Journal of Development Economics 143 (2020) 102380

Contents lists available at ScienceDirect

Journal of Development Economics

journal homepage: www.elsevier.com/locate/devec

Gender gaps in technology diffusion☆

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ARTICLE INFO

JEL Codes:
J16
O12

Keywords:
Gender discrimination
Technology adoption
Agriculture
Social networks

ABSTRACT

Even with comparable innate ability and performance, women may be subject to discrimination. We run a field experiment across 143 Malawian villages in which either men or women were assigned the task of learning about a new agricultural technology, and then communicating it to others to convince them to adopt. Objective measures of these communicators' knowledge and adoption of the new technology show no gender gap in their ability to acquire, retain and use the information. Yet, micro-data on individual interactions from 6500 farmers show that other farmers are less willing to learn from female communicators, whom they perceive not to be as good at farming as their male counterparts. In spite of this, other farmers learn just as much about the technology when the communicator role is reserved for women, and they experience similar farm yields.

1. Introduction

Gender gaps in earnings and in other economic outcomes have been documented extensively by economists (Blau and Kahn, 2000). While gaps favoring men exist in virtually every country, disparities in income, health, education, and decision-making power are more pronounced in developing countries (Jayachandran, 2015). Understanding the causes of these gaps has received a lot of attention in the literature, with most of the empirical work focused in developed countries.[1] Review articles on the topic published a decade apart show that while the early literature emphasized cases of discrimination against women in the market as a source of disparity in outcomes (Altonji and Blank, 1999), a more recent literature has also considered gender differences in innate preferences and ability as underlying causes (Bertrand, 2011).

In this paper we explore the possibility that observed gender differences in preferences, attitudes (e.g. Gneezy et al., 2003; Niederle and Vesterlund, 2007, Flory et al., 2014) or performance in the field may themselves be the result of some discriminatory processes and experiences that women are subjected to earlier. We report on a field experiment in which we randomly assign either male or female farmers in Malawi the task of learning about a new agricultural technique, and then communicating about it to other villagers to convince them to adopt. While 48% of maize farms in rural Malawi are managed by women, male extension workers outnumber females 8 to 1. We use the experiment to understand the drivers of this large gender gap in participation in an activity that is central to economic life in poor agrarian societies.

We administer knowledge tests to both males and females assigned the roles of "communicator" a year and two years after training them, to measure how well they learned about the technology and retained that information, and whether they themselves adopted. Then, to measure

☆ This draft benefited from comments from Sofia Amaral, Manuel Bagues, Esther Duflo, David Evans, Andrew Foster, Arianna Legovini, John Loeser, Isaac Mbiti, David Rorhbach, Gil Shapira, Daniel Stein, and seminar participants at the 2019 ASSA meetings, IFPRI, DECRG, JPAL-Europe Labor Conference, Yale, UC-Merced and Cornell University. Siyao Zhu provided superb research assistance. Generous funding from the World Bank i2i, Gender Action Plan and Research Support budget, the Millennium Challenge Corporation, the Macmillan Center at Yale, and the Center for Business and Environment at Yale made this research possible, as well as support from the World Bank Development Impact Evaluation unit and Innovations for Poverty Action in Malawi. The views expressed in this manuscript do not reflect the views of the World Bank. All errors are our own.

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[1] See Bertrand (2011) and Niederle (2019) for reviews of the literature.

https://doi.org/10.1016/j.jdeveco.2019.102380
Received 6 February 2019; Received in revised form 11 August 2019; Accepted 23 August 2019
Available online 6 September 2019
0304-3878/© 2019 Published by Elsevier B.V.

these communicators' performance in the social diffusion task, we collect two years of follow-up data on a random sample of other farmers in their village. We track how well these other farmers learned and retained information about the technology from their assigned communicator, and whether they also adopted the technology. The first piece (communicator knowledge tests) allow us to compare males and females in terms of their raw innate ability to learn, while the data on others allow us to track how that ability translates into performance in the field when those communicators interact with society at large to complete the assigned task.

We find that in villages where the communicator role was reserved for women, those communicators do just as well as men in learning the details of how to implement the new technique and adopting it themselves. However, we find that message recipients (i.e., other maize farmers) perceive communicators in those female-reserved villages to be less knowledgeable about agriculture and about the technology, although by our objective measures those communicators are just as knowledgeable about the new technology introduced through the experiment as their counterparts in non-reserved villages. Accordingly, other farmers are less likely to interact with communicators' messages in both formal (training) and informal (conversation) settings in the female-reserved villages. Despite these gender gaps in perception and attention, we find that communicators in female-reserved villages perform just as well in diffusing the new technology to other male and female maize farmers resident in their village.

We use micro data on individual interactions collected from around 6500 farmers to explore why these gender gaps emerge. We rule out several potential causes. First, we show that it is not the case that women are worse teachers than they are learners. Direct measures of teaching performance indicate that women put as much effort into teaching, pass on as much information, and farmers they teach experience similar yields compared to those in villages with no gender reservation. These gender gaps do not seem to be about cross-gender frictions in communication either: The gender perception and interaction gaps remain regardless of whether we examine the responses of other male or female maize farmers. We also do not notice any differences in general social interactions across male and female farmers. Overall, patterns in our data suggest that this gender bias relates to issues of social norms and attitudes, either specific to the communicator role (*e.g., "women should not teach about farming"*) or about women in farming (*e.g., "we do not like to talk to women about farming"*).

Most real-world labor market tasks are characterized by situations where a woman must rely on or interact with male (or female) colleagues to be successful in her job. This is true for any job that requires managing or supervising teams of workers, teaching or training others, or interacting with customers. Labor markets in the modern economy rarely offer opportunities for individuals to work and succeed in isolation. Our results lend credence to the hypothesis that in such situations, equally able women may under-perform relative to men because of overt discrimination and lack of cooperation from colleagues (Bagues and Esteve-Volart, 2010; Delfgaauw et al., 2013), because of social norms and attitudes (Jayachandran, 2019, Gneezy et al., 2009, Bertrand et al., 2015), or because gender identities require women to behave differently when interacting with male colleagues (Akerlof and Kranton, 2000).[2] Perceptions and evaluations of women's performance may also not accurately reflect their actual performance (Duflo and Topalova, 2004), with important implications for both gender equity and economic performance. A lab experimental literature presents some related evidence that women either perform worse or display some different innate attitudes when they are in mixed-gender environments compared to single-gender environments (Booth and Nolen, 2012a; 2012b). Our results are also related to Mengel et al. (2018), who document gender bias in university teaching evaluations in the Netherlands despite there being no performance gaps across gender of the instructor.

Finally, our results also contribute to the literature on social learning and communication. Chandrasekhar et al. (2018) and Banerjee et al. (2018) argue that individuals are often reticent to seek information from peers, lest they appear uninformed. Our results add an interesting dynamic to this: Individuals may be more hesitant to receive information from certain types of other people in social networks. The identity of the information source affects what gets passed on, and this may put women at a disadvantage. Beaman et al. (2018b) document a different way through which social-network based information flows put women at a disadvantage: Men are less likely to refer (qualified) women for job openings.

Understanding the role of gender discrimination in the diffusion of a new agricultural technology is important for policy. Agricultural yields have remained low and flat in Sub-Saharan Africa over the last 40 years relative to the rest of the world, and low adoption of productive technologies is thought to be a major cause (World Bank, 2008). Female participation in farming tasks is much more common in Africa than in Asia. Lack of persuasive sources of information may make farmers reticent about new technologies, which makes the communication task we assign to men and women in our field experiment extremely important. Yield and other outcome data collected from 6500 farmers in our study villages suggest that success in the assigned tasks can have large welfare implications. Use of the new technology increases yields by over 30% in arid areas (BenYishay and Mobarak, 2019; Beaman et al., 2018a, 2018b).

The rest of the paper is organized as follows: In section 2, we describe the context and our experimental design. Section 3 discusses the data, while results on communicators' effort and recipient farmers' demand for communicators' teachings are presented in section 4. Mechanisms are discussed in section 5. We discuss policy implications in section 6.

2. Context and experiment

2.1. Extension network

Malawi is predominantly agricultural, and 85% of the population lives in rural areas (Malawi National Statistics Office, 2011). 56.6% of the rural population was classified as poor in 2011 (Malawi National Statistics Office, 2011). Maize is the primary staple food in Malawi. With one rainy season, there is typically one maize harvest per year. The Ministry of Agriculture communicates with maize farmers through a national public, decentralized agricultural extension system. All agrarian areas are in principle staffed by an Agricultural Extension Development Officer (AEDO), but in practice, these frontline positions are chronically understaffed. Each AEDO is responsible for providing extension services to 1,465 households on average, and moreover, many AEDO vacancies remain unfilled. At the outset of our study in 2009, only 56% of all AEDO positions were filled across our study districts, according to Ministry records. As a result, only 18% of farmers participated in extension activity according to the last National Agricultural and Livestock Census (Malawi National Statistics Office, 2007). Informational deficiencies remain a key challenge that hinders adoption of yield-enhancing technologies.

In addition, the traditional extension network is male-dominated: the average ratio of male to female AEDOs from 2005 to 2010 was 8:1 (Masangano and Mthinda, 2012). The Ministry had adopted a 'lead farmer' approach to extend the reach of extension, in which a few farmers are chosen to act as extension partners to communicate with their neighbors. These positions are typically filled by men. These gender imbalances suggest that involving more women to communicate with farmers about new technologies may be a promising way to address informational deficiencies, especially since 48% of maize farms in our study area are cultivated by women.

We conduct an extension experiment in collaboration with the Malawi Ministry of Agriculture to understand why female farmers are

[2] Hoff and Pandey (2014) provide field experimental evidence on how low-caste children in India perform worse on cognitive tasks in the presence of high-caste children, especially when caste identity is made salient.

under-utilized in extension services. One possibility is that women are worse at learning about and applying new agricultural technologies, and as a result, they are not selected for these roles. A different possibility is that women farmers have similar abilities as men, but do not participate in extension roles because they find it more difficult to deliver the messages to the rest of the community, or because they face discrimination in this market. We now describe the experiment we designed to test these competing hypotheses. The Ministry of Agriculture had identified some new promising new technologies for which information dissemination was the key barrier to adoption, and we utilized those technologies to conduct an extension experiment involving both men and women.

2.2. Experimental design

We partner with the Ministry of Agriculture and Food Security (MoAFS) in Malawi to conduct a large-scale field experiment with 143 maize farming communities in 8 districts across the country. In 2009, the MoAFS was preparing to roll out a new extension activity[3] in these eight districts, and we convinced them to incorporate ideas from the social learning literature to improve delivery. Under this approach, a few village residents are chosen as extension partners or *communicators*, and are asked to serve as the interlocutor between the AEDO assigned to the area and the rest of the village farming community. A communicator has two main categories of tasks:

Task A: receive training on a new technology, and acquire, retain and use this knowledge on her own farm.
Task B: communicate about the new technology to other (non-communicator) farmers in her village, and convince them to acquire, retain and use this knowledge on their farms.

To explore gender dimensions of communication, we randomly select 48 villages where we reserved the communicator role for women. In the other 47 treatment villages, we did not impose any such gender reservation.[4] Appendix A details the experimental design. Measuring the relative performance of male and female communicators (in gender-reserved versus non-reserved villages) in Task A allows us to isolate gender differences in innate ability/effort/motivation/performance in terms of learning and retaining information about a new agricultural technology, while the comparison to Task B allows us to gauge gender differences in performance when success is contingent on communicating with others and persuading them to accept their message. Measuring a gender performance gap on Task A would suggest that differences in innate ability/motivation/effort may in part explain the gender gap in participation in the provision of extension services we observe in Malawi. In the absence of a gender gap in performance on Task A, measuring a gender gap in performance on Task B would suggest that women face barriers to communicating their message to others in the village.

Our experimental design cannot disentangle the role of social norms and attitudes from a story of broader frictions in communication, or women communicators having lower teaching abilities than their male counterparts. To shed light on these mechanisms, we collect data on other farmers' yields and social interactions. A difference in farmers' yields across gender reservation arms may suggest a difference in the quality of the signal across female-reserved and non-reserved villages. This would lend support to gender differences in teaching abilities. Similarly, measuring gender gaps in perception and communication around farming and the technology would shed light on the role of social norms and attitudes.

2.3. AEDO training

Each extension officer (AEDO) is responsible for a group of villages, which is called a "section". Our sampling frame is restricted to the 457 sections (out of 822) staffed by an AEDO in our study districts. Within this set, we randomly select 121 sections where we conduct the project. We first randomly assign 26 sections to "pure control" and the 95 other sections to our communicator treatment.[5]

Appendix B provides a detailed timeline of project activities. In August 2009, prior to launching any intervention, AEDOs serving our 95 treatment sections received a three-day training on (a) the new technologies we were introducing for this project, and (b) how to transfer knowledge about those technologies to a village-based communicator. The training materials were prepared and delivered by the two agencies most relevant to the two technologies we introduced (Departments of Agricultural Research Services and Land Resources Conservation). The Department of Agricultural Extension Services (DAES) coordinated the trainings. The sessions were attended by all AEDOs and their direct supervisors (Agricultural Extension Development Coordinators, AEDCs). Each AEDO and AEDC was trained only on the one technology relevant to their assigned districts.

The first day of the training was devoted to familiarizing AEDOs and their supervisors with the aims of the project. The concept of *communicator* was discussed, as well as the motivations for a gender reservation mechanism. This part of the training was key in ensuring good compliance to the study protocols, since the AEDO played a central role in the identification of communicators. The second and third days of training were allocated to classroom and hands-on training on the new technology that the AEDO would then disseminate to communicators. Classroom discussions took place at the training centre, while hands-on modules were held in adjacent demonstration plots. The training closed with an explanation of each AEDO's specific village assignment, including any gender reservation requirements for the extension partner or "communicator" they had to help identify.

2.4. Communicator identification and gender assignment

The first village visit was designed to identify the communicators in all treatment villages. The AEDO assigned to that village convoked and led a half-day meeting that was open to anyone in the community, including local leaders, social groups and associations within the village such as youth groups, church, savings and loan associations, etc. Turnout was usually substantial, with the majority of the village in attendance. Participants at the meeting identified the different important social groups in the village, and each group nominated one representative who was willing to learn and disseminate a new technology to others. From the group of people nominated as potential peer farmers, meeting participants working together with the AEDO and village leaders narrowed it down to five, making sure that the five jointly represent different groups, and that the majority were women in the villages where the communicator role was reserved for women. The farmers nominated by the community agreed that they understood their role and responsibility as a

[3] A decentralized T&V model of extension is set up such that information on new technologies flows from researchers to extension workers and on to producers via farmer communicators, points of contact between extension agents and other farmers (Kondylis et al., 2017).

[4] BenYishay and Mobarak (2019) study social learning and communication in this subset of 47 villages, comparing them to 48 control villages and 25 additional villages not included in this paper where government extension workers were the primary communicators. The relationship between these two studies, the samples and experimental designs are described in further detail in Section 2.7 and Appendix A.

[5] We chose additional "spillover" control villages in 19 of the treated sections, to study whether treatment leads to displacement of AEDO attention away from other villages he is responsible for. We do not find any evidence of effort displacement, and all results reported in this paper are robust to controlling for an indicator for such sections.

peer farmer, and they were presented to the village for endorsement. The specific (random) gender assignment was shared in this first meeting.[6] Both men and women assigned to the communicator role were well integrated in the social tissue of the community and chosen in conjunction with community members, to reduce the chance that any chosen communicator of either gender would be resented thereafter. To reduce gender stereotyping of this new communicator role, AEDOs told the meeting attendees that men and women could be equally successful at this task. It is useful to note that 15.8% of the AEDOs who took part in this experiment were female. Appendix D further details the protocol used in the selection of these communicators. These meetings were completed during August–September 2009.

Appendix Tables C1 and C2 report compliance with the gender reservation treatment, separately for all treatment arms reported in BenYishay and Mobarak (2019). The tables show that there was imperfect compliance with the gender reservation treatment, so we conservatively report *intent-to-treat* (ITT) estimates throughout the paper. The ITT tracks the effect of the village getting *assigned* a female communicator. If different *types* of women or men complied with the treatment assignment, then the local average treatment effect (LATE) of gender reservation becomes difficult to interpret. 61% of villages assigned to the female-reserved treatment choose female lead farmers, whereas every single village not assigned to the gender-reserved treatment chose male lead farmers. 55% of the gender-reserved peer farmer villages (where we required that the majority of communicators be female) complied with the experimental instructions, while 18% of the non-reserved villages had a majority of females as communicators. The experimental assignment therefore did produce a first-stage of increasing the participation of females in communicator roles, but we do not use it as an instrument to estimate the LATE because compliance variation across rounds relate back to communicator performance and, therefore, endogenous. We also directly control for the Lead/Peer farmer assignment, given the compliance variation across these two types of villages.

2.5. Shadow communicators and training

We follow the same communicator identification process in control villages, to designate "shadow communicators" who *would have* played the communicator role, had that village been treated.[7] These shadow communicators are useful for research purposes, because they represent the correct counterfactual against which to compare the actions of the actual communicators in treatment villages. Identifying and surveying the shadow communicators allows us to report experimental results on what actions and activities the communicators participate in as a result of the project, holding constant the social identity and other unobserved characteristics of the communicator. These regressions will prove to be useful to understand the mechanisms underlying the effects that we will observe, such as differences in social interactions and perceptions.

This design implies that the only difference between treatment and control communities is that communicators in treatment villages receive subsequent visits and trainings from the AEDOs on a new technology, while shadow communicators do not. AEDOs trained the communicators soon after identification, and ahead of the main planting season. These trainings lasted for half a day. It involved explaining the merits of and demonstrating the application of the new technology. The AEDOs then made follow-up visits to treatment communicators over the course of the next two years.[8]

2.6. Technology

We promoted one yield-enhancing conservation farming technology in each village. AEDOs in four arid districts were trained on "pit planting" (Rumphi, Neno, Chikwawa, and Balaka districts). "Changu composting" was promoted in villages in the other four districts (Zomba, Mchinji, Dedza, and Mzimba). These conservation agriculture technologies have proven yield benefits and overall positive returns, as documented experimentally for Malawi (BenYishay and Mobarak, 2019; Beaman et al., 2018a,2018b), and observationally for the sub-region (Thierfelder et al., 2015). These techniques do not confer any added benefit to one gender over another, and there is no gender gap in knowledge of these techniques in our control villages at baseline. While the technologies are yield-enhancing, they require some additional up-front labor effort or learning effort. Farmers may be reluctant to invest this effort on new technologies with uncertain benefits. We will briefly describe the two technologies here, and Appendix B provide the training program, and Appendices E and F detailed training manuals for each technology.

Pit planting increases a soil's capacity for storing water while minimizing soil disturbance and, thus, nutrient runoff. In practice, rectangular pits are excavated in a field. Seeds are planted inside the pits, rather than on ridges, which is the status quo practice in Malawi. The pits conserve moisture and allow farmers to use small quantities of inputs more efficiently. Once prepared, pits can be used for at least two consecutive seasons, after which farmers have to reshape the pits. Pit planting was virtually non-existent at baseline in our study area. Only 1 percent of farmers reported ever practicing it, and only 12 percent of farmers had ever heard of the technology.

The main benefits of "Changu composting" over other types of compost are (i) reduced heap maturity and (ii) use of easily accessible materials. At baseline, we record that only 7 percent of farmers in control villages had heard of this type of compost (overall, 53% had heard of compost in general), and only about 25 percent of those who had heard of Changu composting were able to correctly answer questions on preparation, properties and application methods.

The data analysis will pool all eight districts together and use district fixed-effects to absorb any unobserved technique-specific and geographic heterogeneity.

2.7. Relationship to the BenYishay and Mobarak (2019) experiment on incentives

BenYishay and Mobarak (2019) reports on an overlapping, cross-cutting experiment that randomly varied the identity of the communicators (either "lead farmers" who have leadership stature in the village, or "peer farmers" who are average-looking farmers), and provided performance-based incentives to random subsets of those

[6] In all communities, we asked community leaders to designate up to 5 "peer farmers" and 1 "lead farmer". However, the specific communicator type is not the focus of this paper and, in the interest of statistical power, we pool these groups and focus on the gender assignment. In *lead farmer* villages, the gender assignment required that the one selected communicator be a woman. In *peer farmer* villages, our gender treatment required that a majority of communicators be women. We pool these two treatment arms into one general *communicator* treatment and study the effects of the (cross-cutting, random) gender reservation treatment. We control for the lead versus peer farmer treatment in all analysis reported in this paper. A separate paper (BenYishay and Mobarak, 2019) studies the effects of communicator type using only a sub-sample of our villages (the 47 villages) where there was no gender reservation treatment.

[7] In control communities, the process ended after the community endorsed the choice of communicator. Unlike communicators in treatment communities, shadow communicators were not trained nor contacted beyond the second step of the identification process.

[8] In a cross-cutting experiment, performance-based incentive payments were randomly assigned to communicators in half the villages. Results from this treatment assignment are reported in BenYishay and Mobarak (2019). In this study, we pool our results across incentive arms since interacting gender reservation with incentive assignment does not affect our conclusions (Appendix Tables A1–A9 replicate all main results tables in villages subject to the incentive payment). We control for incentive treatment assignment in all regression models.

communicators. Figure A1 succinctly describes the full experimental design in this project, and highlights the differences between data and experimental arms used in this paper versus the data and experimental arms that are the subject of the BenYishay and Mobarak (2019) analysis.

There are a few important points to note. First, the cross-cutting treatments in BenYishay and Mobarak (2019) were balanced by design with respect to the gender-reservations experiments studied in this paper. Not surprisingly, controlling for those treatment arms does not affect our results. Second, BenYishay and Mobarak (2019) only uses a subset of the data used in this paper. They do not use any of the data from villages where the communicator role was reserved for women. Figure A2 highlights and shades the sub-samples used in their paper, while Figure A3 does the same for this paper. Third, in neither paper do we study the interaction effects between the cross-cutting treatments (e.g. "do males and females perform differently when incentives are provided?") because we were not powered to do so.

BenYishay and Mobarak (2019) report the effects of pit planting adoption on agricultural yields, which we do not repeat here. In their preferred estimate, the intent-to-treat effect of introducing the pit planting technology is to increase maize yields by 3% of the baseline value. This translates into a "treatment effect on the treated" amongst pit planting adopters of a 19% increase in maize yields.

3. Data and descriptive statistics

3.1. Data sources

We first conduct a full listing of all households in each of the 143 villages. We randomly select households to survey from this sampling frame. We chose all communicators (treated or shadow), plus 25 other randomly selected households for the surveys. We rotate the sample of households participating in each survey round and create imperfect panels to both minimize survey fatigue for each household and prevent communicators from focusing on just a few households, after observing who we survey; Appendix G details this rotation and corresponding response rate. This yields samples of 3,685, 3943 and 3609 households of 'regular' (non-communicator) farmers and 467, 474, and 329 communicators at baseline, midline and endline, respectively.[9] The baseline was conducted in August–September 2009,[10] a midline in July–September 2010 at the end of the first agricultural season, and an endline in July–September 2011 after the second agricultural season. The primary agricultural decision maker was the key respondent for the full survey. At midline and endline, a spouse/additional farmer was interviewed separately, primarily on production in his/her plots, technology knowledge and adoption, and social networks, increasing the total number of respondents to 6480 and 5022 at midline and endline, respectively.

These surveys capture a rich set of measures of knowledge and adoption of the promoted techniques, along with agricultural production, household demographics, individual characteristics, perception, and social network relationships. To test respondents' knowledge about the technology introduced in their village, we ask seven questions regarding the details of how to apply the technology. The questions are based on the material used by AEDOs to train communicators in treatment villages.[11] We use these questions to construct a [0,1] knowledge index where 0 indicates a respondent could not correctly answer any question, and 1 that a respondent answered all questions correctly. We collect data on adoption of the technology in two different ways: (a) self-reported in the survey, and (b) through direct observations during the on-farm monitoring.

The social network module records farmers' interactions with and perceptions of (shadow or actual) communicators and other farmers in their village. Social network relationships with other non-communicator farmers were recorded as follows. For each respondent, we drew a list of six randomly-picked farmers in the community from our baseline listing. We then asked questions about the nature of the respondent's interactions with each of these farmers, as well as their perceptions about those farmers. Appendix I details the construction of all main outcome variables.

3.2. Descriptive statistics and balance

Table 1 displays sample characteristics of the communicators chosen for the experiment and compares them to both shadow communicators and other non-communicators who were randomly selected to respond to our survey. Communicators are similar to regular farmers on most dimensions, with no significant differences by gender assignment (cols 7, 8, 9). Reassuringly, shadow and actual communicators share similar characteristics (col 11). Randomly varying the gender of chosen communicators does not lead to statistical differences in the observable characteristics of the communicators (col 7). This is important to note for the proper interpretation of the statistical differences in post-treatment outcomes across arms that we will report later. Those outcome differences will be attributable to randomly assigning a task to either men or women, who are otherwise similar along observable dimensions.

Table 2 tests for balance in randomization by comparing non-communicator respondents across treatment assignments. We achieve balance on individual observable characteristics across all treatment arms (cols 3, 6, 9), and reject joint significance of these characteristics in determining treatment status.[12] Farmers in our study area are about 41 years old, work mainly in agriculture and cultivate just under 1 ha of land, own one head of cattle and about 4.6 other assets. These are relatively poor farming households: they live in dwellings made from local material, with only 21 percent owning a tin roof. Their diet consists mainly of maize. Only 5 percent had taken any loan in the year prior to baseline.[13] Central to the interpretation of our experimental results is the fact that there is no maize yield gap between male and female farmers, nor between female-reserved and non-reserved communicators. This signals that male farmers are just as good at farming as their female counterparts in our study sample.

4. Main regression results

In this section, we describe the results of the experiment along its expected causal chain: from communicators' performance in acquiring the new technology (Private Task A), to their performance in teaching and convincing others to adopt the technology (Socially-mediated Task B).

[9] Communicator response rate was 97.3% at baseline 98.8% at midline, and 76.2% at endline (the denominator changes at endline because some random set of control villages were not enumerated). This response rate is balanced across arms (Appendix H).

[10] The baseline survey only allowed for one respondent, the head of the household. This implies that baseline individual characteristics on communicators are not available whenever the communicator was not head of the household. We therefore use our midline communicator survey, collected at the time of the on-farm monitoring survey, to establish compliance to the gender assignment.

[11] See Appendices C and D for a detailed record of the knowledge exam, and training manuals, respectively.

[12] We note an imbalance on "Completed Primary Education" and a few markers of socioeconomic status. These characteristics predict knowledge and adoption of the new technology – because they are highly correlated, we make the choice to only control for "Completed Primary Education" in all regression models to avoid issues of multicollinearity.

[13] In Appendix Tables A1 and A2 we reproduce Tables 1 and 2, additionally reporting balance across incentive arms.

Table 1
Profile of communicator-type farmers.

	Mean						Mean Difference				
	Communicators			Shadow Communicators	Non-Communicators		(1)–(2)	(5)–(6)	(1)–(5)	(2)–(6)	(3)–(4)
	No Reservation	Female Reservation	All	All	No Reservation	Female Reservation					
	1	2	3	4	5	6	7	8	9	10	11
Resp. is household head	0.96	0.90	0.93	0.91	0.94	0.94	0.06	0.00	0.02	−0.05	0.02
Resp. is primary ag. decision maker	0.95	0.99	0.97	0.96	0.91	0.96	−0.04	−0.05*	0.03	0.03	0.01
Household head is male	0.82	0.76	0.79	0.79	0.69	0.74	0.06	−0.05**	0.14*	0.02	0.00
Household head age	40.01	42.02	40.98	39.71	41.42	40.54	−2.01	0.87	−1.41	1.48	1.27
HH head completed primary education	0.62	0.61	0.61	0.56	0.41	0.49	0.01	−0.09**	0.21**	0.12	0.05
Total cultivated land area in 2008/09 (ha)	1.16	1.08	1.12	1.08	0.98	0.91	0.07	0.08	0.17	0.18	0.04
Maize yield (kgs/hectare)	812	605	714	1093	714	788	207	−74	98	−182	−378
HH cultivated cash crops	0.99	0.98	0.99	1.00	0.99	0.99	0.01	0.01	0.00	−0.01	−0.01
Majority of agricultural labor by women	0.25	0.26	0.25	0.29	0.35	0.23	0.00	0.12**	−0.10	0.02	−0.04
Dwelling has improved roof	0.26	0.41	0.33	0.33	0.18	0.24	−0.15**	−0.06**	0.08	0.17**	0.00
Dwelling has improved walls	0.39	0.51	0.45	0.52	0.35	0.44	−0.12	−0.09*	0.04	0.07	−0.07
HH has improved water (dry season)	0.80	0.82	0.81	0.92	0.86	0.81	−0.02	0.05	−0.06	0.01	−0.11**
HH has improved water (rainy season)	0.83	0.82	0.82	0.92	0.86	0.80	0.01	0.06	−0.04	0.02	−0.10**
Primary staple food is maize	0.94	0.97	0.95	0.98	0.94	0.97	−0.03	−0.03	0.00	0.00	−0.03
Primary staple food is sorghum	0.03	0.00	0.02	0.00	0.05	0.01	0.03*	0.03	−0.01	−0.01	0.01
Primary staple food is cassava	0.00	0.02	0.01	0.00	0.00	0.01	−0.02	−0.01	0.00	0.01	0.01
Number of animals owned by the HH	1.58	1.65	1.61	1.66	1.22	1.33	−0.07	−0.11	0.36*	0.32	−0.04
Number of assets owned by the HH	5.57	5.37	5.48	5.50	4.43	4.79	0.20	−0.36*	1.15*	0.58	−0.03
Primary source of income is HH farm	0.90	0.85	0.87	0.85	0.79	0.84	0.05	−0.05	0.11	0.01	0.02
Primary source of income is casual labor	0.45	0.31	0.39	0.39	0.48	0.48	0.14*	0.00	−0.03	−0.17	0.00
Primary source of income is a business	0.30	0.53	0.41	0.41	0.38	0.44	−0.23***	−0.06	−0.07	0.10	0.01
≥1 HH member took loan in past year	0.08	0.14	0.11	0.08	0.04	0.05	−0.06	−0.01	0.04	0.09**	0.03
Adoption	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Number of farmers	115	105	220	248	1206	1260	220	2466	1321	1365	268

Data source: Baseline household survey. Notes: T test inferences are based on standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

4.1. Communicators' performance in the private task (Task A – learning about the new technology)

To explore possible innate gender differences in performance on the assigned tasks, we first compare communicators' relative performance in a task that did not require them to interact with other farmers in society: acquiring, retaining and adopting the new technology themselves. Measuring gender differences in communicators' knowledge and adoption of the new technology across gender reservation arms allows us to test whether a gender raw ability gap may be driving the gender gap in participation to extension services.

For identification, we use the random village-level assignment to gender reservation of the communicator. To standardize our measure, we compare communicators in both types of treatment villages (female-reserved or unreserved) to "shadow communicators" (who *would have been* assigned the task based on their social identity, but were not) in

Table 2
Balance Test (non-communicator farmers).

	By Communication Method			By Gender Reservation		
	Communicator Vlg	Control Vlg	(1)–(2)	No reservation	Female reservation	(4)–(5)
	1	2	3	4	5	6
Respondent is household head	0.94	0.93	0.01	0.94	0.94	0.00
Respondent is primary agricultural decision maker	0.94	0.94	−0.01	0.91	0.96	−0.05 *
Household head is male	0.71	0.70	0.01	0.69	0.74	−0.05 **
Household head age	40.97	40.81	0.16	41.42	40.54	0.87
HH head has completed primary education	0.45	0.46	−0.01	0.41	0.49	−0.09 **
Total cultivated land area in 2008/09 (hectare)	0.94	0.87	0.08 *	0.98	0.91	0.08
Maize yield (kgs/hectare)	752	898	−145.14	714	788	−73.58
HH cultivated cash crops	0.99	1.00	−0.01 *	0.99	0.99	0.01
Majority of agricultural labor done by women	0.29	0.34	−0.05	0.35	0.23	0.12 **
Dwelling has improved roof	0.21	0.24	−0.03	0.18	0.24	−0.06 **
Dwelling has improved walls	0.40	0.41	−0.01	0.35	0.44	−0.09 *
HH uses improved water source in dry season	0.84	0.93	−0.09 **	0.86	0.81	0.05
HH uses improved water source in rainy season	0.83	0.93	−0.09 ***	0.86	0.80	0.06
Primary staple food is maize	0.95	0.96	−0.01	0.94	0.97	−0.03
Primary staple food is sorghum	0.03	0.01	0.02	0.05	0.01	0.03
Primary staple food is cassava	0.01	0.00	0.00	0.00	0.01	−0.01
Number of animals owned by the household	1.27	1.25	0.02	1.22	1.33	−0.11
Number of assets owned by the household	4.61	4.63	−0.02	4.43	4.79	−0.37 *
Primary source of income is the household farm	0.81	0.81	0.00	0.79	0.84	−0.05
Primary source of income is casual labor (*ganyu*)	0.48	0.47	0.01	0.48	0.48	0.00
Primary source of income is a business	0.41	0.39	0.02	0.38	0.44	−0.06
At least one HH member took a loan in past year	0.05	0.04	0.01	0.04	0.05	−0.01
Knowledge Score	0.06	0.01	0.04	0.05	0.06	0.00
Adoption	0.00	0.00	0.00	0.00	0.00	0.00
F - stat, test of joint significance			2.55			2.34
Number of farmers	2467	1219	3686	1207	1260	2467

Notes: See Table 1.

control villages. This implies that we are holding constant all socioeconomic characteristics, network positions and other unobservables associated with identity, and identifying this relationship on the basis of random assignment of the task (or not). We then compare these coefficients to draw out differences across gender reservation. We estimate the following specification, with shadow communicators as the omitted category:

$$y_{ivdt} = \beta_1 Non_Reserved_{vd} + \beta_2 Reserved_Female_{vd} + \Gamma X_{ivd} + D_t + D_d + \varepsilon_{ivdt} \quad (1)$$

y_{ivdt} is the outcome (such as performance on the technology knowledge test) for communicator i in village v in district d in year t. We estimate Eqn 1 using OLS regression and include some control variables measured at baseline,[14] district fixed effects, and survey year fixed effects.[15] We cluster standard errors at the village level, which was the unit of randomization. We also report statistical tests of gender difference in performance ($\beta_1 = \beta_2$). These coefficients and tests are identified off the random assignment of the gender-reservation through the field experiment.

We report intent-to-treat (ITT) estimates of the effect of being assigned to the female-reserved or unreserved communicator arm. Treatment-on-Treated or IV specifications would be more complicated to interpret in our setting because: (a) men or women of different types or abilities may choose to comply with the assignment, and the gender assignment may affect the quality of their replacement[16]; and (b) we report results on many downstream outcomes, such as agricultural yields or crop failure among other farmers who are trained by the either the female-reserved or non-reserved communicators. Given the selection of who choose to adopt, only the ITT estimates are easily interpretable for many specifications we report.

Table 3 reports results on four measures of communicator effort in "private" tasks that do not require any interaction with other farmers in his/her society: extensive and intensive margins of participation in AEDO-led trainings on the promoted technology (cols 1, 2), post-training measures of knowledge about the technology to track how well the information was learnt and retained (col 3), and the propensity to adopt the technology on the communicator's own farm (col 4).

Communicators in treated communities are 38–41 percentage points more likely to have participated in training about the new technology compared to shadow communicators, with a slightly larger estimate for female-reserved villages, but the difference training participation across gender reservation arms is small and imprecisely estimated. Communicators in female-reserved villages attend 0.62 (25%) additional trainings relative to non-reserved villages, but this difference is imprecisely estimated (p-value = 0.34).

Column 3 reports on how well communicators retained the information that they were trained on. Shadow communicators (the omitted category) obtain average knowledge scores of 0.15 across the two survey rounds, which can be interpreted as correctly answering 15 percent of the questions about the technology that they are tested on, or one of the seven questions on average. Trained communicators in treated villages acquire and retain significantly more knowledge about the technology than shadows in control villages. Their test scores are about double or

[14] Controls include a constant, communicator-level characteristics (mean landholdings, mean number of plots worked, proportion of HH heads that are male, proportion of HH heads that have completed primary education), and village characteristics (matrilineal dummy, dummies for religion, dummies for language, dummies for village primary economic activity, percentage of HHs in village growing maize, dummies for type of staple food), and district and survey-year indicators. We also add dummies to indicate whether the village was randomly assigned to the peer farmer and incentive treatments.

[15] We pool both survey rounds for parsimony, with no effect on our central conclusions. For reference, we run the same model on the split survey rounds and find qualitatively similar results (not reported).

[16] Here we refer to replacement in the case of non-compliance to the gender assignment at the time of the initial selection.

Table 3
Communicators' effort & performance.

Village assigned to:	Attended training	# Trainings attended	Knowledge	Adoption
	1	2	3	4
No Gender Reservation	0.38***	1.98*	0.20***	0.17***
	(0.08)	(1.19)	(0.06)	(0.06)
Communicator Role	0.41***	2.61***	0.24***	0.22***
Reserved for Females	(0.08)	(0.99)	(0.05)	(0.07)
Endline Dummy	−0.09**	0.83**	−0.02	−0.06***
	(0.04)	(0.33)	(0.02)	(0.02)
Incentive Treatment	0.06	0.55	0.09**	0.11**
	(0.07)	(0.64)	(0.04)	(0.06)
Peer Farmer Treatment	−0.03	−0.71	−0.05	−0.02
	(0.07)	(0.87)	(0.05)	(0.05)
Constant	0.27**	−0.31	0.34***	0.30***
	(0.11)	(0.50)	(0.09)	(0.09)
N	803	803	803	803
Adjusted R2	0.14	0.07	0.37	0.36
Control Group Mean	0.26	0.45	0.15	0.02
	(0.44)	(1.62)	(0.27)	(0.15)
Gender Difference				
Coefficient for [female reservation. – no reservation]	−0.03	−0.62	−0.04	−0.04
(Standard Error)	(0.06)	(0.63)	(0.04)	(0.05)

Data sources: midline and endline communicator survey. Notes: Regressions include the following control variables: a constant, communicator-level characteristics (land area cultivated, dummy for male HH head, dummy for HH head completed more than primary school) and village characteristics (matrilineal dummy, dummy for primary religion is Islam, dummies for primary language), dummy for peer farmer and incentive treatment status, and district and survey-year indicators. Crop failure effect not included as a dependent because crop failure experienced by only 10 of the communicators. Standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

triple of shadows' scores (0.75–0.88 standard deviations in the control group) and these effects are precisely estimated. Female communicators score slightly (4%) higher than men in the knowledge test, but the difference is again imprecisely estimated.

Column 4 shows that only 2% of shadow communicators adopt the new technology, and that there is a sharp increase in adoption among treated communicators. Communicators are encouraged to use own adoption as a strategy to teach and persuade others to adopt, and adoption of the new technologies increases by 22 and 17 percentage points in female-reserved and non-reserved villages, respectively. While communicators in female-assigned villages are 5 percentage points more likely to adopt than their non-reserved counterparts, this difference is again imprecisely estimated.

4.2. *Communicators' performance in the socially mediated task (Task B – teaching and convincing others about the technology)*

We now explore gender differences in performance in the task that requires communicators to interact with other farmers in society: demonstrating, training and convincing other farmers to adopt the new technology. For this we use data from random samples of farmers who were (possibly) interacting with communicators. Having established no significant gender differences in communicators' ability to acquire, retain and adopt the new technology, we now test for a gender gap in teaching and convincing others about the technology. Finding a gender gap here will suggest that women communicators face barriers to occupying their extension roles that may explain the gender gap in the provision of extension services.

4.2.1. *Interactions between communicators and recipient farmers*

Our treatment encouraged communicators to hold *formal* training activities on the plots in which they adopted the new technology. Differences between communicators' propensity to hold trainings and other farmers' decisions on whether to attend trainings held by men or women provide useful clues for understanding gender differences in performance in our setting. If getting others in the community to pay attention to trainings is harder for female communicators, it would be difficult for them to succeed at Task B: encouraging information diffusion and adoption.

Column 1 in Table 4 shows that male and female communicators are equally likely to organize trainings for other farmers. However, columns 2–4 indicate that other farmers are significantly less likely (by 5 percentage points, p-value < 0.05) to participate in trainings organized in the villages where the communicator role was reserved for females. This is true for both female (−5 pp, p-value < 0.05) and male (−6 pp, p-value < 0.10) recipient farmers. The 5-percentage point lower training participation in female communicator villages is a meaningful difference, compared to training participation in control villages (15 percent), and given the fact that only a third of all communicators organize these trainings. In summary, although the supply of trainings is comparable across female-reserved and non-reserved villages, other farmers evidently pay less attention when the trainer is more likely to be female.

Columns 5–7 and 8–10 report results on more informal interactions between communicators and other farmers about the new technology and farming, respectively. We asked all farmers whether they have ever *discussed the new technology with a communicator*. These informal discussions are 4 percentage points less likely to occur when the communicator role has been reserved for a female (p-value < 0.10). Similarly, we asked whether they have ever *discussed farming with a communicator*. Again, we observe that other farmers are 6 percentage points less likely to have had farming conversations with their communicator when the role has been reserved for a female (p-value < 0.05). To investigate whether this reflects a possibility that women are generally less visible and talkative, columns 11–13 examine maize farmers' *general interactions* with communicators, not necessarily about this new technology. There is no significant difference in general conversations with communicators in either female-reserved or non-reserved villages. In other words, gaps in attention only arise when we focus on discussions about farming or the new agricultural technology.

We use our baseline social network data to identify whether these gender gaps in communication on farming result from the assignment to the role or reflect preëxisting gender norms (Table A10). Regressing baseline interactions with communicators demonstrate the absence of a gender gap at baseline: other farmers are as likely to discuss farming or talk in general with their assigned communicator across gender reservation arms. This suggests that this gender gap in communication is specific to the assignment to the role of extension provider. We return to this in the mechanisms section.

In summary, farmers generally interact with communicators in female-reserved villages, but they appear to be less engaged with information on a new agricultural technology or farming in general when this information originates from a female communicator. We observe this pattern in both informal (conversations) and formal (training) settings. Why do other men and women farmers pay less attention to female communicators? Either women are not perceived to be good at farming (and thereby less qualified to give advice), or there are differentials in male and female "identity" in leadership or training positions (Akerlof and Kranton, 2000). We explore these ideas further using data on villagers' subjective perceptions of the farming ability of men and women.

4.2.2. *Other farmers' perceptions of communicators*

Farmers may choose to engage less with female communicators due to biased perceptions about women's farming and training abilities (Beaman et al., 2009). For instance, if farmers perceive women to be not as good at farming, they may value their advice less. Alternatively, farmers may be less inclined to engage in discussions with female communicators due to social norms and attitudes about women's place in society (e.g., "we do not want to talk to women, they should not teach").

Table 4
Other farmers' interactions with communicators.

Village assigned to:	Comm. led training	Farmers interactions with communicators											
		Participated in trainings			Discussed Technology			Discussed Farming			Talked to Communicator		
		Female	Male	Pooled	Female	Male	Pooled	Female	Male	Pooled	Female	Male	Pooled
	1	2	3	4	5	6	7	8	9	10	11	12	13
No Gender Reservation	0.33***	0.04	0.01	0.02	0.06*	0.06*	0.06*	0.01	0	0.01	−0.14***	−0.12**	−0.13***
	(0.11)	(0.03)	(0.04)	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)	(0.04)	(0.03)	(0.05)	(0.05)	(0.04)
Communicator Role Reserved for Females	0.35***	−0.02	−0.05	−0.03	0.01	0.02	0.02	−0.06*	−0.05*	−0.05*	−0.14***	−0.11**	−0.12***
	(0.11)	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)
Endline	.	.	.	.	−0.02	0.02	0.00	0.07***	0.16***	0.11***	0.23***	0.31***	0.28***
	.	.	.	.	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)
Incentive Treatment	0.15*	0.09***	0.10***	0.09***	0.15***	0.13***	0.13***	0.14***	0.12***	0.13***	0.05	0.12***	0.09***
	(0.08)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)
Peer Farmer Treatment	−0.22**	0	0.02	0.01	0.05*	0.06**	0.06**	0.04	0.07**	0.06**	0.17***	0.16***	0.16***
	(0.09)	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Constant	−0.15*	0.11***	0.17***	0.13***	0.04	−0.08**	−0.03	0.10**	0.02	0.07*	0.67***	0.48***	0.60***
	(0.08)	(0.04)	(0.06)	(0.04)	(0.03)	(0.04)	(0.03)	(0.04)	(0.04)	(0.03)	(0.06)	(0.06)	(0.05)
N	329	2681	2012	4693	3963	6736	10,699	3831	6654	10,485	3943	6720	10,663
Adjusted R2	0.13	0.02	0.03	0.03	0.07	0.07	0.07	0.05	0.07	0.06	0.12	0.16	0.15
Control Group Mean	0.13	0.12	0.19	0.15	0.08	0.08	0.08	0.22	0.24	0.23	0.82	0.67	0.73
	(0.34)	(0.33)	(0.40)	(0.36)	(0.27)	(0.27)	(0.27)	(0.41)	(0.42)	(0.42)	(0.38)	(0.47)	(0.44)
Gender Difference													
Coefficient for [female reservation – no reservation]	0.01	−0.05**	−0.06*	−0.05**	−0.05**	−0.04	−0.04*	−0.07***	−0.05*	−0.06**	0.00	0.01	0.01
(Standard Error)	(0.07)	(0.02)	(0.03)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)

Data sources: Midline & Endline HH Surveys. Communicator led training (column 1) and farmer participation in trainings (columns 2–4) measured at endline only. Notes: Regressions include the following control variables: a constant, HH characteristics (land area cultivated, dummy for male HH head, dummy for HH head completed more than primary school) and village characteristics (matrilineal dummy, dummy for primary religion is Islam, dummies for primary language), dummy for peer farmer and incentive treatment status, and district and survey-year indicators. Standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

To investigate the role of perceptions, we collect data on other farmers' perceptions of the diligence, skills, and knowledge of

Table 5
Other farmers' perceptions of communicators.

Village assigned to:	Midline			Endline			Endline			Endline		
	Index: hardwork + skillful			Index: knowledgeable + good farmer			Knowledgeable			Good Farmer		
	Female	Male	Pooled	Female	Male	Pooled	Female	Male	Pooled	Female	Male	Pooled
	1	2	3	4	5	6	7	8	9	10	11	12
No Gender Reservation	0.06**	0.08***	0.07***	0.06***	0.08***	0.07***	0.07***	0.07***	0.07***	0.06***	0.08***	0.07***
	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)
Communicator Role Reserved for Females	0.04	0.07***	0.06***	0.05***	0.04**	0.04***	0.06***	0.03*	0.05***	0.05***	0.04**	0.04***
	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)
Incentive Treatment	0.05***	0.04***	0.04***	0.01	0.01	0.01	0.00	0.02	0.01	0.01	0.00	0.01
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Peer Farmer Treatment	−0.08***	−0.09***	−0.08***	−0.06***	−0.07***	−0.07***	−0.07***	−0.07***	−0.07***	−0.06***	−0.07***	−0.07***
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Constant	0.77***	0.72***	0.73***	0.80***	0.78***	0.79***	0.81***	0.77***	0.79***	0.79***	0.79***	0.79***
	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
N	913	3072	3985	2413	1844	4257	2362	1804	4149	2377	1825	4202
Adjusted R2	0.09	0.11	0.11	0.07	0.08	0.07	0.06	0.07	0.07	0.06	0.07	0.07
Mean of Control Group	0.80	0.79	0.79	0.78	0.73	0.76	0.78	0.73	0.76	0.77	0.73	0.76
	(0.18)	(0.18)	(0.18)	(0.14)	(0.16)	(0.15)	(0.15)	(0.17)	(0.16)	(0.15)	(0.17)	(0.16)
Gender Difference												
Coefficient for [female reservation – no reservation]	−0.02	−0.01	−0.01	−0.01	−0.04***	−0.02***	−0.01	−0.04***	−0.02***	−0.02*	−0.04***	−0.03***
(Standard Error)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)

Data sources: Midline & Endline HH Surveys. Notes: Regressions include the following control variables: a constant, HH characteristics (land area cultivated, dummy for male HH head, dummy for HH head completed more than primary school) and village characteristics (matrilineal dummy, dummy for primary religion is Islam, dummies for primary language), dummy for peer farmer and incentive treatment status, and district and survey-year indicators. Standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table 6
Other farmers' knowledge and adoption.

Village assigned to:	Knowledge Score			Adoption		
	Female	Male	Pooled	Female	Male	Pooled
	1	2	3	4	5	6
No Gender Reservation	0.07**	0.07**	0.07***	0.02	0.02	0.02
	(0.03)	(0.03)	(0.03)	(0.01)	(0.02)	(0.02)
Communicator Role Reserved for Females	0.03	0.06**	0.05**	0.00	0.02	0.01
	(0.02)	(0.03)	(0.02)	(0.01)	(0.02)	(0.01)
Endline Dummy	−0.04***	−0.05***	−0.06***	−0.02**	−0.03***	−0.03***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Incentive Treatment	0.03*	0.03	0.03*	0.03**	0.03**	0.03**
	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
Peer Farmer Treatment	0.04**	0.02	0.03	0.02**	0.01	0.02
	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
Constant	0.15***	0.24***	0.19***	0.06***	0.06**	0.06***
	(0.03)	(0.04)	(0.03)	(0.02)	(0.02)	(0.02)
N	3946	4258	8204	3946	4258	8204
Adjusted R2	0.17	0.22	0.20	0.05	0.06	0.06
Control Group Mean	0.06	0.09	0.08	0.01	0.02	0.01
	(0.17)	(0.22)	(0.20)	(0.10)	(0.13)	(0.12)
Gender Difference						
Coefficient for [female reservation. – no reservation]	−0.03*	−0.01	−0.02	−0.02*	0.01	−0.01
(Standard Error)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)

Data sources: midline and endline communicator survey. Notes: Regressions include the following control variables: a constant, HH characteristics (land area cultivated, dummy for male HH head, dummy for HH head completed more than primary school) and village characteristics (matrilineal dummy, dummy for primary religion is Islam, dummies for primary language), dummy for peer farmer and incentive treatment status, and district and survey-year indicators. Standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

communicators in their village. Each question elicits a subjective rating on a {1,2,3,4} scale on different dimensions of perception (cf. Appendix C). At midline, perception questions capture how hardworking and skillful a respondent considers the communicator to be, with no reference point. At endline, we ask whether the assigned communicator is (a) knowledgeable about farming and (b) a good farmer, relative to the respondent herself. We construct two separate indices of these measures, and normalize them on a [0, 1] scale.

Table 5 shows that farmers perceive communicators in non-reserved villages to be more hardworking, skillful and knowledgeable than in female-reserved villages. This difference is imprecisely measured at midline. However, this gender gap in perceptions is statistically precise at endline (p-value < 0.01), when the questions focus specifically on a communicator's farming skills and ability in relation to the rest of the community. This gender gap in perception is equally driven by differences in perception of communicators' knowledge and farming abilities (columns 7–12). Strikingly, both men and women think that non-reserved communicators are better at agriculture. This is in line with other findings in the literature, showing that discrimination against women is not solely perpetrated by men (Bagues and Esteve-Volart, 2010; Jayachandran, 2015). We consider these beliefs and perceptions to be *biased* against women, because the results in Table 3 indicate that communicators in female-reserved villages are just as knowledgeable about the new technology introduced through the experiment.

4.2.3. Other farmers' knowledge and adoption

Table 3 focused on tasks that do not require much social interaction with, or dependence on, the rest of the villagers. For such tasks, gender reservation did not affect communicators' effort and performance, and if anything, women slightly out-performed men (but not statistically significantly). However, we find that other farmers were less likely to attend trainings and interact with the communicator about the new technology when the communicator role was reserved for women. We also find that other farmers are less likely to perceive their communicator to be skilled at farming when the role is reserved for women, despite objective evidence to the contrary (Table 3).

Does this attention and perception gap in gender-reserved villages affect communicators' performance in diffusing the new technology? Table 6 tracks the effect of gender reservation on communicators' performance in convincing others in the community to acquire and retain information and, ultimately, use the technology. We use the same information and adoption outcome measures as in Table 3, but re-focus our attention to the sample of other, non-communicator farmers in all villages to evaluate how well information and adoption traveled from the communicators to others.[17] We present the same statistical test as in Table 3, comparing female-reserved villages to unreserved. Table 6 reports results for three different samples: separately for female and male respondents, and the pooled sample.

Communicators successfully transfer knowledge of the new technology to other farmers in their villages: knowledge scores increase by 5–7 percentage points across gender reservation arms, significantly more than in control villages. This corresponds to an increase in knowledge of 0.25–0.35 standard deviations, or 62.5–87.5 percent of the average knowledge score in the control group. Recipient farmers' knowledge scores in female-reserved villages are 2 percentage points lower than those of recipient farmers in unreserved villages, although this difference is imprecisely estimated. This gap is wider (3 percentage points) and more precisely estimated (p-value < 0.10) among female recipients (col 1, Table 4). However, these gains in knowledge of the new technology translate into small, imprecisely estimated gains in adoption, on the order of 1–2 percentage points over the control group (columns 4–6). Similar to the results on knowledge, column 4 shows that adoption is significantly lower (by 2 percentage points, p-value < 0.10) among female farmers in villages where the communicator role is reserved for women.

Overall these results suggest that, despite facing an attention and perception gap, communicators in female-reserved villages perform just

[17] In these regressions, controls (coefficients not reported) include a constant, total landholdings, number of plots cultivated, baseline HH characteristics (HH head male dummy, dummy if respondent is HH head, HH head completed primary school education dummy, improved water source dummy, dummy for dwelling with improved roof, dummy for dwelling with improved walls, dummy for whether any HH member took a loan) and village characteristics (matrilineal dummy, dummies for primary religion, dummies for primary language, dummies for primary economic activity, percentage of maize growers in the village, dummies for type of staple food), an indicator for the cross-cutting experiment on peer vs lead farmers, and district and survey-year indicators.

as well as their male counterparts at passing on knowledge of the new technology to others in the community. This suggests that, while gender reservation may have dampened other farmers' interest in demonstration activities, the identity of the messenger may not have affected the diffusion of this productive technology over our study period.

5. Mechanisms

Our results so far suggest that, despite being as knowledgeable and zealous, communicators in female-reserved villages suffer from an attention and perception gap. In this section we investigate possible alternative explanations to this gender bias, such as the possibility that women may be worse at teaching than they are at learning. We then use detailed social network surveys to place these results in the context of gender differences in perception and communication in the community at large.

5.1. Are women simply worse at teaching than at learning?

The results we have reported thus far may be evidence of discrimination against women in societal interactions, but it also may simply be the case that women are better learners than they are teachers. Differences in teaching performance could also arise due to gender disparities in human capital investment earlier in life. The descriptive data presented in Tables 1 and 2 suggests that this is unlikely to be the case: Maize yields (an imperfect measure of farmer ability) are not any lower at baseline on female-controlled plots. Furthermore, female communicators transmit information about the technology just as well (Table 6), despite getting less face time with the target farmers (Table 4). They don't appear to be less effective at transmitting knowledge per unit of time.

We further investigate differences in teaching quality by gender, by studying crop yields and the incidence of crop failure amongst recipient farmers as additional outcomes. Table 7 reports the results on a random sample of all recipient farmers residing in the village, not conditioning on adoption, to avoid any selection issue regarding who the communicators choose to target across gender-reserved and non-reserved villages.

Columns 1–3 report the effect of our treatments on a measure of maize yield on the farm captured at endline, after the second agricultural season post intervention.[18] These yield differences are extremely noisy, partly because differences in adoption rates across treatment arms is very small.[19] We fail to detect any significant difference in yields across gender reservation arms. If anything, female-reserved villages have a slight advantage, which is not consistent with a "bad teacher" hypothesis.

Given the noise in the yield data, we also study effects on the incidence of crop failure, which easier to measure. Columns 4–6 show that the likelihood of crop failure is smaller (but statistically indistinguishable) in the villages where the communicator roles were reserved for women. Crop failure is a relatively rare event that year (5% in control villages), and there is no evidence that female communicators cause more disasters or are less able to transfer skills to other farmers.

In summary, when women manage to teach and convince others to adopt, the recipients do just as well with the technology. In this sense, the gender perception and interaction bias we document is not congruent with what we observe using objective measures of performance. The perception gaps appear to be related to something else, such as discrimination in the form of perceptions of women as farmers, or people's relative unwillingness to accept messages from women.

Table 7
Other farmers' maize production.

Village assigned to:	Log Maize Yield			Likelihood of crop failure		
	Female	Male	Pooled	Female	Male	Pooled
	1	2	3	4	5	6
No Gender Reservation	−0.10	0.14	0.03	−0.01	−0.01	0.00
	(0.10)	(0.09)	(0.08)	(0.01)	(0.03)	(0.02)
Communicator Role Reserved for Females	−0.09	0.19**	0.05	−0.02	−0.02	−0.02
	(0.11)	(0.09)	(0.08)	(0.02)	(0.02)	(0.01)
Incentive Treatment	0.10	0.05	0.07	0.00	−0.01	0.00
	(0.07)	(0.06)	(0.06)	(0.01)	(0.02)	(0.01)
Peer Farmer Treatment	0.10	0.07	0.08	−0.01	0.01	0.00
	(0.07)	(0.06)	(0.06)	(0.01)	(0.02)	(0.01)
Constant	5.58***	5.84***	5.63***	.	.	.
	(0.14)	(0.16)	(0.12)	.	.	.
N	1406	1452	2858	1763	1623	3820
Adjusted R2	0.28	0.34	0.31	.	.	.
Control Group Mean	6.49	6.66	6.57	0.05	0.06	0.05
	(0.99)	(0.99)	(0.99)	(0.21)	(0.23)	(0.21)
Gender Difference						
Coefficient for [female reservation. – no reservation] (Standard Error)	0.00	0.04	0.02	−0.01	−0.02	−0.01
	(0.07)	(0.07)	(0.06)	(0.01)	(0.02)	(0.01)

Data sources: Endline HH Survey. Notes: Maize yield (1–3) is OLS. Maize yield calculated for all farmers that reported growing maize on at least one plot, and 2.5% top-end winsorized. Likelihood of crop failure (4–6) is probit; sample size varies when included controls perfectly predict failure. Regressions include the following control variables: a constant, HH characteristics (land area cultivated, dummy for male HH head, dummy for HH head completed more than primary school) and village characteristics (matrilineal dummy, dummy for primary religion is Islam, dummies for primary language), dummy for peer farmer and incentive treatment status, and district indicators. Standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

5.2. Compositional effects in training attendance

We found that female-reserved communicators are just as good at increasing other farmers' knowledge of the new technology, despite getting less face time (due to the gap in attendance at the trainings women hold). We explore the possibility that gender-reservation affects the composition of who shows up at this training. Table 2 establishes balance on farmers' observable characteristics at baseline. Table 8 presents descriptive statistics on the same observable characteristics, now comparing the profile of farmers who report attending communicators' trainings across female-reserved and non-reserved villages.

There are indications of positive selection into attending trainings in villages where the communicator role was reserved for women. Although fewer farmers attend those trainings, farmers who attend had more assets at baseline, better housing materials, and higher (imprecisely measured) yields. As these characteristics are likely predictive of farming abilities in our context, this suggest that female-reservation of the communicator role could have disproportionately dissuaded lower-ability farmers from attending their trainings.

5.3. Gender gaps in perception and communication in the community at large

We investigate whether the lack of interest in and perception bias against female-assigned communicators reflect a broader set of social norms and attitudes about women's place in society. For this, we use rich social network data on who in the community talks to whom about what.

[18] Although we record agricultural production in both survey rounds, we only record it at the plot level at the endline. This allows us to directly assign changes in yields to the individual farmer managing the plot, while at midline we can only provide a household level estimate. Yields are winsorized at the top 2.5% end of the distribution.

[19] We cannot reject that these imprecisely estimated effects are similar in magnitude to those reported by BenYishay and Mobarak (2019) or Beaman et al. (2018a, 2018b).

Table 8
Differences in baseline characteristics of farmers who attend trainings across gender-reservation arms.

	By Gender Reservation		
	No reservation	Female reservation	(1)–(2)
	(1)	(2)	(3)
Respondent is household head	0.93	0.93	0.00
Respondent is primary agricultural decision maker	0.94	0.97	−0.03
Household head is male	0.77	0.83	−0.06
Household head age	41.02	38.90	2.12
HH head has completed primary education	0.46	0.54	−0.07
Total cultivated land area in 2008/09 (hectare)	0.99	0.96	0.04
Maize yield (kgs/hectare)	532.48	702.73	−170.25
HH cultivated cash crops	1.00	1.00	0.00
Majority of agricultural labor done by women	0.27	0.18	0.09
Dwelling has improved roof	0.17	0.27	−0.10 *
Dwelling has improved walls	0.35	0.52	−0.18 **
HH uses improved water source in dry season	0.88	0.89	−0.02
HH uses improved water source in rainy season	0.89	0.87	0.02
Primary staple food is maize	0.94	0.94	0.00
Primary staple food is sorghum	0.04	0.02	0.03
Primary staple food is cassava	0.00	0.01	−0.01
Number of animals owned by the household	1.25	1.55	−0.31 **
Number of assets owned by the household	4.49	5.17	−0.67 **
Primary source of income is the household farm	0.87	0.87	0.00
Primary source of income is casual labor (*ganyu*)	0.46	0.53	−0.06
Primary source of income is a business	0.36	0.48	−0.11
At least one HH member took a loan in past year	0.04	0.06	−0.02
Knowledge	0.07	0.12	−0.05*
Adoption	0.01	0.02	−0.01
F - stat, test of joint significance			10.35***
Number of farmers	295	215	510

Notes: Attendance at training measured in the endline survey. Sample includes only households that appear in both the baseline and endline surveys.

We included a social network module in all surveys at midline, which asks the respondent about her interactions with and perceptions of 6 randomly selected other farmers in the village. Table 9 reports the gender dimension of these interactions, by estimating the following model using data in which respondent farmer i is asked about his/her interactions with/perceptions of other farmer j of a given gender residing in the same village:

$$y_{ijvd} = \delta_{FF} FemaleReserved_{vd} \cdot F_j + \delta_{FM} FemaleReserved_{vd} \cdot M_j + \delta_{MF} NonReserved_{vd} \cdot F_j + \delta_{MM} NonReserved_{vd} \cdot M_j + \lambda F_j + \Gamma X_{ivd} + D_t + D_d + \varepsilon_{ivd,j} \quad (2)$$

$FemaleReserved_{vd}$ *and* $NonReserved_{vd}$ are indicators for the village-level random assignment of female-reserved communicators or not, and M_j and F_j denote whether the other farmer j that the respondent i is asked about is male and female, respectively. We control for some respondent characteristics in X_{ivd}, including the respondent's own gender. λF_j captures the effect of gender of the farmer whom the respondent is asked about. The sample size is large in these regressions (up to 22,011) because the unit of observation is now an *(i,j)* pair, and there are up to 6 j's (other farmers) for every i (respondent). The excluded category is a male farmer's interaction with another male farmer in a control village.

The regressions in Table 9 explore three types of interactions: talking to other farmers in general (cols 1–3); discussing farming (cols 4–6); and, discussing the new technology introduced through the field experiment (cols 7–9); as well as farmers' perceptions of other farmers (*"how hard-working and skillful"*; cols 10–12). We make four central observations. First, people are no less likely to talk to females in general in the community (cols 1–3), which confirms our earlier observation that females are generally not less visible or more socially isolated in rural Malawi. Similarly, we do not observe a gender communication gap on issues of farming (cols 4–6) or the new technology (cols 7–9). Second, our interventions create more buzz around farming in the village, especially about the new technology. In all treatment villages, there are significantly more conversations between all farmers about agriculture and about the new technology, relative to control villages. This buzz benefits male and female farmers equally. Third, relatively more conversation and "buzz" occur in male-communicator villages. People appear to engage less in conversations about farming in general (cols 4–6) and the technology in particular (cols 7–9) when the communicator role is reserved for females (4 and 7 percentage points less in interactions with male and female farmers, respectively), although these differences only achieve conventional statistical significance in the case of interactions with female farmers (p-value = 0.06). Fourth, male and female farmers have similar perceptions of other female farmers in their village. The intervention has the same (small, negative) impact on farmers' perceptions of others in their village regardless of gender, and across gender reservation arms.

Taken together, these results suggest that the communication and perception gaps faced by female-reserved communicators stem not from a general information failure or social frictions across gender lines in the community (*e.g., "we do not want to talk about farming with women", or "women are not good at farming"*). Instead, these gaps in communication and perception are circumscribed to female-assigned communicators, and only emerge after their assignment to the role. These patterns suggest that the gender bias we observe is specific communicator role (*e.g., "women should not teach others a new technology/farming"*).

6. Conclusion

We ran a large-scale field experiment to test whether women perform differentially at a 'social task' that requires them to interact with others to succeed, relative to a 'private task' that does not. Women are comparable to men in the private task, and experience similar success at teaching or persuading others. However, other farmers do not perceive female communicators to be as good at farming and teaching, and pay less attention to their message and training.

The data on social relationships suggests that there isn't any generalized gender communication gap in our study setting (*e.g. "nobody talks to women"*), nor is it consistent with gender frictions in communication (e.g. *"women prefer talking to women, men to men"*). Instead, our findings support the notion that farmers in general are less likely to pay attention to and accept a message from a female communicator. Furthermore, our data on farm yields and teaching performance controlling for attendance provide an objective measure of success in the field and indicate that the perception gap is not congruent with objective indicators of performance.

Such gender gaps can impose a large cost on society. Women learn and transmit information about a productive new technology just as successfully as their male counterparts, and others taught by women experience greater farming yields, but the gender gaps in perceptions introduces inefficiencies in the transfer of information. This can have important productivity consequences. About half of all agricultural plots in Malawi are farmed by women, and these gender frictions creates a risk that a large amount of talent gets wasted. Agricultural technology adoption and productivity have remained much lower in Africa than in the rest of the world, and African women play a much greater role in agriculture than women in other continents.

Policy actions empowering women to take a leading role in acquiring

Table 9
Other farmers' interaction with each other, by gender.

	Talks			Discusses Farming			Discusses Technology			Perception Index		
	Female	Male	Pooled	Female	Male	Pooled	Female	Male	Pooled	Female	Male	Pooled
	1	2	3	4	5	6	7	8	9	10	11	12
Female	0.02	0.00	0.00	−0.02	0.00	−0.01	0.00	0.00	0.00	0.00	−0.01	0.00
	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)
Male in No Gender Reservation	−0.03	−0.04	−0.04	0.09	0.06	0.06	0.01**	0.00	0.00	−0.05*	−0.04*	−0.04*
vlg	(0.05)	(0.05)	(0.04)	(0.05)	(0.05)	(0.05)	(0.00)	(0.00)	(0.00)	(0.02)	(0.02)	(0.02)
Male in Communicator Role	0.01	−0.02	−0.01	0.00	0.03	0.02	0.01*	0.00	0.00	−0.05**	−0.03*	−0.04**
Reserved for Females vlg	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.00)	(0.00)	(0.00)	(0.03)	(0.02)	(0.02)
Female in No Gender Reservation	0.02	−0.02	−0.01	0.03	0.03	0.03	0.01**	0.01	0.01	−0.04	−0.04	−0.04*
vlg	(0.06)	(0.05)	(0.05)	(0.07)	(0.06)	(0.06)	(0.00)	(0.00)	(0.00)	(0.03)	(0.02)	(0.02)
Female in Communicator Role	−0.02	−0.06	−0.05	0.10*	0.06	0.07	0.01*	0.00	0.00	−0.03	−0.05**	−0.04**
Reserved for Females vlg	(0.05)	(0.05)	(0.05)	(0.06)	(0.05)	(0.05)	(0.01)	(0.00)	(0.00)	(0.03)	(0.02)	(0.02)
Incentives Treatment	0.11**	0.18***	0.16***	−0.14***	−0.19***	−0.18***	0.00	0.00	0.00	0.04**	0.03*	0.03**
	(0.04)	(0.03)	(0.03)	(0.05)	(0.04)	(0.04)	(0.00)	(0.00)	(0.00)	(0.02)	(0.01)	(0.01)
Peer Farmer Treatment	0.05	0.08**	0.07**	−0.07	−0.07*	−0.07*	−0.01*	0.00	0.00	0.01	−0.01	−0.01
	(0.04)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)	(0.00)	(0.00)	(0.00)	(0.02)	(0.02)	(0.01)
Constant	0.42***	0.30***	0.41***	0.36***	0.58***	0.42***	0.00	0.00	0.00	0.70***	0.70***	0.69***
	(0.07)	(0.06)	(0.06)	(0.07)	(0.07)	(0.06)	(0.00)	(0.01)	(0.00)	(0.03)	(0.03)	(0.02)
N	6717	24,889	31,606	7035	25,595	32,630	5248	16,678	21,926	5147	16,864	22,011
Adjusted R2	0.09	0.1	0.09	0.08	0.1	0.09	0.00	0.00	0.00	0.06	0.04	0.05
Mean of Control Group	0.39	0.36	0.37	0.47	0.54	0.52	0.00	0.00	0.00	0.75	0.75	0.75
	(0.49)	(0.48)	(0.48)	(0.50)	(0.50)	(0.50)	(0.00)	(0.06)	(0.05)	(0.20)	(0.19)	(0.19)
Female farmer = male farmer												
p-values, female reservation vlg	0.75	0.08	0.15	0.05	0.17	0.12	0.37	0.32	0.67	0.08	0.02	0.2
p-values, no reservation vlg	0.03	0.48	0.24	0.04	0.27	0.16	0.66	0.42	0.31	0.5	0.4	0.64
No gender reservation = female reservation												
p-values, female farmer	0.41	0.4	0.36	0.25	0.51	0.4	0.91	0.09	0.16	0.64	0.64	0.77
p-values, male farmer	0.34	0.51	0.44	0.06	0.42	0.3	0.25	0.4	0.35	0.66	0.86	0.99

Data sources: midline household questionnaire. Sample: All "regular" farmers (excludes actual and shadow communicators) in treatment and control villages. Farmers were asked about their interactions with 6 randomly selected "regular" farmers from their village. Each respondent-random farmer pair form one observation in this dataset; dependent variables refer to interactions of the respondent farmer with the randomly selected farmer. Notes: Regressions include the same controls as in Table 4. Sample size varies across columns due because "do not know" and "no opinion" responses are coded as "missing". Standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

and passing a message to others in their community could change perceptions about women's role in society. Our results suggest that a policy of assigning female farmers to teach others on its own may not be sufficient to address inefficiencies in communication and agricultural extension. There are deep-rooted inaccurate perceptions about women's ability in agriculture that need to be addressed. The welfare implications of shifting perceptions about women as innovators in an agrarian society may be quite large, given the importance of new agricultural technologies to raise productivity among poor smallholder farmers.

Appendix A. IE Design

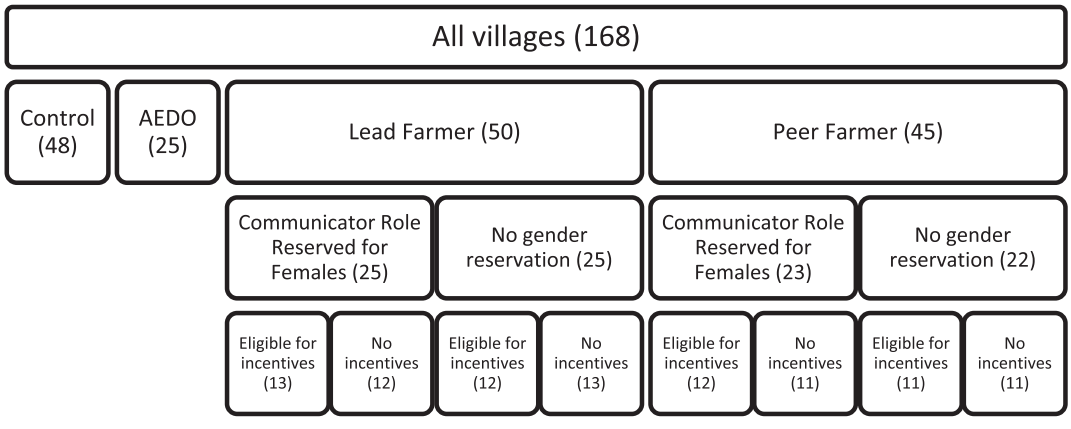

Fig. A1. Full sample.

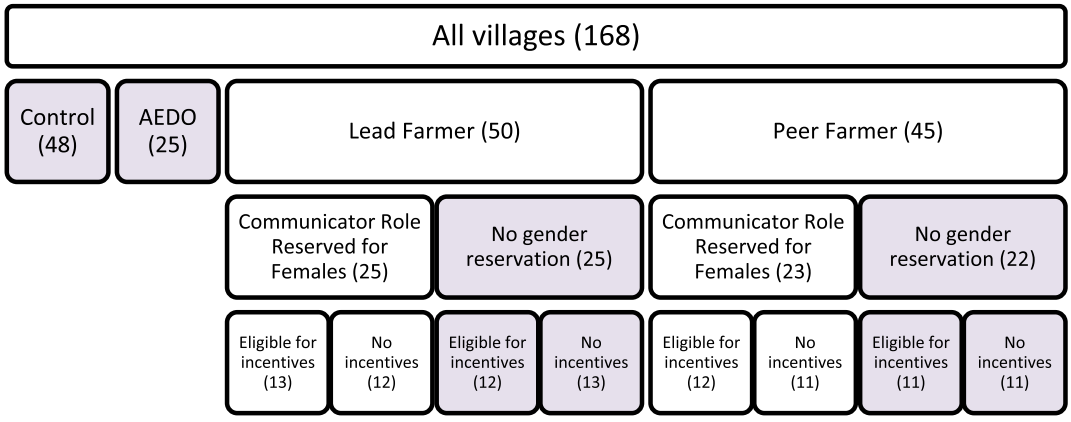

Fig. A2. Study 1 – BenYishay and Mobarak (Review of Economic Studies, 2019).

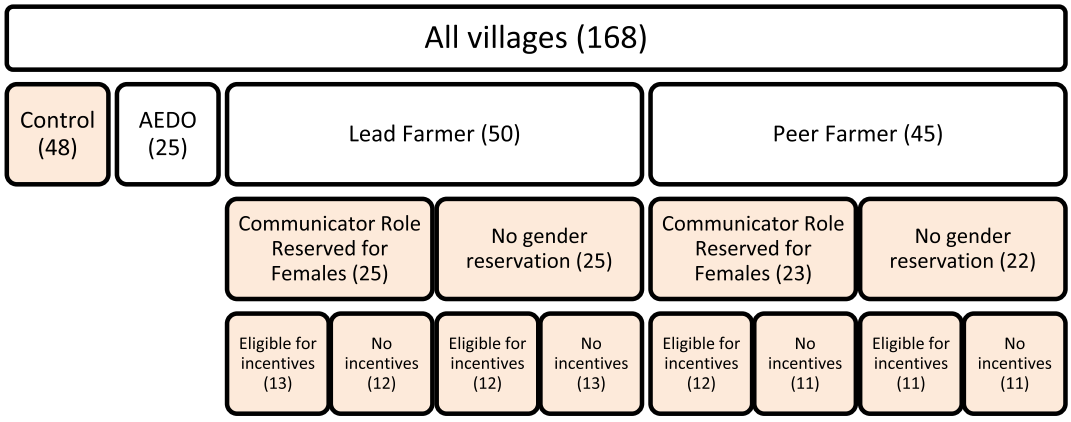

Fig. A3. Study 2 - Gender gaps in technology diffusion.

Table A1
Profile of communicator-type farmers (incentives sample).

	Mean						Mean Difference				
	Communicators			Shadow Communicators	Non-Communicators		(1)–(2)	(5)–(6)	(1)–(5)	(2)–(6)	(3)–(4)
	Male	Female	Pooled		Male	Female					
	1	2	3	4	5	6	7	8	9	10	11
Respondent is household head	0.93	0.98	0.95	0.91	0.92	0.94	−0.05	−0.03	0.01	0.04	0.04
Respondent is primary agricultural decision maker	1.00	0.98	0.99	0.96	0.93	0.96	0.02	−0.03	0.07	0.02	0.03
Household head is male	0.81	0.8	0.8	0.79	0.67	0.75	0.01	−0.08 **	0.14	0.05	0.01
Household head age	41.27	43.08	42.11	39.71	41.56	39.99	−1.81	1.56	−0.29	3.09	2.4
HH head has completed primary education	0.58	0.61	0.59	0.56	0.4	0.52	−0.03	−0.12 **	0.18	0.09	0.03
Total cultivated land area in 2008/09 (hectare)	1.09	0.97	1.03	1.08	0.92	0.89	0.12	0.03	0.17	0.08	−0.05
Maize yield (kgs/hectare)	532.91	707.44	614.13	1092.57	439.64	684.24	−174.52	−244.61 *	93.28	23.2	−478.44
HH cultivated cash crops	1.00	0.98	0.99	1.00	0.99	0.99	0.02	0.00	0.01	−0.01	−0.01
Majority of agricultural labor done by women	0.26	0.24	0.25	0.29	0.36	0.21	0.02	0.15 **	−0.1	0.03	−0.04
Dwelling has improved roof	0.33	0.53	0.42	0.33	0.21	0.24	−0.20 *	−0.03	0.12	0.29 ***	0.09
Dwelling has improved walls	0.46	0.59	0.52	0.52	0.38	0.48	−0.14	−0.11	0.08	0.11	−0.01
HH uses improved water source in dry season	0.93	0.82	0.88	0.92	0.9	0.82	0.11	0.09	0.03	0	−0.04
HH uses improved water source in rainy season	0.96	0.8	0.89	0.92	0.92	0.81	0.17 **	0.10 *	0.05	−0.02	−0.03
Primary staple food is maize	0.96	0.98	0.97	0.98	0.94	0.99	−0.01	−0.04 *	0.02	−0.01	−0.01
Primary staple food is sorghum	0.04	0.00	0.02	0.00	0.03	0.00	0.04	0.03	0.00	0.00	0.01

(*continued on next column*)

Table A1 (*continued*)

	Mean						Mean Difference				
	Communicators			Shadow Communicators	Non-Communicators		(1)–(2)	(5)–(6)	(1)–(5)	(2)–(6)	(3)–(4)
	Male	Female	Pooled		Male	Female					
	1	2	3	4	5	6	7	8	9	10	11
Primary staple food is cassava	0.00	0.02	0.01	0.00	0.01	0.00	−0.02	0.00	−0.01	0.02	0.01
Number of animals owned by the household	1.68	1.45	1.58	1.66	1.22	1.38	0.24	−0.16	0.46	0.07	−0.08
Number of assets owned by the household	5.56	5.35	5.46	5.5	4.28	4.81	0.21	−0.53 *	1.28 **	0.54	−0.04
Primary source of income is the household farm	0.88	0.82	0.85	0.85	0.8	0.89	0.06	−0.08	0.07	−0.07	0
Primary source of income is casual labor (ganyu)	0.51	0.35	0.43	0.39	0.47	0.55	0.16	−0.08	0.04	−0.2	0.04
Primary source of income is a business	0.25	0.45	0.34	0.41	0.4	0.46	−0.20 *	−0.07	−0.15	−0.01	−0.07
At least one HH member took a loan in past year	0.07	0.12	0.09	0.08	0.03	0.05	−0.05	−0.02	0.04	0.07	0.01
Adoption	0.02	0.00	0.01	0.00	0.01	0.01	0.02	0.00	0.01	−0.01	0.01
N	57	49	106	248	597	664	106	1261	654	713	354

Data source: Baseline household survey. Notes: T test inferences are based on standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A2
Balance Test (non-communicator farmers, incentives sample).

	By Communication Method			By Gender Reservation		
	Communicator Vlg	Control Vlg	(1)–(2)	No reservation	Female reservation	(4)–(5)
	1	2	3	4	5	6
Respondent is household head	0.93	0.93	0.00	0.92	0.94	−0.03
Respondent is primary agricultural decision maker	0.95	0.94	0.00	0.93	0.96	−0.03
Household head is male	0.71	0.70	0.01	0.67	0.75	−0.08 **
Household head age	40.73	40.81	−0.08	41.56	39.99	1.56
HH head has completed primary education	0.46	0.46	0.01	0.40	0.52	−0.12 **
Total cultivated land area in 2008/09 (hectare)	0.90	0.87	0.04	0.92	0.89	0.03
Maize yield (kgs/hectare)	571.49	897.62	−326.13	439.64	684.24	−244.61 *
HH cultivated cash crops	0.99	1.00	−0.01	0.99	0.99	0.00
Majority of agricultural labor done by women	0.28	0.34	−0.06	0.36	0.21	0.15 **
Dwelling has improved roof	0.23	0.24	−0.01	0.21	0.24	−0.03
Dwelling has improved walls	0.43	0.41	0.02	0.38	0.48	−0.11
HH uses improved water source in dry season	0.86	0.93	−0.07 *	0.90	0.82	0.09
HH uses improved water source in rainy season	0.86	0.93	−0.06 *	0.92	0.81	0.10 *
Primary staple food is maize	0.97	0.96	0.00	0.94	0.99	−0.04 *
Primary staple food is sorghum	0.02	0.01	0.01	0.03	0.00	0.03
Primary staple food is cassava	0.00	0.00	0.00	0.01	0.00	0.00
Number of animals owned by the household	1.31	1.25	0.05	1.22	1.38	−0.16
Number of assets owned by the household	4.56	4.63	−0.07	4.28	4.81	−0.53 *
Primary source of income is the household farm	0.85	0.81	0.04	0.80	0.89	−0.08
Primary source of income is casual labor (*ganyu*)	0.51	0.47	0.04	0.47	0.55	−0.08
Primary source of income is a business	0.43	0.39	0.04	0.40	0.46	−0.07
At least one HH member took a loan in past year	0.04	0.04	0.00	0.03	0.05	−0.02
Adoption	0.01	0.00	0.00	0.01	0.01	0.00
Knowledge score	0.07	0.01	0.06***	0.06	0.08	−0.02
N	1261	1219	2480	597	664	1261

Notes: See Table 1.

Table A3
Communicators' effort & performance (incentives sample).

Village assigned to:	Attended training	# Trainings attended	Knowledge	Adoption
	1	2	3	4
No Gender Reservation	0.43***	0.47	0.29***	0.32***
	(0.09)	(0.69)	(0.07)	(0.08)
Communicator Role Reserved for Females	0.48***	2.16***	0.30***	0.28***
	(0.10)	(0.66)	(0.06)	(0.08)
Endline Dummy	−0.03	1.15***	−0.02	−0.05*
	(0.05)	(0.38)	(0.02)	(0.02)
Peer Farmer Treatment				

(*continued on next column*)

Table A3 (*continued*)

Village assigned to:	Attended training	# Trainings attended	Knowledge	Adoption
	1	2	3	4
	−0.02	1.45*	−0.04	−0.02
	(0.10)	(0.82)	(0.07)	(0.10)
Constant	0.25**	−1.03*	0.38***	0.28***
	(0.12)	(0.60)	(0.10)	(0.10)
N	592	592	592	592
Adjusted R2	0.15	0.14	0.39	0.37
Control Group Mean	0.26	0.45	0.15	0.02
	(0.44)	(1.62)	(0.27)	(0.15)
Gender Difference				
Coefficient for [female reservation. – no reservation]	−0.05	−1.68*	−0.01	0.03
	(0.09)	(0.87)	(0.07)	(0.10)

Data sources: midline and endline communicator survey. Notes: Regressions include the following control variables: a constant, communicator-level characteristics (land area cultivated, dummy for male HH head, dummy for HH head completed more than primary school) and village characteristics (matrilineal dummy, dummy for primary religion is Islam, dummies for primary language), dummy for peer farmer and incentive treatment status, and district and survey-year indicators. Crop failure effect not included as a dependent because crop failure experienced by only 10 of the communicators. Standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A4
Other farmers' interactions with communicators.

Village assigned to:	Comm. led training	Farmers interactions with communicators											
		Participated in trainings			Discussed Technology			Discussed Farming			Talked to Communicator		
		Female	Male	Pooled	Female	Male	Pooled	Female	Male	Pooled	Female	Male	Pooled
	1	2	3	4	5	6	7	8	9	10	11	12	13
No Gender Reservation	0.54***	0.11***	0.09**	0.10***	0.17***	0.14***	0.15***	0.14***	0.10**	0.11***	−0.08**	−0.01	−0.03
	(0.14)	(0.03)	(0.04)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.05)	(0.04)
Communicator Role Reserved for Females	0.46***	0.06*	0.04	0.05	0.13***	0.10***	0.11***	0.08**	0.04	0.06	−0.08***	0.01	−0.02
	(0.15)	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)
Endline	.	.	.	.	0.00	0.05***	0.03	0.07***	0.18***	0.12***	0.22***	0.30***	0.27***
	.	.	.	.	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)
Peer Farmer Treatment	−0.26*	0.06	0.08	0.06*	0.12***	0.15***	0.14***	0.10***	0.14***	0.13***	0.19***	0.18***	0.19***
	(0.14)	(0.04)	(0.05)	(0.04)	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.05)	(0.04)
Constant	−0.15	0.09**	0.14**	0.11***	0.00	−0.12**	−0.05	0.08	−0.02	0.04	0.72***	0.52***	0.65***
	(0.09)	(0.04)	(0.06)	(0.04)	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)	(0.04)	(0.05)	(0.06)	(0.05)
N	239	1799	1349	3148	2676	4370	7046	2573	4313	6886	2662	4361	7023
Adjusted R2	0.16	0.03	0.04	0.04	0.08	0.09	0.08	0.05	0.08	0.07	0.12	0.15	0.14
Control Group Mean	0.13	0.12	0.19	0.15	0.08	0.08	0.08	0.22	0.24	0.23	0.82	0.67	0.73
	(0.34)	(0.33)	(0.4)	(0.36)	(0.27)	(0.27)	(0.27)	(0.41)	(0.42)	(0.42)	(0.38)	(0.47)	(0.44)
Gender Difference													
Coefficient for [female reservation – no reservation]	−0.08	−0.06	−0.05	−0.05	−0.04	−0.04	−0.04	−0.06	−0.06	−0.06	0.00	0.02	0.01
(Standard Error)	(0.11)	(0.03)	(0.05)	(0.03)	(0.04)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.05)	(0.04)

Data sources: Midline & Endline HH Surveys. Communicator led training (column 1) and farmer participation in trainings (columns 2–4) measured at endline only. Notes: Regressions include the following control variables: a constant, HH characteristics (land area cultivated, dummy for male HH head, dummy for HH head completed more than primary school) and village characteristics (matrilineal dummy, dummy for primary religion is Islam, dummies for primary language), dummy for peer farmer and incentive treatment status, and district and survey-year indicators. Standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A5
Other farmers' perceptions of communicators.

Village assigned to:	Midline			Endline			Endline			Endline		
	Index: hardwork + skillful			Index: knowledgeable + good farmer			Knowledgeable			Good Farmer		
	Female	Male	Pooled	Female	Male	Pooled	Female	Male	Pooled	Female	Male	Pooled
	1	2	3	4	5	6	7	8	9	10	11	12
No Gender Reservation	0.12***	0.12***	0.11***	0.06*	0.09***	0.07**	0.12***	0.14***	0.13***	0.08***	0.09***	0.08***
	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)	(0.01)	(0.02)	(0.01)
Communicator Role Reserved for Females	0.11***	0.10***	0.10***	0.05	0.06**	0.05**	0.10***	0.10***	0.10***	0.06***	0.06***	0.06***
	(0.02)	(0.02)	(0.01)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.01)	(0.02)	(0.01)
Peer Farmer Treatment	−0.11***	−0.07***	−0.08***	0.00	−0.04	−0.02	−0.03	−0.06**	−0.04	−0.07***	−0.08***	−0.07***
	(0.03)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.01)
Constant												

(*continued on next column*)

Table A5 (*continued*)

Village assigned to:	Midline			Endline			Endline			Endline		
	Index: hardwork + skillful			Index: knowledgeable + good farmer			Knowledgeable			Good Farmer		
	Female	Male	Pooled	Female	Male	Pooled	Female	Male	Pooled	Female	Male	Pooled
	1	2	3	4	5	6	7	8	9	10	11	12
	0.78***	0.72***	0.74***	0.66***	0.60***	0.65***	0.58***	0.51***	0.57***	0.79***	0.77***	0.78***
	(0.03)	(0.02)	(0.02)	(0.04)	(0.04)	(0.03)	(0.05)	(0.04)	(0.04)	(0.02)	(0.02)	(0.02)
N	642	2064	2706	1761	1327	3088	1737	1316	3053	1621	1236	2857
Adjusted R2	0.10	0.09	0.09	0.03	0.05	0.04	0.05	0.09	0.07	0.07	0.07	0.07
Mean of Control Group	0.80	0.79	0.79	0.67	0.64	0.66	0.61	0.58	0.6	0.77	0.73	0.76
	(0.18)	(0.18)	(0.18)	(0.22)	(0.22)	(0.22)	(0.25)	(0.24)	(0.25)	(0.15)	(0.17)	(0.16)
Gender Difference												
Coefficient for [female reservation – no reservation]	0.00	−0.01	−0.01	−0.01	−0.03	−0.02	−0.02	−0.04	−0.03	−0.02	−0.03**	−0.02*
(Standard Error)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)	(0.01)	(0.02)	(0.01)

Data sources: Midline & Endline HH Surveys. Notes: Regressions include the following control variables: a constant, HH characteristics (land area cultivated, dummy for male HH head, dummy for HH head completed more than primary school) and village characteristics (matrilineal dummy, dummy for primary religion is Islam, dummies for primary language), dummy for peer farmer and incentive treatment status, and district and survey-year indicators. Standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A6
Other farmers' knowledge and adoption (incentives sample).

Village assigned to:	Knowledge Score			Adoption		
	Female	Male	Pooled	Female	Male	Pooled
	1	2	3	4	5	6
No Gender Reservation	0.07***	0.06**	0.07**	0.04**	0.03	0.03*
	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)
Communicator Role Reserved for Females	0.05**	0.09***	0.07***	0.01	0.05***	0.03**
	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.01)
Endline Dummy	−0.03***	−0.05***	−0.05***	−0.02	−0.02**	−0.02*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Peer Farmer Treatment	0.08**	0.06	0.07**	0.04*	0.01	0.02
	(0.03)	(0.04)	(0.03)	(0.02)	(0.02)	(0.02)
Constant	0.12***	0.21***	0.16***	0.05***	0.03	0.03*
	(0.03)	(0.04)	(0.03)	(0.02)	(0.03)	(0.02)
N	2666	2778	5444	2666	2778	5444
Adjusted R2	0.18	0.24	0.21	0.06	0.06	0.06
Control Group Mean	0.06	0.09	0.08	0.01	0.02	0.01
	(0.17)	(0.22)	(0.20)	(0.1)	(0.13)	(0.12)
Gender Difference						
Coefficient for [female reservation. – no reservation]	−0.02	0.03	0.01	−0.03	0.02	0.00
	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)

Data sources: midline and endline communicator survey. Notes: Regressions include the following control variables: a constant, communicator-level characteristics (land area cultivated, dummy for male HH head, dummy for HH head completed more than primary school) and village characteristics (matrilineal dummy, dummy for primary religion is Islam, dummies for primary language), dummy for peer farmer and incentive treatment status, and district and survey-year indicators. Crop failure effect not included as a dependent because crop failure experienced by only 10 of the communicators. Standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A7
Other farmers' maize production (incentives sample).

Village assigned to:	Log Maize Yield			Likelihood of crop failure		
	Female	Male	Pooled	Female	Male	Pooled
	1	2	3	4	5	6
No Gender Reservation	0.04	0.25**	0.17*	0.01	−0.02	0.00
	(0.14)	(0.1)	(0.1)	(0.02)	(0.04)	(0.02)
Communicator Role Reserved for Females	−0.12	0.22**	0.06	−0.01	−0.03	−0.02
	(0.11)	(0.09)	(0.09)	(0.02)	(0.03)	(0.01)
Peer Farmer Treatment	0.20	0.05	0.11	−0.02	−0.01	−0.02
	(0.13)	(0.1)	(0.09)	(0.02)	(0.03)	(0.01)
Constant	5.61***	5.98***	5.70***	.	.	.
	(0.14)	(0.17)	(0.12)	.	.	.
N	936	974	1910	1289	856	2203
Adjusted R2	0.27	0.33	0.30	.	.	.
Control Group Mean	6.49	6.66	6.57	0.05	0.08	0.06
	(0.99)	(0.99)	(0.99)	(0.21)	(0.26)	(0.23)

(*continued on next column*)

Table A7 (*continued*)

Village assigned to:	Log Maize Yield			Likelihood of crop failure		
	Female	Male	Pooled	Female	Male	Pooled
	1	2	3	4	5	6
Gender Difference						
Coefficient for [female reservation. – no reservation]	−0.16	−0.03	−0.11	−0.02	−0.02	−0.01
	(0.11)	(0.11)	(0.09)	(0.02)	(0.03)	(0.01)

Data sources: Endline HH Survey. Notes: Maize yield (1–3) is OLS. Regressions include the same controls as in Table 4. Maize yield calculated for all farmers that reported growing maize on at least one plot, and 2.5% top-end winsorized. Likelihood of crop failure (4–6) is probit; sample size varies when included controls perfectly predict failure. Standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A8
Differences in baseline characteristics of farmers who attend trainings across gender-reservation arms (incentives sample).

	By Gender Reservation		
	No reservation	Female reservation	(1)–(2)
	(1)	(2)	(3)
Respondent is household head	0.91	0.92	−0.01
Respondent is primary agricultural decision maker	0.95	0.96	−0.01
Household head is male	0.77	0.85	−0.08
Household head age	41.14	38.56	2.58
HH head has completed primary education	0.45	0.54	−0.09
Total cultivated land area in 2008/09 (hectare)	0.92	0.92	0.00
Maize yield (kgs/hectare)	384.82	579.18	−194.37
HH cultivated cash crops	0.99	1.00	−0.01
Majority of agricultural labor done by women	0.28	0.16	0.12
Dwelling has improved roof	0.17	0.24	−0.07
Dwelling has improved walls	0.37	0.54	−0.17 *
HH uses improved water source in dry season	0.89	0.94	−0.05
HH uses improved water source in rainy season	0.92	0.91	0.01
Primary staple food is maize	0.95	0.97	−0.02
Primary staple food is sorghum	0.04	0.01	0.04
Primary staple food is cassava	0.00	0.00	0.00
Number of animals owned by the household	1.20	1.51	−0.31 *
Number of assets owned by the household	4.54	5.15	−0.61 *
Primary source of income is the household farm	0.87	0.89	−0.01
Primary source of income is casual labor (*ganyu*)	0.45	0.60	−0.15 *
Primary source of income is a business	0.37	0.49	−0.12
At least one HH member took a loan in past year	0.04	0.06	−0.02
Adoption	0.02	0.03	−0.01
Knowledge score	0.07	0.15	−0.08
F - stat, test of joint significance			6.19***
Number of farmers	190	142	332

Notes: Attendance at training measured in the endline survey. Sample includes only households that appear in both the baseline and endline surveys.

Table A9
Other Farmers' Interaction with Each Other, by Gender (incentives sample).

	Talks			Discusses Farming			Discusses Technology			Perception Index		
	Female	Male	Pooled	Female	Male	Pooled	Female	Male	Pooled	Female	Male	Pooled
	1	2	3	4	5	6	7	8	9	10	11	12
Female	0.02	0.00	0.00	−0.02	0.00	0	0.00	0.00	0.00	0.01	−0.01	0
	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)
Male in No Gender Reservation vlg	0.11**	0.13***	0.12***	−0.08	−0.11**	−0.11**	0.01	0.00	0.00	−0.01	0.00	0.00
	(0.05)	(0.05)	(0.04)	(0.06)	(0.06)	(0.05)	(0.00)	(0.00)	(0.00)	(0.03)	(0.02)	(0.02)
Male in Communicator Role	0.12*	0.15**	0.15**	−0.16***	−0.17**	−0.17***	0.00	0.00	0.00	−0.01	−0.01	−0.01
Reserved for Females vlg	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.00)	(0.01)	(0.00)	(0.03)	(0.02)	(0.02)
Female in No Gender Reservation vlg	0.14**	0.13**	0.13***	−0.12*	−0.13**	−0.13**	0.00	0.01	0.01	0.02	0	0.01
	(0.06)	(0.05)	(0.05)	(0.07)	(0.06)	(0.06)	(0.00)	(0.01)	(0.00)	(0.03)	(0.02)	(0.02)
Female in Communicator Role	0.11	0.10*	0.10*	−0.06	−0.11*	−0.10*	0.01	0.00	0.00	0.00	−0.02	−0.02
Reserved for Females vlg	(0.07)	(0.06)	(0.06)	(0.08)	(0.06)	(0.06)	(0.01)	(0.00)	(0.00)	(0.04)	(0.02)	(0.02)
Peer Farmer Treatment	0.06	0.09*	0.08*	−0.03	−0.08	−0.07	0.00	0.00	0.00	0.02	−0.02	−0.01
	(0.06)	(0.05)	(0.05)	(0.07)	(0.06)	(0.06)	(0.00)	(0.01)	(0.00)	(0.04)	(0.02)	(0.02)
Constant	0.44***	0.33***	0.44***	0.31***	0.54***	0.37***	−0.01	0.00	0.00	0.72***	0.70***	0.70***
	(0.09)	(0.07)	(0.07)	(0.08)	(0.09)	(0.08)	(0.00)	(0.01)	(0.00)	(0.04)	(0.04)	(0.03)
N	4590	15,951	20,541	4856	16,545	21,401	3690	11,413	15,103	3606	11,480	15,086
Adjusted R2	0.09	0.11	0.1	0.08	0.12	0.1	0.00	0.00	0.00	0.06	0.05	(0.05)

(*continued on next column*)

Table A9 (*continued*)

	Talks			Discusses Farming			Discusses Technology			Perception Index		
	Female	Male	Pooled	Female	Male	Pooled	Female	Male	Pooled	Female	Male	Pooled
	1	2	3	4	5	6	7	8	9	10	11	12
Mean of Control Group	0.39	0.36	0.37	0.47	0.54	0.52	0.00	0.00	0.00	0.75	0.75	0.75
	(0.49)	(0.48)	(0.48)	(0.50)	(0.50)	(0.50)	(0.00)	(0.06)	(0.05)	(0.20)	(0.19)	(0.19)
Female farmer = male farmer												
p-values, female reservation vlg	0.98	0.09	0.20	0.17	0.16	0.16	0.27	0.37	0.8	0.32	0.08	0.2
p-values, no reservation vlg	0.11	0.81	0.65	0.10	0.54	0.34	0.54	0.56	0.82	0.09	0.87	0.47
No gender reservation = female reservation												
p-values, female farmer	0.69	0.62	0.62	0.44	0.79	0.72	0.33	0.29	0.67	0.79	0.20	0.19
p-values, male farmer	0.81	0.61	0.57	0.2	0.43	0.33	0.89	0.86	0.84	0.79	0.74	0.75

Data sources: midline household questionnaire. Sample: All "regular" farmers (excludes actual and shadow communicators) in treatment and control villages. Farmers were asked about their interactions with 6 randomly selected "regular" farmers from their village. Each respondent-random farmer pair form one observation in this dataset; dependent variables refer to interactions of the respondent farmer with the randomly selected farmer. Notes: Regressions include the same controls as in Table 4. Sample size varies across columns due because "do not know" and "no opinion" responses are coded as "missing". Standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Table A10
Other farmers' interactions with communicators – baseline.

Village assigned to:	Farmers interactions with communicators					
	Discussed Farming			Talked to Communicator		
	Female	Male	Pooled	Female	Male	Pooled
	1	2	3	4	5	6
No Gender Reservation	−0.01	−0.16***	−0.11**	−0.23***	−0.23***	−0.23***
	(0.05)	(0.05)	(0.05)	(0.09)	(0.07)	(0.07)
Communicator Role Reserved for Females	−0.03	−0.15***	−0.11***	−0.21**	−0.16**	−0.18**
	(0.04)	(0.04)	(0.04)	(0.09)	(0.07)	(0.07)
Incentive Treatment	−0.05	0.00	−0.02	0.00	0.00	0.00
	(0.03)	(0.04)	(0.03)	(0.07)	(0.06)	(0.05)
Peer Farmer Treatment	0.09***	0.14***	0.12***	0.18**	0.19***	0.18***
	(0.03)	(0.03)	(0.03)	(0.07)	(0.05)	(0.05)
Constant	0.04	−0.04	0.07	0.24***	0.06	0.26***
	(0.05)	(0.1)	(0.05)	(0.09)	(0.14)	(0.09)
N	889	1812	2701	889	1812	2701
Adjusted R2	0.10	0.15	0.13	0.16	0.18	0.18
Control Group Mean	0.14	0.23	0.2	0.57	0.61	0.60
	(0.35)	(0.42)	(0.40)	(0.50)	(0.49)	(0.49)
Gender Difference						
Coefficient for [female reservation. – no reservation]	0.02	−0.01	0.00	−0.02	−0.07	−0.05
(Standard Error)	(0.03)	(0.03)	(0.03)	(0.07)	(0.05)	(0.05)

Data sources: Midline & Endline HH Surveys. Communicator led training (column 1) and farmer participation in trainings (columns 2–4) measured at endline only. Notes: Regressions include the following control variables: a constant, HH characteristics (land area cultivated, dummy for male HH head, dummy for HH head completed more than primary school) and village characteristics (matrilineal dummy, dummy for primary religion is Islam, dummies for primary language), dummy for peer farmer and incentive treatment status, and district and survey-year indicators. Standard errors clustered at the village level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Appendix B. Project Timeline

Field Activities

Activity	Timing	Responsibility
District-level briefings on impact evaluation with regional and district officials	July 2009	Extension, Land Resources, Research, Planning
AEDOs trained on the new technologies	August 2009	Extension, Land Resources, Research, Planning
AEDOs identify and train village Communicators	August–September 2009	AEDOs
Communicators train other farmers and demonstrate the new technologies	Starting September 2009	Communicators, assisted by AEDOs
Incentivized Communicators are briefed on performance-based rewards program	October–November 2009	Research team collaborating with Planning Department
Recipients of first year performance-based reward identified	November–December 2010	Research team
Incentives delivered	Starting January 2011	Planning Department

Data Collection

Baseline: August–October 2009

- Household questionnaire

Agricultural season: November/December 2009 – May/July 2010

Midline: July–October 2010

- Household questionnaire

- Spouse questionnaire
- Communicator questionnaire
- Village focus group questionnaire

Agricultural season: November/December 2010 – May/July 2011
Endline: July–October 2011

- Household questionnaire
- Spouse questionnaire
- Communicator questionnaire
- Village focus group questionnaire

***Training Schedule* – Monday, 10th August to Friday, 14th August 2009**

Day	Time	Topic	Facilitators
Monday		Arrival of participants	
Tuesday	Morning	Introductory Activities: welcome remarks, norms, introductions	DAPS
		Overview of ADP, ADP-SP, and ADP-SP Impact evaluation	DAPS
	Afternoon	Guidelines for Conservation Farming	DLRC
Wednesday	Morning	Field visit to Conservation Farming site	DLRC
	Afternoon	Discussion of observations from Conservation Farming site	DLRC
Thursday	Morning	Concept of Lead Farmer	DAES
		Concept of Peer Farmer	DAES
		Distinction between Lead Farmer and Peer Farmer	DAES
		Selection of Peer and Lead Farmers	DAES
		Random assignment of gender to Peer and Lead Farmers	DAES
		Monitoring strategy: outcomes of interest and Monitoring instruments	DAPS
	Afternoon	Review of the topics covered and feed back	DAPS
Friday		Departure	

Appendix C. Compliance to gender assignment of communicators (Source: midline communicator survey)

Table C1
Gender compliance by communicator type.

	Gender Assignment	Proportion of communicators that are female	Proportion of villages with ≥ 50% female communicators	Number of communicators
Communicator type				
Lead Farmer	Non-reserved	0.00	0.00	22
	Female	0.61	0.61	23
Peer Farmer	Non-reserved	0.31	0.18	101
	Female	0.48	0.55	88
Shadow communicators in control villages		0.23	0.17	236
				470

Table C2
Gender compliance across communicator and incentive arms.

	Gender Assignment	Proportion of communicators that are female	Proportion of villages with ≥ 50% female communicators	Number of communicators
Communicator type				
Lead Farmer	Non-reserved, with incentives	0.00	0.00	11
	Female, with incentives	0.55	0.55	11
	Non-reserved, no incentives	0.00	0.00	11
	Female, no incentives	0.67	0.67	12
Peer Farmer	Non-reserved, with incentives	0.30	0.18	53
	Female, with incentives	0.49	0.45	46
	Non-reserved, no incentives	0.33	0.18	48
	Female, no incentives	0.46	0.64	42
Shadow communicators in control villages		0.23	0.17	236
				470

Appendix D. Selection of Communicators

Selection of lead farmers:
The AEDO selected the lead farmer through the following process:

1. The AEDO convoked a meeting with local leaders and community members to identify a short list of potential lead farmers (specifically a list of female farmers for the gender-reserved villages).
2. The AEDO selected one of the farmers on the short list to be the lead farmer, in consultation with village leaders.
3. The AEDO announced his choice to the village, to be sure that the community will endorse the new lead farmer.

Selection of Peer farmers:

The AEDO selected the 5 peer farmers through the following process:

1. The AEDO convoked and facilitated a meeting with all village members to identify five farmers that represent different social groups in the village, and who are willing to try out the new technology. During training, the AEDO was instructed that the meetings must be well attended, that many different farmers must attend (not just those who may work with the extension agent most often), and that there should be representatives from all the different social groups in the village (males, females, elders, adolescents, people from different clubs or church groups, etc).
2. The AEDO explained that at least three of the representatives should be of the assigned gender.
3. Participants at the meeting identified the different important social groups in the village, and each group nominated one representative. From the group of people nominated as potential peer farmers, meeting participants working together with the AEDO and village leaders narrowed it down to five, making sure that the five all represent different groups (and the majority are of the assigned gender).
4. The farmers nominated by the community agreed that they understood their role and responsibility as a peer farmer, and they are presented to the village for endorsement.

Selection of shadow farmers:

Shadow lead and peer farmers were selected in the same manner as described above, with no gender reservation. Rather than the AEDO, the village meetings were convoked by a local Ministry of Agriculture evaluation officer.

Appendix E. Technical Guidelines for Pit Planting

Pit planting is a conservation farming technology that increases a soil's capacity for storing water while at the same time allowing for minimum soil disturbance. This is because when planting pits are excavated in a field, they may be used for at least two seasons before farmers have to reshape the pits. Planting pits enable farmers to use small quantities of water and manure very efficiently, and are cost and time efficient (although labor to construct the pits can be a constraint). Pits are ideal in areas where rainfall is limited.

The following are the guidelines for pit planting that the project will employ. These guidelines were developed by the MoAFS Department of Land Resources Conservation.

Step 1: Site Selection

Identify a plot with relatively moderate slopes. If possible the site should be secure from livestock to protect the crop residues.

Step 2: Land Preparation

Mark out the pit position using a rope, and excavate the pits following the recommended dimensions (as shown in the table below). These should be dug along the contour. The soil should be placed on the down slope side. Stones may be placed on the upslope side of the pit to help control run off, but this is optional. If available, crop residues from the previous harvest should be retained in the field so there is maximum ground cover.

Pit dimension and spacing:

Spacing between pits	70 cm
Spacing between rows	90 cm
Depth	20 cm
Length	30 cm
Width	30 cm

At this spacing, there will be 15,850 pits per hectare (158 pits per 0.1ha). Where rainfall is limited, pits can be made deeper and wider to make maximum use of rainwater.

Step 3: Planting, Manure and Fertilizer Application

The pit can be planted to maize crop at the spacing below:

Crop	Seeds/pit	Plants/ha
Maize	4	63,492

It is recommended that farmers apply 2 handfuls of manure in each pit. Two weeks before rainfall, apply manure and cover the pit with earth. If basal fertilizer is available, it can also be applied at the same time. When manure has been applied, the pits should be covered with soil. A shallow depression should still remain on top. If top dressing is available, it should be applied when the maize is knee high. In some areas, it may be after 21 days.

Step 4: Weed Control and Pest Management

The pits must be kept free of weeds at all times. Weed as soon as the weeds appear and just before harvesting. This will reduce the amount of weeds in the following season. Use of herbicides to control weeds is optional.

Step 5: Harvesting

Remove the crop. Cut plants at base, leaving stems and leaves on the soil. The roots should not be uprooted; they should be left to decompose within the pit.

Increasing the Efficiency of the Pits

It is important to realize that the use of these pits alone will not produce the highest yields. For best results:

- Always incorporate crop residues, leaving a minimum of 30% of crop residue on the field.
- Apply manure generously.

- Protect crops from weeds, pests, and diseases.
- Always plant with the first productive rains.
- Grow crops in rotation; at least 30% of the cropped land should be planted to legumes.
- Using a cover crop/ground cover in conjunction with pits will give best results

Monitoring and Evaluation Indicators
The following indicators will be used to monitor adoption of pit planting:

1. Number of seeds planted per pit
2. Proper spacing of the pits (measured by the number of pits/size of the plot)
3. Quantity of fertilizer applied
4. Use of crop residues
5. Use of a ground cover/cover crop

Training Plan for Pit Planting

1.0 **Objectives**

By the end of the session, participants should be able to:

- Understand the concept of conservation agriculture
- Distinguish between conservation agriculture and conservation farming
- Understand the options available in conservation agriculture
- Understand the technical recommendations for pit planting
- Demonstrate pit planting

2.0 **Steps and Sequence**
- Prepare a climate setter
- Outline the objectives on a flip chart
- Outline the concept of conservation agriculture on a flip chart
- Explain the differences between conservation agriculture and conservation farming on a flip chart
- Outline the options in conservation agriculture on a flip chart
- List advantages of conservation farming on a flip chart
- Prepare demonstration set up on pit planting

3.0 **Procedure**
- Start by setting the climate
- Outline the objectives
- Present the content
- Brainstorm on the concept of conservation agriculture
- Explain the concept of conservation agriculture
- Brainstorm on differences between conservation agriculture and conservation farming
- Explain differences between conservation agriculture and conservation farming
- Explain options in conservation agriculture
- Explain advantages of conservation farming
- Make a summary of session presentation
- Teach technical guidelines for pit planting
- Demonstrate on pit planting

4.0 **Methodology**
- Lecturette
- Demonstration

5.0 **List of Training Materials**
- Chalk board/Flip chart
- Chalk/Pental pen
- Previously made compost manure
- Equipment and tools
- Stone for hammering
- Pegs
- Hoes
- Measuring stick
- Measuring string
- Pail/bucket

Appendix F. Technical Guidelines for Nutrient Management

The following are the guidelines to the nutrient management strategy the project will employ. These guidelines were developed by the MoAFS Department of Agricultural Research.

Step 1: Materials for compost

The following materials are appropriate for making compost: leguminous crop residues (Groundnuts and Soyabean), fresh leaves of leguminous trees, chopped maize stover (about 6 inches long), animal or chicken manure (optional)

Step 2: Preparation of compost

Mix three parts of leguminous biomass (crop residues and/or fresh leaves) to two parts maize stover.

Put a layer of legume crop residue followed by a layer of stover then a layer of green leaves of legume tree repeat making the layers until the heap is 120 cm high. After constructing a set of three layers add 5 L of water to moisten the materials.

After constructing the heap smear the wet earth around the heap covering the biomass. The materials should be kept moist throughout the composting period. After 60 days the manure is ready, remove the manure and keep them under shade.

Step 3: Application method

Apply the manure at least two weeks before planting. Apply 3 kg of manure applied per 10 m ridge. Split open the ridge about 4 cm deep, spread the manure on the open ridge then bury the manure thus reconstituting the ridge.

Step 4: Planting

At the rain onset plant maize, one maize seed per planting hole on the ridge at a distance of 25 cm between planting holes.

Step 5: Use of Inorganic Fertilizer (optional, depends on availability)

Use 23:21:0+4S for basal dressing. Apply fertilizer as dollop; make a hole about 3 cm deep between the maize planting hills.

- Apply 23 kg N/ha of 23:21:0+4S at a rate 2.5 g per hole (cups to be calibrated to measure 2.5 g fertilizer).
- Apply 37 kg N/ha of Urea at a rate of 2 g per hole (cups to be calibrated to measure 2 g fertilizer)

Apply the inorganic fertilizer one (1) week after maize germination. Note that cups must be carefully calibrated; using a bottle cap will result in fertilizer overdose.

Monitoring and Evaluation Indicators:

The following indicators will be used to determine farmer's adoption of NM technology:

- Compost materials used (should exclude grass)
- Time and method of manure application
- Quantity of inorganic fertilizer applied
- Number of compost heaps per farmer (should increase in the second season)
- Expansion of area of land planted using the intervention (land area should increase in the second season)

Handout: making Changu compost or Changu

This is the type of compost where the organic materials decompose relatively fast hence the name "Changu."

Making of this type of manure undergoes several steps which are outlined as follows:

- Site selection. The best site for the Changu compost is
  - Near the garden where the compost is to applied, to minimize labour and time in transportation, preferably on the edge of the garden to avoid disrupting cultivation operations in the garden.
  - This should be under shade, on a fairly flat ground.
  - Near the source of materials and water
  - Away from dwelling houses with chickens and goats
- Materials required
  Composting materials
  - Grass
  - Crop residues
  - Maize stover
  - Leaves of various plants
- Booster (Khola manure, previously made compost manure, green fresh matter, leguminous leaves, top soil)
- Water
- Equipment and tools
  - Bricks
  - Stone/logs
  - Poles
  - Hoes
  - Measuring stick
  - Pail/bucket

Procedure for Construction

The process for construction of Changu compost heap is as follows:

- Clear the surface of the ground in at least 2 m diameter for easy marking
- Measure a 1.5 m–2 m diameter circle by using a peg and a string
- Heap 20–30 cm thick layer of composting material over the area marked, which will form as the base of the compost heap
- Water the heap adequately until it just oozes out when materials are squeezed to induce decomposition.
- Add a booster (Khola manure, previously made compost manure, green fresh matter, leguminous leaves, top soil) on top to a height of 3–5 cm thick

- Water the booster layer adequately
- Repeat the above process with the diameter of each subsequent layer reducing until the heap is 1.5 m high, thereby achieving a conical shape
- Cover the heap with grass to reduce evaporation

Procedure for turning

After two to three days the heap will have formed three distinctive layers.

- Insert a stick into the compost heap to check if decomposition has started
- If the stick is warm, it shows that there is microbial activity and decomposition has started.
- Where decomposition has started turn the heap after 3–4 days and there after every 4–5 days to speed up decomposition.
- During the turning process remove the outer layer (A) from the heap and separate the middle layer (B) from the inner layer (C).
- In the process of rebuilding the heap
  - Put layer A at the bottom
  - Water adequately
  - Put layer C in the middle
  - Water adequately
  - Lastly, put layer B on top/outside the heap.
  - Water and cover the heap with grass

The process of noted undecomposing heap

This is determined if the stick inserted into the heap is not felt to be warm.

This could be solved by dismantling the heap and remaking the compost, using a different booster, adding more water if the material looks dry.

Duration of composting for this method

The heap will mature after 30–40 days depending on the nature of composting material used.

Appendix G. Household Sampling

Survey Round	Interviews per village	Comm. HH sample	'Regular farmer' HH sample	Response rate (# HH interviews/expected sample)	Notes on 'regular farmer' HH sample	Number of interviews per HH
Baseline	31	6	25	98.7%	The 25 households were randomly selected, using a comprehensive household listing completed by the same survey team as part of the baseline data collection.	1 (agricultural decision-maker)
Midline	20–45	6	14–39	89.4%	**Villages with <50 total HHs (54 villages):** 14 HHs selected. Baseline HHs prioritized for the midline sample. The HH listing was updated at the start of the midline data collection by the same survey team. Replacements were made giving priority to other baseline HHs. Overlap of 100% with baseline expected; 95.1% of overlap was achieved. **Villages with 51–80 total HHs (37 villages):** 39 households selected. Sample includes all 25 baseline HHs, plus 14 randomly selected HHs from the updated listing. Replacements were made using randomly selected HHs. Overlap of 68.9% with baseline sample expected (25 regular farmers + 6 communicators out of 45 total HHs); 68.5% overlap was achieved. **Villages with >80 total HHs (77 villages):** 19 HHs selected in addition to the communicators. Baseline HHs prioritized. Replacements made at random from the updated listing. Overlap of 100% with baseline expected; overlap of 99.7% was achieved.	2 (agricultural decision-maker and his/her spouse)
Endline	31	6	25	90.3%	Household selection prioritized midline households, then households interviewed at baseline but not midline, and finally other households in the village.	2 (agricultural decision-maker and his/her spouse)

Appendix H. Construction of the main variables

Communicators' Effort (Communicator questionnaire, midline and endline)

- *Attended training*: A binary variable that indicates whether a Communicator reports working with an AEDO over the last farming season.
- *# Trainings attended*: A discrete variable that indicates the number of times a Communicator reports working with an AEDO over the last farming season.
- *Communicator led training:* A binary variable that indicates whether a Communicator led any training involving other farmers in his village during the 12 months prior to the interview.

Knowledge and Adoption (Communicators and Other Farmers)

- *Knowledge*: A [0;1] continuous variable that measures a respondent's understanding of the technology. The score is the fraction of correct answers a respondent provides to seven technology-specific questions for pit planting, and six for Changu composting. The percentage of correct answers is the knowledge score.
- *Adoption*: A binary variable that indicates whether a respondent adopted the promoted technology (pit planting or Changu composting) in the last farming season.

Other farmer Interactions with Communicator (Other farmers ML and EL; both main and additional respondent)

- *Discussed Technology*: A binary variable indicating whether farmers report having discussed the technology (pit planting or Changu composing) with the communicator during the 12 months prior to the interview.
- *Participated in trainings*: A binary variable indicating whether the farmer participated in a group training held by the communicator during the past 12 (asked at endline only).
- *Talked to communicator*: A binary variable indicating whether a farmer talked to their assigned communicator about anything over the past 12 months.

Other Farmers' Perception of Communicators (household & spouse/additional respondent questionnaire, Social Network module)

- *Midline perception index (hardworking + skillful):* An index constructed from two categorical variables indicating the respondent's perception of the communicator.
  - o Perception of how hardworking the communicator is, scaled from 0 to 1 into 4 levels, where 0 is "not hardworking" and 1 is "very hardworking"
  - o Perception of how skillful the communicator is, scaled from 0 to 1 into 4 levels, where 0 is "not skillful" and 1 is "very skillful".
- *Endline perception index (knowledgeable + good farmer):* An index constructed from two categorical variables indicating the respondent's perception of the communicator.
  - o Perception of how knowledgeable the communicator is, compared to the respondent. It is scaled from 0 to 1 into 5 levels; 0 is "communicator is much less knowledgeable than me" and 1 is "communicator is much more knowledgeable than me"
  - o Perception of how good the communicator is at farming, compared to the respondent. It is scaled from 0 to 1 into 5 levels; 0 is "communicator is a much worse farmer than me" and 1 is "communicator is a much better farmer than me."

Other farmers' Interaction with Each Other (Midline Social Network Module)

- *Discussed farming*: A binary variable that indicates whether the respondent reports discussing farming with another randomly drawn farmer from the community during the 12 months prior to the interview.
- *Discussed Technology*: A binary variable indicating whether farmers report having discussed the technology (pit planting or Changu composing) with another randomly drawn farmer from the community during the 12 months prior to the interview.

Knowledge Exam

Knowledge Question	Correct answer	Accepted answers
Pit Planting		
How far apart should the planting pits be?	70 cm	52.5–87.5
How deep should planting pits be?	20 cm	15–25
How wide should planting pits be?	30 cm	22.5–37.5
How long should planting pits be?	30 cm	22.5–37.5
How many maize seeds should be planted in each pit?	4	4
Should manure be applied?	YES	YES
How much manure should be applied?	2 double handfuls	2 double handfuls
After harvest what should be done with the stovers?	Maize plants cut off at base, leave roots to decompose in pit, stems and leaves used to cover the soil.	Correct multiple choice option selected.
Changu Composting		
What materials should be used for Changu composting?	Leguminous crop residues (most commonly soybeans and groundnuts), fresh leaves of leguminous trees, maize stoves, chicken or livestock manure	At least 1 correct material listed
How much time should Changu compost be let mature?	60 days	6 weeks–2 months
How should Changu compost be kept while it is maturing?	In a covered heap	In a covered heap
Should it be kept in the sun or the shade?	Shade	Shade
Should it be kept moist or dry?	Moist	Moist
When should Changu compost be applied to the field?	At least 2 weeks before planting	At least 2 weeks before planting

Appendix I. Communicator's response rate across survey rounds

Mean number of communicators interviewed per village

	Lead Farmer	Peer Farmer	Control	LF - PF	LF - Control	PF - Control
	(1)	(2)	(3)	(4)	(5)	(6)
Baseline	4.44	4.87	5.17	−0.43	−0.73**	−0.30
	(1.55)	(1.22)	(1.12)			
Midline	5.14	5.22	4.92	−0.08	0.22	0.31
	(0.9)	(1)	(1.09)			
Endline	3.88	4.04	3.60	−0.17	0.28	0.44
	(1.39)	(1.45)	(1.34)			

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