - \sum_{j=1}^{J_i} c_{ij}^2$, where c_{ij} is the share of the household's total cropland area that is planted with crop j, $j = 1, \dots, J_i$. The dominant crop in Malawi is still maize, but farmers are starting to diversify toward beans, groundnuts, vegetables, and other crops (Ragasa and Comstock 2019).

We focused on management practices rather than external inputs so as to isolate issues of credit or capital availability and focus on the role of informational failures in low adoption of low-external-input management practices. We excluded herbicide, even though it is part of the CA package for some promoters (Holden et al. 2018; Ragasa and Niu 2017). In Malawi, the survey data show that few farmers use herbicide (3 percent of rural households), given that it is very expensive, and there was not much variation in herbicide adoption to model for the purposes of this paper.

Extension services ($\boldsymbol{EXT_i}$): We utilized the household survey responses on the following questions to generate the variables on receipt of extension advice:

- "In the last 2 years (In the last 12 months), did you receive any information or advice on any of these topics?"
  - [IF YES, "From which sources did you receive information or advice about agriculture in the last 2 years (in the last 12 months)?"]
- "In the last 2 years (In the last 12 months), have you participated in any of these activities or used any of these methods to get information on agriculture?"

From the questions above, we generated and used the following indicators:

- Received agricultural advice in the last 2 years (0/1)
- Received agricultural advice in the last 12 months (0/1)
- Received agricultural advice by source in the last 2 years (0/1)
- Received agricultural advice by source in the last 12 months (0/1)
- Received agricultural advice by extension approach in the last 2 years (0/1)
- Received agricultural advice by extension approach in the last 12 months (0/1)

Control variables ($\boldsymbol{X_{ij}}$): We controlled for other sources and methods of accessing information and advice on agriculture, as well as various household-, community-, location-, and climate-related characteristics that can influence technology adoption (defined in Table A.1). Among the household-level variables, we included indicators of financial, physical, human, and social capital. Financial capital and wealth were measured by a household asset index, which was calculated using principal components analysis based on household assets largely adopted from the Malawi Integrated Household Survey questionnaire. Physical land capital was measured by total land acreage. Human capital indicators included years of education of the household head, age of the household head and its square, household size, and the number of laborers in the household. Social capital indicators included membership in groups and organizations. Last, we controlled for several climate-related variables and soil/plot quality that are likely to affect adoption of practices including maximum temperature, average annual temperature, average annual precipitation, and average January precipitation (planting month) during survey year and year before the survey.[1]

[11] Soil quality characteristic are from the ISRIC Data Hub (Hengl et al. 2015) and NASA Langley Research Center POWER Project, funded through the NASA Earth Science Directorate Applied Science Program (NASA POWER | Prediction Of Worldwide Energy Resources); temperature data are from NASA POWER Project; and rainfall data from are from CHIRPS (https://www.chc.ucsb.edu/data/chirps) (Funk et al. 2015).

2.3. Estimation strategy

We use three estimation methods in order to address nonexposure bias (Diagne and Demont 2007; Kabunga, Dubois, and Qaim 2012), nonrandom program placement and selection bias (Feder, Just, and Zilberman 1985), and potential unobserved heterogeneity issues (Ragasa and Mazunda 2018). First, we address nonexposure and selection bias by implementing a two-step process, modeling adoption conditional on awareness.

Second, we address unobserved heterogeneity by applying the Mundlak-Chamberlain (MC) device (Mundlak 1978; Chamberlain 1984), also known as correlated random effects (CRE), which provides an approach to allow for correlation between the unobserved individual omitted variable and variables of interest (extension services and input subsidy receipt), provided the unobserved effect is time-invariant. The MC/CRE device allows for modeling the distribution of the omitted variable conditional on the means of the strictly exogenous variables, instead of treating the omitted variable or heterogeneity as a parameter to estimate. To implement the MC/CRE device, we include the means of all time-varying covariates for a household. These averages have the same value for a given household in every year but vary across households.

An alternative to MC/CRE is the use of fixed-effects (FE) models. However, FE models are generally inconsistent in nonlinear models because the number of observations (*N*) grows with fixed time (*T*), as in our case (because we use only two years of data) (Papke and Wooldridge 2008; Wooldridge 2019;). As experts have noted, FE models in short panels are generally not estimable due to the incidental parameters problem (Wooldridge 2019; Papke and Wooldridge 2008). MC/CRE models are recommended for shorter time series (Woodridge 2019; Papke and Wooldridge 2008) and unifying the FE and random-effects (RE) estimation approaches. By including a vector of time-averaged variables, we still control for time-constant unobserved heterogeneity, as with FE, while avoiding the problem of incidental parameters in nonlinear models. At the same time, the MC/CRE device allows measurement of the effects of time-constant independent variables, just as in a standard RE environment (Papke and

Wooldridge 2008; Wooldridge 2002, 2019).

Third, for awareness and adoption of technologies (binary responses), we used MC/CRE. For intensity of adoption, which is the percentage of crop area where the specific technology was adopted, represented by a fractional response from 0 to 1, we extended the CRE to account for the fractional responses in the intensity of adoption, using multivariate weighted nonlinear least squares or the related generalized estimating equation (using the *xtgee* command in Stata). For a sensitivity check, we ran FE models for the intensity of adoption, where the outcome variables were continuous, although bounded from 0 to 1 (see Table 5 in section 4.1). We used the Hausman test to check the consistency and efficiency of standard RE (linear) and MC/CRE (linear) compared with FE (linear) models. In almost all of these models, we rejected the null hypothesis that standard RE (linear) is consistent and more efficient than FE (linear); however, we could not reject the null hypothesis that CRE is consistent and more efficient than FE, as shown in the Hausman test. This is another proof of the efficiency gained by using CRE compared with FE (linear) or standard RE (linear).

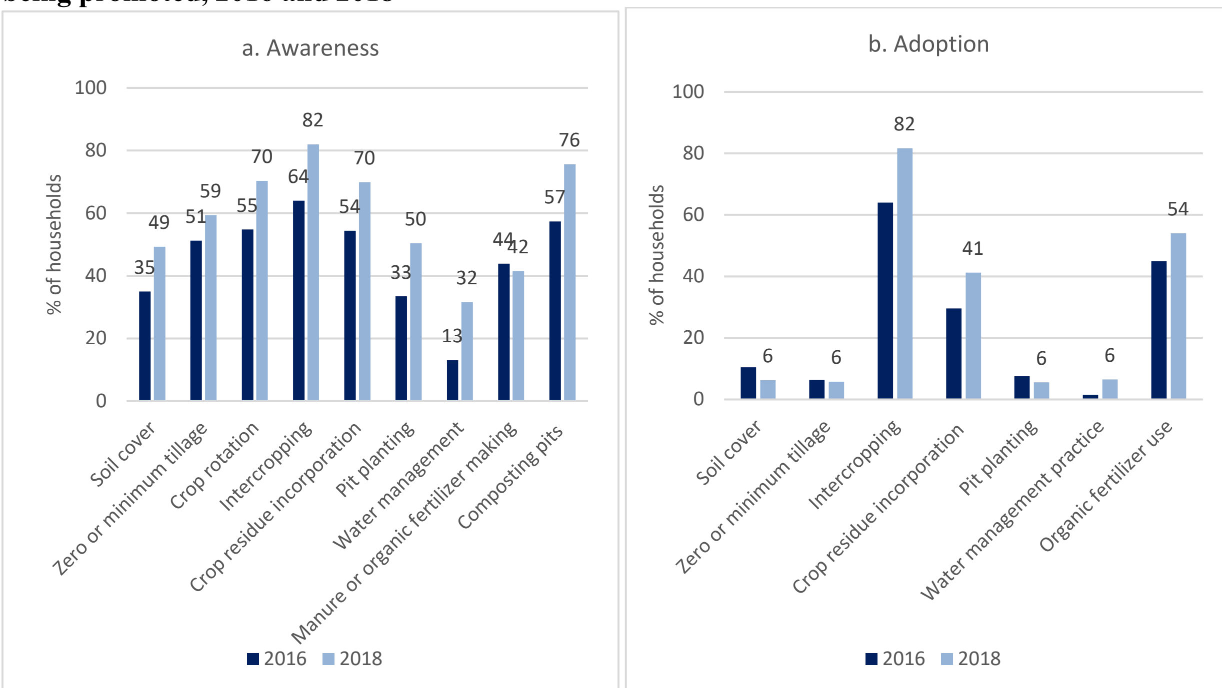
Last, we complemented these MC/CRE and fractional MC/CRE methods with Heckman selection probit and bivariate probit models to check for robustness and consistency of the results. Altogether, these three methods showed consistent results. In this paper, we show only the MC/CRE model results (Tables 1–8 in section 4.1) because they are largely similar to the results of the Heckman selection probit and bivariate models.

3. Descriptive Analysis

3.1. Level of farmers' awareness and adoption of technologies

There was general improvement in farmers' awareness of all technologies from 2016 to 2018, except for fertilizer or manure making (Figure 2, panel a). There was also some improvement in the adoption of some technologies, although adoption of other technologies decreased, from 2016 to 2018 (Figure 2, panel b). Major improvements were seen in the adoption of crop residue incorporation, water management, and intercropping. We do not see improvements in soil cover, minimum tillage, and pit planting.

Figure 2. Percentage of rural households aware of and adopting sustainable management practices being promoted, 2016 and 2018



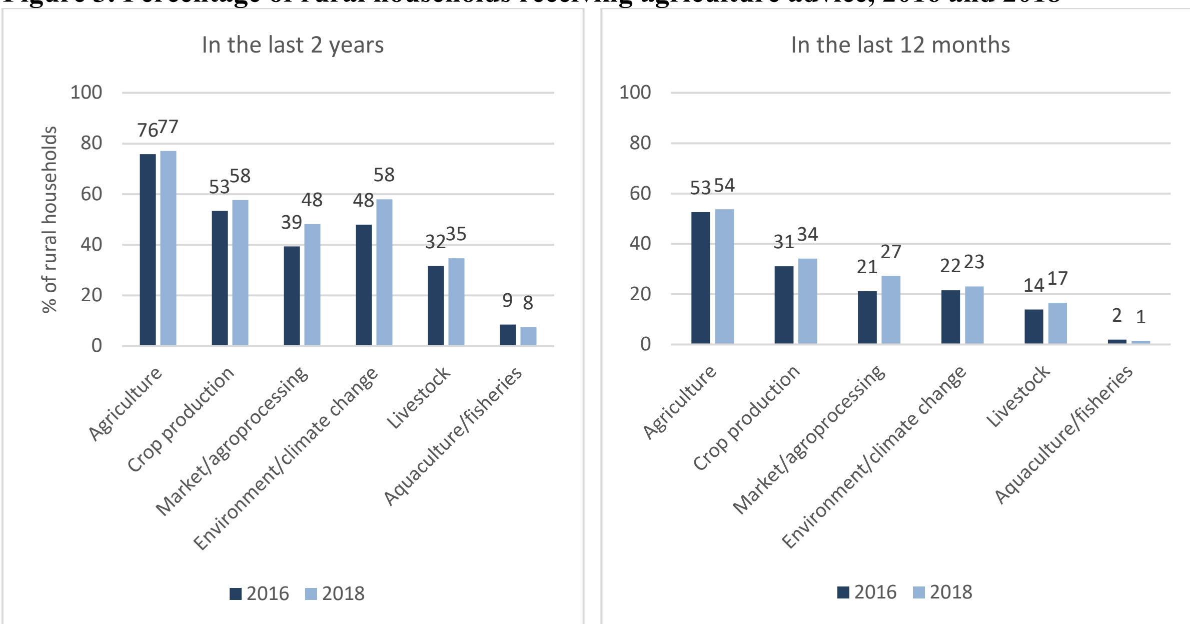
Source: IFPRI household surveys (2016, 2018).

A huge gap is seen between awareness and adoption of these practices (Figure 2, panels a and b). This gap is what our econometric models, below, are trying to explain. Conditional on awareness of a technology, we model whether extension advice contributes to explaining the gap between awareness levels and adoption levels.

3.2. Access to extension services

In 2016, 77 percent of the households reported access to any agricultural advice in the last 2 years—a fairly high mark (Figure 3). However, 53 percent of the households reported access to agriculture advice in the last 12 months, suggesting that advice is not frequent and does not come yearly, because we see a large difference between the two time references. In 2018, 77 percent and 54 percent of households received advice in the last 2 years and last 1 month, respectively. We see a small change (only a 1 percent increase) in households receiving agricultural advice from 2016 to 2018. Improvements are mainly in access to marketing/agroprocessing and environment/climate change information.

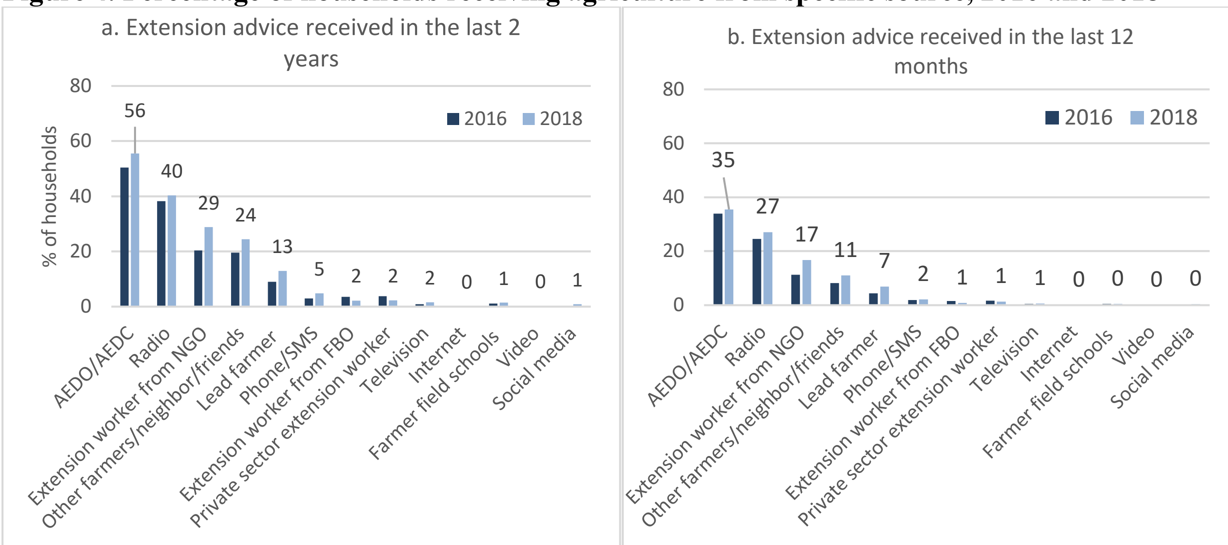
Figure 3. Percentage of rural households receiving agriculture advice, 2016 and 2018



Source: IFPRI household and community surveys (2016, 2018).
Note: Agriculture (the first item) combines crop production, marketing/agroprocessing, environment/climate change, livestock, aquaculture and fisheries, and nonfarm livelihoods.

The main source of advice was government extension workers (agricultural extension development officers or agricultural extension development coordinators), followed by radio, nongovernmental organization (NGO) extension workers, other farmers, lead farmers, and phone or short message service (SMS) (Figure 4). There was a slight increase in the percentage of households receiving advice from all sources except extension workers from farmer-based organizations and the private sector. The most noticeable improvements from 2016 to 2018 are seen in more households who report having received agriculture advice from NGO extension workers, other farmers, lead farmers, and SMS/phone.

Figure 4. Percentage of households receiving agriculture from specific source, 2016 and 2018

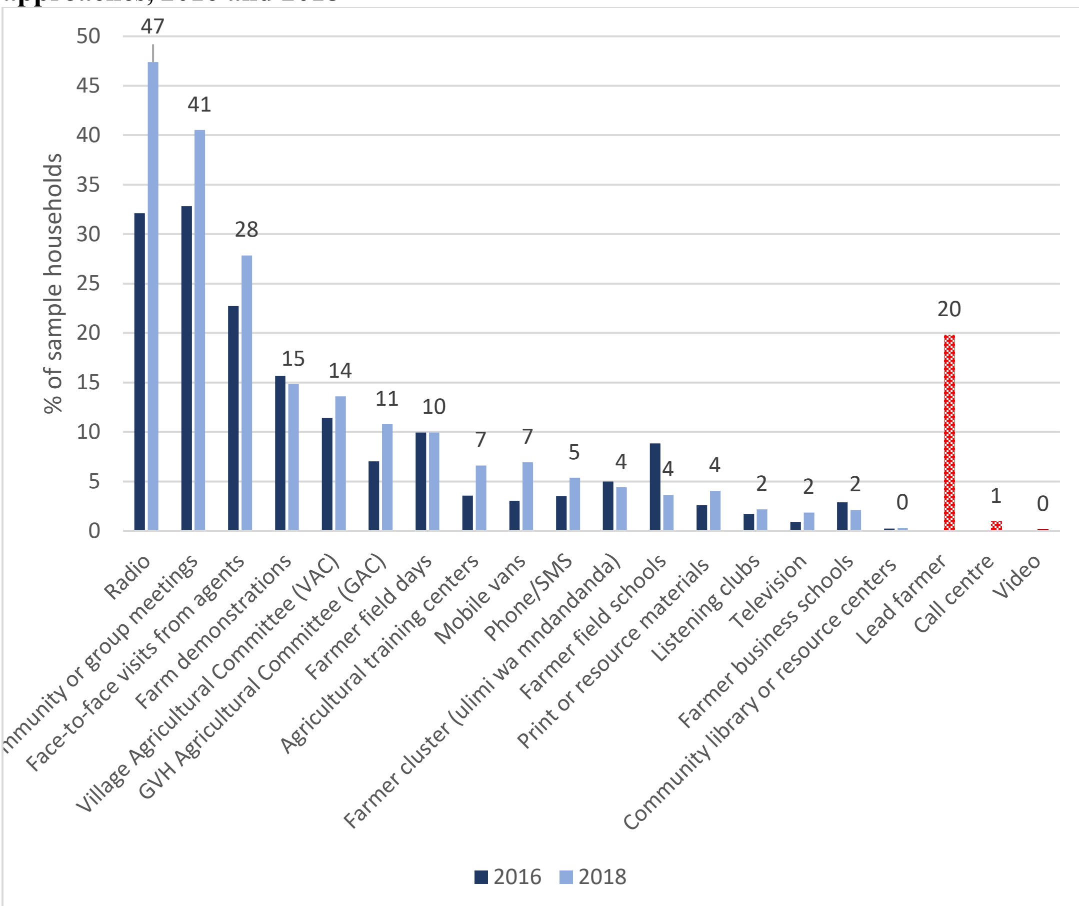


Source: IFPRI household surveys (2016, 2018).
Note: AEDC = agricultural extension development coordinator; AEDO = agricultural extension development officer; FBO = farmer-based organization; NGO = nongovernmental organization; SMS = short message service.

Among the surveyed households, radio was the main method of receiving agriculture advice (48 percent of households) (Figure 5). This was followed by community or group meetings and face-to-face visits from extension agents. These have consistently been the primary methods of receiving advice in both 2016 and 2018. The greater access to agriculture advice observed in 2018 seems to be driven by increases in access through radio, community/group meetings, and face-to-face visits from extension agents.

Other communication methods showing slight improvement, in terms of households reporting them as having been used, are village agricultural committees (VACs) or group-village agricultural committees (GACs), training centers, mobile vans, mobile phone/SMS, print materials, and television shows. However, there is a slight decrease in the percentage of households reporting farm demonstrations, farmer clusters, farmer field schools, and farmer business schools.

Figure 5. Percentage of households using or participating in various extension methods or approaches, 2016 and 2018



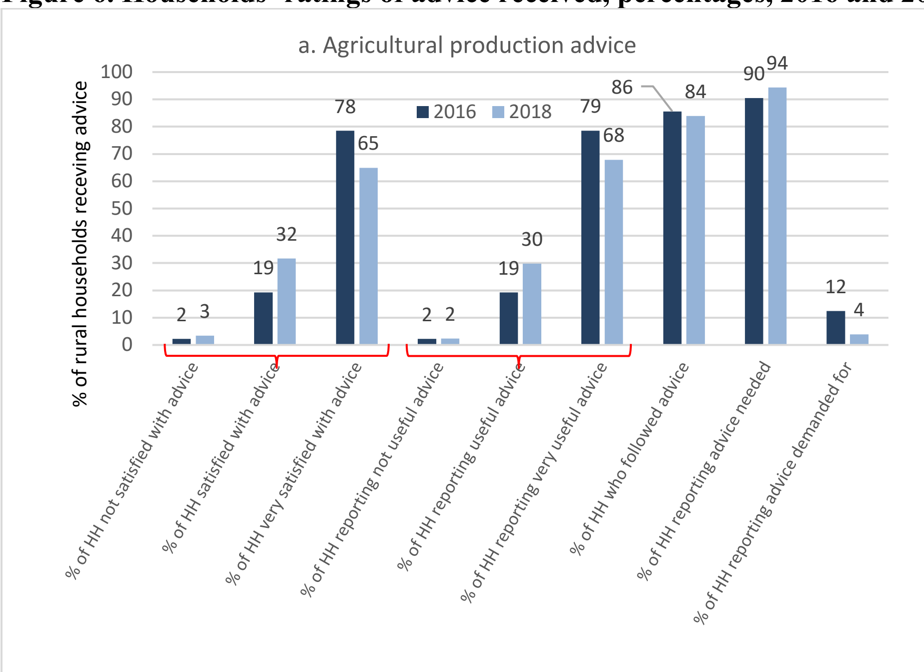
Source: IFPRI household surveys (2016, 2018).
Note: The dotted red bar (lead farmer, call center, video) means that data were collected on this method only in 2018. Survey question: "In the last 2 years (in the last 12 months), have you participated in any of these activities or used any of these methods to get information on agriculture?"

In addition to asking questions about access to different extension services, the surveys in question also aimed to assess the perceived quality of the services accessed. To investigate this, they asked five questions (pertaining to the latest advice received):

- Were you satisfied with the advice? (Likert scale: very satisfied, satisfied, somewhat satisfied, not satisfied)
- Was the advice useful? (Likert scale: very useful, useful, somewhat useful, not useful)
- Did you act upon it or did you follow up on the advice? (0/1)
- Was it something that you needed or wanted? (0/1)
- Was it something that you expressed demand for or have requested? (0/1)

Overall, the ratings were generally high for both 2016 and 2018 across four of the different ways of asking the perceived quality questions, and similar patterns of high ratings emerged across all topics, sources, and delivery methods (Figure 6). However, for agriculture advice, fewer households rated advice as "very useful" or reported being "very satisfied" in 2018 than in 2016, instead downgrading the rating to just "useful" or "satisfied."

Figure 6. Households' ratings of advice received, percentages, 2016 and 2018



Source: IFPRI household surveys (2016, 2018).

4. Regression Analysis

4.1. Effects of extension advice on awareness and adoption of technologies

The regression analysis focuses on the effects of (1) different measures of agricultural information access, (2) two indicators of labor availability, and (3) the government fertilizer subsidy on the awareness and adoption of the major climate-smart agricultural practices being promoted, controlling for household-level, community-level, soil-related, and climate-related factors. We see a strong positive effect of extension services receipt on farmers' awareness of technologies being promoted, but no effect on farmers' adoption of most of the technologies being promoted (Table 1). This is consistent across different estimation methods, time periods of extension receipt, and technologies (Tables 1–3). The only exceptions are a significantly negative effect on minimum tillage and water management adoption, and a significantly positive effect on the likelihood of organic fertilizer use and crop residue incorporation (Tables 1–3). For minimum tillage, receipt of extension is significant and negative (3–5 percent) in the likelihood-of-adoption model (binary variable), although not significant in the intensity-of-adoption model (percentage of acreage in which the practice was adopted) (Table 4). This means that farmers receiving extension services were less likely to adopt minimum tillage, even though they were aware of or knowledgeable about the technology. There is also a negative effect of water management advice received in the last 12 months on the likelihood of adoption (4 percent), but no significant effect on the intensity of adoption.

Table 1. Effects of receipt of extension advice on the likelihood of awareness and adoption of sustainable agricultural practices

Variable	Soil cover (=1)		Minimum tillage (=1)		Intercropping (=1)		Pit planting (=1)	
	Aware	Adopted	Aware	Adopted	Aware	Adopted	Aware	Adopted
Extension advice received in the last 12 months (=1)	**0.134***** **(0.019)**	**-0.011** **(0.027)**	**0.017** **(0.020)**	**-0.033**** **(0.016)**	**0.044**** **(0.021)**	**-0.018** **(0.021)**	**0.095***** **(0.019)**	**-0.028** **(0.022)**
Household characteristics								
Head education	0.013	-0.022	0.001	-0.024	0.047**	-0.014	0.008	0.019
	(0.019)	(0.028)	(0.019)	(0.016)	(0.021)	(0.023)	(0.018)	(0.022)
Head age	0.000	-0.004	-0.003	-0.013*	-0.005	-0.003	0.004	-0.016
	(0.008)	(0.012)	(0.008)	(0.008)	(0.008)	(0.013)	(0.007)	(0.012)
Male head (=1)	0.254	-0.043	0.222	0.049	0.225	0.081	0.199	-0.015
	(0.157)	(0.172)	(0.155)	(0.132)	(0.165)	(0.212)	(0.159)	(0.174)
Household size	0.002*	0.019*	0.035***	-0.001	-0.008	0.001	-0.003	0.008
	(0.007)	(0.010)	(0.008)	(0.006)	(0.008)	(0.008)	(0.007)	(0.007)
Asset quintile (reference=1st or poorest quintile)								
2nd asset quintile	(0.014)	0.017	0.032	-0.013	0.068**	-0.046	0.053*	-0.001
	(0.029)	(0.042)	(0.030)	(0.028)	(0.031)	(0.030)	(0.029)	(0.032)
3rd asset quintile	-0.067*	0.013	0.043	-0.007	0.068*	0.023	0.046	0.009
	(0.037)	(0.052)	(0.038)	(0.034)	(0.040)	(0.038)	(0.037)	(0.041)
4th asset quintile	-0.101**	-0.007	0.015	-0.033	0.006	-0.070	0.083**	0.049
	(0.042)	(0.055)	(0.043)	(0.036)	(0.044)	(0.044)	(0.041)	(0.043)
5th asset quintile	(0.074)	0.027	0.017	-0.036	0.009	-0.085*	0.061	0.095**
	(0.046)	(0.061)	(0.048)	(0.037)	(0.049)	(0.048)	(0.045)	(0.047)
Number of organizations joined	0.021*** (0.005)	0.011** (0.005)	0.010* (0.006)	0.002 (0.003)	0.029*** (0.006)	0.014*** (0.005)	0.029*** (0.005)	0.003 (0.004)
FISP fertilizer used on any plot (rainy) (=1)	0.014 (0.022)	0.034 (0.029)	-0.016 (0.023)	0.008 (0.016)	0.000 (0.024)	-0.024 (0.024)	-0.065*** (0.022)	-0.018 (0.023)
Ganyu labor (person-days per acre)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.001 (0.001)
Crop acreage	(0.002)	0.049**	0.012	0.003	-0.007	-0.135***	-0.016	0.001
	(0.009)	(0.019)	(0.012)	(0.009)	(0.017)	(0.010)	(0.015)	(0.016)
Crop acreage squared	0.000	-0.003**	0.000	0.001	0.000	0.000***	0.000	-0.002
	(0.000)	-0.001	(0.001)	(0.001)	-0.002	0.000	-0.001	-0.001
Community-level controls	YES	YES	YES	YES	YES	YES	YES	YES
Soil type controls	YES	YES	YES	YES	YES	YES	YES	YES
Climate-related controls	YES	YES	YES	YES	YES	YES	YES	YES
Constant	1.772	-16.117***	4.856**	-25.328***	-9.557***	-5.833	-14.509***	-29.756***
	(2.543)	(4.844)	(2.417)	(6.816)	-2.283	-5.068	-2.712	-6.631
Observations	5172	2961	5172	2840	5172	2961	5172	2113

Variable	Soil cover (=1)		Minimum tillage (=1)		Intercropping (=1)		Pit planting (=1)	
	Aware	Adopted	Aware	Adopted	Aware	Adopted	Aware	Adopted
Log likelihood	-3047.9043	-947.188	-3099.799	-665.167	-3209.342	-1221.836	-3000.836	-600.530
Wald chi2(57)	524.940	112.400	543.430	103.240	536.410	151.390	526.170	116.100
Prob > chi2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Source of raw data: IFPRI household and community surveys (2016, 2018).
Note: FISP = Farm Input Subsidy Programme. Estimated using correlated random effects and the *xtlogit* command in Stata for binary responses as outcome variables. Adoption models are conditional on awareness. Various household-level, community-level, soil type, and climate-related variables were used as controls in the models; see their descriptive statistics in Table A.1. Figures are the marginal effects, and those in parentheses are the standard errors. Significant at *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table 2. Effects of extension advice received in the last 12 months on the likelihood of awareness and adoption of other sustainable agricultural practices

Climate-smart practice	Aware (=1)	Adopted (=1)
Water management (=1)	0.095***	-0.045*
	(0.016)	(0.028)
Crop residue (=1)	0.093***	0.052*
	(0.020)	(0.028)
Composting (=1)	0.042**	
	(0.020)	
Manure making (=1)	0.121***	
	(0.026)	
Organic fertilizer use (=1)		0.058***
		(0.019)

Source of raw data: IFPRI household and community surveys (2016, 2018).
Note: Estimated using correlated random effects and *xtlogit* command in Stata for binary response as outcome variables. Significant at $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

Table 3. Marginal effects of extension advice received in the last 2 years on the likelihood of awareness and adoption of sustainable agricultural practices

Climate-smart practice	Aware (=1)	Adopted (=1)
Soil cover (= 1)	0.149***	0.048
	(0.025)	(0.041)
Minimum tillage (= 1)	0.023	-0.047*
	(0.024)	(0.024)
Intercropping (= 1)	0.050**	-0.050
	(0.025)	(0.026)
Pit planting (= 1)	0.058**	(0.051)
	(0.024)	(0.031)
Water management (= 1)	0.120***	(0.021)
	(0.022)	(0.042)
Crop residue (= 1)	0.066***	0.017
	(0.024)	(0.036)
Composting (= 1)	0.094***	
	(0.023)	
Manure making (= 1)	0.140***	
	(0.020)	
Organic fertilizer use (= 1)		0.074***
		(0.023)

Source of raw data: IFPRI household and community surveys (2016, 2018).
Note: Estimated using correlated random effects and *xtlogit* command in Stata for binary response as outcome variables. Significant at $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

Table 4. Effects of extension advice receipt on the intensity of technology adoption and crop diversification

Practice	Marginal effect of extension received in last 12 months on adoption			
	(1) FE, linear	(2) RE, linear	(3) CRE, linear	(4) CRE, fractional
Soil cover	0.003	-0.001	0.003	-0.001
	(0.031)	(0.014)	(0.020)	(0.023)
Minimum tillage	-0.014	-0.008	-0.019*	-0.019
	(0.014)	(0.007)	(0.010)	(0.013)
Intercropping	-0.015	0.004	-0.003	-0.005
	(0.024)	(0.014)	(0.019)	(0.023)
Pit planting	0.004	(0.008)	(0.003)	(0.028)
	(0.024)	(0.011)	(0.011)	-0.018
Water management	0.015	-0.014	-0.020	-0.023
	(0.036)	(0.014)	(0.019)	(0.021)
Crop residue incorporation	0.059*	0.036**	0.046*	0.047*
	(0.033)	(0.017)	(0.025)	(0.028)
Organic fertilizer	0.055***	0.066***	0.054***	0.055***
	(0.016)	(0.012)	(0.016)	(0.019)
Crop Diversification /a	0.008	0.024***	0.012	0.013
	(0.008)	(0.006)	(0.008)	(0.019)

Source of raw data: IFPRI household and community surveys (2016, 2018).
Note: FE = fixed effects; RE = random effects; CRE = correlated random effects. [a] Crop diversification index. Models 1-3 were estimated using the *xtreg* command in Stata, conditional on awareness. Model 4 were estimated using a generalized estimating equation via *xtgee* for fractional response, conditional on awareness (including only those who were aware of the specific technology). Figures are the marginal effects, and those in parentheses are the standard errors. Various household-level, community-level, soil type, and climate-related variables were used as controls in the models; see their descriptive statistics in Table A.1. Significant at $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

In terms of intensity of adoption, extension advice received in the last 12 months continues to have a positive effect on the percentage of acreage using organic fertilizer, a positive effect for advice on crop residue incorporation received in the last 12 months, and no effect on the percentage of acreage using minimum tillage and water management (Table 4). Extension services received in the last 12 months have a 5 percent effect on the likelihood of adopting crop residue incorporation, and such services increase the intensity of adoption by 4–6 percent (but there is no effect for receipt of advice in the last 2 years) (Tables 2 and 3).

Table 5 summarizes the main results on the relationship that extension advice receipt has with awareness and adoption of technologies. Extension advice on all practices except minimum tillage was highly significant, contributing a 4–14 percent higher likelihood of awareness of these practices. However, there was no effect on the adoption of most technologies promoted; we see a positive effect on adoption of only crop residue incorporation and organic fertilizer use. Receipt of advice on crop residue incorporation in the last 12 months increased the likelihood of adoption by 5 percent and increased the intensity of adoption by 4–6 percent. Receipt of advice on organic fertilizer use in the last 12 months increased the intensity of adoption by 5–8 percent; receipt of advice in last 2 years had a 7–8 percent positive effect on intensity.

Table 5. Summary of results on the effect of extension advice receipt on the awareness and adoption of sustainable agricultural practices

Practice	Awareness (=1)[a]	Adoption (=1)[b]
Soil cover	Receipt of advice in the last 12 months increases the likelihood by 13%; advice in the last 2 years, 15%	No effect
Minimum tillage	No effect	Negative effect (3%–5%) on the likelihood of adoption, but no effect on the intensity of adoption
Intercropping	Receipt of advice in last 12 months increases likelihood of awareness by 4%; advice in last 2 years, 5%	No effect
Pit planting	Receipt of advice in the last 12 months increases the likelihood of awareness by 9%; advice in the last 2 years, 6%	No effect
Water management	Receipt of advice in the last 12 months increases the likelihood of awareness by 10%; advice in the last 2 years, 12%	Negative effect (4%) only for advice received in the last 12 months; but no effect for advice received in the last 2 years and no effect on the intensity of adoption
Crop residue incorporation	Receipt of advice in the last 12 months increases the likelihood of awareness by 9%; advice in the last 2 years, 7%	Receipt of advice in the last 12 months increases likelihood of adoption by 5% and increases intensity of adoption by 4%–6% (no effect for receipt of advice in the last 2 years)
Organic fertilizer	Composting pits: Receipt of advice on composting in the last 12 months increases likelihood of awareness by 4%; receipt of advice in the last 2 years, 9% Fertilizer or manure making: Receipt of advice on composting in the last 12 months increases likelihood of awareness by 12%; receipt of advice in the last 2 years, 14%	Receipt of advice in last 12 months increases intensity of adoption by 5%–7%; receipt of advice in last 2 years, 7%–8% effect in intensity
Crop diversification		No effect

Source of raw data: IFPRI household and community surveys (2016, 2018).
Note: Shaded cell was not modeled. [a] based on Tables 1–3; [b] based on Tables 1–4.

For most practices, the education level of the household head was not significant (Table 1). The only time it was significant was in the model explaining the likelihood of awareness of intercropping. The age and gender of the household head were not significant in explaining awareness or adoption of any practices. Asset quintiles also were not significant in most practices. The exceptions were pit planting and water management, in which the richest quintile had greater likelihood of adoption than the poorest quintile, but the situation was the opposite for intercropping. We see a highly significant effect of the number of groups or associations a farmer is a member of on the likelihood of awareness of all of the technologies promoted, and on the likelihood of adoption of soil cover and intercropping.

In terms of our two indicators on labor availability, household size is significant in explaining adoption of soil cover and awareness of minimum tillage. Hired labor (*ganyu*) is not significant in any of our models of awareness and adoption of any management practice. This is different from the picture depicted by the FGDs, which indicated that several practices, such as soil cover and pit planting, are labor-intensive, which tends to discourage farmers from adopting them. In our nationally representative dataset, we do not see any statistical effect of labor availability indicators on the adoption of soil cover and pit planting.

We do not see any effect of input subsidy receipt on the likelihood of either awareness or adoption of any of the technologies. We generally see no effect of the amount of land cultivated on the likelihood of awareness or adoption of technologies promoted, except for a nonlinear relationship between land cultivated and soil cover adoption and an opposite nonlinear relationship between land cultivated and intercropping adoption. That is, farmers with very small crop acreages were less likely to adopt soil cover and those with very large crop acreages were more likely to adopt intercropping.

4.2. Heterogeneous effects by source and method

In terms of the source of information, government, NGO, and radio extension advice together are the main contributor of greater awareness of most practices being promoted. Table 6 reveals that, for soil cover, extension advice received from the government, NGOs, lead farmers, and radio in the last 12 months all had a positive effect on the likelihood of awareness. For minimum tillage, lead farmer extension advice (received in the last 12 months) had a negative effect on the likelihood of awareness. For intercropping, NGO extension advice received in the last 12 months had a positive effect on the likelihood of awareness, whereas extension advice from other farmers in the last 12 months had a negative effect on the likelihood of awareness. For pit planting, extension advice received from the government, NGOs, and radio in the last 12 months had a positive effect on the likelihood of awareness, and other-farmer extension in the last 12 months had a small positive effect on the likelihood of awareness. As seen in Table 7, for water management, several sources contributed to greater likelihood of awareness, including government, NGOs, radio, and other farmers. For crop residue incorporation, NGO and SMS extension advice received in the last 12 months had a positive effect on awareness. Government extension advice received in last 12 months had a positive effect on awareness of crop residue incorporation.

Table 6. Effects of extension advice receipt by source on the likelihood of technology awareness and on the adoption of major agricultural practices

	Soil cover		Minimum tillage		Intercropping		Pit planting	
Source of advice	Aware (= 1)	Adopted (= 1)	Aware (= 1)	Adopted (= 1)	Aware (= 1)	Adopted (= 1)	Aware (= 1)	Adopted (= 1)
Government	0.074***	0.008	0.010	-0.044***	-0.018	-0.034	0.059***	(0.034)
	(0.022)	(0.027)	(0.023)	(0.016)	(0.024)	(0.023)	(0.021)	(0.022)
NGO	0.069**	-0.089***	0.045	0.004	0.102***	(0.028)	0.066**	0.015
	(0.029)	(0.032)	(0.032)	(0.017)	(0.032)	(0.030)	(0.028)	(0.025)
Lead farmer	0.086**	0.011	-0.080*	(0.005)	0.007	(0.011)	0.028	0.036
	(0.042)	(0.048)	(0.044)	(0.025)	(0.044)	(0.046)	(0.040)	(0.037)
Other farmer	-0.00145	(0.009)	-0.026	(0.040)	-0.073**	-0.086***	0.058*	(0.004)
	(0.032)	(0.041)	(0.034)	(0.026)	(0.034)	(0.033)	(0.031)	(0.038)
Radio	0.085***	0.048*	-0.030	0.026	0.023	-0.001	0.064***	0.019
	(0.023)	(0.029)	(0.024)	(0.017)	(0.025)	(0.023)	(0.023)	(0.024)
Phone/SMS	(0.068)	0.047	0.054	0.041	0.087	-0.032	(0.041)	0.036
	(0.064)	(0.063)	(0.076)	(0.040)	(0.076)	(0.056)	(0.062)	(0.055)

Source of raw data: IFPRI household and community surveys (2016, 2018).
Note: NGO = nongovernmental organization; SMS = short message service. Models were estimated using the *xtreg* command in Stata; adoption models were estimated conditional on awareness. Figures are the marginal effects, and those in parentheses are the standard errors. Various household-level, community-level, soil-related, and climate-related variables were used as controls in the models; see their descriptive statistics in Table A.1. Significant at $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

Table 7. Effect of extension advice receipt, by source, on the likelihood of technology awareness and adoption of other agricultural practices

	Water management		Crop residue incorporation		Composting	Manure making	Organic fertilizer
Source of advice	Aware (= 1)	Adopted (= 1)	Aware (= 1)	Adopted (= 1)	Aware (= 1)	Aware (= 1)	Adopted (= 1)
Government	0.045***	0.012	0.039**	(0.022)	0.073	0.096***	0.143
	(0.017)	(0.029)	(0.023)	(0.032)	(0.119)	(0.023)	(0.122)
NGO	0.060***	0.023	0.080**	0.014	0.684***	0.060**	0.055
	(0.018)	(0.028)	(0.031)	(0.040)	(0.165)	(0.030)	(0.162)
Lead farmer	0.029	0.014	(0.069)	0.037	0.054	0.011	0.455*
	(0.023)	(0.034)	(0.043)	(0.059)	(0.228)	(0.043)	(0.233)
Other farmer	0.057***	(0.042)	(0.008)	(0.041)	0.119	(0.004)	0.224
	(0.018)	(0.030)	(0.034)	(0.046)	(0.170)	(0.033)	(0.177)
Radio	0.029*	(0.029)	(0.011)	0.113**	-0.251**	0.099***	0.089
	(0.017)	(0.027)	(0.025)	(0.048)	(0.126)	(0.024)	(0.129)
Phone/SMS	(0.003)	0.073	0.144*	(0.052)	(0.103)	(0.073)	0.287
	(0.035)	(0.049)	(0.077)	(0.083)	(0.402)	(0.067)	(0.354)

Source of raw data: IFPRI household and community surveys (2016, 2018).
Note: NGO = nongovernmental organization; SMS = short message service. Models were estimated using the *xtreg* command in Stata, conditional on awareness. Figures are the marginal effects, and those in parentheses are the standard errors. Various household-level, community-level, soil-related, and climate-related variables were used as controls in the models; see their descriptive statistics in Table A.1. Significant at $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

In terms of adoption, although we do not see effects of extension advice receipt on either likelihood or intensity of adoption in most technologies, we see some significant heterogeneous effects by source and delivery method. Table 8 presents the results summary, and we see that each practice has its own contributor toward greater adoption. For soil cover, NGO extension advice has a negative effect, whereas lead farmer extension advice (received only in the last 2 years) has a positive effect on both likelihood and intensity of adoption. For crop residue incorporation, radio extension (received only in the last 12 months) has a positive effect on both likelihood and intensity, and other-farmer extension (received only in the last 2 months) has a positive effect on intensity but not on likelihood. For organic fertilizer use, government and lead farmer extension advice have positive effects on both likelihood and intensity, whereas other-farmer extension advice has an effect only on intensity of adoption.

Table 8. Summary of effects of extension advice by source and delivery method on the likelihood of awareness, likelihood of adoption, and intensity of adoption of major agricultural practices

Practice	**Effect of extension advice on likelihood of awareness**[a]	**Effect of extension advice by source on likelihood and intensity of adoption**[b]	**Effect of extension advice by delivery method on likelihood and intensity of adoption**[b]
Soil cover	Government, NGO, radio, and lead farmer extension have + effect	NGO extension advice has - effect; lead farmer extension advice (only in the last 2 years) has + effect	No effect
Minimum tillage	No effect	Government extension received (only in last 12 months) has - effect	No effect
Intercropping	NGO extension has + effect	Other farmer has - effect (in dummy and acreage in last 2 years, but not in last 12 months)	Radio has - effect
Pit planting	Government, NGO, and radio extension have + effect	No source has effect	No method has effect
Water management	Government, NGO, radio, other farmers have + effect	Government (only in last 12 months) has - effect	Face-to-face visits have - effect in some models
Crop residue incorporation	NGO extension and phone/SMS have + effect	Radio extension (only in last 12 months) has + effect on both likelihood and intensity; other-farmer extension (only in last 12 months) has + effect on intensity but not likelihood	Farmer field day has - effect; radio has + effect in some models
Organic fertilizer	NGO has + effect on likelihood of awareness of composting and manure making; government extension and radio have some + effect (although not consistent)	Government and lead farmer have + effect on both likelihood and intensity; other farmer has + effect on intensity	Face-to-face visits have + effect in some models
Crop diversification		No effect	Radio has + effect (in most models but not fractional logit)

Source of raw data: IFPRI household and community surveys (2016, 2018).
Note: Shaded cell was not modeled. NGO = nongovernmental organization; SMS = short message service; + = positive effect; - = negative effect. [a] based on Tables 6–7; [b] based on Tables 6–7 and A.1–A.19.

5. Insights from the interviews and focus group discussions

We discuss the main messages from the results and their implications on technology relevance, the role of extension advice, and the relative effectiveness of different sources and methods of extension provision to rural communities.

5.1. What agricultural practices are valued by the farmers?

The FGDs asked participants to identify, out of the technologies and practices being promoted that had been adopted, which were the three most valuable, and why. FGD results show that farmers most value the technologies promoted by the Sasakawa Africa Association in its Sasakawa Global 2000 project, including proper and timely planting, proper spacing, and proper planting densities. Farmers reported that, in a Sasakawa field, the crop grows well and remains healthy, and this translates to high yields. Sasakawa also allows farmers to harvest a lot on a small piece of land.

Fertilizer or manure making and using organic fertilizer in plots are consistently mentioned. Manure serves as an alternative to fertilizer because many farmers cannot afford commercial fertilizer. In the communities, manure making was described in two different ways. In the first method, farmers mix together animal dung, maize bran, ash, fertilizer, and water, and then wrap the mixture with plastic and allow it to decompose. The other method is that of making compost manure. In this method, farmers dig a pit and bury a mixture of kitchen waste, cow dung, crop residues, and water. This is left to rot before it is used in the field. Manure has the advantages of keeping moisture in the soil and improving its fertility. Applying manure increases yields.

Other practices that are valued are minimum tillage. Several respondents said, *"It keeps moisture. You don't use a hoe and if there are weeds you just remove them using hands"* and *"It improves soil fertility because of the covers on the soil."*

Agroforestry is also mentioned in the FGDs. A respondent said, *"The benefit of planting trees is that when heavy rains fall, there is not much flooding and also when trees grow we sell them to earn some money…. they [extension workers] tell us that we should be planting the tree seedlings in our gardens in order to add fertility to the soil to improve growth of our crops since most of us cannot afford fertilizer because we are poor."*

5.2. What practices are challenging according to farmers?

Technologies mentioned that are promoted but challenging for farmers are (1) conservation agriculture (particularly soil cover or mulching and minimum tillage) and (2) pit planting. For minimum tillage, FGD respondents perceived it to be less labor-intensive initially but to make weeding more difficult, with the result that they might end up spending more time weeding. For soil cover and pit planting, FGD respondents perceived them to be labor-intensive; further, the pits and plots with soil cover were perceived to create waterlogging with excessive rain. FGD participants also mentioned inadequate information or conflicting messages given to them on the size and dimensions of pits and the right amount of mulch and soil cover. Others mentioned that there was not enough soil cover or mulch to use. Additionally, mulching is not commonly adopted because it harbors pests that can attack the crop.

> *"... we need to remove mulching because it's tiresome [and] hence many people do not practice it, and to say the truth, in our village no one has ever done it." Female respondent, Mchinji, remote community*

All of these perceptions about the technology imply a need to intensify training and engagement with the farmers, possibly including demonstrations so that farmers develop favorable perceptions about the technology.

With the multiple sources of information available to farmers, there are bound to be contradictions in the messages that are delivered. In the case of minimum tillage, for instance, the low adoption and negative effect of extension services on adoption may be due to confusion among famers because minimum tillage was heavily promoted in the 1990s, and then the emphasis changed to using ridges later (Brown et al. 2017; personal communication with George Vilili, Farm Radio Trust). Now, messaging is going back to minimum tillage. From the FGDs, it is apparent that there is some confusion among farmers on the different agricultural practices being promoted. Therefore, strong coordination and harmonization of messages from various sources is very important for improved delivery of quality extension services.

"… most of us here like intercropping, planting maize together with the beans. According to the extension messages we receive, they discourage planting maize together with the beans because it encourages the competition and so the maize cannot do better than when you plant the crop alone. Considering that most people want to intercrop because of the benefit of beans in providing the relish, most people get discouraged to practice 1-1 planting. They instead shun 1-1 and intercrop." Male respondent, Chitipa, remote community

"On the radio, [as for] issues in agriculture like conservation agriculture, we are told that we should be leaving the maize stems to decompose in our fields to increase fertility, [but] there is a diverging opinion that the decomposition of the maize stems gives birth to some worms which are pests, so that is somehow confusing to the farmer." Male respondent, Kasungu, remote community

"We just heard about conservation agriculture, but we really do not know much about it… we have not tried it …. We have not seen any demonstration on how it is done and how we will benefit from it" Male respondent, Chitipa, remote community

"This lack of adoption is simply lack of interest … because with 1-1 planting, you can't use ridges which are very far apart, but they need to be close to each other, so availability of fertilizer is not easy. When you have planted 1-1 per station, whether you like or not, you are supposed to get three bags of fertilizer per 1 acre to harvest more yield." Female respondent, Balaka, central community

What is clear is the need for regular communication and engagement between farmers, service providers, and researchers to sort out misperceptions, co-learn from experiences on these technologies, and co-motivate in terms of the value of the technology. Recent evidence has suggested that failure of actors to co-innovate can lead to nonadoption of agricultural technologies or practices (Mikwamba, Dessein, and Kambewa 2020). Mikwamba, Dessein, and Kambewa (2020) showed that research and extension experts continue to resort to blaming farmers if the farmers disregard scientific knowledge in their practices. Our results show that extension advice often has no effect on adoption (and even a negative effect on the adoption of a few practices). The results of Mikwamba, Dessein, and Kambewa (2020) imply that this may likely be because some experts (providers of extension advice) do not constructively pay attention to farmers' attitudes, knowledge, and experiences regarding these management practices.

Microeconomic studies often start with a notion of improved technologies, with the implicit assumption that the technologies are "improved," but often do not offer a description or explanation for why they are considered "improved," or any test for whether they indeed represent an improvement over the status quo or alternatives. Central to the notion of technology adoption are the expected net benefits compared with the status quo or alternatives. Aside from being location-specific, valuation of the benefits and costs of technologies can be subjective and may depend on individual preferences, aspirations, and attitudes toward risk. Thus, rigorous valuation is challenging but at the same time important. Even when technologies have been shown to have early positive impacts, pilot or early-stage implementation of promoted technologies largely engages well-off farmers and is not representative of the farming community (Haile et al. 2016). For example, strong self-selection and selection bias were found in the participatory action research under the Africa RISING (Research in Sustainable Intensification for the Next Generation) project in Malawi (Haile et al. 2016). Duflo, Kremer, and Robinson (2008) also highlighted that returns on fertilizer use are often high in experimental trials but much lower in actual farmers' fields, where farmers are constrained by less ideal conditions. Therefore, we need a thorough review of these technologies and practices, in terms of where and when they can contribute and be promoted within integrated farming system and value chain perspectives, rather than promoting technologies piecemeal.

5.3. Which extension sources and delivery methods are valued by farmers?

Both survey data and FGDs consistently show that government agricultural extension workers remain the most important source of information to the farmers. They are considered valuable because they are educated and so trusted by the farmers, and farmers see the benefits when they practice what the government agricultural extension workers teach. This was the case across all the communities.

"We trust them because it is their job; they went to school to learn about the job, so we believe in their work, and when we put into practice whatever we learn from them we see that it is beneficial to us." Female respondent, Mangochi, central community

The government extension workers visit the farmers in groups and have demonstration plots where the farmers can see and practice what they have been taught before doing it in their fields. So the farmers learn effectively by doing. However, most remote communities reported that the extension workers visit rarely. In such communities, lead farmers provide agricultural information to the farmers almost daily in small groups or individually.

Farmers also mentioned NGOs and radio as important sources of agricultural information. NGOs are considered important because they fulfill their promises and farmers see results in the work that they do. However, these NGOs are concentrated in more central communities, rather than in more remote ones, and funding is not sustainable. When their projects end, all activities also cease. Radio is considered an important source of information because the farmers can learn what other different areas are doing. Because some NGOs, lead farmers, and government extension workers target people in groups, radio also gives an opportunity to people who are not in groups to get agricultural information. Information on the radio is in the form of a discussion, which makes it interesting to listen to while learning. Information from the radio can be accessed daily or weekly.

A respondent in a focus group discussion said, "*We learn a lot of things from the radio. We discuss in the group; and everybody does it in his/her home, and also when it's time, they tell how to take care of crops...."* Another respondent said, *"They tell us that we should not store our produce in moist places.... when it's close to rainy season, we are able to know the amount of rains that we will receive and which crops to plant depending on the amount of rainfall expected in a particular year."* Another respondent said ,*"We rely on the radio a lot as they tell us how the weather is like in conjunction to our farming. They also tell us what to be doing in farming regarding to the weather. We listen during Tuesdays and Friday as a group."*

Radio is the first source of market information, which is not as easily accessible to the farmers as is agricultural information. It is an important source because farmers can hear about prices in other areas, although they may not access such markets. Government extension workers, a second important source of market information, also encourage farmers to form cooperatives through which they can easily find markets for their produce. Vendors or traders and mobile phones are also sources of market and price information although market access by farmers is still a challenge.

5.4. What extension sources and delivery methods are most effective?

We combine various data and summarize effectiveness based on a set of criteria including national coverage (Figures 4–5), farmers' perception of a source's or method's usefulness and relevance (Figure 6 and FGD discussion above), effects on technology awareness (Tables 1–3, 5, and 8), and effects on technology adoption (Tables 1–8). Extension services from government, NGOs, and radio programming have the most coverage, are considered most useful and relevant, and also make the strongest contribution to greater awareness of most technologies being promoted (Table 9). Ideally, combining these three would yield the greatest effect on technology awareness. In areas where government and NGO extension workers are not available, radio programming can be a cost-effective tool for the broad-based promotion of climate-smart agricultural practices.

Table 9. Indications and comparison of effectiveness of different extension sources, based on various indicators of effectiveness

Source	Coverage (HH survey)[a]	Usefulness (HH survey)[b]	Usefulness (FGD)[c]	Technology awareness (HH survey)[d]	Technology adoption (HH survey)[d]	Crop diversification (HH survey)[d]
Government extension	*****	****	******	****	*	
Radio	*****	****	****	****	*	*
NGO extension	***	****	***	******		
Other farmer	**	***		**	***	
Lead farmer	*	****	**	*	*	
Mobile phone/SMS	*	****		*		
Private sector	*	***				

Source of raw data: IFPRI household and community surveys (2016, 2018).
Note: FGD = focus group discussion; HH = household; NGO = nongovernmental organization; SMS = short message service. The greater the number of asterisks, the greater the effect and the greater the statistical significance of the effect on awareness or adoption of technologies, based on [a] Figures 4–5; [b] Figure 6; [c] first part of Section 5, Insights; [d] Tables 5 and 8.

In terms of adoption, radio seems to consistently help in promoting crop diversification and intensity of adoption of crop residue incorporation, but not any of the other technologies (Tables 9–10). Across the different technologies, it seems that other farmers can induce greater impact on adoption. In terms of delivery methods, farm demos, farmer field days, print materials, and community/group meetings help in the intensity of adoption, appearing significant and positive in a few models although their effects are not consistent in all estimation models (Table 10).

Table 10. Indications and comparison of effectiveness of different extension methods, based on various indicators of effectiveness

Method/approach	Coverage (HH survey)[a]	Usefulness (HH survey)[b]	Usefulness (FGD)[c]	Technology awareness (HH survey)[d]	Technology adoption (HH survey)[d]	Crop diversification (HH survey)[d]
Community/group meetings	******	****	***	**	**	
Radio	******	****	****	**	**	**
Face-to-face visits	****	****	*****	***	*	
Farm demo	***	****	*****	*	**	
Lead farmer	***	****	*			
VAC/GAC	**	****		*	*	
Farm field day	**	****		*	*	
Print materials	*	****		***	*	

Source of raw data: IFPRI household and community surveys (2016, 2018).
Note: FGD = focus group discussion; GAC = group-village agricultural committee; HH = household; VAC = village agricultural committee. The greater the number of asterisks, the greater the effect and the greater the statistical significance of the effect on awareness or adoption of technologies, based on [a] Figures 4–5; [b] Figure 6; [c] first part of Section 5, Insights; [d] Tables 5 and 8.

6. Discussion and Concluding Remarks

This paper aims to contribute to understanding the low adoption of agricultural technologies, particularly low-cost and sustainable agricultural management practices, being promoted among smallholder farmers. Financial and credit constraints have been well cited in the literature as major bottlenecks in the adoption of external inputs and several agricultural technologies, but a puzzle remains as to why low-cost management practices are not well adopted. Our results show that receipt of extension services has contributed to improved awareness and knowledge of different sustainable management practices being promoted. However, when we control for awareness, receipt of extension services from any source does not contribute to greater adoption of most management practices being promoted, and this is consistent across all models estimated. The only technologies for which we see some positive effect of extension advice are crop residue incorporation and organic fertilizer use. Heterogeneous effects by source of extension services or delivery method can explain a bit of the puzzle. Government and other farmers (and to some extent lead farmers) contribute to organic fertilizer adoption. Radio extension and other farmers help in promoting the intensity of adoption of crop residue incorporation and crop diversification. Across the different technologies, advice from other farmers is associated with greatest impact on adoption, consistent with Bell et al. (2018) and Ward et al. (2016). In terms of delivery methods, farm demos, farmer field days, print materials, and community/group meetings help in the intensity of adoption, appearing significant and positive in most models.

Extension services and awareness campaigns play a major role in making agricultural practices known and igniting demand and interest from the rural communities. Across all practices examined and adopting a set of criteria for evaluating effectiveness, government and NGO extension services and radio messaging to farmers have the most coverage, are considered most useful and relevant, and also make the strongest contribution to greater awareness of most technologies being promoted. Ideally, combining these three methods would yield the greatest effect on technology awareness, but, in areas where government and NGO extension workers are not available, radio programming can be a cost-effective tool for the broad-based promotion of climate-smart agricultural practices. Because traditional extension services are either very expensive or not accessible, new and more efficient models of innovation delivery have to be sought and implemented on a wider scale. Such new delivery models should build on existing social structures and networks at community levels to induce better outcomes. Moreover, to reduce outreach costs, greater use of modern information and communication tools, particularly radio, could potentially be made to induce broad-based awareness and exposure.

It seems that extension services can help only in the general awareness of the technologies, but the current state of extension service provision does not clearly encourage adoption of most agricultural practices. Some evidence points to the importance of the quality of information provision and communication. The FGDs presented in this paper clearly show different perceptions and misperceptions by farmers on these technologies, even when neither they nor anybody in their community has adopted them because of the lack of deep understanding of these technologies. Niu and Ragasa (2018) reported substantial information loss along the knowledge chain in Malawi and that the majority of information loss happens at the researcher–to–extension agent link and the extension agent–to–lead farmer link, indicating weak training and learning among extension agents and lead farmers. The results of Ragasa and Mazunda (2018) also show that providing generalized outreach is not enough, but the advice to farmers must be locally tailored to be effective. This implies the need for more intensive and interactive engagement between farmers and service providers to change perceptions and behaviors toward adoption and adaptation.

The present study also does not find any effect of fertilizer subsidy on the adoption of practices being promoted. While recent studies continue to provide strong evidence of the importance of external support (cash, inputs, or both) on adoption of sustainable management practices (Amadu, McNamara, and Miller 2020; Ambler, de Brauw and Godlonton et al. 2018; Bell et al. 2018; Ward et al. 2016, 2018), our results suggest that the adoption of sustainable management practices is less sustainable when external support is provided. Our study chose and analyzed low-cost technologies with low requirements for external inputs. So the external support seems less plausible. A more plausible explanation is to look at the nature of the practices themselves within the farming system perspective and how they are addressing issues of low productivity and incomes over time.

This paper makes some contributions to understanding the level of technology adoption nationwide and the role of extension services, as well as input subsidy to some extent, as contributing or constraining factors. Nevertheless, it remains unclear how much of the nonadoption is due to farmers' perception or misperception of different dimensions of sustainable agricultural management practices, how much is due to the nature of the technology itself, and how much is due to limited rationality on the part of the farmers. This is an area that deserves further and careful examination. In the meantime, these unknowns can be managed through regular communication and engagement between farmers, service providers, and researchers to sort out misperceptions, co-learn from experiences on these technologies, and co-motivate in terms of the long-term value of the technology.

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Appendix

Table A.1 Descriptive statistics of variables used

Variable	Definition	2016 (N = 2,938)		2018 (N = 2,776)	
		Mean	Std. Dev.	Mean	Std. Dev.
Outcome variables					
Awareness (= 1)	Any one of the household primary decision makers is aware or knowledgeable of [Practice]				
Soil cover		0.34	0.47	0.50	0.50
Minimum tillage		0.50	0.50	0.59	0.49
Intercropping		0.47	0.50	0.83	0.46
Crop residue incorporation		0.52	0.50	0.69	0.46
Water management		0.13	0.34	0.32	0.47
Pit planting		0.33	0.47	0.50	0.50
Composting pits		0.55	0.50	0.76	0.43
Manure or fertilizer making		0.44	0.50	0.40	0.49
Adoption (= 1)	Any one of the household primary decision makers adopts [Practice] on his/her farm(s)				
Soil cover		0.16	0.37	0.12	0.32
Minimum tillage		0.07	0.25	0.06	0.24
Intercropping		0.63	0.48	0.83	0.37
Crop residue incorporation		0.29	0.45	0.41	0.49
Water management		0.02	0.13	0.07	0.25
Pit planting		0.08	0.28	0.06	0.24
Organic fertilizer		0.45	0.50	0.54	0.50
Intensity of adoption (%)	% of total crop acreage				
Soil cover		0.12	0.30	0.08	0.24
Minimum tillage		0.04	0.18	0.04	0.16
Intercropping		0.49	0.44	0.58	0.41
Crop residue incorporation		0.24	0.40	0.31	0.42
Water management		0.01	0.09	0.05	0.19
Pit planting		0.06	0.21	0.04	0.18
Organic fertilizer		0.32	0.41	0.37	0.41
Crop diversification	Simpson index of crop diversification	0.44	0.24	0.46	0.20
Extension-related variables					
Received agricultural advice in the last 2 years (= 1)	Any one of the household primary decision makers received extension advice in the last 2 years prior to survey	0.75	0.43	0.76	0.43
Government extension		0.49	0.50	0.54	0.50
NGO extension officers		0.21	0.40	0.28	0.45
Lead farmers		0.09	0.29	0.13	0.34
Other farmers		0.20	0.40	0.24	0.42
Radio programming		0.39	0.49	0.39	0.49
Phone/SMS		0.03	0.17	0.05	0.22
Received agricultural advice in the last 12 months (= 1)	Any one of the household primary decision makers received agricultural advice in the last 12 months prior to survey	0.54	0.50	0.54	0.50
Government extension		0.34	0.47	0.35	0.48
NGO extension officers		0.12	0.33	0.16	0.37
Lead farmers		0.04	0.20	0.07	0.25
Other farmers		0.09	0.29	0.11	0.31
Radio programming		0.26	0.44	0.26	0.44
Phone/SMS		0.02	0.13	0.02	0.15

Variable	Definition	2016 (N = 2,938)		2018 (N = 2,776)	
		Mean	Std. Dev.	Mean	Std. Dev.
Extension delivery methods (= 1)	Any one of the household primary decision makers uses or participates in [Method] for agricultural information				
Farmer field day		0.10	0.30	0.10	0.30
Farm demo		0.16	0.36	0.15	0.36
Print materials		0.03	0.16	0.04	0.20
Radio		0.33	0.47	0.46	0.50
SMS/phone		0.04	0.19	0.05	0.23
Face-to-face visits		0.22	0.41	0.27	0.44
Community/group meeting		0.33	0.47	0.41	0.49
GAC/VAC		0.14	0.34	0.15	0.35
Household-level characteristics					
Household head's education	Level of highest educational attainment by household head (0–23)	5.90	4.04	5.92	4.06
Household head's age		40.72	15.82	41.41	15.79
Household head's gender	Male = 1	0.75	0.43	0.76	0.43
Household size		5.07	2.39	5.26	2.25
Asset/wealth quintile (reference = poorest quintile)	Household asset index was calculated using principal components analysis based on dwelling roof material; dwelling wall material; and the number of air conditioners, radios, cell phones, tape or CD players, televisions, refrigerators, washing machines, bicycles, motorcycles/scooters, cars, ox-carts, power tillers, and/or tractors owned.				
Asset quintile 2		0.26	0.44	0.13	0.34
Asset quintile 3		0.19	0.40	0.21	0.41
Asset quintile 4		0.15	0.36	0.26	0.44
Asset quintile 5		0.22	0.42	0.17	0.38
Number of organizations joined		1.35	2.26	1.41	2.16
Received fertilizer subsidy (= 1)		0.30	0.46	0.25	0.43
Ganyu (hired labor)	person-days per season	9.35	58.75	9.07	51.02
Crop acreage		1.76	1.79	1.98	17.72
Crop acreage squared		6.31	18.15	317.90	15,959.79
Community-level variables					
Number of projects		3.01	1.61	2.19	1.48
Distance to nearest road quintile (reference = nearest)					
Distance quintile 2		0.17	0.38	0.22	0.41
Distance quintile 3		0.24	0.43	0.15	0.36
Distance quintile 4		0.20	0.40	0.21	0.41
Distance quintile 5 (farthest)		0.19	0.39	0.19	0.39
Extension agents in community	Number of extension agents working in the community	1.19	0.73	1.24	0.72
VAC is present in community (= 1)		0.53	0.50	0.62	0.49

Variable	Definition	2016 (N = 2,938)		2018 (N = 2,776)	
		Mean	Std. Dev.	Mean	Std. Dev.
Model village (= 1)	Community has started model village approach[a]	0.20	0.40	0.34	0.48
Location- and climate-related controls					
Soil type (reference = best quality)	Soil type index was calculated using principal components analysis based on whether soil is affected by ponding, erosion, poor drainage, low cation exchange capacity, and/or very low nitrogen, potassium, and phosphorous				
Soil type 2		0.24	0.42	0.24	0.42
Soil type 3 (poorest quality)		0.31	0.46	0.31	0.46
Slope		1.63	0.74	1.63	0.74
Max. mean monthly temperature during survey year	Celsius	30.27	1.33	27.57	1.39
Max. mean monthly temperature during year prior to survey	Celsius	29.63	1.45	27.86	1.42
Average mean monthly temperature during survey year	Celsius	23.37	1.34	22.12	1.49
Annual rainfall during survey year	Millimeters	969.77	95.91	1,498.68	174.00
Annual rainfall during year prior to survey	Millimeters	1,043.69	89.54	1,384.75	244.27
Monthly rainfall (January prior to survey)	Millimeters	282.48	21.45	276.23	16.48
Monthly rainfall (February prior to survey)	Millimeters	201.05	13.02	213.95	15.01

Source of raw data: International Food Policy Research Institute household and community surveys (2016, 2018).
Note: [a] The model village approach is defined as the use of participatory extension methods to design integrated and multisectoral interventions and partnerships. GAC = group-village agricultural committee; NGO = nongovernmental organization; SMS = short message service; VAC = village agricultural committee.

Table A.2 Soil cover: Effects of advice received, by source, on the intensity of adoption

Source of extension advice (reference = no advice received)	Marginal effects of extension advice received from [Source] in last 2 years on soil cover adoption				Marginal effects of extension advice received from [Source] in the last 12 months on soil cover adoption			
	(1) FE, linear	(2) RE, linear	(3) CRE, linear	(4) CRE, fractional	(5) FE, linear	(6) RE, linear	(7) CRE, linear	(8) CRE, fractional
Government	-0.001	0.022	0.015	0.013	0.028	0.022	0.018	0.018
	(0.032)	(0.014)	(0.021)	(0.024)	(0.030)	(0.014)	(0.021)	(0.023)
NGO	-0.056*	0.001	-0.040*	-0.042*	-0.102***	-0.012	-0.060**	-0.062**
	(0.031)	(0.014)	(0.022)	(0.024)	(0.036)	(0.016)	(0.026)	(0.028)
Lead farmer	0.121***	0.039**	0.100***	0.089***	0.008	0.001	0.019	0.013
	(0.038)	(0.018)	(0.028)	(0.031)	(0.049)	(0.023)	(0.036)	(0.040)
Other farmer	-0.073**	-0.021	-0.034	-0.032	-0.056	-0.004	-0.020	-0.017
	(0.032)	(0.015)	(0.022)	(0.025)	(0.044)	(0.020)	(0.030)	(0.035)
Radio	-0.000	-0.030**	-0.026	-0.023	0.045	-0.016	0.017	0.020
	(0.030)	(0.013)	(0.020)	(0.022)	(0.032)	(0.014)	(0.022)	(0.025)
Phone/SMS	0.047	0.070***	0.064	0.054	0.107	0.079**	0.106**	0.082
	(0.056)	(0.027)	(0.040)	(0.043)	(0.068)	(0.036)	(0.052)	(0.056)

Source of raw data: International Food Policy Research Institute household and community surveys (2016, 2018).

Note: CRE = correlated random effects; FE = fixed effects; NGO = nongovernmental organization; RE = random effects; SMS = short message service. Models 1–3 and 5–7 were estimated using the *xtreg* command in Stata, conditional on awareness (that is, including only those who were aware of the specific technology). Models 4 and 8 were estimated using a generalized estimating equation via the *xtgee* command in Stata for fractional response, again conditional on awareness. Figures are the marginal effects, and those in parentheses are the standard errors. Various household-level, community-level, soil type, and climate-related variables were used as controls in the models; see their descriptive statistics in Table A.1. Significant at $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

Table A.3 Soil cover: Effects of advice received, by method, on the intensity of adoption

Method	(1) FE, linear	(2) RE, linear	(3) CRE, linear	(4) CRE, fractional
Farmer field day	-0.002	0.036*	0.031	0.028
	(0.042)	(0.020)	(0.031)	(0.032)
Farm demo	0.027	0.032*	0.038	0.031
	(0.037)	(0.017)	(0.026)	(0.029)
Print materials	-0.055	-0.026	-0.038	(0.040)
	(0.055)	(0.029)	(0.043)	(0.046)
Radio	-0.013	-0.005	-0.013	(0.015)
	(0.028)	(0.013)	(0.020)	(0.022)
SMS/phone	-0.005	0.033	0.003	0.000
	(0.050)	(0.026)	(0.038)	(0.040)
Face-to-face visits	0.051	0.016	0.013	0.007
	(0.031)	(0.015)	(0.022)	(0.024)
Community/group meeting	-0.018	-0.010	-0.025	(0.024)
	(0.030)	(0.014)	(0.020)	(0.023)
GAC/VAC	-0.008	0.010	0.020	0.017
	(0.037)	(0.018)	(0.027)	(0.028)

Source of raw data: International Food Policy Research Institute household and community surveys (2016, 2018).
Note: CRE = correlated random effects; FE = fixed effects; GAC = group-village agricultural committee; RE = random effects; SMS = short message service; VAC = village agricultural committee. Models 1–3 were estimated using the *xtreg* command in Stata, conditional on awareness (that is, including only those who were aware of the specific technology). Model 4 was estimated using a generalized estimating equation via the *xtgee* command in Stata for fractional response, again conditional on awareness. Figures are the marginal effects, and those in parentheses are the standard errors. Various household-level, community-level, soil type, and climate-related variables were used as controls in the models; see their descriptive statistics in Table A.1. Significant at *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table A.4 Minimum tillage: Effects of advice received, by source, on the intensity of adoption

Source of extension advice (reference = no advice received)	Marginal effects of extension advice received from [Source] in last 2 years on minimum tillage adoption				Marginal effects of extension advice received from [Source] in the last 12 months on minimum tillage adoption			
	(1) FE, linear	(2) RE, linear	(3) CRE, linear	(4) CRE, fractional	(5) FE, linear	(6) RE, linear	(7) CRE, linear	(8) CRE, fractional
Government	-0.017	-0.004	-0.013	(0.014)	-0.016	-0.009	-0.030***	-0.031**
	(0.014)	(0.008)	(0.011)	(0.014)	(0.014)	(0.008)	(0.011)	(0.014)
NGO	-0.020	0.007	-0.013	(0.012)	-0.010	0.033***	0.016	0.014
	(0.015)	(0.008)	(0.012)	(0.013)	(0.017)	(0.009)	(0.014)	(0.014)
Lead farmer	0.007	0.005	-0.003	0.000	-0.017	0.007	-0.005	0.001
	(0.018)	(0.010)	(0.015)	(0.016)	(0.024)	(0.014)	(0.020)	(0.021)
Other farmer	-0.025*	-0.010	-0.022*	(0.017)	-0.015	-0.020*	-0.018	(0.022)
	(0.015)	(0.008)	(0.012)	(0.014)	(0.020)	(0.011)	(0.016)	(0.022)
Radio	-0.004	-0.002	0.002	0.002	0.022	-0.003	0.016	0.015
	(0.014)	(0.007)	(0.011)	(0.013)	(0.015)	(0.008)	(0.012)	(0.014)
Phone/SMS	0.032	0.018	0.015	0.015	0.008	-0.002	0.010	0.013
	(0.024)	(0.015)	(0.021)	(0.023)	(0.032)	(0.020)	(0.028)	(0.033)

Source of raw data: International Food Policy Research Institute household and community surveys (2016, 2018).
Note: CRE = correlated random effects; FE = fixed effects; NGO = nongovernmental organization; RE = random effects; SMS = short message service. Models 1–3 and 5–7 were estimated using the *xtreg* command in Stata, conditional on awareness (that is, including only those who were aware of the specific technology). Models 4 and 8 were estimated using a generalized estimating equation via the *xtgee* command in Stata for fractional response, again conditional on awareness. Figures are the marginal effects, and those in parentheses are the standard errors. Various household-level, community-level, soil type, and climate-related variables were used as controls in the models; see their descriptive statistics in Table A.1. Significant at *p < 0.10, **p < 0.05, ***p < 0.01.

Table A.5 Minimum tillage: Effects of advice received, by method, on the intensity of adoption

Method	(1) FE, linear	(2) RE, linear	(3) CRE, linear	(4) CRE, fractional
Farmer field day	0.003	-0.005	-0.008	(0.009)
	(0.019)	(0.011)	(0.016)	(0.018)
Farm demo	0.030*	0.022**	0.015	0.009
	(0.016)	(0.010)	(0.014)	(0.015)
Print materials	0.020	0.009	0.002	0.007
	(0.025)	(0.016)	(0.022)	(0.023)
Radio	0.002	-0.001	0.006	0.007
	(0.013)	(0.007)	(0.010)	(0.012)
SMS/phone	-0.045*	-0.002	-0.020	(0.016)
	(0.024)	(0.014)	(0.021)	(0.023)
Face-to-face visits	-0.003	-0.000	-0.009	(0.009)
	(0.015)	(0.008)	(0.012)	(0.014)
Community/group meeting	-0.023*	-0.015*	-0.021*	(0.019)
	(0.013)	(0.008)	(0.011)	(0.013)
GAC/VAC	0.005	0.013	0.018	0.015
	(0.018)	(0.010)	(0.015)	(0.016)

Source of raw data: International Food Policy Research Institute household and community surveys (2016, 2018).
Note: CRE = correlated random effects; FE = fixed effects; NGO = nongovernmental organization; RE = random effects; SMS = short message service. Models 1–3 were estimated using the *xtreg* command in Stata, conditional on awareness (that is, including only those who were aware of the specific technology). Model 4 was estimated using a generalized estimating equation via the *xtgee* command in Stata for fractional response, again conditional on awareness. Figures are the marginal effects, and those in parentheses are the standard errors. Various household-level, community-level, soil type, and climate-related variables were used as controls in the models; see their descriptive statistics in Table A.1. Significant at *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table A.6 Intercropping: Effects of advice received, by source, on the intensity of adoption

Source of extension advice (reference = no advice received)	Marginal effects of extension advice received from [Source] in last 2 years on intercropping adoption				Marginal effects of extension advice received from [Source] in the last 12 months on intercropping adoption			
	(1) FE, linear	(2) RE, linear	(3) CRE, linear	(4) CRE, fractional	(5) FE, linear	(6) RE, linear	(7) CRE, linear	(8) CRE, fractional
Government	0.010	-0.006	-0.006	(0.006)	-0.011	0.000	-0.022	(0.022)
	(0.026)	(0.014)	(0.020)	(0.024)	(0.025)	(0.015)	(0.020)	(0.025)
NGO	-0.034	-0.020	-0.029	(0.033)	-0.025	-0.011	-0.034	(0.030)
	(0.027)	(0.015)	(0.021)	(0.026)	(0.032)	(0.018)	(0.026)	(0.032)
Lead farmer	0.037	0.045**	0.014	0.011	0.029	0.022	0.002	(0.003)
	(0.036)	(0.021)	(0.028)	(0.036)	(0.047)	(0.028)	(0.038)	(0.048)
Other farmer	-0.023	-0.045***	-0.048**	-0.047*	-0.043	-0.042*	-0.043	(0.050)
	(0.026)	(0.016)	(0.021)	(0.025)	(0.035)	(0.022)	(0.029)	(0.035)
Radio	-0.037	-0.023	-0.034*	(0.030)	-0.001	-0.005	-0.002	(0.003)
	(0.024)	(0.014)	(0.019)	(0.023)	(0.026)	(0.015)	(0.021)	(0.026)
Phone/SMS	-0.041	0.018	-0.015	(0.005)	-0.049	0.024	-0.007	(0.024)
	(0.046)	(0.028)	(0.040)	(0.050)	(0.058)	(0.038)	(0.051)	(0.063)

Source of raw data: International Food Policy Research Institute household and community surveys (2016, 2018).
Note: CRE = correlated random effects; FE = fixed effects; NGO = nongovernmental organization; RE = random effects; SMS = short message service. Models 1–3 and 5–7 were estimated using the *xtreg* command in Stata, conditional on awareness (that is, including only those who were aware of the specific technology). Models 4 and 8 were estimated using a generalized estimating equation via the *xtgee* command in Stata for fractional response, again conditional on awareness. Figures are the marginal effects, and those in parentheses are the standard errors. Various household-level, community-level, soil type, and climate-related variables were used as controls in the models; see their descriptive statistics in Table A.1. Significant at $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table A.7 Intercropping: Effects of advice received, by method, on the intensity of adoption

Method	(1) FE, linear	(2) RE, linear	(3) CRE, linear	(4) CRE, fractional
Farmer field day	0.026	0.045*	0.041	0.030
	(0.037)	(0.023)	(0.031)	(0.038)
Farm demo	0.032	0.015	0.029	0.012
	(0.031)	(0.019)	(0.026)	(0.031)
Print materials	-0.033	-0.043	-0.031	(0.031)
	(0.047)	(0.030)	(0.041)	(0.051)
Radio	-0.029	-0.019	-0.040**	-0.039*
	(0.023)	(0.013)	(0.018)	(0.022)
SMS/phone	-0.000	0.016	-0.021	0.022
	(0.043)	(0.027)	(0.037)	(0.047)
Face-to-face visits	-0.010	-0.030*	-0.038*	(0.035)
	(0.027)	(0.017)	(0.022)	(0.027)
Community/group meeting	0.022	0.019	0.029	0.026
	(0.023)	(0.014)	(0.019)	(0.022)
GAC/VAC	0.041	0.056***	0.037	0.038
	(0.035)	(0.020)	(0.027)	(0.034)

Source of raw data: International Food Policy Research Institute household and community surveys (2016, 2018).
Note: CRE = correlated random effects; FE = fixed effects; NGO = nongovernmental organization; RE = random effects; SMS = short message service. Models 1–3 were estimated using the *xtreg* command in Stata, conditional on awareness (that is, including only those who were aware of the specific technology). Model 4 was estimated using a generalized estimating equation via the *xtgee* command in Stata for fractional response, again conditional on awareness. Figures are the marginal effects, and those in parentheses are the standard errors. Various household-level, community-level, soil type, and climate-related variables were used as controls in the models; see their descriptive statistics in Table A.1. Significant at $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table A.8 Pit planting: Effects of advice received, by source, on the intensity of adoption

Source of extension advice (reference = no advice received)	Marginal effects of extension advice received from [Source] in last 2 years on pit planting adoption				Marginal effects of extension advice received from [Source] in the last 12 months on pit planting adoption			
	(1) FE, linear	(2) RE, linear	(3) CRE, linear	(4) CRE, fractional	(5) FE, linear	(6) RE, linear	(7) CRE, linear	(8) CRE, fractional
Government	(0.014)	0.000	(0.003)	(0.001)	(0.003)	0.002	(0.022)	(0.027)
	(0.026)	(0.011)	(0.017)	(0.020)	(0.023)	(0.011)	(0.016)	(0.019)
NGO	(0.003)	0.024**	0.004	0.004	0.031	0.014	0.011	0.011
	(0.024)	(0.011)	(0.017)	(0.018)	(0.026)	(0.012)	(0.019)	(0.021)
Lead farmer	0.050*	(0.001)	0.003	(0.001)	0.098***	0.044**	0.038	0.028
	(0.028)	(0.014)	(0.021)	(0.023)	(0.036)	(0.018)	(0.027)	(0.030)
Other farmer	(0.029)	(0.005)	0.011	0.009	(0.022)	(0.019)	(0.003)	(0.016)
	(0.025)	(0.012)	(0.017)	(0.021)	(0.036)	(0.016)	(0.024)	(0.032)
Radio	0.022	-0.018*	(0.001)	(0.002)	0.018	-0.022*	0.011	0.017
	(0.022)	(0.010)	(0.016)	(0.018)	(0.024)	(0.011)	(0.017)	(0.021)
Phone/SMS	(0.043)	(0.003)	(0.043)	(0.023)	0.007	0.013	0.002	0.015
	(0.040)	(0.020)	(0.031)	(0.035)	(0.060)	(0.029)	(0.043)	(0.050)

Source of raw data: International Food Policy Research Institute household and community surveys (2016, 2018).
Note: CRE = correlated random effects; FE = fixed effects; NGO = nongovernmental organization; RE = random effects; SMS = short message service. Models 1–3 and 5–7 were estimated using the *xtreg* command in Stata, conditional on awareness (that is, including only those who were aware of the specific technology). Models 4 and 8 were estimated using a generalized estimating equation via the *xtgee* command in Stata for fractional response, again conditional on awareness. Figures are the marginal effects, and those in parentheses are the standard errors. Various household-level, community-level, soil type, and climate-related variables were used as controls in the models; see their descriptive statistics in Table A.1. Significant at *p < 0.10, **p < 0.05, ***p < 0.01.

Table A.9 Pit planting: Effects of advice received, by method, on the intensity of adoption

Method	(1) FE, linear	(2) RE, linear	(3) CRE, linear	(4) CRE, fractional
Farmer field day	0.012	0.025	0.022	0.013
	(0.030)	(0.016)	(0.023)	(0.025)
Farm demo	-0.022	0.001	-0.004	0.001
	(0.027)	(0.013)	(0.020)	(0.022)
Print materials	0.017	0.019	0.039	0.034
	(0.041)	(0.022)	(0.033)	(0.040)
Radio	-0.008	-0.006	0.001	0.003
	(0.021)	(0.010)	(0.015)	(0.017)
SMS/phone	-0.042	-0.015	-0.032	(0.007)
	(0.040)	(0.020)	(0.030)	(0.036)
Face-to-face visits	0.003	0.014	0.020	0.014
	(0.024)	(0.012)	(0.018)	(0.019)
Community/group meeting	0.030	0.004	-0.001	(0.002)
	(0.022)	(0.011)	(0.015)	(0.017)
GAC/VAC	0.026	-0.015	-0.005	(0.003)
	(0.027)	(0.014)	(0.021)	(0.022)

Source of raw data: International Food Policy Research Institute household and community surveys (2016, 2018).
Note: CRE = correlated random effects; FE = fixed effects; GAC = group-village agricultural committee; RE = random effects; SMS = short message service; VAC = village agricultural committee. Models 1–3 were estimated using the *xtreg* command in Stata, conditional on awareness (that is, including only those who were aware of the specific technology). Model 4 was estimated using a generalized estimating equation via the *xtgee* command in Stata for fractional response, again conditional on awareness. Figures are the marginal effects, and those in parentheses are the standard errors. Various household-level, community-level, soil type, and climate-related variables were used as controls in the models; see their descriptive statistics in Table A.1. Significant at *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table A.10 Water management: Effects of advice received, by source, on the intensity of adoption

Source of extension advice (reference = no advice received)	Marginal effects of extension advice received from [Source] in last 2 years on water management adoption				Marginal effects of extension advice received from [Source] in the last 12 months on water management adoption			
	(1) FE, linear	(2) RE, linear	(3) CRE, linear	(4) CRE, fractional	(5) FE, linear	(6) RE, linear	(7) CRE, linear	(8) CRE, fractional
Government	-0.004	-0.020	0.000	(0.002)	-0.018	-0.024*	-0.031*	-0.031*
	(0.037)	(0.014)	(0.020)	(0.022)	(0.032)	(0.013)	(0.019)	(0.019)
NGO	0.015	0.017	0.022	0.024	0.006	0.002	0.017	0.017
	(0.030)	(0.013)	(0.019)	(0.022)	(0.031)	(0.014)	(0.021)	(0.021)
Lead farmer	0.007	-0.006	-0.002	(0.013)	0.051	-0.003	-0.017	-0.017
	(0.034)	(0.016)	(0.023)	(0.028)	(0.048)	(0.021)	(0.031)	(0.031)
Other farmer	-0.007	0.002	-0.018	(0.014)	-0.052	0.015	-0.013	-0.013
	(0.032)	(0.014)	(0.020)	(0.023)	(0.051)	(0.018)	(0.028)	(0.028)
Radio	0.001	-0.015	-0.012	(0.018)	-0.012	-0.021	-0.012	-0.012
	(0.032)	(0.013)	(0.019)	(0.022)	(0.032)	(0.014)	(0.020)	(0.020)
Phone/SMS	0.059	0.003	0.025	0.029	0.095	0.017	0.056	0.056
	(0.043)	(0.022)	(0.031)	(0.044)	(0.068)	(0.033)	(0.044)	(0.044)

Source of raw data: International Food Policy Research Institute household and community surveys (2016, 2018).

Note: CRE = correlated random effects; FE = fixed effects; NGO = nongovernmental organization; RE = random effects; SMS = short message service. Models 1–3 and 5–7 were estimated using the *xtreg* command in Stata, conditional on awareness (that is, including only those who were aware of the specific technology). Models 4 and 8 were estimated using a generalized estimating equation via the *xtgee* command in Stata for fractional response, again conditional on awareness. Figures are the marginal effects, and those in parentheses are the standard errors. Various household-level, community-level, soil type, and climate-related variables were used as controls in the models; see their descriptive statistics in Table A.1. Significant at $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table A.11 Water management: Effects of advice received, by method, on the intensity of adoption

Method	(1) FE, linear	(2) RE, linear	(3) CRE, linear	(4) CRE, fractional
Farmer field day	0.010	0.007	0.012	0.012
	(0.044)	(0.019)	(0.019)	(0.019)
Farm demo	0.039	-0.009	-0.013	(0.013)
	(0.035)	(0.016)	(0.017)	(0.017)
Print materials	-0.027	0.011	0.005	0.005
	(0.048)	(0.024)	(0.025)	(0.025)
Radio	-0.004	-0.010	-0.010	(0.010)
	(0.028)	(0.012)	(0.013)	(0.013)
SMS/phone	0.068	-0.007	-0.005	(0.005)
	(0.054)	(0.023)	(0.023)	(0.023)
Face-to-face visits	-0.058*	-0.038***	-0.037**	-0.037**
	(0.034)	(0.014)	(0.015)	(0.015)
Community/group meeting	0.029	0.024*	0.016	0.016
	(0.030)	(0.014)	(0.014)	(0.014)
GAC/VAC	-0.017	0.014	0.017	0.017
	(0.037)	(0.015)	(0.015)	(0.015)

Source of raw data: International Food Policy Research Institute household and community surveys (2016, 2018).
Note: CRE = correlated random effects; FE = fixed effects; GAC = group-village agricultural committee; RE = random effects; SMS = short message service; VAC = village agricultural committee. Models 1–3 were estimated using the *xtreg* command in Stata, conditional on awareness (that is, including only those who were aware of the specific technology). Model 4 was estimated using a generalized estimating equation via the *xtgee* command in Stata for fractional response, again conditional on awareness. Figures are the marginal effects, and those in parentheses are the standard errors. Various household-level, community-level, soil type, and climate-related variables were used as controls in the models; see their descriptive statistics in Table A.1. Significant at *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table A.12 Crop residue incorporation: Effects of advice received, by source, on the intensity of adoption

Source of extension advice (reference = no advice received)	Marginal effects of extension advice received from [Source] in last 2 years on crop residue incorporation adoption				Marginal effects of extension advice received from [Source] in the last 12 months on crop residue incorporation adoption			
	(1) FE, linear	(2) RE, linear	(3) CRE, linear	(4) CRE, fractional	(5) FE, linear	(6) RE, linear	(7) CRE, linear	(8) CRE, fractional
Government	-0.013	-0.017	-0.000	(0.001)	-0.014	-0.029	-0.013	(0.013)
	(0.035)	(0.017)	(0.027)	(0.030)	(0.036)	(0.018)	(0.028)	(0.030)
NGO	0.025	-0.022	0.017	0.019	-0.016	-0.046**	0.016	0.019
	(0.038)	(0.019)	(0.029)	(0.032)	(0.046)	(0.022)	(0.035)	(0.039)
Lead farmer	0.083*	-0.009	0.019	0.019	0.024	0.002	-0.007	(0.008)
	(0.050)	(0.026)	(0.039)	(0.043)	(0.071)	(0.035)	(0.052)	(0.056)
Other farmer	0.092**	0.047**	0.058**	0.056*	0.008	0.034	-0.001	(0.002)
	(0.036)	(0.020)	(0.028)	(0.031)	(0.051)	(0.027)	(0.040)	(0.043)
Radio	0.016	0.024	0.013	0.013	0.075**	0.072***	0.088***	0.088**
	(0.033)	(0.017)	(0.026)	(0.028)	(0.038)	(0.019)	(0.029)	(0.031)
Phone/SMS	0.044	0.028	0.027	0.023	0.054	0.057	-0.022	(0.028)
	(0.065)	(0.036)	(0.055)	(0.060)	(0.092)	(0.049)	(0.073)	(0.078)

Source of raw data: International Food Policy Research Institute household and community surveys (2016, 2018).
Note: CRE = correlated random effects; FE = fixed effects; NGO = nongovernmental organization; RE = random effects; SMS = short message service. Models 1–3 and 5–7 were estimated using the *xtreg* command in Stata, conditional on awareness (that is, including only those who were aware of the specific technology). Models 4 and 8 were estimated using a generalized estimating equation via the *xtgee* command in Stata for fractional response, again conditional on awareness. Figures are the marginal effects, and those in parentheses are the standard errors. Various household-level, community-level, soil type, and climate-related variables were used as controls in the models; see their descriptive statistics in Table A.1. Significant at $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

Table A.13 Crop residue incorporation: Effects of advice received, by method, on the intensity of adoption

Method	(1) FE, linear	(2) RE, linear	(3) CRE, linear	(4) CRE, fractional
Farmer field day	-0.092*	-0.040	-0.091**	-0.087**
	(0.052)	(0.028)	(0.042)	(0.046)
Farm demo	-0.007	0.047*	0.039	0.037
	(0.044)	(0.024)	(0.035)	(0.038)
Print materials	0.020	0.038	0.006	0.004
	(0.069)	(0.040)	(0.058)	(0.063)
Radio	0.041	0.051***	0.084***	0.086***
	(0.032)	(0.017)	(0.025)	(0.027)
SMS/phone	0.040	0.019	0.012	0.012
	(0.063)	(0.035)	(0.052)	(0.056)
Face-to-face visits	-0.035	-0.018	-0.027	(0.027)
	(0.038)	(0.020)	(0.030)	(0.033)
Community/group meeting	0.033	0.036**	0.034	0.035
	(0.033)	(0.017)	(0.026)	(0.028)
GAC/VAC	0.060	-0.018	0.045	0.044
	(0.049)	(0.025)	(0.037)	(0.041)

Source of raw data: International Food Policy Research Institute household and community surveys (2016, 2018).

Note: CRE = correlated random effects; FE = fixed effects; GAC = group-village agricultural committee; RE = random effects; SMS = short message service; VAC = village agricultural committee. Models 1–3 were estimated using the *xtreg* command in Stata, conditional on awareness (that is, including only those who were aware of the specific technology). Model 4 was estimated using a generalized estimating equation via the *xtgee* command in Stata for fractional response, again conditional on awareness. Figures are the marginal effects, and those in parentheses are the standard errors. Various household-level, community-level, soil type, and climate-related variables were used as controls in the models; see their descriptive statistics in Table A.1. Significant at *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table A.14 Organic fertilizer: Effects of advice received, by source, on the intensity of adoption

Source of extension advice (reference = no advice received)	Marginal effects of extension advice received from [Source] in last 2 years on organic fertilizer adoption				Marginal effects of extension advice received from [Source] in the last 12 months on organic fertilizer adoption			
	(1) FE, linear	(2) RE, linear	(3) CRE, linear	(4) CRE fractional	(5) FE, linear	(6) RE, linear	(7) CRE, linear	(8) CRE, fractional
Government	0.031*	0.048***	0.037**	0.042**	0.018	0.047***	0.022	0.023
	(0.017)	(0.012)	(0.017)	(0.020)	(0.018)	(0.013)	(0.018)	(0.020)
NGO	0.002	0.011	0.006	0.018	-0.004	0.009	-0.011	(0.002)
	(0.019)	(0.014)	(0.019)	(0.022)	(0.023)	(0.017)	(0.023)	(0.027)
Lead farmer	0.095***	0.109***	0.093***	0.087***	0.094***	0.117***	0.099***	0.090
	(0.025)	(0.018)	(0.024)	(0.028)	(0.033)	(0.024)	(0.033)	(0.037)
Other farmer	0.038**	0.034**	0.035*	0.033	0.058**	0.050***	0.051**	0.052*
	(0.019)	(0.014)	(0.018)	(0.021)	(0.026)	(0.019)	(0.025)	(0.029)
Radio	0.008	0.000	0.010	0.008	0.013	0.008	0.017	0.017
	(0.017)	(0.012)	(0.016)	(0.019)	(0.019)	(0.013)	(0.019)	(0.022)
Phone/SMS	0.016	-0.021	0.025	0.036	0.002	-0.045	0.002	(0.004)
	(0.038)	(0.028)	(0.038)	(0.045)	(0.051)	(0.039)	(0.050)	(0.060)

Source of raw data: International Food Policy Research Institute household and community surveys (2016, 2018).
Note: CRE = correlated random effects; FE = fixed effects; NGO = nongovernmental organization; RE = random effects; SMS = short message service. Models 1–3 and 5–7 were estimated using the *xtreg* command in Stata, conditional on awareness (that is, including only those who were aware of the specific technology). Models 4 and 8 were estimated using a generalized estimating equation via the *xtgee* command in Stata for fractional response, again conditional on awareness. Figures are the marginal effects, and those in parentheses are the standard errors. Various household-level, community-level, soil type, and climate-related variables were used as controls in the models; see their descriptive statistics in Table A.1. Significant at $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

Table A.15. Organic fertilizer: Effects of advice received, by method, on the intensity of adoption

Method	(1) FE, linear	(2) RE, linear	(3) CRE, linear	(4) CRE, fractional
Farmer field day	-0.038	-0.014	-0.037	(0.036)
	(0.028)	(0.021)	(0.028)	(0.032)
Farm demo	0.037	0.020	0.037	0.036
	(0.023)	(0.018)	(0.023)	(0.027)
Print materials	-0.015	0.013	-0.019	(0.019)
	(0.041)	(0.031)	(0.040)	(0.047)
Radio	0.012	-0.022*	0.009	0.008
	(0.016)	(0.012)	(0.016)	(0.019)
SMS/phone	0.044	0.028	0.050	0.051
	(0.036)	(0.027)	(0.036)	(0.042)
Face-to-face visits	0.032	0.033**	0.038*	0.038*
	(0.020)	(0.015)	(0.019)	(0.023)
Community/group meeting	0.007	0.013	0.003	0.002
	(0.017)	(0.012)	(0.017)	(0.019)
GAC/VAC	0.005	0.046***	0.009	0.007
	(0.024)	(0.018)	(0.023)	(0.027)

Source of raw data: International Food Policy Research Institute household and community surveys (2016, 2018).
Note: CRE = correlated random effects; FE = fixed effects; GAC = group-village agricultural committee; RE = random effects; SMS = short message service; VAC = village agricultural committee. Models 1–3 were estimated using the *xtreg* command in Stata, conditional on awareness (that is, including only those who were aware of the specific technology). Model 4 was estimated using a generalized estimating equation via the *xtgee* command in Stata for fractional response, again conditional on awareness. Figures are the marginal effects, and those in parentheses are the standard errors. Various household-level, community-level, soil type, and climate-related variables were used as controls in the models; see their descriptive statistics in Table A.1. Significant at *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table A.16 Intercropping: Effects of advice received, by source, on the intensity of adoption

Source of extension advice (reference = no advice received)	Marginal effects of extension advice received from [Source] in last 2 years on SID				Marginal effects of extension advice received from [Source] in the last 12 months on SID			
	(1) FE, linear	(2) RE, linear	(3) CRE, linear	(4) CRE, fractional	(5) FE, linear	(6) RE, linear	(7) CRE, linear	(8) CRE, fractional
Government	0.002	0.011*	0.004	0.008	-0.004	0.010	-0.003	(0.002)
	(0.009)	(0.007)	(0.009)	(0.021)	(0.009)	(0.007)	(0.009)	(0.025)
NGO	0.001	0.010	-0.001	0.001	-0.010	0.001	-0.008	(0.008)
	(0.010)	(0.007)	(0.010)	(0.023)	(0.012)	(0.009)	(0.012)	(0.033)
Lead farmer	0.015	0.001	0.015	0.024	0.023	0.001	0.017	0.016
	(0.013)	(0.010)	(0.013)	(0.030)	(0.017)	(0.013)	(0.017)	(0.047)
Other farmer	-0.004	-0.009	-0.007	(0.014)	0.007	-0.004	0.011	0.011
	(0.010)	(0.007)	(0.010)	(0.022)	(0.014)	(0.010)	(0.013)	(0.036)
Radio	0.010	0.009	0.013	0.010	0.009	0.016**	0.009	0.010
	(0.009)	(0.007)	(0.009)	(0.020)	(0.010)	(0.007)	(0.010)	(0.026)
Phone/SMS	-0.006	0.004	-0.015	(0.013)	-0.046*	-0.028	-0.047*	(0.047)
	(0.020)	(0.015)	(0.020)	(0.046)	(0.027)	(0.021)	(0.026)	(0.072)

Source of raw data: International Food Policy Research Institute household and community surveys (2016, 2018).
Note: CRE = correlated random effects; FE = fixed effects; NGO = nongovernmental organization; RE = random effects; SMS = short message service. Models 1–3 and 5–7 were estimated using the *xtreg* command in Stata, conditional on awareness (that is, including only those who were aware of the specific technology). Models 4 and 8 were estimated using a generalized estimating equation via the *xtgee* command in Stata for fractional response, again conditional on awareness. Figures are the marginal effects, and those in parentheses are the standard errors. Various household-level, community-level, soil type, and climate-related variables were used as controls in the models; see their descriptive statistics in Table A.1. Significant at *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table A.17 Crop diversification: Effects of advice received, by method, on the intensity of adoption

Method	(1) FE, linear	(2) RE, linear	(3) CRE, linear	(4) CRE, fractional
Farmer field day	0.026*	0.014	0.021	0.019
	(0.015)	(0.011)	(0.014)	(0.039)
Farm demo	-0.009	0.006	-0.005	(0.003)
	(0.012)	(0.009)	(0.012)	(0.033)
Print materials	0.015	-0.005	0.014	0.015
	(0.021)	(0.017)	(0.021)	(0.057)
Radio	0.016*	0.022***	0.019**	0.021
	(0.009)	(0.006)	(0.008)	(0.023)
SMS/phone	-0.013	-0.010	-0.023	(0.026)
	(0.019)	(0.015)	(0.019)	(0.051)
Face-to-face visits	-0.019*	-0.005	-0.019*	(0.019)
	(0.010)	(0.008)	(0.010)	(0.027)
Community/group meeting	0.005	0.012*	0.004	0.003
	(0.009)	(0.007)	(0.009)	(0.023)
GAC/VAC	0.003	0.003	-0.001	(0.003)
	(0.013)	(0.010)	(0.012)	(0.033)

Source of raw data: International Food Policy Research Institute household and community surveys (2016, 2018).
Note: CRE = correlated random effects; FE = fixed effects; GAC = group-village agricultural committee; RE = random effects; SMS = short message service; VAC = village agricultural committee. Models 1–3 were estimated using the *xtreg* command in Stata, conditional on awareness (that is, including only those who were aware of the specific technology). Model 4 was estimated using a generalized estimating equation via the *xtgee* command in Stata for fractional response, again conditional on awareness. Figures are the marginal effects, and those in parentheses are the standard errors. Various household-level, community-level, soil type, and climate-related variables were used as controls in the models; see their descriptive statistics in Table A.1. Significant at *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

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