TECHNOLOGY ADOPTION AND FOOD SECURITY IN SUBSISTENCE AGRICULTURE – EVIDENCE FROM A GROUP-BASED AID PROJECT IN MOZAMBIQUE*

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This paper evaluates the impact of an intervention to improve farming techniques and food security in the Gaza area of rural Mozambique. We examine the impact of a group-based approach to technology adoption in subsistence agriculture, using panel data collected by our research team on over 200 households from treatment and control villages from 2008–10. The intervention was successful in encouraging vulnerable households to participate in farmers' groups, and the impacts on farming techniques, such as fertilizer use, are significant in the first treatment year. The impact on food security is mixed across indicators but similar in both treatment years and cannot be attributed to whether or not households adopted new technologies. (JEL: O1, O2)

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1. Introduction

The crucial role of agriculture in the sustainable development of sub-Saharan Africa (SSA) has been widely recognized (World Bank 2007). The case of Mozambique is illustrative in this regard. Despite years of high GDP growth rates, the latest living standard measurement survey revealed that headcount poverty had not declined at all (LSMS 2010). Arndt et al. (2011) examine the reasons for this disappointing development and argue that one of the key reasons is that productivity in agriculture has not improved. Farming households use almost no modern inputs or irrigation technologies. Under 5 percent use fertilizer and pesticides and under 10 percent receive extension services. Since the agricultural sector supports 80 per cent of Mozambique's population, productivity growth in agriculture is vital in improving the welfare of the vast majority of the poor.

In this study we explore the impacts of an intervention that aimed to facilitate the adoption of improved technologies made available by the government of Mozambique, but which are not reaching the farmers. The intervention, carried out by an NGO in the Gaza area of rural Mozambique, aimed to improve subsistence farming yields. The intervention focused on creating groups of farmers, training these groups and setting up shared farms as a medium for technology transfer, which may lead to greater commitment and benefits of social learning.

Slow technology adoption in agriculture in poor, rural areas has been the focus of much research. Issues such as input availability, knowledge and education, profitability, risk preferences, and imperfect credit and insurance markets have been found to be important determinants (Dercon and Christiaensen 2011). This also concerns the context of Mozambique (Zavale, Mabaye and Christy 2005; Uaiene, Arndt and Masters 2009). The magnitude of risk in many low-income, rural areas is substantial, resulting in highly variable farm profits and food shortfalls that can be a threat to subsistence (Zimmerman and Carter 2003). It has long been argued that poor farmers with subsistence constraints minimize their exposure to risk by, among other things, avoiding new technologies. Kurosaki and Fafchamps (2002) find that in the presence of imperfect insurance markets, households adapt their production to avoid risk. In their study of risk avoidance in fertilizer adoption in Ethiopia, Dercon and Christiaensen (2011) show that both ex-ante credit constraints and limited ex-post consumption smoothing capacity constrain poor farmers from adopting new technologies. In anticipation of covariate shocks, such as droughts and cyclones that hit hard on poor households, new technologies are avoided. Thus, understanding risk preferences in the presence of imperfect markets appears to be important when designing interventions directed to improve agricultural productivity (de Brauw and Eozenou 2011).

The role of social networks, particularly social learning from neighbours, is found to be of importance for technology adoption (Foster and Rosenzweig 2010; Bandiera and Rasul 2006; Conley and Udry 2010; Moser and Barret 2006). Whether introduced by farmers' own experimentation or through formal sector intervention, the process of social learning encourages the diffusion of new technologies (Rogers 1995; Bindlish and Evenson 1997). However, as Centola (2010) points out, technology adoption requires reinforcement from multiple sources. Also, there is nothing to say that learning from others increases the use of a technology, if what was learned suggests that the new technology is not profitable (Foster and Rosenzweig 2010). In a study on rural Ethiopia, Todo, Mojo, Matous and Takahashi (2011) distinguish between knowing and adopting a new technology. They find that while social networks are likely to enhance technology diffusion, they do not necessary promote adoption of agricultural techniques. General networks with relatives and friends are more effective in promoting adoption of agricultural techniques than frequent meetings with extension agents. They also find that geography matters to knowledge diffusion indirectly through its effect on social networks. In Mozambique, Bandiera and Rasul (2006) find that social networks and risk behaviour interact: The marginal benefit of knowing one more adopter is diminishing in villages that have access to outside insurance.

In this study, we focus on an NGO intervention that aims to encourage technology adoption through social learning. The agriculture intervention is part of a comprehensive village development programme carried out by the Lutheran World Federation (LWF) in the Gaza region in southern Mozambique[1]. Our research focuses on an intervention to improve subsistence farming yields, which is mainly the responsibility of the women in the household. Poor, uneducated women are often in a particularly vulnerable situation and may lack sufficient resources and capacity to benefit from new techniques. Earlier research ~~C~~onley and Udry (2010) in the Ghanaian context, and Bandiera and Rasul (2006) in Mozambique ~~ha~~s studied the diffusion of information and social effects of technology adoption for a cash crop that is primarily intended for the market or input use and often cultivated by men.

Our analysis is based on panel data, collected by the authors, from more than 200 households from two villages where the LWF has operated (treatment villages) and four control villages, before and after the intervention. The households were randomly sampled for the baseline study, and after the baseline we have followed the same households for two years. We measure the mean impact for households who live in the treatment villages and who are therefore eligible for participation in the aid programme using the difference-in-differences (DD) approach. The outcome variables concentrate on the adoption of new farming practices, including the use of improved seeds and fertilisation, as well as food security that could partially be a result of the successful adoption of these practices. The DD analysis captures both the impacts of group participants and the potential impacts on households living in the project villages but not participating in the farming groups via village-level externalities[2]. However, if externalities are small, the DD analysis underestimates the impacts on group participants. Therefore, we also estimate IV models, where living in the treatment village is used as an instrument for group participation.

The results indicate that the participation in farmers' groups was high and the adoption of new technologies increased during the the first year of the intervention. The impacts on farming techniques appear to dissipate in the second aid year, but this is partly due to delays in aid delivery. The model that predicts participation in the farmers' groups find that important determinants for participation are female head, low livestock holdings and exposure to covariate shocks. Thus, while the intervention was successful in encouraging vulnerable households to participate, it appears that it did not succeed in relaxing constraints that hinder farmers from taking up new technologies. This was particularly the case in the second year when drought got worse in the treatment villages. Results from other studies find that the types of households that selected into the intervention typically have high risk aversion profiles and are careful about adopting new technologies (Dercon and Christiaensen 2011). The impact on food security is mixed across indicators but fairly stable over the treatment years, with a slight decline in the second year. Thus, the results on food security cannot be attributed to whether or not households adopted new technologies. The fact that those farmers that adopted new technologies in the first year dropped them in the second year points to an explanation whereby the new technologies were not found to be profitable enough in the face of severe drought. This is in line with findings from Ghana and Ethiopia where farmers switch in

1 The particular intervention we examine is supported by Finnish donors. As a part of a broader research project examining impacts of Finland's bilateral development aid, this paper presents the first econometric impact evaluation carried out of a Finnish-funded development project.

2 Externalities across treatment and control villages are not expected because of the distances between the villages in the study.

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and out of fertilizers in response to (expected) profitability (Dercon and Christiaensen 2011; Conley and Udry 2010). As said, delays in delivering the aid due to administrative changes on the implementation partner's side reinforced these results.

The remainder of the paper is organized as follows. Section 2 overviews the context, the aid intervention and the village development programme. Section 3 describes the data, while Section 4 introduces our econometric approach. Section 5 presents the treatment effects on farming techniques and crops harvested and section 6 takes a closer look at selection into the programme. Section 7 studies the impacts on food security and coping strategies that households adopt to feed the household. Section 8 concludes.

2. The context

2.1. The intervention area

The two project villages are located in the district of Chigubo in the Gaza province of Mozambique. The villages are located in the maize-dominant semi-arid interior livelihood zone of Mozambique. Water scarcity is one of the most serious challenges in the zone. The region is vulnerable to cyclical droughts and as crop production is entirely rain-fed, drought is the most common shock affecting access to food and income. Apart from droughts, livestock/crop disease outbreaks are historically the most destabilizing factors for local production (FEWSNET 2011). Unexpectedly heavy floods may also wash away cultivations and seed storages. Despite the unfavourable climate, subsistence farming is the main source of livelihood in the area. Crop production is combined with some livestock rearing. Risk-management strategies (ex-ante) include inter-cropping and cropping on high or low land depending on weather conditions. Risk coping strategies (ex-post) include livestock sale, seasonal employment in agriculture, migratory work and self-employment (handicrafts, construction of huts and furniture, brewing and distilling and coal production). The villages are remote, sparsely populated and poorly integrated with markets at all levels (FEWSNET, 2011). Most households in the zone therefore sell their crop produce and livestock only locally. The lean season when people struggle to have enough to eat, stretches from October to February.

The Chigubo setting is not unusual in Mozambique: 64 percent of the population lives in rural areas and most of these are subsistence farmers exposed to shocks such as droughts and floods. Especially the southern part of the country suffers from poor soil quality. Isolation is also a typical feature of poverty in Mozambique (IFAD 2013).

In Gaza, the local government aims to operationalize the government's framework, created in cooperation with donors to build an enabling environment for agricultural development (PAEI,[3] PARPA, MADER's Visão, and ProAgri) by providing seeds for new crops and fertilizers free for farmers who proactively take the initiative. Despite the government policies, the adoption rate without interventions remains marginal (Uaiene et al. 2009; Zavale et al. 2005). Hence, without the presence of supportive organisations it is possible, but rare, to form farmers' groups and applying for government support.

2.2. The LWF village development programme in Chigubo district

The agriculture intervention is part of a village development programme that LWF started up in June 2008 in compliance with the policies of the local government. The objectives of the village development programme are to improve villagers' livelihoods and welfare. These objectives are largely pursued by strengthening local community support structures and enhancing community capacity. The entire villages are therefore subject to interventions and the project objectives are pursued through both community and household-level interventions. The programme started by organizing the village into committees, training the committee members and facilitating the work of working groups on areas such as agriculture, health, education, microcredit, water, prevention of catastrophes. The agriculture group is the largest and most active of these. We are interested in seeing how the farming intervention is transmitted to actual adoption of technologies.

The project interventions on food security focus on creating groups of farmers, training these groups, and setting up demonstration farms/joint plots as a means of technology transfer. An introductory meeting and farmers' group activities were organized so that everyone in the village could be informed and have the possibility to join. All interested villagers have the possibility to participate in actual hands-on working groups.

The intervention started in October 2008 in two villages near the administrative post of Dindiza. In 2009, it continued in the same villages. Later, in mid-2010, the village development program expanded to a third village. However, the farming activities using new techniques started only after the third round of interviews. Thus, in practice, there are only two treatment villages in this study. The two effective villages that were chosen to join the programme in Chigubo were selected according to relevance and their own consent/interest. Water insecurity and economic vulnerability were important criteria. In each of the two treatment villages, there are two farmers' groups. Participation in groups is voluntary and one member is free to join several groups. Particularly women are encouraged to participate. The farmers may consume and sell their harvest and products freely.4 The Gaza intervention supports social learning as it takes place in a group on a shared field that has fences to mark the cultivated plots of land.5 The farmers meet the aid workers twice a month to discuss farming practices, problems, and concerns with the aid workers. Otherwise they solve problems independently or together with other group members on the field.

The government and LWF provide training, seeds, fertilizers, pesticides and some small equipment at no cost. The idea is also to introduce up to eight new plants or varieties of existing plants. The first two of these new plants are root vegetables, sweet potato and cassava, which are important sources of essential nutrients in the region. Cassava is a promising plant for the farmers in Chigubo as it gives one of the highest yields of food energy per cultivated area and does well on poor soils and with low precipitation. Because it is a perennial plant, it can be harvested as necessary, which allows it to act as a famine reserve or as a cash crop. Sweet potato is also a suitable plant for limited farming conditions as it grows in poor soils with little fertilizer. The six other horticultural plants are cabbage, tomatoes, lettuce, onion, butter beans and Matuba maize. Matuba maize is an improved open-pollinated white variety of maize that has been selected by Mozambique's national agricultural research system INIA6 and is well adapted to poor management conditions, drought and low input farming. Matuba's earliness (up to 110 days maturity) represents a drought mitigation strategy (Ransom et al.1996). Moreover, maize is the most cultivated plant in the area, so this improvement may be adopted more easily. Matuba maize can be used as a food and cash crop. The farmers were also provided with fertilizers (ammonium sulphate and urea) regularly for the entire evaluation period and pesticides (Mancozeb and Cipermetrim) for the first year to improve the yield of the new plants. Each farmers group was provided with

3 This government support (seeds and tools for poor farmers) aims to increase agricultural productivity and is part of the Mozambique Agrarian Policy and Strategy of Implementation (PAEI).

4 No particular entrepreneurship training was given to the farmers.

5 Normally the land is owned by the state of Mozambique and farmers have rights to use it. This may have adverse effects on the land productivity in the sense that farmers cannot let it fallow for natural revitalization in fear of losing it. In the intervention the farmers were given rights from the government to build fences for their group plot, so the risk of losing the land in the future is smaller.

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a motor pump, a garden rake, a hoe, an axe and an irrigation blade.7

Due to administrative changes on the implementation partner's sideand upcoming elections at the start of 2010, there were some delays and in seed distribution and other activities. This might have some impact on the results in 2010.

3. Data

3.1. Data collection

We administered a household survey in 2008, 2009 and 2010. The baseline data for 2008 was collected in September prior to the start of the activities of the agriculture interventions in October (Figure 1). Two survey rounds were carried out after the baseline; in November 2009 and September 2010. The data were collected in two project villages (Swiswi and Nongoti) and four control villages (Saute, Nhanal, Queque, Solane). Control villages were chosen based on comparability and similarity of the development patterns. Geographically, the control villages are also relatively close to the treatment villages.

Data collection was carried out with the help of qualified and trained local interviewers, LWF staff and the National Institute of Health of Mozambique (NIH). The interviewers were trained by experienced researchers from the NIH and supervised in the field by our research team members. Interviews were carried out with 232 randomly selected households in the six villages. Table 1 reports the number of households interviewed in each survey year and the total number of households in each village. The non-response rate in the first round and the attrition rates in the subsequent rounds were very low – partly because of our intentional effort to track all households in all years – and should not lead to any bias in the result (Table 1, Appendix 1). The head of the household was interviewed if he/she was present, otherwise the nearest adult with information about household matters.8 The same person was usually interviewed from year to year, depending on feasibility.

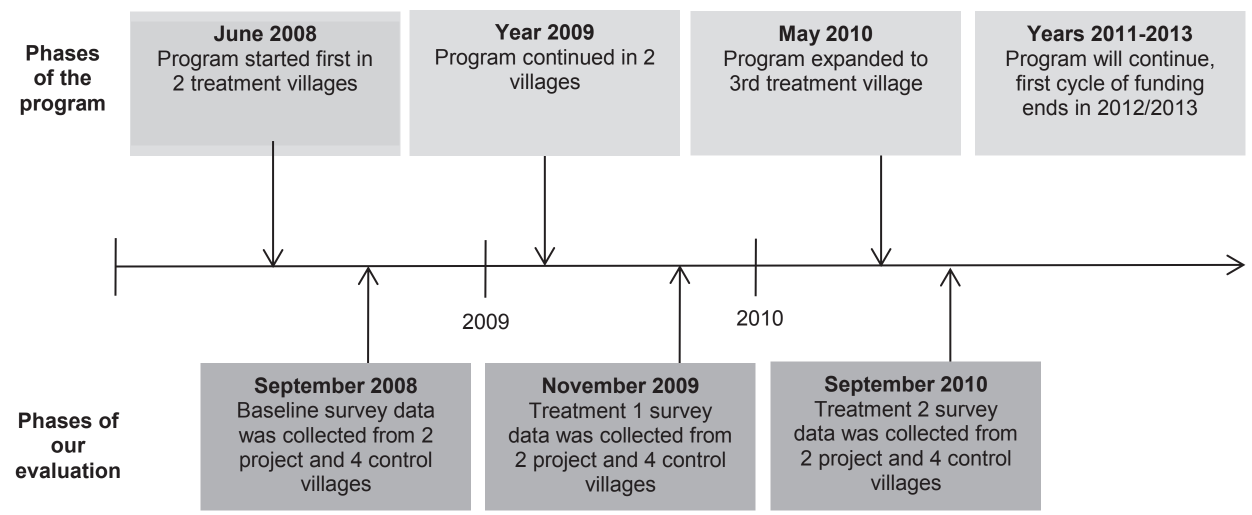

Figure 1. Timeline of the development programme and our evaluation
Source: Authors' illustration

7 *This equipment was provided by the government and brought to farmers by the implementing partner.*

8 *Household decision-making over participation and technology adoption is assumed to follow a collective model. However, the yields could benefit the subsistence farmer and her children more.*

The household survey questionnaire was based on the Living Standard Measurement Surveys of the World Bank and the Mozambique Household Budget Survey. Additional questions relevant for the present study were also included. To design relevant questionnaires, semi-structured interviews were carried out in village meetings in the two project villages, Nongoti and Swiswi prior to the data collection. The household questionnaire collected a wide range of detailed information on various aspects of household economy, including wealth, assets and food security, remittances, networks, shocks and coping strategies, activities, household characteristics, education, land use, health, demographic characteristics, GPS coordinates of households and central places, and aid from other organizations.

The villages are small with typically less than 300 households in each. They are remote – the journey time by car to the nearest town takes up to three hours or more. In character they are more like dispersed settlements than traditional villages. Dwellings belonging to the same village can be located several kilometres from each other.

In terms of uptake, the answers provided by the households in the 2009 survey and the figures from the implementing partner match surprisingly well. LWF reports that the aggregate adoption rate was 90 per cent in Swiswi and over 45 per cent in Nongoti and the implementing partner did not report any dropouts from the programme. However, in the data, the adoption rate decreased during the intervention from 94 per cent to 81 per cent in Swiswi and from 51 per cent to 39 per cent in Nongoti. Particularly in Nongoti, some new households had joined the groups that did not report being there in 2009 (26 per cent)9. Thus, in 2010, new untrained households had replaced households that had dropped out of the programme. These self-reports can, however, be subject to missing information bias. There were a handful of households who had a farmers' group in one of the control villages.

3.2. Descriptive statistics: households' demographics, livelihoods and water security

Below we report some descriptive statistics of the data that we analyse further in section 5 to 7. Demographic characteristics of the households, their means of livelihood and their water security are likely to affect how households respond to the intervention and will therefore be central in our analysis. We will concentrate on these aspects below. This section will also give us a sense of the extent to which the control villages represent a good counterfactual to the programme villages. Most of the variables presented below will be used as controls in Sections 5 to 7.

Table 2 in Appendix 1 reports some basic household and member characteristics for the baseline year 2008. Differences in demographic characteristics are mostly marginal between project and control villages and the differences in the means and proportions are not statistically significant. The baseline survey was undertaken at the end of the most active season for migrant work which stretches from June to September when there is a break in the agricultural activities. In 43 per cent of the households, either the head or another household member is away for migration. In 13 per cent of the households, the head is away. Approximately 75 per cent of the migrants are male. As a consequence, there are more women than men present in the villages and 37 per cent of the household heads are women.10 Hence, migration, the sex distribution within the villages and the prevalence of female-headed households are related.

Crop production complemented with livestock rearing forms the basis of livelihoods

9 *Reasons for why more farmers did not participate in the farmers' groups even if inputs were provided at no costs include: long distances to the joint field; subsistence farming being considered a women's business; participation in other LWF groups instead (even if that did not hinder them from participating); people being suspicious about new technologies.*

10 *If the original head is migrated, another member, usually the spouse, has been assigned to be head of household.*

in this area. Since crop production is entirely rain fed and the sandy soil is of low fertility and generally has poor moist retention capacity, ownership of livestock is important and a key determinant of wealth. Better-off and middle-income households typically raise cattle whereas poor households only have goats and chickens (FEWSNET 2011). Our data suggest that while there are households that live on agriculture alone, there are only a very small number of pure pastoralists.

Table 3 shows details about farming and livestock. The top panel shows the number of hectares used by the households in 2008. The median farm size is 3 hectares for both project and control villages, and the mean size is between 3.5 and 4.11 Three per cent of the households in project villages and six per cent in control villages report that they did not cultivate any crops. Households in control villages generally cultivate a smaller number of crops. This is explained by the fact that livestock rearing is more common in control villages. The lowest panel in Table 3 gives details of type of animal groups that households own and tropical livestock units (TLU), that summarizes the number of animals owned per household by the type and size of the animal12. Of the households, 15 per cent in the project villages and 14 per cent in the control villages report that they have no livestock. Poultry is owned by a little more than 70 per cent of the households. Sheep and goats are more commonly held in control villages (64 per cent) than project villages (41 per cent). However, the average TLU is not statistically significantly different between project and control villages.

As noted above, crop production is entirely rain-fed and as a consequence, droughts are one of the most destabilizing factors for local production. Table 4 shows the cumulative amount of rain in the villages for the rainy seasons of the years 2008-10. The amount of rain decreases over the period and the trend is weaker in the treatment villages compared to the control villages.

Climatic conditions are also reflected by the land households cultivate on. High land is prone to droughts whereas low lands are prone to floods. Households that have access to both high and low land diversify according to rain fall. As is evident from Table 4, the use of low land increases over 2008–10 as the rain fall decreases in most villages over the same period.13 In 2008, 85 per cent of the households in project villages and 84 per cent in control villages use high land. In 2010 this has fallen to 52 and 63 per cent respectively. A higher proportion of farmers have started to use both low and high land in project villages.

Not only drought, by also other shocks might have an impact on household level decision making. We asked households about both covariate and idiosyncratic shocks that have impacted negatively on them during the year preceding the survey (Table 4). While covariate shocks, particularly drought, are mentioned by most of the households, a wide range of idiosyncratic shocks, mostly sickness and death of household members, are also reported. The percentage of households that were negatively impacted by drought is fairly even over the years. However, the amount of rain and the increasing use of low land indicate that the intensity of drought increased over the survey years.

In terms of comparability of project and programme villages, the conclusion to be drawn from the descriptive statistics is that they are on average very similar when it comes to demographic characteristics. In terms of livelihood strategies, the differences are not large, but project villages are slightly more agricultural while control villages are more agro-pastoral. Given the importance of livestock as a determinant of wealth, it also suggests that control villages are a bit better-off. Project villages are also more affected by drought than control villages as measured by rain fall. All these aspects are important to control for in the analysis below.

11 The means are close to the threshold between poor and middle income households in the area (4 hectares) as reported by FEWSNET (2011).

12 Tropical livestock units (TLU) provide a convenient method for quantifying a wide range of different livestock types and sizes in a standardised manner. One TLU is approximately 250 kg of live weight. We use the following weights: 0.7 for bulls and cows, 0.4 for donkeys, 0.15 for sheep, 0.1 for goats and dogs and 0.02 for poultry. In other words a cow is worth 35 times a chicken.

13 The use of low and high land is self-reported by the households. There is a clear distinction between high and low land.

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3.3. Food security and coping strategies

Food security is a central part of our analysis since it enables us to examine if technology adoption and food security are interrelated. Below we will describe the indicators used to analyse food security, their descriptive statistics and the correlation of different indicators used.

Food sufficiency was asked about in a number of questions. In all survey rounds, households were inquired about their ability to have regular meals, how many meals they consumed on average per day, and about sufficient availability of the main staples (maize, cow peas and sorghum) during the six months preceding the survey.

In 2009, questions to construct two composite indicators that typically are used to measure food security were added (see World Food Program 2009). One of the indicators is the food consumption score (FCS), a proxy indicator for food security based on the number of food groups consumed over a seven-day recall period (see Appendix 2 for details). Each food group is given a frequency score depending on the number of days it was consumed, and a weight reflecting its nutrient density. The score obtained is compared with pre-established thresholds, indicating whether the food consumption is poor, borderline or acceptable. Validation studies show that the FCS is highly correlated with measures of food security that draw on more detailed food consumption data such as per capita caloric availability derived from seven day recall of food quantities consumed (Wiesmann, Bassett, Benson and Hoddinott 2009).

The coping strategy index (CSI) is another proxy indicator for food security which is based on questions around the food-based coping strategies that people use, with the past month as the recall period. The questions range from relying on less preferred and less expensive food to sending household members to beg. Each question is given a frequency score depending on the number of times this strategy was used and a weight reflecting its severity (see Appendix 1 for details). In the case of the CSI, a high score reflects more negative coping strategies. The questions for the CSI and the corresponding weights are based on WFP (2009) and adapted to local conditions.14 Unlike the FCS, thresholds are not established for this index.

Figure 2 shows the availability of the main staples for the six months preceding the survey in 2008. The main staples are harvested early in the year so sufficient availability falls as expected from March to August. The point to be illustrated here is that households at the time of the interview hold relatively small amounts of the main staples which will affect their food security and coping strategies. The intra-year food insecurity is not at its peak, however, as the lean season starts in October.

Table 5 reports descriptive statistics of FCS, CSI and ability to have regular meals in 2009. The average FCS is just below 30 in both project and control villages. This represents a level of borderline food consumption and indicates that subsistence risk is non-trivial. One year into the intervention, project villages have lower CSI than control villages, indicating that project villages use less severe coping strategies to maintain their food security.

14 To gather wild food, hunt or harvest immature crops is normally given the highest severity weight. In Chigubo gathering wild food and hunting is a very common coping strategy and was therefore given a lower weight.

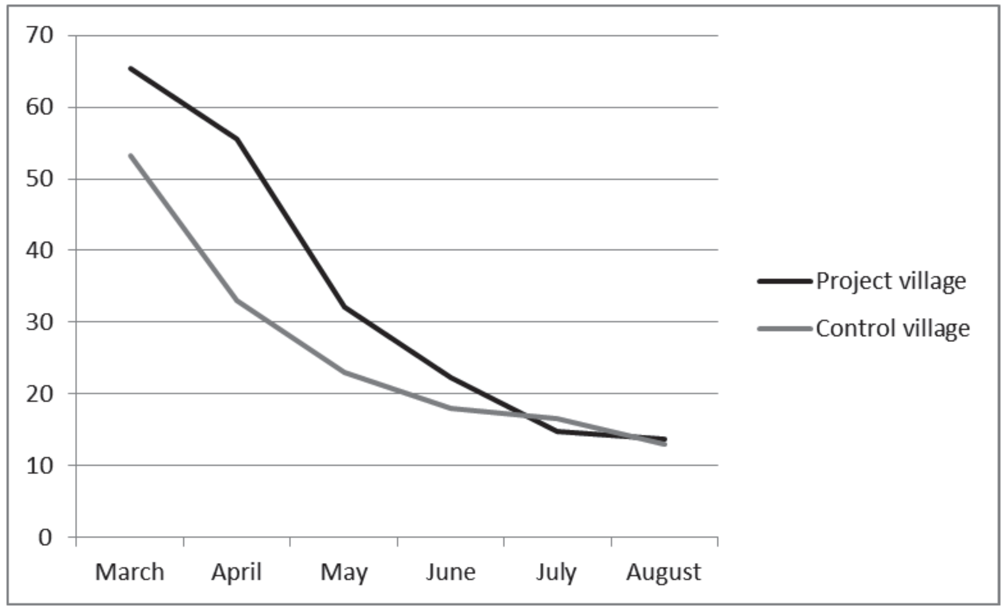

Figure 2. Percentage of households holding sufficient quantities of maize, sorghum and cow peas, by month 2008
Source: Authors' illustration.

The households in both project and control villages are spread fairly evenly over the categories indicating poor, borderline and acceptable food consumption. As expected, FCS and CSI are negatively correlated: the lower the FCS, the more negative coping strategies the households have to resort to. What is not very correlated at all is the ability to have regular meals and FCS. This probably reveals weaknesses in both of the indicators and shows that food security has to be measured in several different ways.

Table 6 takes a closer look at the components of CSI. Households are asked how often they have had to resort to a number of coping strategies as a result of not having enough food the past month. Here we only report the share of households that use a specific strategy, not how often this strategy is being used. Strategies such as relying on less preferred or less expensive food or limiting portion sizes are very common and used by 75 to 80 per cent of the households. Typically for this area, gathering wild plants, hunting and harvesting immature crops are also common.

4. Empirical strategy

We start out by estimating three types of models to capture the intention to treat effect (ITT) and the local average treatment effect (LATE). Our first approach is a difference-in-differences (DD) analysis whereby we compare changes for households living in treatment villages to those living in control villages. We first estimate a pooled regression of the form:

$$(1)\ y_{i,v,t} = \alpha^1 + X_{i,t}\beta^1 + \sum \lambda_t^1 year_t + \sum \phi_v^1 village_v + \delta^{1\_2009}(treat\_vil*2009)_{i,v} + \delta^{1\_2010}(treat\_vil*2010)_{i,v} + \varepsilon^1_{i,v,t}$$

and household-level fixed effects equations of the form:

$$(2)\ y_{i,v,t} = \alpha_i^2 + X_{i,t}\beta^2 + \sum \lambda_t^2 year_t + \delta^{2\_2009}(treat\_vil*2009)_{i,v} + \delta^{2\_2010}(treat\_vil*2010)_{i,v} + \varepsilon^2_{i,v,t}$$

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where $y_{i,v,t}$ denotes the outcome variable of household i in village v at time t and $year_t$ is the year dummy. $X_{i,t}$ refers to a vector of household-level controls in the case of the pooled regression and to a set of time-variant household-level controls in the household fixed effects regression. In the pooled regression, $village_v$ is the village dummy. Note that village-level dummies are not included in the fixed effects regression since we have household fixed effects and households typically do not move. The parameters δ^{1_2009}, δ^{1_2010}, δ^{2_2009} and δ^{2_2010} are our main interest as they measure the effect of living in a treatment village in a specific treatment year.

The identifying assumption is a standard difference-in-difference assumption that the households' situation would evolve similarly across the villages in the absence of the aid project. We can allow for permanent, time-invariant, differences between the households (and the villages) and year effects that are common for all villages. We are not aware of any threats to the identification; i.e. it is unlikely that there would have been other simultaneous forces that would have favoured those living in the treatment villages. In fact, the need factors that affected choosing the treatment villages in the first place may have disfavoured those living in the treatment villages. Hence, it may have made the counterfactual growth pace slower in the treatment villages, which may bias our results, but this bias can partly be taken care of by including the covariates.

One of the benefits of the difference-in-differences analysis is that it measures the impact of the intervention, not only on those participating in the groups helped by the LWF, but also on those who stay outside of the groups and potentially benefit from the aid work via spill-over effects. Using the jargon of impact-evaluation econometrics, the DD analysis represents 'intention to treat' effects; i.e. the mean effect of aid among those eligible for it. However, since not all of the households participate in the aid groups, but the treatment is also measured among the non-participating households, the DD analysis underestimates the impact of the aid project on group participants. Therefore, it can be seen as a lower bound for the effects of the aid programme.

To capture the impact of aid on group participants, we cannot directly compare group members and outsiders, since group membership can easily be endogenous with respect to the same unobservable variables that determine success in farming. We therefore use living in the treatment village as an instrument for group participation. The use of the intention to treat variable as an instrument hinges on the assumption that programme placement is as good as randomized from a group formation perspective[15]. Our third approach is to estimate equations of the form:

$$(3)\ y_{i,v,t} = \alpha_i^3 + X_{i,t}\beta^3 + \sum \lambda_t^3 year_t + \delta^3 \hat{m}_{i,v,t} + \varepsilon^3_{i,v,t}$$

where refers to those who are members of a farmers' group. This equation is estimated using 2SLS, where the first stage is:

$$(4)\ m_{i,v,t} = \alpha_i^4 + X_{i,t}\beta^4 + \sum \lambda_t^4 year_t + \delta^4 treat\_vil_{i,v,t} + \varepsilon^4_{i,v,t}$$

This is estimated using linear probability models in both stages. In this IV framework, we use the same set of control variables than in the case of the DD analysis.

In the absence of treatment heterogeneity, the estimate for δ^3 is the average treatment effect (ATE). However, due to imperfect take-up and the existence of farmers' groups in the control villages, we identify the effect of the intervention on those households that start to participate in farmers' groups due to a change in the instrument, in this case because of the introduction of the aid intervention.[16] Monotonicity also holds since the instrument affects everybody in the same direction. In other words, farmers do not stop participating in farmers' groups due to the introduction of

15 A conservative approach would be only to use the 'intention to treat variable' only if programme placement was randomized.
16 In the case of imperfect take-up in the treatment group, but no farming groups in the control villages we would have identified the average treatment effect on the treated (ATET).

the aid intervention. Thus, we capture a local average treatment effect (LATE) (Angrist and Pischke 2009).17 While LATEs are not always especially informative, we would argue that in this case our LATE is, since the instrument is itself the policy in question and it is relevant to know how programme participants' positions are affected.

While there are also groups set by the farmers themselves in the control villages, there are not many of them, and therefore the IV estimates are approximately equal to the DD estimates divided by the share of the group members from the village population (Angrist and Pischke 2009). In other words, the DD estimates are multiplied by the inverse of the 'take-up' rate of aid. To see this, since both the eligibility for the aid project and group membership are dummy variables, the IV estimate for the effect of the aid project is the Wald estimate:

$$(5)\quad \delta_{WALD} = \frac{E[Y_i \mid R_i = 1] - E[Y_i \mid R_i = 0]}{E[m_i \mid R_i = 1] - E[m_i \mid R_i = 0]}$$

where Y is the outcome of interest, R denotes the aid villages and m indicates that the household is a group member. The numerator in this expression is the difference in the outcome variable between the households that are eligible for aid (ITT), and the denominator is the difference in the fraction which actually receives aid (the 'take-up' rate); i.e. belongs to a group. If group participation is uncommon among those who are not eligible for the intervention, then is close to zero, and the Wald estimate simply scales up the effects by multiplying the difference between eligible and ineligible persons by the inverse of the take-up rate.

The outcome variables that we use relate to farming techniques and food security. These include:

- an indicator variable if the household uses fertilizers on its fields (alternatively the number of improved techniques used, i.e. manure, fertilizer and pesticides)
- the number of crops farmed (this is used to measure if the farmers start to use new crops)
- a variable if the household uses improved varieties of existing crops
- an indicator variable on the ability to have regular meals
- food consumption score
- coping strategy index

The outcome indicators on farming techniques are indicators of technology adoption since the participation in the farmers' groups and the work on the joint fields by no means guarantee that the farmer uses the new technologies on their own fields.

The control variables relate to the key aspects noted in section 4: demographics, means of livelihood and access to water. We include demographic information as reported in Section 4 on household size, number of children, whether household head is female, if head or spouse is literate and marital status of head (monogamy used as reference category). We also control for whether there is an ill person in the household, or not, and whether the head of the household has migrated or not. We expect that the head being away might have an impact on household decision-making. To control for the wealth level of the household, we add information on number of TLUs owned and number of hectares in use. Related to climatic circumstances we add a variable on the cumulative rainfall during the rainy season over the three years and control for the type of land the household uses each year: high land (reference category), low land or a combination of both. This can be controlled for, since the project did not seek to affect this choice.

Heteroscedasticity robust standard errors are used throughout; in the pooled regression we also account for the fact that the same household appears several times in the data. Clustering at a village level is not well-founded, as some of the villages are very scattered and it is unclear if households that officially belong to village A, but reside nearer to the centre of another village B, face the same shocks as an average household in village A. For the IV regressions we report results from the first stage F-tests to show the strength of the instrument.

17 LATE is due to Imbens and Angrist (1994). See also Heckman (1997) and Angrist et al. (1996).

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5. Results on farming techniques and crops harvested

We first consider the impact of the intervention on farming techniques. We study the use of fertilizers, the number of crops harvested and the number of new crop varieties used.

Figure 3 below illustrates what has happened to the use of fertilizers during this period. It demonstrates that there was a large increase in the share of farmers' group members using fertilizers in the treatment villages at their plots immediately after the start of the intervention, but the effect drops back to the pre-intervention level the following year.

The results from the regression analysis are presented in Table 7 (Appendix 1). The first three columns display the results from the DD analysis, while the last three columns refer to the IV estimates where year 2010 is dropped.18 Recall that the IV estimates are approximately equal to the DD estimates divided by the share of the group members from the village population. The models in columns (1), (2), (4) and (5) are pooled regressions accounting for year and village fixed effects, while columns (3) and (6) include household fixed effects along with the year effects. The results suggest that the reform had a statistically significant positive impact on the propensity to use fertilizers in 2009, but no effect in 2010. Fertilizer use increased by almost 20 per cent among programme participants in 2009. The coefficients for aid village and aid group participation in 2009 do not change much between columns (1) and (2) and columns (4) and (5) respectively, suggesting that the covariates are not correlated with treatment status to any large extent. This lends some support to our assumption that treatment is as good as randomly assigned and is encouraging given our IV model. However, when household fixed effects are included in columns (3) and (6), the significance of the treatment variable drops, indicating the presence of unobservable factors not captured by our control variables. The results of the first stage F-tests remain strong throughout even if adding covariates and particularly household fixed effects cause a decline. The strong results on the F-tests are expected, given the nature of the instrument. We also tested estimating a similar regression on the number of improved techniques used (manure, fertilizers and pesticides) and obtained very similar results.

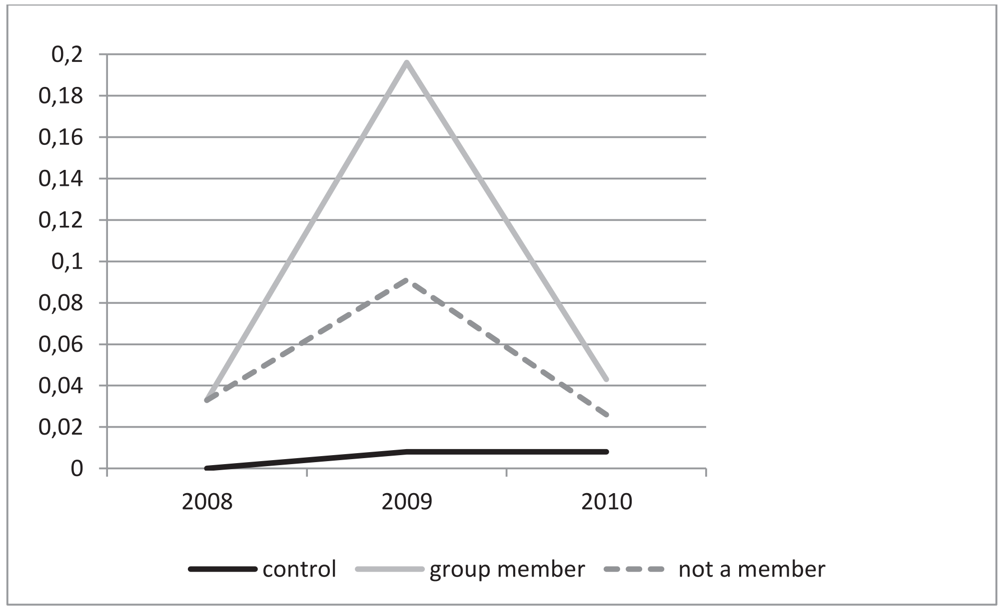

Figure 3. The share of farmers using fertilizers
Source: Authors' illustration.

18 Results from 2010 available upon request. In all cases they show results that are not significantly different from zero.

Figure 4 reports an increase in the number of crops among farmers' group members in 2009, but a drop again in 2010. A drop in the number of crop varieties from 2009–10 could also be a positive signal, if farmers replaced old varieties with new ones. A simple decomposition shows, however, that the drop in the number of crops farmed in 2010 is concentrated on the 'new plants', i.e. those not farmed in 2008. The share of new plants farmed in 2010 was still 34 per cent, indicating that there has been a shift in farmers' crop portfolios.

Table 8 (Appendix 1) shows the regression results of number of crops harvested. Aid village with a positive and significant sign in 2009 when covariates are not included. Note, though, that the drop in the coefficient and level of significance when covariates are included is entirely driven by the cumulative amount of rain during the rainy season. Households participating in the farmers' groups use on average almost one additional crop in 2009. While hectares in use increase the number of crops harvested, use of low land decreases the number of crops cultivated. As we showed in Section 4, use of low land becomes more common as rain fall decreases, and is especially common in 2010.

While the aid programme attempted to increase the number of crops farmed, the main goal was to encourage the farmers to use new varieties of existing plants (mainly maize). The baseline questionnaire did not include a question on whether the crops farmed were of the traditional or the improved variety, and therefore we are not able to carry out a DD analysis on this outcome. The question on the use of improved varieties of existing seeds was added to the questionnaires in 2009 and 2010, and therefore we can make a cross-sectional comparison on the propensity to use improved varieties between households in treatment and control villages, controlling for household characteristics. More formally, we estimate regressions for the two post reform years, 2009 and 2010, of the form:

$$(6)\quad y_{i,v,t} = \alpha^5 + X_{i,t}\beta^5 + \sum \lambda_t^5 year_t$$
$$+\delta^{5\_2009}(treat\_vil_{i,v} * 2009)$$
$$+\delta^{5\_2010}(treat\_vil_{i,v} * 2010) + \varepsilon_{i,v,t}^5$$

where the interesting variables are the dummies for living in a treatment village in each of

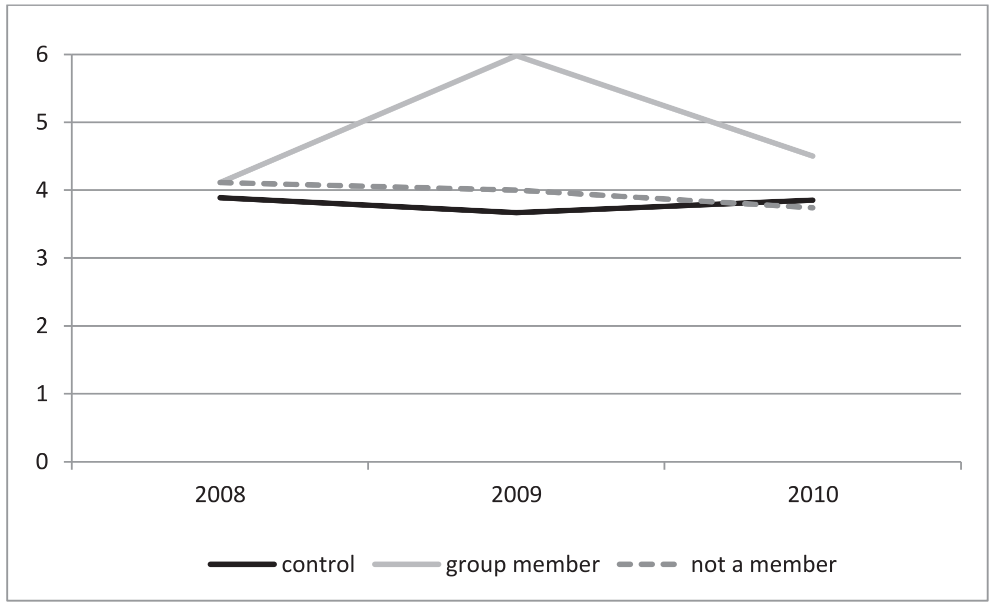

Figure 4. The number of crops farmed
Source: authors' illustration.

the treatment years. The IV estimations are otherwise similar, but there the idea is to look at the effect of group membership. Living in a treatment village is an instrument for group participation.

The results are reported in Table 9. The dependent variable is the number of improved varieties used. Column (1) and (2) report the OLS estimates and Column (3) and (4) the IV estimates. Both are strongly significant and positive with participating households using almost one new crop variety in 2009, suggesting that the reform had a positive impact. Again, the impact vanishes in 2010.

Finally, we also examined if any heterogeneous effects could be detected by interacting the predicted aid-group variable with female-head status, livestock ownership, hectare ownership below or below the median, and literacy. No significant effects were found and are therefore not reported here.

We can conclude that the results reveal that there were some immediate gains from the aid intervention. However, the impact of the programme on farming outcomes disappeared during its second year. A likely factor behind the decrease in impacts was a delay (of the order of three-four months) in delivering aid in 2010, which can have negatively affected farmers' activities during the planting season.

6. Selection into the programme

The analysis in the section above on farming outcomes consistently points to significant treatment effects in 2009 but no effects in 2010. We are interested to examine why this happens. We first examine the selection into the programme for the households living in the treatment villages.We estimate:

$$(7)\quad PR(m_{i,v,t} = 1) = \alpha^6 + X_{i,t}\beta^6 + \sum \lambda_t^6 year_t$$
$$+\sum \gamma_v^6 village_v + \varepsilon_{i,v,t}^6 .$$

We use the same controls as in the outcome regressions but include a variable that measures the distance (measured by a GPS device) from the household dwelling to the centre of the village where the farmers' group meetings took place, and shock variables. We separate between covariate and idiosyncratic shocks and add variables on number of household level shocks, drought, cyclones and, plagues and epidemics.19 Geography affects the participation in farmers' groups. The fact that the distance variable is negative and highly significant suggests that spatial factors are important in this context.20 Households with female heads (not widows) are more likely to participate in farmers' groups, while households with migrated heads are less likely to do so. The number of hectares a household uses enters positively and significantly and the number of TLUs negatively. Those that cultivate on high and low land at the same time are more likely to participate. While idiosyncratic shocks do not appear to affect participation, covariate shocks do to some extent. Households that have been negatively affected by cyclones are more likely to participate.

The results on participation show that the households that chose to participate are vulnerable, which was in line with the goals of the NGO. The likelihood to participate increases with female head status, low livestock ownership and negative exposure to some covariate shocks. Results from other studies find that these types of households typically have high risk aversion profiles and face considerable constraints when it comes to adopting new technologies (Dercon and Christiaensen 2011). Low livestock holdings limit the ability to cope with shocks and in the anticipation of yet another year of drought, a likely explanation is that the participating

19 We tested to include shocks in all outcome regressions but dropped them since different outcomes would have required different lag structures. Robustness checks revealed that dropping them has no effect on the magnitude or significance of the treatment variable in the regression reported in Tables 7–9. We drop the rain variable since the rain data that we have is the same for the two treatment villages.

20 However, in an analysis of the error terms, we did not find any evidence for spatial autocorrelation.

households did not use the new technologies or dropped their use to avoid risk.

7. Food security and coping strategies

We now turn to the effects on food security and coping strategies. Since treated households increased their use of improved technologies in 2009 but did not do so in 2010, it is of interest to see how household food security developed during the same period.

We use the indicators described in section 4 to measure food security: the binary indicator on whether the households were able to have regular meals, the FCS and the CSI. The two latter are only available in 2009 and 2010, so our ability to make strong conclusions on the overall effect on food security is limited. Importantly though, we are able to compare 2009 and 2010. As we showed in Table 5, the ability to have regular meals is not highly correlated with the FCS. We use it here, however, since it is available for all the years.

The regressions on the ability to have regular meals reported in Table 11 (Appendix 1) indicate improvements in the treatment villages in both 2009 and 2010. Without controlling for rainfall, the results are not statistically significant in 2010. The rainfall variable alone explains the increase in the coefficient of the treatment variable when controls are added to the model. Since the treatment effect is significant in both years, we show the results for aid groups in both 2009 and 2010. Here, limiting the analysis to those participating in the aid groups makes the treatment variable drop in significance when covariates are added.

We then study changes in the FCS and CSI. The intervention did not have any significant impact on the FCS compared to the control group (Table 12). On the other hand, there is no evidence that it would have fallen between 2009 and 2010 either. When it comes to the CSI, reported in Table 13, we note that the treatment variable is significant in both years (in 2009 even without controls). Recall that the higher the CSI is, the more negative coping strategies are, so here a negative coefficient entails a positive effect. In 2010, the significance of the treatment variable drops when the analysis is limited to the aid group participation only. An analysis of the individual coping strategies revealed that treatment villages are less likely to (1) borrow food or rely on help from friends or relatives, (2) consume wild food or harvest immature crops, (3) consume seed stock held for the next season and (4) restrict adult consumption so that children could eat. These differences were significant in 2009 only. In 2010, households in treatment villages were less likely to feed working member at the expense of non-working members.

The conclusion to be drawn from the analysis above is that the results on food security are mixed across indicators, but that the treatment villages appear somewhat more food secure than the control villages. The difference between project and control villages diminishes slightly in 2010. With the exception of CSI in 2009, the impacts on food security do not appear to be much stronger for participants in the farmers' groups. Also, while the effect on agricultural technologies vanishes completely in the second year, the results on food security are more persistent. This suggests that the results on food security cannot directly be related to technology adoption. We are not able to identify why the results on food security remain fairly stable even if the farmers drop fertilizer use. One explanation might be that the farmers still receive the harvest from the project plots that they possibly share with other villagers. Since the results on food security are not limited to those participating in the farmers' groups, an income effect (because farmers were given inputs for free) is an unlikely explanation.

Our results put to question the profitability for the farmers of adopting new technologies. Evidence from other context, notably Ghana and Ethiopia, suggest that farmers move in and out of fertilizers in response to (expected) profitability (Dercon and Christiaensen 2011; Conley and Udry 2010). In anticipation of shocks, vulnerable household become more risk averse and avoid adopting technologies of whose profitability they are not sure. It could be argued that the use of fertilizer should not have entailed any risk for the farmers since it was distributed at no costs. However, evidence from e.g. Ethiopia suggests that farmers perceive that the gains from fertilizer use are small during droughts. When asking farmers why they do not use fertilizer, non-suitability of agro-climatic conditions was one reason given (Dercon & Christiansen 2011).

8. Conclusion

This paper examined the effectiveness of a farming development project in rural Mozambique using household-level panel data from treatment and control villages before and in two consecutive years after the intervention started. The aid project concentrated on improving the livelihoods of poor farmers via the adoption of new varieties of existing seeds and improved technology, most notably fertilizers. One feature of the intervention was its bottom-up design: it was based on the villagers' own discussions on village development and especially on setting up farmers' groups, which received support from the NGO managing the aid. The project is also interesting because it focused on improving farming practices among subsistence farmers, many of whom are poor women.

We used two types of empirical approaches to evaluate the impacts of the intervention. First, a difference-in-difference analysis was conducted to measure 'the intention to treat' effect, i.e. the effect of living in the villages receiving aid after the intervention. While this DD estimate can capture potential spill-over effects to those who remain outside of the groups, it is also likely to underestimate the impact of aid on those who actually participate. To measure this latter effect, we also used an IV analysis, where eligibility for aid was used as an instrument for participating in the farmers' groups.

The results reveal that there were some immediate gains from the aid intervention. Fertilizer use increased by 20 per cent among programme participants and the participating households used almost one new improved variety of seeds. However, the impact of the programme on farming outcomes disappeared during its second year, but this also due to the delays in aid delivery. The impact on food security is more stable, as measured by the ability to have regular meals, as well as the CSI.

Our attempts to understand these results point to a few important insights. The model that predicts participation in the farmers' groups show that important determinants for participation are female headship, low livestock holdings and exposure to covariate shocks. While the intervention was successful in encouraging vulnerable households to participate, it appears that it did not succeed in relaxing constraints that hinder farmers from taking up new technologies. This was particularly the case in the second year, when the drought got worse in the treatment villages. Some of the new plants, particularly perennial crops like cassava, might require more time than this study covered before the benefits are realised. E.g. Weber (2012) shows that adoption requires several years if the yield effects take long to appear.

The results on food security cannot be directly attributed to whether or not households adopted new technologies. The fact that those farmers who adopted new technologies in the first year dropped them in the second year is consistent with an explanation whereby the new technologies were not found to be profitable enough in the face of severe drought. Delays in delivering aid reinforced these results. The fact that the project was group based might also have reinforced the results. As Foster and Rosenzweig (2010) point out, there is nothing to say that learning from others increases the use of a technology, if what was learned suggests that the new technology is not profitable. If learning from others encourages technology adoption, the opposite might also be true.

While the setting that we study is by no means untypical for Mozambique and some other parts of Sub-Saharan Africa, one should exercise caution when extrapolating them to other settings. That being said, the results point to huge challenges faced by NGOs and other actors trying to facilitate technology adoption in poor areas in the presence of risk, subsistence constraints and imperfect credit and insurance markets. For policies to be effective, they have to relax constraints on many levels and operate smoothly, minimizing delays in aid delivery. This can be beyond what a single NGO can achieve and points to the importance of coherent government policies and several complementary initiatives

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Appendix 1

Table 1. Project and control villages, sample size, attrition and participation in farmers' groups

	Project villages		Control villages			
	Swiswi	Nongoti	Saute	Nhanal	Queque	Solane
Total number of households in the village	36	121	97	340	279	31
Households interviewed (2008)	34	59	37	61	18	23
Households interviewed (2009)	31	53	33	58	17	20
Households interviewed (2010)	32	52	30	60	17	20
Farming intervention, group participation						
Village adoption rate to treatment, LWF 2009–10, %	89	46	-	-	-	-
Sample adoption rate to treatment, survey 2009, %	94	51	-	5	-	-
Sample adoption rate to treatment, survey 2010, %	81	39	-	10	-	-
Δ dropouts % (Δ newcomers %) 2009–10, %	21 (12)	41 (26)				
Other NGO operates in the village: farming development			No	Caritas	No	No

Source: Authors' calculations.

Table 2. Basic household and member characteristics in the baseline survey 2008

	Project villages	Control villages	Total	P value for difference between project and control villages
Number of households	92	140	232	
Household size				
Mean	6.3	6.3	6.3	0.956
Median	6.0	6.0	6.0	
Max	22	23	23	
Number of children age <15				
Mean	3.0	3.0	3.0	0.990
Median	3.0	3.0	3.0	
Max	9	11	11	
	%	%	%	
Female head	38	36	37	0.803
Head/spouse literate	30	37	34	0.293
Head migrated	13	12	13	0.839
Other members migrated	33	28	30	0.439
Ill member(s) in household	48	39	43	0.198
Marital status of head				
Married (monogamy)	45	44	44	0.919
Married (polygamy)	24	28	26	0.484
Divorced/separated	3	5	4	0.516
Widow/widower	26	18	21	0.140
Never married	2	5	4	0.271
Number of persons	581	880	1461	
Age				
Mean	23.0	21.7	22.3	0.248
Median	15.0	14.0	15.0	
	%	%	%	
Sex				
Male	44	45	45	0.643
Female	56	55	55	0.643

Source: Authors' calculations.

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Table 3. Farming and livestock in the baseline survey 2008

	Project villages	Control villages	P value for difference between project and control villages
Number of households	92	140	
Fields (hectares)			
Average size	3.51	3.87	0.384
Median sixe	3.00	3.00	
Five most common crops (%)			
Maize	99	100	0.646
Cow peas	83	86	0.850
Peanuts	73	55	0.004
Pumpkin	61	40	0.002
Water melon	44	37	0.256
Number of crops harvested (%)			
No crops	3	6	0.390
One crop	8	4	0.174
Two crops	4	24	0.000
3-4 crops	46	32	0.038
More than 5 crops	39	35	0.523
Livestock owned by households (% of households)			
Oxen/bulls and/or cows	35	42	0.261
Goats and sheep	41	64	0.001
Chicken and other poultry	71	73	0.714
No livestock	15	14	0.726
Tropical livestock units			
Average size	2.98	3.99	0.310
Median size	0.54	1.29	

Source: Authors' calculations.

Table 4. Water security and shocks 2008–10

	Project villages			Control villages			P-value for difference between project and control villages		
Number of households	92			140					
	2008	2009	2010	2008	2009	2010	2008	2009	2010
Cumulative amount mm of rain in the rainy season (Nov–Apr)	708	634	539	642	634	572			
Landtype used for cultivation (percent)									
High land	85	79	52	84	83	63	0.948	0.669	0.143
Low land	12	8	31	13	13	32	0.816	0.370	0.918
High land and low land	2	11	15	1	5	5	0.678	0.084	0.008
Self-reported experience of shocks with negative effects on the household (percent)									
Drought	79	89	81	86	84	84	0.206	0.247	0.569
Cyclones	12	16	13	16	16	10	0.348	0.977	0.551
Plauges and epidemics	29	57	44	22	52	62	0.217	0.495	0.009
Household-level shocks*	27	39	32	13	56	27	0.006	0.021	0.443

* Cattle death, loss of livelihood/income, sickness/death of household member, robbery /fire (10 categories)

Source: Authors' calculations.

Table 5. FCS, CSI and ability to have regular meals by FCS classification, 2009

	Project villages	Control villages	P-value for difference between project and control villages
Number of households	84	128	
FCS average	29.54	28.53	0.573
CSI average	11.18	15.07	0.049
% of households in each FCS category			
Poor	30	34	0.486
Borderline	38	38	0.931
Acceptable	32	28	0.533
Average CSI by FCS category			
Poor	18.5	18.5	0.990
Borderline	9.4	15.7	0.036
Acceptable	6.6	10.0	0.167
% of households able to have regular meals by FCS category			
Poor	32.0	36.4	0.719
Borderline	59.4	45.8	0.241
Acceptable	48.1	44.4	0.775
Average TLU by FCS category			
Poor	1.7	2.9	0.190
Borderline	4.7	5.6	0.700
Acceptable	5.2	4.9	0.843

Source: Authors' calculations.

Table 6. Coping strategies used to feed the household, month preceding the survey 2009

	Project villages	Control villages	Severity weight
	%	%	
Rely on less preferred and less expensive food	79.5	84.2	1
Limit portion sizes	74.4	67.5	1
Gather wild food, hunt or harvest immature crops	52.6	58.3	2
Consume seed stock held for next season	41.0	55.0	2
Restrict adult cons so that children can eat	28.2	40.0	3
Borrow food or rely on help from a friend or a relative	26.9	34.2	2
Feed working hh members on the expense of non-working members	9.0	6.7	2
Send household members to beg	6.4	5.0	3

Table 7. Use of fertilizer

VARIABLES	(1)	(2)	(3) Fixed effects	(4) IV	(5) IV	(6) Fixed effects IV
Aid village 2009	0.115**	0.104**	0.090*			
	(0.046)	(0.045)	(0.048)			
Aid village 2010	-0.006	-0.013	-0.029			
	(0.029)	(0.029)	(0.029)			
Aid group participation 2009				0.183**	0.198**	0.178
				(0.075)	(0.087)	(0.119)
Household size		-0.004	-0.002		-0.004	0.005
		(0.003)	(0.006)		(0.004)	(0.014)
Number of children		0.003	0.000		0.005	-0.012
		(0.003)	(0.005)		(0.005)	(0.019)
Female head		0.005	0.048		0.013	0.039
		(0.037)	(0.031)		(0.034)	(0.116)
Hh head/spouse literate		0.016	-0.022		0.013	
		(0.015)	(0.039)		(0.019)	
Marital st head: polygam		-0.012	0.012		-0.020	0.001
		(0.014)	(0.037)		(0.021)	(0.075)
Marital st head: single		0.009	0.000		0.007	0.074
		(0.036)	(0.025)		(0.036)	(0.147)
Marital st head: widow		0.009	-0.066**		-0.019	0.003
		(0.044)	(0.029)		(0.037)	(0.127)
Head migrated		0.054	0.069		0.062	0.114
		(0.039)	(0.047)		(0.039)	(0.125)
Ill member in hh		-0.015	-0.021		-0.021	-0.015
		(0.013)	(0.015)		(0.015)	(0.031)
N of tropical livestock units		0.001	0.002		-0.000	-0.002
		(0.001)	(0.002)		(0.001)	(0.004)
N of hectares		0.003	0.005		0.004	0.005
		(0.003)	(0.004)		(0.004)	(0.005)
Rain		-0.000	-0.000		0.000	0.000
		(0.000)	(0.000)		(0.000)	(0.001)
Fields: low land		0.011	0.014		0.042	0.052
		(0.017)	(0.022)		(0.035)	(0.044)
Fields: high and low land		0.074	0.036		0.043	0.060
		(0.061)	(0.074)		(0.092)	(0.068)
Observations	650	642	642	441	434	434
R-squared	0.116	0.138	0.101	0.092	0.097	
First stage F-test				52.81***	20.16***	13.42***
Number of hhcode			240			237

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Year effects included but not shown. Village effects included in the models in column (1), (2), (4) and (5).

Source: Authors' calculations.

Table 8. Number of crops harvested

VARIABLES	(1)	(2)	(3) Fixed effects	(4) IV	(5) IV	(6) Fixed effects IV
Aid village 2009	0.866**	0.590	0.643			
	(0.392)	(0.498)	(0.489)			
Aid village 2010	-0.215	-0.728	-0.623			
	(0.368)	(0.653)	(0.659)			
Aid group particip. 2009				1.389**	0.785	0.847
				(0.618)	(1.035)	(1.205)
Household size		0.037	0.074		0.038	0.122
		(0.043)	(0.092)		(0.047)	(0.138)
Number of children		0.003	0.019		0.012	0.043
		(0.062)	(0.135)		(0.071)	(0.192)
Female head		0.379	0.624		0.301	2.390**
		(0.283)	(0.565)		(0.357)	(1.187)
Hh head/spouse literate		0.291*	-0.403		0.368*	
		(0.175)	(0.476)		(0.209)	
Marital st head: polygam		-0.102	0.663		0.145	1.126
		(0.237)	(0.736)		(0.265)	(0.762)
Marital st head: single		-0.474	-1.149		-0.292	-1.256
		(0.358)	(0.711)		(0.419)	(1.479)
Marital st head: widow		-0.481	-0.472		-0.378	-1.537
		(0.321)	(0.649)		(0.384)	(1.297)
Head migrated		0.100	-0.500		0.239	-2.203*
		(0.320)	(0.622)		(0.384)	(1.281)
Ill member in hh		-0.127	-0.060		-0.071	-0.123
		(0.160)	(0.222)		(0.178)	(0.315)
N of tropical livestock units		-0.008	-0.008		-0.001	0.027
		(0.011)	(0.023)		(0.013)	(0.043)
N of hectares		0.094***	0.089**		0.061	0.104**
		(0.027)	(0.041)		(0.039)	(0.048)
Rain		-0.004	-0.004		-0.005	-0.005
		(0.004)	(0.004)		(0.006)	(0.007)
Fields: low land		-0.414**	-0.559**		-0.617**	-0.609
		(0.209)	(0.264)		(0.253)	(0.452)
Fields: high and low land		0.003	0.251		-0.001	0.264
		(0.436)	(0.561)		(0.590)	(0.690)
Observations	653	645	645	444	437	437
R-squared	0.068	0.139	0.128	0.045	0.154	
First stage F-test				52.82***	20.15***	13.63***
Number of hhcode			240			237

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Year effects included but not shown. Village effects included in the models in column (1), (2), (4) and (5).

Source: Authors' calculations.

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Table 9. Number of improved varieties used

VARIABLES	(1)	(2)	(3) IV	(4) IV
Aid village 2009	0.471***	0.474***		
	(0.169)	(0.174)		
Aid village 2010	0.0165	-0.0452		
	(0.144)	(0.172)		
Aid group participation 2009			0.751***	0.766***
			(0.281)	(0.292)
Household size		0.011		0.006
		(0.025)		(0.028)
Number of children		-0.012		0.011
		(0.039)		(0.049)
Female head		0.038		0.314
		(0.121)		(0.216)
Hh head/spouse literate		0.104		0.437**
		(0.114)		(0.195)
Marital st head: polygam		-0.149		-0.273
		(0.182)		(0.252)
Marital st head: single		-0.269*		-0.579**
		(0.144)		(0.251)
Marital st head: widow		-0.192		-0.401*
		(0.150)		(0.217)
Head migrated		0.028		0.073
		(0.186)		(0.235)
Ill member in hh		-0.229**		-0.042
		(0.095)		(0.151)
N of tropical livestock units		0.009		-0.008
		(0.012)		(0.006)
N of hectares		-0.015		-0.013
		(0.012)		(0.017)
Rain		-0.002		-0.001
		(0.002)		(0.002)
Fields: low land		0.016		0.060
		(0.132)		(0.221)
Fields: high and low land		-0.007		0.139
		(0.198)		(0.354)
Observations	421	418	212	210
R-squared	0.024	0.058		0.029
First stage F-test			132.77***	17.16***

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Year effects and village included but not shown.

Source: Authors' calculations.

Table 10. Selection into farmers' groups in the treatment villages

VARIABLES	(1) Marginal effects
Nongoti	-0.317***
	(0.072)
2010	-0.092*
	(0.055)
Household size	-0.013
	(0.013)
Number of children	0.008
	(0.023)
Female head	0.226**
	(0.091)
Hh head/spouse literate	-0.089
	(0.076)
Marital stat head: polygam	-0.027
	(0.092)
Marital stat head: single	-0.142
	(0.139)
Marital stat head: widow	-0.264**
	(0.117)
Head migrated	-0.220**
	(0.095)
Ill member in hh	-0.132**
	(0.062)
N of tropical livestock units	-0.011*
	(0.006)
N of hectares	0.024**
	(0.010)
Fields: low land	-0.082
	(0.084)
Fields: high and low land	0.323***
	(0.113)
Household-level shocks	0.046
	(0.060)
Drought	0.027
	(0.089)
Cyclones	0.226***
	(0.080)
Plauges and epidemics	-0.051
	(0.068)
Distance to village centre	-0.041***
	(0.010)
Observations	165

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Source: Authors' calculations.

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Table 11. Ability to have regular meals

VARIABLES	(1)	(2)	(3) Fixed effects	(4) IV 2009	(5) IV 2009	(6) FE IV 2009	(7) IV 2010	(8) IV 2010	(9) FE IV 2010
Aid village 2009	0.166*	0.367***	0.371***						
	(0.092)	(0.119)	(0.124)						
Aid village 2010	0.016	0.299*	0.303*						
	(0.092)	(0.153)	(0.158)						
Aid group particip.				0.263*	0.353	0.474	0.056	0.279	0.521
				(0.144)	(0.271)	(0.295)	(0.207)	(0.400)	(0.557)
Household size		-0.016*	-0.001		-0.027**	-0.029		-0.013	0.004
		(0.009)	(0.023)		(0.011)	(0.033)		(0.010)	(0.029)
Number of children		0.006	-0.037		0.017	0.011		-0.002	0.018
		(0.015)	(0.032)		(0.018)	(0.043)		(0.016)	(0.051)
Female head		-0.016	0.267		-0.076	0.076		-0.046	0.191
		(0.074)	(0.189)		(0.097)	(0.202)		(0.093)	(0.201)
Hh head/spouse literate		-0.036	-0.165		-0.089*			-0.025	-0.196
		(0.042)	(0.131)		(0.050)			(0.060)	(0.161)
Marital st head: polygam		0.004	0.038		0.033	-0.121		-0.004	0.260
		(0.054)	(0.130)		(0.067)	(0.185)		(0.067)	(0.167)
Marital st head: single		-0.094	0.059		-0.168	-0.021		-0.037	0.216
		(0.078)	(0.226)		(0.112)	(0.202)		(0.099)	(0.319)
Marital st head: widow		-0.059	-0.125		-0.050	0.200		-0.008	-0.062
		(0.081)	(0.150)		(0.103)	(0.232)		(0.105)	(0.219)
Head migrated		0.055	-0.238		0.121	0.092		0.093	-0.213
		(0.086)	(0.216)		(0.119)	(0.217)		(0.117)	(0.223)
Ill member in hh		-0.019	-0.061		-0.039	-0.068		-0.019	-0.032
		(0.038)	(0.053)		(0.048)	(0.079)		(0.044)	(0.065)
N of tropical livest. units		0.010***	0.006		0.011***	-0.012		0.012***	0.008
		(0.002)	(0.005)		(0.003)	(0.009)		(0.003)	(0.008)
N of hectares		0.008	0.011		0.009	0.010		0.004	0.007
		(0.006)	(0.008)		(0.008)	(0.012)		(0.007)	(0.012)
Rain		0.002**	0.002**		0.000	0.001		0.001	0.001
		(0.001)	(0.001)		(0.002)	(0.002)		(0.001)	(0.002)
Fields: low land		0.082	0.138**		0.062	0.181		0.114*	0.067
		(0.056)	(0.068)		(0.074)	(0.113)		(0.065)	(0.099)
Fields: high & low land		-0.099	-0.132		-0.089	-0.013		-0.110	-0.232
		(0.098)	(0.118)		(0.137)	(0.169)		(0.127)	(0.203)
Observations	653	645	645	444	437	400	441	435	392
R-squared	0.055	0.105	0.117	0.016	0.070	0.114	0.125	0.168	0.162
First stage F-test				54.25***	23.21***	10.92***	26.62***	11.12***	7.07***
Number of hhcode			240			200			196

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Year effects included but not shown. Village effects included in the models in column (1), (2), (4) and (5).

Source: Authors' calculations.

Table 12. Food consumption score

VARIABLES	(1)	(2)	(3) IV 2009	(4) IV 2009	(5) IV 2010	(6) IV 2010
Aid village 2009	1.014	1.847				
	(1.810)	(1.812)				
Aid village 2010	-0.044	1.452				
	(1.875)	(2.206)				
Aid group participation 2009			1.616	3.626	-0.099	6.402
			(2.870)	(2.832)	(4.203)	(6.165)
Household size		0.259		0.296		0.279
		(0.337)		(0.414)		(0.414)
Number of children		-0.375		-0.324		-0.585
		(0.509)		(0.652)		(0.649)
Female head		-0.929		-1.897		-0.475
		(2.235)		(2.739)		(2.822)
Hh head/spouse literate		2.419		5.119***		-0.351
		(1.487)		(1.872)		(2.149)
Marital st head: polygam		0.472		4.104		-1.602
		(1.969)		(2.811)		(2.817)
Marital st head: single		0.036		1.891		-2.168
		(2.676)		(3.523)		(3.396)
Marital st head: widow		0.476		0.712		1.691
		(2.257)		(2.769)		(3.438)
Head migrated		0.789		-0.372		5.825
		(2.613)		(2.738)		(4.100)
Ill member in hh		-0.873		0.131		-2.424
		(1.288)		(1.630)		(1.847)
N of tropical livestock units		0.321***		0.075		0.532***
		(0.087)		(0.113)		(0.105)
N of hectares		-0.071		-0.239		0.028
		(0.156)		(0.203)		(0.245)
Rain		0.015		0.018		0.077
		(0.029)		(0.032)		(0.057)
Fields: low land		-0.927		-0.980		-1.116
		(1.614)		(3.036)		(2.002)
Fields: high and low land		-4.182*		-6.965*		-3.562
		(2.488)		(3.825)		(3.175)
Observations	421	418	212	210	209	208
R-squared	0.001	0.082	0.005	0.110	-0.000	0.144
First stage F-test			132.77***	110.55***	52.76***	43.82***

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Year and village effects included but not shown.

Source: Authors' calculations.

Table 13. Coping strategy index

VARIABLES	(1)	(2)	(3) IV 2009	(4) IV 2009	(5) IV 2010	(6) IV 2010
Aid village 2009	-3.892**	-5.000***				
	(1.933)	(1.814)				
Aid village 2010	-1.660	-5.189**				
	(2.355)	(2.527)				
Aid group participation 2009			-6.201**	-8.738***	-3.742	-10.736
			(3.123)	(2.908)	(5.327)	(9.074)
Household size		-0.036		0.649		-0.563
		(0.359)		(0.498)		(0.501)
Number of children		0.276		-0.590		1.015
		(0.534)		(0.750)		(0.802)
Female head		1.786		0.814		3.047
		(3.425)		(4.695)		(4.338)
Hh head/spouse literate		-3.827**		-2.964		-3.649
		(1.655)		(2.072)		(2.821)
Marital st head: polygam		1.214		-3.063		4.514
		(2.186)		(2.586)		(3.759)
Marital st head: single		0.754		-1.759		3.927
		(3.410)		(4.555)		(4.651)
Marital st head: widow		1.964		-0.827		2.854
		(3.711)		(4.460)		(5.516)
Head migrated		1.545		3.644		-5.317
		(3.922)		(5.533)		(5.603)
Ill member in hh		5.884***		5.070***		6.783**
		(1.463)		(1.764)		(2.673)
N of tropical livestock units		-0.214**		-0.354***		-0.209*
		(0.083)		(0.117)		(0.123)
N of hectares		-0.381*		-0.556***		-0.151
		(0.213)		(0.196)		(0.353)
Rain		-0.034		-0.028		-0.044
		(0.034)		(0.035)		(0.092)
Fields: low land		-1.238		1.303		-0.710
		(1.932)		(3.587)		(2.668)
Fields: high and low land		14.646***		14.188***		18.195***
		(3.372)		(4.451)		(4.846)
Observations	421	418	212	210	209	208
R-squared	0.024	0.176	-0.011	0.169	-0.013	0.114
First stage F-test			132.77***	110.55***	52.76***	41.22***

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Year and village effects included but not shown.

Source: Authors' calculations.

Appendix 2

Food consumption score (FCS). Based on question on consumption of the food items listed below during the seven past days.

Food items	Food group	Weight	Max. freq.	Max. points
Maize, rice, sorghum, millet, bread and other cereals Cassava, potatoes and sweet potatoes	Cereals and tubers	2	7	14
Beans (butter/soya), peas, cow peas, groundnuts, peanuts and cashew nuts	Pulses	3	7	21
Vegetables, relish and leaves	Vegetables	1	7	7
Fruits	Fruits	1	7	7
Beef, goat, poultry, pork, eggs and fish	Meat and fish	4	7	28
Milk and other dairy products	Milk	4	7	28
Sugar and sugar products	Sugar	0,5	7	3,5
Oils, fats and butter	Oil	0,5	7	3,5
Max. possible score				112

Note: Cut-off points: 0-21 poor, 22-35 borderline, >35 acceptable.

Source: Based on data from World Food Programme (2009).

Coping strategy index (CSI). Based on the question: In the **past month**, as a result of not having enough food, how often has your household had to:

Coping strategy:	All the time/ every day	Fairly often/3-6 times per week	Occasionally /1-2 times per week	Rarely/ less than once a week	Never	Severity weight
Rely on less preferred and less expensive food?						1
Borrow food or rely on help from a friend or relative?						2
Gather wild food, hunt or harvest immature crops?						3
Consume seed stock held for next season?						3
Send household members to beg?						3
Limit portion sizes?						1
Restrict adult consumption so that children can eat?						3
Feed working household members at the expense of non-working members?						2
Frequency weight	7	4,5	1,5	0,5	0	

Source: Based on data from World Food Programme (2009).

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