Final Technical and Financial Report: Adoption of Conservation Agriculture (CA) in Malawi

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1. Introduction

The study conducted under this Agreement investigates farmer uptake of natural resource management (NRM) practices that have been promoted under Malawi's Agricultural Sector-Wide Project Support Program (ASWAp-SP), namely contour ridges, contour bunds, box ridges, pit planting, minimum tillage, herbicide use, organic manure making and application, mulching, agroforestry technologies, intercropping of legumes and other crops, drought-tolerant maize varieties. From among these, the study focuses on the technologies that are the most relevant in the context of conservation agriculture (CA). We decided to give most emphasis to the following technologies, partly based on their relevance in relation to the CA principles and partly based on them being commonly used in Malawi: Crop rotation, minimum tillage, use of herbicides, mulching, and use of organic manure. Later we added also maize-legume intercropping to the set of technologies as it may be seen as a form of "spatial crop rotation".

The study focuses on a single country, Malawi, in order to facilitate an in-depth and rigorous assessment of the adoption of a range of conservation-related technologies. Several of the above focal NRM practices have been developed and/or disseminated by CGIAR programs in Malawi. For example, the Sustainable Intensification of Maize and Legume Systems for Eastern and Southern Africa (SIMLESA) program managed by CIMMYT has promoted maize-legume intercropping and the Drought Tolerant Maize for Africa (DTMA) project managed by CIMMYT and IITA has developed and disseminated drought-tolerant maize varieties.

The objectives of this study are to:

1) Measure the level and intensity of CA adoption;
2) Track adoption dynamics;
3) Compare the performance of CA practices under varying agro-ecological and climatic conditions;
4) Gain an understanding of how Lead Farmers influence the diffusion of CA practices, and verify and validate these adoption findings.

2. The Farm Household Survey:

A farm household survey was implemented between May and August 2016 using the World Bank software Survey Solutions. Two experienced supervisors and 15 enumerators were recruited for the survey and participated in training sessions facilitated by Prof Stein Holden and Sam Katengeza.

We used a novel sampling approach to assess variation in CA adoption rates: collecting data from Lead Farmers, Followers of Lead Farmers and a Random Sample of Households in the same areas in Central and Southern Regions of Malawi. The Random Sample was the same as had been surveyed by NMBU in 2006, 2009 and 2012 allowing us to observe changes in adoption over the last 10 years. It was also a benchmark in 2016 for comparison of the adoption rates among the sample of Lead Farmers and Followers.

A pilot study was done for a period of 12 days between 17th and 28th May 2016. The objective of the pilot was to obtain detailed information about the lead farmers, such as:

i. Their locations (distances) with respect to NMBU/LUANAR panel households;
ii. Onset (starting time) of adoption by lead farmers, and any dis-adoption (dropout rate);
iii. Number and details of followers (onset of adoption, adoption continuity/dropout rate);
iv. Technologies relevant to conservation agriculture the lead farmers are implementing.

The pilot identified 597 lead farmers as shown in Table 1 in 9 extension planning areas (EPAs) in the six districts where there are NMBU panel households, which are Lilongwe, Kasungu, Machinga, Zomba, Chiradzulu and Thyolo districts. For each lead farmer, the pilot listed randomly five follower farmers where a sample would be drawn.

Following the pilot, we decided that the survey sampling would be conducted as follows:

i. Only lead farmers close to NMBU/LUANAR households were to be sampled;
ii. All NMBU/LUANAR panel households were to be treated separately from the sampled lead farmers and/or followers;
iii. All of the 350 NMBU/LUANAR households were to be sampled;
iv. 500 lead farmers and 1,500 followers were to be sampled;
v. Sampling was to be random but proportional to the number of lead farmers in each of the six districts.

Table 1 below gives a detailed initial sample. Sampling was in proportion to number of lead farmers in the EPA and number of panel households. This sampling was based on the assumption that one enumerator would conduct four interviews per day.

Table 1: Initial sample

District	Households identified		
	Lead farmers	**Followers**	**Total**
Lilongwe	128	640	768
Kasungu	114	570	684
Machinga	67	335	402
Zomba	172	860	1032
Chiladzulu	66	330	396
Thyolo	50	250	300
Total	**597**	**2985**	**3582**

The final sample size for the survey is 1055 farm households, with a break-down as follows; 317 panel households, 182 lead farmer households and 546 follower farmer households. The figures

indicate a 10% attrition rate for the panel households and substantially smaller samples of lead farmer households and follower farmer households than we had initially planned. The failure to reach the target was mainly due to the following reasons:

i. *Attrition for panel households.*
Some households have completely moved from the areas and their farms have been divided among several new cultivators such that it was difficult to replace the former cultivator with a new cultivator.

ii. *Unavailability of sampled households*.
Some panel households in particular were unavailable during the period of the survey due to other family commitments. Due to limited resources, it was difficult for the survey team to follow up with these households once the team moves to another district.

iii. *Limited resources.*
Based on a discussion with the funding agency after funding had been granted, the project was asked to focus more narrowly on CA technologies as defined by FAO (2017), emphasizing the three principles: minimum soil disturbance, permanent soil cover and crop rotation. The research team had a broader assessment of conservation related technologies in mind when preparing the project proposal. The changes implied a need to change the survey instruments compared to those used in earlier survey rounds in Malawi by the researchers. The most recent LSMS (IHS4) survey instrument was then chosen as a starting point for designing the new CA survey. This was much more demanding to implement than the earlier survey instrument used. As such, while we initially planned to interview at least four households per day, it was not possible with the new questionnaire as enumerators could only manage two households per day. We therefore had to significantly reduce the sample, as our resources were not enough to cover the whole initial sample.

Relation to other data collection efforts

We had hoped to access ASWAp-SP on-farm trials data from Chitedze research station but were unable to obtain these data during the project period despite several attempts.

We had also hoped to link our survey to the IHS4/LSMS survey to get a bigger and more nationally representative sample to compare with and utilize the spatial references of Lead Farmers versus the locations of the IHS4 survey sample but we were denied access to these data by the World Bank. They did not want any "piggy-backing" on their surveys and this may be related to the protection of the anonymity of their sample households.

3. Defining conservation agriculture technologies

The following table shows for each farmer category the adoption rates for the key technologies of interest.

Table 1. Which of these technologies did you use on your own farm in 2015/16?

	LEAD FARMERS		FOLLOWERS OF LEAD FARMERS		PANEL HOUSEHOLDS	
Technology	Obs	Mean	Obs	Mean	Obs	Mean
Maize-legume intercropping	182	0.379	546	0.408	317	0.360
Crop rotation	**182**	**0.462**	**546**	**0.403**	**317**	**0.353**
Vetiver/elephant grass	182	0.148	546	0.101	317	0.060
Contour bunds/terraces	182	0.143	546	0.128	317	0.151
Contour ridges	182	0.022	546	0.020	317	0.025
Box ridges	182	0.192	546	0.154	317	0.114
Pit planting	182	0.231	546	0.156	317	0.038
Minimum tillage	**182**	**0.198**	**546**	**0.139**	**317**	**0.044**
Herbicide use	**182**	**0.066**	**546**	**0.020**	**317**	**0.009**
Mulching (residue retention)	**182**	**0.170**	**546**	**0.128**	**317**	**0.101**
Ripper	182	0.000	546	0.000	317	0.000
Planting stick	182	0.011	546	0.005	317	0.003
Jab planter	182	0.000	546	0.000	317	0.000
Organic manuring	**182**	**0.500**	**546**	**0.474**	**317**	**0.363**
Agroforestry technologies	182	0.038	546	0.020	317	0.013
Drought-tolerant maize varieties	182	0.165	546	0.147	317	0.126
Other Improved maize	182	0.352	546	0.363	317	0.372
Compost making	182	0.104	546	0.108	317	0.057
Storage technology	182	0.011	546	0.000	317	0.000

Towards a narrowing in on CA technologies, we identified the **bolded** technologies as the most relevant/key technologies and did further analyses with these.

We were later advised by an agronomist working on CA in southern Africa to use a more strict definition of CA based on the three CA principles emphasized by FAO (2017). One suggestion was to include maize-legume intercropping as an alternative to crop rotation as part of the first CA principle. We were also advised to treat the minimum soil disturbance CA principle (i.e. minimum tillage and zero tillage) as a fundamental basic requirement for CA. Finally, it was suggested that two of the CA principles must be used in order to qualify as partial CA adoption (with one of these being minimum soil disturbance). Full CA adoption then obviously requires all three principles to be met. This strict definition of CA is illustrated in Figure 1. Table 2 shows the share of each farmer category that are aware of and have adopted (in 2015/16) the technologies associated with the three CA principles. Table 3 shows the extent of partial and full adoption of CA based on the strict CA definition by farmer category.

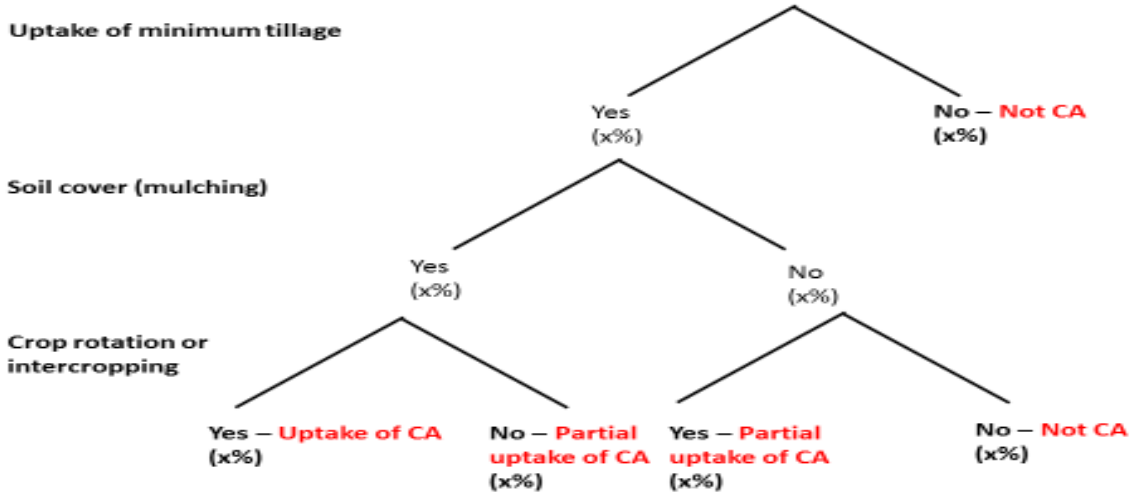

Figure 1. Towards a strict definition of CA

Table 2. Awareness/familiarity and adoption of CA principles/technologies: Shares of hhs.

	PANEL HOUSEHOLDS		LEAD FARMERS		FOLLOWER OF LEAD FARMERS	
Familiar with CA principles:	Share	N	Share	N	Share	N
CAp1: Crop rotation/intercropping	0.845	317	0.835	182	0.850	546
CAp2: Minimum tillage	0.479	317	0.731	182	0.658	546
CAp3: Mulching	0.325	317	0.495	182	0.429	546
Adopted CA principle technologies						
adCAp1: Crop rotation/intercropping	0.593	317	0.626	182	0.630	546
adCAp2: Minimum tillage	0.044	317	0.198	182	0.139	546
adCAp3: Mulching	0.101	317	0.170	182	0.128	546

Source: NMBU Malawi CA survey 2016.

Table 3. Partial and full adoption of CA based on strict CA definition (Figure 1).

Strict CA	Stats	PANEL HHs	LEAD FARMERS	FOLLOWERS	Total
No adoption	Freq.	331	188	533	1,052
	%	97.93	91.71	92.86	94.18
Partial adoption	Freq.	6	12	34	52
	%	1.78	5.85	5.92	4.66
Full adoption	Freq.	1	5	7	13
	%	0.3	2.44	1.22	1.16
Total	Freq.	338	205	574	1,117
	%	100	100	100	100

Source: NMBU Malawi CA survey 2016.

Table 3 shows that there is very limited full and partial adoption of CA in the study area using this strict definition of CA. Even among lead farmers there are only 2.4% that have adopted fully. Furthermore, this is based on questions about whether these technologies were used by the farmers in 2015/16 without asking for the share of their farms this applies to and whether all three principles are applied on the same unit of land on their farms.

4. Data cleaning, organization, literature review, analysis and paper development

The research team had the following division of labor for these tasks. Stein Holden took main responsibility for organizing the new data for analysis and implementing the econometric analyses. Monica Fisher took the lead role in reviewing relevant literature. Two papers were first agreed upon and prepared as working papers and also submitted to journals. One paper focuses on the adoption potential for CA technologies utilizing particularly the data from Lead Farmers. The second paper looks at the influence of Lead Farmers on the CA adoption among their Followers. Samson Katengeza is taking the lead of a third paper utilizing the panel data from the random household sample for selected technologies (maize-legume intercropping and use of organic manure). This will also be one of the papers in his PhD-dissertation at NMBU. Stein Holden is his supervisor.

5. Summary of findings

Below we extract the key findings from the three papers prepared for this project. These papers have been prepared for publication in international journals. Work is still ongoing on revisions of the papers. We apply a "softer" definition of CA technologies in the first two papers, rather than the strict CA definition explained above as the strict definition gives limited variation in adoption levels.

5.1. CA Adoption Potential Assessment Based on the Lead Farmer Survey

Paper 1: The adoption potential of Conservation Agriculture technologies in Malawi: A lead farmer promoter-adopter approach and assessment.

By Monica Fisher, Stein T. Holden, and Samson P. Katengeza

Abstract. *This paper assesses the adoption potential of conservation agriculture (CA) technologies in Malawi, where CA appears highly appropriate. Estimation of CA adoption rates and their determinants is complicated by the relatively recent introduction of these technologies and limited awareness of CA among the general population of smallholder farmers. We propose a lead farmer promoter-adopter approach and use it to assess the adoption potential of CA among smallholder farmers in Malawi. This approach relies on the promoters being potential adopters themselves, [not being too different from other smallholders in the target population], having had sufficient exposure and access to the technologies, and their incentives not having been distorted*

by excessive incentives. These conditions are reasonably satisfied in our application with a sample of 181 lead farmers from central and southern Malawi.

We find adoption rates for the lead farmers of 56% for organic manure and crop rotation, 26% for minimum tillage, 30% for mulching, and 12% for herbicide application. Lead farmers recommend CA to their followers at rates of 66% for organic manure, about 50% for crop rotation and minimum tillage, 28% for mulching, and less than 10% for herbicide application.

Assuming the validity of the promoter-adopter approach, these findings together suggest that, in central and southern Malawi, organic manure and crop rotation have the highest adoption potential, mulching and minimum tillage come next, and herbicide application has the lowest potential. With the farmer-to-farmer extension approach gaining popularity in many countries, we expect that our promoter-adopter approach to assessing adoption potential of new technologies will be of broad interest.

Introduction

To identify the adoption potential for CA, we assess the extent of adoption among the lead farmers that are familiar with each of the CA technologies. For this adoption rate to be useful as a measure of adoption potential it is important the lead farmers are fairly representative of other farmers in their areas. Likewise, it is important that their adoption has not been influenced by any distorting incentives to promote their own adoption. We assess the first of these by comparing the household and farm characteristics of lead farmers versus a random sample of households in the same areas. For the latter we investigate whether the lead farmers have received any incentives, beyond their improved access to information that could bias their own adoption levels.

We assess CA adoption potential using new data for a sample of 181 lead farmers in four districts of central and southern Malawi. A conceptual framework is developed that identifies potential links between the incentives, training, and extension information received by lead farmers and their motivation, activity level, familiarity, own adoption, and recommendations to follower farmers. The conceptual framework guides the empirical analysis of five research questions: (1) How motivated and active are the lead farmers, and what are the main factors associated with these variables? (2) What proportions of lead farmers are aware of the different CA technologies, and how is familiarity related to their exposure to training, motivation, experience, and having held demonstration trials? (3) To what extent have lead farmers themselves adopted the CA technologies on their own farms, and what factors influence lead farmer adoption? (4) What are the pros and the cons of the CA technologies that lead farmers emphasize and that are important for the adoption potential? (5) What drives lead farmers to recommend adoption of CA technologies to their followers?

Conceptual framework

We develop a framework to assess the adoption potential of new technologies based on the exposure, perceptions, and behaviors of well-informed promoters (i.e. lead farmers) who are also potential users of the technologies. Technology adoption may be constrained by many factors including limited awareness and information about the technologies, limited availability, low profitability, high initial costs, delayed returns, high risk, high skill or other specific requirements.

In particular, farmers who have not been exposed to the new technology cannot adopt it, but they might have adopted had they known about it (Diagne and Demont, 2007). For these reasons it is challenging to judge the potential of new technologies from a general sample of farmers. However, a sample of promoters who may be early adopters or at least well-informed prospective adopters can provide useful insights about the potential of such technologies. This group should be more informed and have better access to the technologies than the general farming population, and their perceptions and behavior therefore reveal valuable insights about the underlying technology potential, so long as these promoters are not too different from the average farmer in their area in other relevant characteristics, or they have not been given distorting incentives (Andersson and D'Souza, 2014).

We assess this promoter and potential adopter model through a study of lead farmers and the potential of CA technologies in Malawi. Lead farmers are promoters of CA technologies as well as potential adopters. As promoters they may, however, also be constrained by their motivation or level of information. We assess such variation and control for it. This also gives additional insights about the information channels and efficiency of the lead farmer model to technology promotion. The conceptual framework that guides our empirical analyses is illustrated in Figure 2. The hashed lines indicate how adoption potential may be drawn from a number of indicators, while the posited underlying causal mechanisms are represented by solid lines.

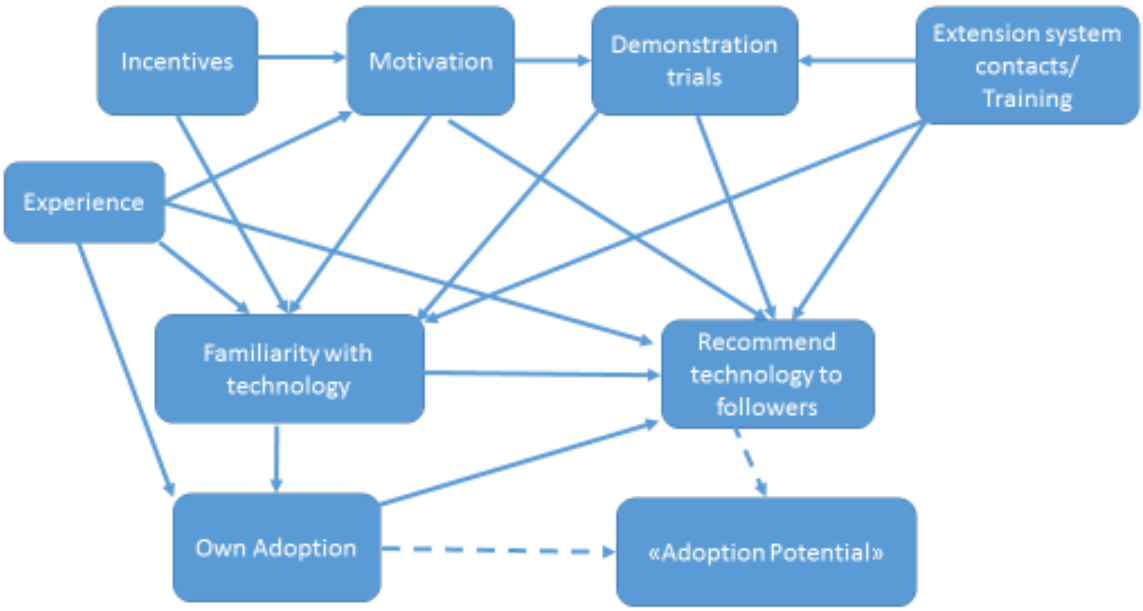

Figure 2. Lead Farmers' awareness of and adoption of CA as basis for assessing CA adoption potential

The conceptual framework indicates that government inputs into F2FE (incentives, extension system contacts, and training) influence lead farmers' motivation and activity levels (number of demonstration trials and number of followers). Inputs into F2FE on the part of government and lead farmers (i.e. motivation and activity levels) are posited to impact lead farmers' familiarity with CA practices. All of these factors may directly or indirectly encourage lead farmers to adopt and recommend CA to their followers. And, it is the lead farmers' adoption and recommendation rates that provide insights on the adoption potential of CA practices in Malawi. We assess adoption potential for a bundle of five CA technology components: crop rotation, minimum tillage, use of herbicides, soil coverage (mulching), and use of organic manure.

One issue is whether the lead farmers are so different from other farmers in farm and household characteristics that their adoption cannot be used as a guide to the adoption potential of CA. We compared the lead farmer characteristics with those of the random sample of households. Table 4 shows that the lead farmers were slightly better off but not dramatically different from the random sample of households.

Table 4. Selected characteristics of lead farmers and a random sample of smallholder households in the same districts

	Random sample households			Lead farmers		
	Mean	St.Err.	N	Mean	St.Err.	N
Hh size	5.189	0.147	243	**5.808**	0.146	177
Average education of adults in hh	2.492	0.137	243	**3.300**	0.194	177
Female headed household	**0.270**	0.029	241	0.136	0.026	177
Age of household head	**52.282**	0.984	241	47.169	0.885	177
Adult labor availability in hh	26.350	0.707	243	**29.169**	0.909	177
Owned farm size, ha GPS measured	1.060	0.058	238	**1.420**	0.117	176
Livestock value MK	117156	24256	244	**211069**	49287	178
Fertilizer coupons (subsidy)	0.539	0.034	243	0.576	0.039	177
Seed coupons (subsidy)	0.181	0.025	243	0.237	0.033	177

Source: Comparisons for four districts (Kasungu, Lilongwe, Machinga and Zomba). Bolded figures indicate that they are significantly larger than for the other group.

As an example of results of the paper, Table 5 shows factors associated with lead farmers' recommendation to use CA technology components and shows that their own familiarity, adoption and having had demo-trials overshadow all other factors. We refer to Fisher et al. (2017a) for more details about the mechanisms.

Key findings

In summary, with reference to the study's research questions, our first set of findings in this paper concern the motivation and activity level of the lead farmers. The surveyed lead farmers expressed considerable motivation and their motivation level is significantly associated with provision of incentives and CA trainings. Activity level is influenced by provision of incentives, other forms of training, contacts with government extension workers, farm field visits, participation in agricultural extension courses, and motivation. These findings reveal the importance of providing

incentives to motivate lead farmers who in turn become more active by conducting more demonstration trials and reaching out to more followers.

The second study research question asks how familiar lead farmers are with the different CA technologies and what factors influence familiarity? Lead farmer familiarity with organic manure, crop rotation, and minimum tillage is very high in the study area, but familiarity is lower for herbicide application and mulching (about 50% were familiar), and this may somewhat limit the lead farmers' ability to judge adoption potential of these two practices. Regression results indicate that familiarity is associated with CA trainings and number of demonstration trials, suggesting the importance of experience and provision of technical information.

Third, we examined the extent of adoption of CA technologies by lead farmers themselves on their own farms. The results reveal "maximum exposure" adoption rates (rates conditional on lead farmers being familiar with the technologies) for 2015/16 of 56% for organic manure and crop rotation, 26% for minimum tillage, 30% for mulching, and 12% for herbicide application. Familiarity with CA is found to be the most important factor influencing lead farmer adoption.

Table 5. How lead farmers' experience with CA technologies is associated with whether they recommend the technologies to other farmers

	Crop rotation	Minimum tillage	Herbicide use	Mulching	Organic manure
Number of incentives received	0.029	0.069	-0.004	-0.013	-0.041
Number of CA trainings received	-0.014	0.008	0.012	-0.043	-0.014
Number of other trainings received	0.025	0.000	-0.007	0.019	0.037
Years of experience as lead farmer	-0.008	-0.003	-0.002	0.007	0.000
Number of demo trials by lead farmer	-0.003	-0.006	0.006	0.017	0.004
Familiar with technology	0.244***	0.195**	0.039	0.166***	0.444****
Adopted technology	0.422****	0.308****	0.602****	0.320****	0.237***
Demo trials with technology	0.248***	0.323****	0.133**	0.380****	0.158**
Female headed household	0.074	0.038	0.000	-0.069	0.134
Age of household head	0.001	-0.001	-0.001	0.006***	0.001
Household size	-0.014	-0.009	-0.015*	-0.003	-0.032*
Average education of adults in hh	0.001	0.023	-0.004	0.016	-0.012
Owned farm size, ha GPS measured	0.035	-0.002	0.007	-0.023	0.019
District FE: Base: Kasungu district					
Lilongwe	0.087	-0.045	-0.006	-0.107	-0.104
Machinga	0.156	0.150	0.022	-0.054	-0.060
Zomba	0.030	0.000	0.046	-0.134*	0.018
Chiradzulu	0.149	0.078	-0.141	0.142	0.339
Thyolo	0.039	-0.185	0.039	-0.112	0.179
Constant	-0.055	-0.003	0.104	-0.214	0.238
Prob > chi2	0.000	0.000	0.000	0.000	0.000
R-squared	0.448	0.373	0.526	0.562	0.362
Number of observations	180	180	180	180	180

Note: Linear probability models. Significance levels: * 0.10 ** 0.05 *** 0.01 **** 0.001.

The fourth study research question concerns the pros and cons of CA technology adoption potential as reported by the farmers. Farmers reported improved yield, moisture conservation, and reduced pest and disease as the most important reasons, in that order, for adopting CA technologies, while cash constraints was the most limiting factor for herbicide use.

Finally, we investigated the determinants of lead farmers' recommendations of CA technologies to their followers. We find lead farmer recommendation rates of 66% for organic manure, about 50% for crop rotation and minimum tillage, 28% for mulching, and less than 10% for herbicide application. Findings indicate that lead farmers' recommendation decisions are strongly driven by their experience with CA (i.e. demo trials), familiarity with CA, and own adoption.

Assuming the validity of the promoter-adopter approach, our research findings together suggest that, in central and southern Malawi, organic manure and crop rotation have the highest adoption potential, mulching and minimum tillage come next, and herbicide application has the lowest adoption potential. Furthermore, study findings suggest some practical approaches to ensuring that adoption potential is reached among the general population of smallholder farmers. Although our findings imply correlation rather than causality, given the data are cross-sectional, empirical results are suggestive of the following chain of causality: Incentives, training, and agricultural extension contacts positively influence motivation and/or activity level which, in turn, promote familiarity of CA technologies. And familiarity is a main factor influencing lead farmer own adoption and has both indirect and direct associations with farmer recommendations of CA to their followers. In short, our findings may suggest that adoption potential can be reached for CA technologies by providing smallholder farmers with small adoption incentives complemented by training and agricultural extension visits focused on the use of CA technologies. The exception is herbicide use for which the most important adoption constraint appears to be cash availability.

5.2. CA Adoption among Followers of Lead Farmers

Paper 2: Adoption of CA technologies among Followers of Lead Farmers: How Strong is the Influence from Lead Farmers?

By Monica Fisher [a], Stein T. Holden [b], and Samson P. Katengeza [b]

Abstract. *This study investigates how the Farmer-to-Farmer-Extension (F2FE) system with lead farmers and follower farmers influences adoption of Conservation Agriculture (CA) technologies in Malawi. Using data from 180 lead farmers and their 455 followers in central and southern Malawi, we assess the level of influence lead farmers have on their followers' familiarity with and adoption of CA. The main findings are that (a) lead farmers have significant influence on CA familiarity and adoption among followers through their motivation, familiarity, and own adoption and (b) F2FE is a complement rather than a substitute for other agricultural extension activities. Policy implications are discussed.*

This paper presents a case study of the Malawi government's reliance on F2FE to spread conservation agriculture (CA). F2FE offers a potentially low-cost and wide-reach approach to diffusing CA to smallholders. Malawi's Department of Agricultural Extension Services (DAES) currently works with more than 12,000 lead farmers country-wide who train and promote

agricultural technologies, including CA, through their networks of follower farmers ("followers") and through demonstration trials.[1]

Using new data collected in 2016 from a survey of lead farmers and their followers in four districts of central and southern Malawi, we examine how much influence lead farmers have on the awareness and uptake of CA among their follower farmers. We test hypotheses that familiarity with and adoption of CA technologies among followers of lead farmers is influenced by the lead farmers' motivation, familiarity with CA, and own adoption of CA technologies. We also test the hypothesis that other extension contacts that followers have are more important for the diffusion of CA technologies than the influence from lead farmers. The study focuses on five specific CA practices: crop rotation, minimum tillage, use of herbicides, soil coverage (mulching), and organic manure.

Conceptual framework and hypotheses

The simple conceptual framework in Figure 1 illustrates four hypotheses for how information about the CA technologies flows from lead farmers to their followers, while also considering other information sources that may influence followers' familiarity with and adoption of these technologies. Hypothesis 1 is that lead farmers' motivation (as lead farmers) influences the familiarity with and adoption of CA technologies among their followers. We assume lead farmers who are more motivated are better at convincing followers about the advantages of the CA technologies than less motivated lead farmers. BenYishay and Mobarak (2014) found that offering peer farmers in Malawi a small performance incentive increased their effort to learn about pit planting and, in turn, their effectiveness at convincing other farmers to adopt. And qualitative studies suggest that motivation of lead farmers is important to the success of F2FE in disseminating new technologies (Davis, Franzel, and Spielman, 2016).

Hypothesis 2 is that lead farmers' familiarity with CA technologies increases followers' familiarity with and adoption of CA technologies. This hypothesize is self-evident: familiarity with a CA practice is a necessary condition for a lead farmer to diffuse the technology to other farmers. The third hypothesis proposes that lead farmers' own adoption of CA technologies is positively associated with followers' familiarity with and adoption of CA technologies. That is, we assume that a key way followers learn about new technologies is by observing lead farmers' experimentations.

[1] We use the term "lead farmer" when referring to such farmer trainers, given its prominence in Malawi the geographic focus of our study, but several other labels are also commonly used (e.g., opinion leader, model farmer, community knowledge worker, contact farmer, volunteer farmer), depending on the specific roles and tasks performed.

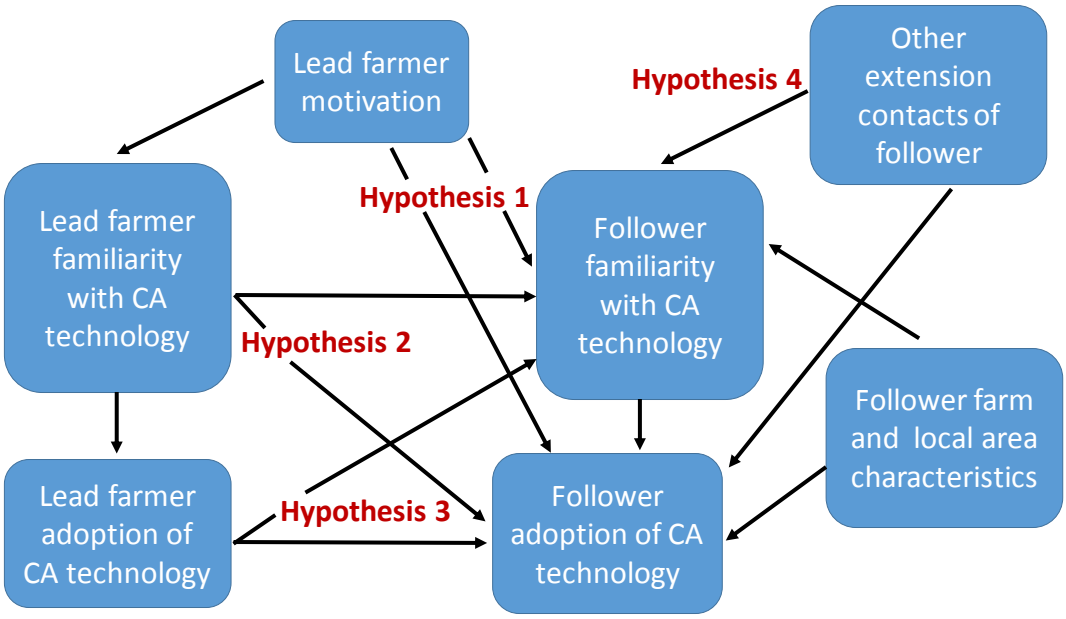

Figure 3. Conceptual framework

Finally, Hypothesis 4 is that other sources of extension information (e.g., agricultural extension officer visits, ICTs) are also very important for the familiarity and adoption of CA technologies by followers, i.e. multiple sources of information can help diffuse new technologies.

Sampling

The uniqueness of this dataset lies in the sampling of lead farmers with the subsample of followers which allows us to assess the impacts of lead farmer characteristics on their followers' familiarity with and adoption of CA technologies. We got a list of follower farmers for each sampled lead farmer from which the sample of follower farmers was drawn. The lead farmer is directly in contact with his/her followers. Usually these are farmers from the same EPA section and in most cases from the same village as the lead farmer. This implies that both the lead farmer and follower farmers are quite familiar with each other. The follower farmer is able to follow the activities of their lead farmer and is likely to be influenced by his/her familiarity and adoption of the technologies and may be able to witness their performance on the lead farmers' own fields as well as on demonstration field plots.

Estimation strategy

We first assess factors associated with follower farmers' familiarity with the five CA technologies using linear probability models with robust standard errors. We also include simple OLS models with robust standard errors for the aggregate number of CA technologies that the followers are familiar with. We start with parsimonious models for follower farmer familiarity that include only

the lead farmer (i.e. motivation, familiarity with CA, and adoption of CA) and other extension contact variables. These models can indicate the relative importance of the various potential sources of information and the extent to which they may explain the systematic difference in familiarity with CA technologies among the sample of followers of lead farmers.

Next, we run a set of familiarity models where we add to the first specification a range of follower household and farm characteristics and district fixed-effects as controls, as these may contribute to the observed variation in followers' familiarity. We assess how inclusion of the control variables affects the significance and size of the parameters on the lead farmer variables as a robustness check of their importance across the five CA technologies. The changes in these parameters across specifications give insights into the issue of potential selection bias related to the different sources of information, and the consistency of the results and significance levels across models indicate the degree of robustness of the results.

The final step of empirical modelling identifies the main factors that explain adoption of the five CA technologies by followers. We use an approach that takes the familiarity into account, as it is endogenous. For this we use bivariate probit models for each CA technology. Similarly to the familiarity models, we start with more parsimonious models and then add controls for household characteristics and district fixed effects. A comparison of the changes in the coefficients across models and technologies provides insights about the mechanisms in the adoption process. The adoption models also include binary variables for follower farmer familiarity with the CA technologies, since adoption is conditional on familiarity.

There are a number of endogeneity issues of concern in this analysis. The number of extension contacts themselves with different sources are potentially endogenous. We assess this by regressing them on the additional follower and farm control variables. These models are presented in Table A2 in the Appendix. We can see that observable follower household and farm characteristics to a small extent are correlated with these extension contact variables. By running models without and with the same set of control variables and inspecting the key variables of interest, we further assess the extent to which there can be endogeneity bias in the results.

Descriptive analyses

Table 6 shows the difference in familiarity with the five different CA technologies between followers of lead farmers and lead farmers and similarly for adoption of the CA technologies. Familiarity and adoption levels are higher for the lead farmers than their followers for all the technologies but the differences are not large in most cases. The difference is largest for the adoption of minimum tillage with 24% for lead farmers versus 13.8% for followers and for adoption of herbicides with 7.1% for lead farmers and 1.8% for followers.

Table 7 shows the cumulative adoption of the CA technologies. Hardly any (<1%) of the farmers have adopted all the five CA technologies. 2.6% of the lead farmers and 0.9% of the followers have adopted four out of the five CA technologies, while 7.7 and 4.4% of lead farmers and followers respectively have adopted three of the CA technologies. At the other end, we see that 11 and 22% of the lead farmers and followers have adopted none of the CA technologies, while 48.4 and 49.5% of the lead farmers and followers have adopted one of the CA technologies.

Summary of findings

Followers' familiarity with CA technologies models

Table 8 presents the results for how the familiarity of follower farmers with the CA technologies relate to the lead farmers' familiarity and adoption for each CA technology, the lead farmers' motivation, and other extension contacts of followers. Table 6 shows that lead farmers' familiarity with four of the five CA technologies is significantly (to varying degree) positively associated with followers' familiarity with these technologies. For example, lead farmers' familiarity with minimum tillage is associated with a 16.5% higher likelihood that their followers also are familiar with minimum tillage. Lead farmers' adoption of the CA technologies is significantly and positively associated with followers' awareness of minimum tillage and the overall count of CA technologies they are aware of (CA combined). Lead farmers' adoption of minimum tillage is associated with a 15.7% higher likelihood that the followers were familiar with minimum tillage. Lead farmers' motivation is also positively and significantly associated with followers' awareness of herbicide, mulching, and organic manure technologies and the total number of CA technologies they were aware of.

Table 8 shows that many of the other extension variables are significant. For example, government agricultural extension contacts positively correlates to almost all the CA practices (herbicide and mulching are exceptions), and the marginal effects are particularly large for private agricultural extension and village extension meetings in the CA combined model. These results suggest that multiple sources of information are important for followers' awareness of CA technologies. There are systematic variations across the CA technologies, however. Follower familiarity with crop rotation, minimum tillage, and organic manure is positively associated with several of the other extension contact variables. Surprisingly, however, the coefficients are negative for several of the extension contact variables in the case of the mulching and herbicide technologies. We have no good explanation for this. An assessment of the robustness of the results by inclusion of a set of controls for follower characteristics and district dummies is presented in the paper. The lead farmer familiarity and adoption variables remained significant in most of the models while the lead farmer motivation variable remained significant only in one of the models, that for mulching.

Followers' adoption of CA technologies models

Table 9 presents average marginal effects from bivariate probit models for the adoption of each CA technology conditional on farmers being familiar with it, including only the lead farmer and other extension contacts variables. The marginal effects relate to the probability that both the adoption and familiarity variables are equal to one. The full results from the bivariate probit models are presented in the paper.

Findings in Table 8 indicate that followers are 11.9% more likely to have adopted crop rotation if their lead farmers are familiar with the practice. Adoption of crop rotation by followers is 7.1% more likely when their lead farmers have adopted crop rotation. Other extension contacts are also important for the adoption of this technology. Lead farmers' familiarity is not significantly related to the adoption of any of the other CA technologies by followers, but lead farmers' adoption of herbicides has a positive influence on followers' adoption of herbicides. Lead farmers' motivation is positively associated with followers' adoption of minimum tillage and mulching. Participation

in village extension meetings is significantly positively related to crop rotation and organic manure adoption and negatively related to herbicides and mulching. The coefficients are quite large for this variable, but we should interpret these results cautiously given the low frequency of this variable in the data.

We now summarize the results in relation to the four study hypotheses. The first hypothesis states that lead farmer motivation affects the familiarity with and adoption of CA technologies among their followers. Results show lead farmer motivation is significant and positively associated with follower familiarity of three CA technologies (herbicides, mulching, and organic manure) and follower adoption of two technologies (minimum tillage and mulching). We therefore cannot reject Hypothesis 1.

The second hypothesis is that lead farmer familiarity with the CA technologies affects their followers' familiarity and adoption. Lead farmer familiarity is significant and positive for four of five CA technologies (exception is organic manure) and the CA count variable in the follower familiarity models. Lead farmer familiarity influences follower farmer adoption only for the case of crop rotation, in the parsimonious model (Table 9); but familiarity also influences follower adoption of minimum tillage and organic manure in the extended models. These results are in support of Hypothesis 2 and suggest that lead farmer familiarity primarily influences followers' familiarity. The results for the followers' adoption decisions are less robust, as could be expected.

Table 6. Familiarity with and adoption of CA technologies among followers and the lead farmers

	Crop rotation	Minimum tillage	Herbicides	Mulching	Organic manure	CA combined
Followers						
Familiarity with CA technologies	0.735	0.659	0.317	0.427	0.801	2.939
Adopted CA technologies	0.401	0.138	0.018	0.125	0.475	1.158
Lead farmers of followers						
Familiarity with CA technologies	0.760	0.710	0.405	0.501	0.818	3.194
Adopted CA technologies	0.459	0.240	0.071	0.150	0.514	1.434

Source: NMBU Malawi CA survey 2016. The table gives average rates for followers and the lead farmers of the same followers (lead farmers weighted by the number of followers in the sample). CA combined is the within household count for familiarity and adoption of all the five CA technologies.

Table 7. Aggregate adoption levels of CA technology components at farm level by household type

	----------Followers--------			---------Lead farmers---------		
Number of CA technologies adopted	Freq.	Percent	Cum.	Freq.	Percent	Cum.
0	100	21.98	21.98	50	10.99	10.99
1	225	49.45	71.43	220	48.35	59.34
2	105	23.08	94.51	136	29.89	89.23
3	20	4.4	98.9	35	7.69	96.92
4	4	0.88	99.78	12	2.64	99.56
5	1	0.22	100	2	0.44	100
Total	455	100		455	100	

Source: NMBU Malawi CA survey 2016. *Note:* The table gives the distribution of the number of CA technologies adopted by followers and their lead farmers.

Table 8. Followers' familiarity with CA technologies and how it is correlated with their lead farmers' awareness and adoption of the CA technologies, lead farmers' motivation, and other extension contacts of followers.

	Crop rotation	Min. tillage	Herbicide	Mulching	Org. Manure	CA combined
Lead farmer familiar with technology	0.147***	0.165***	0.083*	0.109**	0.003	0.185****
Lead farmer has adopted technology	0.029	0.157***	0.153*	0.111	0.040	0.176**
Lead farmer motivation: 1(low)-4(high)	0.037	-0.004	0.057**	0.074**	0.047*	0.191**
Government ag extension contacts	0.035****	0.019**	-0.005	-0.030***	0.028****	0.047*
Private ag extension contacts	0.091***	0.031	0.108	0.156****	0.014	0.437***
NGO contacts	0.065**	0.061**	0.012	-0.079***	0.014	0.051
Farm field day visits	0.039****	0.002	-0.051****	-0.053***	0.017	-0.059
Village extension meetings	0.056****	0.061****	-0.041***	0.044	0.051****	0.164***
Other farmer advice contacts	0.056	-0.021	0.130*	0.038	-0.017	0.204
Electronic media contacts	0.009	0.033**	0.069***	-0.046**	-0.010	0.059
Constant	0.378****	0.457****	0.067	0.195*	0.538****	1.280****
Prob > chi2	0.000	0.000	0.000	0.000	0.000	0.000
R-squared	0.087	0.081	0.077	0.102	0.040	0.098
Number of observations	455	455	455	455	455	455

Source: NMBU Malawi CA survey 2016. *Note*: Results from Linear Probability Models (OLS) with robust standard errors. Significance levels: * 0.10 ** 0.05 *** 0.01 **** 0.001.

Table 9. Average marginal effects from bivariate probit models for adoption conditional on familiarity with CA technologies

	Crop rotation	Min. tillage	Herbicides	Mulching	Org. Manure
Lead farmer familiar with technology	0.119 **	0.033	-0.007	0.026	0.065
Lead farmer has adopted technology	0.071 *	0.027	0.037 **	0.054	0.052
Lead farmer motivation: 1(low)-4(high)	0.014	0.060 ***	0.007	0.043 **	0.012
Government ag extension contacts	0.036 ****	0.003	0.002	0.000	0.037 ****
Private ag extension contacts	0.059	-0.941 ****	0.010	0.104 ****	0.049
NGO contacts	0.097 ***	0.010	-0.010	-0.030	0.014
Farm field day visits	0.094 ****	0.018 *	0.001	0.004	-0.015
Village extension meetings	0.400 ****	0.048	-0.144 ***	-0.585 ****	0.374 ****
Other farmer advice contacts	0.038	0.049	0.004	-0.135 *	-0.010
Electronic media contacts	-0.025	-0.002	0.002	-0.007	0.001

Source: NMBU Malawi CA survey 2016. *Note*: Results from bivariate probit models with robust standard errors. Significance levels: * 0.10 ** 0.05 *** 0.01 **** 0.001.

The third hypothesis states that lead farmers' adoption of CA technologies affects their followers' familiarity and adoption. Lead farmer adoption is significant with a positive sign in two of the familiarity models and in two of the adoption models. Lead farmers' own adoption decisions therefore seem to influence the decisions of their followers. It is not only what the lead farmers say but also what they do that matters for the followers' learning and doing.

The final hypothesis states that other extension contacts are important for the followers' familiarity and adoption. The empirical findings provide some support for this contention although the results are somewhat mixed across the CA technologies. Other extension contacts are important for the familiarity with crop rotation and minimum tillage; but contrary to expectations, we find negative significant results for herbicide and mulching technologies. We are not sure how to interpret the latter findings. Low adoption rates of herbicides and mulching may partly explain these unexpected results.

Our study reveals variation in lead farmer influences on their followers across CA practices. In terms of follower familiarity, lead farmer influences are greatest for minimum tillage and mulching and weakest for organic manure. For follower adoption of CA practices, lead farmers appear to exert more influence for the case of crop rotation and herbicides and less influence for organic manure.

5.3. Adoption of CA principles and CA by strict definition of CA

Table 10 shows factors associated with the familiarity with the key CA principles/technologies associated with the CA principles as well as the extent to which these technologies/principles have been adopted by lead farmers. We see that CA training and demo-trials are important for the lead farmers' awareness/familiarity with the CA principles/technologies and that familiarity is also the key to their adoption by the lead farmers. We have specified CA principle 1 (CA p1) is crop rotation and/or intercropping, CA principle 2 (CA p2) as minimum soil disturbance (minimum tillage) and CA principle 3 (CA p3) as soil coverage (mulching, organic manure retention).

Table 11 shows the results for partial and full adoption of CA, based on the strict definition of CA (Figure 1). Ordered probit models were used for the analyses for different farmer categories. Adoption levels for the random sample of households were too low to get any meaningful results and adoption levels were also low (5-6%) for the lead farmers and followers (see Table 3). Lack of familiarity with/exposure to the technologies seems to be a major constraint.

Table 10. Factors associated with familiarity with and adoption of CA principle technologies among lead farmers.

	---------- Familiar ----------			---------- - Adopted ----------		
	CA p1	CA p2	CA p3	CA p1	CA p2	CA p3
Number of incentives received	-0.022	0.034	0.000	0.001	0.048	0.041
Number of CA trainings received	0.095***	0.192****	0.028	0.028	-0.010	-0.052
Number of other trainings received	0.010	-0.098****	0.084***	0.015	-0.004	-0.010
Years of experience as lead farmer	-0.020**	-0.002	-0.004	0.001	-0.007	-0.006
Number of demo-trials	0.032***	0.026*	0.015	0.023*	-0.014	0.022
Female headed household	-0.067	-0.103	-0.055	0.038	-0.021	0.125
Age of household head	-0.007***	0.000	0.000	0.001	0.001	0.004
Household size	0.001	0.008	0.026	-0.017	0.000	0.015
Average education of adults in hh	0.011	0.001	0.026*	-0.005	0.006	0.008
Owned farm size, ha GPS measured	-0.011	-0.017	-0.012	0.027	-0.036	0.017
District FE: Base: Kasungu district	0.000	0.000	0.000	0.000	0.000	0.000
Lilongwe	-0.006	0.083	0.330***	-0.171	-0.059	0.044
Machinga	0.003	0.073	0.058	0.059	0.032	0.105
Zomba	0.086	-0.012	0.002	0.028	0.017	0.078
Chiradzulu	-0.263	-0.319	0.226	0.375*	0.400*	-0.052
Thyolo	-0.046	0.042	-0.241*	0.699***	-0.191	0.024
Government ag extension contacts	0.003	0.006	-0.061****	-0.006	-0.002	-0.005
Private ag extension contacts	-0.069	0.194**	0.178*	-0.150	0.098	-0.053
NGO contacts	0.067***	0.072**	-0.005	-0.036	0.013	0.005
Farm field day visits	-0.017	0.006	0.042*	0.017	0.084***	0.077**
Village extension meetings, no	-0.020	0.003	-0.027	-0.001	0.037	-0.003
Other farmer advice contacts	-0.226*	0.081	0.144	0.165	-0.196**	-0.248***
Electronic media contacts	0.014	0.044***	-0.036*	0.019	-0.025**	0.007
Familiar with CA p1				0.637****		
Familiar with CA p2					0.249****	
Familiar with CA p3						0.248****
Constant	0.944****	0.418*	0.098	-0.010	0.015	-0.313*
Prob > chi2	0.000	0.000	0.000	0.000	0.000	0.000
R-squared	0.300	0.268	0.263	0.359	0.187	0.249
Number of obs.	180	180	180	180	180	180

Source: NMBU Malawi CA survey 2016. Results from Linear Probability models. Coefficients are marginal effects. Significance levels: * 0.10 ** 0.05 *** 0.01 **** 0.001.

Table 11. Ordered probit models for partial and full adoption of CA, by strict definition of CA

	Lead farmers	Followers	Panel hhs	Full sample
CAp1: Crop rotation/intercropping	3.326	0.029	4.980	0.074
CAp2: Minimum tillage	5.469	1.247****	2.036	1.038****
CAp3: Mulching	0.428	0.392**	-1.555	0.355**
Number of incentives received	-0.036			
Number of CA trainings received	0.329			
Number of other trainings received	0.042			
Years of experience as lead farmer	-0.069			
Number of demo-trials	0.023			
Female headed household	0.108	-0.086	-7.540	-0.151
Age of household head	-0.014	-0.001	0.063	0.001
Household size	0.087	0.076	0.149	0.041
Average education of adults in hh	0.115*	0.004	0.272	0.023
Owned farm size, ha GPS measured	-0.057	0.008	-1.233	0.006
District FE: Base: Kasungu district	0.000	0.000	0.000	0.000
Lilongwe	-0.163	-0.790**	10.779	-0.314
Machinga	0.535	-0.504	8.628	-0.062
Zomba	0.200	-0.043	8.908	0.185
Chiradzulu	5.660	0.224	5.622	0.505*
Thyolo	-3.385	-4.177	8.216	-0.011
Government ag extension contacts	0.018	0.032	-0.102	0.024
Private ag extension contacts	-0.243	-3.470	-2.211	-0.537
NGO contacts	0.260	-0.005	-2.587	0.073
Farm field day visits	0.397*	0.217****	1.041	0.255****
Village extension meetings, no	0.085	-2.852	1.016	0.083
Other farmer advice contacts	-5.405	0.169	1.439	0.286**
Electronic media contacts	-0.007	0.037	0.139	0.026
Hhtype: Base=Panel hhs				0.000
Lead farmers				0.768***
Followers				0.592**
Cut1 constant	11.317	3.025****	22.755	3.709****
Cut 2 constant	12.234	3.993****		4.623****
Prob > chi2	0.017	0.000	0.002	0.000
Number of observations	180	529	309	1019

Source: NMBU Malawi CA survey 2016. Results from ordered probit models. Significance levels: * 0.10 ** 0.05 *** 0.01 **** 0.001.

5.4. Adoption of Maize-legume intercropping and organic manure

Paper 3: Adoption of Organic Manure and Maize-Legume Intercropping in Malawi

By Samson P. Katengeza, Stein T. Holden, and Monica Fisher

This paper is work in progress. Some preliminary findings are presented.

Abstract. *This paper investigates the impact of markets, weather shocks and population density on adoption of organic manure and maize-legume intercropping in Malawi. Data comes from household surveys conducted between 2006 and 2015 in central and southern regions. We employ nonparametric and parametric methods of data analysis utilizing correlated random effects models. Results show an increase in adoption from 30% (33%) in 2006 to 53% (76%) in 2015 for organic manure (maize-legume intercropping).*

Introduction

We investigate the impact of markets, weather shocks and population density on adoption of organic manure and maize-legume intercropping over time. Specifically the paper tests the following hypotheses: a) improved market access is associated with higher investment in organic manure and maize-legume intercropping. b) Increase in output price (maize grain and pigeon pea) motivates farmers to invest in organic manure and maize-legume intercropping. c) An increase in inorganic fertilizer price has a substitutive effect on adoption of organic manure and maize-legume intercropping. d) Previous exposure to dry spells promotes adoption of climate-resilient technologies such as organic manure and maize-legume intercropping. e) Increase in population density increases farmer response to land saving technologies such as organic manure and maize-legume intercropping.

Data

We use panel data collected through household surveys between 2006 and 2015 from central and southern Malawi. The first round of the panel surveys in 2006 drew a random sample of 450 households using a simple random sampling technique following the second integrated household survey of 2004 (HIS2). Of these 450 households, 378 were resurveyed in 2009, 350 in 2012 and 353 in 2015 giving four-rounds of unbalanced panel data.

Table 12: Sample Size

District	2006	2009	2012	2015	Total
Thyolo	62	51	47	47	207
Zomba	86	84	76	79	325
Chiradzulu	53	35	36	35	159
Machinga	51	49	47	45	192
Kasungu	102	88	83	82	355
Lilongwe	96	71	61	65	293
Total	450	378	350	353	1531

Source: NMBU household panel survey 2006-2015.

Preliminary findings

Table 13 shows an overview of adoption rates and intensity of adoption of organic manure and maize-legume intercropping by year. Figures 4a and 4b show the pattern of adoption over years and by farm size. There seems to be a trend towards higher adoption levels over the ten year period for both technologies.

Table 13: Adoption and intensity of adoption for manure and maize-legume intercropping

Technology	2006	2009	2012	2015	Total
Applied manure (1=yes)	0.30	0.43	0.49	0.53	0.43
Manure quantity (Kg/ha)	2182	1616	1526	1456	1724
Maize-legume intercropping (1=yes)	0.33	0.45	0.53	0.76	0.51
Farm size share of maize-legume intercropping	0.27	0.25	0.34	0.37	0.30

Source: NMBU household panel survey 2006-2015.

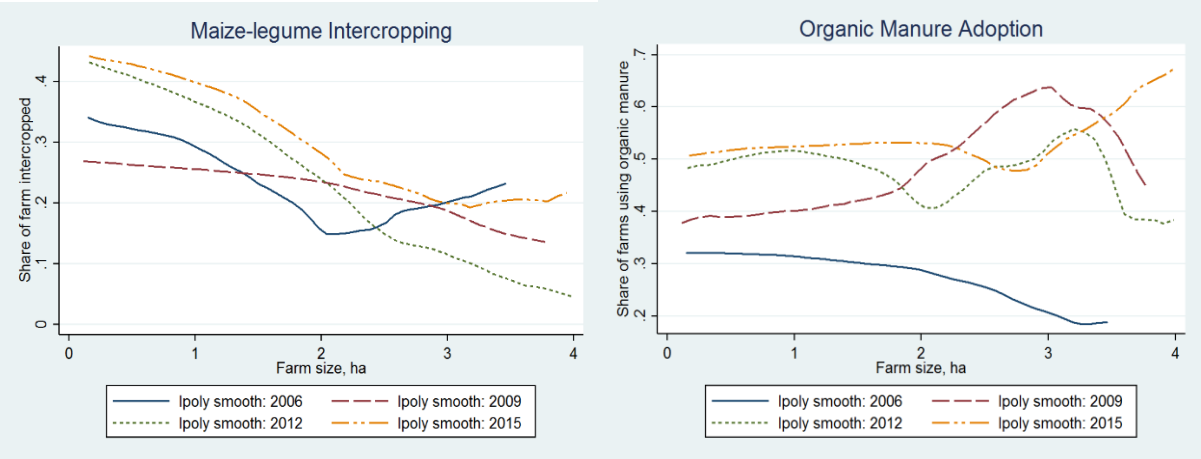

Figure 4a. Maize-legume intercropping and 4b. Organic manure adoption by farm size and year.

The paper with final regression results is still being worked on and revised and the paper will be submitted before the end of August. Preliminary econometric results are presented in Table 14. Both types of technologies appear more important in areas with lower rainfall. Maize and pigeon pea prices appear important for adoption of maize-legume intercropping. Maize-legume intercropping is also more common in the Southern region and for female-headed households. Exposure to early dry spells may have triggered more adoption of both technologies. Better market access is associated with more adoption of organic manure.

Table 14. CRE results on adoption of organic manure and maize-legume intercropping

Variable	Organic Manure		Maize-legume intercropping	
	Adoption (1=yes)	**Intensity**	**Adoption (1=yes)**	**Intensity**
Distance to market (km)	-0.072**	-0.353*	0.030	-0.004
	(0.034)	*(0.198)*	*(0.040)*	*(0.015)*
1-year lag maize price (Mk/Kg)	0.016	-0.076	0.039***	0.015***
	(0.011)	*(0.065)*	*(0.014)*	*(0.005)*
1-year lag pigeon pea price (Mk/Kg)	0.002**	0.000	0.002**	0.001**
	(0.001)	*(0.005)*	*(0.001)*	*(0.000)*
Fertilizer price (Mk/Kg)	0.002	0.016***	-0.002	-0.001
	(0.001)	*(0.006)*	*(0.002)*	*(0.001)*
Log-fertilizer (Kg/ha)	0.119	1.556**	0.186	0.028
	(0.105)	*(0.610)*	*(0.128)*	*(0.052)*
Fertilizer subsidy dummy	0.084	0.666	-0.042	-0.010
	(0.095)	*(0.548)*	*(0.130)*	*(0.048)*
Rainfall (mm)	-0.001*	-0.005**	-0.002***	-0.001***
	(0.000)	*(0.002)*	*(0.000)*	*(0.000)*
Early dry spell (1-year lag)	0.020***	0.068*	0.018**	0.004
	(0.007)	*(0.039)*	*(0.009)*	*(0.003)*
Late dry spell (1-year lag)	-0.003	-0.032	-0.005	0.000
	(0.007)	*(0.043)*	*(0.011)*	*(0.004)*
Southern region dummy	-0.133	0.611	1.687***	0.688***
	(0.189)	*(1.054)*	*(0.250)*	*(0.099)*
Log-population density	-0.368	-6.204*	0.227	0.507
	(0.598)	*(3.385)*	*(0.829)*	*(0.314)*
Log-farm size (ha)	0.145	-0.259	0.810***	0.135
	(0.168)	*(0.982)*	*(0.264)*	*(0.104)*
Household head sex (1=male)	-0.032	-0.202	-0.360***	-0.095**
	(0.106)	*(0.595)*	*(0.129)*	*(0.047)*
Log-male labor (adult equivalent/ha)	0.236*	0.598	-0.158	-0.053
	(0.135)	*(0.797)*	*(0.145)*	*(0.057)*
Log-female labor (adult equivalent/ha)	0.099	0.627	0.084	0.017
	(0.148)	*(0.901)*	*(0.165)*	*(0.066)*
Error from fertilizer equation	-0.111	-1.591***	-0.179	-0.028
	(0.106)	*(0.617)*	*(0.129)*	*(0.053)*
Seed subsidy dummy			-0.505	-0.181
			(0.389)	*(0.155)*
Error from seed subsidy equation			0.487	0.162
			(0.375)	*(0.149)*
Constant	-3.016***	1.089	-3.469***	-1.653***
	(1.040)	*(5.849)*	*(1.116)*	*(0.431)*
Prob > chi2	0.000	0.000	0.000	0.000
Rho	0.233	0.153	0.212	0.138
Number of observations	1492	1492	1482	1482

Significance levels: ∗10%, ∗∗5%, ∗∗∗1%. The household endowments, mean household endowments and year dummies are left out to shorten the size of the table.

Financial report

The financial report will be submitted at the end of July after having recorded and paid for the last work on the project.

References (available on line - click on the documents)

Monica Fisher, Stein T. Holden and Samson P. Katengeza (2017). Adoption of CA technologies among Followers of Lead Farmers: How Strong is the Influence from Lead Farmers? CLTS Working Paper No. 7/2017. Centre for Land Tenure Studies, Norwegian University of Life Sciences, Aas, Norway.

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Adoption of Conservation Agriculture Technologies in Malawi Survey, 2016-17