Food and Agriculture Organization of the United Nations

Agricultural practices and disaster risk reduction strategies in Malawi

Baseline analysis and programmatic implications of a Farmer Field School approach

Evaluating the impacts of promoting coherence between disaster risk reduction, climate action and social protection in Malawi

Baseline analysis and programmatic implications of a Farmer Field School approach

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Abbreviations and acronyms

AIP	affordable inputs programme
ANOVA	analysis of variance
CC	climate change
CHIRPS	Climate Hazards Group InfraRed Precipitation with Station data
CSA	climate-smart agriculture
CT	cash transfer
DRR	disaster risk reduction
FAO	Food and Agriculture Organization of the United Nations
FFS	farmer field school
FMM	Flexible Multi-Partner Mechanism
GoM	Government of Malawi
ha	hectares
HH	household
Kg	kilogram
MWK	Malawi Kwacha
SCT	social cash transfer
SF	stochastic frontier
SMF	school meals feeding
SP	social protection
SPI	standardized precipitation index
TA	traditional authority
USD	United States Dollar

Executive summary

Background

The project “Promoting coherence between disaster risk reduction, climate action and social protection in sub-Saharan Africa (Malawi)” aims to support poor and vulnerable households to strengthen their resilience to climate change and climate variability through social protection (SP) and the adoption of proven climate-smart agriculture (CSA) practices blended with disaster risk reduction (DRR). FAO Malawi leads the implementation of the project in two targeted districts of Mwanza and Neno, targeting 2 400 farmers, some of them being beneficiaries of existing SP programmes. At community level, the project is implemented through the farmer field school (FFS) approach and delivered through 80 FFS groups located in 74 villages.

The standard package of support provided by the project includes the following elements: CSA training, farming as a business training, and an enterprise grant disbursed collectively to each of the 80 FFS group. To this standard packet, the project randomly provided some combination of the following forms of support to the beneficiaries:

1) In-kind transfer of CSA related inputs comprising maize and pigeon peas seeds, basal and top-dressing fertilizers and inoculants for pigeon pea seeds.
2) Cash transfer equivalent in value to CSA input packet.

Impact evaluation design

To evaluate impacts of the project, we use a crossover design to compare the relative merits of its different components and combine various evaluation methods. The FFS groups were selected randomly into one of three groups:

- T1: receives the standard packet of CSA training, farming as business training, and an enterprise grant for the FFS;
- T2: standard packet + in-kind transfer of CSA inputs;
- T3: standard packet + cash transfer equivalent in value to the CSA input transfer.

A fourth group (C) of farmers receive the same CSA input transfer offered to group T2, without being involved in the FFS. This fourth group comes from neighbouring communities within the same districts and beneficiary farmers were deemed to be selected in the same way of farmers in the FFS.

Baseline survey findings

The descriptive analysis of the baseline survey data of the project confirmed that the randomization across the three experimental arms worked very well, with very few indicators showing small imbalances. We also found large differences between the FFS and the comparison groups, which were expected due to diverse agro-ecological conditions. This confirms the need for a difference-in-difference design to evaluate impacts of the farmer field school alone. Overall, the comparison group looks poorer, less engaged with markets, relying on a less diverse crop production and income generation, adopting less agricultural practices. Both groups have a large share of beneficiaries of the affordable input programme and the school meals programme and a very small share of cash transfers beneficiaries. Sample households have been affected significantly by recent weather shocks and a large share have received information on climate.

The stylized findings from the descriptive analysis point to a partially successful targeting approach: if the main objective of the project was to create synergies between social protection and agriculture broadly at the village/community level, the large share of beneficiaries of the two important programmes in the communities can positively interact with the project and generate spillovers effects. However, if the main idea was instead to create synergies at the individual/household level, especially for the most vulnerable segment of the population, this objective is likely unmet, given the low coverage rate of the social cash Transfer programme in the two districts targeted by the project.

The econometric analysis carried out with the baseline survey data provided some relevant insights concerning the expected direction and magnitude of the effects of the main project components. The cash transfer and the inputs' transfer have the potential to generate strong impacts on the food security domain, while the training provided by the FFS approach has the potential to help households better manage risks. Given the agro ecological conditions of the districts targeted by the project, and the existing agricultural technology, maize yields could be enhanced by strengthening the adoption of maize-legume intercropping. This appears to be beneficial on both an efficiency perspective (better use of available farmland) and a growth perspective (expanding available farmland). Similarly, the adoption of improved early maturing maize seeds may contribute to greater volumes of maize production.

1. Introduction

According to the climate-smart approach, climate change poses a major challenge to achieving the Sustainable Development Goals (SDGs) aiming to eliminate poverty and reach zero hunger by 2030. According to the latest figures, global hunger appears to be on the rise, with undernourishment currently affecting 9.9 percent of the global population (768 million people) (SOFI, 2021). Climate variability and extremes in weather conditions have been identified as key drivers of this rise in hunger. Indeed, it is estimated that current climate trends will double humanitarian needs by 2030, significantly taxing an already strained humanitarian system. This is mainly due to increasing climate variability and more frequent and severe extreme weather events affecting agricultural productivity and adding pressure to already fragile food and ecological systems.

Recent observable events indicate that the frequency of extreme weather events in Malawi has increased: more droughts and floods have occurred in the last decade (2000–2010) than in the past three decades before (1970–2000). Recurrent disasters are having a cumulative impact on affected populations. As of 2019, 3.3 million people were categorized as food insecure, with the majority concentrated in places affected by devastating floods in 2015 (1.1 million affected) and a drought in 2016 (6.4 million persons declared as food insecure). As a result of exposure to multiple and recurrent shocks, "*Malawi is highly vulnerable to the impacts of extreme weather events given its location along the great African Rift Valley, rapid population growth, unsustainable urbanization, climate variability and change, and environmental degradation. The most common weather-related shocks affecting Malawi include floods, drought, stormy rains and hailstorms. Over the past five decades, Malawi has experienced more than 19 major floods and seven droughts, with these events increasing in frequency, magnitude and scope over the years*" (GoM, 2019).

Adopting appropriate, climate-smart agricultural practices to reduce the vulnerability of smallholder systems to increasing climate risks is critical for achieving poverty reduction and improved food security among smallholders in the context of climate change. This is particularly the case in rainfed agricultural systems in Malawi, where farmers' livelihoods and production systems are acutely vulnerable to weather variations and where entrenched poverty limits the capacity of many to cope with major disruptions to production.

However, a persistent challenge for climate adaptation in Malawi and other countries with a high number of vulnerable smallholder farmers is the low rate of adoption of climate-smart agricultural (CSA) practices. Moreover, when poor households adopt CSA practices, they are often unable to sustain adoption long enough for meaningful benefits to accrue. This challenge is often explained by poor farmers lacking the resources to finance the costs of adopting CSA practices, and the potential risks of adopting these practices to income and food security are too high.

Emerging evidence on social protection programmes in rural developing countries suggests that these programmes, when well targeted and predictable, can address the risk and liquidity constraints that limit poor farmers' capacity to invest in new agricultural practices, including CSA practices (Scognamillo and Sitko, 2021). There is, therefore, reason to believe that combining social protection with appropriate information on CSA agriculture can lead to more widespread and sustained adoption of CSA practices by the rural poor, leading to improved welfare and resilience among smallholders.

However, evidence on the potential synergies between social protection and CSA is limited. In this report, we describe the impact evaluation design and the findings of the baseline data collection of an existing pilot programme linking farmer field school training on CSA practices with social protection support in two districts of Southern Malawi. The programme, known as "Promoting coherence between disaster risk reduction, climate action and social protection in sub-Saharan Africa (Malawi)" and labelled as FMM/GLO/148/MUL, is funded through the Flexible Multi-Partner Mechanism (FMM) of the Food and Agriculture Organization of the United Nations (FAO). It aims to support poor and vulnerable households to strengthen their resilience to climate change and climate variability through social protection (SP) and the adoption of proven CSA practices blended with disaster risk reduction (DRR), while also addressing capacity gaps in policy implementation, harmonization and monitoring at national and district levels. The project has two main overarching outcomes:

1. Increasing food and nutrition security and the resilience of poor and vulnerable farmers
2. Strengthening capacities of national government institutions, local authorities and farming communities to cope with impacts of climate change.

The activities under the project are anchored in five outputs:

<u>Outcome 1</u>

Output 1: Uptake and upscaling of proven climate-smart agriculture and disaster risk reduction practices and sustainable management of natural resources among poor and vulnerable farming households in targeted communities promoted.

Output 2: Diversity of sustainable and resilient livelihoods and regular income generating activities increased among beneficiary households.

Output 3: Predictable, adequate and regular support provided to target households in the face of a climate related shock affecting agricultural livelihoods (e.g. dry spells, drought and floods).

<u>Outcome 2</u>

Output 4: Policy implementation capacity of Government institutions strengthened to integrate agricultural livelihoods resilience, disaster risk management, climate action and social protection sub-programmes at national and district levels.

Output 5: Planning and multi-sectorial coordination and monitoring systems for social protection, climate action, resilience and disaster risk management programmes supported.

FAO Malawi leads the implementation of the project in two targeted districts of Mwanza and Neno (see annexes), targeting 2 400 farmers, some of them being beneficiaries of existing SP programs. At community level, the project is implemented through the farmer field school (FFS) approach and delivered through 80 FFS groups located in 74 villages.[1]

[1] In 4 villages, multiple groups have been formed: 4 FFS in Donda (Section Neno Central, TA Ngozi), 2 FFS each in Chirombo (section Kalioni, TA Ngozi), Tulonkhondo (section Tulonkhondo, TA Kanduku) and Nyakoko (section Ligowe North, TA Dambe).

2. National policy framework

Over the years, Malawi has developed an ambitious agenda of economic and social development, taking key steps towards the expansion of a social protection system as a critical component of it (Meerendonk, Cunha, Juergens and Pellerano, 2016).

The legal foundation of the Malawian economic and social development agenda is enshrined in the 1994 Constitution. The provisions contained in the Constitution have been operationalized in the development strategies, such as the 2017 to 2022 Malawi Growth and Development Strategy (MGDS) III, which aims at supporting Malawi becoming a nation with productive capacity, able to compete at a global level and equipped with resilient systems to withstand shocks and stresses.

Besides defining priority areas of intervention, MGDS III identifies complementary development areas essential for the successful realization of the strategy. One of these sectors is Disaster Risk Management and Social Support: the MGDS III acknowledges the role of social protection in effectively reducing chronic poverty and protecting against risks and recommends leveraging the national social protection system to build resilience at individual, household and community-level.

The 2012 National Social Support Policy (NSSP) together with the Malawi National Social Support Programme (MNSSP) II form the building blocks of the Government of Malawi's approach to social protection (Meerendonk, Cunha, Juergens and Pellerano, 2016). The NSSP provides a policy framework to design, implement, coordinate, monitor and evaluate social protection interventions as well as to link them with strategic sectors, such as agriculture and disaster risk management (Holmes, Scott, Both and Chinsinga, 2018; GoM, 2012).

MNSSP II, which runs from 2018 to 2023, shares the same vision, mission, goal and strategic objective of the National Social Support Policy, and was developed to operationalize it. Recognizing that the needs of vulnerable individuals change throughout their lifecycle and during shock times, the MNSSP II is articulated around three pillars (GoM, 2018):

1. Pillar 1: Consumption Support to prevent deprivation and enable households meeting basics needs, including food security, shelter, education and health;
2. Pillar 2: Resilient livelihoods to support households developing livelihood strategies aimed at enhancing resilience; and
3. Pillar 3: Shock-sensitive social protection to protect poverty reduction and human capital development gains by preventing, mitigating and responding to shocks.

Another key policy document in Malawi is the National Resilience Strategy, which aims to build a country without chronic vulnerability and food and nutrition insecurity, to create opportunities for everyone through sustainable economic growth, and to enhance people's resilience to economic and environmental shocks. To achieve this, the NRS aims at reorienting existing and planned interventions around four complementary pillars:

1. Pillar 1: Resilient Agricultural Growth;
2. Pillar 2: Risk Reduction, Flood Control, and Early Warning and Response Systems;
3. Pillar 3: Human Capacity, Livelihoods, and Social Protection; and
4. Pillar 4: Catchment Protection and Management.

Each of the four pillars contains an explicit reference to the contribution of social protection to their overall outcome. Moreover, social protection explicitly figures as a key component of Pillar 3, which aims at protecting individuals and households against vulnerability and multi-dimensional poverty. The strategies foreseen to achieve this outcome are aligned with the MNSSP II and include: (i) providing consumption support to vulnerable populations; (ii) strengthening resilient livelihoods; (iii) establishing a shock responsive social protection system; and (iv) increasing the adoption of nutrition-specific and nutrition-sensitive practices.

The 2016 National Agriculture Policy (NAP), which provides comprehensive guidance to the sector, aims at supporting the sustainable transformation of agriculture in a way that expands the wellbeing of farmers, improves food and nutrition security for all Malawians and increases export revenues.

The NAIP recognizes the key role social protection plays in reducing poverty and achieving food and nutrition security, especially when it is completed by agricultural interventions. For this reason, the NAIP makes explicit reference to the need of operating in close coordination with the MNSSP II and relevant actors within social protection. Cooperation is especially envisaged in the following areas: enabling poor rural households to participate in productive interventions, supporting livelihood diversifications, complementing disaster risk management interventions to avoid food security crises, facilitating the uptake of climate-resilient practices and using public works for building community infrastructure facilities that support climate change adaptation.

Finally, the legal framework for climate change management at country-level is represented by the 2016 National Climate Change Management Policy (NCCMP), which provides guidance on interventions aimed at reducing the release of greenhouse gas emissions in the atmosphere, as well as adapting to the adverse effects of climate change. To successfully reach this goal, NCCMP outlines six priority areas for climate change management: (i) climate change adaptation; (ii) climate change mitigation; (iii) capacity building, education, training and awareness; (iv) research, technology development and transfer, and systematic; (v) climate change financing; and (vi) cross-cutting issues, including gender, vulnerable groups and HIV and AIDS.

Within this policy framework, the impact evaluation aims to support the implementation of social protection, agriculture and climate change policy objectives by strengthening integrated approaches that help communities and farmers, anticipate, prevent and better cope with impacts of climate change and reduce rural poverty. Malawi represents an ideal scenario, given the interesting policy alignment across sectors.

3. Conceptual framework

Social protection may influence the capacity of vulnerable small-scale producers to adopt CSA practices along two dimensions. Directly, social protection interventions can help to stabilize incomes and consumption when weather risks occur through transfers of cash and in-kind resources to households with few alternative resources to manage these risks (Devereux, 2016). Poor smallholder households are particularly vulnerable to production and price volatility risks associated with weather shocks, due to limited access to resources, weak markets, and a lack of formal risk management instruments (Dorward *et al.,* 2006).

By helping to smooth consumption and/or income when shocks occur, social protection instruments can mediate household sensitivity to adverse weather events, and reduce the likelihood that a household will turn to negative coping strategies, such as productive asset liquidation and reduction in the quality and quantity of food consumed (Tirivayi *et al.*, 2016). Moreover, social protection programmes can directly ease the credit and liquidity constraints faced by poor rural households, thus increasing their capacity to invest in productive farm assets (Covarrubias *et al.*, 2012). Indirectly, by providing households with cash or in-kind transfers, social protection programmes can help reduce constraints associated with the opportunity costs and risks of adopting new farm practices (Devereux, 2016; Tirivayi *et al.*, 2016). Access to social protection systems may be particularly important for supporting the adoption of the CSA practices, which entail significant short-term consumption risks, because they often require a reallocation of scare production factors, without generating substantial immediate benefits (and can even contribute to short-term reductions in yield). Due to the risks associated with adopting many CSA practices, farmers who do adopt them often do so on a limited basis (Corbeels *et al.*, 2014; McCarthy, Lipper and Branca, 2011; Thierfelder *et al.*, 2017).

This includes dedicating small parts of their land to experiment with CSA practices and only adopting the practices for short periods of time (Doss, 2006). Under conditions of low intensity or short duration adoption, the benefits of the practices are quite limited, because the biological benefits of adoption take time to develop, as does the managerial expertise needed for successful implementation (Corbeels *et al.*, 2014). If access to social protection programmes is able to reduce these risks in ways that enable farmers to adopt CSA practices with higher level of intensity or for longer durations, the combined impact of CSA with social protection on weather risk sensitivity will be marginally higher than their standalone impacts.

4. Study design

Impact evaluation aims at providing feedback to help policymakers to improve the design of programmes and policies, increase accountability and ultimately enhance the allocation of funds across programmes. Therefore, impact evaluation is an essential instrument to test the validity of specific approaches to development and poverty alleviation, helping those involved on a project to establish whether there is a causal link between an intervention and those outcomes that are of importance to the policymaker. The study at hand aims at quantifying the impacts of the first outcome of the FMM/GLO/148/MUL project, the existing complementarities between the various livelihood components, and at looking into the causal links and channels through which these interventions affect the outcome and outputs of interest. This study will try to answer the following research questions: Does the FMM/GLO/148/MUL project achieve its intended objectives? Should it be scaled up? Can the changes in outcome and outputs be explained by the project, or are they the result of some other factors occurring simultaneously? Do project impacts vary across different groups of intended beneficiaries (male/female head farmers, beneficiaries/non-beneficiaries of SP programmes)?

To evaluate impacts of the FMM/GLO/148/MUL project, we will use a crossover design to compare the relative merits of its different components, and combine various evaluation methods.

The standard package of support provided by the FMM project includes the following elements: CSA training, farming as a business training, and an enterprise grant for the field school groups.[2] To this standard packet, the project could randomly provide some combination of the following forms of support to the beneficiaries:

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[2] The enterprise grant consists of a one-off transfer valued at USD 1 250, disbursed collectively to each of the 80 FFS group, not to the single farmer, with the aim of fostering group formation and consolidation.

1) In-kind transfer of CSA related inputs comprising at least 10 kg of maize seeds, 50 kg of NPK (basal) fertilizers, 50 kg of Urea (top dressing) fertilizers, 4 kg of Pigeon pea seeds and Nyonga pack (inoculants for pigeon pea seeds). The complete package per farmer is valued at USD 127.75.[3]
2) Cash transfer equivalent in value to CSA input packet. In some ways the addition of cash would help to mimic cash transfers, which was one of the major motivations for the project.

The FFS groups are selected randomly by the Evaluation Team into one of three groups described below.[4] The groups are:

- T1: receives the standard FMM packet of CSA training, farming as business training, and an enterprise grant for the FFS
- T2: standard FMM packet + in-kind CSA input packet transfer
- T3: standard FMM packet + cash transfer equivalent in value to the CSA packet

A fourth group (C) of farmers receive the same CSA packet offered to group T2, without being involved in the FFS. This fourth group comes from neighboring communities within the same districts and beneficiary farmers would be selected in the same way that farmers in the field schools are selected.

This design allows calculating different types of impacts at the project level in relation to the outcomes and outputs of interest:

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[3] At an average exchange rate in November 2021 of 802 Malawi Kwacha (MWK) per USD, the complete package is equivalent to a subsidy of approximately MWK 102 500.

[4] Originally, it was foreseen to organize a public event and a lottery to randomly allocate the benefits provided by the project. However, given the existing difficulties related to travel because of the outbreak of the COVID-19 pandemic, and especially to organize an open event with public authorities and the civil society, the randomization procedure was managed by the Evaluation Team with a statistical software.

1) the differential impact of the CSA input package (T2 vs. T1)
2) the differential impact of cash (T3 vs. T1)
3) the relative effectiveness of CSA input package vis-à-vis the cash (T3 vs. T2)
4) the impact of the standard FMM packet (T2 vs. C)

Impacts described in bullets 1, 2 and 3 will be estimated experimentally, while impacts described in bullet 4 will be estimated non-experimentally through a difference-in-difference approach. For both the experimental and the non-experimental analysis, the agricultural/development economics literature provides us little guidance in terms of the expected magnitude of impacts. This information is required, because it provides an important reference for determining the sample size needed to detect impacts. Ambler *et al.* (2020) analyses impacts of large, one-time cash transfers and farm management plans among farmers in Senegal. Farmers were randomized into three groups: group 1 received advisory visits; group 2 received the visits and an individualized farm management plan; finally, group 3 received the visits, the plan, and a cash transfer.

This setting is similar to our three experimental treatment arms, in which every farmer is part of the FFS. The cash transferred to beneficiaries in the project evaluated by Ambler *et al.* (2020) was around 200$, while the cash transfers and the equivalent CSA packages foreseen by the FMM project are smaller (approximately USD 125). The literature on agricultural subsidies is relatively more abundant. However, as shown by the systematic review conducted by Walls *et al.* (2018), this evidence base is weak when considering the impacts of these programmes on food security and nutrition.[5] Daidone *et al.* (2016) analyse how a CSA package of interventions in Lesotho provided with the national social cash transfer contributes to improvement in rural livelihoods. However, from the study it is not possible to disentangle whether the estimated impacts are due to the cash or the CSA component. Finally, in relation to the FFS approach, Waddington *et al.* (2014) find that FFS are beneficial in improving

[5] Three of the four articles considered in this literature review come from the evaluation of the Malawi Farm Input Subsidy Programme, which, however, does not promote adoption of neither CSA inputs nor practices.

intermediate outcomes relating to knowledge learned and adoption of beneficial practices, such as integrated pest management (IPM) technology.

These researchers provided also a rigorous meta-analysis of several adoption measures, such as the index of adoption of practices, or the probability of adopting positive practices. The estimated effect size is significant and large in magnitude (0.789). These findings are not surprising, since knowledge sharing and adoption of CSA is the gist of FFS activities. However, the impact evaluation evidence base is still small and there are no studies that they were able to identify as having a low risk of bias. This review does not include work by Larsen and Lilleør (2014), who estimate the impact of a FFS intervention among small-scale farmers in northern of the United Republic of Tanzania on two main development objectives: food security and poverty. Depending on the econometric approach used, they found a positive impact on the share of farmers not suffering from hunger between 17.2 and 23.8 percentage points and an increase in the share of farmers eating at least three meals in the worst months between 8.3 and 17 percentage points. These effects correspond approximately to about 50 and 20 percent increase relative to the comparison group baseline.

Comparison group selection

The Evaluation Team carried out the sampling of the comparison households in 25 villages. These villages were selected among those in Mwanza and Neno districts that are located farther away from the FFS. The identification of these villages has been carried out with the following procedure:

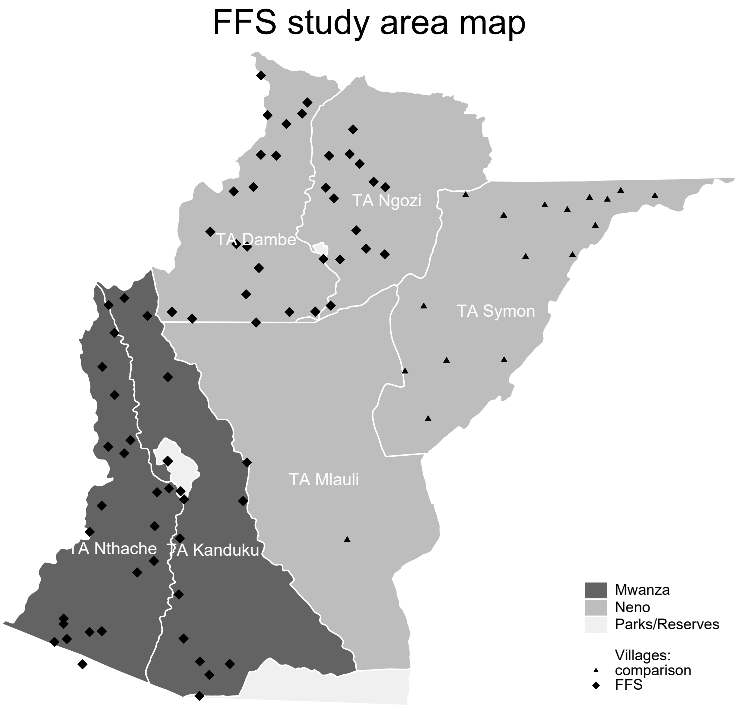
1. From a national shapefile of Malawi published in 2015, we extracted 427 villages located in Mwanza and Neno districts.[6]
2. From a mapping exercise conducted in early 2021 by FAO Malawi in Mwanza and Neno for the purposes of project targeting, we extracted 212 villages not selected for the FFS.

[6] http://landscapeportal.org/layers/geonode:villagesgeo

3. We match the two sources based on the following string variables: village names, district, traditional authority (TA), section (156 matched villages).
4. Based on available GPS coordinates, we constructed distances between each matched village and the location of the 74 villages where the 80 FFS are located.
5. We created a ranking of villages, based on the maximum minimum distances between the pot of potential comparison villages and the FFS.

In Figure 1 we show the location of the comparison villages and of those hosting FFS. In each village, we randomly select at least 22 farmers for at least 530 farmers. Each sample from each village should have similar characteristics to the treatment groups.

Figure 1. Location of FFS and comparison villages



***Note**:* Authors' elaboration from FAO monitoring and spatial data. FFS = farmer field schools.
Source: **World Agroforestry Centre.** 2015. *Malawi villages.* Cited 24 of February. http://landscapesportal.org/layers/geonode:villagesgeo.

The sampling of farmers in the comparison villages tried to mimic the FMM project targeting. Hence, we selected a group of farmers in each village according to the criteria listed below.

1. Both women and men being equally eligible to be sampled. Women and men to be selected should be within the active age group of 18 to 69 and able to engage in agricultural production activities.
2. At least 33 percent of the sample being composed of young people engaged in farming activities.
3. Potential farmers should be smallholders, with some land available for crop production.
4. The farmers meeting the above requirements and targeted by different social protection programmes, such as the affordable inputs programme (AIP), the Social Cash Transfer Programme (SCTP), the Malawi Social Action Fund (MASAF) Public Works Programme and/or micro-credit programmes, were prioritized in the sampling process.

These criteria were verified with the village chief or the elderly committees. Further, after identification of potential interviewees, enumerators approached them, asking the following questions:

1. "Are you interested in innovating your agricultural practices to improve your productivity?"
2. "Are you interested in agroforestry or soil and water conservation fertility enhancement practices?"

If the answers were positive for both questions, the farmer was confirmed for the sample. If the farmer answered no to at least one of the above two questions or could not be reached by phone, another farmer was randomly selected. When 22 farmers were reached and answered positively to the two questions, the sampling for the village was finished and enumerators proceeded with interviews. Similarly to the case of treatment villages, refusal/non-compliance with the survey led to farmers' replacement.

The decision to restrict the comparison villages within the Mwanzo and Neno districts was driven by the pressure to conduct the fieldwork before the end of June, at a time of the year when the COVID-19 pandemic curve was increasing and travel restrictions within Malawi seemed a realistic threat to the rollout of the survey. In fact, while the permissions to conduct the fieldwork were already obtained from the Mwanza and Neno authorities, the necessary administrative steps were not undertaken in the neighbour districts, which could have actually also represented an equally good alternative for the counterfactual. We have to remark that despite being located within the same target district and at most 80 km distance from the FFS, comparison villages come from Lower Neno, in proximity to the Shire river and to a tarmac road leading to Blantyre. Geographic and agro-ecological conditions in this area are slightly different relative to upper Neno and Mwanza. It is therefore important to take into account these considerations while presenting the descriptive analysis comparing the experimental groups with the comparison villages.

Data collection

Quantitative data are collected in two rounds: baseline and 24-months follow-up. The baseline data collection was necessary to capture the baseline living conditions of the FFS participants and the comparison group before the start of the FFS activities and before any cash transfers and CSA inputs vouchers had been disbursed. In addition, these data provide a detailed description of beneficiaries and allow the evaluation team to assess whether any systematic differences between the treatment and the comparison groups exist at baseline so that the differences can be controlled for during the impact evaluation analysis. It is crucial that the baseline data be collected before the three experimental groups received support payments and before the comparison group received the CSA inputs voucher. Because some short-term indicators, such as land management practices and inputs use will be impacted by the FMM project soon after households start FFS activities and eventually receive cash transfers or CSA input vouchers, we conducted the baseline survey before these impacts occurred to ensure that we properly measure the full impacts of the programme. Otherwise, benefits from the project that take effect in the short term would be lost and not attributed to the FFS, the cash transfers and CSA inputs vouchers themselves.

The baseline data collection occurred from 17 June to 14 July 2021. The fieldwork was carried out by two supervisors and 19 enumerators, all led by one national consultant specialized in survey data collection. The original goal set by the Evaluation Team was to collect 1 856 interviews, distributed as follows:

- Approximately 442 interviews for each of the three experimental groups (1 326 overall), divided in 26 equally sized clusters of 17 farmers each. However shortly after the establishment of the FFS, it appeared that multiple FFS were formed in two target villages. This led to a reduction from 78 to 74 clusters available for the experimental study and the decision to interview 18 farmers per cluster.
- For the non-experimental C group, it was planned to have at least 530 interviews, divided in 25 equally sized groups.

Identification of households in FFS villages was a relatively straightforward process, facilitated by the targeting activity carried out in the previous months to form the farmer field schools. However, the sampling of households had to balance gender and age composition of farmers participating in the FFS activities, following the existing registry data. For this reason, and combined with some tracking problems of FFS households, in a small share of FFS clusters it was not possible to reach the target of 18 households. This led to slightly unequal cluster size. Identification of farmers and their households in comparison villages was instead supported and monitored by village heads, councilors and other key community leaders.

As shown in Table 1, the team successfully gathered the expected data from the two districts, collecting surveys from 1 886 households in 99 clusters, representing 8 961 individuals. Comparison households come almost exclusively from villages located in TA Symon and one residual cluster in TA Mlauli. Because of the above-mentioned issue resulting in unequal cluster size, the clusters randomization procedure conducted after the data collection in the FFS villages boiled down in a slight oversampling of 457 households in the FFS+inputs group, followed by 440 and 436 households in the FFS+cash group and FFS only group respectively.

Table 1. Sample size of households, individuals and communities, by treatment group and traditional authority

	Chekucheku	Dambe	Govati	Kanduku	Nthache	Mlauli	Symon	total
comparison						22	531	553
						103	*2 474*	*2 577*
						(1)	(24)	(25)
FFS only	133	87	36	108	72			436
	610	*404*	*183*	*529*	*324*			*2 050*
	(7)	(5)	(2)	(6)	(4)			(24)
FFS+inputs	35	182	36	126	78			457
	144	*899*	*176*	*577*	*400*			*2 196*
	(2)	(10)	(2)	(7)	(4)			(25)
FFS+cash	68	125	54	90	103			440
	335	*608*	*257*	*438*	*500*			*2 138*
	(4)	(7)	(3)	(5)	(6)			(25)
total	236	394	126	324	253	22	531	1 886
	1 089	*1 911*	*616*	*1 544*	*1 224*	*103*	*2 474*	*8 961*
	(13)	(22)	(7)	(18)	(14)	(1)	(24)	(99)

***Note**:* Figures in italic (grey shaded rows) represent individuals. Number of clusters and community survey interviews in parentheses.
Source: Authors' elaboration from survey data.

Survey instruments

Two survey instruments were used in the impact evaluation of the FMM/GLO/148/MUL project: household questionnaire and community questionnaire. The design of the household instrument was guided by three core principles:

- The instrument must contain the key list of indicators presented in the project's log frame that will allow the programme to be assessed against its stated objectives. These core indicators include land management and agricultural practices, agroforestry, crop production, climate shocks, climate information and coping strategies, food security, access to markets and savings, although the final instrument contains many more relevant indicators.

- Where possible, indicators are measured using the questions and approaches that have already been field tested in similar surveys in the country, thus ensuring that they are appropriate for local conditions and that the resulting data can be compared with national data. We followed two main household surveys currently available to researchers: 1) The Fifth Integrated Household Survey (IHS) 2019–2020, carried out by the Malawi National Statistical Office in collaboration with the Living Standard Measurement Survey group at the World Bank. 2) The impact evaluation data of the Malawi National Social Cash Transfer Programme 2013–2014, collected by the University of Malawi in collaboration with the University of North Carolina at Chapel Hill

- The survey instrument must be a manageable length to avoid interviewer or respondent fatigue. Table 2 provides a list of topics covered in each of the two instruments. The final household questionnaire took about 44 minutes, though there were differences in length by treatment arm. In the comparison C group, it took on average 35 minutes to the enumerators to complete the survey, while it took between 44 and 50 minutes in the three experimental groups.

Table 2. Topics in the survey questionnaires

Household survey	**Community survey**
Roster, time use and wage labour	Community roster
Land	Agricultural inputs price
Crop production	Wages
Fruits and vegetables	Distances
Livestock holding	
Livestock by-products	
Agricultural assets	
Agricultural inputs expenses	
Non-farm enterprises	
Hired labour	
Non-timber forest products	
Transfers	
Decision-making	
Access to information	
Climate	
The COVID-19 pandemic	
Food insecurity	
Housing	
Credit	

Source: Authors’ elaboration.

5. Descriptive analysis

Methodology

This baseline study provides a snapshot of the livelihoods and family characteristics of future recipients before they started attending the farmer field schools and/or receiving the cash transfers or the input voucher. We describe demographic features of the sample and several characteristics that relate to either the goals of the programme or potential mediators.

To check that the three experimental groups are comparable in terms of the main outcome variables, outputs and observed characteristics, we carry out one-way analysis of variance (ANOVA) for each variable. ANOVA is used to determine whether there are any statistically significant differences between the means of three or more independent groups, such as in the evaluation design of the FFS treatment arms of the FMM programme. Specifically, we test the null hypothesis:

$$H_0: \mu_{T1} = \mu_{T2} = \mu_{T3} \qquad (1)$$

where μ_{T1}, μ_{T2} and μ_{T3} are the group means for the T1 group (FFS only), the T2 group (FFS+inputs'transfer) and the T3 group (FFS+cash transfer) respectively. ANOVA uses F-tests to statistically test the equality of means. The F statistics are based on the ratio of the between-groups variability (numerator) and the within-group variability (denominator). If the one-way ANOVA returns a statistically significant result, we accept the alternative hypothesis that there are at least two group means that are statistically significantly different from each other.[7] Because of their random allocation, we expect to find minimal differences across households included in the T1, T2 and T3 groups.

[7] One-way ANOVA is an omnibus test statistic, meaning that it cannot tell which specific groups were significantly different from each other statistically, but only that at least two groups were. To determine which specific groups differed from each other, we should use post hoc pairwise comparisons to check which group is causing the imbalance. However, given the low number of indicators that were found unbalanced across the experimental groups, carrying out pairwise t-tests does not provide any special value added to our analysis.

Given the evaluation design of the FMM programme, we are likely to observe instead many significant differences between the FFS groups and the comparison sample, which is not based on a randomized assignment. To test for statistical differences, we carry out simple t-tests of the mean difference between: a) the comparison group and the full sample of the FFS households, independently of their allocation in the T1, T2 or T3 group; b) the comparison group and the T2 group. While the former statistical exercise allows us understanding broader differences between the treatment groups and the comparison group, the latter comparison is crucial for the impact analysis, because at follow-up we will evaluate the impacts of the FFS approach by comparing the T2 and C groups. Establishing that the comparison and FFS+inputs' transfer groups are observationally equivalent at baseline allows the analyst to attribute to the FFS (and not to pre-existing baseline differences) any differences in the relevant outcomes and outputs measured at follow-up.

The tables with the baseline comparisons across the treatment groups for the demographic variables, the main outcomes of interest and the transfer variables are organized as follows, from left to right. Under the column *All* we provide the overall sample average. Under the columns *T1*, *T2* and *T3* we report group means for the FFS only, the FFS+inputs and the FFS+cash groups respectively. In the fifth and sixth columns we provide the ANOVA F-test and the related p-value for the null hypothesis that the sample mean of a given variable is the same in all three treatment experimental arms. Under columns *FFS* and *C* we report for each variable the means of the three combined FFS clusters and of the comparison group, followed by their mean differences (*FFS-C*) and the p-value of the related t-test (*p-val FFS-C*). The last two columns of these tables report the mean differences between the T2 and C groups (*T2-C*) and the p-value of the related t-test (*p-val T2-C*). Because of the substantial lack of statistical difference found for the three experimental groups' means, the descriptive tables for the remaining domains restrict their focus to the binary comparisons between the combined FFS arms and the C group and between the T2 and C groups.[8]

In this report we are faced with the issue of multiple comparisons. This issue arises when the same null hypothesis is tested for multiple outcomes or across multiple treatment arms. Classical hypothesis tests assess statistical significance by calculating the probability under a null hypothesis of obtaining estimates as large as, or larger than, the observed estimate. When multiple tests are conducted, however, classical p-values are incorrect – they no longer reflect the true probability under the null. A Type I error occurs when a researcher falsely concludes that an observed difference is 'real' when, in fact, there is no difference. The Type I error rate is usually set to 0.05. This means that the researcher is willing to commit a Type I error 5 percent of the time. But when we move to the world of multiple comparisons this simple testing framework is no longer sufficient. In the world of multiple testing, the Type I error rate is called Family-Wise Error Rate (FWER). The FWER is the probability of incorrectly rejecting even one null hypothesis in a sequence of hypotheses.[9] To control for the FWER, we employ the Holm-Sidak correction for the binary comparisons only (McDonald, 2008),[10] since the overwhelming majority of the variables analysed in this report do not show already statistical mean differences across the three experimental arms. We provide unadjusted and Holm-Sidak-adjusted p-values in the annex 6 for the 208 variables analysed in this baseline study. While comparing the overall FFS group vis-à-vis the comparison group, for 133 variables we

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[8] Out of 208 variables analysed in this study, at a five percent significance level, we would expect at most 11 variables with a statistically significant difference across the three experimental arms. Indeed, only 7 variables have a p-value below 0.05. This result confirms the validity of the randomization exercise.

[9] Suppose we have three null hypotheses, all of which are true. When the null hypothesis is true, but we nevertheless reject it in favour of some alternative, we commit a Type I error. If we set *alpha* (the Type I error rate) to be 0.05, we have a [$1-(1-0.05)^3=14.21-(1-0.05)^3=14.2$] chance of rejecting at least one of them.

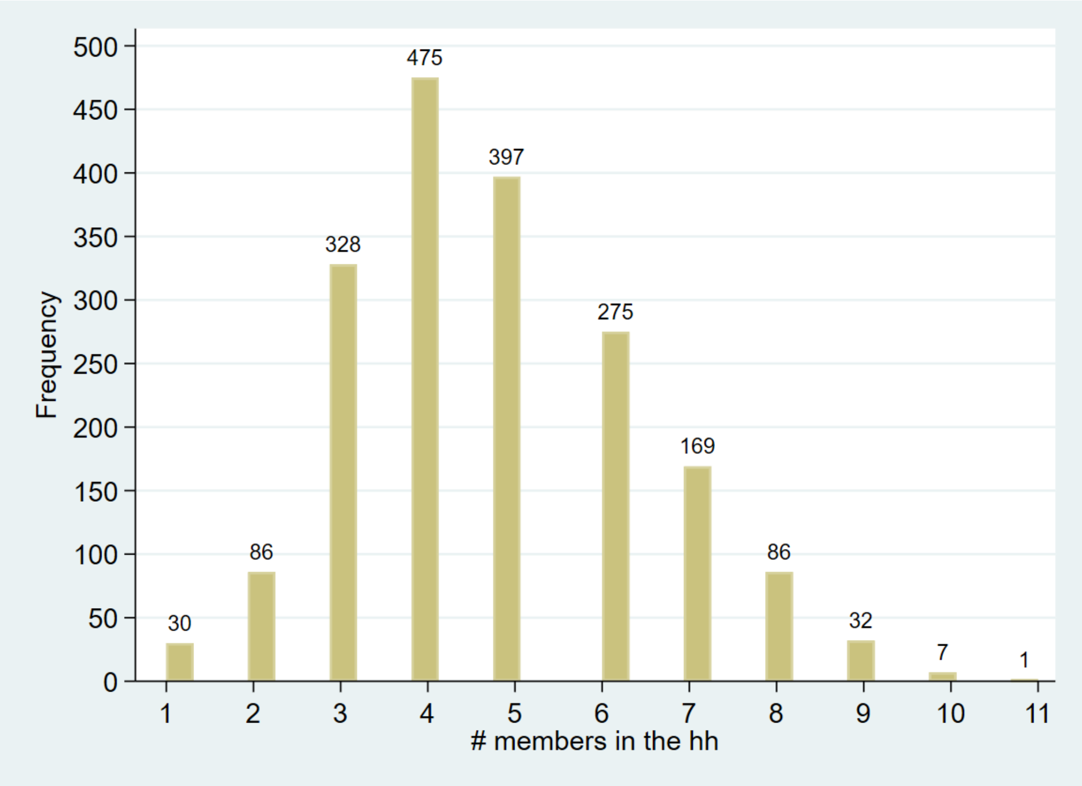
[10] The procedure behind the Holm-Sidak test is to first find all of the p-values for all of the individual tests we were performing and then rank them from smallest to largest. We compare the smallest to $\alpha=\alpha_T/k$ where α_T is the Type I error rate. If we fail to reject the null hypothesis for the first step, then we stop here. If we reject it, then we compare the next smallest to $\alpha=\alpha_T/(k-1)$. Again, we stop here if we fail to reject the null hypothesis; if we do reject it, we continue on and use $\alpha=\alpha_T/(k-2)$.

have found a p-value below 0.05. Applying the Holm-Sidak correction reduces the number of significant differences to 82, which still represents quite a significant imbalance. Similarly, if we analyse the difference between the T2 and the C groups, we obtain 116 unadjusted and 72 Holm-Sidak-adjusted p-values below 0.05 respectively. This tells us that the T2 group is slightly more similar to the comparison group than the overall FFS households in terms of the considered baseline characteristics, though there are still several differences across the two groups that need to be taken into account at follow-up in the impact analysis.

Demographics

The sample contains 1 886 households, with 1 333 in the three experimental groups and 553 in the comparison group. The median household size is five people, with a standard deviation of 1.69 for the average size of 4.75 persons per household. The distribution of households by size is presented in Figure 2, where we can observe that the majority of households is comprised of three to seven members.

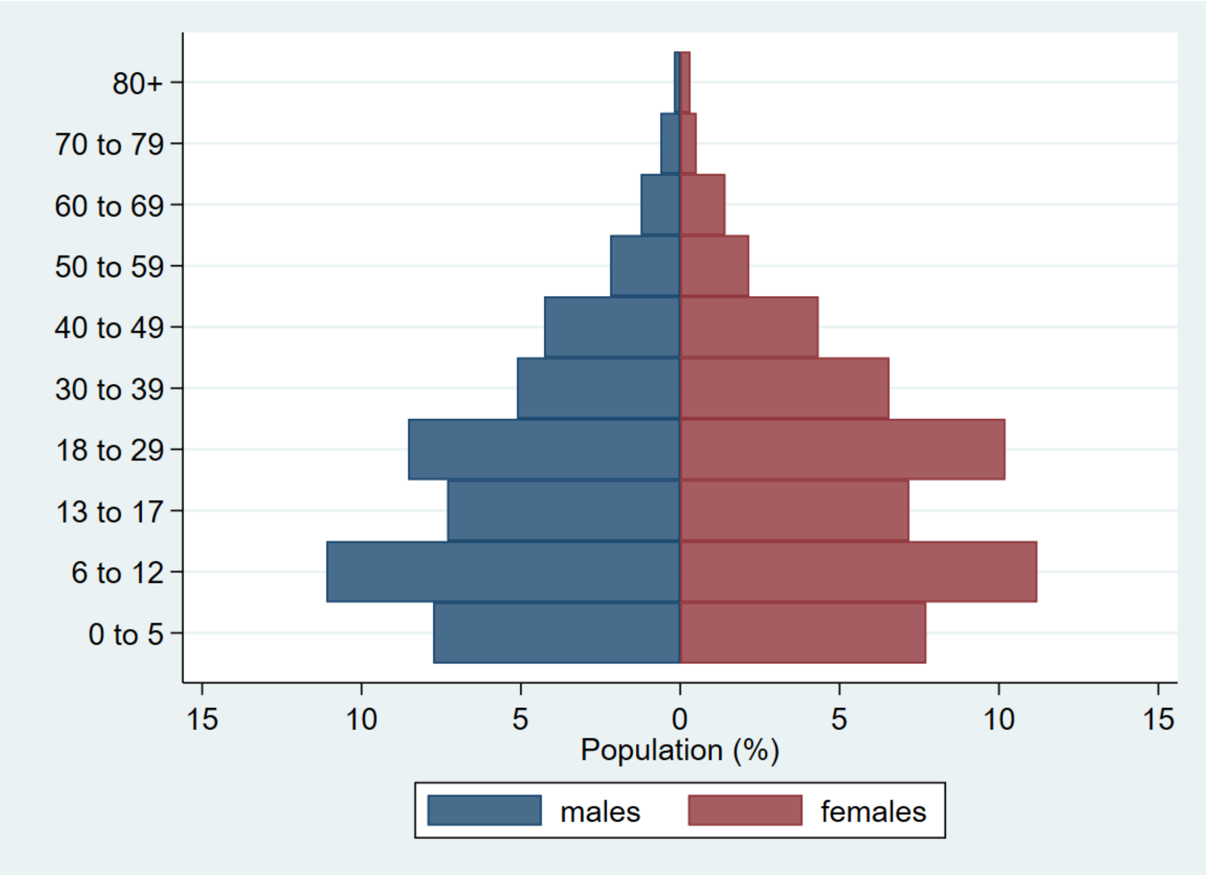
Figure 2. Household size distribution



Source: Authors' elaboration from survey data.

Figure 3 shows the distribution by age and gender of the evaluation sample. There are a couple of features worth mentioning concerning the demographic distribution of these households. First, there is a very slight majority of women sampled for the study, especially in the age groups 18–29 and 30–39. Second is the presence of a relatively large share of people in working age and a minor share of elderly people. This is indicative of successful targeting made for the FFS, which focused on both men and women with labour capacity.

Figure 3. Sample distribution by age and gender



Source: Authors' elaboration from survey data.

The availability of Table 3, in which we show the mean socio-demographic characteristics by treatment group. Households in the FFS groups have on average 2.1 adult members (1 male and 1.1 females), with similar figures reported by the comparison group, though we observe a statistical difference between the FFS and the C groups for the number of female members 18–59. The number of children does not differ statistically across treatment groups, irrespectively of the age range. Further, the shares of elderly and disabled members are relatively small. With respect to household headship, 64.7 percent of households are headed by a woman, of almost 40 years of age, 73.9 percent of them being married and with about six years of schooling. Only one third of the sample of heads have at least completed primary school.

From a statistical point of view, the three experimental groups are very balanced in terms of all demographic characteristics, except the indicator of the head being married, with a p-value of 0.018 due to the relatively higher share of married heads in the T2 group. Three statistical differences out of 15 indicators are found between the overall FFS or the T2 group and the comparison group, though the magnitude of these differences is relatively small. Overall, it seems that the sample selected for the comparison group is broadly similar to the households participating in the FFS activities, at least from the angle of socio-demographic variables.

One of the objectives of the FFS approach developed through the FAO FMM project is to reach social protection beneficiaries, with the idea of stimulating cross-sectoral synergies. During the targeting process of the project, special effort was given to coordinate with local leaders and village committees to identify beneficiaries of the SCTP and of other important interventions, such as the recently discontinued MASAF Public Works Programme. However, if we look at the population pyramid of the SCTP eligible households as shown in the baseline SCTP impact evaluation report by Handa *et al.* (2014), the age structure of our sample seems quite different in many aspects. In fact, SCTP households have a much larger share of women and are characterized by higher dependency ratios, driven by the larger proportion of elderly members and a lower proportion of young adults. Further SCTP household heads are overwhelmingly women (83 percent), with an average 58 years of age, a large share of them being widows (43 percent) and a minor share being married (29 percent). Our sample is instead generally much more similar to the national rural ultra-poor population, both in terms of demographic composition and characteristic of the head (Handa *et al.,* 2014).

Table 3. Average household characteristics by treatment group

	All	T1	T2	T3	F-test	p-value	FFS	C	FFS-C	p-val FFS-C	T2-C	p-val T2-C
# members in the hh	4.8	4.7	4.8	4.9	0.48	0.621	4.8	4.7	0.1	0.130	0.1	0.165
# hh members 0–5 yrs	0.7	0.7	0.8	0.7	0.14	0.873	0.7	0.7	0.0	0.928	0.0	0.779
# hh members 6–12 yrs	1.1	1.0	1.0	1.1	0.60	0.550	1.0	1.1	0.0	0.415	-0.1	0.234
# hh members 13–17 yrs	0.7	0.7	0.7	0.7	0.59	0.559	0.7	0.7	0.0	0.416	0.0	0.552
# male hh members 18–59 yrs	1.0	1.0	1.0	1.0	1.09	0.341	1.0	0.9	0.1	0.008	0.1	0.001
# female hh members 18–59 yrs	1.1	1.1	1.1	1.1	1.90	0.156	1.1	1.1	0.0	0.520	0.1	0.126
# hh members 60+ yrs	0.2	0.2	0.2	0.2	2.61	0.080	0.2	0.2	0.0	0.451	0.0	0.394
female headed hh	0.647	0.626	0.639	0.670	1.21	0.304	0.645	0.651	-0.006	0.809	-0.012	0.691
head of hh age	39.6	40.9	37.7	39.9	2.64	0.078	39.5	39.7	-0.2	0.727	-2.0	0.015
head of hh married	0.739	0.709	0.794	0.718	4.22	0.018	0.741	0.734	0.007	0.753	0.060	0.026
head of hh widow	0.099	0.119	0.072	0.102	2.22	0.115	0.098	0.101	-0.004	0.804	-0.029	0.105
# disabled hh members	0.1	0.1	0.2	0.2	0.55	0.582	0.2	0.1	0.0	0.034	0.0	0.125
head of hh yrs of education	5.9	6.2	6.0	5.9	0.48	0.622	6.1	5.6	0.4	0.019	0.3	0.137
highest yrs of education in hh	8.2	8.4	8.3	8.3	0.07	0.934	8.3	8.1	0.2	0.106	0.2	0.329
head of hh completed primary school	0.330	0.358	0.341	0.323	0.33	0.718	0.341	0.304	0.037	0.122	0.038	0.203

Note: FFS=farmer field school group; C=comparison group; T1=FFS only group; T2=FFS+inputs' transfer group; T3=FFS+cash group. HH stands for household, yrs for years.

Source: Authors' elaboration from survey data.

Main outcome variables

In this section we describe a list of indicators that corresponds to the goal and outcomes included in the FMM programme's log frame. This will allow to assess the programme against its main stated objectives, namely: income diversification, crop diversification, climate-adaptive agricultural practices, food security, climate information and coping strategies. This array of indicators further underscores the substantial complexity involved in designing and implementing the survey instrument, since the effects of the FFS approach and complementary cash transfer and inputs' transfers could occur across a range of domains. However, many of these outcomes are multidimensional concepts and many indicators can be used to measure them. Testing the relationship between the FMM programme and each of these indicators can be problematic for two reasons: a) testing many relationships at the same time may suffer from multiple comparison problem (see section 4.1); b) it does not allow the researcher to make broader statements about the effects of the programme on a specific outcome area.

For these reasons, we decided to consider for the main outcome variables a summary index approach, which allows to accommodate a single hypothesis test, while at the same time facilitating generalized findings about the programme's effectiveness. The main criticism related to the summary index approach is that these indexes are a "black box," as they fail to unpack programme's mechanisms (Schwab *et al.*, 2020). However, using this approach does not prevent researchers from getting deeper into the details, reporting and discussing the individual indicators. This is what the most recent development literature has been doing, disentangling the summary index findings (Haushofer and Shapiro, 2016; Janzen *et al.*, 2018; Bandiera *et al.*, 2020). In this section of the baseline study, we will show the balance for the summary indexes, while their single components will be discussed in separate sections.

We calculate summary indexes by adopting the standardized weighted mean approach of Anderson (2008), where we use the comparison group as the default reference group for the standardization.[11] These standardized summary indexes *à la Anderson* do not have a specific meaning as they merely reflect deviations from the comparison group and can be thus interpreted as effect sizes.

To summarize, we compute the following index variables:

i) The income diversification index is a standardized weighted average of the (positively coded) number of income sources, a Simpson index of income concentration (Simpson, 1949) and a Shannon index of income diversity (Shannon and Weaver, 1948).
ii) The crop diversification index is a standardized weighted average of the (positively coded) number of crops planted, a Simpson index of farmland distribution and a Shannon index of farmland diversity by crop.[12]
iii) The agricultural practices index is a standardized weighted average of the following indicators: share of farmland under crop rotation, share of farmland with crop residue used to cover land, share of farmland where zero/minimum tillage is practiced, share of farmland where two or more crops have been intercropped in the same plot, dummy variables for whether any water conservation structure has been applied, trees have been planted on farmland, land has been irrigated, manure has been used, land was left fallow for more than one year in the last five years and finally avoided use of pesticides.
iv) The food security index is a standardized weighted average of the (negatively coded) indicators for whether during the last 12 months there was a time when, because of lack of money or resources, the main respondent: was worried about not having enough food to eat, was unable to eat healthy and nutritious food, ate only a few kinds of foods, had to skip a meal, ate less than they thought they should, thought their household ran out of food, was hungry but did not eat, went without eating for a whole day; and the (positively coded) number of meals, including breakfast, eaten per day by

[11] See Schwab *et al.* (2020) for a detailed step-by-step guide to construct such summary indexes à la Anderson.

[12] Simpson and Shannon indexes for income and crop diversity are explained in greater details in their corresponding sections.

the household members, the number of months the maize from the previous year harvest lasted, the number of months the maize currently in the grainery is expected to last.

v) The climate information index is a standardized weighted average of the (positively coded) indicators for whether the household received information on sudden catastrophes, slow-onset disasters, pest/disease outbreak, timing of rains, weather forecasts for the next three days and weather forecasts for the next three months.

vi) The coping strategies index is a standardized weighted average of the (negatively coded) indicators for household level ex-post adaptation mechanisms (after the occurrence of climatic shock): children's migration, changes in food consumption habits (relying on less preferred food, reducing the proportion or number of meals per day, etc.), reduction of health and/or education expenditures, and sale of household assets, and the (positively coded) indicators for the following farm-level adaptation strategies after forecast of weather shocks: change in cropping pattern, improved seeds adoption, change in sowing date, increased use of organic compost, increased use of chemical fertilizers, investment in irrigation, greater crops diversification, weather insurance.

In Table 4 we describe the main outcome variables by treatment group. Because the summary indexes are standardized relatively to the comparison group, the comparison group mean equals to zero (and the unreported standard deviation is equal to one). While the reported mean values do not have an immediate interpretation, a positive (negative) sign is indicative of larger (smaller) values of the index relative to the comparison group.

So, for instance, the summary index of income diversification of the overall FFS group equals 0.28, this means that this index is 0.28 standard deviations (SD) larger than in the comparison group. While the three experimental groups are perfectly balanced with respect to all the summary indexes, we find imbalances across the board when comparing the comparison group with either the overall FFS group or the T2 group only. The only summary index which does not show a statistically significant difference is the summary index of agricultural practices (0.05 SD). Finally, the only summary index where the comparison group has better outcomes to the FFS and the T2 groups is the index of climate information, indicating that households in the C group have been exposed to more information related to severe climate events.

Table 4. Main programme outcomes by treatment group

	All	T1	T2	T3	F-test	p-value	FFS	C	FFS-C	p-val FFS-C	T2-C	p-val T2-C
Summary index of income diversification	0.20	0.39	0.19	0.26	1.85	0.165	0.28	0.00	0.28	0.00	0.19	0.00
Summary index of crop diversification	0.27	0.34	0.35	0.44	0.90	0.413	0.38	0.00	0.38	0.00	0.35	0.00
Summary index of agricultural practices	0.03	-0.03	0.09	0.08	0.85	0.431	0.05	0.00	0.05	0.27	0.09	0.13
Summary index of food security	0.39	0.54	0.60	0.51	0.30	0.742	0.55	0.00	0.55	0.00	0.60	0.00
Summary index of climate information	-0.15	-0.12	-0.29	-0.21	1.38	0.259	-0.21	0.00	-0.21	0.00	-0.29	0.00
Summary index of coping strategies	0.14	0.15	0.15	0.28	1.20	0.307	0.19	0.00	0.19	0.00	0.15	0.02

Note: FFS=farmer field school group; C=comparison group; T1=FFS only group; T2=FFS+inputs' transfer group; T3=FFS+cash group.
Source: Authors' elaboration from survey data.

Transfers

In Table 5 we provide descriptive evidence concerning the economic support received by the households in the 12 months prior to the survey. Overall, 89.7 percent of households received any transfer, with the FFS group benefitting slightly more than the comparison group (91 vs 86.6 percent). This statistical significant difference is led primarily by public transfers (3.9 percentage points difference) and to a less extent by private transfers (1.6 percentage points difference), which include both remittances from abroad and cash and in-kind transfers from within the community. The three experimental groups overall are very well balanced, with only one variable out of 14 showing a p-value of the F-test below 5 percent. The size of the overall transfers received by the sample households is quite small indeed. At November 2021 average exchange rate of 802 MWK per USD, the transfers are equivalent to around USD 29. Further, if we consider the latest figure from 19/20 LSMS survey, the national food poverty line, which marks ultra-poverty, stands at MWK 101 293 per capita.

Among public transfers, a large share of sample households' benefit from AIP (74 percent) and the School Meals Feeding (SMF) programme (58.3 percent). Interestingly, for the former programme, there is a slight imbalance in both the proportion of beneficiary households and in the value of redeemed vouchers between FFS and comparison groups, while the proportion benefitting from SMF and the equivalent value of the food rations are almost perfectly balanced. Another interesting statistic concerns cash transfers, since both the FFS and the comparison groups report relatively low benefits, both at the extensive and intensive margin. In fact, only 4.8 percent of sampled households reported receiving a cash transfer and the difference between the two main groups is negligible and statistically not significant.[13] Further, only 7 percent households reported benefitting from in-kind transfers such as food aid. Cirillo, Györi and Veras-Soares (2017) suggest that targeting could be an important aspect to promote synergies between social protection and agricultural/rural development

[13] The cash transfers aggregate include the SCTP, the Old Age pension and any other cash disbursements received either conditionally or unconditionally. The SCTP makes up approximately 60 percent of the beneficiaries of the overall aggregate.

interventions. However, we may expect SP and agricultural programmes to bring about synergies at the individual/household level only if both types of intervention target the same individuals. This does not seem to be the case in our sample, given the low proportion of beneficiaries of cash and in-kind programmes, which reflects the low coverage rate of the SCTP in the two districts targeted by the FMM project.[14] Unfortunately in this study we will not be able to test synergies at the local economy level, due to the lack of a sample on ineligible households.

[14] According to the Ministry of Gender, Children and Community Development, the number of households covered by the SCTP is 1 887 in Mwanza and 2 018 in Neno. (https://mtukula.com/content?view=9&pageName=Recipient%20Households)

Table 5. Public and private transfers received by treatment group

	All	T1	T2	T3	F-test	p-value	FFS	C	FFS-C	p-val FFS-C	T2-C	p-val T2-C
hh received transfers	0.897	0.911	0.915	0.905	0.06	0.945	0.910	0.866	0.044	0.004	0.048	0.015
value of transfers received, MWK	23 118	23 994	23 318	25 527	0.21	0.813	24 268	20 346	3921	0.040	2 971	0.205
hh received private transfers	0.094	0.085	0.114	0.098	0.63	0.538	0.099	0.083	0.016	0.284	0.031	0.102
value of private transfers received, MWK	4 465	3 431	6 447	3 748	0.85	0.431	4 570	4 214	356	0.815	2 234	0.284
hh received public transfers	0.883	0.897	0.897	0.889	0.04	0.964	0.894	0.855	0.039	0.017	0.042	0.046
value of public transfers received, MWK	18 653	20 563	16 870	21 779	2.56	0.084	19 698	16 133	3565	0.002	737	0.473
hh received SMF programme	0.583	0.562	0.595	0.600	0.36	0.699	0.586	0.575	0.011	0.664	0.020	0.518
value of SMF received, MWK	7 055	6 745	6 438	8 404	0.91	0.407	7 187	6 736	452	0.493	-297	0.665
hh received AIP	0.741	0.761	0.764	0.750	0.03	0.966	0.758	0.698	0.060	0.006	0.066	0.020
value of AIP received, MWK	8 070	8,866	8 660	8 011	0.77	0.466	8 513	7 004	1509	0.000	1 656	0.000
hh received cash transfers	0.048	0.062	0.039	0.050	0.60	0.553	0.050	0.042	0.009	0.422	-0.002	0.860
value of cash transfers received, MWK	2 704	3 601	1 057	4 332	4.01	0.022	2 970	2 063	907	0.267	-1 006	0.104
hh received in-kind transfers	0.073	0.101	0.083	0.095	0.13	0.878	0.093	0.024	0.070	0.000	0.060	0.000
value of in-kind transfers received, MWK	630	887	706	718	0.15	0.861	769	295	474	0.002	411	0.036

Note*:* FFS=farmer field school group; C=comparison group; T1=FFS only group; T2=FFS+inputs' transfer group; T3=FFS+cash group. HH: household, MWK: Malawian Kwacha; SMF: school meals feeding; AIP: Affordable Input Programme.
Source: Authors' elaboration from survey data.

Income sources and diversification

This section provides insights on summary index of income diversification components along with the sources of income for the sample studied.

As mentioned in section 4.3, the summary index of income diversification is a standardized weighted average of the number of income sources and of both a Simpson and Shannon index of income diversity/concentration. In this study we consider the following labour and non-labour income sources: crop production, vegetables production, fruits production, livestock production, livestock-by-products, non-farm businesses, sales of forest products, private transfers, which includes both remittances from abroad and within the community/village, public transfers, and off-farm wage income. The general formula of a Simpson index is the following:

$$Simpson = 1 - \sum_{i=1}^{I} sh_i^2 \qquad (1)$$

where sh_i is the income share of source *i*, calculated over total household gross income. The Simpson index ranges between zero and one; a value of zero implies that the household relies only on one income source while a value closer to one reflects a more even distribution of income by source.

The general formula of a Shannon index is instead:

$$Shannon = -\sum_{i=1}^{I} sh_i \log(sh_i) \qquad (2)$$

Where again sh_i is the income share of source *i*. Values for the Shannon index can range from zero to the value of the log of the highest number of income sources of the household. The Shannon index ranges from 0, which flags households relying on one income source only, to a maximum of log I (when all shares equal 1/n). Considered together the Simpson and Shannon identify the distribution or “evenness of income” by source. In so doing, they add granularity to the number of income sources, which captures only the raw diversity of livelihoods.

Table 6 provides an overview of the indexes mentioned above and all the sources of income of the households, including the total gross and the agricultural gross monetary income in MWK. For each income source, we provide the share of households and the average earnings. Since groups T1, T2 and T3 have approximately the same values across all the variables, the tables from the report from this section will present only the mean of the FFS group overall, without distinguishing for each group of the sample. Overall, the income sources for the sample are slightly less than 4 for households, however, there are imbalances between the groups. The FFS group has an average above 4 instead the comparison group has approximately 3.45 sources of income. Income diversification is slightly better for the FFS groups, having a higher Simpson and Shannon indexes of diversification. There are less differences comparing T2 vs C, having the pairwise tests accepting both the hypothesis of equal diversification. Regarding the most common income sources, almost all the sample is involved in agriculture but the FFS is producing more harvest and selling more vegetables and fruits than comparison households. On the contrary, the comparison group relies more on livestock sales and non-timber products. Interestingly, even if the comparison households are more likely to be involved in wage labour, the FFS group has a higher average wage.

Table 6. Sources of income by treatment group

	All	FFS	C	FFS-C	p-val FFS-C	T2-C	p-val T2-C
Summary index of income diversification	0.20	0.28	0.00	0.28	0.000	0.19	0.005
Simpson income diversity index	0.48	0.48	0.47	0.01	0.493	-0.02	0.138
Shannon income diversity index	0.86	0.88	0.83	0.05	0.007	0.01	0.799
# income sources	3.93	4.14	3.44	0.70	0.000	0.67	0.000
hh gross income, MWK	1 899 897	2 490 220	476 931	2 013 289	0.185	1 191 649	0.078
hh agricultural gross income, MWK	181 245	210 938	109 670	101 269	0.000	93 165	0.000
hh has crop production	0.986	0.985	0.987	-0.002	0.696	0.000	0.947
total value of harvest	134 753	158 514	77 476	81 038	0.000	69 744	0.000
hh has vegetable sales	0.359	0.431	0.188	0.243	0.000	0.239	0.000
value of vegetable sales	14 342	18 284	4 838	13 446	0.000	15 141	0.000
hh has fruit sales	0.312	0.406	0.085	0.321	0.000	0.302	0.000
value of fruits sales	11 119	15 398	804	14 595	0.000	12 436	0.000
hh has livestock sales	0.243	0.241	0.248	-0.007	0.750	0.000	0.986
value of livestock sales, MKW	1 7218	1 6049	20 035	-3986	0.440	486	0.948
hh has livestock by product sales	0.065	0.079	0.033	0.046	0.000	0.029	0.029
value of livestock by-products sales, MKW	1050	1225	627	598	0.499	95	0.818
hh has livestock by revenues by non-farm business	0.230	0.264	0.146	0.118	0.000	0.136	0.000
non-farm business revenues last 12 months, MKW	13 4013	15 7018	78 558	78 460	0.035	165 334	0.005
hh has non-timber forest products sales	0.062	0.055	0.080	-0.025	0.042	-0.031	0.044
value of sales of non-timber forest products, MKW	2 763	1 467	5 889	-4 422.04	0.000	-4 736	0.004
hh has at least a member with a wage work	0.695	0.681	0.729	-0.048	0.041	-0.072	0.013
hh total annual wage, MKW	1 561 521	2 097 995	268 356	1 829 639	0.228	93 0178	0.167
hh received private transfers	0.094	0.099	0.083	0.016	0.284	0.031	0.102
value of private transfers received, MKW	4 465	4 570	4 214	356	0.815	2 234	0.284
hh received public transfers	0.883	0.894	0.855	0.039	0.017	0.042	0.046
value of public transfers received, MKW	18 653	19 698	16 133	3 565	0.002	737	0.473

***Note**:* FFS=farmer field school group; C=comparison group; T2=FFS+inputs' transfer group; MWK=Malawian Kwacha; NTFP: non-timber forest products; hh: household.
Source: Authors' elaboration from survey data.

Crop production and diversification

Agriculture is the first source of income for rural households in Malawi, contributing to the national economy with approximately 30 percent of the gross domestic product (GoM, 2021).

Table 7 shows the share of crop growers by crops, the indexes of crop diversification, and the yields for the two main crops (maize and pigeon pea). Regardless of the treatment arm, all households cultivate maize. Pigeon pea is the second most widely spread crop (49 percent), though we observe a statistically significant difference between the share of farmers cultivating it in the FFS group (61 percent) and the comparison group (20 percent). Beans are cultivated by 10 percent of the farmers included in our sample, though the overwhelming majority of them is part of the FFS arms. Other minor cultivations reported by the survey respondents are Irish potato, cowpea, and sorghum. While the former crop is concentrated among FFS (7 percent), the latter two crops are exclusively grown by farmers in the comparison group (16 and 10 percent respectively). Maize and pigeon pea yields are significantly lower in the comparison group, with the pairwise tests rejecting the null hypothesis of zero differences in yields for both crops. However, the FFS group yields of maize are 1 433 kg/ha, which are much lower compared to the national average of 2 208 kg/ha.[15]

Crop diversification is an important strategy to increase food security, healthy diets and to reduce land degradation (FAO, 2012). The Simpson index of crop diversification is the one's complement to the algebraic average of the squared shares of cultivated land with the following crops: maize, pigeon peas, beans, groundnuts, Irish potatoes, cow peas, sweet potatoes, cassava, sorghum, sugar cane, peas, cotton, other cereals, other legumes, and a residual category of other crops. The Shannon index is the one's complement to the algebraic average of the variable multiplied with the log of shares of cultivated land same variables of the Simpson crop diversity index. Finally, we added the average number of crops planted for households. The FFS group present a larger crop diversification compared to the comparison group, having both Shannon and Simpson index significantly higher relative to the comparison group.

[15] https://tradingeconomics.com/malawi/maize-yield-kg-per-hectare-wb-data.html

Table 7. Crop diversification and crop production

	All	FFS	C	FFS-C	p-val FFS-C	T2-C	p-val T2-C
Summary index of crop diversification	0.27	0.38	0.00	0.38	0.000	0.35	0.000
Simpson crop diversity index	0.34	0.38	0.24	0.14	0.000	0.13	0.000
Shannon crop diversity index	0.51	0.57	0.37	0.20	0.000	0.19	0.000
# crops planted	1.95	2.03	1.74	0.29	0.000	0.25	0.000
hh cultivates…							
maize	1.00	1.00	1.00	0.00	0.363	0.00	
pigeon pea	0.49	0.61	0.20	0.41	0.000	0.36	0.000
beans	0.10	0.14	0.01	0.12	0.000	0.13	0.000
groundnut	0.07	0.06	0.11	-0.04	0.001	-0.05	0.002
irish potato	0.05	0.07	0.00	0.07	0.000	0.09	0.000
cow pea	0.05	0.00	0.16	-0.16	0.000	-0.16	0.000
sorghum	0.03	0.00	0.10	-0.10	0.000	-0.10	0.000
yield maize, kg/ha	1433	1651	809	842	0.000	720	0.000
yield pigeon pea, kg/ha	546	640	184	457	0.000	222	0.000

***Note**:* FFS=farmer field school group; C=comparison group; T1=FFS only group; T2=FFS+inputs' transfer group; T3=FFS+cash group.
Source: Authors' elaboration from survey data.

Land management and agricultural practices

Table 8 summarizes the principal characteristics of plots operated by households in the sample interviewed. Overall, households in the study area own less than two plots (1.69 on average), with the comparison group owning a smaller number of plots than both the FFS group and the T2 group. Most of the cultivated land is owned, with very little land operated by the households using other arrangements (less than 0.1 acres of land rented in for cultivation). Comparison households are more likely to leave land fallow in the last 5 years, both as operated land size (0.11 acres) and as a share of total cultivated land (3 percentage points) compared to the FFS group. However, these differences are respectively weakly significant and not statistically significant when the pairwise test involves the T2 group rather than the full FFS group.

Regarding crop residues, 44 percent of the sample studied uses residues to cover the land and 40 percent to produce composting. A smaller proportion of 25 percent of farmers decided to burn or remove residues in the season prior to the survey. Zero/minimum tillage techniques are scarcely adopted by the farmers overall (9 percent), but it is adopted by a larger share in the comparison households (16 vs. 10 percent). The most common practice to prepare land is ridging, used by 94 percent of the overall sample, though statistically significant differences exist between the FFS and the comparison group in terms of both the share of farmers adopting ridging (98 vs 84 percent) and the amount of land under ridging (2.2 vs. 1.75 acres). The use of both basal and top-dressing fertilizers is high across all the groups, though we observe statistically significant differences in favor of the FFS experimental arms both at the extensive and intensive margins. Manure is used by almost half of the sample, even though the comparison group has a slightly higher percentage of farmers using it.

Erosion is an important aspect to observe in the surveyed households, as adopting soil conservation practices is one of the project's primary goals. Most farmers operate on land under low levels of erosion; however, a large share of farmers, 31 percent, have medium or even high erosion in the operated land. Households from the FFS groups suffer significantly more from erosion phenomena in their land than the comparison group.

Table 8. Land management

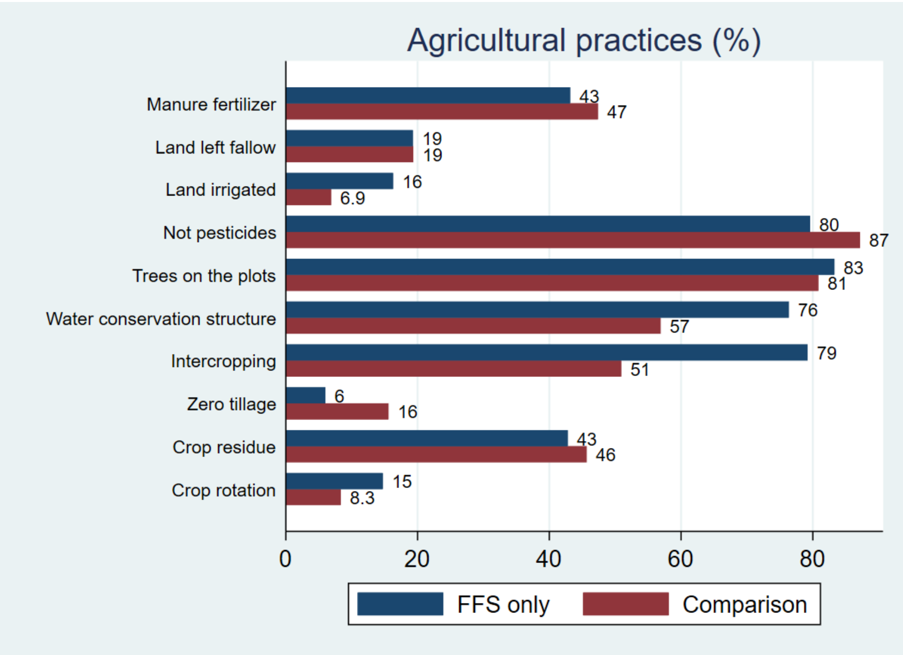
	All	FFS	C	FFS-C	p-val FFS-C	T2-C	p-val T2-C
# plots owned/cultivated	1.69	1.81	1.41	0.41	0.000	0.49	0.000
land area owned for crop cultivation, ac	2.18	2.25	2.03	0.22	0.006	0.23	0.016
land area operated for crop cultivation, ac	2.26	2.32	2.11	0.22	0.006	0.24	0.011
land area rented in for crop cultivation, ac	0.08	0.08	0.08	0.00	0.975	0.01	0.662
land area rented out for crop cultivation, ac	0.00	0.00	0.00	0.00	0.269	0.00	
land area left fallow, ac	0.34	0.31	0.42	-0.11	0.020	-0.12	0.048
% operated land area left fallow	0.14	0.13	0.16	-0.03	0.044	-0.03	0.165
land area operated and irrigated, ac	0.18	0.22	0.09	0.13	0.000	0.16	0.000
% operated land area that is irrigated	0.08	0.09	0.04	0.05	0.000	0.06	0.000
hh uses crop residue to cover land	0.44	0.43	0.46	-0.03	0.255	-0.04	0.247
hh burns/removes crop residue	0.25	0.23	0.28	-0.05	0.013	-0.09	0.001
hh uses crop residue to produce composting	0.40	0.44	0.31	0.13	0.000	0.16	0.000
hh prepares land with zero/minimum tillage	0.09	0.06	0.16	-0.10	0.000	-0.10	0.000
land area prepared with minimum/zero tillage, ac	0.12	0.07	0.25	-0.18	0.000	-0.16	0.000
hh prepared land with ridging	0.94	0.98	0.84	0.14	0.000	0.15	0.000
land area prepared with ridging, ac	2.09	2.22	1.75	0.47	0.000	0.50	0.000
hh adopts crop rotation	0.13	0.15	0.08	0.06	0.000	0.08	0.000
land area subject to crop rotation, ac	0.18	0.20	0.13	0.06	0.038	0.12	0.002
hh used basal fertilizer	0.93	0.98	0.82	0.15	0.000	0.16	0.000
basal fertilizer used, kg	85	100	48	52	0.000	51	0.000
hh used top-dressing fertilizer	0.93	0.97	0.84	0.13	0.000	0.13	0.000
top-dressing fertilizer used, kg	86	102	50	52	0.000	50	0.000
hh used manure fertilizer	0.44	0.43	0.47	-0.04	0.094	-0.04	0.175
land area operated under low erosion, ac	1.56	1.57	1.53	0.04	0.615	-0.01	0.886
% operated land area under low erosion	0.69	0.67	0.73	-0.06	0.007	-0.11	0.000
land area operated under high erosion, ac	0.70	0.76	0.58	0.18	0.005	0.25	0.001
% operated land area under medium/high erosion	0.31	0.33	0.27	0.06	0.007	0.11	0.000

***Note**:* FFS=farmer field school group; C=comparison group; T1=FFS only group; T2=FFS+inputs' transfer group; T3=FFS+cash group. AC: acres. Indicators on land left fallow refer to practice adopted more than one year in the last 5 years.
Source: Authors' elaboration from survey data.

One of the FMM project's objectives is to integrate CSA practices with DRR management to prevent climate's long-lasting impact. The critical aspect of this methodology is to address the causes of vulnerability while reducing exposure to future shocks. We identify the sample's adoption of CSA practices, by looking at the following ten agricultural practices:[16] land left fallow, plot irrigated, residue usage to cover the land, prepared the land with minimum tillage, used manure fertilizer, not used pesticides, crop rotation, intercropping, planted trees on operated land, and applied water conservation structure.

In Figure 4, we compare the adoption of the practices by the FFS and comparison groups. The most adopted practices by the sample are planting trees on the plot, with a rate of 83 percent of adoption, and not using pesticides, with a rate of 82 percent of adoption. The FSS households are also widely implementing intercropping and water conservation structures on their plots. Those practices are less used by the comparison households but they still present consistent percentage. The least adopted practices are minimum tillage (particularly for the FFS group with only a rate of 6 percent), crop rotation and irrigation (particularly for the comparison group, with rates of 8 and 7 percent, respectively).

Figure 4. Agricultural practices



Note: FFS: farmer field school.
Source: Authors' elaboration from survey data.

[16] For each agricultural practice, the household is considered adopting the method if implemented in at least one plot.

Food security

Malawi's population is currently facing high levels of food security. More than 1 million people are experiencing acute food insecurity, classifying in the third phase in the Integrated Food Security Phase Classification (IPC), and over 3 million people are classified in phase 2, mild level of food insecurity. In detail, the districts of the surveyed households, Neno and Mwanza, experienced climate events such as dry spells and sporadic rains, leading to lower production and increasing food insecurity, classifying as phase 2 in the IPC scale (IPC, 2021). The food security domain is primarily analysed through the Food Insecurity Experience Scale (FIES), an experience-based measure of household or individual food security, consisting of eight questions regarding people's access to adequate food (Ballard *et al.*, 2013). The FIES raw score goes from zero (food security) to eight (severe food insecurity).

Table 9 shows the summary statistics for food security. Overall, the sample has a high level of food insecurity. The average FIES raw score is 5.58, and it is statistically significantly higher in comparison households, reaching a 6.1 average score. The FIES methodology consists of a statistical model that assigns the probability to a household to be moderate or severe food insecure. According to this model, 75 percent of the sample is likely to experience at least moderate food insecurity, and 38 percent can even reach severe food insecurity. The comparison households are more likely to face food insecurity in both categories than the FFS group households. Similar results occur with the other three metrics used to measure food insecurity, i.e. the number of meals per day taken by the household, the number of months the maize harvested in the previous year lasted and the number of months the maize currently stored in the granary is expected to last. For all these indicators, households in the comparison group consistently report average worse outcomes than households in the FFS/T2 group.

Table 9. Food security by treatment group

	All	FFS	C	FFS-C	p-val FFS-C	T2-C	p-val T2-C
Summary index of food security	0.39	0.55	0.00	0.55	0.00	0.60	0.00
raw FIES score	5.58	5.36	6.10	-0.74	0.00	-0.80	0.00
number of meals take per day in the HH	2.42	2.47	2.31	0.17	0.00	0.18	0.00
months maize harvest lasted in the last year	8.26	8.86	6.82	2.05	0.00	2.11	0.00
months will last maize currently in the granary	6.97	7.65	5.35	2.29	0.00	2.10	0.00
FIES: prob(moderate + severe)	0.75	0.72	0.81	-0.09	0.00	-0.09	0.00
FIES: prob(severe)	0.32	0.30	0.38	-0.08	0.00	-0.11	0.00

Note*:* FFS=farmer field school group; C=comparison group; T1=FFS only group; T2=FFS+inputs' transfer group; T3=FFS+cash group. FIES: Food Insecurity Experience Scale; hh: household.
Source: Authors' elaboration from survey data.

Access to information

Getting early information on climate is an important strategy to implement prompt actions, provide support, and build resilience before future shocks occur (FAO, 2020). Table 10 shows the summary statistics of the information provided to households on sudden catastrophes, slow-onset disasters, pest outbreaks, rains, and weather forecasts. On average, sample households got access to adequate information related to various types of shocks and climate. In fact, while the survey instruments asked about six types of potential shocks, on average households received 3.7 types of information. The comparison group consistently reported greater access to information, overall and by shock type, with the information on pest outbreak being the only one with a statistically non-significant difference. The most common information provided to households is about pest outbreaks and rain. The most difficult information to receive is about the weather forecast in 2–3 months, which was provided to slightly less than half of the sample.

Table 10. Information received on weather and shocks by treatment group

	All	FFS	C	FFS-C	p-val FFS-C	T2-C	p-val T2-C
# of types of information received	3.70	3.57	4.01	-0.44	0.00	-0.61	0.00
received info about…							
sudden catastrophes	0.62	0.59	0.69	-0.10	0.00	-0.08	0.01
slow-onset disasters	0.59	0.57	0.64	-0.07	0.01	-0.09	0.00
pest outbreak	0.74	0.73	0.76	-0.03	0.23	-0.05	0.06
rains	0.71	0.68	0.78	-0.10	0.00	-0.15	0.00
weather forecasts in 2/3 days	0.54	0.52	0.60	-0.08	0.00	-0.10	0.00
weather forecasts in 2/3 months	0.49	0.47	0.54	-0.07	0.01	-0.14	0.00

***Note**:* FFS=farmer field school group; C=comparison group; T1=FFS only group; T2=FFS+inputs' transfer group; T3=FFS+cash group.
Source: Authors' elaboration from survey data.

Coping strategies

This section shows the negative coping strategies and the farm-level responses adopted by the households in the aftermath of a climate/weather shock (Table 11). Four negative coping strategies were identified in the questionnaire, which are here listed in order of rate of adoption: change in food habits (82 percent), reduction of health and education expenses (44 percent), distress sale of assets (24 percent) and finally sending children to live elsewhere (10 percent). Besides the change in food habits, we did not observe statistically significant differences for the other negative coping strategies, so that the total number of negative strategies adopted is also the same across treatment groups (1.59 and 1.63 for the FFS and the comparison groups respectively).

In the survey instrument we have also included questions concerning the farm-level response strategies adopted by households because of weather events. Among the eight potential strategies, the most widely adopted one in the sample is the change in sowing date (81 percent), followed by the adoption of improved seeds (73 percent), the change in cropping pattern (68 percent), the increased use of chemical fertilizer (55 percent) and of organic compost (50 percent). Virtually nobody adopted crop insurance. Half of these indicators show statistically significant differences between the FFS and the comparison groups, though differences are less important if we restrict to the T2 group.

Table 11. Coping strategies

	All	FFS	C	FFS-C	p-val FFS-C	T2-C	p-val T2-C
Summary index of coping strategies	0.14	0.19	0.00	0.19	0.000	0.15	0.019
# of negative coping strategies to shocks	1.60	1.59	1.63	-0.05	0.358	-0.06	0.344
because of weather shock hh…							
sent children living elsewhere	0.10	0.11	0.10	0.01	0.718	0.02	0.398
changed food habits	0.82	0.81	0.85	-0.04	0.031	-0.06	0.016
reduced health and education expenses	0.44	0.44	0.43	0.02	0.517	0.00	0.952
sold assets	0.24	0.23	0.26	-0.02	0.247	-0.02	0.557
# of farm-level coping strategies	3.82	3.94	3.55	0.39	0.000	0.24	0.056
hh farm-level strategies due to weather events:							
change in cropping pattern	0.68	0.71	0.63	0.07	0.001	0.04	0.230
improved seeds adoption	0.73	0.75	0.69	0.06	0.012	0.02	0.482
change in sowing date	0.81	0.82	0.80	0.01	0.501	0.01	0.788
increased use of org compost	0.50	0.51	0.49	0.02	0.397	-0.01	0.714
increased use of chemical fertilizer	0.55	0.59	0.48	0.11	0.000	0.09	0.006
investment in irrigation	0.25	0.27	0.20	0.07	0.001	0.07	0.008
greater diversification of crops	0.29	0.30	0.26	0.04	0.096	0.03	0.237
crop insurance	0.00	0.00	0.00	0.00	0.382	0.00	0.456

Note*:* FFS=farmer field school group; C=comparison group; T1=FFS only group; T2=FFS+inputs' transfer group; T3=FFS+cash group.
Source: Authors' elaboration from survey data.

Agroforestry

Agroforestry is defined as a system that includes both modern and traditional land management to combine together trees and crops or livestock in rural contexts. When done correctly, implementing agroforestry systems can mitigate the impact of climate events and reduce land erosion. Growing trees can promote income diversification by harvesting various products and supporting food security. It can also increase employment by bringing new opportunities for processing tree products (FAO, 2013a). Permanent trees intercropping with maize is traditionally practiced by Malawaian farmers (Garrity *et al.*, 2010). Beyond nitrogen fixing properties, local trees species such as *Faidherbia albida* shed their leaves in the rainy season, reducing competition for water and light during maize growing (Akinnifesi *et al.*, 2008). All these factors lead to maize crop productivity boost, especially in presence of approximately 20 to 30 mature crops per hectare of farmland (Kang and Akinnifesi, 2000).

To measure the adoption of agroforestry systems in the sample, we consider the following variables: the acquisition of trees, the number of trees in operated land, and the information received on agroforestry practices (Table 12). Overall, a minority of households reported purchasing trees in the 12 months prior to the survey, the main acquisition being on tree saplings (10 percent). On the other hand, a very high proportion of households reported planting new trees on their plots (83 percent) and on average 17 trees are planted on cultivated land. Regarding information received, half of the sample declared having received information on agroforestry. Most of the indicators do not show statistically significant differences across groups.

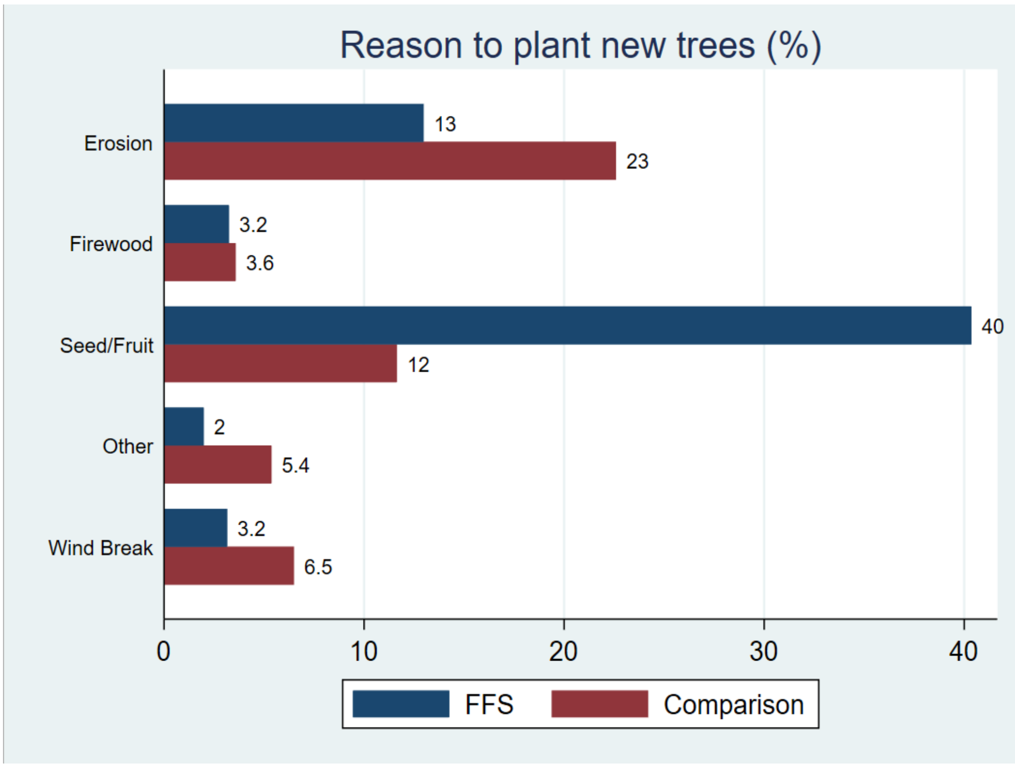
Table 12. Agroforestry

	All	FFS	C	FFS-C	p-val FFS-C	T2-C	p-val T2-C
Hh acquired…							
tree saplings	0.10	0.11	0.08	0.03	0.03	0.02	0.20
fertilizer trees	0.01	0.01	0.01	0.00	0.37	0.00	0.86
fodder trees	0.00	0.00	0.00	0.00	0.26	0.00	0.12
fruit trees	0.04	0.05	0.01	0.04	0.00	0.04	0.00
fuel wood trees	0.06	0.06	0.06	0.00	0.91	-0.02	0.18
Total expenditure on…							
tree saplings	167.4	215.9	50.5	165.5	0.10	135.0	0.14
fertilizer trees	3.7	0.0	12.5	-12.5	0.04	-12.5	0.22
fruit trees	73.1	87.6	38.0	49.6	0.24	30.2	0.51
fuel wood trees	90.7	128.3	0.0	128.3	0.17	117.3	0.13
hh planted trees on operated land	0.83	0.83	0.81	0.02	0.20	0.04	0.13
# trees planted on operated land	17.2	16.4	19.3	-2.92	0.48	-4.9	0.15
hh received info on agro-forestry	0.49	0.48	0.51	-0.02	0.37	0.00	0.98

Note: FFS=farmer field school group; C=comparison group; T1=FFS only group; T2=FFS+inputs' transfer group; T3=FFS+cash group.
Source: Authors' elaboration from survey data.

The reasons for plantings new trees are very unbalanced across the two groups (Figure 5): households in the FFS group planted new trees mostly for fruits and seeds production (40 percent), and to a minor extent to prevent erosion (13 percent). The opposite occurs in comparison households, who grew trees mainly to prevent erosion (25 percent) rather than for producing seeds/fruits (12 percent).

Figure 5. Reason for planting new trees



Source: Authors' elaboration from survey data.

Productive inputs and assets

In this section we discuss agricultural assets ownership and productive inputs acquisition in the study sample. Table 13 reports the share of households owning various types of agricultural assets in working conditions. Overall farmers seem decently equipped with basic tools for crop production such as hand hoes (99 percent), panga knives (70 percent), axes (73 percent) and sickles (51 percent). However, the proportion of households owning more expensive, sizable and capital intensive assets such as tractors, generators, water pumps plummets close to zero. These statistics are consistent with the well-known problem of under-capitalized subsistence agriculture, which permeates smallholder's production in Malawi and more generally sub-Saharan Africa (Benson, 2021). Approximately half of these indicators are well balanced across treatment arms, possibly because some of them are owned only by a very small number of farmers. Further, for those indicators of agricultural assets holdings for which we observed a statistically significant difference, there is no specific pattern in terms of whether the share of farmers owning them is higher for the comparison or the FFS group.

Table 13. Agricultural assets ownership by treatment group

	All	FFS	C	FFS-C	p-val FFS-C	T2-C	p-val T2-C
assets owned by the hh	6.25	6.15	6.49	-0.34	0.07	-0.24	0.33
hh owns…							
hand hoe	0.99	0.99	1.00	-0.01	0.14	-0.01	0.16
slasher	0.22	0.25	0.13	0.13	0.00	0.13	0.00
axe	0.63	0.63	0.64	-0.01	0.66	-0.01	0.74
ox cart	0.01	0.00	0.03	-0.02	0.00	-0.02	0.01
ox plough	0.01	0.00	0.01	-0.01	0.11	-0.01	0.25
generator or motorised pump	0.01	0.00	0.01	-0.01	0.11	-0.01	0.10
scotchcart	0.00	0.00	0.00	0.00		0.00	
tractor	0.00	0.00	0.00	0.00	0.36	0.00	0.27
sprayer	0.11	0.10	0.11	-0.01	0.54	0.01	0.60
panga knife	0.70	0.67	0.79	-0.12	0.00	-0.08	0.00
micro-solar water pump	0.00	0.00	0.00	0.00	0.79	0.00	0.51
sickle	0.51	0.46	0.62	-0.16	0.00	-0.15	0.00
treadle pump	0.02	0.01	0.03	-0.02	0.01	-0.02	0.02
watering can	0.29	0.34	0.16	0.18	0.00	0.16	0.00

Note*:* FFS=farmer field school group; C=comparison group; T1=FFS only group; T2=FFS+inputs' transfer group; T3=FFS+cash group.
Source: Authors' elaboration from survey data.

Table 14 shows instead the main summary statistics concerning productive inputs. Virtually everybody has acquired inputs in the 12 months prior to the survey, though households in the FFS group spent, on average, MWK 26 243 more than the comparison group, and redeemed a higher value of AIP vouchers. The primary source for buying inputs was AIP, irrespective of the treatment group. The most acquired seeds are the maize seeds (67 percent), followed by the legume seeds (23 percent). The majority of the sample (70 percent) bought improved seeds. Basal fertilizer is the most common even if a large percentage of the households also purchased top-dressing fertilizer. Most households in this sample do not have problems in terms of access to farmland, so only a small share of them rented land (5 percent). Further, pesticides use is limited to 12 percent of the sample.

Table 14. Acquisition of productive inputs by treatment group

	All	FFS	C	FFS-C	p-val FFS-C	T2-C	p-val T2-C
hh has aquired any inputs	0.97	0.99	0.92	0.06	0.00	0.07	0.00
total expenditure on inputs, MWK	38 529	46 224	19 981	26 243	0.00	27 307	0.00
value of AIP vouchers, MWK	8 079	8 620	6 774	1 846	0.00	1 573	0.00
AIP primary source of acquisition	0.75	0.75	0.73	0.02	0.35	-0.01	0.78
hh acquired							
maize seeds	0.67	0.69	0.63	0.06	0.02	0.04	0.15
legume seeds	0.23	0.26	0.14	0.12	0.00	0.11	0.00
other seeds	0.15	0.17	0.08	0.09	0.00	0.09	0.00
improved seeds	0.70	0.72	0.65	0.07	0.00	0.07	0.02
pesticides	0.12	0.12	0.11	0.01	0.69	0.04	0.05
organic fertilizer / manure	0.33	0.33	0.32	0.01	0.64	0.05	0.10
basal fertilizer	0.92	0.96	0.81	0.16	0.00	0.16	0.00
top-dressing fertilizer	0.91	0.94	0.81	0.13	0.00	0.12	0.00
land rent-in	0.05	0.05	0.04	0.01	0.21	0.03	0.06
herbicides	0.00	0.01	0.00	0.01	0.05	0.00	0.27
any crop inputs	0.97	0.99	0.92	0.06	0.00	0.07	0.00
any livestock inputs	0.06	0.06	0.05	0.01	0.23	0.01	0.39

***Note**:* FFS=farmer field school group; C=comparison group; T1=FFS only group; T2=FFS+inputs' transfer group; T3=FFS+cash group. MWK: Malawaian Kwacha; AIP: Affordable inputs programme.
Source: Authors' elaboration from survey data.

Credit and access to markets

Access to credit is essential for investment in modern inputs and increasing farm and non-farm production. However, in the case of incomplete markets, often pervasive in rural areas of low- and middle-income countries, credit constraints limit investments (IMF, 2021). Overall, in the 12 months prior to the survey, 46 percent of the households borrowed money from either formal or informal lenders (Table 15). Households in the FFS group are significantly more likely to borrow than those in the comparison group (9 percentage points difference). Further, they are also much more likely to have one member participating in a village savings and loans scheme, for a 57 vs 46 percent share in the two groups, respectively. Finally, only 2 percent of the sample households acquired agricultural inputs on credit. This is connected to the relatively wide access to inputs via AIP, which has been shown in section 4.12.

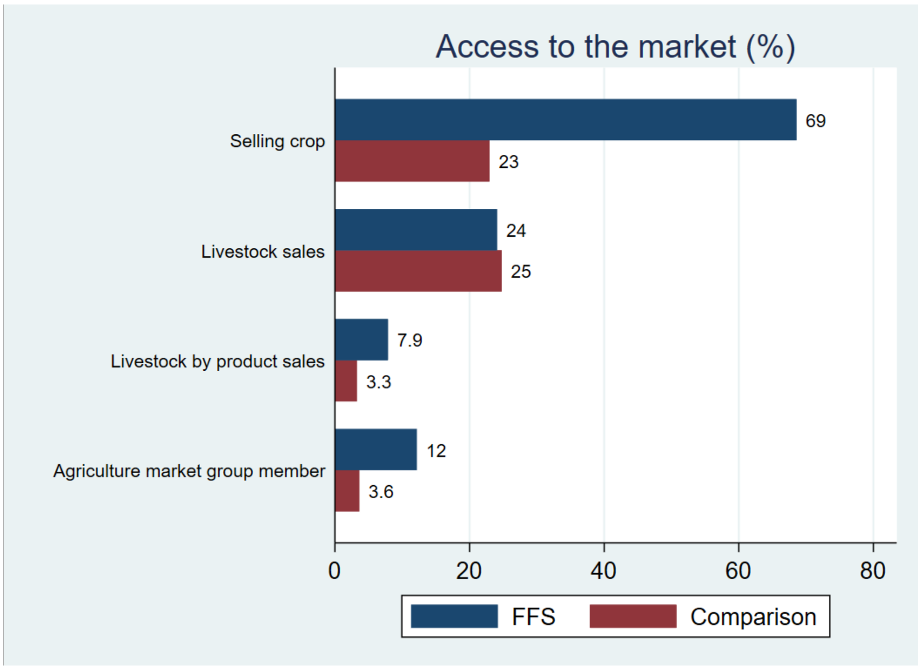
Table 15. Credit

	All	FFS	C	FFS-C	p-val FFS-C	T2-C	p-val T2-C
borrowed money	0.46	0.48	0.39	0.09	0.00	0.10	0.00
acquired agricultural inputs on credit	0.02	0.03	0.01	0.01	0.07	0.01	0.26
member in a group of savings and loans	0.54	0.57	0.46	0.12	0.00	0.07	0.02

***Note**:* FFS=farmer field school group; C=comparison group; T1=FFS only group; T2=FFS+inputs' transfer group; T3=FFS+cash group.
Source: Authors' elaboration from survey data.

We assess households' market participation with crop and livestock sales made in the last 12 months, and engagement in agricultural market groups (Figure 6). While the FFS group is largely involved in crop sales (69 percent), the comparison group is significantly less likely to engage in a market transaction for their crop production (23 percent). Livestock sales are lower for the full sample (24 percent), with both FFS and comparison group showing very similar participation rates, though the FFS group tend to report slightly more sales of livestock by-products (7.9 percent vs. 3.3). Participation in group marketing of agricultural produce is low; only 12 percent of FFS farmers and 3.6 percent of comparison farmers reported having a least a member joining these groups.

Figure 6. Access to the market



Source: Authors' elaboration from survey data.

Shocks

Shocks can cause significant losses in the livelihoods of smallholder farmers in Malawi since their high dependency on natural resources. Vulnerability to climate change creates a shortage of food and increases prices in the markets, leading to an increase in poverty and food deprivation (GoM, 2021).

For the indexes we consider two versions: one including only climate shocks (count indicator taking values from zero to ten) and one including three additional non-climate related shocks. Because of our interest on medium to long-term changes of climate, the survey instrument had to include questions on the experience of these events occurring over an extended reference period. However, it is well known that events happening a long time ago can be very difficult to remember and that as more time passes, we make more errors in dating them (Baddeley *et al.*, 1978; Janssen *et al.*, 2006). To reduce telescoping errors without shortening the reference period of the survey, the psychometric literature suggests providing a highly salient landmark event that can mark the beginning of the reference period (Loftus and Marburger, 1983). The landmark event used in this survey is the death of the President Bingu wa Mutharika, who died in office on April 5, 2012. Since the baseline survey took place between June and July 2021, this entails nine years recall period.

On average, in the last nine years households have been reported to have experienced approximately eight shocks, out of which almost six are related to climate (Table 16). The most common shocks are insect pests and heavy rain (94 and 89 percent respectively). The t-tests between FFS and comparison households show few unbalances. Comparison households are more exposed to both climate and non-climate related shocks than FFS households. In particular, households in the comparison group are more likely to have experienced drought, windstorms, sporadic rains, and insect pests than FFS households. Comparison group households are more likely to report not only climate and non-climate related shocks, but also to be hit economically from these shocks compared to FFS households (87 vs 77 percent respectively).

Table 16. Climate and non-climate shocks experienced by treatment group

	All	FFS	C	FFS-C	p-val FFS-C	T2-C	p-val T2-C
# shocks experienced	8.15	8.02	8.48	-0.46	0.00	-0.56	0.00
shock index	-0.14	-0.19	0.00	-0.19	0.00	-0.26	0.00
# climate shocks	5.88	5.74	6.24	-0.50	0.00	-0.60	0.00
climate shock index	-0.18	-0.26	0.00	-0.26	0.00	-0.32	0.00
Shock experienced…							
drought	0.84	0.82	0.88	-0.06	0.00	-0.06	0.01
fires	0.27	0.28	0.27	0.01	0.67	-0.01	0.72
flood	0.30	0.30	0.30	0.01	0.79	0.00	0.92
windstorm	0.71	0.69	0.75	-0.07	0.00	-0.03	0.36
thunder storm	0.54	0.52	0.57	-0.05	0.04	-0.06	0.04
hail storm	0.49	0.47	0.53	-0.07	0.01	-0.10	0.00
heavy rains	0.89	0.88	0.89	-0.01	0.63	-0.01	0.49
sporadic rains	0.86	0.84	0.90	-0.06	0.00	-0.07	0.00
erosion	0.80	0.82	0.77	0.05	0.02	0.03	0.28
landslide	0.51	0.53	0.48	0.04	0.09	0.06	0.04
heat wave	0.59	0.53	0.72	-0.18	0.00	-0.21	0.00
cold wave	0.41	0.41	0.43	-0.02	0.38	-0.04	0.18
insect pests / diseases	0.95	0.94	0.98	-0.05	0.00	-0.05	0.00
shock impact: big/very big	0.80	0.77	0.87	-0.10	0.00	-0.05	0.04

***Note**:* FFS=farmer field school group; C=comparison group; T1=FFS only group; T2=FFS+inputs' transfer group; T3=FFS+cash group.
Source: Authors' elaboration from survey data.

Additionally, to the information on shocks reported by the households, we merged household-level GPS coordinates with monthly rainfall data to have more objective climate information. We computed the Standardized Precipitation Index (SPI) using monthly precipitation data from the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS), a 35+ year quasi-global rainfall data set, with a 0.05° resolution satellite imagery, and in-situ station data to create gridded rainfall time series for trend analysis and seasonal drought monitoring.[17]

The SPI measures rainfall deviations in a location of the total rainfall data in a specified period (i.e. one, three, six, or more months) compared with the historical precipitation data. A SPI between -1.0 and 1.0 is indicative of normal precipitation conditions. The SPI indicates dry to very dry weather conditions if the index ranges between -1.0 and -1.5 and below -1.5 respectively. Wet to very wet weather conditions instead occur when SPI ranges between 1.0 and 1.5 and above 1.5 respectively. For this study's purpose, we used the 6-month SPI, which refers to six months of a period of rainfall data accumulation. We also reported the number of weather anomalies reported for each household. Table 17 shows the summary statistics for the SPI variables. On average, the sample did not experience many precipitation anomalies in the six months. The SPI average is between -1.0 and 1.0 for all the groups. Including all the shocks experienced by the sample, the average number of shocks reported is 2.57 considering both moderate and intense conditions. The number of very wet conditions experienced by the households is below 1 for all the samples; further, the FFS groups have more rainfalls episodes compared to the comparison group instead the numbers of anomalies of moderate wet conditions are higher and similar between the groups. Also, dry conditions are rarely experienced by households, with less than a shock for household on average both for moderate and intense dry conditions. However, the comparison households are slightly more exposed to dry weather than FFS groups, as shown by the average rainfall precipitations (mm/month) either in the 12 months prior to the survey or in the growing season (from November to April).

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[17] CHIRPS rainfall data are available at https://www.chc.ucsb.edu/data/chirps

Table 17. Rainfall precipitations, standardized Precipitation Index and number of shocks by treatment group

	All	FFS	C	FFS-C	p-val FFS-C	T2-C	p-val T2-C
rainfall precipitations, last growing season	164.91	176.19	137.72	38.47	0.00	32.57	0.00
rainfall precipitations, last 12 months	92.64	99.32	76.54	22.78	0.00	19.77	0.00
SPI 6	0.27	0.30	0.19	0.11	0.00	0.08	0.00
# of SPI6 shocks in presence of…							
very wet conditions	0.21	0.30	0.00	0.30	0.00	0.20	0.00
moderately wet conditions	0.81	0.80	0.83	-0.03	0.26	-0.03	0.25
very dry conditions	0.74	0.69	0.86	-0.17	0.00	-0.23	0.00
moderately dry conditions	0.82	0.71	1.07	-0.35	0.00	-0.37	0.00
very wet/dry conditions	0.95	0.99	0.86	0.12	0.00	-0.03	0.34
moderately wet/dry conditions	1.62	1.51	1.90	-0.39	0.00	-0.40	0.00
very/moderately wet/dry conditions	2.57	2.50	2.76	-0.26	0.00	-0.44	0.00

Note*:* FFS=farmer field school group; C=comparison group; T1=FFS only group; T2=FFS+inputs' transfer group; T3=FFS+cash group. Rainfall precipitations expressed in mm per month. Growing season goes from November to April.
Source*:* Authors' elaboration adapted from **InfraRed Precipitation with Station data (CHIRPS).** 2023. CHIRPS-2.0. *Global monthly.* https://www.chc.ucsb.edu/data/chirps

The COVID-19 pandemic

The COVID-19 shock hit hard Malawi's economy. GDP growth substantially reduced from 5.4 in pre-pandemic levels to 0.9 in 2020. Already facing many challenges due to climate change and fall armyworm outbreak, the pandemic increased market prices and worsened food insecurity (GoM, 2021). Table 18 shows the impacts of the COVID-19 pandemic on the sample. The farming sector was the most severely affected: 71 percent of the FFS households and 63 percent from the comparison households reported a reduction in farm income. The second most affected livelihood source by the pandemic was the non-farm sector, whereas 52 percent households in the FFS groups and 45 percent in the comparison group reported an income reduction. For both farm and non-farm activities, these effects were statistically significantly larger in the FFS than in the comparison group. However, the latter suffered a greater income reduction in wage employment activities (52 vs 46 percent). Remittances diminished for 26 percent of the overall sample. To face the income reductions, 31 percent of the surveyed households used their savings, 21 percent postponed investment or borrowed money, and 15 decided to sell some assets. Only 1 percent of the overall sample declared to have at least one member suspected to be ill of the COVID-19, but the low percentage could be due to the stigma related to the contraction of the COVID-19.

Table 18. The COVID-19 pandemic effects by treatment group

	All	FFS	C	FFS-C	p-val FFS-C	T2-C	p-val T2-C
After the COVID-19 income from…							
farming decreased	0.68	0.71	0.63	0.07	0.00	0.05	0.07
farming stayed the same	0.30	0.28	0.35	-0.06	0.01	-0.04	0.17
non-farm activities decreased	0.50	0.52	0.45	0.07	0.00	0.08	0.02
non-farm activities stayed the same	0.49	0.47	0.54	-0.07	0.01	-0.08	0.02
wage employment decreased	0.48	0.46	0.52	-0.05	0.04	-0.02	0.56
wage employment stayed the same	0.51	0.53	0.48	0.05	0.05	0.01	0.73
remittances decreased	0.26	0.26	0.24	0.02	0.30	0.04	0.15
remittances stayed the same	0.73	0.72	0.75	-0.03	0.26	-0.05	0.10
After the COVID-19 hh…							
Postponed agricultural investment	0.21	0.22	0.17	0.06	0.01	0.05	0.06
Used savings	0.31	0.36	0.20	0.16	0.00	0.21	0.00
Sold assets	0.15	0.15	0.15	0.01	0.76	0.03	0.25
Borrowed	0.21	0.23	0.17	0.06	0.01	0.07	0.00
hh member suspected to be ill of COVID-19	0.01	0.01	0.01	0.00	0.77	0.00	0.62

Note*:* FFS=farmer field school group; C=comparison group; T1=FFS only group; T2=FFS+inputs' transfer group; T3=FFS+cash group.
Source: Authors' elaboration from survey data.

6. Econometric analysis

In this section we use the baseline evaluation data to carry out a range of diverse econometric analyses with the aim of informing potential pathways of impact of the project carried out by FAO in Mwanza and Neno districts. While we do not make any causal claims between the variables, our estimates offer some insights concerning the expected direction and magnitude of the effects of the main project components and how they could translate into greater productivity and efficiency.

Prediction of programme impacts

We assess the potential impact of the programme by estimating the relationship between the six summary outcome indexes described in section 4.3 and three indicators: a) per capita transfers; b) per capita input expenditures; and c) participation in extension training activities,[18] which mimic the treatment effect of the main programme components: the cash transfer, the inputs' transfer and the participation into the FFS activities. For each outcome, we carry-out multivariate regressions, controlling for household and housing characteristics, assets and credit indicators, climate variables and village fixed effects. Depending on the summary index, we included additional variables that can influence the outcome. For instance, in the regression for agricultural practices we included the number of plots owned by the households or the number of days worked by household members in crop activities. Further, we estimate a system of equations jointly using seemingly unrelated regression, which allows us to perform Wald tests of joint significance of treatment coefficients. We carry out these estimations only on the sub-sample of households assigned to the treatment groups that will be part of the impact analysis for the corresponding programme component. For instance, the

[18] We define participation in extension training activities when household respond positively to the following two questions: 1) Due to weather events, has any household member participated in flood / landslide risk reduction and water management practices in the last 9 years? 2) Due to weather events, have any household members participated in community-based natural resource management activities during the last 9 years?

prediction of programme impacts for the cash transfer component, which is proxied by per capita transfers, uses only households in groups T1 and T3. Similarly, the predictions of the impacts for the inputs' transfer and FFS components, which are proxied by per capita inputs expenditure and participation in extension training activities respectively, use only households in groups T1/T2 and C/T2. Because we have standardized the units of measure across outcomes, we report the standard deviation (SD) of the effect for a one SD increase in per capita transfer, per capita inputs expenditure and participation in extension training, to easily compare the relative magnitude of potential programme effects across different outcomes.

Table 19 shows the results of this exercise for the six summary indexes. The potential impact of the cash component depends critically not only on the per capita amount of cash provided to programme beneficiaries, but also on the strength of the income effect on the outcomes of interest. If a particular outcome is not expected to vary with income, the cash component is not likely to affect that outcome. This is, for instance, the case for the climate information summary index. While it is possible for better off households to get more and better access to information in general and on climate more specifically, this link is potentially weaker in remote rural areas, where information is mostly shared through simple technologies like radio, which are normally owned by the vast majority of households in these communities. In our sample, around 84 percent of the households got information on risks related to climate change, and three quarters of them have received it via radio or television.

For outcomes where the expected income effect is large, the actual magnitude of change evoked by the programme will depend on the value of the cash transfer, which is set at USD 127.75. At an exchange rate of 802 MKW/USD, and based on household's composition, the average per capita value of the transfer is approximately 24520MKW.[19] While our impact evaluation survey does not include information on consumption expenditure, from the

[19] We consider the average exchange rate of November 2021, since at the end of this month the FMM project started delivering both the inputs and the cash transfers. The mean household size in the T3 group is 4.86 members (see T able 3).

2019/20 LSMS survey we can infer that this amount is approximately equivalent to 13.1 percent of the average per capita expenditure in the rural South (NSO Malawi, 2021). If we consider the two poorest quintiles only, irrespective of their urban/rural location, this share goes up to 31.9 and 20.2 percent.[20] So, in a nutshell, the cash transfer amount seems relatively sizeable for worse off farmers, decent for farmers in the middle of the consumption/income distribution and modest for better off households. However, results shown in Table 19 refer to estimates where our proxy for the cash transfer is the per capita amount of public and private transfer received, whose average for the T1 and T3 groups equals 5817MKW, which is substantially lower to the amount that T3 beneficiary households will receive from the FMM project. Despite this, we observe a significant positive association of per capita transfer with the income diversification index, the food security index and, weaklier from a statistical point of view, with the agricultural practices index. A one SD increase in per capita transfer is associated with a 0.07 SD and a 0.045 SD increase in the income diversification and food security index. According to the rule of thumb formulated by Sawilowski (2009), Cohen's *d* below 0.2 is considered to be a small effect size. However, since the programme will deliver a four-times larger cash transfer, these predictions are likely to be conservative.

A strong impact of the cash component on food security is unsurprising. Evidence across Africa suggests that cash transfers can have strong effects on availability, access, and utilization of food, especially for poor and vulnerable households, living in remote rural areas (Tiwari *et al.*, 2016; Hidrobo *et al.*, 2018; Daidone *et al.*, 2019). In Malawi, Handa *et al.* (2016) found that the SCT programme brought about a significant and substantial improvement on various indicators of food security, especially for the poorest segment of the population.

A robust impact of cash transfers on income diversification is disputable. Theoretically, we could expect two opposite effects. On the one hand, cash transfers can induce diversification by enabling households to invest in income-generating activities that offer a higher return than subsistence agriculture. On the other hand, cash transfers can reduce diversification if

[20] According to NSO Malawi (2021), the average per capita consumption in the lowest and in the second consumption quintiles are 76823 MKW and 121091 MKW respectively.

households, before programme inclusion, engage in low-return income-generating activities by necessity. By reducing risk, cash transfers can help households, especially the ultra-poor, move away from piecemeal work and specialize in agriculture by focusing their labour on the farm. The scarce evidence available is inconclusive. Daidone *et al.* (2019) find cash transfers allowing to engage in high-return non-farm activities, but only in two countries out of seven. In Malawi, Handa *et al.* (2016) did not find any significant effect of the SCT programme on many dimensions of non-farm enterprises operations. Macours *et al.* (2012) found that households diversified their economic activities only when the conditional cash transfer was combined with complementary interventions.

The impact of the inputs' transfer depends critically on three factors: i) the amount of inputs provided to the farmers; ii) the variety of inputs delivered; and iii) the timing of the inputs delivery. The first requirement is essential to achieve greater agricultural production and consequently household food security. In our sample, households in groups T1 and T2 already acquire crop inputs for an average value of MKW 45 225 (median value MKW 24 500), which includes the value of subsidies and the money spent out-of-pocket by the farmers. Since the average farmland size is below one-hectare, average inputs expenditure per hectare of land is equal to MKW 53 840 (median MKW 34 925). Considering that the FMM project is delivering the equivalent of MKW 102 455 in inputs for the T3 group, this represents on average more than a doubling in inputs acquisition, which is likely to strongly affect household's food security. However, it is important to clarify that impacts on food security may not happen if inputs are delivered with delays. The timing of the delivery is crucial, such that farmers can plant at the beginning of the rainy season, applying basal fertilizers just before sowing or planting, while using top-dressing fertilizers few weeks after sowing/planting.

We look at the predicted impacts of the inputs' transfer in the second column of table 19, where we notice that inputs acquisition per hectare of land is positively associated with the food security index, as we anticipated. We also do not observe significant coefficients related to climate information and agricultural practices, which are expected without messaging or training accompanying the inputs' transfer. Income diversification is negatively associated with increased input acquisition, and this is also an unsurprising result since crop inputs are expected to foster greater agricultural production. Crop diversification is also not affected by greater inputs expenses. In the case of the FMM project component, it is very unlikely to observe a different pattern since the subsidized package contains inputs for maize and pigeon peas production only. Finally, we notice that the coping strategy index is positively and significantly associated with higher levels of inputs expenditure per hectare of land, though the magnitude of the coefficient is relatively small (0.037 SD). This is probably related to some of the variables composing the index, such as the adoption of improved seeds and chemical fertilizers. Given the content of the package delivered to farmers in the FMM project, we anticipate this to be a domain where the FMM project can have an impact too.

Finally, we look at the impacts of participating in extension training activities, which represent the focus of the FFS approach. In principle, these trainings are supposed to promote behavioural change and information in the short-term, and to have a deeper impact on higher-level goals such as greater income and farm production in the medium term. It is therefore unsurprising that the food security index is not statically significantly associated with participation in extension services. Instead, we find relatively larger and statistically significant coefficients for adoption of agricultural practices, access to climate information and coping strategies. All these domains are usually affected by community-based extension services, even if they do not entail any specific in-kind or cash benefit. Given the strong focus of the FFS approach in the FMM project, we expect impacts to be consistent with the results obtained in this econometric exercise.

Table 19. Predicted impact of programme components on summary outcome indexes

	Impacts in standard deviation units		
outcomes	Per capita transfer	input expense per unit of land	extension particip. (0/1)
income diversification	0.0773 **	-0.00923	0.0821 *
	[0.0246]	[0.0200]	[0.0332]
crop diversification	0.00134	0.0179	0.0677 *
	[0.0149]	[0.0130]	[0.0279]
agricultural practices	0.0294 +	-0.0192	0.11 **
	[0.0176]	[0.0156]	[0.0295]
food security	0.0455 *	0.0868 **	0.0315
	[0.0217]	[0.0175]	[0.0270]
climate information	0.0156	0.026	0.152 **
	[0.0228]	[0.0191]	[0.0294]
coping strategy	0.0279	0.0371 *	0.148 **
	[0.0216]	[0.0185]	[0.0312]
χ^2 Wald test	18.2 **	32.16	65.04 **
N	870	888	1007

Note: Standard errors in brackets. Statistical significance: + p<0.10, * p<0.05, ** p<0.01. The χ^2 statistics performs Wald tests of joint significance of the treatment coefficients.
Source: Authors' elaboration from survey data.

Determinants of farmer's efficiency

Increasing productive efficiency is critical for increasing productivity and generating higher agricultural incomes. If markets work perfectly, the producers always maximize their output. However, market failures are pervasive in rural areas of low- and middle-income countries. Small-holder farmers can face credit and liquidity constraints that prevent them from developing their full production (Feder *et al.,* 1990, Deaton 1992, Townsend 1994). Further, markets could have high transition costs due to remote locations and production risk (i.e weather shocks), and some households could decide not to sell their products and be self-sufficient (Key *et al.,* 2000). Under these conditions, inefficiency can arise because consumption decisions cannot be separated from consumption decisions (Singh *et al.,* 1986).

In this section, we use the stochastic frontier (SF) methodology to understand the relationship between productive inefficiency and: a) the components of the FMM project; b) agricultural practices, some of which are promoted in the FFS approach. We provide a technical description of the model in Annex 2.

In table 20, we report the determinants of crop production technical inefficiency and the predicted technical efficiency scores, whose average is very similar across models between 0.528 and 0.556. This indicates that in the study area farmers produce only 52–55 percent of what would be technically feasible given the available technology. Cash and in-kind transfers and input expenses do not seem to be associated with efficiency gains: irrespective of the model, the per capita transfer, and the input expenditure per hectare of land variables are always insignificant. Receiving information on agro-forestry instead is associated with a large reduction of inefficiency (≈46/56 percent). Also, the participation in community-based natural resource management activities is mostly associated with a reduction in inefficiency, though the statistical significance vanishes in the last model in which we have added the adoption of several agricultural practices. Among these, intercropping is the only practice significantly associated with lower levels of inefficiency. Leaving land fallow for two years or more in the last five years is linked with more inefficiency in crop production. Better use of resources are observed also with higher levels of human capital endowment, which is given by the maximum number of years of education in the household, and with access to credit, proxied by having one of the household members having borrowed money formally or informally.

Table 20. Stochastic frontier analysis, determinants of farmer's efficiency

	(1)		(2)		(3)		(4)		(5)	
IHS per capita transfers	-0.0133		-0.00773		-0.0156		-0.0159		0.00533	
	[0.0374]		[0.0361]		[0.0364]		[0.0357]		[0.0305]	
IHS input expenses per ha	-0.0429		-0.0402		-0.0196		-0.019		-0.0208	
	[0.0339]		[0.0324]		[0.0315]		[0.0310]		[0.0271]	
info on agro-forestry	-0.537	*	-0.567	*	-0.462	+	-0.462	+	-0.471	*
	[0.259]		[0.253]		[0.253]		[0.252]		[0.211]	
info on soil/water conservation	0.148		0.156		0.151		0.151		0.14	
	[0.212]		[0.225]		[0.229]		[0.228]		[0.199]	
particip. flood/landslide risk reduction	0.237		0.289		0.255		0.259		0.151	
	[0.245]		[0.247]		[0.249]		[0.260]		[0.264]	
particip. community-based NRM activities	-0.3	+	-0.338	*	-0.307	*	-0.309	*	-0.223	
	[0.163]		[0.154]		[0.148]		[0.150]		[0.153]	

Table 20. Stochastic frontier analysis, determinants of farmer's efficiency

SPI 6			-2.494	+	-2.498	+	-2.476	+	-1.971	
			[1.385]		[1.396]		[1.390]		[1.221]	
# climate shocks last 9 years			0.0151		0.0178		0.0175		0.0162	
			[0.0378]		[0.0382]		[0.0381]		[0.0378]	
highest yrs of education in hh					-0.0903	**	-0.0907	**	-0.0938	**
					[0.0303]		[0.0290]		[0.0273]	
borrowed money					-0.429	+	-0.427	*	-0.397	*
					[0.222]		[0.216]		[0.196]	
particip. savings group					-0.204		-0.203		-0.247	
					[0.233]		[0.234]		[0.218]	
# of agricultural practices							-0.00987			
							[0.0764]			
Agricultural practices:										
land left fallow 2+ years in last 5									0.479	*
									[0.210]	
irrigate land									0.228	
									[0.312]	
uses crop residue to cover land									-0.11	
									[0.194]	
prepare land with zero/minimum tillage									-0.0888	
									[0.243]	
apply manure									-0.103	
									[0.214]	
does not use pesticides									0.0108	
									[0.270]	
practice crop rotation									-0.0478	
									[0.221]	
practice intercropping									-0.667	**
									[0.238]	
plant trees on farmland									0.19	
									[0.230]	
any water conservation structure									0.105	
									[0.166]	
mean TE	0.536		0.539		0.547		0.547		0.556	

***Note**:* Standard errors in brackets. Statistical significance: + p<0.10, * p<0.05, ** p<0.01. IHS: inverse hyperbolic sine transformation; NRM: natural resource management; SPI: Standardized Precipitation Index; hh: household; TE: technical efficiency. The frontier equation in all models includes also traditional authorities fixed effects, the altitude of farmer's residence and a shifter for tractor use.

Source: Authors' elaboration from survey data.

Adoption of agricultural practices and farmers' productivity

Like in many other countries of Southern Africa, agriculture in Malawi depends heavily on rains, requiring the development of adaptation practices to changes in rainfall regimes. In the last three decades, conservation agriculture-related practices (CA) have emerged and been promoted as an adaptation strategy to climate change for soil improvement and sustainable maize yield (Kaczan *et al.*, 2013; FAO, 2016). CA seeks to achieve 'resource-efficient' crop production by utilizing three farming principles: (1) minimum soil disturbance, (2) organic soil cover and (3) diversified crop rotations/associations (Hobbs *et al.*, 2008). The three components of CA jointly aim to maintain a permanent or semi-permanent organic covering on the ground, protecting the soil from erosion and providing a better environment for soil biota. However, despite CA has been widely promoted by researchers and development organizations, uptake remains sparse, especially in Africa where it has been estimated that zero/minimum tillage is practiced only on 0.3 percent of arable land (Derspsch *et al.*, 2010). In Central Malawi, which is considered to have a relatively high uptake of CA, Ngwira *et al.* (2014) suggested that membership to farmer groups, resource endowment (hired labour and total land cultivated), and institutional factors play an important role in shaping adoption and extent of CA. Further, public extension workers remain the prime agents of promoting agricultural technologies though they are not provided with adequate resources necessary to facilitate CA adoption. Instead, Bouwman *et al.* (2021) found that the CA principles were rarely practised as intended,[21] while Chinseu *et al.* (2018) pointed to shortfalls of CA promoters' implementation arrangements among the reasons for smallholders CA dis-adoption.

In this section, we provide a comprehensive analysis of the factors that influence crop productivity. We focus on a range of practices that are normally promoted in the FFS

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[21] According to Bouwman *et al.* (2021, p. 1) "First, one-third of non-ridged land was tilled during the growing season, and half was again ridged in the following season. Second, unless crop residues were added, the soil's surface of non-ridged plots was usually bare at planting, causing weed control problems, and an increased risk of erosion. Most farmers added large volumes of crop residues to their non-ridged plots. They collected these from the surrounding fields, but this practice severely restricted the size of these plots. Third, crop rotation/intercropping was practiced less when farmers stopped ridging. Thus overall, very few farmers practised all of the three CA principles simultaneously."

approach, which includes mainly CA, and that have the potential to improve farmer's adaptive capacity. Given the overwhelming importance of maize for food security and the Malawi economy, we focus on maize yields. Table 21 reports the estimates of the maize yield production function using alternative estimation strategies. In column 1 we have the village or cluster fixed effects (CLFE) specification shown in eq. (5) in Annex 3 We observe that several plot-level characteristics are significantly and positively associated with greater maize yields, especially maize seeds use per hectare of land, whether the farmer uses improved early maturing maize seeds and whether they intercrop maize with either legumes or other crops. A statistically weaker but still positive conditional correlation is observed for crop rotation. Finally, negative associations are found for plots when land is left fallow for more than one year in the five years prior to the survey, and when land is cultivated without pesticides, the latter coefficient being significant only at ten percent. In column 2, we included a model with a household fixed effects (HHFE) specification, in which we removed the household characteristics. The estimates of this model are roughly comparable with the previous specification. Maize intercropping remain highly significant and positively associated with yields, confirming the benefits of maize-legume intercropping system relative to mono-cropping in terms of yields and improvements in soil quality that are found in the agronomic literature (Schmidt et al., 2003; Rusinamhodzi et al., 2012). Further, adoption of improved early maturing maize seeds also shows similar results in both significance and magnitude. The quantity of seeds used is positively associated to yields in both models, though in the household fixed effects model both magnitude and significance are lower. Interestingly, the quantity of fertilizers used in the plot is weakly associated to maize yields. This is likely due to soil degradation and use of inappropriate fertilizer types (Burke, Jayne, Snapp, 2022). We observe some minor differences both in terms of statistical significance and magnitude between the two models. The use of improved medium/long maturing maize seeds and the application of organic barriers as water conservation structures are positively and statistically significantly associated with yields in the household fixed effects model, in which, however, the correlation with crop rotation vanishes.

We also estimate fixed-effects two-stage least squares models where we control for the potential endogeneity of agricultural practices adoption. We test the instrumenting strategy discussed in Annex 2 only on those agricultural practices showing greater coherence between the two fixed effects estimates. Model IV-CLFE1 (column 3) reports results when only the two variables for maize intercropping are treated as endogenous regressors, while model IV-CLFE2 (column 4) also considers adoption of improved early maturing seeds. Further, model IV-CLFE3 in column 5 reports the same instrumenting strategy of model IV-CLFE2 augmented with an additional instrument, to make the model overidentified. Once we consider endogeneity of practices, maize intercropped with legumes and other crops produces much larger yields relative to maize monocropping (approximately 800 kg/ha and 290 kg/ha respectively). Further, the adoption of improved early maturing maize seeds strongly affects yields too relative to local seeds, an increase of about 200 kg/ha.

Table 21. Determinants of plot maize yields (kg/ha): fixed effects and instrumental variables models' estimates (n=2 719)

	(1)		(2)		(3)		(4)		(5)	
	CLFE		HHFE		IV-CLFE1		IV-CLFE2		IV-CLFE3	
maize seeds, kg/ha	0.516	**	0.419	*	0.506	**	0.5	**	0.5	**
basal fertilizer, kg/ha	0.402		0.211	+	0.401		0.4		0.399	
top-dressing fertilizer, kg/ha	0.14		-0.0383		0.139		0.141		0.141	
Type of maize seeds used:										
improved early maturing	249.1	**	257.5	*	247.4	**	196.9	*	197.2	*
improved medium/long maturing	204.5		343	*	213.1		182.5		182.5	
maize intercropped with:										
legumes	766.2	**	633.6	**	805.5	**	801.7	**	793.9	**
other crops	452.6	**	580.2	**	292.2	+	287.2	+	278.1	+
use of crop residue:										
cover land	24.21		-58.44		26.26		24.19		24.47	
crop is burn	19.08		169.8		15.92		11.13		10.58	
land preparation:										
zero/minimum tillage	-5.983		-77.04		-12.6		-10.78		-11.17	
tied or box ridging	29.59		162.8		36.62		38.83		38.36	
other methods	-40.48		-149.7		-50.59		-48.65		-50.91	
water conservation structures:										
bunds/terraces	53.01		-102.4		54.74		57.45		58.24	
ditches	143.8		346.4		144.7		148.6		149.2	
mulching	133.4		-87.68		127.9		128.1		129	

Table 21. Determinants of plot maize yields (kg/ha): fixed effects and instrumental variables models' estimates (n=2 719)

organic barriers	-51.73		274.3	+	-41.16		-39.13		-38.32	
swales	59.63		197.8		60.99		63.8		64.07	
box ridges	-43.75		-37.59		-36.91		-24.94		-23.81	
other ag practices:										
plot left fallow 2+ years (0/1)	-161.4	*	-68.58		-159.5	*	-163.1	*	-163	*
plot irrigated (0/1)	153.2		0.642		178.3		181.9		182.4	
crop rotation (0/1)	350.9	+	100.8		353.8	+	352.4	+	351.5	+
manure applied on plot (0/1)	-21.38		-73.11		-19.76		-19.19		-19.15	
pesticides not used in plot (0/1)	-191	+	-393.8	*	-196.1	+	-199.3	+	-199.8	+
trees planted on plot (0/1)	-82.85		59.31		-82.97		-80.32		-80.54	
plot erosion level: medium/high	-21.31		51.58		-24.02		-26.57		-26.49	
village FE	Yes		No		Yes		Yes		Yes	
household FE	No		Yes		No		No		No	

Note: Standard errors clustered at the village level but not reported. Statistical significance: + p<0.10, * p<0.05, ** p<0.01. CLFE: cluster fixed effects; HHFE: household fixed effects; IV-CLFE: instrumental variables model with cluster fixed effects. All models except HHFE include household-level characteristics. Model IV-CLFE1 considers two endogenous regressors: whether maize has been intercropped with legumes and whether maize has been intercropped with other crops in the plot. The exclusion restrictions are the share of village households adopting a) maize intercropped with legumes and b) maize intercropped with other crops. Model IV-CLFE2 considers three endogenous regressors: the two endogenous regressors included in Model IV-CLFE1 and whether improved early maturing maize seeds had been adopted in the plot. The additional exclusion restriction is given by the share of village households adopting improved early maturing maize seeds. Model IV-CLFE3 is equivalent to model IV-CLFE2 but includes the share of village households receiving agro-forestry information as an overidentifying restriction. We use the following base categories for categorical variables: local seeds for the type of maize seeds, maize monocropping for the variables indicating whether the maize has been intercropped with legumes or other crops, residue is removed/used for animal feeding/used as compost for the use of crop residues, traditional ridging for land preparation, no water conservation structure has been applied on the plot for typology of water conservation structure, no/low plot erosion for medium/high plot erosion.
Source: Authors' elaboration from survey data.

7. Conclusions

In this report we described the impact evaluation design of the project “Promoting coherence between disaster risk reduction, climate action and social protection in sub-Saharan Africa (Malawi)”, which is carried out by FAO in the districts of Mwanza and Neno in Malawi. Farmers in targeted villages have been randomized across three experimental arms: i) a group of farmers benefitting from a standard packet of CSA training, farming as a business training, and an enterprise grant for the farmer field school groups; ii) a group of farmers receiving a CSA inputs’ transfer on top of the standard packet; iii) a group of farmers receiving a one-off cash transfer for an amount equivalent to the inputs subsidized to the second group on top of the standard packet. Further, a comparison group was created in villages not targeted by the project but located in the same districts, which receive the CSA inputs’ transfer offered to the second experimental group. This is the counterfactual for the analysis of the impacts of the farmer field schools.

The descriptive analysis of the project's baseline survey data confirmed that the randomization across the three experimental arms worked well, with very few indicators showing small imbalances. We also found large differences between the FFS and the comparison groups, which were expected due to diverse agro-ecological conditions. This confirms the need for a difference-in-difference design to evaluate impacts of the farmer field school alone. Overall, the comparison group looks poorer, less engaged with markets, relying on a less diverse crop production and income generation, adopting less agricultural practices. Both groups have a large share of beneficiaries of the Affordable Input Programme and the School Meals Programme and a very small share of cash transfers beneficiaries. Sample households have been affected significantly by recent weather shocks and a large share have received information on climate.

The stylized findings from the descriptive analysis point to a partially successful targeting approach: if the main objective of the project was to create synergies between social protection and agriculture broadly at the village/community level, the large share of beneficiaries of these two important programmes in the communities can positively interact with the FAO project and generate spillovers effects. For instance, if school meals are locally sourced, they can create demand for agricultural products of both better-off and worse-off households, boosting their prices. Similarly, adoption of modern inputs through the Affordable Input Programme can positively influence non-adopters in the community and contribute to diffusion via social learning. In both circumstances, knowledge created via Farmers Field Schools should facilitate supply response.

However, if the main idea was instead to create synergies at the individual/household level, especially for the most vulnerable segment of the population, this objective is likely unmet. The FAO project is a productive intervention supposed to stimulate supply. This will eventually put a downward pressure on prices, lowering food costs for consumers. Households not benefiting from the project can potentially see their agricultural incomes declining, especially if they are net-sellers, unless demand expands. This can be achieved with a regular and predictable cash transfer. However, this does not seem to be the case in our sample, given the low proportion of beneficiaries of cash and in-kind programmes, which reflects the low coverage rate of the Social Cash Transfer programme in the two districts targeted by the FAO project.

The econometric analysis carried out on the baseline survey data provided some relevant insights concerning the expected direction and magnitude of the effects of the main project components:

1. The cash transfer and the inputs' transfer have the potential to generate strong impacts on the food security domain. While the former can contribute to greater income diversification and, to some extent, improved adoption of the agricultural practices promoted by the farmer field schools, the latter component can contribute

to expand coping strategies in the face of weather shocks, especially concerning ex-post response at the farm-level.

2. The training provided by the farmer field schools approach can help households better manage risks, especially through greater knowledge and information around weather events and improved coping strategies in the aftermath of shocks. This can also translate in greater income and crop diversification opportunities. It is also expected that farmer field schools will contribute to boosting the uptake of conservation agriculture and climate-smart agricultural practices.
3. Given the agro-ecological conditions of the districts targeted by the project, and the existing agricultural technology, it is foreseen that maize yields can be enhanced significantly by strengthening the adoption of maize-legume intercropping. This appears to be beneficial on both an efficiency perspective (better use of available farmland) and a growth perspective (expanding available farmland). Similarly, the adoption of improved maize seeds, especially early maturing, may contribute to greater volumes of maize production. Farmers attending agro-forestry capacitation typically have better outcomes, probably because of their better knowledge of more modern farming techniques.

From a policy perspective, these findings provide useful evidence to existing national strategies. For instance, the second pillar of the Malawi National Social Support Programme (MNSSP) II is centered on the concept of developing livelihood strategies that enhance rural households' resilience. The results of the econometric analysis highlight that maize yields and harvest value can be boosted by appropriately adopting simple maize/intercropping and early maturing seeds. Further, providing extension services and agro-forestry information can contribute to a more efficient use of resources. This will likely impact income, including better opportunities in more diversified agricultural and non-agricultural activities. Further, while waiting for the fully-fledged impact evaluation results that will be available after the endline, the simulation exercise we carried out point out that participation in extension and advisory services and training are very likely to contribute to greater awareness concerning the effects of climate change. This corroborates the role played by the National Climate Change

Management Policy (NCCMP), which outlines climate change adaptation and mitigation among priority areas for climate change management.

We conclude the report by providing a series of programmatic recommendations:

a. **Timely payments**. The predicted impacts by the cash transfers and inputs' transfer are based on the assumption that these transfers are made timely, synchronizing them with the agricultural calendar. However, while cash transfer beneficiaries can still diversify their livelihoods, for instance through greater off-farm income opportunities, and achieve the food security impacts though market purchases, delayed input transfers may have consequently a reduced impact on the expected domains.
b. **Strengthen FFS engagement and uptake**. Information on agro-forestry and adoption of agricultural practices seems key to improving farm efficiency and productivity. It is critical that farmers acquire the abilities to adopt these practices and apply them appropriately. The FFS have therefore the potential to contribute to a transformative process of agricultural livelihoods.
c. **Support link to markets and foster investment in income generating activities**. In the presence of limited market outlets for food staples, especially maize and pigeon peas, the expansion of agricultural products supply may result in lower prices. It is therefore critical to support farmers' marketing knowledge and skills. Further, given the availability of labour, households need to be supported for investing in income generating activities, also off-farm where rate of returns are higher than in agriculture, to promote their long-term productive inclusion.

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Annexes

Annex 1. Project districts map

***Source**:* **National Statistics Office of Malawi.** 2020. *Malawi - Subnational Administrative Boundaries.* https://data.humdata.org/dataset/cod-ab-mwi

Annex 2. The stochastic frontier approach

We define the single output stochastic frontier production function as:

$$y_i = f(\mathbf{x}_i, \boldsymbol{\beta})\exp(v_i - u_i) \qquad (3)$$

Where y_i is the production for farmer *i*, which is proxied by the value of harvest, $\mathbf{x}_i$ is a vector of inputs for farmer *i*, such as land, labour, etc., $\boldsymbol{\beta}$ is the vector of technology parameters associated to the inputs of production, v_i is an iid random error distributed as a $N(0, \sigma^2)$, representing random factors that are not under the farmer's control, and u_i is a non-negative random variable associated with factors that prevent farmer i from being efficient. Aigner et al. (1977) assumed a half-normal distribution, that is, $u_i \sim N^+(0, \sigma_u^2)$, while Meeusen and van den Broeck (1977) opted for an exponential one, $u_i \sim Exp(\sigma_u)$.

Given the frontier production of farmer i is $y_i^* = f(\mathbf{x}_i, \boldsymbol{\beta})\exp(v_i)$, their technical efficiency can be defined as:

$$TE_i = \frac{y_i}{y_i^*} = \frac{f(\mathbf{x}_i, \boldsymbol{\beta})\exp(v_i - u_i)}{f(\mathbf{x}_i, \boldsymbol{\beta})\exp(v_i)} = \exp(u_i) \qquad (4)$$

A very important issue in SF analysis is the inclusion in the model of variables that are supposed to affect the distribution of inefficiency. These variables, which usually are neither the inputs nor the outputs of the production process but nonetheless affect the productive unit performance, could be incorporated in a variety of ways. In this analysis we modelled the ancillary equation representing the inefficiency term (Usigma) with an exponential distribution. Therefore, inefficiency determinants are obtained by parameterizing its variance (Caudill and Ford, 1993; Caudill, Ford and Gropper, 1995), while jointly estimating the parameters of the technology. This avoids a biased two-steps approach, in which inefficiency scores are first obtained without controlling for these factors, and then in the second step, the estimated inefficiency scores are regressed with them (Wang and Schmidt, 2002).

Like for any production function, we can estimate output elasticities. In Table 22 we reported factor elasticities and not model coefficients, since we used the inverse hyperbolic sine transformation for both the output and the inputs of production, to avoid the issues with zeros and the impossibility of using a logarithmic transformation (Bellemare Wichman, 2020). Unsurprisingly, crop production is land intensive, accounting for the largest value-added share, which depending on the specification ranges between 0.53 and 0.552. This means that we could expect significant increases in crop production if farmers had the potential to considerably expand the area of cultivated land. Output elasticities are also relatively high for fertilizers (around 0.14) and seeds (between 0.09 and 0.11). Overall we cannot reject the null hypothesis of constant returns to scale. In the lower panel of Table 22 we also include an important statistics in the context a SF estimation: the lambda. This is the ratio between the inefficiency and measurement error variability and potentially suggests whether a technical efficiency story holds: very small values indicate that the compound error is essentially dominated by the idiosyncratic component and that inefficiency is negligible. In our sample, we estimated lambda ranging from 1.85 and 2.02, which indicate that inefficiency permeates crop production.

Annex 3. Stochastic frontier analysis, crop production factor elasticities

Factor elasticities	(1)		(2)		(3)		(4)		(5)	
land	0.552	**	0.551	**	0.532	**	0.531	**	0.53	**
	[0.0458]		[0.0449]		[0.0447]		[0.0463]		[0.0461]	
household labour	0.0971	**	0.0975	**	0.101	**	0.101	**	0.099	**
	[0.0293]		[0.0297]		[0.0299]		[0.0299]		[0.0305]	
hired labour	0.0344	**	0.0345	**	0.0319	**	0.0319	**	0.0322	**
	[0.00443]		[0.00446]		[0.00441]		[0.00443]		[0.00450]	
fertilizers	0.141	**	0.145	**	0.144	**	0.144	**	0.147	**
	[0.0220]		[0.0222]		[0.0221]		[0.0222]		[0.0218]	
seeds	0.102	*	0.0982	*	0.0942	*	0.0937	*	0.0899	*
	[0.0448]		[0.0432]		[0.0406]		[0.0405]		[0.0399]	
p-value RTS=1	0.252		0.236		0.111		0.116		0.0955	
lambda: σ_u / σ_v	2.005		1.984		1.929		1.928		1.854	

***Note**:* Standard errors in brackets. Statistical significance: + p<0.10, * p<0.05, ** p<0.01. RTS: returns to scale. The frontier equation in all models includes also traditional authorities fixed effects, the altitude of farmer's residence and a shifter for tractor use.

Source: Authors' elaboration from survey data.

Annex 4. Econometric approach to crop productivity determinants

We investigate the impact of agricultural practices adoption on yields using the following linear mixed-effects model:

$$y_{\mathrm{pic}} = \alpha_0 + \mathbf{g}_{pic}\boldsymbol{\beta} + \mathbf{x}_{ic}\boldsymbol{\gamma} + \delta_c + \varepsilon_{pic} \qquad (5)$$

Where y_{pic} represent our yield variable (kg of maize per hectare of cultivated land) for farmer *i* in plot *p* located in village (cluster) *c*, while $\mathbf{g}_{pic}$ is a vector of plot-level determinants of maize yields that include both input variables and adoption of practices. Since farmers can cultivate more than one plot we include a vector of household/farmer's characteristics, $\mathbf{x}_{ic}$. Finally, δ_c and ε_{pic} are the village-specific unobserved farmer's invariant heterogeneity and the idiosyncratic error term, respectively.

For comparative purposes only, we have included a model with a household fixed effects specification, in which obviously we have removed the household characteristics. In presence of multiple time periods or even an average large number of plots per household, this would have been the ideal specification. However, the presence of singleton groups, i.e. groups with only one observation (farmers with only one plot), may lead to underestimate standard errors and overstate statistical significance (Cameron *et al.*, 2011).

In principle, village fixed effects can rule-out the main cause of endogeneity, i.e. input variables and adoption decisions being correlated with unobserved farmer's invariant heterogeneity (Mundlak, 2001). However, fixed-effects estimation can still produce biased estimates for the decision to adopt agricultural practices (Ricker-Gilbert *et al.*, 2011; Manda *et al.*, 2016). For this reason we also estimate a fixed-effects two-stage least squares model where we control for this potential source of endogeneity. Our instrumenting strategy is based on the concept of "social learning" (Conley and Udry, 2010). The main idea behind this notion is that in presence of multiple adopters of a new technology in a similar setting, the process of learning may be social. New users of the technology may learn its characteristics from each other, generating knowledge spillovers. In the absence of a direct elicitation of information interconnections and social networks in our survey, we follow Arslan *et al.* (2017) and capture the notion of "learning from others" by calculating the average agricultural practice adoption rate of the neighbouring households in the same village, excluding the household's own adoption of the practice. Further, one of the model is augmented with an additional instrument, the average share of the neighbouring households receiving agro-forestry training in the same village, excluding the household's own participation, so as to make the model overidentified.

We carry out a range of model diagnostics, which are customary in the fixed effects and instrumental variables literature. For instance, the robust Hausman test reported in table 23 highlights the presence of farmer-invariant unobserved heterogeneity correlated with the explanatory variables, confirming that a random-effects estimator would be inconsistent. Our instrumenting strategies appear to be relevant as corroborated by various diagnostic tests. The Angrist and Pischke first-stage multivariate F-statistics is greater than 10 by far for all agricultural practices in the three models (results not reported) and the Kleibergen-Paap underidentification test confirms that the instruments are significantly correlated with the endogenous regressors. Most importantly, we fail to reject the null of the Anderson-Rubin Wald test, $\boldsymbol{\beta}$=0, at the 1 percent confidence level. Given that the maintained hypothesis of the Anderson-Rubin test is that the instruments are valid, this evidence, together with the Hansen J statistic obtained for the overidentified model (IV-CLFE3), suggests that the orthogonality conditions are valid. Finally, we reject the null hypothesis that our adoption variables are exogenous (see third line in the table), even though for the overidentified model only at the 10 percent level. Qualitatively, the findings from the instrumental variable approach are largely consistent with the simple fixed effects model.

Annex 5. Determinants of plot maize yields (kg/ha), models' diagnostics (n=2 719)

	(1)	(2)	(3)	(4)	(5)
	CLFE	HHFE	IV-CLFE1	IV-CLFE2	IV-CLFE3
village FE	Yes	No	Yes	Yes	Yes
household FE	No	Yes	No	No	No
H0: Exogeneity of practices			7.665	7.975	6.838
			[0.022]	[0.047]	[0.077]
Kleibergen-Paap rk LM statistic			66.139	67.5	67.913
			[0.000]	[0.000]	[0.000]
Anderson-Rubin Wald test			31.908	31.806	32.328
			[0.000]	[0.000]	[0.000]
Robust Hausman test	295.64				
	[0.000]				
Hansen J					1.548
					[0.213]

***Note**:* CLFE: cluster fixed effects; HHFE: household fixed effects; IV-CLFE: instrumental variables model with cluster fixed effects.
Source: Authors' elaboration from survey data.

Annex 6. Unadjusted and Sidak-Holm adjusted p–values for baseline comparisons

variable	p–value T1/T2/T3	sidak adjustment T1/T2/T3	p-value FFS-C	sidak adjustment FFS-C	p-value T2-C	sidak adjustment T2-C
# members in the hh	0.621	1.000	0.130	1.000	0.165	1.000
# hh members 0-5 yrs	0.873	1.000	0.928	1.000	0.779	1.000
# hh members 6-12 yrs	0.550	1.000	0.415	1.000	0.234	1.000
# hh members 13-17 yrs	0.559	1.000	0.416	1.000	0.552	1.000
# male hh members 18-59 yrs	0.341	1.000	0.008	0.531	0.001	0.099
# female hh members 18-59 yrs	0.156	1.000	0.520	1.000	0.126	1.000
# hh members 60+ yrs	0.080	1.000	0.451	1.000	0.394	1.000
female headed hh	0.304	1.000	0.809	1.000	0.691	1.000
head of hh age	0.078	1.000	0.727	1.000	0.015	0.823
head of hh married	0.018	0.554	0.753	1.000	0.026	0.946
head of hh widow	0.115	1.000	0.804	1.000	0.105	1.000
# disabled hh members	0.582	1.000	0.034	0.951	0.125	1.000
head of hh yrs of education	0.622	1.000	0.019	0.833	0.137	1.000
highest yrs of education in hh	0.934	1.000	0.106	1.000	0.329	1.000
head of hh completed primary school	0.718	1.000	0.122	1.000	0.203	1.000
Summary index of income diversification	0.165	1.000	0.000	0.000	0.005	0.518
Summary index of crop diversification	0.413	1.000	0.000	0.000	0.000	0.000
Summary index of agricultural practices	0.431	1.000	0.269	1.000	0.132	1.000
Summary index of food security	0.742	1.000	0.000	0.000	0.000	0.000
Summary index of climate information	0.259	1.000	0.000	0.004	0.000	0.001
Summary index of coping strategies	0.307	1.000	0.000	0.016	0.019	0.919
hh received transfers	0.945	1.000	0.004	0.395	0.015	0.823
value of transfers received, MKW	0.813	1.000	0.040	0.966	0.205	1.000
hh received private transfers	0.538	1.000	0.284	1.000	0.102	1.000
value of private transfers received, MKW	0.431	1.000	0.815	1.000	0.284	1.000
hh received public transfers	0.964	1.000	0.017	0.800	0.046	0.996

Annex 6. Unadjusted and Sidak-Holm adjusted p–values for baseline comparisons

value of public transfers received, MKW	0.084	1.000	0.002	0.184	0.473	1.000
hh received school meals feeding programme	0.699	1.000	0.664	1.000	0.518	1.000
value of school meals received, MKW	0.407	1.000	0.493	1.000	0.665	1.000
hh received Affordable Input programme	0.966	1.000	0.006	0.496	0.020	0.946
value of Affordable Input programme received, MKW	0.466	1.000	0.000	0.013	0.000	0.002
hh received cash transfers	0.553	1.000	0.422	1.000	0.860	1.000
value of cash transfers received, MKW	0.022	0.674	0.267	1.000	0.104	1.000
hh received in-kind transfers	0.878	1.000	0.000	0.000	0.000	0.002
value of in-kind transfers received, MKW	0.861	1.000	0.002	0.234	0.036	0.986
Simpson income diversity index	0.034	0.999	0.493	1.000	0.138	1.000
Shannon income diversity index	0.120	1.000	0.007	0.523	0.799	1.000
# income sources	0.931	1.000	0.000	0.000	0.000	0.000
hh gross income, MWK	0.777	1.000	0.185	1.000	0.078	1.000
hh agricultural gross income, MWK	0.860	1.000	0.000	0.000	0.000	0.000
hh has crop production	0.451	1.000	0.696	1.000	0.947	1.000
total value of harvest	0.631	1.000	0.000	0.000	0.000	0.000
hh has vegetable sales	0.969	1.000	0.000	0.000	0.000	0.000
value of vegetable sales	0.427	1.000	0.000	0.000	0.000	0.000
hh has fruit sales	0.695	1.000	0.000	0.000	0.000	0.000
value of fruits sales	0.356	1.000	0.000	0.000	0.000	0.000
hh has livestock sales	0.543	1.000	0.750	1.000	0.986	1.000
value of livestock sales, MKW	0.378	1.000	0.440	1.000	0.948	1.000
hh has livestock by product sales	0.431	1.000	0.000	0.028	0.029	0.980
value of livestock by-products sales, MKW	0.544	1.000	0.499	1.000	0.818	1.000
hh has livestock by revenues by non-farm business	0.765	1.000	0.000	0.000	0.000	0.000
non-farm business revenues last 12 months, MKW	0.088	1.000	0.035	0.954	0.005	0.406
hh has non-timber forest products sales	0.010	0.554	0.042	0.968	0.044	0.996

Annex 6. Unadjusted and Sidak-Holm adjusted p–values for baseline comparisons

value of sales of non-timber forest products, MKW	0.335	1.000	0.000	0.005	0.004	0.406
hh has at least a member with a wage work	0.103	1.000	0.041	0.966	0.013	0.745
hh total annual wage	0.739	1.000	0.228	1.000	0.167	1.000
Simpson crop diversity index	0.409	1.000	0.000	0.000	0.000	0.000
Shannon crop diversity index	0.315	1.000	0.000	0.000	0.000	0.000
# crops planted	0.198	1.000	0.000	0.000	0.000	0.000
hh cultivates maize	0.363	1.000	0.363	1.000		
hh cultivates pigeon pea	0.623	1.000	0.000	0.000	0.000	0.000
hh cultivates beans	0.779	1.000	0.000	0.000	0.000	0.000
hh cultivates groundnut	0.618	1.000	0.001	0.124	0.002	0.256
hh cultivates irish potato	0.229	1.000	0.000	0.000	0.000	0.000
hh cultivates cow pea	0.213	1.000	0.000	0.000	0.000	0.000
hh cultivates sorghum	0.208	1.000	0.000	0.000	0.000	0.000
yield maize, kg/ha	0.390	1.000	0.000	0.000	0.000	0.000
yield pigeon pea, kg/ha	0.073	1.000	0.000	0.028	0.000	0.057
# plots owned/cultivated	0.192	1.000	0.000	0.000	0.000	0.000
land area owned for crop cultivation, ac	0.271	1.000	0.006	0.465	0.016	0.840
land area operated for crop cultivation, ac	0.445	1.000	0.006	0.488	0.011	0.745
land area rented in for crop cultivation, ac	0.127	1.000	0.975	1.000	0.662	1.000
land area rented out for crop cultivation, ac	0.077	1.000	0.269	1.000		
land area left fallow > 1 year in the last 5, ac	0.061	0.999	0.020	0.837	0.048	0.996
% operated land area left fallow >1 year in the last 5	0.098	1.000	0.044	0.971	0.165	1.000
land area operated and irrigated, ac	0.030	0.983	0.000	0.013	0.000	0.006
% operated land area that is irrigated	0.067	1.000	0.000	0.000	0.000	0.001
hh uses crop residue to cover land	0.841	1.000	0.255	1.000	0.247	1.000
hh burns/removes crop residue	0.083	1.000	0.013	0.725	0.001	0.087
hh uses crop residue to produce composting	0.371	1.000	0.000	0.000	0.000	0.000

Annex 6. Unadjusted and Sidak-Holm adjusted p–values for baseline comparisons

hh prepares land with zero–minimum tillage	0.839	1.000	0.000	0.000	0.000	0.000
land area prepared with minimum–zero tillage, ac	0.369	1.000	0.000	0.000	0.000	0.004
hh prepared land with ridging	0.458	1.000	0.000	0.000	0.000	0.000
land area prepared with ridging, ac	0.702	1.000	0.000	0.000	0.000	0.000
hh adopts crop rotation	0.673	1.000	0.000	0.021	0.000	0.016
land area subject to crop rotation, ac	0.169	1.000	0.038	0.962	0.002	0.256
hh used basal fertilizer	0.037	0.999	0.000	0.000	0.000	0.000
basal fertilizer used, kg	0.401	1.000	0.000	0.000	0.000	0.000
hh used top-dressing fertilizer	0.034	0.999	0.000	0.000	0.000	0.000
top-dressing fertilizer used, kg	0.198	1.000	0.000	0.000	0.000	0.000
hh used manure fertilizer	0.727	1.000	0.094	0.999	0.175	1.000
land area operated under low erosion, ac	0.339	1.000	0.615	1.000	0.886	1.000
% operated land area under low erosion	0.124	1.000	0.007	0.523	0.000	0.016
land area operated under high erosion, ac	0.559	1.000	0.005	0.432	0.001	0.078
% operated land area under medium/high erosion	0.124	1.000	0.007	0.523	0.000	0.016
raw fies score	0.780	1.000	0.000	0.000	0.000	0.000
number of meals take per day in the HH	0.767	1.000	0.000	0.000	0.000	0.000
months maize harvest lasted in the last year (2019-2020)	0.486	1.000	0.000	0.000	0.000	0.000
months will last maize currently in the grainery	0.600	1.000	0.000	0.000	0.000	0.000
# of climate information received	0.327	1.000	0.000	0.007	0.000	0.002
climate information index	0.259	1.000	0.000	0.004	0.000	0.001
<u>hh received info about</u>						
sudden catastrophes	0.318	1.000	0.000	0.005	0.010	0.745
slow-onset disasters	0.593	1.000	0.009	0.579	0.005	0.518
pest outbreak	0.446	1.000	0.231	1.000	0.059	1.000
rains	0.065	1.000	0.000	0.002	0.000	0.000
weather forecasts in 2–3 days	0.527	1.000	0.001	0.127	0.001	0.148

Annex 6. Unadjusted and Sidak-Holm adjusted p–values for baseline comparisons

weather forecasts in 2–3 months	0.118	1.000	0.006	0.482	0.000	0.001
# of negative coping strategies to shocks	0.827	1.000	0.358	1.000	0.344	1.000
<u>because of weather shock hh</u>						
sent children living elsewhere	0.630	1.000	0.718	1.000	0.398	1.000
changed food habits	0.465	1.000	0.031	0.938	0.016	0.840
reduced health and education expenses	0.839	1.000	0.517	1.000	0.952	1.000
sold assets	0.912	1.000	0.247	1.000	0.557	1.000
# of farm-level coping strategies to shocks	0.402	1.000	0.000	0.013	0.056	1.000
<u>hh strategies due to weather events</u>:						
change in cropping pattern	0.397	1.000	0.001	0.163	0.230	1.000
improved seeds adoption	0.381	1.000	0.012	0.688	0.482	1.000
change in sowing date	0.925	1.000	0.501	1.000	0.788	1.000
increased use of org compost	0.469	1.000	0.397	1.000	0.714	1.000
increased use of chemical fertilizer	0.740	1.000	0.000	0.001	0.006	0.589
investment in irrigation	0.400	1.000	0.001	0.150	0.008	0.703
greater diversification of crops	0.228	1.000	0.096	0.999	0.237	1.000
crop insurance	0.567	1.000	0.382	1.000	0.456	1.000
hh acquired tree samplings	0.789	1.000	0.026	0.903	0.199	1.000
hh acquired fertilizer trees	0.793	1.000	0.375	1.000	0.857	1.000
hh acquired fodder trees	0.212	1.000	0.264	1.000	0.120	1.000
hh acquired fruit trees	0.890	1.000	0.000	0.013	0.000	0.042
hh acquired fuel wood trees	0.416	1.000	0.907	1.000	0.178	1.000
total expenditure on tree samplings	0.801	1.000	0.105	1.000	0.136	1.000
total expenditure on fertilizer trees			0.036	0.956	0.219	1.000
total expenditure on fruit trees	0.553	1.000	0.242	1.000	0.510	1.000
total expenditure on fuel wood trees	0.420	1.000	0.166	1.000	0.131	1.000
hh planted trees on operated land	0.794	1.000	0.204	1.000	0.131	1.000
# trees planted on operated land	0.699	1.000	0.483	1.000	0.152	1.000

Annex 6. Unadjusted and Sidak-Holm adjusted p–values for baseline comparisons

hh received info on agro-forestry	0.532	1.000	0.375	1.000	0.978	1.000
assets owned by the hh	0.775	1.000	0.066	0.994	0.332	1.000
hh owns hand hoe	0.950	1.000	0.138	1.000	0.163	1.000
hh owns slasher	0.477	1.000	0.000	0.000	0.000	0.000
hh owns axe	0.241	1.000	0.660	1.000	0.744	1.000
hh owns ox cart	0.214	1.000	0.000	0.000	0.008	0.703
hh owns ox plough	0.568	1.000	0.115	1.000	0.248	1.000
hh owns generator or motorised pump	0.460	1.000	0.115	1.000	0.099	1.000
hh owns scotchcart						
hh owns tractor	0.362	1.000	0.362	1.000	0.272	1.000
hh owns sprayer	0.391	1.000	0.538	1.000	0.598	1.000
hh owns panga knife	0.123	1.000	0.000	0.000	0.003	0.363
hh owns micro-solar water pumps	0.679	1.000	0.788	1.000	0.507	1.000
hh owns sickle	0.949	1.000	0.000	0.000	0.000	0.000
hh owns treadle pump	0.690	1.000	0.006	0.482	0.022	0.946
hh owns watering can	0.802	1.000	0.000	0.000	0.000	0.000
principal component analysis	0.804	1.000	0.097	0.999	0.421	1.000
hh has aquired any inputs	0.553	1.000	0.000	0.000	0.000	0.000
total expenditure on inputs	0.790	1.000	0.000	0.000	0.000	0.000
voucher value purchase inputs, MWK	0.712	1.000	0.000	0.000	0.000	0.007
hh used aip as primary source to buy input	0.598	1.000	0.350	1.000	0.784	1.000
hh acquired maize seeds	0.878	1.000	0.019	0.833	0.151	1.000
hh acquired legume seeds	0.920	1.000	0.000	0.000	0.000	0.001
hh acquired other seeds	0.974	1.000	0.000	0.000	0.000	0.004
hh acquired pesticides	0.191	1.000	0.693	1.000	0.054	0.996
hh acquired organic fertilizer / manure	0.556	1.000	0.641	1.000	0.100	1.000
hh acquired basal fertilizer	0.800	1.000	0.000	0.000	0.000	0.000
hh acquired top-dressing fertilizer	0.258	1.000	0.000	0.000	0.000	0.000

Annex 6. Unadjusted and Sidak-Holm adjusted p–values for baseline comparisons

hh acquired land rent-in	0.252	1.000	0.206	1.000	0.062	1.000
hh acquired herbicides	0.227	1.000	0.053	0.985	0.272	1.000
hh acquired crop inputs	0.580	1.000	0.000	0.000	0.000	0.000
hh acquired livestock inputs	0.122	1.000	0.233	1.000	0.386	1.000
hh acquired fertilizers	0.679	1.000	0.000	0.000	0.000	0.000
hh acquired improved seeds	0.980	1.000	0.003	0.263	0.022	0.946
HH has borrowed money from any person or istitution	0.732	1.000	0.000	0.036	0.001	0.135
HH aquired any agricultural inputs on credit	0.774	1.000	0.072	0.996	0.264	1.000
HH member is in a group of savings and loans schemes	0.183	1.000	0.000	0.001	0.019	0.946
# shocks experienced by the hh in the last 9 years	0.910	1.000	0.001	0.137	0.001	0.078
shock index	0.800	1.000	0.001	0.133	0.000	0.029
# climate shocks experienced by the hh in the last 9 years	0.855	1.000	0.000	0.006	0.000	0.004
climate shock index	0.764	1.000	0.000	0.002	0.000	0.000
shock experienced: drought	0.965	1.000	0.001	0.110	0.005	0.518
shock experienced: fires	0.762	1.000	0.673	1.000	0.724	1.000
shock experienced: flood	0.599	1.000	0.790	1.000	0.918	1.000
shock experienced: windstorm	0.431	1.000	0.004	0.399	0.359	1.000
shock experienced: thunder storm	0.803	1.000	0.040	0.966	0.044	0.996
shock experienced: hail storm	0.478	1.000	0.009	0.598	0.001	0.082
shock experienced: heavy rains	0.463	1.000	0.629	1.000	0.487	1.000
shock experienced: sporadic rains	0.880	1.000	0.002	0.168	0.002	0.241
shock experienced: erosion	0.407	1.000	0.023	0.876	0.277	1.000
shock experienced: landslide	0.658	1.000	0.091	0.999	0.041	0.996
shock experienced: heat wave	0.680	1.000	0.000	0.000	0.000	0.000
shock experienced: cold wave	0.848	1.000	0.384	1.000	0.180	1.000
shock experienced: insect pests / diseases	0.160	1.000	0.000	0.002	0.000	0.004
shock impact: big/very big	0.097	1.000	0.000	0.000	0.036	0.996
rainfall precipitations, last growing season	0.241	1.000	0.000	0.000	0.000	0.000
rainfall precipitations, last 12 months	0.317	1.000	0.000	0.000	0.000	0.000
SPI 6	0.202	1.000	0.000	0.000	0.000	0.000
# of SPI 6 with very wet conditions	0.344	1.000	0.000	0.000	0.000	0.000
# of SPI 6 with moderately wet conditions	0.997	1.000	0.260	1.000	0.251	1.000
# of SPI 6 with very dry conditions	0.685	1.000	0.000	0.000	0.000	0.000
# of SPI 6 with moderately dry conditions	0.825	1.000	0.000	0.000	0.000	0.000
# of SPI 6 with very wet/dry conditions	0.399	1.000	0.000	0.037	0.341	1.000
# of SPI 6 with moderately wet/dry conditions	0.949	1.000	0.000	0.000	0.000	0.000
# of SPI 6 with extreme/very/moderately wet/dry conditions	0.109	1.000	0.000	0.000	0.000	0.000
<u>After COVID-19 income from:</u>						
farming decreased	0.717	1.000	0.002	0.201	0.071	1.000
farming stayed the same	0.679	1.000	0.007	0.512	0.169	1.000

Annex 6. Unadjusted and Sidak-Holm adjusted p–values for baseline comparisons

non-farm activities decreased	0.550	1.000	0.003	0.329	0.016	0.840
non-farm activities stayed the same	0.585	1.000	0.007	0.523	0.015	0.823
wage employment decreased	0.446	1.000	0.038	0.962	0.556	1.000
wage employment stayed the same	0.347	1.000	0.049	0.981	0.729	1.000
remittances decreased	0.772	1.000	0.302	1.000	0.153	1.000
remittances stayed the same	0.697	1.000	0.257	1.000	0.101	1.000
Postponed agricultural investment after the COVID-19 pandemic	0.785	1.000	0.006	0.496	0.063	1.000
Used savings after the COVID-19 pandemic	0.256	1.000	0.000	0.000	0.000	0.000
Sold assets after the COVID-19 pandemic	0.136	1.000	0.762	1.000	0.249	1.000
Borrowed after the COVID-19 pandemic	0.703	1.000	0.006	0.490	0.004	0.406
hh member suspected to be ill of the COVID-19 pandemic	0.726	1.000	0.767	1.000	0.621	1.000

Note: FFS: farmer field school; C: comparison group; T2: FFS+inputs group; hh: household; MKW: Malawian Kwacha; ac: acres; kg: kilograms; SPI: Standardized Precipitation Index.
Source: Authors' elaboration from survey data.

FAO, together with its partners, is generating evidence on the impacts of coordinated agricultural and social protection interventions and is using this to provide related policy, programming and capacity development support to governments and other actors.

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