



INTERNATIONAL
FOOD POLICY
RESEARCH
INSTITUTE



RESEARCH
PROGRAM ON
Policies,
Institutions,
and Markets

Led by IFPRI

IFPRI Discussion Paper 01848

June 2019

**Modeling the Effectiveness of the Lead Farmer Approach
in Agricultural Extension Service Provision**

Nationally Representative Panel Data Analysis in Malawi

Catherine Ragasa

Development Strategy and Governance Division

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

The International Food Policy Research Institute (IFPRI), established in 1975, provides research-based policy solutions to sustainably reduce poverty and end hunger and malnutrition. IFPRI's strategic research aims to foster a climate-resilient and sustainable food supply; promote healthy diets and nutrition for all; build inclusive and efficient markets, trade systems, and food industries; transform agricultural and rural economies; and strengthen institutions and governance. Gender is integrated in all the Institute's work. Partnerships, communications, capacity strengthening, and data and knowledge management are essential components to translate IFPRI's research from action to impact. The Institute's regional and country programs play a critical role in responding to demand for food policy research and in delivering holistic support for country-led development. IFPRI collaborates with partners around the world.

AUTHORS

Catherine Ragasa* (c.ragasa@cgiar.org) is a Senior Research Fellow in the Development Strategy and Governance Division of the International Food Policy Research Institute (IFPRI), Washington, DC.

**Corresponding author*

Notices

¹ IFPRI Discussion Papers contain preliminary material and research results and are circulated in order to stimulate discussion and critical comment. They have not been subject to a formal external review via IFPRI's Publications Review Committee. Any opinions stated herein are those of the author(s) and are not necessarily representative of or endorsed by IFPRI.

² The boundaries and names shown and the designations used on the map(s) herein do not imply official endorsement or acceptance by the International Food Policy Research Institute (IFPRI) or its partners and contributors.

³ Copyright remains with the authors. The authors are free to proceed, without further IFPRI permission, to publish this paper, or any revised version of it, in outlets such as journals, books, and other publications.

ABSTRACT

The lead farmer (LF) approach has been implemented and heavily promoted nationwide in Malawi since 2009 to support government extension workers and accelerate technology dissemination. Earlier reports have shown that donor-funded projects in Malawi widely adopted the LF approach, indicating positive roles and contributions of LFs. However, national data show persistently low rates of adoption of management practices being promoted by the LFs, prompting this study to look closely at the nationwide implementation and effectiveness of the LF approach. Specifically, we model the effects of farmers' interaction with and exposure to LFs and farmers' access to LFs' advice on farmers' awareness of and adoption of several promoted technologies and management practices. We use data from 531 randomly selected LFs linked to panel data from 2,800 farming households and, using correlated random effects, model the effectiveness of the LF approach on technology awareness and adoption. This is complemented by 55 focus group discussions and in-depth interviews with agricultural extension development officers (AEDOs) and service providers.

Our results point to two major conclusions. First, LFs support and assist AEDOs in their work, especially in organizing community meetings and farm demonstrations, and are also an important bridge between farmers and AEDOs. But LFs complement AEDOs' work rather than substitute for it. In communities without strong AEDOs and community leaders to work with and monitor them, LFs were not active or performed at a substandard level. Second, results show limited coverage and weak implementation and effectiveness of the LF approach at the national level. Only 13 percent of farmers reported receiving agricultural advice from an LF in the last two years, and only 20 percent reported having interacted with an LF. Our econometric models also consistently show neither the farmers' exposure or interaction with LFs nor farmers' access to LFs' advice had an effect on awareness of and adoption of the major agricultural management practices being promoted. When heterogeneity and types of LFs are unpacked, results show that quality of LFs, adoption behavior of LFs, and regular training of LFs have strong and consistent effect on the awareness and adoption of most agricultural practices promoted.

Keywords: extension services, lead farmers, farmer-to-farmer extension, social learning, conservation agriculture, effectiveness analysis

ACKNOWLEDGMENTS

Funding for this study was provided by the government of Flanders (602134.002.001); the Gesellschaft für Internationale Zusammenarbeit (GIZ) (602137.002.001), the development agency of the German government; the Strengthening Agricultural and Nutrition Extension (SANE) (602138.002.001) project, funded by the United States Agency for International Development mission in Malawi; and the CGIAR Research Program on Policies, Institutions, and Markets (PIM), led by the International Food Policy Research Institute (IFPRI). The author would like to thank Dr. Javier Parada for his excellent research assistance. The author is very thankful to Dr. Ephraim Chirwa and his team at the Wadonda Consult for collecting two rounds of household survey data. The author is grateful for the research assistants and graduate students at IFPRI and LUANAR for administering the in-depth interviews and two rounds of focus group discussions. Gratitude is also extended to Mirriam Matita, Kenan Kalagho, Diston Mzungu, an anonymous reviewer, and participants of the IFPRI Malawi Country Strategy Support Program's work-in-progress seminar in Lilongwe on February 27, 2019, for the useful comments and suggestions on the earlier versions of the paper.

1. Introduction

The development of knowledge and skills among farmers is key to productivity growth and agricultural transformation. Many different models and approaches have been tried in the past to provide for knowledge and skills, but many of those have struggled to find ways to deliver those services at scale cost-effectively and efficiently and to contribute to technology adoption, productivity, and development outcomes (Anderson 2004; Feder et al. 2010; Kondylis, Mueller, and Zhu 2017; Ragasa and Mazunda 2018).

An approach that continues to garner attention is the farmer-to-farmer extension approach or the use of contact farmers. The use of contact farmers (or model or lead farmers) has been traditionally part of most extension models for decades. For example, under the training and visit system (implemented in many countries in the 1980s and 1990s), extension agents are required to work with contact farmers to transfer technologies and disseminate information in the communities. Many countries have long histories of using contact farmers, such as model farmers in Ethiopia or master farmers or progressive farmers (*achikumbi*) in Malawi, to support government extension workers in technology transfer and information dissemination. However, those past approaches have been criticized for the selection of richer and progressive farmers (also at times linked to clientelism and elite capture) and for limited productivity and development impacts (Lefort 2012; Knorr, Benyata, and Hoffmann 2007). More recently, the concept has been revived to focus more on a supposedly different set of farmer-trainers—those closer to or more representative of the average farmer in the community rather than a more progressive farmer—and to employ a community-based and participatory selection process rather than allowing farmer-trainers to be cherry-picked by extension workers, chiefs, or politicians, which were main criticisms in the past. Thus, this “new batch” of farmer-trainers are also often called community-based extensionists (Wellard et al. 2013), communicators (Benyishay and Mobarak 2018), seed farmers (Beaman et al. 2015), or disseminating farmers (Shikuku 2019), in addition to many other names used interchangeably.¹ Ideally, the “new batch” of farmer-trainers comprises those who better represent the community, have closer ties to social networks, are motivated volunteers, and have been voted for and chosen by participatory processes within the community.

A related concept that the literature has addressed is the role of groups or producer organizations in accessing information. In Malawi, the master farmer approach from the 1950s and 1960s shifted to a group approach (1970s), before the training and visit system was implemented in the 1980s. Numerous studies show that farmers’ groups and associations can play an important role in targeting information provision and interventions (Ragasa and Golan 2014; Quisumbing and Kumar 2011; Islam et al. 2011; IFPRI and World Bank 2009; Barham and Chitemi 2009; Katungi, Edmeades, and Smale 2008; Nijuki et al. 2008; Davis et al. 2004). Targeted beneficiaries are required to be part of a group or association. For reasons of economies of scale, peer effect, collective agency, and social capital, there are many advantages of participation in such groups and for projects and programs to promote them. More recently, the concept of the social network has gained popularity with its emphasis on more informal groups, pre-existing or organically formed networks, and not necessarily formal groups or associations, as crucial vehicles for information dissemination (Krishnan and Patnam 2014; Magnan et al. 2015; Duflo and Suri 2010; Conley and Udry 2010). Leaders or those most influential or those most well-connected

¹ Other names are farmer promoters, community educators, rural promoters, indigenous promoters, farmer extensionists, paraprofessionals, village technicians, volunteer extension workers, local facilitators, extension multipliers, farmer technicians, progressive farmers/*achikumbi*, and beacon farmers (DAES 2015).

within such groups or social networks would often be targeted as entry points for information and interventions. This also relates to finding network “injection points” or optimal entry points in maximizing and speeding up information and technology diffusion (Ashraf et al. 2014; Leonard and Vasilaky 2016; Beaman et al. 2015; Benyishay and Mobarak 2018). Similarly, these network “injection points” could ideally be the LFs selected in the community because of their influence and social connections.

A review by Davis, Franzel, and Spielman (2016) of studies published from 2012–2017 did not find any effectiveness analysis or impact evaluations of the farmer-to-farmer approach. They cite two studies but criticize those studies for major weaknesses in the methodology and the internal and external validity of the results. Similarly, Wellard et al. (2013) evaluate and show indications of the positive impact of the lead farmer (LF) approach implemented on a small scale by nongovernmental organizations (NGOs) in Malawi, Uganda, and Ghana, but the study is based on a very small sample size of 80 farmers per country. A number of studies have been done interviewing the LFs themselves (Kiptot and Franzel 2014, 2015; Kiptot et al. 2016; Fisher et al. 2018; Khaila et al. 2015; Kalagho 2013) or the organizations using or working with them (Kundhlande et al. 2015; Masangano and Mthinda 2012), but not studying the effectiveness of the LF approach or of farmer-to-farmer extension more generally, not even the coverage and outcomes at the household or farm level. While these LF approaches are heavily promoted in some countries, such as Malawi, their coverage is limited to up to 13 percent of households nationwide, thereby suggesting some limitations to their effectiveness (Malawi IHS-Panel; IFPRI-Panel).

Some relevant randomized control trials have been conducted to test design features within the LF approach (such as profile of the LF, performance-based incentives or training approach for LFs). The results of these studies are very informative and useful for designing and implementing the LF approach, although they are not appropriate for evaluating the coverage or effectiveness of LFs or the LF approach. For example, Benyishay and Mobarak (2018) show that LFs’ own adoption and effort are susceptible to small performance incentives, that is, one small bag of legume seeds. They also show that social identity of LFs affects other farmers’ knowledge and adoption, that is, farmers appear most convinced by LFs who share a group identity with them, or who face comparable agricultural conditions. Similarly, Kondylis, Mueller, and Zhu (2017) show that LFs with similar farm size and conditions as other farmers is positively associated, although modestly, with technology adoption among other farmers in the community. Other authors have also shown that the gender of the LF matters. For example, Kondylis et al. (2016) suggest that training more women LFs resulted in more women farmers being reached with information and in better knowledge scores for women and improved adoption of sustainable land management practices. Benyishay and Mobarak (2018) further suggest that the number of peer farmers (5 versus 1) may have contributed to greater adoption of technologies. Similarly, Beaman et al. (2015) indicate that technology diffusion is characterized by a complex contagion learning environment in which most farmers need to learn from multiple people and sources before they adopt themselves.

Kondylis, Mueller, and Zhu (2017) show that training LFs together at the same time (that is, central training of LFs) is better than the traditional approach of training extension workers first and then having them train contact workers due to potential loss of information along the knowledge chain. Similarly, Niu and Ragasa (2018), looking particularly at pit planting, a heavily promoted technology in Malawi, show that the average knowledge scores of LFs and other farmers in the same community are similar and that information loss from extension agents to both LFs and other farmers is large, therefore questioning the effectiveness of the LF approach in the context of pit-planting technology promotion.

Holden et al. (2018) found that only a few LFs fully adopted conservation agriculture, one of the major technology packages that many of the LFs are trained to disseminate to other farmers. The authors speculate that if LFs do not adopt the practice, it is very likely that other farmers also will not adopt it. The authors therefore question the appropriateness of conservation agriculture and at the same time suggest some limitations of the LF approach in promoting conservation agriculture technologies.

To our knowledge, ours is the first evaluation of the effectiveness of the LF approach. It builds on Holden et al. (2018)'s study and extends it to trace farmers' exposure to and interactions with LFs and how these affect farmers' adoption decisions and broad-based adoption of agricultural technologies. Malawi's nationwide implementation of the LF approach offers a unique setting to assess the effectiveness and sustainability of the LF approach when scaled up. Often, donor-funded pilot projects are well supported and extension workers or contact farmers are supported with per diems and mobility and input support, but when such projects are scaled up and institutionalized at the national level, with government oversight characterized by limited resources and weaker monitoring, we see different results than in the pilot cases (Hirvonen and Headey 2018). The availability of a nationally representative panel dataset, coupled with qualitative data, that contains details on LF implementation and farmers' ratings of and experiences with LFs provides a unique opportunity to analyze these issues.

Our results show that although LFs are assisting and supporting extension workers in their work, there is limited coverage and weak implementation and effectiveness of the LF approach at the national level. In particular, we see no effect of the presence of LFs in the community or of farmers' exposure and access to LFs on awareness of and adoption of almost all major management practices being promoted. When heterogeneity and types of LFs are unpacked, results show that quality of LFs, adoption behavior of LFs, and regular training of LFs have strong and consistent effect on the awareness and adoption of most agricultural practices promoted.

The paper is structured as follows. Section 2 presents the operational definition of LF in the Malawi context and related concepts. Section 3 presents the data and methods. Section 4 describes the LF implementation and LF characteristics and activities. Section 5 presents the modeling results. Section 6 discusses the implications of the results, and in section 7 we offer some concluding remarks.

2. Related Concepts

Lead farmer (LF) approach is deeply rooted in the concept of social learning, where farmers learn from each other. Having been identified and selected by the community, LFs can play a role as network “injection points” or optimal entry points in maximizing and speeding up information and technology diffusion. The approach is also related to the centrality of farmers and their experimentation within the agricultural innovation system perspective (see World Bank 2012).

There are varied definitions and roles of an LF (or contact farmer or community-based extensionist) given the various concepts related to them and different organizations that train and work with them. These varied roles and expectations from LFs are linked to the current debate on optimal profile and selection criteria of these LFs: some look at early adopters or innovative farmers, others look at opinion leaders in the community, while others look at those who are close to or similar in characteristics and agricultural conditions to the average farmer in the community. The latter stems from the observations that farmers appear to be most convinced by the advice of others who face comparable agricultural conditions to those they face themselves, with empirical evidence from Benyishay and Mobarak (2018) and Kondylis, Mueller and Zhu (2017). Wellard et al. (2013) list a broad range of roles and expectations for LFs, including these: (1) mobilization of the community; (2) liaison and provision of feedback between the community and programs/projects; (3) training of farmers; (4) being role models in the community, particularly in the adoption of agricultural technologies and practices being promoted; and (5) facilitation of development processes in the community. In the case of Malawi, the focus of this paper, an LF is officially defined as “an individual farmer (male and female) who has been elected by the village to voluntarily assist in the delivery of a maximum of three good agricultural practices/technologies that are enterprise specific and is trained in those technologies” (DAES 2015, 6). Therefore, the roles and contributions of LFs are heavily linked to agricultural extension services as described in DAES (2015). LF roles are seen in various ways:

- a. **Supporting or assistant role:** LFs support the activities of extension agents in the communities, such as organizing community meetings, identifying farmers to do farm demonstrations, volunteering plots for farm demonstrations, and so on. They act as assistants to extension agents in those communities, and therefore we refer to the “assistant role” of LFs to extension agents of government organizations and NGOs. They have local “inside” knowledge and proximity to farmers that can enable them to work effectively with farmers in the community.
- b. **Filling-gaps role:** LFs can potentially cover locations or areas not covered or supported by government extension workers. LFs are physically closer to farmers, as they live in the community, and so even if an extension agent is not available to answer a question, LFs are there to provide answers and support the farmers. Therefore, LFs can play a role in filling in gaps not currently covered by agricultural extension development officers (AEDOs). This is also related to the argument that training LFs reduces the pressure to invest in and maintain a large cadre of public extension agents since LFs can help fill the gaps and areas where AEDOs are not present.
- c. **Representative role:** LFs in theory are representative of farmers and chosen in a participatory and transparent way among farmers. Therefore, farmers may be more likely to listen to an LF than to an AEDO, and farmers can relate to them more. On the other hand, the literature and the DAES guidelines (2015) also point to the need for LFs to be role models—that is, they are meant to be much ahead and more advanced than most of the farmers in the community. This

tension creates difficulties in terms of practical criteria and the processes by which LFs are selected.

- d. **Information-bridging role:** LFs can potentially help farmers articulate their needs, concerns, and demands to the extension agent, village chief, or other service provider. Therefore, LFs can be important players bridging the demand for and supply of services and filling the information gap between users and service providers and suppliers.

Various historical and social factors exist that may limit the effectiveness of the LF approach and the performance and impact of LFs in their communities. For example, in Malawi, there is a long history of master and progressive farmers, who were privileged and supported with inputs and subsidies in the past (Knorr, Benyata, and Hoffmann 2007; DAES 2015). Envy and perceptions may have developed in some communities, which continue with other variants of these contact farmers (DAES 2015).

A related issue is the process by which LFs are selected, and the transparency thereof. Progressive farmers who are better off or elite often have been cherry-picked and used in the political machinery (Lefort 2012). It matters how credible and participatory the selection process is.

Another issue is capacity and how the community perceives an LF's capacity and role. Interviews suggest that some communities do not recognize the LF role and that, in some locations, LFs are viewed at a lower status than AEDOs and rarely viewed as experts or trainers with superior knowledge and information to that of other farmers. Some communities report that it is important that LFs are selected by the community rather than by an extension worker. But it is still not clear how many people attend the selection meetings and how participatory and transparent the processes are. In addition, the quality of the LF training and capacity-strengthening programs affects whether they can effectively perform their work as technology promoters.

And, finally, there is the question of incentive. The LFs are volunteers with their own farms, enterprises, and activities to manage. It is challenging, especially for female LFs, to balance household chores, child care, farming, and other responsibilities with LF activities (Kalagho 2015). Questions remain about what incentives will work for LFs (and compensate them fairly) what will avoid the past failures of privileged progressive farmers.

In considering all of the above, we should remember that the LF approach is just one approach and that there are many alternative approaches to extension service provision. How the LF approach complements or substitutes for other approaches will be explored empirically in this paper.

3. Data Sources and Empirical Strategy

3.1. Data sources

This paper uses nationally representative household data collected from August to October 2016 (wave 1) and from July to September 2018 (wave 2) by the International Food Policy Research Institute (IFPRI). All districts (except Likoma) are covered in the survey. 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). See Ragasa and Niu (2017) for more details of the sampling method.

A household listing for each selected community was conducted, and households were stratified into those with and those without LFs. Up to two households with LFs were selected. Within the sample households, 531 households had LFs, who were interviewed with a separate semistructured module within the household survey. Of those LFs, 69 percent were trained by the government, 12 percent were trained by donor/NGO projects, 17 percent served as an LF for both the government and an NGO, and 3 percent claimed that they were chosen by the community as an LF but not trained by either the government or an NGO. Data were gathered on the characteristics of the LFs, their activities and roles, their expectations and incentives, support from AEDOs and other organizations, challenges, and their suggestions for improvement, among other things. Linking the LFs and the households with LFs and other households enables us to compare characteristics of LFs and other farmers and their households.

We used community surveys and focus group discussions (FGDs) to complement the household surveys, in order to understand the process of LF selection and monitoring, ratings and perceptions of LFs, activities and performance of LFs, and suggestions for improvement. A total of 22 gender-disaggregated FGDs were conducted in January–February 2017; most of the communities were revisited in January 2019 while others were added totaling 33 FGDs in 2019. In total, 55 FGDs cover 180 male and 221 female respondents, sampled from 18 communities in nine districts from the same geographic areas as the household and community surveys. The locations of the FGDs are illustrated in Figure 1. The nine districts were sampled purposively using a maximum variation approach to capture different agro-economic 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, as we hypothesized that quality and frequency of service delivery might differ according to remoteness. Adults from households (10 to 12 per community) were purposively sampled based on different headship and wealth characteristics; however, fewer men 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 and the locations of the focus group discussions and districts covered in the household and community surveys



Source: IFPRI surveys (2016, 2018) covering all districts (except Likoma) and 55 focus group discussions conducted by IFPRI in January–February 2017 and January 2019 in 18 communities in eight districts, as marked above. The areas shaded blue are bodies of water.

3.2. Empirical model

The main goal of this paper is to model the contribution of the LF approach to the adoption of agricultural technologies and management practices that LFs are expected to promote in their communities. There are numerous studies that model farmers’ decision to adopt or not adopt certain agricultural technologies and management practices based on several factors (see Foster and Rosenzweig 2010). More recent papers on technology adoption have modeled the adoption decision as a step-wise process, starting with discovery, exposure or awareness, then trying out the technology (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:

$$\text{Awareness: } Y_{iAW} = 1[\beta'_{AW}X_{ij} + \gamma_{AW}LF_i + \varepsilon_{iAW} > 1] \quad (1)$$

= 0, otherwise

$$\text{Adoption: } Y_{iAd} = \begin{cases} 1[\beta'_{Ad}X_{ij} + \gamma_{Ad}LF_i + \varepsilon_{iAd} > 1] & \text{if } Y_{iAw} = 1 \\ = 0, & \text{otherwise} \end{cases} \quad (2)$$

We use the binary outcome variable Y_{iAw} for awareness and both binary and continuous variables Y_{iAd} for adoption during that cropping season of agricultural technologies or management practices that LFs are trained to disseminate in their communities; LF_i is the variable of interest that describes the presence of LF in the community; and X_{ij} is a vector of explanatory variables. All these are defined below, and the descriptive statistics are in Table 1.

Technology (Y_{iAw} and Y_{iAd}): The main objective of the nationwide implementation of the LF approach in Malawi was to create a “critical mass of adopters on a specific technology in designated locations” (DAES 2015, 2). Therefore, the outcome variables being measured are 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 have knowledge of the following technologies and practices?*” For adoption, we used two measures of adoption: (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 cropping season (in the plot-level production module). If a farmer practices technology x in any of his or her plots we consider it adopted. Both measures of adoption were largely consistent. We also computed the intensity of adoption, both in terms of acres and percentage of total acreage in which a particular technology or practice was adopted.

We chose technology packages and practices that the government most commonly promoted through its LFs, namely, soil cover or mulching, minimum tillage or minimum disturbance of the soil, crop diversity (intercropping or crop rotation), pit planting, composting pits, manure or fertilizer making, and crop residue incorporation. Most often, such practices are also referred to as climate-smart or conservation agriculture.²

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

Lead farmer approach (LF_i): We have three indicators for farmers’ exposure to and interaction with LFs, which are all from the household survey, and whether such interaction significantly affects technology awareness and adoption:

- i. Farmer’s exposure to LFs: The proxy use is the number of LFs in the community that a farmer-respondent knows;

² There are several definitions of conservation agriculture. For the purposes of this paper, conservation agriculture refers to a set of practices to manage soil fertility and moisture retention to adapt to climate change.

- ii. Farmer's access to LFs: This is proxied by the farmer's self-reported interaction with and participation in activities organized by LFs; and
- iii. Farmer's access to information and advice from LFs on agriculture: The proxy used is whether farmers reported receiving information or advice on agriculture from any LF.

We further explored the different types and heterogeneity of LFs and communities, namely:

- i. Quality of LFs: We disaggregate LFs based on farmers' rating of them, classifying LFs as excellent, good, or not good (using both an average and an index computed from principal components analysis based on a set of nine perception questions, see Figure 3, panel c below) (in Likert scale);
- ii. Physical proximity of LFs: We characterize LFs according to their different physical distance or proximity to farmers (in kilometers);
- iii. Adoption behavior of LFs: We grouped communities into whether at least one LF adopts a particular technology being promoted (binary variable, 0/1);
- iv. Gender of LFs: We computed the percentage of male or female LFs in the community (in percentage);³ and
- v. Training of LFs: We grouped communities by whether at least one LF in the community received training on the LF concept, communication, and specific technologies in the last two years (binary variable, 0/1).

Control variables (X_{ij}): We control for other sources and methods of accessing information and advice on agriculture; various household- and community-level characteristics that can influence technology adoption (see Table 1). Access to information is measured by the following variables: membership in an agricultural association and the frequency of listening to agricultural radio programs. Financial capital and wealth are measured by household livestock holdings, an index of household assets, and a dummy variable for access to off-farm income. Asset index was calculated using principal components analysis based on dwelling roof material, dwelling wall material, and the number of air conditioner, radio, cellphone, tape or CD player, television, refrigerator, washing machine, bicycle, motorcycle/scooter, car, ox-cart, power tiller and tractor, largely based and adopted from the Malawi Integrated Household Survey questionnaire. Alternatively, value of these assets during time of survey was also used. Physical land capital is measured by total land acreage. Human capital indicators include 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 include membership in a nonagricultural organization, participation in community collective action initiatives, and number of people one could borrow money from. Geographic variables include distance to the market in minutes and a territory dummy.

3.3. Estimation strategy

We used three estimation methods in order to address nonexposure bias (Diagne and Demont 2007; Kabunga et al. 2012), nonrandom program placement and selection bias (Feder et al. 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.

³ A variable that captures direct contact with a female or male LF would have been more informative, but this is not available in our dataset.

This is done by limiting the adoption model to only those who are aware. Second, we address 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 as a parameter to estimate. To implement the MC/CRE device, we include the means of all time-varying covariates for household. These averages have the same value for a given household in every year but vary across households. In general, the MC/CRE device unifies the fixed-effects and the random-effects estimation approaches. By including the vector of time-averaged variables, we still control for time-constant unobserved heterogeneity, as with fixed effects, 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 traditional random-effects environment (Wooldridge 2002). Third, we complemented the CRE method with Heckman selection probit and bivariate probit models to check for robustness and consistency of the results. Altogether, these three methods show consistent results. In this paper, we show only the MC/CRE model results (Tables 2 through 5) since they are largely similar to the results of the Heckman selection probit and bivariate models, which are available upon request.

Table 1 Descriptive statistics of outcome and explanatory variables

Description	Source	2016		2018	
		Mean	Std. Dev.	Mean	Std. Dev.
<u>Technology awareness (= 1)</u>	Household survey				
Soil cover		0.34	0.47	0.48	0.50
Min tillage		0.49	0.50	0.58	0.49
Crop rotation		0.55	0.50	0.67	0.47
Intercropping		0.47	0.50	0.66	0.47
Crop residue incorporation		0.52	0.50	0.67	0.47
Composting pits		0.55	0.50	0.73	0.44
Pit planting		0.32	0.47	0.48	0.50
Manure or fertilizer making		0.44	0.50	0.39	0.49
<u>Technology adoption (= 1)</u>	<u>Household survey</u>				
Min tillage		0.06	0.24	0.06	0.24
Crop residue incorporation		0.28	0.45	0.41	0.49
Pit planting		0.08	0.27	0.06	0.24
Intercropping		0.62	0.49	0.47	0.50
Soil cover		0.16	0.37	0.08	0.27
Organic fertilizer		0.45	0.50	0.54	0.50
<u>Farmer's exposure and access to Lead farmer (LF)</u>	<u>Household survey</u>				
Number of LFs in the community a household is aware of		0.99	1.99	0.92	2.01
Farmer received advice from LF in the last 2 years (=1)		0.09	0.13	0.13	0.22
Farmer received advice from LF in the last 12 months (=1)		0.04	0.14	0.07	0.13
If household has interacted with LF (= 1)				0.19	0.39
<u>Heterogeneity of lead farmers</u>					
Rating by household of LFs in the community (control = not good)	Household survey				
Not good		0.15	0.19	0.22	0.23
Good		0.56	0.50	0.45	0.50
Excellent		0.29	0.46	0.33	0.47
Distance from farmer homestead to nearest LF (km)	Household survey	0.90	1.64		
	From lead farmer interviews as part of the household survey, aggregated at community level				
If at least one LF in the community adopts . . . (= 1)					
Min tillage		0.31	0.46	0.24	0.43
Crop residue incorporation		0.52	0.50	0.61	0.49
Pit planting		0.33	0.47	0.15	0.35
Intercropping		0.88	0.33	0.74	0.44
Soil cover		0.67	0.47	0.54	0.34
Organic fertilizer		0.47	0.50	0.17	0.37
	From lead farmer interviews as part of the household survey, aggregated at community level				
Percentage of male LFs in the community		0.77	0.30	0.72	0.29
	From lead farmer interviews as part of the household survey, aggregated at community level				
LF received training on LF concept		0.70	0.28		
	From lead farmer interviews as part of the household survey, aggregated at community level				
LF received training on communication		0.58	0.29		

Description	Source	2016		2018	
		Mean	Std. Dev.	Mean	Std. Dev.
LF received training on specific technology	From lead farmer interviews as part of the household survey, aggregated at community level	0.62	0.32		
Controls					
<i>Household-level controls</i>					
Highest grade level of education head attained	<i>Household survey</i>	6.36	4.57	6.33	4.58
Asset index		-0.03	1.02	-0.03	1.01
Number of cell phones owned by household		0.90	0.94	0.98	0.89
Frequency of household head listening to radio (1–5 Likert scale)		3.58	1.50	3.62	1.61
Land owned by household (acres)		2.41	2.04	2.81	5.00
Male household head (= 1)		0.73	0.44	0.73	0.44
Age of household head		40.54	15.78	43.04	15.66
<i>Community-level controls</i>					
Number of projects/programs in the community	<i>Community survey</i>	3.02	1.61	2.16	1.49
Community has implemented “model village” concept (= 1)		0.20	0.40	0.35	0.48
Number of associations/organizations in the community		2.03	1.93	1.98	1.89
Number of extension agents who came to provide advice in the community		1.19	0.73	1.24	0.73

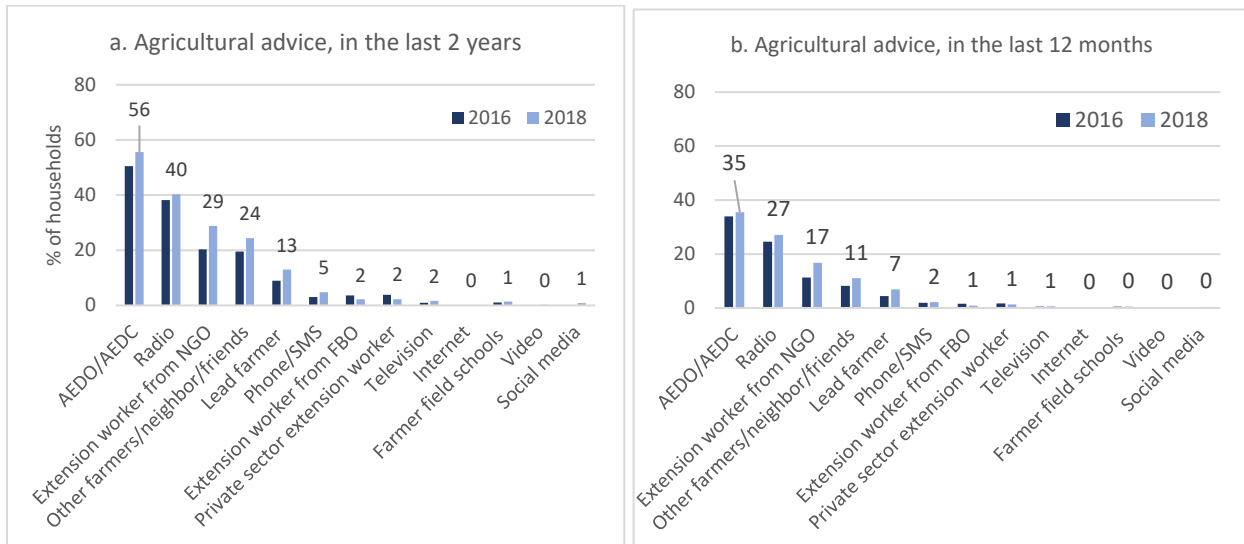
Source: IFPRI household and community surveys (2016, 2018).

4. Descriptive Analysis

4.1. Coverage

Of the 299 communities sampled, 88 percent had at least one trained LF. Of those communities with an LF, communities had four LFs on average in 2018, up from three LFs in 2016. The number of LFs in a community ranged from one to 40. However, of the 2,880 households surveyed, only 34 percent reported knowing any LF working in the community in 2018, down from 44 percent who reported knowing at least one LF in the community in 2016. On average, a household would know zero or one LF working in the community. Twenty percent of households reported having interacted with or participated in any activities with LFs. When asked about specific agricultural topics (production, livestock, market access, and so forth), only 13 percent of households reported receiving agricultural advice from an LF in the last two years, and only 7 percent reported receiving advice from an LF in the last 12 months (Figure 2). These results consistently show limited coverage and outreach of LFs. The dominant sources of agricultural advice are government extension workers and radio programming (Figure 2). Advice from other farmers, friends, and neighbors (not necessarily those trained as LFs) is also common, with 24 percent of households reporting to have received advice from them in the last two years. This is consistent with the literature that farmer-to-farmer knowledge exchange and social learning plays a key role in technology adoption. Therefore, identifying the most connected farmers in the social networks to target for information intervention will be key to technology awareness and adoption. The limited outreach of LFs may also suggest that LFs may not necessarily be the most connected farmers in the community and that therefore a rethinking of possible improvements in the selection criteria and processes would be vital.

Figure 2 Percentage of households receiving agricultural advice from lead farmers, 2016 and 2018



Source: IFPRI survey (2016, 2018). Survey question: “From which sources did you receive information or advice about agriculture or nutrition in the last 2 years (in the past 12 months)?”

Note: AEDO = agricultural extension development officer; AEDC = agricultural extension development coordinator; NGO = nongovernmental organization; SMS = short message service; FBO = farmer-based organizations or producer groups.

4.2. Quality of LFs

According to the FGDs, all communities reported knowing a lead farmer. A lead farmer is known as an exemplary farmer who is trained to train other farmers on new farming technologies and practices. The communities explained how they differentiate the lead farmer from other farmers. According to them, a lead farmer

- is trained by the extension worker and thus know more about farming than other farmers
- follows all recommended and/or good agricultural practices and technologies
- has resources, i.e., seed, fertilizer and herbicides for demonstration plots
- is closer to the extension worker than other farmers
- grows different types of crops; and
- practices what he/she has learnt, unlike other farmers.

The main role of the lead farmer, as reported by the communities, is to teach other farmers new technologies and/or practices, mainly through demonstrations. On top of teaching these technologies, lead farmers also inspect farmers' fields, respond to farmers' problems, and link farmers to extension workers whenever there is a problem that they cannot respond to. Based on the FGDs, there were mixed reactions about the ratings or feedback on the performance and effectiveness of lead farmers, with some participants and communities valuing and recognizing the support that lead farmers provide to the extension agents while the others reported that lead farmers are usually not respected in their communities.

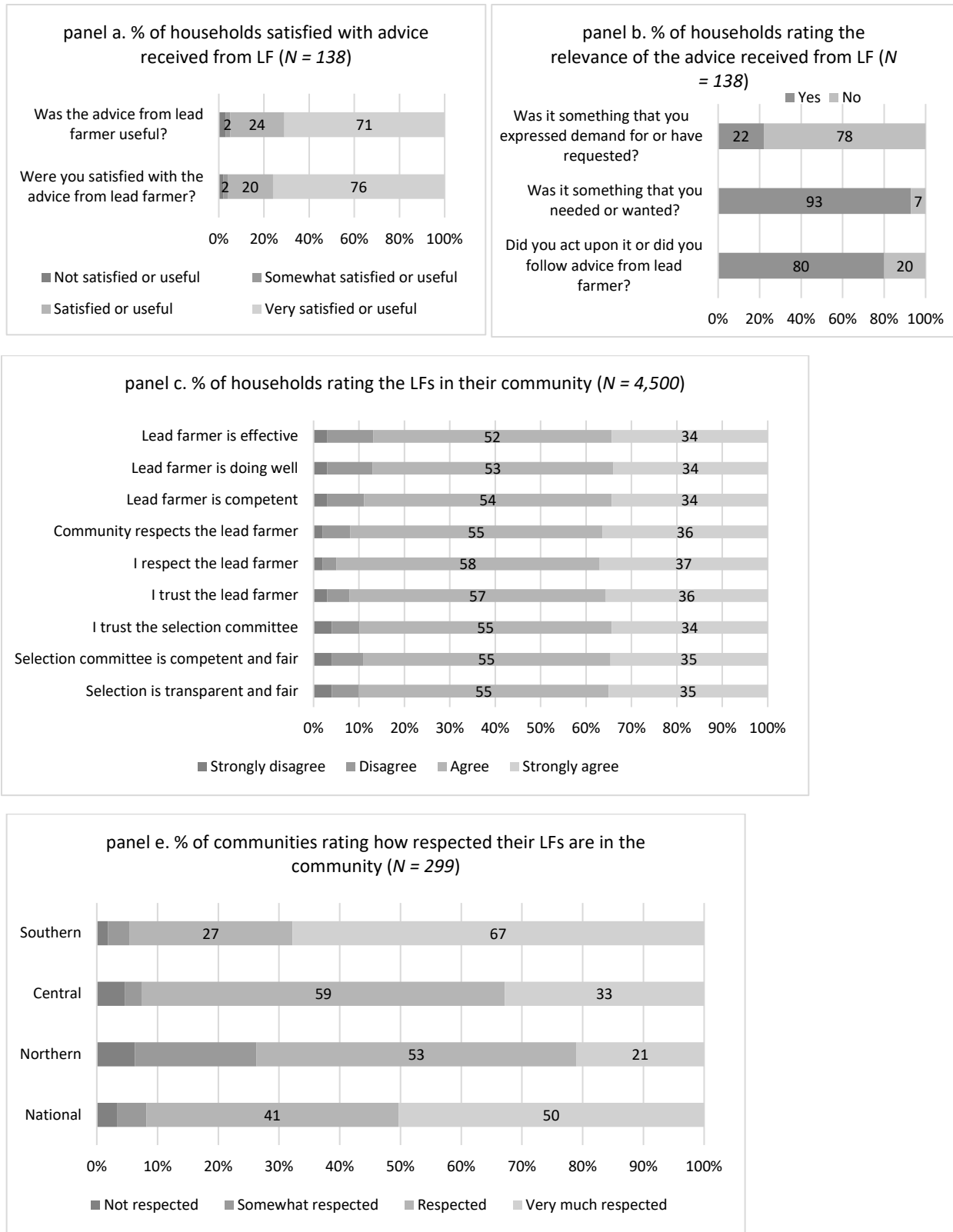
Based on the household surveys, however, the ratings of LFs were generally high. Of those few households receiving advice from LFs, the majority said the advice was very useful (Figure 3, panels a and b). Regardless of the source and method, almost all agricultural advice received by farmers was rated very highly, likely because of the free extension service farmers were getting and the potential effects to the provision of free service if they rated the advice poorly. Of the households who knew at least one LF, a third rated the LF and the selection process very highly, based on nine Likert-scale questions, and 52 to 58 percent gave them good ratings (Figure 3, panel c). This variation was utilized to characterize the quality of LFs (excellent, good, not good) used in the regression analyses. Similarly, community surveys showed generally good ratings for LFs, although there is wide variation across regions (Figure 3, panels d and e). But these ratings should be interpreted with caution. It seems that people were giving good ratings to all rating/satisfaction questions across the board and not only specifically to the LF approach. Responses are likely prone to social desirability bias. For example, when double-checked with actual adoption, there is some discrepancy between what farmers said about advice being followed and the reported adoption at the plot level. Also, only 13 percent of households reported demanding or requesting this advice from an LF in 2018, down from 22 percent in 2016. Very few are demanding and requesting information, and advice just comes to them for free mainly through community meetings and radio programs and occasionally from visits from extension agents.

4.3. Technology awareness and adoption

As expected, LFs showed greater awareness of and adoption of the priority agricultural technologies and management practices being promoted (Figure 4). This is due to the training and some input provision targeted to LFs and not to other farmers. Due to the focus of two technologies per government-trained LF, LFs were not aware of all the technologies being promoted (upper panel). There was generally improvement in awareness by other farmers and LFs of all technologies from 2016 to 2018, except for fertilizer or manure making (Figure 5). However, there was generally no improvement or was even a decrease in adoption for most technologies, except organic fertilizer and crop residue incorporation, from 2016 to 2018 for both other farmers and LFs (Figure 6). A huge gap is seen between those who were aware and those who did adopt for both LFs and other farmers (Figure 7). Even for those trained in a technology, there is no guarantee that LFs would adopt, which is consistent with the findings of Holden et al. (2018).

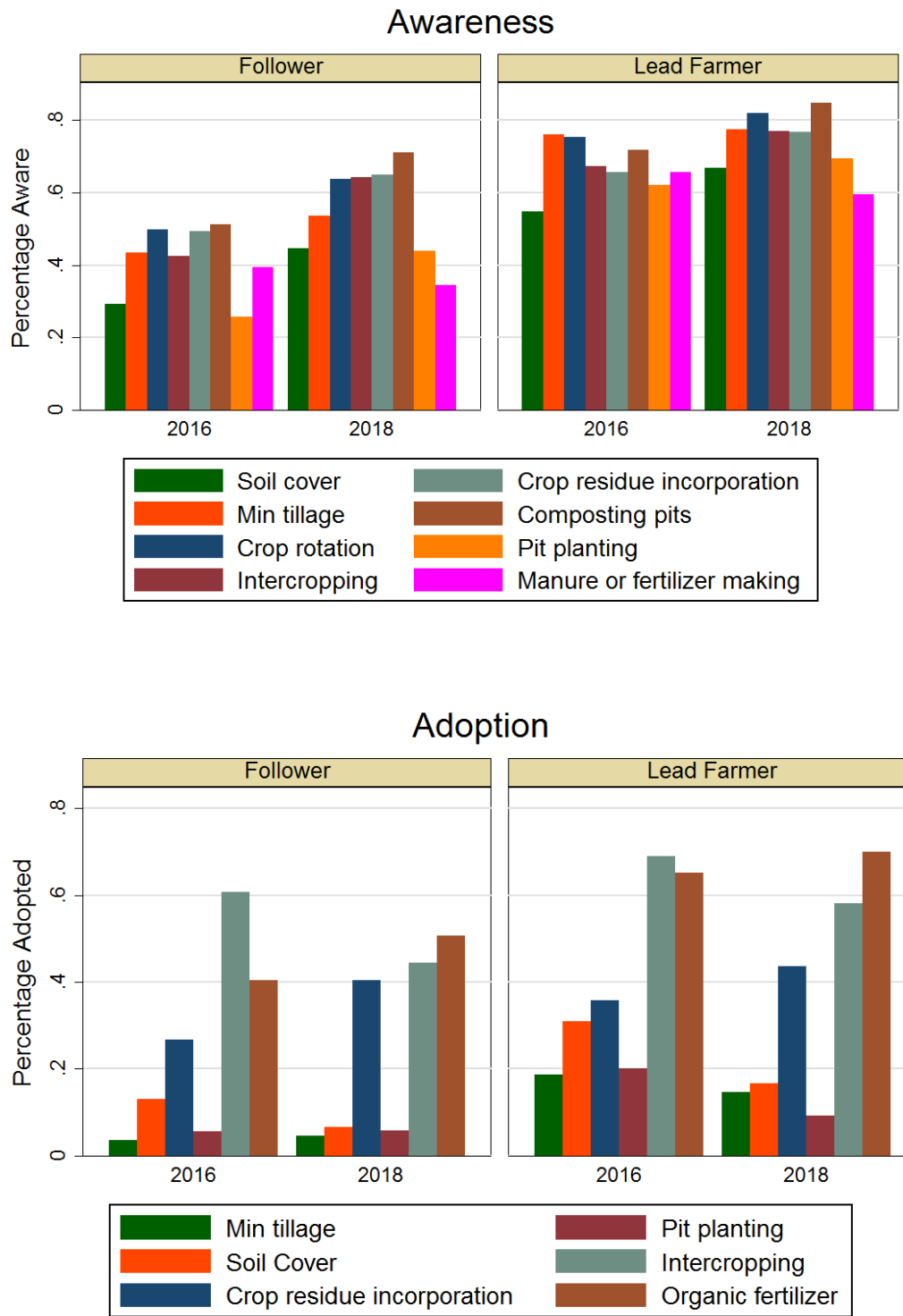
“Sometimes a lead farmer does not practice what he preaches, that is why they are not mentioned, but when a lead farmer is practicing the methods and he is doing better than other people, he is followed and respected.” Male respondent, Mangochi, central community

Figure 3 Ratings on the quality of LFs and their information provision



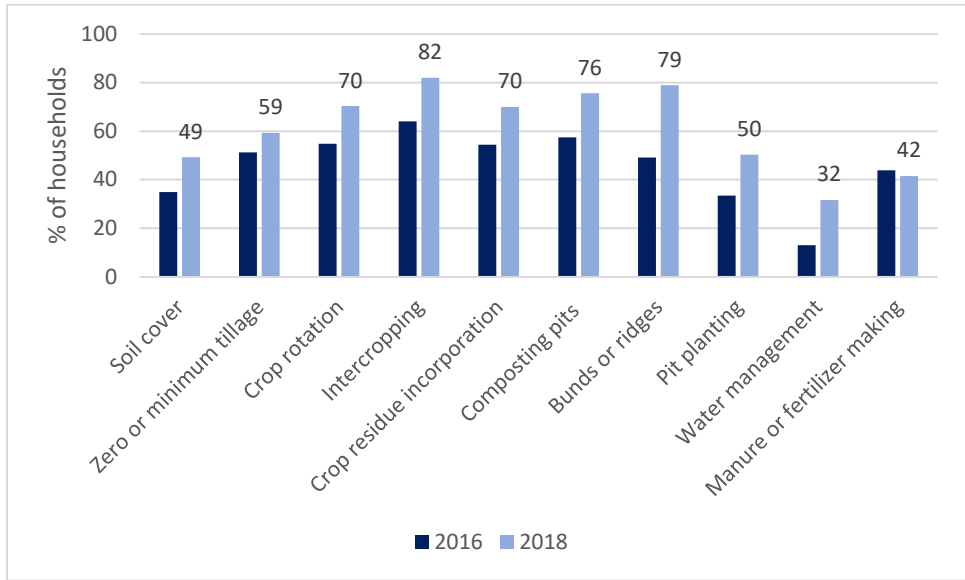
Source: IFPRI household and community surveys (2016, 2018).

Figure 4 Percentage of lead farmers and other farmers aware of and adopted agricultural technologies being promoted, 2016 and 2018



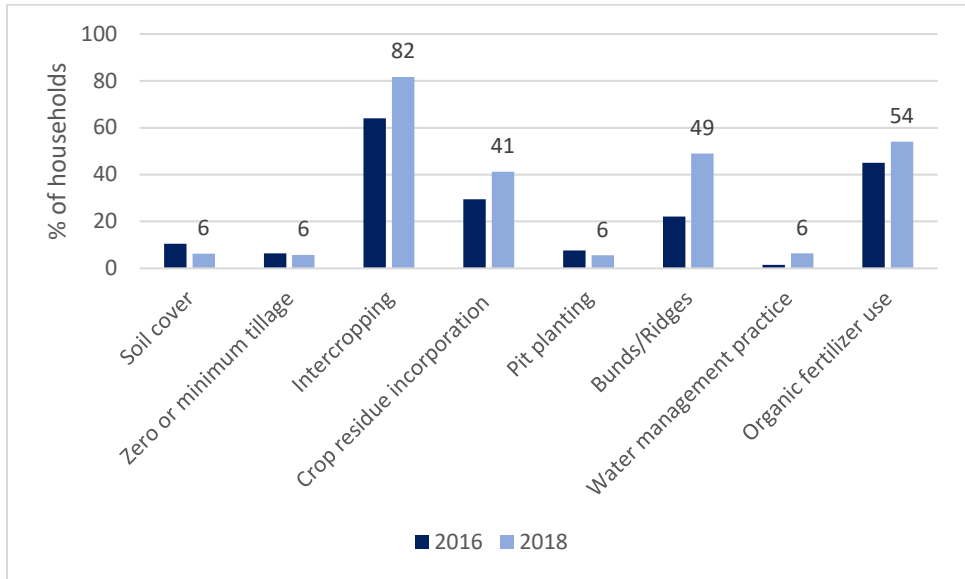
Source: IFPRI household surveys (2016, 2018).

Figure 5 Percentage of households aware and knowledgeable of agricultural technologies being promoted, 2016 and 2018



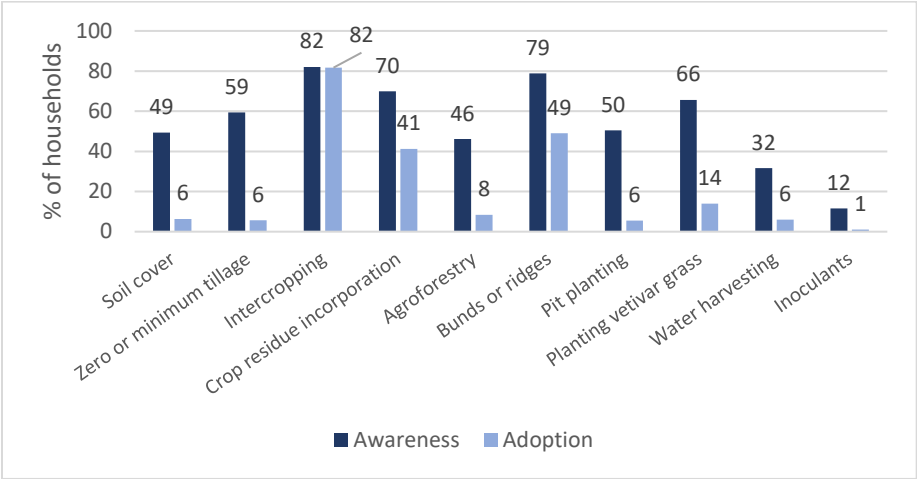
Source: IFPRI household surveys (2016, 2018).

Figure 6 Percentage of households adopting agricultural technologies being promoted, 2016 and 2018



Source: IFPRI household surveys (2016, 2018).

Figure 7 Gap in the percentage of households who are aware versus adopt specific agricultural technologies being promoted, 2018



Source: IFPRI household surveys (2016, 2018).

5. Modeling the Effects of Exposure to LFs on Technology Awareness and Adoption

5.1. Technology awareness and adoption

Neither the presence of LFs nor the number of LFs that households know in the community has a statistical association with farmers' awareness of and adoption of promoted technologies (Tables 2 and 3). Only 20 percent of farmers reported interacting with LFs. Farmers' exposure and access to LF and their advice do matter for awareness of soil cover but not for other management practices (Table 3 and 4). Farmers' interaction with LFs and their participation in LF-organized activities also do matter in adoption of organic fertilizer, but not other practices (Table 3). If farmers interact with LFs or participate in LF activities, it increases the likelihood of their having exposure to and knowledge on soil cover by 10 percent. Conditional on awareness, farmers who interact with LFs have a 9 percent higher likelihood of adopting soil cover than those not interacting with LFs and have 8 percent greater likelihood of adopting organic fertilizer, but no statistical difference is seen for other practices.

In terms of socioeconomic characteristics, male heads of household were generally more aware of the technologies being promoted, but when awareness is controlled for, female and male heads were equally likely to adopt technologies. Usage of radio is a highly significant predictor of technology awareness but not adoption. Similarly, education level is positively significant in the awareness model but not in the adoption model. Age of household head is not significant in the awareness of technologies, but older heads were less likely to adopt residue incorporation and fertilizer making technologies, conditional on awareness. The richest asset quintile seems to be consistently more likely to be aware of and adopt the pit-planting technology package than those in the other asset groups, but asset grouping seems to be insignificant in the awareness and adoption of other technologies.

5.2 Heterogeneity of LFs

When we further unpack the heterogeneity of LFs, we see more nuanced results in terms of technology awareness and adoption (Tables 4 and 5). We find a positive association between the quality of LFs, based on average or index-computed ratings given by other farmers, and greater awareness of soil cover, minimum tillage, crop rotation, crop residue incorporation, and composting pits (excellent > not good) (Table 4). Households having access to "excellent" LFs have greater likelihood of being knowledgeable about these technologies. Conditional on awareness, the quality of LFs is positively associated with greater adoption of soil cover and crop residue incorporation (Table 5). Households having access to "excellent" LFs have greater likelihood of adopting these technologies.

We also see a strong association between communities with at least one LF adopting and greater adoption by other farmers of minimum tillage, pit planting, and organic fertilizer use. Households in communities with at least one LF adopting this technology have greater likelihood of adopting these technologies. This is linked to the promoter-adopter approach in Holden et al. (2018).

In terms of training received by LFs, results show that households in communities with regularly-trained LFs have greater likelihood of being knowledgeable about minimum tillage and composting pit technology. Households in communities with regularly-trained LFs have greater likelihood of adopting minimum tillage, soil cover, pit planting, and intercropping.

We also examined several other LF-related variables, but they were not significant. For example, we see no evidence that distance or proximity to an LF is associated with awareness of or adoption of technologies. Gender of LFs in the community did not seem to matter in affecting awareness of and adoption of technologies at the household level.

Table 2 Results of the logit models on awareness of main agricultural management practices promoted

	1	2	3	4	5	6	7	8
	Soil cover	Min tillage	Crop rotation	Inter-cropping	Crop residue incorporation	Compost-ing pits	Pit planting	Fertilizer making
Number of LFs that HHs know	-0.006 (0.03)	0.022 (0.03)	-0.011 (0.03)	-0.006 (0.03)	0.000 (0.03)	-0.035 (0.03)	0.089** (0.03)	0.029 (0.03)
<i>Household-level controls</i>								
Education level	0.028* (0.01)	0.054*** (0.01)	0.02 (0.01)	0.022* (0.01)	0.013 (0.01)	0.005 (0.01)	-0.009 (0.01)	0.026** (0.01)
<i>Asset quintile (control = poorest)</i>								
Quantile 2	-0.185 (0.18)	0.08 (0.17)	-0.158 (0.18)	0.431** (0.16)	0.177 (0.16)	0.485** (0.17)	0.278 (0.18)	-0.11 (0.17)
Quantile 3	-0.328 (0.23)	0.279 (0.22)	-0.206 (0.23)	0.409 (0.21)	0.499* (0.21)	0.423 (0.22)	0.385 (0.24)	0.192 (0.22)
Quantile 4	-0.372 (0.26)	0.105 (0.25)	-0.102 (0.26)	-0.039 (0.24)	0.329 (0.24)	0.504* (0.25)	0.693* (0.27)	0.187 (0.24)
Quantile 5	-0.568 (0.30)	-0.002 (0.29)	-0.055 (0.30)	-0.03 (0.27)	0.247 (0.28)	0.463 (0.29)	0.811** (0.31)	0.02 (0.28)
Number of cell phones	0.159 (0.09)	0.097 (0.08)	0.290** (0.09)	0.115 (0.08)	0.098 (0.08)	0.126 (0.08)	0.114 (0.09)	0.139 (0.08)
Radio use frequency (Likert scale)	0.175*** (0.05)	0.087* (0.04)	0.098* (0.04)	0.015 (0.04)	0.082* (0.04)	0.106* (0.04)	0.173*** (0.05)	0.124** (0.04)
Land acreage	0.000 (0.02)	0.001 (0.02)	-0.016 (0.02)	-0.003 (0.02)	-0.005 (0.02)	-0.014 (0.02)	0.055 (0.03)	0.001 (0.03)
Male head (= 1)	0.256* (0.10)	0.511*** (0.10)	0.408*** (0.09)	0.182* (0.08)	0.357*** (0.09)	0.417*** (0.09)	0.611*** (0.11)	0.222* (0.09)
Age of head	-0.12 (0.20)	-0.317 (0.19)	-0.076 (0.19)	-0.274 (0.17)	0.072 (0.17)	-0.307 (0.17)	-0.014 (0.22)	0.155 (0.18)
<i>Community-level controls</i>								
Number of projects	-0.132** (0.04)	-0.044 (0.04)	-0.071 (0.04)	0.01 (0.04)	-0.046 (0.04)	-0.029 (0.04)	-0.012 (0.04)	0.015 (0.04)
Model village (= 1)	0.364* (0.15)	0.038 (0.14)	-0.223 (0.15)	-0.148 (0.14)	0.223 (0.14)	0.099 (0.14)	0.189 (0.15)	-0.326* (0.14)
Number of groups	-0.103** (0.03)	0.059* (0.03)	-0.033 (0.03)	-0.035 (0.03)	0.035 (0.03)	0.013 (0.03)	-0.039 (0.03)	-0.031 (0.03)
Number of agents	-0.1 (0.08)	-0.062 (0.08)	0.054 (0.08)	-0.002 (0.07)	-0.091 (0.07)	-0.173* (0.08)	-0.06 (0.08)	0.072 (0.08)
Year 2018 (= 1)	1.012* (0.40)	1.057** (0.37)	0.987** (0.36)	1.645*** (0.34)	0.521 (0.33)	1.579*** (0.34)	1.148** (0.42)	-0.386 (0.34)
<i>Region (control = North)</i>								
Central	0.644*** (0.17)	0.594*** (0.16)	0.078 (0.17)	0.07 (0.14)	-0.091 (0.15)	0.062 (0.15)	-0.081 (0.17)	0.038 (0.15)
South	0.360* (0.17)	0.272 (0.16)	-1.226*** (0.17)	0.334* (0.14)	-0.532*** (0.15)	-0.434** (0.15)	-0.408* (0.17)	0.021 (0.15)
Mean (number of LFs known)	0.129** (0.04)	0.057 (0.04)	0.057 (0.04)	0.011 (0.04)	-0.011 (0.04)	0.074 (0.04)	0.124** (0.04)	0.074* (0.04)
Mean (asset2)	0.252 (0.25)	-0.06 (0.23)	0.344 (0.24)	0.123 (0.22)	0.039 (0.22)	-0.346 (0.23)	-0.254 (0.26)	0.249 (0.23)
Mean (asset3)	0.54 (0.28)	-0.282 (0.27)	0.406 (0.27)	-0.14 (0.25)	-0.469 (0.25)	-0.338 (0.26)	-0.408 (0.29)	0.02 (0.26)

	1	2	3	4	5	6	7	8
	Soil cover	Min tillage	Crop rotation	Inter-cropping	Crop residue incorporation	Composting pits	Pit planting	Fertilizer making
Mean (asset4)	0.221 (0.31)	-0.154 (0.30)	0.31 (0.31)	0.244 (0.28)	-0.3 (0.28)	-0.383 (0.29)	-0.674* (0.33)	0.136 (0.29)
Mean (asset5)	0.543 (0.34)	0.062 (0.33)	0.271 (0.34)	-0.064 (0.31)	-0.242 (0.31)	-0.204 (0.33)	-0.841* (0.36)	0.037 (0.32)
Mean (cell phone)	0.129 (0.11)	0.053 (0.11)	0.081 (0.11)	0.058 (0.10)	0.086 (0.10)	-0.015 (0.10)	0.143 (0.12)	0.111 (0.10)
Mean (radio use)	-0.038 (0.06)	0.028 (0.06)	-0.024 (0.06)	0.065 (0.05)	-0.005 (0.05)	-0.007 (0.05)	-0.106 (0.06)	-0.025 (0.05)
Mean (land acre)	-0.015 (0.03)	0.008 (0.02)	0.018 (0.02)	-0.025 (0.03)	0.000 (0.02)	-0.001 (0.02)	-0.048 (0.04)	-0.042 (0.03)
Mean (projects)	0.131* (0.05)	0.072 (0.05)	-0.003 (0.05)	-0.012 (0.05)	0.098* (0.05)	0.093 (0.05)	0.096 (0.06)	0.01 (0.05)
Mean (model village)	-0.068 (0.19)	0.13 (0.18)	0.361 (0.19)	0.001 (0.17)	-0.186 (0.17)	0.065 (0.18)	-0.151 (0.20)	0.347* (0.18)
Mean (groups)	0.028 (0.04)	0.008 (0.04)	0.019 (0.04)	0.035 (0.04)	-0.049 (0.04)	-0.015 (0.04)	-0.002 (0.05)	0.053 (0.04)
Mean (agents)	-0.105 (0.11)	0.041 (0.11)	-0.043 (0.11)	-0.021 (0.10)	0.088 (0.10)	0.101 (0.10)	-0.077 (0.12)	-0.179 (0.11)
Constant	-2.334*** (0.37)	-2.524*** (0.35)	-0.194 (0.34)	-1.390*** (0.31)	-0.452 (0.31)	-1.009** (0.32)	-2.158*** (0.39)	-1.245*** (0.33)
N	3,518	3,518	3,518	3,518	3,518	3,518	3,518	3,518
Pseudo R2	0.33	0.32	0.29	0.28	0.27	0.31	0.32	0.33

Source of raw data: IFPRI household and community surveys (2016, 2018).

Note: Estimated using Mundlak-Chamberlain device or correlated random effects (MC/CRE). Figures are the marginal effects, and those in parentheses are the standard errors. LF = lead farmer; HH = household head. Significant at * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 3 Results of the logit models on adoption of main agricultural management practices promoted

	1	2	3	4	5	6
	Min tillage	Soil cover	Crop residue incorporation	Pit planting	Intercropping	Organic fertilizer
Number of LFs that HHs know	0.097 (0.09)	-0.095 (0.08)	-0.011 (0.03)	0.113 (0.07)	0.078 (0.04)	0.025 (0.03)
<i>Household-level controls</i>						
Education level	0.007 (0.03)	-0.021 (0.03)	-0.005 (0.01)	-0.056 (0.03)	0.008 (0.01)	0.02 (0.01)
Asset quintile (control = poorest)						
Quantile 2	-0.286 (0.60)	0.667 (0.61)	0.04 (0.20)	0.808 (0.55)	-0.057 (0.24)	-0.025 (0.20)
Quantile 3	0.399 (0.78)	0.365 (0.71)	0.516 (0.27)	0.351 (0.68)	-0.055 (0.31)	0.181 (0.26)
Quantile 4	-0.492 (0.83)	1.011 (0.83)	0.292 (0.30)	0.85 (0.73)	-0.703 (0.36)	-0.029 (0.28)
Quantile 5	-0.503 (0.94)	0.494 (0.90)	0.39 (0.35)	2.154* (0.96)	-0.298 (0.41)	-0.103 (0.31)
Number of cell phones	0.122 (0.29)	0.239 (0.26)	0.16 (0.10)	0.275 (0.27)	-0.184 (0.12)	-0.082 (0.09)
Radio use frequency (Likert scale)	0.044 (0.14)	-0.26 (0.14)	0.032 (0.05)	-0.132 (0.13)	0.034 (0.06)	0.04 (0.05)
Land acreage	0.002 (0.04)	-0.058 (0.20)	-0.033 (0.03)	-0.142 (0.17)	-0.135 (0.07)	-0.034 (0.04)
Male head (= 1)	0.008 (0.31)	0.289 (0.32)	0.004 (0.11)	-0.322 (0.30)	-0.226 (0.13)	-0.234 (0.12)
Age of head	0.274 (0.67)	-0.475 (0.64)	-0.568* (0.25)	-0.135 (0.75)	-0.594 (0.30)	-0.743** (0.28)
<i>Community-level controls</i>						
Number of projects	0.083 (0.13)	-0.037 (0.13)	0.009 (0.05)	0.07 (0.12)	0.032 (0.06)	0.026 (0.05)
Model village (= 1)	0.13 (0.48)	0.469 (0.43)	0.299 (0.17)	1.134* (0.48)	0.266 (0.20)	-0.027 (0.15)
Number of groups	-0.012 (0.10)	-0.025 (0.09)	-0.090* (0.04)	0.117 (0.08)	-0.066 (0.04)	-0.035 (0.03)
Number of agents	-0.276 (0.27)	-0.006 (0.26)	0.124 (0.09)	-0.299 (0.27)	-0.031 (0.11)	-0.123 (0.09)
Year 2018 (= 1)	-0.294 (1.30)	-0.698 (1.23)	1.284** (0.48)	-0.214 (1.46)	0.102 (0.59)	1.692** (0.54)
Region (control = North)						
Central	0.114 (0.66)	1.269 (0.80)	-0.079 (0.17)	0.218 (0.69)	0.035 (0.22)	0.609** (0.19)
South	1.394* (0.67)	2.842** (0.92)	-0.585*** (0.17)	1.698* (0.71)	0.779*** (0.23)	0.828*** (0.19)
Mean (number of LFs known)	-0.025 (0.13)	0.158 (0.09)	-0.033 (0.05)	0.002 (0.11)	-0.123* (0.06)	0.044 (0.04)
Mean (asset2)	-0.34 (0.80)	-0.663 (0.83)	0.239 (0.27)	-1.684* (0.76)	0.034 (0.32)	-0.019 (0.29)
Mean (asset3)	-0.895 (0.97)	-0.095 (0.84)	-0.492 (0.33)	-1.494 (0.82)	-0.075 (0.37)	0.226 (0.32)
Mean (asset4)	0.647 (0.96)	-0.413 (0.95)	-0.213 (0.36)	-1.919* (0.90)	0.987* (0.44)	0.498 (0.34)
Mean (asset5)	0.409 (1.06)	-0.175 (1.01)	-0.208 (0.39)	-3.922** (1.23)	0.478 (0.47)	0.46 (0.37)

	1	2	3	4	5	6
	Min tillage	Soil cover	Crop residue incorporation	Pit planting	Intercropping	Organic fertilizer
Mean (cell phone)	-0.306	-0.23	-0.098	-0.43	0.228	0.206
	(0.37)	(0.34)	(0.13)	(0.35)	(0.15)	(0.12)
Mean (radio use)	-0.141	0.137	-0.024	0.204	-0.012	-0.018
	(0.18)	(0.18)	(0.07)	(0.18)	(0.08)	(0.07)
Mean (land acre)	0.015	0.125	0.042	0.236	0.230*	0.035
	(0.06)	(0.23)	(0.03)	(0.21)	(0.09)	(0.04)
Mean (projects)	0.009	-0.079	-0.018	0.18	0.004	-0.068
	(0.17)	(0.17)	(0.06)	(0.16)	(0.07)	(0.06)
Mean (model village)	-0.692	-0.186	-0.273	-1.467*	-0.223	0.091
	(0.61)	(0.57)	(0.22)	(0.65)	(0.26)	(0.21)
Mean (groups)	-0.224	-0.041	0.123*	-0.01	0.176**	0.024
	(0.15)	(0.12)	(0.05)	(0.11)	(0.06)	(0.05)
Mean (agents)	0.257	-0.08	-0.091	0.012	0.041	0.028
	(0.33)	(0.35)	(0.12)	(0.34)	(0.14)	(0.13)
Constant	-3.299*	-3.866**	-0.885*	-5.032***	-0.404	-1.589***
	(1.42)	(1.43)	(0.40)	(1.53)	(0.49)	(0.45)
N	1,731	1,321	2,071	1,255	1,878	3,224
Pseudo R2	0.07	0.07	0.12	0.13	0.07	0.13

Source of raw data: IFPRI household and community surveys (2016, 2018).

Note: Estimated using Mundlak-Chamberlain device or correlated random effects (MC/CRE), conditional on awareness (included only those who were aware of the specific technology). Figures are the marginal effects, and those in parentheses are the standard errors. LF = lead farmer; HH = household head. Significant at * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 4. Results of different logit models on the association between various LF-related variables and technology awareness

	1	2	3	4	5	6	7	8
	Soil cover	Min tillage	Crop rotation	Inter-cropping	Crop residue incorporation	Composting pits	Pit planting	Fertilizer making
Model set 1								
Farmer received advice from LF (=1)	0.101*** (0.033)	-0.069** (0.035)	0.009 (0.031)	0.019 (0.035)	-0.096*** (0.035)	-0.076** (0.035)	0.010 (0.032)	0.041 (0.034)
Model set 2								
Farmer has interacted with LF	0.026 (0.033)	0.034 (0.032)	0.042 (0.041)	0.064 (0.053)	0.042 (0.041)	0.021 (0.037)	0.055 (0.038)	0.016 (0.023)
Model set 3								
HH ratings on LF advice (reference = not good)								
Good	0.301* (0.150)	0.180 (0.140)	0.047 (0.170)	-0.494*** (0.140)	-0.001 (0.140)	0.177 (0.140)	-0.206 (0.190)	0.024 (0.140)
Excellent	0.428** (0.160)	0.458** (0.150)	0.490* (0.190)	0.109 (0.160)	0.580*** (0.160)	0.946*** (0.170)	-0.029 (0.200)	0.018 (0.150)
Model set 4								
Distance from HH homestead to nearest LF	0.084* (0.040)	0.053 (0.040)	0.044 (0.040)	0.016 (0.040)	0.117* (0.060)	0.05 (0.040)	0.054 (0.040)	-0.052 (0.050)
Model set 5								
Received training on LF concept (= 1)	-0.009 (0.210)	-0.03 (0.190)	-0.066 (0.200)	0.169 (0.180)	0.278 (0.180)	0.559** (0.190)	0.350 (0.220)	-0.016 (0.180)
Received communication training (= 1)	0.026 (0.170)	0.253 (0.160)	-0.009 (0.160)	-0.239 (0.150)	-0.174 (0.150)	-0.100 (0.150)	0.166 (0.170)	-0.082 (0.150)
Received training on specific technologies (= 1)	0.055 (0.160)	0.393** (0.150)	-0.078 (0.160)	-0.097 (0.150)	-0.243 (0.150)	0.388** (0.150)	-0.109 (0.170)	0.212 (0.150)
Model set 6								
% of male LFs in the community	-0.01 (0.240)	-0.112 (0.240)	-0.205 (0.250)	-0.035 (0.230)	-0.197 (0.230)	-0.225 (0.240)	-0.072 (0.250)	0.198 (0.230)

Source of raw data: IFPRI household and community surveys (2016, 2018).

Note: Estimated using Mundlak-Chamberlain device or correlated random effects (MC/CRE). Figures are the marginal effects, and those in parentheses are the standard errors. LF = lead farmer; HH = household head.

Significant at * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Variables presented here are those that relate to LF only; other control variables as in Tables 1 through 3 were included in these models.

Table 5 Results of different logit models on the association between various LF-related variables and technology adoption

	1	2	3	4	5	6
	Min tillage	Soil cover	Crop residue incorporation	Pit planting	Intercropping	Organic fertilizer
Model set 1						
Farmer received advice from LF (=1)	0.005 0.021	0.094** 0.038	0.062 0.047	-0.002 0.030	0.025 0.038	0.089*** 0.033
Model set 2						
Farmer has interacted with LF	0.011 0.015	0.003 0.028	0.004 0.028	0.005 0.015	0.022 0.031	0.005 0.026
Model set 3						
HH ratings on LF advice (control = not good)						
Good	0.102 (0.44)	0.478 (0.57)	0.339 (0.19)	0.165 (0.39)	-0.158 (0.23)	0.297 (0.20)
Excellent	-0.054 (0.48)	0.956 (0.63)	0.661*** (0.20)	0.11 (0.41)	-0.172 (0.24)	0.141 (0.21)
Model set 4						
Distance from HH homestead to nearest LF	-0.036 (0.18)	0.06 (0.04)	-0.024 (0.06)	0.009 (0.07)	-0.027 (0.04)	0.013 (0.04)
Model set 5						
% of LFs adopting this technology in the community	0.934** (0.33)	0.379 (0.23)	0.176 (0.10)	1.346*** (0.34)	0.212 (0.14)	1.295*** (0.14)
Model set 6						
Received training on LF concept (= 1)	-0.45 (0.30)	0.513* (0.20)	-0.273 (0.15)	-0.213 (0.28)	0.475** (0.15)	-0.093 (0.14)
Received communication training (= 1)	0.878** (0.30)	0.178 (0.18)	0.16 (0.15)	0.625* (0.26)	-0.231 (0.14)	-0.122 (0.13)
Received training on specific technologies (= 1)	-0.151 (0.24)	0.024 (0.17)	0.341** (0.13)	0.032 (0.22)	0.352** (0.12)	0.022 (0.12)
Model set 7						
% of male LFs in the community	0.318 (0.79)	-1.535 (0.84)	0.013 (0.28)	-0.367 (0.77)	0.127 (0.34)	-0.192 (0.26)

Source of raw data: IFPRI household and community surveys (2016, 2018).

Note: Estimated using Mundlak-Chamberlain device or correlated random effects (MC/CRE), conditional on awareness (included only those who were aware of the specific technology). Figures are the marginal effects, and those in parentheses are the standard errors. LF = lead farmer; HH = household head. Significant at * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Variables presented here are those that relate to LF only; other control variables as in Tables 1 through 3 were included in these models.

6. Discussion and Reflections

Here, we reflect on the possible pathways or reasons for the modeling results and contribution of LFs, largely based on the rich qualitative data collected from focus group discussions and interviews with lead farmers. We organize the discussion into four themes.

Are LFs effective in their role of supporting or assisting extension workers?

In our both qualitative and quantitative data, we show some evidence to support this. FGDs show that LFs help extension agents in organizing community and group meetings, which is the top source of information, along with radio programming. They help in organizing farm demonstrations. In the FGDs, participants value both extension workers and LFs supporting them. AEDOs command a lot of trust because they are well trained by the government to deliver technologies to the farmers. LFs are also trusted because they act as the “AEDOs’ walking sticks,” meaning they work on behalf of the AEDOs to reach out to the farmers. According to the FGDs, a reason why many survey respondents might not have mentioned LFs as their source of agricultural advice is that LFs are viewed as “assistants only” to AEDOs. LFs, as compared to AEDOs, are much closer to farmers in terms of their status, education level, and level of material possessions. As a result, farmers usually forget to mention them because they see them as “equals.” In addition, LFs are synonymous to government extension workers and so if farmers mention that they get information from a government extension worker, they may also likely be referring to and including LFs. In one FGD, a participant mentioned that “lead farmers are ‘hidden’ in the armpits of an extension worker.”

“I would say lead farmer and extension workers should be quantified as one because they work hand in hand.” Male respondent, Nkhotakota, central community

“The lead farmer gets the messages from extension worker. He is an extension workers’ helper. So, if we mention an agriculture extension worker, we are mentioning the lead farmer as well.” Male respondent, Chitipa, remote community

While this may account for the low reported coverage of LFs in the provision of agricultural advice, it speaks to the limited value and recognition of their role in extension provision.

“We do receive information from the lead farmers. I think they are not reported as a source of information because they are not regarded as important. Maybe because they live in the same community.” Male respondent, Mchinji, remote community

“We do not mention receiving information from the lead farmer because he/she does not teach other farmer. They go for training but once they come back from the training, they do not share what they learnt, they simply practice it in their fields. Perhaps, that’s why most of us do not know them as lead farmers.” Female respondent, Mchinji, remote community

“Maybe it’s possible that the lead farmer is not performing his/her duties in a community because if he/she is really doing their work, people can fail to mention him/her.” Male respondent, Nkhotakota remote community

Are LFs filling the voids created by limited presence and mobility of extension workers?

There is no evidence in our data to support the proposition that LFs are filling such gaps. Our evidence shows that LFs generally operate and are active in locations and areas where extension agents are also active, as clearly indicated in the farmers' quotes above. Only in one FGD did participants mention that LFs are active and visiting farmers and farms during the other visits that AEDOs could not attend. This is more related to a supporting or assisting role and still largely complementary to the AEDO's work. However, in areas where there are no AEDOs, LFs are not also active. Therefore, there is no evidence supporting the arguments for and expectations that LFs could be the solution to the high farmer-to-extension agent ratio and poor coverage by AEDOs across the districts of Malawi. LFs support or assist AEDOs in areas where they are present and active; otherwise, we see no LFs or no activity of LFs.

Are LFs representative of the community?

Our data show mixed results in terms of how similar LFs and other farmers are and the community's perception of the role and capacity of these LFs. Both our survey data and the FGDs show that LFs are different from the other farmers in the community—they are better off economically, with larger plots and more assets, and they are more progressive than the average farmer in the community (Table 6).

Table 6. Socioeconomic differences between lead farmer and other farmers.

	Other farmer	Lead farmer
Male (=1)	0.74	0.82 ***
Age (number)	40.43	45.79 **
Farming years (number)	19.64	22.42 ***
Can read Chichewa (=1)	0.70	0.93 ***
Can read English (=1)	0.29	0.55 ***
At least elementary school (=1)	0.19	0.35 ***
Household size (number)	4.80	6.30 ***
Agricultural social network size (number)	0.85	1.55 ***
Number of associations (number)	0.24	0.90 ***
Ever held a political office (number)	0.05	0.13 ***
Ever held a traditional office (number)	0.11	0.21 ***
Has bicycle (=1)	0.46	0.78 ***
Has motorcycle/scooter (=1)	0.03	0.05 ***
Total landholdings (acre)	2.50	4.12 ***
Livestock units (number)	5.70	15.32 ***
Per hectare value of agricultural production (MWK 000/hectare)	78.14	98.82 ***

	Other farmer	Lead farmer
Commercialization index (% of harvest sold)	16.84	21.31 ***
Tried new agricultural practice (=1)	0.05	0.16 ***
Tried new livestock practices (=1)	0.04	0.14 ***
Engaged in aquaculture (=1)	0.00	0.02 ***
Crop diversification index	0.44	0.56 ***
Household dietary diversity score	4.66	5.55 ***

Source of raw data: IFPRI household and community surveys (2016, 2018). Significantly different at * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ using a mean comparison test (t-test) of unequal variances using both Satterthwaite's and Welch's formulas.

Some FGD participants valued the closeness (both physical and social) and representativeness of LFs, compared with the AEDO. However, for some farmers, such closeness to their own characteristics limits their respect and recognition of the abilities of the LFs.

"Most times, the lead farmers are ignored and disrespected. This is because we know the person and we do not trust him. When he calls for meetings we do not attend." Female respondent, Mangochi, remote community

"We usually undermine the lead farmer but trust those who have gone through college from NGOs. We usually believe that extension workers are more skilled than lead farmers, but a lead farmer is most important because he resides with us in the village and can easily assist us when we need advice/information." Male respondent, Rumphi, remote community

"Mostly people try to show them as failures deliberately because of jealousy. To add on that, most people don't attend the meetings as called by a lead farmer." Male respondent, Mangochi, remote community

There are other farmers who do not want to get information from the lead farmers. They feel like getting information from them would make them feel superior. They end up insulting the lead farmers, discouraging them from doing their job.

"This friend of mine is a lead farmer and for me to go and beg her to advise me, I feel she will be too proud of herself. Mostly it is jealous. Everyday talking about him/her. Even if he says something people do not listen." Female respondent, Chitipa, remote community

Are LFs effective in bridging the demand for and supply of extension services?

Both the surveys and FGDs show some activities by LFs in articulating farmers' needs, concerns, and demands to extension agents, village chiefs, and other service providers. They help organize community

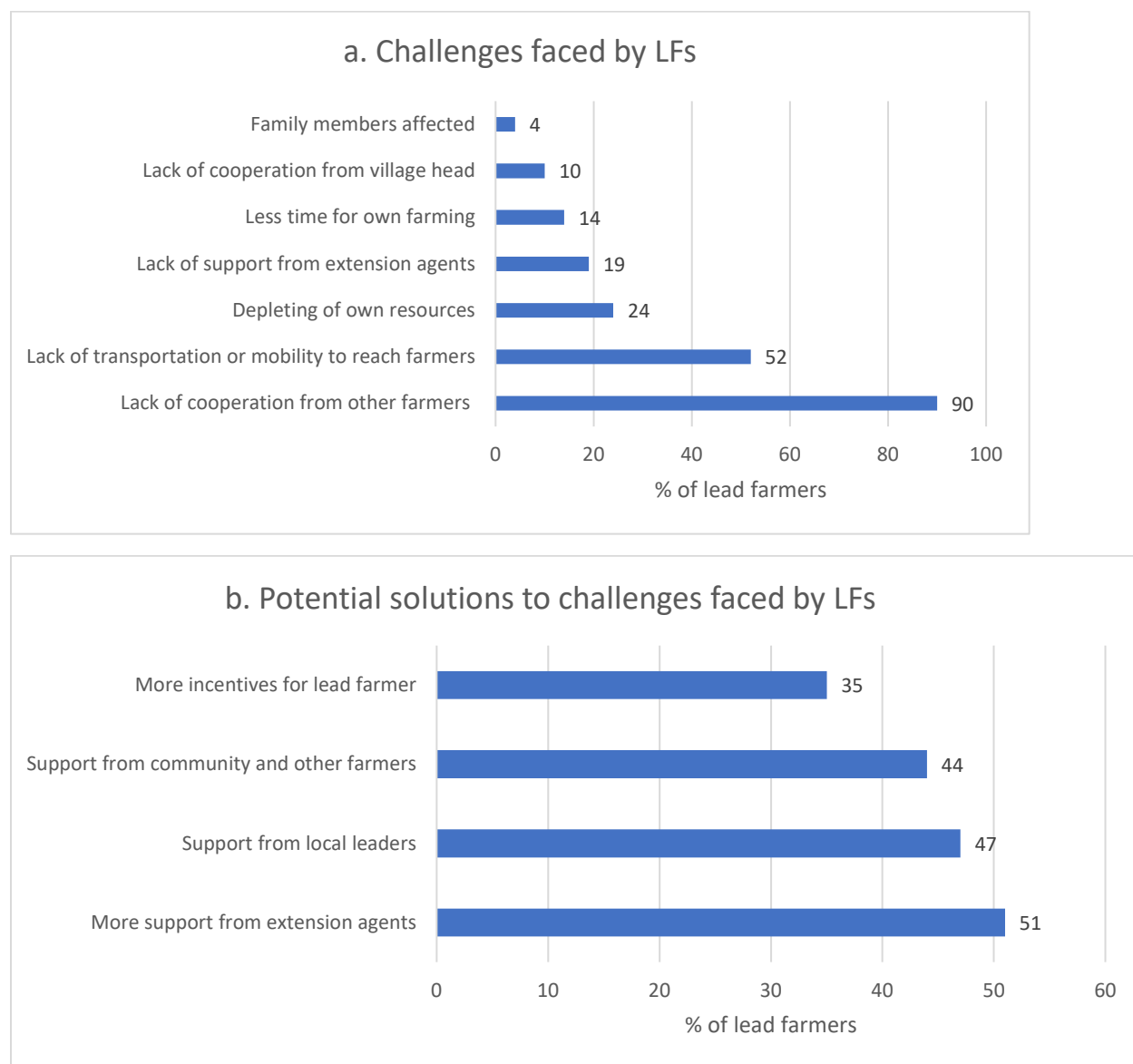
and village agricultural committee (VAC) meetings where farmers can express their concerns and demands. They are the eyes and ears of the AEDO and other extension agents and service providers in the community. Therefore, LFs seem to have been playing a role as a bridge between demand for and supply of services and to fill the information gap between users and service providers and suppliers. However, the low coverage rates and limited interaction between LFs and the rest of the community, beyond the few followers that they have, show the limits of their role as a bridge between the demand for (by farmers) and supply of (by service providers) information and extension services. More outreach and inclusion of farmers in LF activities could be a strategy going forward.

Major challenges in the implementation of the LF approach are plenty. FGDs provide insight into farmers' perceptions of the value and role of LFs, into why the survey data show limited coverage of LFs nationwide, and into why our model results indicate a limited effect of LFs on technology awareness and adoption at a national level:

- Sometimes LFs lack the necessary materials to demonstrate what they teach. In the absence of these materials, most farmers ignore LFs as a reliable source of information and opt to mention just the extension workers.
- In some communities, LFs are present although they are not well established and promoted, and therefore it is difficult for other farmers to identify a lead farmer. Unlike extension workers who come on a motorbike or pushbike and command respect, LFs usually do not get that same level of respect.
- In some communities, some farmers deliberately choose to work against LFs because they think LFs have a lot more benefits than they do; this finding is similar to the findings of other studies (Lefort 2012; Knorr, Benyata, and Hoffmann 2007). It could also be a reason that they do not mention them as a source of information on agriculture-related practices.
- Similarly, some communities value LFs' work and performance lowly. According to them, some LFs do not really practice what they have been taught. In addition, they do not teach fellow farmers about the recommended agriculture practices they have learned. As a result, they indeed do not deserve to be mentioned as a source of information on agriculture-related practices.

From the perspective of LFs, the challenges they face include lack of cooperation from other farmers, followed by the lack of transportation or mobility to reach farmers. Other challenges are effects on their resources and families (such as depletion of own resources, less time for own farming, and family members affected) indicating that there are opportunity costs for being a lead farmer, and at times may be higher than the benefits and gains derived. Other challenges reported are lack of support from extension agents and lack of cooperation from the village head. As potential solutions, lead farmers mentioned: more support from extension agents and from local leaders; more respect and cooperation from community and other farmers, and more incentives (in terms of recognition, mobility support, and inputs provided for farm demonstrations (Figure 8).

Figure 8. Challenges faced by lead farmers and their proposed solutions (in percent of lead farmers interviewed)



Source: IFPRI household survey (2016).

A major implication of the above results is that the LF approach is not a substitute for the AEDO or other extension approaches. LFs support AEDOs and implement farm demonstrations and community meetings. LFs are closer to farmers in the village and are more readily available than AEDOs when farmers want to ask something. They complement the AEDOs' work, rather than substitute for it. Without strong AEDOs to work with them and monitor them, LFs will not be active and will be performing at a substandard level.

Another related major implication concerns the quality of implementation and the support given to LFs. As elaborated in DAES (2015), much support from AEDOs, community and local leaders, and other

service providers is expected and needed for LFs to do their work effectively and sustainably. Interviews with LFs and community leaders and FGDs reveal major gaps in this expected support from various organizations and actors. First, LFs need training and retraining (on the LF concept, on communication, and in the specific technologies), but our data show only 60 to 70 percent of LFs get such trainings, and retrainings are rare. We see more intensive training provided for those LFs trained by NGOs (see Ragasa and Niu 2017). In a detailed study on pit-planting practices, Niu and Ragasa (2018) show no difference in knowledge scores between LFs and other farmers in the same geographical locations, implying that LFs demonstrate no particular knowledge advantage over other farmers and that serious training and learning challenges exist with the LF approach.

Third, LFs should also be supported with regular supervision and mentoring to reinforce implementation of work plans and their support to farmers. Based on the interviews, supervision is not regularly done, and the absence of it was even reported by some LFs, and this is one of the areas LFs suggested as improvement. Fourth, LFs should also be supported with resource materials—this includes basic materials like tape measures, paper pads, pens, protective gear, and push bikes. At the same time, incentives should be balanced so as not to ignite further jealousy and envy in the communities, as also highlighted in the FGDs.

Fifth, communities and local leaders are in theory major contributors to the LF implementation and its success. For example, community mobilization is needed to find ways to motivate LFs. Moreover, support should come in the form of ensuring proper and transparent selection; recognition and appreciation of good-performing LFs; monitoring and follow-up of LFs' activities; and engaging LFs in VAC and community development processes. Based on the community surveys, the interviews with LFs, and the FGDs, most communities claim transparency in the selection of LFs and that LFs are engaged in VAC and community processes. However, monitoring, performance evaluation, and an incentive structure based on these performances are weakly or not at all implemented in most communities surveyed.

When comparing training and support given and monitoring of lead farmers by an NGO project and government program through AEDOs in Dowa district, the study team found that the LFs work and are active only if there is a donor-funded project. Without these projects, AEDOs are not often seen and only come to the community during the FISP fertilizer coupon distribution period and during livestock vaccination campaigns. As a result, the LFs are not monitored by extension workers. If no new technologies are being promoted and supported through projects, the LFs do not have sufficient mobility and incentives to continue the technology promotion they started with an extension worker. This strong association between having a project or support from the local AEDO and the performance and motivation of lead farmers are clearly illustrated in the results presented in Table 7.

TABLE 7—COMPARISON OF TRAINING AND SUPPORT GIVEN AND MONITORING OF LEAD FARMERS BY AN NGO PROJECT AND BY AGRICULTURAL EXTENSION DEVELOPMENT OFFICER, DOWA DISTRICT

	Project's field officer	Government AEDO
Nature of training	One week on agriculture (focus on conservation agriculture); one week on gender; one week on nutrition; one week on market access	Two days on lead farmer concept; then join other farmers in a community meeting where AEDO disseminate on technologies
Nature of monitoring	Field officer and lead farmer draw a calendar, work plan, and targets/indicators; then field officer meets with lead farmer to discuss progress	No monitoring; no follow-up
Nature of support	Inputs (fertilizer, seed, herbicide) for farm demonstrations only; allowance; gears/supplies; pushbike	Inputs for their plots (fertilizer, seed)
Nature of technologies being promoted (CA)	It depends on the project; for the particular lead farmer interviewed, focus on conservation agriculture (CA)	Depends on whether lead farmer is to promote general agriculture or specific technologies; for the particular lead farmer interviewed, s/he was supposed to be trained and expected to promote general agriculture: conservation agriculture, pit planting, manure-making, irrigation, early maturing varieties, soybean and groundnut production.
Method of reaching farmers	Visits with producer groups (those members of VSLA who formed PGs, with 10-25 members); visits will depend on the calendar that each group prepared, but generally two visits per group per week (mostly)	Lead farmer usually combines visits and dissemination with the NGO project work. For example, when visiting the groups and the villages, he is also disseminating the other practices he learned from extension agents.
Activities/ Performance	Lead farmer follows the activities set and performs on the targets.	No activities; but since lead farmer is working under the project, if ever s/he will be evaluated by AEDO, he can report his/her activities under the project as his accomplishments.

Source: In-depth interview of a lead farmer, who is both a lead farmer under an NGO project and also trained as lead farmer by the government. This interview took place on 9 November 2016 in Dowa district.

This table may not be representative of all projects or all government AEDOs, as district by district experiences may differ. However, the table illustrates that LFs may not have the incentive to work hard and train other farmers without support from extension agents. In general, if an AEDO is active in the community (mainly because there is a project or is otherwise motivated to do so), lead farmers are also more active. If an AEDO is not active in the community, lead farmers may be appointed and selected, but they generally are also not active in training their neighbors.

There is also a lack of accountability: it does not matter whether LFs perform well or not as there seem to be no rewards or sanctions given to LFs based on good or bad performance. There are no incentives for LFs to report to and follow AEDOs. Most communities and local leaders also do not monitor the LFs' performance, and usually provide no rewards or sanctions for good or bad performance.

Despite the big fuss or attention given to the LF, or farmer-to-farmer extension, approach, it is not a new approach and has been used for decades. Working with farmers to accelerate the diffusion of technologies to other farmers has been a fundamental ingredient in agricultural extension systems. Rather, the focus of future studies should be on how optimal are the selection criteria and processes, the incentive structure, and the nature of training and learning for LFs. Who should be selected—a

progressive farmer or closer-to-average farmer? What materials or support can be given so as to encourage and motivate LFs but at the same time not cause envy and conflict in the community? Is the current training on a maximum of three technologies working well or should this be expanded to training on integrated agrifood systems in order to cover all management practices relevant to the major agricultural challenges faced by households? Should nutrition be included in the LF training and learning sessions? There are trade-offs on each side, and these are not easy from the practical implementation perspective.

A related issue concerns processes of selection and transparency. Unfortunately, more progressive or better-off farmers are cherry-picked and often used in the political machinery (Lefort 2012; Knorr, Benyata, and Hoffmann 2007). It matters how credible and participatory the selection process is. The majority (94 percent) reported that selection is through community meetings, but it is not clear how many are present during such meetings, who wield influence and who make the decisions in such meetings, and how transparent the selection processes are. Six percent of communities reported that the LF was selected by a village head or chief or extension worker, which is in contrast to the DAES guide (2015). One question that we can pose to implementers is this: Has the selection process really changed from that used in the heavily criticized master farmer or *achikumbi* (progressive farmer) approaches? If they are similar, we might just be repeating historical failures.

7. Conclusions

Nationally representative household panel data (2016, 2018) and FGDs show limited coverage of lead farmers in Malawi in terms of agricultural information provision and limited contribution to technology awareness and adoption. No statistical association exists between the presence and number of LFs in the community and farmers' awareness of and adoption of promoted technologies. Only 20 percent of farmers reported interacting with LFs. Farmers' exposure and access to LFs and their advice do matter for awareness of soil cover but not for other management practices. Farmers' interaction with LFs and their participation in LF-organized activities also do matter in adoption of organic fertilizer, but not other practices. If farmers interact with LFs or participate in LF activities, it increases the likelihood of their having exposure to and knowledge on soil cover by 10 percent. Conditional on awareness, farmers who interact with LFs have a 9 percent higher likelihood of adopting soil cover than those not interacting with LFs and have 8 percent greater likelihood of adopting organic fertilizer, but no statistical difference is seen for other practices.

When we further unpack the heterogeneity of LFs in our modeling, we see more nuanced results. Access to quality LFs, adoption behavior of LFs and regular training received by LFs have strong and consistent effects on awareness and adoption of most technologies promoted based on the technology adoption models. These results have important implications, namely:

- **Regular training:** Lead farmers need training and retraining on LF concepts, communication, and agricultural management systems. Furthermore, farm demonstrations need to be supported and LFs intensively trained to fully absorb technology packages and their long-term benefits.
- **Ensuring selection of quality LF:** To ensure inclusive and quality participation in the selection process, greater sensitization of and ownership by communities of the LF approach are necessary.
- **Maintaining and incentivizing quality LFs:** To do their work effectively and sustainably, LFs need support from AEDOs, community and local leaders, and other service providers.

We see these results of limited effect on farmers' adoption of promoted technologies due to gaps in the performances of LFs in their expected roles and functions as shown in the FGD data. Regarding whether LFs fill a "supporting role" and "information-bridging role," our data show evidence to support this, and their performance seems to depend heavily on how active and motivated the AEDO or extension officer in that community is. However, the poor coverage by LFs and limited interaction with the rest of the community, beyond the few followers that they have, should be addressed if LFs are to effectively perform these roles for the benefit of large segments of the community. LFs help organize community and VAC meetings where farmers can express their concerns and demands, but beyond that, the activities of LFs to support the articulation of farmers' demands to the various service providers or local leaders are limited.

Our data show no evidence that LFs can fill in the gaps where AEDOs are not working or not present (limited filling-gaps role). There is no evidence supporting the arguments for and expectations that LFs could be the solution to the high farmer-to-extension agent ratio and the too few AEDOs across the districts of Malawi. A major implication of the above results is that LFs are not a substitute for the use of AEDOs or other extension approaches. LFs support AEDOs and implement farm demonstrations and community meetings. LFs complement AEDOs' work, rather than substitute for it. Without strong AEDOs and community leaders to work with and monitor them, LFs often will not be active and will be performing at a substandard level.

The limited coverage and outcomes from the LF approach are reflections not on the approach per se but on the poor implementation of the approach: AEDOs, as well as communities and local leaders, are key to the LF implementation and its success; however, the interviews conducted show limited activities by most AEDOs, communities, and local leaders on monitoring, performance evaluation, and mobilizing support and devising incentive structures based on performance. These are major areas to improve if LFs are to be effective drivers for agricultural knowledge and development processes in the communities. AEDOs can provide better support by periodically orienting local leaders on the LF approach, conducting joint stakeholder supervisory visits, and mobilizing communities and local leaders to find ways of motivating LFs. For AEDOs to do this, they must be supported with resources and performance-based incentive systems through district- and national-level management.

Our data show that LFs differ in characteristics from the rest of the farmers in the community: they are better off economically and more advanced in terms of overall technology adoption. Therefore, there is evidence to show that LFs may not be as representative of the community as expected (limited representative role). Related to this are how LFs are selected and whether the process is transparent. Better-off and more progressive farmers are often selected and used as part of the political machinery (Lefort 2012; Knorr, Benyata, and Hoffmann 2007). While the majority reported that selection is done through community meetings, it is not clear how many are present during the meetings, who are influential or who makes the decisions in these meetings, and how transparent these selection processes are. There is a need to revisit the selection processes, including who participates and how they participate in the process. It may be important in the sensitization of communities to emphasize how different the selection and monitoring processes of LFs are than those used in the past implementations of the heavily criticized master farmer or *achikumbi* (progressive farmer) approaches. This would help reduce resentment and envy in some communities toward selected LFs, as well as ensure greater cooperation among farmers to select and support effective LFs for their community's benefit. Emphasis could be placed on selecting LFs who are socially connected (so as to maximize coverage and outreach among farmers and the diffusion of technologies), who are well respected in the community, who are motivated and active in community processes, and who are innovators and likely to adopt new technologies.

Lastly, LFs themselves did not adopt the technologies. This finding is consistent with that of Holden et al. (2018), who found that only a few LFs fully adopted conservation agriculture. That paper and ours question the appropriateness and feasibility of conservation agriculture technologies in Malawi and at the same time suggest some limitations of the LF approach in promoting conservation agriculture technologies as well as other management practices. Regarding awareness, LFs can help a bit, but only limited to promoting awareness of pit-planting technology. As for adoption, LFs have no impact. Other factors and interventions are needed before farmers adopt. This also implies a need to revisit the appropriateness of the technologies being promoted and the limitations of the LF approach in promoting improved technology adoption without institutional support and improvements in training, monitoring, and incentive structures at different levels of the extension system.

References

- Anderson, J., and G. Feder. 2004. "Agricultural Extension: Good Intentions and Hard Realities." *World Bank Research Observer* 19 (1): 41–60.
- Anderson, J., R. Birner, and K. Deininger. 2010. "Promises and Realities of Community-based Agricultural Extension," Chapter 12 (pp. 187–208) in K. Otsuka and K. Kalirajan. 2010. *Community, Market and State in Development*. London: Palgrave Macmillan.
- Barham, J., and C. Chitemi. 2009. "Collective Action Initiatives to Improve Marketing Performance: Lessons from Farmer Groups in Tanzania." *Food Policy* 34 (1): 53–59. <https://doi.org/10.1016/j.foodpol.2008.10.002>.
- Beaman, L., A. BenYishay, J. Magruder, and A. M. Mobarak. 2015. "Can Network Theory–Based Targeting Increase Technology Adoption?" Draft paper. Accessed August 9, 2017. faculty.wcas.northwestern.edu/_lab823/MNW_june15.pdf.
- BenYishay, A., and A. M. Mobarak. 2018. "Social Learning and Incentives for Experimentation and Communication." *Review of Economic Studies* (2018) 0: 1-34.
- Conley, T., and C. Udry. 2001. "Social Learning through Networks: The Adoption of New Agricultural Technologies in Ghana." *American Journal of Agricultural Economics* 83 (3): 668–673. <https://doi.org/10.1111/0002-9092.00188>.
- . 2010. "Learning about a New Technology: Pineapple in Ghana." *American Economic Review* 100 (1): 35–69. <https://doi.org/10.1257/aer.100.1.35>.
- DAES (Department of Agricultural Extension Services). 2015. *Lead Farmers Approach Guidelines*. Malawi: Ministry of Agriculture, Irrigation, and Water Development–DAES.
- Davis, K., S. Franzel, P. Hildebrand, T. Irani, and N. Place. 2004. "Extending Technologies among Small-Scale Farmers in Meru, Kenya: Ingredients for Success in Farmer Groups." *Journal of Agricultural Education and Extension* 10 (2): 53–62. <https://doi.org/10.1080/13892240485300101>.
- Davis, K., S. Franzel, and D. J. Spielman. 2016. *Extension Options for Better Livelihoods and Poverty Reduction: A Selected Review 2012–2015*. MSU International Development Working Paper 143. East Lansing, Michigan: Michigan State University.
- Diagne, A. and M. Demont. 2007. "Taking a New look at Empirical Models of Adoption: Average Treatment Effect estimation of Adoption rate and its Determinants." *Agricultural Economics* 37 (2–3): 201–210.
- Duflo, E., and T. Suri. 2010. *Diffusion of Technologies within Social Networks: Evidence from a Coffee Training Program in Rwanda*. London: International Growth Centre.
- Feder, G., R. Just, and D. Zilberman. 1985. "Adoption of Agricultural Innovations in Developing Countries: A Survey." *Economic Development and Cultural Change* 33 (2): 255–298.
- Fisher, M., S. T. Holden, C. Thierfelder, and S. P. Katengeza. 2018. "Awareness and Adoption of Conservation Agriculture in Malawi: What Difference Can Farmer-to-Farmer Extension Make?" *International Journal of Agricultural Sustainability* 16 (3): 310–325. <https://doi.org/10.1080/14735903.2018.1472411>.

- Foster, A. D., and M. R. Rosenzweig. 1995. "Learning by Doing and Learning from Others: Human Capital and Technical Change in Agriculture." *Journal of Political Economy* 103 (6): 1176–1209.
- Foster, A., and M. Rosenzweig. 2010. "Microeconomics of Technology Adoption." *Annual Review of Economics* 2: 395–424.
- Haggblade, S., and G. Tembo. 2003. *Conservation Farming in Zambia*. EPTD Discussion Paper 108. Washington, DC: International Food Policy Research Institute.
- Hanna, R., S. Mullainathan, and J. Schwartzstein. 2014. "Learning through Noticing: Theory and Evidence from a Field Experiment." *Quarterly Journal of Economics* 129 (3): 1311–1353.
- Hirvonen, K., and D. Headey. 2018. "Can Governments Promote Homestead Gardening at Scale? Evidence from Ethiopia." *Global Food Security* 19: 40–47.
- Holden, S. T., M. Fisher, P. K. Samson, and C. Thierfelder. 2018. "Can Lead Farmers Reveal the Adoption Potential of Conservation Agriculture? The Case of Malawi." *Land Use Policy* 76: 113–123. <https://doi.org/10.1016/j.landusepol.2018.04.048>.
- IFPRI (International Food Policy Research Institute) and World Bank. 2009. *Gender and Governance in Rural Services: Insights from India, Ghana, and Ethiopia*. Washington, DC: World Bank.
- Islam, M. M., D. Gray, J. Reid, and P. Kemp. 2011. "Developing Sustainable Farmer-Led Extension Groups: Lessons from a Bangladeshi Case Study." *Journal of Agricultural Education and Extension*. 17 (5): 425–443. <https://doi.org/10.1080/1389224X.2011.596658>.
- Kabunga, N.S., T. Dubois, and M. Qaim. 2012. "Heterogeneous Information Exposure and Technology Adoption: The Case of Tissue Culture Bananas in Kenya." *Agricultural Economics* 43: 473–485.
- Kalagho, K. 2013. "The Contributions of Lead Farmer Concept towards Women Lead Farmers' Empowerment in Agriculture: Case Studies from Kasungu District, Malawi." MS thesis, Van Hall Larenstein University of Applied Sciences.
- Katungi, E., S. Edmeades, and M. Smale. 2008. "Gender, Social Capital, and Information Exchange in Rural Uganda." *Journal of International Development* (special issue: *Gender and Collective Action: Motivations, Effectiveness, and Impact*) 20 (1): 35–52. <https://doi.org/10.1002/jid.1426>.
- Khaila, S., F. Tchuwa, S. Franzel, and S. Simpson. 2015. *The Farmer-to-Farmer Extension Approach in Malawi: A Survey of Lead Farmers*. ICRAF Working Paper 189. Nairobi: World Agroforestry Centre.
- Kiptot, E., and S. Franzel. 2014. "Voluntarism as an Investment in Human, Social, and Financial Capital: Evidence from a Farmer-to-Farmer Extension Program in Kenya." *Agriculture and Human Values* 31 (2): 231–243. <https://doi.org/10.1007/s10460-013-9463-5>.
- . 2015. "Farmer-to-Farmer Extension: Opportunities for Enhancing Performance of Volunteer Farmer Trainers in Kenya." *Development in Practice* 25 (4): 503–517. <https://doi.org/10.1080/09614524.2015.1029438>.
- Kiptot, E., M. Karuhanga, S. Franzel, and P. B. Nzigamasabo. 2016. "Volunteer Farmer-Trainer Motivations in East Africa: Practical Implications for Enhancing Farmer-to-Farmer Extension." *International Journal of Agricultural Sustainability* 14 (3): 339–356. <https://doi.org/10.1080/14735903.2015.1137685>.

- Knorr, J., M. G. Benyata, and V. Hoffmann. 2007. *The History of Agricultural Extension in Malawi*. Weikersheim, Germany: Margraf.
- Kondylis, F., V. Mueller, and J. Zhu. 2017. "Seeing Is Believing? Evidence from an Extension Network Experiment." *Journal of Development Economics* 125: 1–20.
<https://doi.org/10.1016/j.jdevco.2016.10.004>.
- Kondylis, F., 2019. "What Have We Learnt from Evaluations of Extension Interventions for NRM Technologies?" World Bank Research Group, draft PowerPoint presentation,
https://ispc.cgiar.org/sites/default/files/files/events/NRM%20Workshop/Kondylis_lessonslearnt_extension.pdf
- Krishnan, P., and M. Patnam. 2014. "Neighbors and Extension Agents in Ethiopia: Who Matters More for Technology Adoption?" *American Journal of Agricultural Economics* 96 (1): 308–327.
<https://doi.org/10.1093/ajae/aat017>.
- Kundhlande, G., S. Franzel, B. Simpson, and E. Gausi. 2015. *Farmer-to-Farmer Extension Approaches in Malawi: A Survey of Organizations Using the Approach*. ICRAF Working Paper 183. Nairobi: World Agroforestry Centre. <https://doi.org/http://dx.doi.org/10.5716/WP14384.PDF>.
- Lambrecht, I., B. Vanlauwe, R. Merckx, and M. Maertens. 2014. "Understanding the Process of Agricultural Technology Adoption: Mineral Fertilizer in Eastern DR Congo." *World Development* 59: 132–146.
- Lefort, R. 2012. "Free Market Economy, 'Developmental State' and Party-State Hegemony in Ethiopia: The Case of the 'Model Farmers.'" *Journal of Modern African Studies* 50 (4): 681–709.
- Levitt, S. D., J. A. List, and C. Syverson. 2013. "Toward an Understanding of Learning by Doing: Evidence from an Automobile Assembly Plant." *Journal of Political Economy* 121 (4): 643–681.
- Magnan, N., D. J. Spielman, T. J. Lybbert, and K. Gulati. 2015. "Leveling with Friends: Social Networks and Indian Farmers' Demand for a Technology with Heterogeneous Benefits." *Journal of Development Economics* 116: 223–251.
- Maguza-Tembo, M. M. 2010. "The Effectiveness of Farmer-to-Farmer Extension: A Case Study of Lobi and Mlomba Extension Planning Areas in Dedza and Lilongwe Districts, Malawi." MSc thesis, Bunda College, University of Malawi, Lilongwe.
- Masangano, C., and C. Mthinda. 2012. *Pluralistic Extension System in Malawi*. IFPRI Discussion Paper 01171. Washington, DC: International Food Policy Research Institute.
- Micheels, E. T., and J. F. Nolan. 2016. "Examining the Effects of Absorptive Capacity and Social Capital on the Adoption of Agricultural Innovations: A Canadian Prairie Case Study." *Agricultural Systems* 145: 127–138.
- Nijuki, J. M., M. T. Mapila, S. Zingore, and R. Delve. 2008. "The Dynamics of Social Capital in Influencing Use of Soil Management Options in the Chinyanja Triangle of Southern Africa." *Ecology and Society* 13 (2): article 9.
- Niu, C., and C. Ragasa. 2018. "Selective Attention and Information Loss in the Lab-to-Farm Knowledge Chain: The Case of Malawian Agricultural Extension Programs." *Agricultural Systems* 165: 147–163.

- Quisumbing, A. R., and N. Kumar. 2011. "Does Social Capital Build Women's Assets? The Long-Term Impacts of Group-Based and Individual Dissemination of Agricultural Technology in Bangladesh." *Journal of Development Effectiveness* 3 (2): 220–242.
- Ragasa, C., and J. Golan. 2014. "The Role of Rural Producer Organizations for Agricultural Service Provision in Fragile States." *Agricultural Economics* 45 (5): 527–553.
- Ragasa, C., and C. Niu. 2017. *The State of Agricultural Extension and Advisory Services Provision in Malawi: Insights from Household and Community Surveys*. Technical report. IFPRI, Malawi.
- Ragasa, C., and J. Mazunda. 2018. "The Impact of Agricultural Extension Services in the Context of a Heavily Subsidized Input System: The Case of Malawi." *World Development* 105: 25–47.
- Shikuku, K.M. 2019. "Information Exchange Links, Knowledge Exposure, and Adoption of Agricultural Technologies in Northern Uganda." *World Development* 115: 94–106
- Ward, P. S., A. R. Bell, K. Droppelmann, and T. Benton. 2018. "Early Adoption of Conservation Agriculture Practices: Understanding Partial Compliance in Programs with Multiple Adoption Decisions." *Land Use Policy* 70: 27–37.
- Wellard, K., J. Rafanomezana, M. Nyirenda, M. Okotel, and V. Subbey. 2013. "A Review of Community Extension Approaches to Innovation for Improved Livelihoods in Ghana, Uganda and Malawi." *Journal of Agricultural Education and Extension* 19 (1): 21–35.
<https://doi.org/10.1080/1389224X.2012.714712>.
- Wooldridge, J. 2002. *Econometric Analysis of Cross Section and Panel Data*. Cambridge, MA: MIT Press.

ALL IFPRI DISCUSSION PAPERS

All discussion papers are available [here](#)

They can be downloaded free of charge

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

www.ifpri.org

IFPRI HEADQUARTERS

1201 Eye Street, NW
Washington, DC 20005 USA
Tel.: +1-202-862-5600
Fax: +1-202-862-5606
Email: ifpri@cgiar.org