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Comparative Impacts of Input Subsidies, Irrigation Investments, and Social Cash Transfers on Food and Nutrition Security in Malawi

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Abstract

This study examines the impact of farm input subsidies, food and cash transfers, and irrigation investments on the dietary diversity, food consumption scores, and coping strategy index in Malawi. Despite the potential for synergies to address a range of vulnerabilities affecting food consumption, very few studies focus on combined program effects. The analysis employs three-waves of integrated household panel surveys for Malawi from 2013, 2016, and 2019, and uses instrumental variable Poisson and Tobit regression to address endogeneity. The findings show weak joint program participation effects, which may be due to program design or data limitations in this evaluation. Households that receive food and cash transfers showed improvements in diet diversity and the food consumption score. Input subsidies were less effective in helping households cope with food insecurity and reduced diet diversity and the food consumption score. This suggests that overreliance on agricultural input subsidies may lead to reduced variety in food consumption. Policies that are aimed at more linkages between programs should also diversity and rebalance public spending to reduce food and nutrition insecurity.

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Comparative Impacts of Input Subsidies, Irrigation Investments, and Social Cash Transfers on Food and Nutrition Security in Malawi

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1. Introduction

Addressing food and nutrition insecurity is one of the global priorities outlined in the sustainable development goals, due to its implications for social and economic advancement of communities (FAO et al., 2020). However, its accomplishment is threatened by several issues. For example, risks of droughts and floods made worse by climate change and weather unpredictability make people more vulnerable to production, livelihood, and asset losses (Aderinto, 2023; FAO, IFAD, UNICEF, WFP, & WHO, 2018). Food production strategies are constrained by economic shocks linked to the growing debt crisis, pandemics and disruption of supply chains due to localized and global conflicts (Bizikova et al., 2022; De Weerdt & Duchoslav, 2022; Poole et al., 2021; UNCTAD, 2023). In addition to having serious repercussions on hunger and nutrition, the situation makes it difficult for countries' food systems to provide better, more affordable, and sustainable diets—in line with global aspirations (FAO et al., 2020).

Several African countries, including Malawi, use agricultural input subsidy programs (AISP) as a strategy to increase the productivity and incomes of resource-constrained smallholder farmers (Jayne et al., 2018). In Malawi, the program constitutes between 40 and 70 percent of the Ministry of Agriculture's budget and approximately 10% of the national budget (Chirwa & Dorward, 2013). The recent national budget allocated 6.87 percent of the resources to the subsidy program (GoM, 2023). While this is in keeping with the Malabo commitment to spend at least 10 percent of budget resources in agriculture (Chinsinga, 2012; Global Panel on Agriculture and Food Systems for Nutrition, 2022), there are several gaps with the subsidies model. More broadly, public investments in irrigation, research, and agricultural extension —all important for fostering agricultural growth and poverty reduction are precluded by the emphasis on input subsides (Holden, 2019; Jayne, Mather, & Mghenyi, 2010). This is apart from the general financing gaps to address food security concerns in the longer term (Bizikova et al., 2022). Further, the narrow focus of the program on subsidizing inorganic fertilizers for growing the staple crop maize is associated with limited diversification of production (Chibwana, Fisher, & Shively, 2012; Fisher & Kandiwa, 2014; Kankwamba, Kadzamira, & Pauw, 2018) which according to Ickowitz et al. (2019) may reduce the variety of foods available for consumption in this context where the majority of the population produce own food for survival. In relation to this, there are challenges with shifting dietary preferences away from maize in Malawi (Aberman & Roopnaraine, 2020; Chirwa & Dorward,

2013; Verduzco-Gallo, Ecker, & Pauw, 2014). Even with a low maize prices and higher incomes that can support wider food purchasing, there is still a lack of variety in consumption diets (Ecker & Qaim, 2011; Matita et al., 2023). Similarly, production patterns have not changed much with incentives for growing nutrient-rich crops such as legumes (Ortega et al., 2016; Waldman et al., 2017). Addressing hunger often takes precedence over diversifying diets which is linked to micronutrient deficiencies and ensuing health effects (Nuss & Tanumihardjo, 2010; Poole et al., 2021; Verduzco-Gallo et al., 2014). For instance, 37 percent of children under the age of five are stunted, only 25 percent meets the minimum dietary requirements, and female obesity is on the rise, a contributing factor to non-communicable diseases (NSO & ICF, 2017). Depending on context and the measure used, the evidence regarding the effects of AISP on food and nutrition security has also been mixed. While some studies (Chakrabarti et al., 2024; Harou, 2018; Mason et al., 2020; Matita et al., 2022; Mwale et al., 2022; Snapp & Fisher, 2015; Tione et al., 2022) show positive effects, others (Hemming et al., 2018; Karamba, 2013; Ragasa & Mazunda, 2018; Jacob Ricker-Gilbert & Jayne, 2017; Walls et al., 2018) report weak and inconsistent results. Increasingly, more marginal lands are being cleared for the cultivation of maize and soil health is at risk because the subsidies are not tied to any initiative to improve the environment (Holden, 2018). Thus, the effectiveness of standalone AISP is in question. This study therefore examines whether integrating input subsides with other interventions, such as irrigation schemes and social transfers, can result in improved food and nutrition security indicators (dietary diversity, food consumption scores, coping strategy index).

The combined effects of such interventions are only occasionally evaluated by studies (Matita & Chirwa, 2014; Pace et al., 2017; Shigute, Strupat, Burchi, Alemu, & Bedi, 2019; Thome, Filipski, Kagin, Taylor, & Davis, 2013; Thome, Taylor, & Filipski, 2014). For example, Pace et al. (2018) taking advantage of random assignment of participants to a social cash transfer program (SCTP) in Malawi, assessed the joint effects of the program with input subsidies. They found that participating in both programs can improve household expenditures, livestock, and agricultural productivity. Specifically, among households without labor constraints, the number of meals per day was higher for those who received input subsidies and cash transfers. Similarly, synergies between a community health insurance program and Ethiopia's productivity safety net program were reported by Shigute et al. (2019). The effects on labor supply, the number of livestock holdings, and the utilization of health care facilities were all favorable. According to an impact

simulation study by Thome et al. (2014), integrating input subsidies with SCTP in Malawi has larger multiplier effects on income than implementing the programs separately. Specifically, even though SCTP targets households with fewer productive assets, its benefits for production are amplified. Similarly, households receiving subsidies found it easier to obtain inputs with reduced liquidity constraints when they took part in both programs. A review by Tirivayi et al. (2016) concurs that combining social protection and agricultural programs builds synergies for increased food security, incomes, and crop productivity to a greater extent than when implemented in isolation. Development practitioners are also made aware of the importance of harmonizing these programs by comparing and contrasting their features that can be utilized to enhance food and nutrition security in Malawi (Ellis & Maliro, 2013; Matita & Chirwa, 2014). This is particularly relevant because, depending on the context, the effects frequently vary and involve trade-offs between different policy instruments (Qureshi, Dixon, & Wood, 2015). For instance, public investments in irrigation and roads lift more individuals above the poverty line in India than input subsidies (Akber, 2020), in contrast to Uganda, where agricultural research and education was more effective (Pauw & Thurlow, 2015).

Figure 1 conceptualizes likely impact pathways from various public interventions supporting crop production and enabling exchange entitlement and their influence on food and nutrition security outcomes. For production-based investments such as input subsidies and irrigation infrastructure, the anticipated results might include increased agricultural productivity and potentially higher incomes for farmers (Hemming et al., 2018), but with trade-offs in terms of environmental impact (Slater, Baker, & Lawrence, 2022). In contrast, transfer-based policies are expected to directly improve household purchasing power and food access, potentially leading to immediate improvements in food security and dietary diversity (Baird, McIntosh, & Özler, 2019; Brugh et al., 2017; Miller et al., 2011; Tiwari et al., 2016). However, the fungibility of cash transfers may have unintended consequences if a person chooses to buy unhealthy foods or non-food items that do not improve food and nutrition outcomes. Production and transfer-based policies may interact and be optimized together for a synergistic effect on food and nutrition security. For example, increased agricultural productivity (a result of production-based policies) could be complemented by enhanced market access and purchasing power (outcomes of transfer-based policies). This combination could lead to a more substantial and sustainable improvement in food and nutrition security, beyond what might be achieved by either stream in isolation.

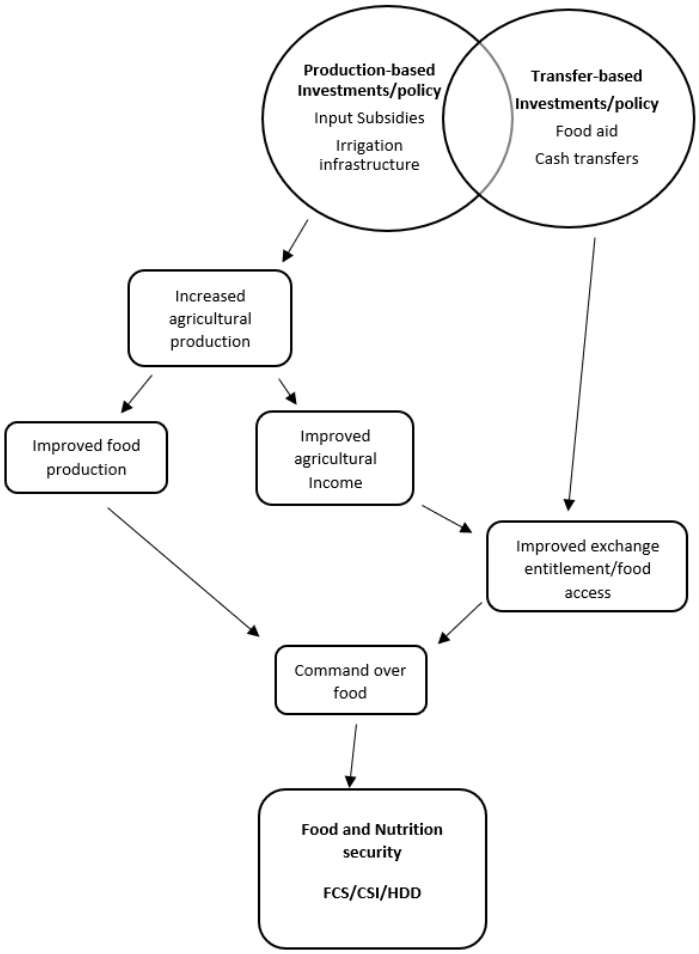

Figure 1: Conceptual framework linking public investments to food and nutrition security.

2 Background to the programs in Malawi

2.1 Farm input subsidy programs

Malawi has a history of implementing input subsidies before and after the structural adjustment programs of the 1980s to address hunger. The programs have been changing in targeting criteria and name, including the Drought Recovery Inputs Programme (DRIP), Supplementary Inputs Programme (SIP), Targeted Input Subsides (TIP), universal subsidy program to Farm Input Subsidy Programme (FISP) (Nkhoma, 2018). The FISP implemented in Malawi for 15 years (2005-2020) was replaced with the Affordable Inputs Programme (AIP) in 2020 following the change of government from the Democratic Progressive Party to the Tonse Alliance. However, the tenet of the program remains essentially the same. The input subsidies aim at increasing

agricultural production and incomes of smallholder farmers (Chirwa & Dorward, 2013). The program provides two 50 kg bags of inorganic fertilizers to farmers and a choice of improved maize and legume seeds; however, the successor program AIP no longer makes legume seeds available due to fiscal challenges. The AIP has also introduced alternative cereals such that farmers have a choice of improved seeds for maize or rice or sorghum. With growing concern about climate change, there is a greater need than ever for drought tolerant crops specified as sorghum, millet, cassava, and potatoes to increase diversity (CIAT and World Bank, 2018). Small ruminants, mainly goats, are also featured in the AIP for selected districts. Thus, opportunities exists to move the program away from the bias on subsidies for maize in line with government agricultural transformation agenda (GoM, 2020). Other changes aim to improve beneficiary targeting, with a focus on productive poor farmers—unlike in the past, when target groups included resource poor and vulnerable households (Holden & Lunduka, 2012; Logistics Unit, 2017). It remains to be seen if the program successfully includes the productive poor and excludes those farmers unable to effectively use the inputs. In the same vein, possible program graduation was not stated or included in the program design. There is limited private sector involvement in the program, which could cause input market disruption (Mason & Ricker-Gilbert, 2013; J Ricker-Gilbert, Jayne, & Chirwa, 2011). Other challenges relate to the late distribution/ delivery of inputs and network connectivity issues at market outlets since the national registration system is used for identifying farmers (Centre for Development Management (CDM), 2017).

2.2 Social cash transfer programs

Malawi's government implements an unconditional social cash transfer program (SCTP) with the objective of increasing school enrollment and alleviating poverty and hunger. The program targets ultra-poor households – those unable to meet basic needs and labor constrained. The SCTP started as a pilot project in Mchinji district in 2006. By September 2017, the program had expanded to 18 out of the 28 districts in the country (Pace et al., 2017). Currently, the program has national coverage and benefits 1.3 million people from 300,800 ultra-poor households (GoM, 2022). The government estimates an average household benefit of MK9000 (equivalent to 5 USD; 1USD=MK1700) that has since increased to MK14,919 per month.[4] The transfer amount is

[4] https://mtukula.com/content?view=18&pageName=Cash%20Transfers

adjusted by household characteristics and number of children in school. Finances for the program are largely sourced from development partners, and the government contributes 5 percent of the cost, just enough to cover one district only (UNICEF, 2022). The SCTP has also been a key instrument to respond to shocks such as floods/cyclone occurrence, lean season food inadequacy and the COVID-19 pandemic. Recent reforms being implemented include the use of unified beneficiary register and associated information management system. Further, the government is piloting an electronic payment system that is posed to replace cash payments at designated outlets. Innovations to the program framework are also being sought to make it more shock and nutrition sensitive (UNICEF, 2022).

2.3 Food aid

Food aid is another direct welfare transfer from government used to abate shock-induced hunger and food insecurity. The Malawi Vulnerability Assessment Committee (MVAC) estimates show that increasingly more people are vulnerable to food insecurity due to the occurrence of climatic shocks. For instance, the numbers have risen from 63,234 people in 2007/08 to 1.3 million in 2014/15 (GoM, 2015). A further increase to 6 million people in dire need of food assistance was reported in 2016/17 (GoM, 2017) which fell to 1.06 million in 2019/20 (GoM, 2019). Recent floods and dry spells have caused food insecurity for nearly a third of the population of almost 20 million people in 2022 (IPC, 2022). Apart from the cyclone Freddy that resulted in loss of crop in field, livestock, and livelihoods in 2022, the Malawi economy has been unstable. The Malawi kwacha lost half of its value against the US dollar and the associated increase in prices of basic commodities will spur further challenges to food access (FEWS NET, 2023). Therefore, the need for food aid distributed through MVAC response, public works programs, school meals, supplementary feeding or other programs is unprecedented. The government humanitarian response is coordinated by the Department of Disaster Management Affairs and typically provides cereals (maize), pulses (beans), cooking oil and nutritious food (corn soya blend). The supplementary feeding component often targets pregnant women and malnourished children at health centers.

2.4 Irrigation investments

Government irrigation investments enabled the establishment of both small- and large-scale irrigation projects across the country. Initially, extension workers from the Ministry of Agriculture managed the schemes. However, with structural reforms for reduced government intervention in the 1980s, farmers were organized into cooperatives to take up all management responsibilities (Nkhata, Jumbe, & Mwabumba, 2014). Thus, government irrigation policy shifted from government-owned schemes to farmer-managed schemes (GoM 2001). Increasingly, more land is being used for irrigation farming. As of 2016, about 41,053 hectares of land benefiting 348,572 smallholder farmers was used for irrigation farming (Chafuwa, 2018). Despite the increases, the irrigated land is estimated at only 36 percent of the potential 407,862 hectares (draft National Irrigation Policy, 2022). Recent government irrigation investments with credit financing include, among others, the ongoing Shire Valley Transformation Project supported by the World Bank in Nsanje and the Linga irrigating scheme in Nkhatabay supported by the African Development Bank. During the dry season, individual farmers also privately perform irrigated farming, often in wetlands and along rivers. This practice, known locally as "dimba cultivation," is a supplement to rain-fed agriculture for farming households having access to such land. This study considers only access to and use of government irrigation investments.

3 Data and methodology

3.1 Data sources

The study uses Living Standards and Measurement Study (LSMS) data for Malawi; panel data for the years 2013, 2016 and 2019. The 2013 survey was conducted between April and October 2013; the 2016 survey field work happened between April 2016 and April 2017, and the 2019 survey was conducted between April 2019 and March 2020. The surveys included individual and community questionnaires collecting data on agriculture, employment, and consumption assets, among others, to explain the living conditions of Malawians. In Malawi the surveys are conducted by the National Statistical office with support from the World Bank.

3.2 Empirical model

To estimate the impact of social protection and irrigation investment on food and nutrition security, we estimate a model of the following form:

$$FNS_{it} = \alpha_i + \beta_1 Interv1_{it} + \beta_2 Interv2_{it} + \beta_3 (Interv1_{it} * Interv2_{it}) + \sum \beta X_{it} + \varepsilon_{it} \quad (1)$$

Where FNS_{it} represents the food and nutrition security measure for an individual household *i* in the period of survey *t*. $Interv1_{it}$ and $Interv2_{it}$ captures the individual/stand-alone effects of participation in farm input subsidies program, social assistance program or public irrigation scheme. The combined effects of farm input subsidies with social protection or irrigation investment on food and nutrition security are assessed using the interaction term $(Interv1_{it} * Interv2_{it})$. Control variables including household socio-economic characteristics and location specific fixed effects are denoted by X_{it} whereas ε_{it} is the idiosyncratic error term.

3.3 Definitions of variables

3.3.1 Dependent variables

The study uses several measures of food and nutrition security, including household dietary diversity, food consumption score and coping strategy index. Household dietary diversity (DD) is the number of food groups consumed by a household in the past 7 days of the survey as per FAO (2011) guidance. Twelve food groups namely: cereals, roots and tubers, vegetables, fruits, meat/poultry/offal, eggs, fish and seafood, pulses/legumes/nuts, milk and milk products, oils/fats, sugar/honey, and Spices/condiments/beverages are used. The food consumption score (FCS) differs from the DD in that it considers the frequency and diversity of food groups consumed in the past seven days of the survey as well as their nutritional significance (Maxwell et al., 2014). According to the WFP (2008), a FCS 0 – 21 represents poor food security; 21.5 – 35 represents border line, and more than 35 represents acceptable food security. Households with a higher FCS are more food secure. The study also considers the coping strategy index (CSI), which is based on the frequency of use of different coping mechanism and severity weights (Maxwell et al., 2014). CSI is a proxy of food insecurity interpreted such that higher scores indicate greater use of coping mechanisms, hence higher food insecurity in a household.

3.3.2 Key independent variables

The main independent variables are production and cash transfers-based investments. Production policies under consideration include the input subsidies and irrigation investment measures. The study uses a dummy variable equal to one if a household received farm input subsidies (FISP/AIP), and zero otherwise. Irrigation investments are defined in two ways including a dummy variable representing presence of an irrigation scheme in a community and whether a household uses an irrigation scheme. The study also considers participation in social assistance programs, in particular receipt of cash transfer and/or food aid. Due to the modest sample sizes for each component, participation in the two social assistance programs was pooled to facilitate meaningful analysis.

Household characteristics include particulars of the household head (age, sex, years of schooling, main economic activity); household size and age structure composition in terms of the number of members in each age category, whether a member of household accessed any credit, extension services, ownership of durable asset and land holding size. The study accounts for location fixed effects by including variables such as the region of residence, agro-ecological zones, presence of a farmer organization in the community and distance to the nearest weekly market. These factors have been shown in the literature to affect households' food and nutrition security (Nandi, Nedumaran & Ravula, 2021).

3.4 Estimation strategy

Equation (1) can be estimated using simple ordinary least squares (OLS) methods. However, because selection into the intervention programs is non-random, estimates are likely to be biased. Endogeneity problems including those arising from selection bias, must be addressed in studies where participants are not randomly assigned to treatment and control groups (Gertler et al., 2016). Several methods, such as propensity score matching (PSM) (Ragasa & Mazunda, 2018), the control function procedure (Matita et al., 2022), instrumental variables and two-stage least squares (IV-2SLS) (Harou, 2018), have been employed in the literature to address endogeneity in input subsidies impact studies. The evaluation of social cash transfer programs is made easier by the widespread use of randomized controlled research designs. Associated studies employ PSM approach and difference-in-difference (DID) (Bastagli et al., 2019; Hoddinott, Berhane, Gilligan, Kumar, & Taffesse, 2012; Nisbett et al., 2017; Pace et al., 2017). Other studies on the impact of irrigation investment typically include endogenous switching regressions (Nkhata et al., 2014;

Nonvide, 2019) in addition to PSM methods (Dillon, 2010; Palmer-jones, 2012). Authors with time series data have also used lagged variables to address endogeneity (Akber, 2020; Akber, Paltasingh, & Mishra, 2022) in a systems estimation approach including seemingly unrelated regression and 3SLS; and the single equation approach (OLS and 2SLS). To compare and assesses the interactions of impacts of (i) input subsidies; (ii) irrigation infrastructure; and (iii) food/cash transfers implies that our modeling must address three endogenous variables. We could not, however, find an applicable econometric approach that can address selection bias of three variables at once. Therefore, the study resolved to assess individual effects and paired effects.

Table 1: Instrumental variables used in the models.

Endogenous variable	Instrumental variable used
Input subsidies	Member of Parliament visited the community in the past three months. Household head has always lived in village. Deviation of particular-year rainfall from long term median.
Cash transfers/food aid	Deviation of particular-year rainfall from long term median. Member of Parliament visited the community in the past three months.
Irrigation infrastructure	Deviation of particular-year rainfall from long term median. Whether the village chief receives payment for land use or sale Member of Parliament visited the community in the past three months.

For models assessing the impact of production and social assistance programs on household DD, the Poisson model is appropriate because the outcome of interest is a non-negative count variable (Woodridge, 2010). Models are estimated using instrumental variable Poisson regression (IV Poisson) via the generalized method of moments (GMM) consistent with a prior study by Karamba (2013). This approach further allowed us to account for two endogenous variables in the estimation and assess joint effects of the interventions. Several instrumental variables are used depending on the endogenous variable under consideration as summarized in Table 1. For instance, receipt of a farm input subsidy is instrumented with three variables, namely: Member of Parliament visited the community in the past three months, household head has always lived in village and deviation of

particular-year rainfall from the long-term median.[5] The choice of IV is consistent with existing literature (Fisher & Kandiwa, 2014; Harou, 2018; Karamba, 2013; Ragasa & Mazunda, 2018; Sibande et al., 2017). The variables also reflect the social and political capital that influences access to subsidized inputs.

Provision of irrigation infrastructure is a less endogenous in the sense that household behavior may not be integrated in the policy choice to make the investment. However, it becomes an issue if the government targets locations with specific characteristics; for instance, locations that are dry or with the poorest communities. This may dampen the impact estimates. Therefore, our modeling accounts for geospatial indicators reflecting agroecological zones. We additionally include a variable for whether the village chief receives payment for land use or sale as one of the IVs. The actions of the chief may facilitate access to irrigatable land for some individuals but may not alter household food consumption. The instrumental variables validity is checked using the IV-2SLS for panel-data models since the IV Poisson method does not produce post estimation tests. The combined effects of the interventions are assessed by including interaction terms in the models.

Models estimating program effects on food consumption scores are estimated using single-equation instrumental-variables regression via the GMM to take advantage of pooled data. Additional analysis considers food and nutrition security as measured by coping strategies using Tobit estimation. A comparison of the panel Tobit model with the pooled Tobit model using the likelihood-ratio test shows that there were panel-level effects in the relationship; hence, results based on panel data analysis are reported.

4 Results

4.1 Descriptive statistics

Table 2 presents the descriptive statistics for the pooled sample. On average, households consumed food from 8 food groups and the maximum was 12 food groups. The consumption of 8 food groups compares well with other national-level studies (Jones et al., 2014; Matita et al., 2022). The mean FCS was 49, which indicates that food and nutritional insecurity are not severe but visible. The proportion of households with borderline and poor food security situation were 20.4 and 2.5

[5] Long-term median rainfall data is sourced from World Bank Group, Climate Change Knowledge Portal (2023). URL: https://climateknowledgeportal.worldbank.org/.

percent of the sample, respectively. Close to 77.1 percent reported acceptable levels of food security. About coping with food shortages, at least 61 percent of the sample used some coping strategy in the past week of the survey to deal with food insecurity. The average score was 6 with a maximum of 56. Our finding of a lower CSI, and a higher FCS and HDD is in line with consensus that there is inverse relationship between CSI and other related scores (Maxwell, 2008).

Table 2:Food and Nutrition indicators and programme participation

Variable	Overall mean	SD	Min	Max
Household dietary diversity	8.058	2.017	1	12
Food consumption score	49.28	18.53	8	126
Coping strategy index	5.664	7.603	0	56
Received subsidized inputs (1/0)	0.280	0.449	0	1
Received food/cash transfer (1/0)	0.115	0.319	0	1
Community has irrigation scheme (1/0)	0.133	0.340	0	1
HH uses irrigation scheme (1/0)	0.032	0.177	0	1
Subsidized inputs*irrigation scheme presence (1/0)	0.037	0.188	0	1
Subsidized inputs*use of irrigation scheme (1/0)	0.012	0.107	0	1
Subsidized inputs*share of HH in irrigation scheme	0.001	0.007	0	0.09
Subsidized inputs*food/cash transfer (1/0)	0.042	0.200	0	1
Food/cash transfer*irrigation scheme presence (1/0)	0.015	0.120	0	1
Food/cash transfer*share of HH in irrigation scheme	0.001	0.013	0	0.30
Food/cash transfer*HH use an irrigation scheme (1/0)	0.004	0.066	0	1
Received cash transfer	0.028	0.164	0	1
Received food aid	0.087	0.282	0	1
Number of observations	3009			

Notes: HH=household

About 28 percent of the sample received subsidized farm inputs. Government transfers were accessible to few households; 3 percent received cash transfers and 9 percent obtained food aid. In the econometric analysis we considered receipt of either cash transfers and/or food aid representing 11 percent of the sample. The presence of an irrigation schemes in a community was reported by 13 percent of the sample and only 3 percent have access to use the schemes. Joint program participation is minimal in the sample. For example, only 4 percent of households reporting presence of an irrigation scheme in their community received input subsidies. According to pairwise correlation in Table 3, receiving input subsidies is weakly associated with use of irrigation scheme ($p<0.10$). The proportion using the irrigation schemes and benefiting from the subsidy program is far less at only 1.2 percent. A qualitative assessment of the eligibility of SCTP

beneficiaries for other social assistance programs demonstrates that while stakeholders support multiple program participation to enhance possibility of graduation, informal rules of exclusion are promoted by chiefs and communities in the targeting process (Chirwa et al., 2016).

Our estimates show that participation in both cash transfer and input subsidy programs is limited to only 4 percent of the sample with no significant correlation. There is, however, strong positive correlation between receiving food aid and input subsides ($p<0.01$) suggesting that households might concurrently benefit from the programs.

Table 3: Pairwise correlation of programme participation

	Received subsidized inputs (1/0)	HH use an irrigation scheme (1/0)	Irrigation scheme presence (1/0)
HH use an irrigation scheme (1/0)	0.0323*	-	-
Irrigation scheme presence (1/0)	-0.0029	-	-
Food aid and/or cash transfer (1/0)	0.0688***	0.0115	-0.0035
Food aid	0.0795***	0.0237	-0.0052
Cash transfer	-0.0060	-0.0193	0.0005

Notes: HH=household. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4 presents mean differences in food and nutrition measures by program participation. We observe that although households receiving input subsidies cope less with food insecurity, their FCS is significantly lower. A significantly lower FCS and DD as well as an increase in usage of coping strategies to address food insecurity is linked to presence and use of an irrigation scheme. Further, receiving food/cash transfers is associated with higher DD; but such households cope significantly more with food insecurity.

Table 4: Mean differences in food and nutrition security measures by programme

	Household dietary diversity	Food consumption score	Coping strategy index	*Number of observations*
Received subsidized inputs (yes)	8.144	48.27	5.24	846
Received subsidized inputs (no)	8.024	49.81**	5.83**	2163
HH use an irrigation scheme (yes)	7.89	45.83	6.16	97
HH use an irrigation scheme (no)	8.06	49.50**	5.65	2912
Irrigation scheme presence (yes)	7.76	47.52	7.09	396
Irrigation scheme presence (no)	8.10***	49.66	5.45***	2613

Received food/cash transfer (yes)	8.23	50.82	6.71	343
Received food/cash transfer (no)	8.04*	49.19	5.53***	2666
Food aid (yes)	8.58	52.29	5.79	262
Food aid (no)	8.01***	49.10**	5.65	2747
Cash transfer (yes)	7.12	45.99	9.61	83
Cash transfer (no)	8.08***	49.47*	5.55***	2926

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Our modeling approach also controlled for several variables whose descriptive statistics are reported in Table 5. Majority of the household heads (74%), who are on average 44 years old and have seven years of schooling, are men. On average a household with five members cultivates 1.9 acres of land. Only 25 percent of the sample accessed credit, although over half received extension services (68%).

Table 5: Descriptive statistics for pooled sample

Variable	Mean	Std. Dev.	Min	Max
Age of household head (years)	44.06	15.98	10	104
Male headed household 1/0)	0.735	0.441	0	1
Household size	4.995	2.195	1	16
Years of education for the head	7.152	3.725	0	23
Number of household members 0-5 years	0.872	0.841	0	5
Number of household members 6-14 years	1.168	1.175	0	8
Number of household members 15-55years	2.410	1.298	0	9
Number of household members 56	0.412	0.689	0	4
Wage employment (1/0)	0.130	0.336	0	1
Business employment (1/0)	0.107	0.310	0	1
Agriculture employment (1/0)	0.591	0.492	0	1
Asset index	0.794	4.263	-.042	23.22
Distance to nearest weekly market	7.605	5.745	0	37
Number of crops cultivated	2.632	1.397	0	9
Received any extension service (1/0)	0.680	0.466	0	1
Received credit (1/0)	0.246	0.431	0	1
Farmland size (acreage)	1.780	1.604	0	18
Southern region (1/0)	0.494	0.500	0	1
Central region (1/0)	0.387	0.487	0	1
Number of observations	3021			

4.2 Regression results

We present summarized results on a set of food and nutrition measures including household dietary diversity, food consumption scores and coping strategy index in Tables 6, 7 and 8, respectively. Detailed models are added in appendix (Tables A1 – A3). The models presented are all jointly statistically significant at 1 percent level as indicated by the obtained log-likelihood ratio chi-squared statistic. The included IV passes the validity tests and the test of endogeneity was significant. Two endogenous variables are considered in each paired analysis. All models include control variables such as household socio-economic characteristics and location-fixed effects.

4.2.1. Effects of interventions on household dietary diversity

Table 6 reports the effects of various interventions on household dietary diversity estimated using IV Poisson regression. We find that there are no statistically significant joint effects on dietary diversity from participation in any of the programs under consideration. However, receiving food/cash transfers improves food consumption ($p<0.01$). The results suggest households receiving food/cash transfers consume additional two food groups compared to those without such transfers (Panels C, D & F).[6] Nonetheless, this significant stand-alone effect driven by food aid does not persist when food/cash transfers are considered in combination with other interventions. For instance, the results show that households receiving food/cash transfers in communities where an irrigation scheme exist do not experience dietary diversity that is significantly different from those in communities without irrigation scheme and not receiving government social transfers.

Table 6: Effects of interventions on household dietary diversity

Dependent var: HDD	Model1	
	IRR	SE
Panel A		
Received subsidized farm inputs (1/0)	1.348	(0.317)
HH uses an irrigation scheme (1/0)	1.509	(0.925)
Subsidized inputs*use of irrigation scheme (1/0)	0.550	(0.397)
Panel B		
Received subsidized farm inputs (1/0)	1.348	(0.277)
Community has irrigation scheme (1/0)	1.183	(0.438)

[6] Further analysis of separate regressions for food aid and cash transfers showed that this result is largely driven by food aid. The same result is obtained when we use the quantity of subsidized fertilizers received as reported in Table A4.

Subsidized inputs*community has irrigation scheme (1/0)	0.690	(0.299)
Panel C		
Received subsidized farm inputs (1/0)	0.808	(0.321)
Received food/cash transfer (1/0)	2.072***	(0.528)
Subsidized inputs*food/cash transfer (1/0)	0.660	(0.237)
Panel D		
Community has irrigation scheme (1/0)	0.706	(0.375)
Received food/cash transfer (1/0)	1.738***	(0.287)
Irrigation scheme*food/cash transfer (1/0)	0.858	(0.447)
Panel E		
Received food/cash transfer (1/0)	1.810***	(0.300)
HH uses an irrigation scheme (1/0)	1.401	(0.773)
HH use an Irrigation scheme*food/cash transfer (1/0)	0.443	(0.263)

Notes: All models include control variables such as household characteristics and location fixed effects.
HH=household. Exponentiated coefficients. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.2.2 Effects of interventions on food consumption

Table 7 shows the effects of different interventions on food consumption scores generated from IV Poisson regression. We find positive joint effects on FCS are lacking. In other words, there are no significant combined effects on food consumption scores from investing in irrigation and receiving input subsidies. Additionally, the findings demonstrate that households are significantly disadvantaged in FCS when they combine participation in input subsidies with food/cash transfers (Panel C). Households receiving input subsidies as well as food/cash transfers experience reduced FCS by a margin of 55 points ($p<0.10$). However, receiving food/cash transfers alone has significant favorable benefits on FCS (Panel C, D & F), implying that household receiving government food/cash transfers experience greater balance in food consumption. This finding is also obtained when we use quantity of subsidized fertilizers (Table A5).

Table 7: Effects of interventions on food consumption score

Dependent var: FCS	Model 1	
	Coef.	SE
Panel A		
Received subsidized farm inputs (1/0)	29.146	(20.216)
HH uses an irrigation scheme (1/0)	72.026	(67.444)
Subsidized inputs*use of irrigation scheme (1/0)	-90.862	(77.749)
Panel B		
Received subsidized farm inputs (1/0)	31.290	(20.468)
Community has irrigation scheme (1/0)	47.295	(36.394)
Subsidized inputs*community has irrigation scheme (1/0)	-66.622	(44.156)

Panel C		
Received subsidized farm inputs (1/0)	-12.241	(21.464)
Received food/cash transfer (1/0)	72.839**	(35.939)
Subsidized inputs*food/cash transfer (1/0)	-55.317*	(31.705)
Panel D		
Community has irrigation scheme (1/0)	2.341	(23.620)
Received food/cash transfer (1/0)	45.362***	(16.032)
Irrigation scheme*food/cash transfer (1/0)	-40.182	(26.488)
Panel E		
Received food/cash transfer (1/0)	47.961***	(17.949)
HH uses an irrigation scheme (1/0)	45.316	(50.633)
HH use an Irrigation scheme*food/cash transfer (1/0)	-86.161	(57.079)

Notes: All models include control variables such as household characteristics and location fixed effects. Obtained coefficients are the same as conditional marginal effects (dy/dx); Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.2.3 Effects of interventions on coping mechanisms

Table 8 presents panel Tobit estimates of the effects of social assistance and irrigation investments on food and nutrition security as measured by coping strategy index. The results indicate no significant combined effects from multiple program participation. However, receiving input subsidies alone has significant effect on a household's ability to cope with food insecurity (Panel A & C). For example, households receiving input subsidies cope between 13-16 percent less with food poverty on average. Conversely, receiving food/cash transfers is linked to significant use of coping mechanisms. On average, beneficiaries of food/cash transfers cope 21-26 percent more with food and nutrition insecurity ($p<0.05$). A finding also noted in Table A6 where we use quantity of subsidized fertilizers received.

Table 8: Effects of interventions on coping with food insecurity

Dependent var: CSI	Model2	
	Coef.	SE
Panel A		
Received subsidized farm inputs (1/0)	-0.135*	(0.074)
HH uses an irrigation scheme (1/0)	-0.318	(0.217)
Subsidized inputs*use of irrigation scheme (1/0)	0.267	(0.360)
Panel B		
Received subsidized farm inputs (1/0)	-0.115	(0.077)
Community has irrigation scheme (1/0)	-0.001	(0.108)
Subsidized inputs*community has irrigation scheme (1/0)	-0.094	(0.203)
Panel C		

Received subsidized farm inputs (1/0)	-0.158**	(0.078)
Received food/cash transfer (1/0)	0.144	(0.120)
Subsidized inputs*transfer (1/0)	0.182	(0.200)
Panel D		
Received food/cash transfer (1/0)	0.257**	(0.104)
Community has irrigation scheme (1/0)	0.026	(0.098)
Irrigation scheme*food/cash transfer (1/0)	-0.412	(0.283)
Panel E		
Received food/cash transfer (1/0)	0.224**	(0.099)
HH uses an irrigation scheme (1/0)	-0.159	(0.187)
HH use an Irrigation scheme*food/cash transfer (1/0)	-0.548	(0.503)

Notes: All models include control variables such as household characteristics and location fixed effects. Because the dependent variable is log transformed the obtained coefficients can be interpreted in terms of percentage change. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5 Discussion and conclusion

A growing number of Malawian households are experiencing food and nutrition insecurity because of recent COVID-19 threats, supply chain disruptions caused by wars like the one between the Russian Federation and Ukraine, and climate shocks that result in the loss of produce, livestock, and livelihoods. Furthermore, the recent devaluation of the Malawi kwacha relative to the US dollar has made the macroeconomic environment even more dire, making it difficult to afford nutritious foods. Public programs to achieve food and nutrition security include provision of input subsidies, establishment of irrigation infrastructure and direct welfare transfers in form of food or cash. Prior evaluation of these programs found a positive association with food and nutrition security; however, there is a dearth of studies evaluating the impacts of participating in multiple programs (Tirivayi et al., 2016). We extend the literature by comparing and assessing the combined effects of social protection and irrigation investments using integrated household panel surveys for three years.

Overall, the findings suggest weak and insignificant joint effects from participating in several programs. In particular, the availability of irrigation infrastructure in a community and its use by households that receive food/cash transfers or input subsidies have no influence on food and nutrition security outcomes. This is contrary to evidence demonstrating stand-alone positive effects of irrigation infrastructure on production, livestock and livelihoods (Fan, Gulati, & Thorat, 2008; Nkhata et al., 2014), but these are localized studies and did not focus on food and nutrition

security measures. It is also likely that the low coverage of the programs may be driving the counterintuitive results.

This study has also revealed that receiving input subsidies has no effect on DD, consistent with other studies suggesting the effects are indirect —that is, through the sale of maize, growing of nutrient rich crops, food expenditures or filling of the maize basket (Karamba, 2013; Matita et al., 2022; Smale, Thériault, Mason, & Mason, 2020; Snapp & Fisher, 2015). The finding about the lack of input subsidies effect on FCS, however, differs from Harou (2018), who reported that, depending on the number of vouchers received between 2008 and 2013, the effects are positive in Malawi. Nevertheless, a recent study by Chakrabarti et al. (2024) corroborates that the impacts of input subsidies on food and nutrition are largely indirect through improvements in productivity and income. Therefore, the lack of joint impacts may not necessarily reflect a lack of relationship but rather that the association is indirect between food security and the programs.

This study indicated that the combined effects of food/cash transfers and input subsidies on FCS are negative, which is contrary to study expectations. Especially in light of research showing that input subsidies raise household food production capacity while cash transfers address liquidity constraints, which when combined have positive incremental effects (Pace et al., 2017; Thome et al., 2014). Even then, the lack of influence of the two programs could be a manifestation of the characteristics of the beneficiaries. Since typically social cash transfer programs targets labor constrained households in Malawi, households receiving food assistance or cash transfers are already constrained. They lack the labor to use the subsidized inputs in their production. Furthermore, those receiving food/cash transfers are more vulnerable to food insecurity and sourcing food for consumption would take precedence over making efficient use of the subsidized inputs. There is also literature indicating that households that are food insecure in terms of meeting their calorie requirements are unlikely to respond to incentives to grow nutrient rich crops as well as participate in output marketing to earn income, both of which are key to improving the diversity of foods consumed (Aberman & Roopnaraine, 2020; Carletto, Corral, & Guelfi, 2017; Chirwa & Matita, 2012; Matita et al., 2022). Additionally, this is in keeping with Thome et al. (2014) that households with larger land holdings benefit more from the input subsidies and Pace et al.'s (2017) finding that positive synergies exists for labor unconstrained households receiving cash transfers and input subsidies. Therefore, the combined effects could be heterogeneous.

Additionally, looking across the indicators, we find that input subsidies have no effect on DD and FCS measures and are only useful in lowering the use of negative coping strategies, in keeping with Zingwe et al. (2021). It is likely that food availability assured through own-food production makes it less likely for households to use negative coping mechanisms, a finding also collaborated by Tirivayi et al. (2016) in a review of the linkages between social protection and agriculture. The notion that the CSI captures more food quantity than quality helps to further explain this (Vaitla et al., 2017). The CSI is therefore more sensitive to input subsidies, as subsidies in Malawi aim at increasing the quantity of maize. In other words, subsidizing farm inputs for growing maize increases food monotony rather than diversification, which is also demonstrated by Chakrabarti et al. (2024). Conversely, receipt of food/cash transfers is associated with increased use of negative food coping mechanisms and positively impacts both DD and FCS – measures of diversity of dietary intake. This exemplifies how cash/food transfers may not be sufficient to promote other dimensions of food and nutrition security in Malawi. Providing food/cash transfers supports market purchases and consumption of a wider variety of foods at home but not the quantity of food consumption.

There are very few collaborative programs in Malawi that encompasses both production- and transfer-based instruments. This results from, among other things, the structural or inherent distinctions in the program designs, where the targeting of transfer-based programs focuses on a criterion linked to the characteristics of individuals or households. For instance, transfer-based instruments are primarily designed for ultra-poor and labor constrained households, whereas production-based instruments are purposed to enhance crop productivity among resource constrained smallholder farmers but with land (Harou, 2018). This implies that in as much as joint programs show significant impact elsewhere (Sulaiman, 2016), there are no deliberate efforts to consolidate these instruments into a unified approach in Malawi.

This study concludes that the combined effects of input subsidies, food/cash transfers, and irrigation investments on food and nutrition security are minimal. Therefore, there might not be many opportunities to build synergies between social assistance and irrigation investments through the existing stand-alone implementation model. Nevertheless, households simply receiving food/cash transfers showed improvements in food consumption and dietary diversity scores. In addition, input subsidies helped households to cope less with food insecurity even if the program

also reduced DD and FCS, suggesting that over-reliance on agricultural input subsidies leads to reduced variety in consumption. Although policy pursuits for more explicit linkages between programs are commendable, they might require addressing in parallel the need to diversify and rebalance public spending intended to reduce food and nutrition insecurity. This might include rebalancing spending toward food/cash transfers from high spending on agricultural input subsidies, sequencing interventions as well as targeting agricultural input subsidies to poor households receiving food/cash assistance that might make better use of these inputs.

The results of this study should be interpreted with caution. First, the various program impacts on food and nutrition security are largely indirect via crop production, productivity and likely income increases, pathways that have not been addressed in this study. Therefore, the weak joint program effects may be resulting from the indirect relation between the food security and the programs, and not necessarily a lack of relationship. Second, low coverage and under-sampling of program participants might have contributed to the weak effects estimated. Future studies could address these limitations.

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SUPPLEMENTARY MATERIALS

Key to variable names

Code used	Description of the variable
fispirrschHH	Subsidized inputs*use of irrigation scheme (1/0)
subcoup	Received subsidized inputs (1/0)
qfert	Quantity of subsidized fertiliser received (kgs)
irrschHH	HH uses irrigation scheme (1/0)
fispirrsch	Subsidized inputs*irrigation scheme presence (1/0)
irrsch	Community has irrigation scheme (1/0)
fispsctp	Subsidized inputs*food/cash transfer (1/0)
foodcashaid	Received food/cash transfer (1/0)
irrschsctp	Subsidized inputs*irrigation scheme presence (1/0)
irrschHHsctp	Subsidized inputs*use of irrigation scheme (1/0)
agehh	Age of household head (years)
sexhh	Male headed household 1/0)
hhsize	Household size
yrseduc_hh	Years of education for the head
n05	Number of household members 0-5 years
n614	Number of household members 6-14 years
n1555	Number of household members 15-55years
n56	Number of household members 56
wage_e	Wage employment (1/0)
hhbus_e	Business employment (1/0)
agri_e	Agriculture employment (1/0)
asseti_mca	Asset index
dislmrkt	Distance to nearest weekly market
no_crops	Number of crops cultivated
extany	Received any extension service (1/0)
credit	Received credit (1/0)
farmlandsze	Farmland size (acreage)
comm_org	Presence of community organization (1/0)

south	Southern region (1/0)
centre	Central region (1/0)
wsemarid	Warm semi-arid region (1/0)
wsubhumid	Warm sub-humid region (1/0)
csemarid	Cold sub-humid region (1/0)
MPvst	Member of Parliament visit village in past months (1/0)
hlivedvg	Head has always lived in village (1/0)
devrainmedian	Deviation of rainfall from median amount
vglandchief	Village chiefs receive money to access and use land (1/0)
shockfprol	Shock resulted in food production loss in past 2 years (1/0)
shockfsl	Shock resulted in food stocks loss in past 3 years (1/0)
shockfpurl	Shock resulted in food purchases loss in past 3 years (1/0)

Table A5: Effects of interventions on dietary diversity score (Detailed regressions summarised in Table 5)

Dependent Var: DD	Panel A		Panel B		Panel C		Panel D		Panel E	
subcoup	1.348	(0.317)	1.348	(0.277)	0.808	(0.321)	-	-	-	-
irrschHH	1.509	(0.925)	-	-	-	-	-	-	1.401	(0.773)
fispirrschHH	0.550	(0.397)	-	-	-	-	-	-	-	-
irrsch	-	-	1.183	(0.438)	-	-	0.706	(0.375)	-	-
fispirrsch	-	-	0.690	(0.299)	-	-	-	-	-	-
foodcashaid	-	-	-	-	2.072***	(0.528)	1.738***	(0.287)	1.810***	(0.300)
fispsctp	-	-	-	-	0.660	(0.237)	-	-	-	-
irrschsctp	-	-	-	-	-	-	0.858	(0.447)	-	-
irrschHHsctp	-	-	-	-	-	-	-	-	0.443	(0.263)
agehh	0.998***	(0.001)	0.998***	(0.001)	0.998*	(0.001)	0.998***	(0.001)	0.998***	(0.001)
sexhh	1.005	(0.014)	1.007	(0.013)	1.042*	(0.024)	1.022	(0.015)	1.026*	(0.015)
hhsize	0.989	(0.011)	0.988	(0.012)	0.996	(0.021)	0.978	(0.020)	0.990	(0.018)
yrseduc_hh	1.011***	(0.002)	1.011***	(0.002)	1.011***	(0.003)	1.011***	(0.002)	1.012***	(0.002)
n05	0.993	(0.014)	0.995	(0.016)	0.991	(0.024)	1.011	(0.025)	0.993	(0.022)
n614	1.000	(0.012)	1.002	(0.014)	0.977	(0.025)	1.004	(0.023)	0.986	(0.020)
n1555	1.022*	(0.013)	1.023*	(0.013)	1.006	(0.025)	1.024	(0.022)	1.012	(0.021)
n56	1.008	(0.015)	1.009	(0.017)	0.978	(0.028)	1.010	(0.025)	0.987	(0.024)
wage_e	1.140***	(0.022)	1.146***	(0.026)	1.120***	(0.029)	1.121***	(0.025)	1.126***	(0.025)
hhbus_e	1.119***	(0.021)	1.123***	(0.023)	1.135***	(0.030)	1.124***	(0.025)	1.127***	(0.026)
agri_e	0.985	(0.024)	0.994	(0.016)	1.009	(0.023)	1.000	(0.018)	0.991	(0.021)
asseti_mca	1.008***	(0.002)	1.008***	(0.002)	1.007***	(0.002)	1.007***	(0.002)	1.008***	(0.001)
dislmrkt	1.000	(0.001)	1.000	(0.001)	1.000	(0.001)	1.001	(0.001)	1.000	(0.001)
no_crops	1.001	(0.008)	1.003	(0.006)	1.010	(0.010)	1.004	(0.006)	1.007	(0.005)
extany	0.985	(0.020)	0.990	(0.014)	1.003	(0.018)	0.998	(0.013)	0.992	(0.013)
credit	1.028*	(0.016)	1.033***	(0.011)	1.006	(0.021)	1.014	(0.015)	1.011	(0.018)
farmlandsze	1.009	(0.005)	1.010**	(0.004)	1.027***	(0.010)	1.018***	(0.004)	1.021***	(0.004)
comm_org	0.968*	(0.017)	0.976	(0.021)	0.977	(0.029)	0.960	(0.025)	0.969	(0.024)
south	0.945**	(0.021)	0.944***	(0.020)	0.950**	(0.020)	0.931***	(0.019)	0.936***	(0.021)
centre	0.933***	(0.016)	0.932***	(0.020)	0.930***	(0.021)	0.907***	(0.029)	0.939***	(0.018)

Table A6: Effects of interventions on food consumption score (Detailed regressions summarised in Table 6)

Dependent Var: FCS	Panel A		Panel B		Panel C		Panel D		Panel E	
subcoup	29.146	(20.216)	31.290	(20.468)	-12.241	(21.464)	-	-	-	-
irrschHH	72.026	(67.444)	-	-	-	-	-	-	45.316	(50.633)
fispirrschHH	-90.862	(77.749)	-	-	-	-	-	-	-	-
irrsch	-	-	47.295	(36.394)	-	-	2.341	(23.620)	-	-
fispirrsch	-	-	-66.622	(44.156)	-	-	-	-	-	-
foodcashaid	-	-	-	-	72.839**	(35.939)	45.362***	(16.032)	47.961***	(17.949)
fispsctp	-	-	-	-	-55.317*	(31.705)	-	-	-	-
irrschsctp	-	-	-	-	-	-	-40.182	(26.488)	-	-
irrschHHsctp	-	-	-	-	-	-	-	-	-86.161	(57.079)
agehh	-0.045	(0.048)	-0.040	(0.049)	-0.013	(0.058)	-0.052	(0.040)	-0.036	(0.041)
sexhh	0.087	(1.161)	0.470	(1.125)	2.675	(1.681)	1.247	(0.944)	1.572	(1.072)
hhsize	0.677	(0.975)	1.163	(1.061)	1.083	(1.538)	0.251	(1.284)	0.840	(1.260)
yrseduc_hh	1.054***	(0.185)	1.016***	(0.170)	0.972***	(0.191)	0.970***	(0.125)	1.047***	(0.149)
n05	-2.805**	(1.167)	-3.553**	(1.490)	-2.544	(1.665)	-1.757	(1.478)	-2.679*	(1.499)
n614	-1.377	(1.051)	-1.910	(1.207)	-2.901	(1.837)	-1.462	(1.413)	-2.339*	(1.411)
n1555	-0.073	(1.077)	-0.367	(1.142)	-0.975	(1.792)	-0.017	(1.322)	-0.677	(1.407)
n56	-1.306	(1.280)	-1.979	(1.509)	-3.107	(2.091)	-1.422	(1.558)	-2.686	(1.690)
wage_e	8.533***	(1.700)	9.870***	(2.177)	6.963***	(1.958)	7.321***	(1.622)	7.217***	(1.744)
hhbus_e	7.627***	(1.638)	8.245***	(1.943)	8.041***	(1.885)	7.658***	(1.533)	7.562***	(1.660)
agri_e	-1.779	(2.002)	-0.680	(1.409)	0.487	(1.519)	-0.403	(1.122)	-1.059	(1.476)
asseti_mca	1.048***	(0.192)	1.125***	(0.223)	0.876***	(0.167)	0.932***	(0.127)	0.970***	(0.119)
dislmrkt	0.044	(0.082)	-0.029	(0.111)	0.058	(0.083)	0.102	(0.088)	0.063	(0.083)
no_crops	-0.257	(0.701)	0.134	(0.521)	0.549	(0.624)	0.386	(0.427)	0.383	(0.347)
extany	-2.273	(1.619)	-1.886	(1.343)	-0.616	(1.262)	-1.126	(0.870)	-1.294	(0.944)
credit	1.074	(1.411)	1.889*	(1.089)	0.291	(1.564)	1.027	(1.053)	0.555	(1.343)
farmlandsze	0.332	(0.426)	0.584	(0.380)	1.765**	(0.728)	1.208***	(0.309)	1.289***	(0.337)
comm_org	-4.786***	(1.806)	-2.752	(2.248)	-3.883*	(2.301)	-4.494**	(1.974)	-4.685**	(1.977)
south	-5.278***	(1.805)	-5.898***	(2.011)	-4.175***	(1.554)	-5.397***	(1.389)	-5.313***	(1.598)
centre	-5.793***	(1.477)	-4.716**	(2.069)	-6.289***	(1.613)	-6.340***	(2.116)	-5.430***	(1.456)
cons	44.382***	(3.246)	36.487***	(7.261)	43.017***	(4.101)	45.160***	(5.783)	43.582***	(3.439)
Chi-squared	481.814***		404.770***		409.076***		540.694***		496.183***	
N	3009		3009		3009		3009		3009	

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A7: Effects of interventions on coping with food insecurity (Detailed regressions summarised in Table 7)

Dependent Var: CSI	Panel A		Panel B		Panel C		Panel D		Panel E	
fispirrschHH	0.267	(0.360)	-	-	-	-	-	-	-	-
subcoup	-0.135*	(0.074)	-0.115	(0.077)	-0.158**	(0.078)	-	-	-	-
irrschHH	-0.318	(0.217)	-	-	-	-	-	-	-0.159	(0.187)
fispirrsch	-	-	-0.094	(0.203)	-	-	-	-	-	-
irrsch	-	-	-0.001	(0.108)	-	-	0.026	(0.098)	-	-
fispsctp	-	-	-	-	0.182	(0.200)	-	-	-	-
foodcashaid	-	-	-	-	0.144	(0.120)	0.257**	(0.104)	0.224**	(0.099)
irrschsctp	-	-	-	-	-	-	-0.412	(0.283)	-	-
irrschHHsctp	-	-	-	-	-	-	-	-	-0.548	(0.503)
agehh	0.007**	(0.003)	0.007**	(0.003)	0.007**	(0.003)	0.006**	(0.003)	0.006**	(0.003)
sexhh	-0.294***	(0.073)	-0.292***	(0.073)	-0.293***	(0.073)	-0.295***	(0.073)	-0.295***	(0.073)
hhsize	0.111	(0.070)	0.111	(0.070)	0.107	(0.070)	0.107	(0.070)	0.111	(0.070)
yrseduc_hh	-0.055***	(0.010)	-0.055***	(0.010)	-0.055***	(0.010)	-0.055***	(0.010)	-0.055***	(0.010)
n05	0.066	(0.080)	0.066	(0.080)	0.069	(0.080)	0.069	(0.080)	0.067	(0.080)
n614	-0.007	(0.077)	-0.006	(0.077)	-0.006	(0.077)	-0.004	(0.077)	-0.010	(0.077)
n1555	-0.081	(0.075)	-0.081	(0.075)	-0.081	(0.075)	-0.084	(0.075)	-0.086	(0.075)
n56	-0.074	(0.093)	-0.074	(0.093)	-0.077	(0.093)	-0.075	(0.093)	-0.080	(0.093)
wage_e	-0.382***	(0.124)	-0.383***	(0.124)	-0.381***	(0.124)	-0.377***	(0.124)	-0.372***	(0.124)
hhbus_e	-0.404***	(0.122)	-0.401***	(0.122)	-0.396***	(0.122)	-0.397***	(0.122)	-0.398***	(0.122)
agri_e	-0.144*	(0.085)	-0.148*	(0.085)	-0.150*	(0.085)	-0.150*	(0.085)	-0.146*	(0.085)
asseti_mca	-0.067***	(0.010)	-0.067***	(0.010)	-0.067***	(0.010)	-0.066***	(0.010)	-0.066***	(0.010)
dislmrkt	-0.004	(0.006)	-0.004	(0.006)	-0.004	(0.006)	-0.004	(0.006)	-0.004	(0.006)
no_crops	-0.034	(0.026)	-0.036	(0.026)	-0.035	(0.026)	-0.041	(0.025)	-0.039	(0.025)
extany	0.064	(0.072)	0.065	(0.072)	0.057	(0.072)	0.060	(0.072)	0.057	(0.072)
credit	0.195***	(0.073)	0.190***	(0.073)	0.185**	(0.073)	0.183**	(0.073)	0.190***	(0.073)
farmlandsze	-0.105***	(0.023)	-0.104***	(0.023)	-0.103***	(0.023)	-0.105***	(0.023)	-0.106***	(0.023)
comm_org	0.621***	(0.143)	0.617***	(0.143)	0.613***	(0.143)	0.616***	(0.143)	0.621***	(0.143)
south	0.382***	(0.133)	0.373***	(0.134)	0.374***	(0.133)	0.368***	(0.133)	0.381***	(0.133)
centre	0.134	(0.149)	0.131	(0.150)	0.139	(0.149)	0.131	(0.150)	0.138	(0.149)
wsemarid	0.052	(0.188)	0.053	(0.188)	0.045	(0.188)	0.051	(0.188)	0.045	(0.188)
wsubhumid	0.065	(0.169)	0.063	(0.169)	0.059	(0.169)	0.064	(0.169)	0.051	(0.169)
csemarid	-0.137	(0.214)	-0.130	(0.214)	-0.129	(0.213)	-0.120	(0.214)	-0.134	(0.214)
MPvst	0.071	(0.076)	0.073	(0.076)	0.078	(0.076)	0.078	(0.076)	0.075	(0.076)
hlivedvg	-0.144**	(0.068)	-0.144**	(0.068)	-0.144**	(0.068)	-0.150**	(0.068)	-0.146**	(0.068)
devrainmedian	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)
vglandchief	0.314***	(0.070)	0.314***	(0.070)	0.304***	(0.070)	0.301***	(0.070)	0.303***	(0.070)

shockfprol	0.433***	(0.146)	0.432***	(0.146)	0.431***	(0.146)	0.431***	(0.146)	0.432***	(0.146)
shockfsl	0.440***	(0.144)	0.439***	(0.144)	0.436***	(0.144)	0.440***	(0.144)	0.442***	(0.144)
shockfpurl	-0.084	(0.070)	-0.086	(0.070)	-0.088	(0.070)	-0.086	(0.070)	-0.083	(0.070)
_cons	-0.370	(0.385)	-0.361	(0.385)	-0.349	(0.387)	-0.364	(0.392)	-0.377	(0.392)
/										
sigma_u	0.433**	(0.180)	0.431**	(0.179)	0.436**	(0.182)	0.449**	(0.187)	0.449**	(0.187)
sigma_e	1.572***	(0.029)	1.573***	(0.029)	1.571***	(0.029)	1.572***	(0.029)	1.572***	(0.029)
chi2	425.717***		423.893***		428.912***		426.178***		427.045***	
N	3009		3009		3009		3009		3009	

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A8: Effects of interventions on household dietary diversity (using quantity of subsidized fertilizer for AISP)

Dependent Var: DD	Panel A		Panel B		Panel C	
	IRR	SE	IRR	SE	IRR	SE
qfert	1.001***	(0.000)	1.001***	(0.000)	1.000	(0.000)
irrschHH	4.567**	(3.361)	-	-	-	-
qfertirrschHH	0.972**	(0.013)	-	-	-	-
irrsch	-	-	2.681	(1.707)	-	-
qfertirrsch	-	-	0.983*	(0.009)	-	-
foodcashaid	-	-	-	-	1.739***	(0.289)
qfertsctp	-	-	-	-	1.000	(0.000)
agehh	1.000	(0.002)	1.000	(0.002)	0.998***	(0.001)
sexhh	0.990	(0.030)	1.003	(0.024)	1.021	(0.016)
hhsize	1.011	(0.030)	1.026	(0.034)	0.985	(0.018)
yrseduc_hh	1.008**	(0.003)	1.007**	(0.003)	1.011***	(0.002)
n05	0.952	(0.040)	0.942	(0.045)	1.000	(0.020)
n614	0.975	(0.031)	0.959	(0.036)	0.993	(0.019)
n1555	1.009	(0.031)	1.001	(0.030)	1.017	(0.019)
n56	0.954	(0.054)	0.942	(0.056)	0.994	(0.021)
wage_e	1.099**	(0.048)	1.162***	(0.046)	1.135***	(0.024)
hhbus_e	1.143***	(0.037)	1.152***	(0.049)	1.132***	(0.025)
agri_e	0.926	(0.064)	0.968	(0.038)	0.993	(0.017)
asseti_mca	1.010***	(0.003)	1.011***	(0.004)	1.008***	(0.001)
dislmrkt	0.999	(0.002)	0.997	(0.003)	1.000	(0.001)
no_crops	1.004	(0.010)	1.018*	(0.010)	1.005	(0.005)
extany	0.964	(0.033)	0.980	(0.023)	0.991	(0.013)
credit	0.995	(0.041)	1.026	(0.025)	1.011	(0.015)
farmlandsze	1.008	(0.008)	1.018*	(0.009)	1.020***	(0.005)
comm_org	0.922	(0.046)	0.980	(0.038)	0.968	(0.022)
south	0.875*	(0.064)	0.907*	(0.047)	0.939***	(0.017)
centre	0.892***	(0.033)	0.961	(0.046)	0.934***	(0.018)
chi2						
p						

N	3009	3009	3009

Exponentiated coefficients; Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A9: Effects of interventions on food consumption score (using quantity of subsidized fertilizer for AISP)

Dependent Var: FCS	Panel A		Panel B		Panel C	
	Coeff.	SE	Coeff.	SE	Coeff.	SE
qfert	0.128	(0.088)	0.154	(0.127)	-0.014	(0.043)
irrschHH	149.166	(104.727)	-	-	-	-
qfertirrschHH	-2.840	(2.004)	-	-	-	-
irrsch	-	-	112.571	(88.058)	-	-
qfertirrsch	-	-	-2.081	(1.596)	-	-
foodcashaid	-	-	-	-	46.001***	(17.605)
qfertsctp	-	-	-	-	-0.012	(0.042)
agehh	0.053	(0.071)	0.105	(0.119)	-0.046	(0.042)
sexhh	-0.293	(1.519)	-0.016	(1.958)	1.523	(1.125)
hhsize	1.376	(1.455)	3.002	(2.295)	0.222	(1.227)
yrseduc_hh	0.856***	(0.190)	0.753***	(0.263)	1.023***	(0.143)
n05	-4.102**	(1.849)	-6.190*	(3.438)	-1.715	(1.324)
n614	-2.087	(1.552)	-4.080	(2.617)	-1.674	(1.320)
n1555	-0.097	(1.557)	-1.057	(2.057)	-0.116	(1.317)
n56	-3.166	(2.294)	-5.909	(4.350)	-1.599	(1.480)
wage_e	6.688***	(2.193)	10.613***	(3.431)	7.811***	(1.636)
hhbus_e	8.244***	(1.748)	9.807***	(3.338)	7.937***	(1.579)
agri_e	-3.484	(2.894)	-1.865	(2.679)	-0.132	(1.213)
asseti_mca	1.006***	(0.158)	1.193***	(0.317)	0.911***	(0.102)
dislmrkt	0.041	(0.084)	-0.138	(0.200)	0.081	(0.074)
no_crops	0.166	(0.595)	1.089	(0.684)	0.264	(0.350)
extany	-2.548	(1.765)	-2.683	(2.244)	-1.203	(0.920)
credit	-0.018	(2.141)	1.342	(2.017)	0.786	(1.151)
farmlandsze	0.446	(0.472)	1.042*	(0.612)	1.384***	(0.381)
comm_org	-6.485***	(2.417)	-2.400	(3.403)	-4.303**	(1.933)
south	-8.051**	(3.185)	-8.008**	(3.945)	-4.567***	(1.379)
centre	-8.104***	(1.837)	-3.064	(3.811)	-5.618***	(1.419)
_cons	48.431***	(5.028)	27.627*	(14.775)	44.206***	(3.362)
chi2	395.132		182.713		526.499	

p	0.000	0.000	0.000
N	3009	3009	3009

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A10: Effects of interventions on coping with food insecurity (using quantity of subsidized fertilizer for AISP)

Dependend Var: CSI	Panel A		Panel B		Panel C	
	Coeff.	SE	Coeff.	SE	Coeff.	SE
qfertirrschHH	0.003	(0.007)	-	-	-	-
qfert	-0.000	(0.000)	-0.000	(0.000)	-0.000	(0.000)
irrschHH	-0.289	(0.210)	-	-	-	-
qfertirrsch	-	-	-0.004	(0.004)	-	-
irrsch	-	-	0.023	(0.105)	-	-
qfertsctp	-	-	-	-	0.001**	(0.000)
foodcashaid	-	-	-	-	0.172*	(0.098)
agehh	0.006**	(0.003)	0.006**	(0.003)	0.006**	(0.003)
sexhh	-0.298***	(0.073)	-0.295***	(0.073)	-0.295***	(0.073)
hhsize	0.109	(0.070)	0.109	(0.070)	0.109	(0.070)
yrseduc_hh	-0.055***	(0.010)	-0.055***	(0.010)	-0.054***	(0.010)
n05	0.068	(0.080)	0.067	(0.080)	0.066	(0.080)
n614	-0.005	(0.077)	-0.003	(0.077)	-0.009	(0.077)
n1555	-0.082	(0.075)	-0.081	(0.075)	-0.085	(0.075)
n56	-0.071	(0.093)	-0.071	(0.093)	-0.078	(0.093)
wage_e	-0.373***	(0.124)	-0.374***	(0.124)	-0.379***	(0.124)
hhbus_e	-0.402***	(0.122)	-0.399***	(0.122)	-0.397***	(0.122)
agri_e	-0.143*	(0.085)	-0.147*	(0.085)	-0.146*	(0.085)
asseti_mca	-0.066***	(0.010)	-0.066***	(0.010)	-0.066***	(0.010)
dislmrkt	-0.004	(0.006)	-0.004	(0.006)	-0.004	(0.006)
no_crops	-0.039	(0.025)	-0.040	(0.025)	-0.040	(0.025)
extany	0.064	(0.072)	0.065	(0.072)	0.056	(0.072)
credit	0.194***	(0.073)	0.189***	(0.073)	0.187**	(0.073)
farmlandsze	-0.107***	(0.023)	-0.106***	(0.023)	-0.106***	(0.023)
comm_org	0.621***	(0.143)	0.618***	(0.143)	0.613***	(0.143)
south	0.386***	(0.133)	0.374***	(0.134)	0.380***	(0.133)
centre	0.137	(0.149)	0.130	(0.150)	0.145	(0.149)
wsemarid	0.049	(0.188)	0.049	(0.188)	0.041	(0.188)
wsubhumid	0.058	(0.169)	0.052	(0.169)	0.056	(0.169)

csemarid	-0.136	(0.214)	-0.130	(0.214)	-0.126	(0.213)
MPvst	0.068	(0.076)	0.072	(0.076)	0.070	(0.076)
hlivedvg	-0.149**	(0.068)	-0.147**	(0.068)	-0.149**	(0.068)
devrainmedian	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)
vglandchief	0.309***	(0.070)	0.311***	(0.070)	0.291***	(0.070)
shockfprol	0.432***	(0.146)	0.431***	(0.146)	0.429***	(0.145)
shockfsl	0.446***	(0.144)	0.444***	(0.144)	0.437***	(0.144)
shockfpurl	-0.084	(0.070)	-0.086	(0.070)	-0.077	(0.070)
_cons	-0.373	(0.389)	-0.364	(0.387)	-0.352	(0.390)
/						
sigma_u	0.442**	(0.184)	0.438**	(0.182)	0.447**	(0.186)
sigma_e	1.574***	(0.029)	1.574***	(0.029)	1.571***	(0.029)
chi2	422.059		421.300		429.680	
p	0.000		0.000		0.000	
N	3009		3009		3009	

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$