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Gender, Nutrition-Sensitive Agricultural Interventions, and Resilience

Evidence from Rural Bangladesh

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ABSTRACT

We assess whether a gender- and nutrition-sensitive agricultural interventions, fielded in rural Bangladesh, aimed at improving food production diversity enhanced resilience and whether impacts persisted post-intervention. Four years post-program, treatment arms that included both agriculture and nutrition training reduced the likelihood that households undertook more severe forms of coping strategies during the Covid-19 pandemic. There were persistent improvements in household consumption and diet quality; impacts were largest for poor but not the poorest households in our sample. Underlying these results were the long-term beneficial impacts on women's agricultural knowledge, agency, and increased engagement in agricultural activities.

Keywords: Resilience, shocks, consumption, agriculture and nutrition training, gender, Bangladesh

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In the original ANGeL study, we received permission from the Ministry of Agriculture, Government of Bangladesh who issued Letters of Authorization to conduct these surveys. The surveys received ethical approval from the Institutional Review Board of IFPRI, (IRB approval number 00007490). The study was registered on the Registry for International Development Evaluations (RIDIE-STUDY-ID- afbe43292b4c) We received permission from the Ministry of Agriculture, Government of Bangladesh who issued Letters of Authorization to conduct the 2022 survey. We received ethical approval from the Institutional Review Board of Cornell University (IRB approval number 2001009312). The study was registered on the Registry for International Development Evaluations (RIDIE-STUDY-ID-626008d5663c8).

ACRONYMS

ANCOVA	Analysis of Covariance
ANGeL	Agriculture, Nutrition, and Gender Linkages
BARI	Bangladesh Agricultural Research Institute
BCC	Behavior change communication
BIRTAN	Bangladesh Institute of Research and Training on Applied Nutrition
BRRI	Bangladesh Rice Research Institute
CNW	Community nutrition workers
GDQS	Global Diet Quality Score
hGDQS	Household-level GDQS
HKI	Helen Keller International
IFPRI	International Food Policy Research Institute
ITT	Intent-to-treat
LCSI	Livelihoods Coping Strategy Index
RCT	Randomized controlled trial
SAAO	Sub-assistant agricultural officer

1. INTRODUCTION

Over 2 billion people worldwide depend on smallholder agriculture for their livelihoods (Lowder et al., 2016; FAO, 2014), yet many face persistent poverty, malnutrition (Ricciardi et al., 2018), and vulnerability to shocks (Morton, 2007). Understanding how to build resilience in these populations (Barrett et al., 2021; Barrett and Constas, 2014)—particularly through gender- and nutrition-sensitive approaches (Ruel, Quisumbing and Balagamwala (2018))—represents one of the most pressing challenges in development economics (Banerjee et al., 2015; Barrett et al., 2021) especially as the growing frequency and severity of climate-related shocks as well as the increased probability of widespread zoonotic disease transmission may mean that strategies undertaken by households to cope with those shocks may undermine their livelihoods in the long run (Singh et al (2023); Fanzo et al (2025)).

Coinciding with this is a growing understanding of the importance of healthy diets that provide the nutrients needed for a healthy, active life has prompted the design and implementation of policies, programs, and innovations to improve diet quality. Healthy diets include a diversity of foods — fruits, vegetables, legumes, nuts, whole grains, and varying amounts of animal-source foods (ASFs) (Menon and Olney 2023). Despite this increased interest, less than half of the world's population consumes diverse diets that include enough fruits, vegetables, and other nutritious foods (Global Diet Quality Project 2022). For many people, these nutrient-dense foods are unaffordable, not readily available, or not preferred for a variety of reasons.

Diversification of agricultural production offers the potential to address both challenges. Encouraging smallholder farmers to diversify production is considered a promising pathway for improving rural diets, see Ruel, Quisumbing and Balagamwala (2018), Gillespie et al. (2019), Bird et al. (2019), and Ahmed et al (2024), particularly when twinned with efforts to inform these farmers about the nutritional benefits of consuming a more diverse diet. It is also seen as a means by which farmers can build resilience to climatic and other types of shocks (Pratap and Hazrana, 2019; Hertel et al, 2023; Vernooy, 2022). However, the evidence base supporting these views is thin. Many assessments of efforts to diversify agricultural production look only at short-term impacts; few look at longer term impacts, and even fewer look at long term impacts when, post-intervention, shocks occur. Nor is it known whether the long-term effectiveness of these interventions can be enhanced through the addition of complementary interventions such as nutrition social behavioral change (SBC) or efforts to make these interventions gender sensitive.

We seek to fill these knowledge gaps in the context of a nutrition- and gender-sensitive agricultural pilot project implemented in Bangladesh between 2017 and 2018. We investigate whether an

intervention aimed at improving food production diversity enhances resilience, the contribution of complementary programming, including nutrition SBC and gender sensitization, to these impacts, and whether this increased resilience is sufficient to protect consumption post-shock. We also investigate the distribution of benefits—do all participants benefit, or only some—and the mechanisms that underly both the persistence and distribution of benefits from the intervention.

The Agriculture, Nutrition, and Gender Linkages (ANGeL) project was implemented in Bangladesh between 2017 and 2018. Following the end of ANGeL, households were exposed to several shocks including the significant economic disruptions arising from the Covid-19 pandemic. Four years post-program (2022), we re-interviewed ANGeL participants. Using data from this follow-up survey, we demonstrate that ANGeL enhanced resilience, that is, the ability of households to cope with shocks, by reducing the probability of using more severe forms of coping strategies (Crisis and Emergency) that undermine long-term resilience. Complementary programming, including nutrition SBC and gender sensitization was important to generating this resilience. Benefits were largest for poor, but not the poorest, households in our sample. Underlying these results were the long-term beneficial impacts of ANGeL on women's agricultural knowledge and their sense of agency.

Our study contributes to three literatures. First, we contribute to the growing evidence on 'bundled' interventions (Banerjee et al. 2015; Bandiera et al. 2017) by isolating the marginal effects of nutrition and gender components with a particular focus on impacts on household resilience. Second, we provide rare experimental evidence on medium-term persistence of development interventions, addressing concerns about 'fade-out' (Blattman et al. 2020). Third, since the ANGeL project was implemented by the Bangladesh Ministry of Agriculture, it offered a directly scalable path through existing government infrastructure. This addresses a critical gap, as interventions delivered through government systems often show different effectiveness patterns than NGO implementations (Bold et al., 2018) but offer clearer pathways to scale (Muralidharan and Niehaus, 2017; Davis et al., 2023). By examining outcomes four years post-program—after households weathered the COVID-19 pandemic—we provide unique evidence on whether government-run pilots can build lasting resilience through complementary nutrition and gender programming.

2. THE AGRICULTURE, NUTRITION, AND GENDER LINKAGES PROJECT

While Bangladesh has made significant progress in the production of staple foods, most notably rice, diet quality remains an issue of considerable concern. Diets, particularly in rural areas, are rice-dominated, monotonous and lacking in diversity with the result that micronutrient deficiencies are widespread (Ahmed et al, 2024). However, nationally representative household survey data indicated that greater agricultural production diversity was associated with dietary diversity, as was increased women's empowerment (Sraboni et al. 2014; Malapit et al. 2019). Other work indicated that nutrition behavior change communication (BCC) training imparted to women and men improved child diet quality and led to improvements in complementary feeding practices (Ahmed et al. 2016; Menon et al. 2016).

These considerations motivated the development of the Agriculture, Nutrition, and Gender Linkages (ANGeL) project, a multi-arm cluster Randomized Control Trial implemented over a 17-month period, from July 2016 to December 2017 (Ahmed et al, 2024). ANGeL consisted of the following treatment arms: T-N (SAAO): Nutrition Behavior Change Communication (BCC) delivered by government extension agents; T-N (CNW): Nutrition Behavior Change Communication (BCC) delivered by community nutrition workers; T-A: Agricultural Production training ; T-AN: Agricultural Production training and Nutrition BCC; T-ANG: Agricultural Production training, Nutrition BCC, and Gender Sensitization; and C: Control. The logic behind this design was as follows. Nutrition BCC would, by improving knowledge around healthy diets, lead to higher consumption of nutrient-rich foods, through the consumption of own production or through market purchases. Agricultural production training focused on agricultural practices specific to non-rice products such as vegetable and fruit cultivation, livestock, poultry, and fishponds. Adoption of these practices was hypothesized to result in an increased number of non-rice crops and animal-source foods grown, as well as increased productivity in those crops and animal source-foods resulting in greater quantities available for home consumption.

In addition to the T-N and T-A treatment arms, ANGeL assessed whether there would be greater effects on diet quality if efforts were made to improve both production diversity and knowledge of good nutrition practices, hence the inclusion of the T-AN treatment arm. It was also hypothesized that including an explicit effort to improve women's empowerment through gender sensitization activities could lead to additional gains in diet quality and this motivated the inclusion of the T-ANG treatment arm. Both the nutrition and agriculture training were delivered by sub-assistant agricultural officers (SAAOs) – also referred to as agricultural extension agents –permanent employees of the Bangladesh Ministry of Agriculture. Both men and women attended all types of training. Further details on ANGeL are found in Ahmed et al (2024) and in Appendix (1).

3. STUDY DESIGN, DATA, SAMPLING, AND STATISTICAL METHODS

3.1 Study design and data

Because training would be conducted by SAAOs, and each SAAO was assigned to a "block," cluster-randomization was conducted at the block level, using blocks as clusters. Working with the Ministry of Agriculture, 484 rural *upazilas* were identified as being agro-ecologically suitable for agricultural diversification and had good market connectivity, thus considered appropriate for the ANGeL interventions. From these, 16 *upazilas* were purposively selected, such that each of the eight administrative divisions of Bangladesh was represented. Ten blocks were randomly selected from each *upazila*, yielding 160 blocks. Based on the power calculations, these were randomly assigned as follows: 25 blocks to each treatment arm (T-A, T-N, T-AN, T-ANG, as well as the additional treatment described in footnote 2), and 35 blocks to the control group. One village from each block was randomly selected.

In each selected village, a census was conducted to identify households that had: (1) engaged in crop production in the previous 12 months; and (2) had a child aged less than 24 months. From the list of all households who met these two criteria, 25 were randomly selected. This yielded 625 households in each treatment arm (3,125 households in total), and 875 households in the control group, for a total target sample of 4,000 households. This provided statistical power (80% power at 0.05 level of significance) to detect impacts of a 10% increase in households' per capita daily calorie availability, an increase of one new food crop produced in homestead gardens and a 7.5% increase in the household Global Diet Quality Score – measures used to assess impacts on production diversity and diets at project endline (Ahmed et al, 2024).

Baseline data were collected between November 2015 and January 2016. Endline data were collected between January and March [2018. In February and March 2022, we re-interviewed study participants who were in the T-A, T-AN, T-ANG and Control groups using essentially the same survey instrument. The timing of the 2022 survey matched the timing of the 2016 (baseline) and 2018 (endline) surveys, meaning that seasonality considerations should not confound our results.

3.2. Sample and attrition

The baseline sample included 3,994 households residing in 160 clusters. We did not include the two T-N arms in this follow-up study (partly because the impact of these treatment arms had been small, see Ahmed et al. (2024) and partly because the size of the survey budget meant that we had to prioritize those treatment arms where, *a priori*, we would be most likely to observe sustainable effects). At baseline, there were 2,749 households in the T-A, T-AN, and T-ANG treatment arms and the control group located in 110 clusters. Between baseline and endline, 71 households attrit, leaving 2,678 households at endline. A

further 77 attrited between the ANGeL endline and the 2022 survey, but we also were able to find and interview 43 households that had been interviewed as part of the ANGeL baseline but not endline. This yields a sample of 2,601 households in 110 clusters who were interviewed in all three rounds and 2,644 households that were interviewed at baseline and in 2022. A participant flow diagram is found in Appendix Figure A3.1.

Attrition does not differ across treatment groups. We regress attrition status on treatment arms using a Linear Probability Model and clustering at the level of randomization, the block, both without and with control variables. Appendix Table A3.1 shows that there is no indication that attrition over time is correlated with treatment assignment; the magnitudes of the point estimates are small, and none of the point estimates are statistically different from zero.

Between the endline survey and the 2022 follow-up, some households split into two (or, much more rarely, three). Where this occurred, data were collected on all these split households. For this analysis, we follow the split household containing the individuals who participated in the ANGeL training. In the case of the control households, we "follow" the household containing the individuals who would have taken part in the training had they been included in a treatment group. Of the 2,644 households interviewed in 2022, 7.8 percent (206) are households that split, and 92.2 percent (2438 households) never split. As was the case with attrition, there is no indication that the likelihood that household splits is correlated with treatment assignment; the magnitudes of the point estimates are small, and none of the point estimates are statistically different from zero (results available on request).

3.3 Outcome variables

We assessed the immediate impacts of the Covid-19 pandemic by fielding an adapted version of the Livelihoods Coping Strategy Index (LCSI) (World Food Programme, 2023). The LCSI is designed to elicit how households respond to a shock. Behaviors are categorized across three levels: "Stress" - actions that increase access to food but reduce households' ability to deal with future shocks because of a reduction in current resources or an increase in debts; "Crisis" – actions that reduce future incomes or productivity, including human capital; and "Emergency" – actions that may generate increased access to food in the short term but are extremely difficult to reverse (World Food Programme, 2023). More specifically, we asked the following question. "We would now like to ask whether, and how often, members of your household have to engage in any of the following behaviors due to a lack of food or a lack of money to buy food or meet other basic needs since the start of the coronavirus (Covid 19) pandemic in March 2020?" Behaviors were: "Stress" – spent savings; borrowed food on credit; borrowed money to buy food; selling household goods (radio, furniture, mobile, solar panel); "Crisis" - reduced health expenditures; reduced other essential non-food expenditures such as education, clothing; reduced

expenses on agricultural, livestock or fisheries inputs; and "Emergency" - mortgaging or selling jewelry/gold; selling productive assets or means of transport (including livestock); selling land. Respondents were asked about the frequency with which they undertook these actions: Never; Once; Sometimes (every few months); Often (once a month); or Very frequently (more than once per month).

We assess impacts on household consumption. We measure consumption as the sum of the value of total food consumption and total nonfood (nondurable and durable) expenses. Identical food and non-food consumption modules were used in all survey rounds as were the methods for producing the consumption aggregates to ensure comparability. We use the rural general consumer price index (RGCPI) estimated by the Bangladesh Bureau of Statistics (BBS), to deflate all values to 2016 (baseline) Taka; see Appendix (2) for details on the construction of the consumption aggregate.

Given the focus of ANGeL on improving diets, we consider two measures. First, we extract the quantities of food available for consumption from our detailed food consumption module (with a recall period of the last seven days). Using food composition tables specific to Bangladesh, we convert these quantities to calories, divide by household size and then by seven. This gives us daily per capita caloric availability. Second, we calculate a household Global Diet Quality Score (hGDQS). The GDQS is constructed by allocating points for consumption of 25 food groups. Points associated with healthy food groups increase with higher consumption, while points associated with unhealthy food groups decrease as their consumption increases. For the two food groups that are unhealthy in excessive consumption, the points associated with the GDQS food group increase up to a certain threshold of quantity of consumption, then decrease. The hGDQS ranges 0 to 49. Appendix (2) describes the construction of the hGDQS.

4.STATISTICAL METHODS

4.1 Statistical methods

We estimate intent-to-treat (ITT) impacts. Where we have baseline values for our outcomes of interest, we use an ANCOVA specification (McKenzie 2012):

$$Y_{ibt} = \alpha_t + \beta_Y Y_{ibt-1} + \beta_A TA_b + \beta_{AN} TAN_b + \beta_{ANG} TANG_b + \beta_X X_{ibt-1} + \varepsilon_{ibt} \quad (1)$$

where Y_{ibt} is the outcome of interest for individual *i* residing in block *b* at time *t*; Y_{ibt-1} is the outcome in the prior period (usually baseline); TA_b, TAN_b, and $TANG_b$ are dummy variables that take the value of 1 if block *b* was assigned to T-A, T-AN, and T-ANG, respectively, and takes the value of 0 otherwise; X_{ibt-1} is a vector of baseline covariates; and ε_{ibt} is an error term. β_A, β_{AN}, and β_{ANG} represent the impact estimates for T-A, T-AN, and T-ANG, respectively.

We also assess whether combing agricultural and nutrition training (with or without gender sensitization) has a different effect when compared to agricultural training alone. To do so, we estimate:

$$Y_{ibt} = \alpha_t + \beta_Y Y_{ibt-1} + \beta_A TA_b + \beta_{Comb}(TAN_b + TANG_b) + \beta_X X_{ibt-1} + \varepsilon_{ibt} \quad (2)$$

For outcomes not measured at baseline, we estimate equation (3):

$$Y_{ib} = \alpha + \beta_A TA_b + \beta_{AN} TAN_b + \beta_{ANG} TANG_b + \beta_X X_{ibt-1} + \varepsilon_i \quad (3)$$

All models include the following baseline covariates, intended to capture demographic and socioeconomic characteristics, human capital, land and labor availability, as well as access to information prior to intervention: age of household head, sex of household head, mean education level of males age 18 and older, mean education level of females age 18 and older, number of adults in the household, dependency ratio, wealth index, whether the household had access to electricity, amount of land owned at baseline, whether any fishponds were owned at baseline, the number of mobile phones owned, whether the household owned a television, whether the household had recently received an extension visit for crop production, whether the household had recently received an extension visit for livestock or fish production, and dummies for baseline *upazila* (the geographic unit above the unit of randomization).

Unless otherwise noted, we estimate ordinary-least-squares regressions for all outcome variables, including those where outcomes are dichotomous (i.e., linear probability models). Standard errors are clustered at the block level, which is the level at which the randomization was conducted (Abadie et al. 2023). For each outcome, we conduct Wald tests to assess whether the difference in impacts estimated

from various treatment arms are statistically significant. Specifically, we assess whether T-A = T-AN; T-A = T-ANG; and T-AN = T-ANG. These comparisons allow us to infer how combined interventions compare with the single intervention (T-A); and how adding gender sensitization to the combined agriculture and nutrition intervention changes impacts.

5. RESULTS

5.1 Sample characteristics and exposure to the Covid-19 pandemic

Means and standard deviations of the baseline covariates are presented in Appendix Table 3.2. A typical household is headed by a man in his early forties, both he and his spouse (and other adults in the household) have completed some primary school education. Landholdings are small, around one acre or 0.4 hectares. Most have a mobile phone and access to electricity. In the 12 months prior to the start of ANGeL, interactions with extension agents were relatively uncommon; between 19 and 25 percent of households had received a visit from an extension officer relating to crop cultivation, and between 2 and six percent had received a visit from an extension officer relating to livestock, poultry, or fish production. Magnitudes of baseline covariates are similar across treatment and control arms, although there are small differences. We include baseline covariates in our regressions to help account for these small differences.

In Bangladesh, the Covid-19 pandemic took the form of two waves. The first, from March to June 2020, led to widespread lockdowns and significant restrictions on movement and on economic activity. The second wave, from March to August 2021, lasted longer and was accompanied by the delta variant of the virus, which affected south Asia particularly badly. There were intermittent lockdowns in Bangladesh, but these were not as severe as those that accompanied the first wave. By late 2021, the delta variant had run its course and lockdowns were largely ended. Results from phone surveys conducted in both rural and urban areas of Bangladesh during the pandemic showed that moderate-to-severe food insecurity increased dramatically in both rural and urban areas in June 2020 relative to one year before the pandemic, then declined to roughly pre-pandemic levels in January 2021 and September-October 2021; however, mild food insecurity remained much higher than in pre-pandemic times (Ahmed et al, 2023).

Our survey instrument included a module on Covid-19; whether respondents were aware of the pandemic and how it had affected them. All households in our sample had heard of Covid-19, 2.5 percent reported that at least one household member had been diagnosed with Covid-19, and 0.50% reported that a household member had died from Covid-19. But when asked “Which aspect of the Corona crisis had the greatest impact on you and your household?”, overwhelmingly, respondents described an economic impact (see Appendix Figure A3.2), with 55.2 percent reporting unemployment or loss of income. Direct health effects, or fear of health effects were reported by less than 15 percent of respondents.

We note that in May 2019, northeast India and Bangladesh were struck by Cyclone Fani. India suffered most from this storm as it initially made landfall in the Odisha state. Fani then travelled east and north, through Bangladesh. While wind speeds diminished as Fani moved northwards, gusts of up to 70km/hr were reported and there was heavy rain and widespread flooding. Four of the 16 districts (25 percent) included in the ANGeL study reported damage, primarily to cropland and housing. The Ministry

of Disaster Management and Relief estimated that 13,000 houses were damaged nationwide, while the Ministry of Agriculture estimated that around 63,000 hectares of crops were affected in 35 districts (Daily Star 2019).

Our survey instrument contained a short module designed to elicit information on the effects of Cyclone Fani on assets and income. *However,* only 12 percent of households surveyed in all rounds (baseline, endline, 2022) reported any damage – mostly crop losses or damage to housing. There was relatively little loss of livestock or productive assets, see Supplementary Appendix Table A3.3. It is possible that with the passage of time, and with the Covid-19 pandemic dominating respondents' memories, these are under-reports of damage caused by the cyclone. That said, we asked very specific questions (for example, about damage to housing) to prod respondents' memories and so the low percentages of households reporting any adverse impacts may well be correct.

The implications of all this are the following. Our data on outcomes include outcomes (usually) measured in 2018 and 2022. We do not have data on outcomes that occur between these dates and, as such, we do not (for the most part, at least at this point in our analysis) distinguish between the malign effects of Cyclone Fani and the Covid-19 pandemic. That said, it is not unreasonable to argue that the major shock that affected our respondents over this period was the pandemic.

5.2 Coping with the Covid-19 pandemic

Descriptive statistics on the most severe coping strategy used as measured by the LCSI show that, across the full sample, 10.5 percent of households used an emergency strategy, 31.7 percent used a crisis strategy (but not an emergency strategy), 31.2 percent used a stress strategy (but not a crisis or emergency strategy) and 26.6 percent did not use any livelihood coping strategy (Appendix Figure A3.3). When we disaggregate by treatment group, we see little difference between usage of these strategies when we compare the T-A treatment group and the control group. There is some suggestive evidence that, relative to the control group, the T-AN treatment group was less likely to use any coping strategy, and the T-ANG treatment group was less likely to use more severe strategies.

Participants varied in the use and frequency of Livelihood Coping Strategies (Appendix Figure A3.4). Three "Crisis" strategies were used by many participants: spending savings; buying food on credit; or borrowing money to buy foods. Between 48 and 58 percent of respondents reported using one of these strategies and some, such as buying food on credit, were used every few months. Approximately 32 percent of households also reported reducing expenditures on health-related items and another 27 percent reduced expenditures on other essential non-food items. Only around 12 percent of households reduced expenditures on agricultural inputs and there was little evidence of households selling assets, either household goods, productive assets, livestock, jewellery, or land.

We estimated a single difference model to see whether pre-Covid treatment status affected the likelihood of using these coping strategies. Given the ordered nature of these (None, Stress, Crisis, Emergency) we use an ordered probit model with higher values denoting the use of a more extreme coping strategy. In addition to our treatment variables, we include the covariates described in section 3.3. Results are reported in Table 1.

Table 1: Ordered probit estimates of the impact of ANGeL on use of Livelihood Coping Strategies

	(1)	(2)
Treatment		
Agriculture (T-A)	0.060	0.060
	(0.07)	(0.07)
Agriculture & Nutrition (T-AN)	-0.174**	
	(0.07)	
Agriculture, Nutrition and Gender (T-ANG)	-0.157*	
	(0.08)	
T-AN or T-ANG		-0.166**
		(0.07)
P values, equality of treatments		
T-A = T-AN	<0.01	
T-A = T-ANG	<0.01	
T-AN = T-ANG	0.83	
T-A = (T-AN or T-ANG)		<0.01
Number of observations	2,601	2,601

Notes. * p < 0.10; ** p <0.05; *** p < 0.01. All specifications include treatment indicators, upazila fixed effects and the following baseline characteristics: age and sex of household head, mean education levels of males and females 18 and older, number of adults, dependency ratio, wealth index, land owned, fishpond owned, access to information as measured by (baseline) number of mobile phones owned, ownership of television, received extension visit for crop production, received extension visit for livestock or fish production, and household has access to electricity. Standard errors are clustered at the unit of randomization.

Both the T-AN and T-ANG treatment arms reduced the use of Livelihood Coping Strategies but T-A did not. We can reject the null that the impacts of T-A and T-AN, and T-A and T-ANG, are equal. We do not reject the null that T-AN and T-ANG have equal effects. As ordered probit parameter estimates are not directly interpretable, in Table 2, we convert these to marginal effects. These show that the T-AN and T-ANG increased the likelihood that households did not need to rely on these coping strategies during the Covid-19 pandemic by approximately five percentage points and they reduced the likelihood of using the more severe coping behaviours, crisis and emergency, by approximately three percentage points each.

Table 2: Marginal effects of ANGeL treatment arms on the use of Livelihood Coping Strategies

Treatment		None	Stress	Crisis	Emergency
T-A	Marginal effect	-0.018	-0.004	0.014	0.009
	Standard error	0.022	0.006	0.017	0.011
T-AN	Marginal effect	0.056**	0.010***	-0.042**	-0.025**
	Standard error	0.024	0.004	0.018	0.010
T-ANG	Marginal effect	0.051*	0.010**	-0.038*	-0.023**
	Standard error	0.027	0.004	0.019	0.011

Treatment		None	Stress	Crisis	Emergency
T-A	Marginal effect	-0.018	-0.005	0.014	0.009
	Standard error	0.022	0.052	0.017	0.012
T-AN or T-ANG	Marginal effect	0.052**	0.012**	-0.039**	-0.025**
	Standard error	0.021	0.005	0.016	0.010

Notes. Marginal effects are generated from results reported in Table 2A.

5.3 Impacts on consumption

Information on median monthly per capita consumption, by round, treatment group and region, expressed in 2016 Taka, is found in Appendix Table 3.4. Starting with households in the control group, in real terms, median per capita consumption grew by 9.2 percent between 2016 and 2018, 14.4 percent between 2018 and 2022 with the result that real median per capita consumption was 24.9 percent higher in 2022 than it was at the time of the baseline survey in 2016. An implication of these changes is that increases in consumption levels in households that received support from ANGeL are not in themselves evidence of sustained impacts; evidence of sustainability comes from growth rates in consumption that are higher than those observed in the control groups.

Real per capita median consumption in the T-A treatment group grew by 10.0 percent between 2016 and 2018, 15.0 percent in the four years after ANGeL ended and was 26.4 percent higher in 2022 than it was at baseline (Appendix Table 3.4). Consumption growth was faster in the arms that included both agriculture and nutrition training, 22.9 and 13.5 percent between 2016 and 2018, and 7.7 and 15.6 percent between 2018 and 2022, in T-AN and T-ANG respectively. In 2022, real per capita median consumption in T-AN and T-ANG was, respectively, 32.4 and 31.2 percent higher than at baseline. While this suggests that the T-AN and T-ANG treatment arms had sustained impacts on real median per capita consumption – not only have these increased since 2016, but their values are also larger than that

observed in the control group – Appendix Table 3.4 also documents that about one-third of households saw their consumption fall between 2018 and 2022 by five percent or more.[1]

Growth in consumption will have minimal effects on other welfare indicators if they are concentrated among better off households. With this in mind, we graph kernel density functions of log per capita monthly consumption (in 2016 Taka) by treatment group and survey round. We superimpose on these graphs the median log of real per capita monthly consumption for the control group at the time of the baseline survey in 2016 (Supplementary Appendix Figure A3.5). In 2016, at baseline, there is little difference in the distributions of consumption by treatment group, a result formally confirmed by an exact Kolmogorov–Smirnov test of equality of distributions for all pairwise comparisons except for T-ANG and the control group (the former being somewhat more leptokurtic). In 2018, consumption in all treatment groups had shifted rightwards and we reject the null hypotheses that the distributions of each treatment group are equal to the Control group. In 2022, consumption levels of all groups remain rightward shifted relative to the baseline median of the control group (denoted by the vertical rule) but with the shift more pronounced for the T-AN and the T-ANG treatment groups.

Table 3 provides evidence of the impact of ANGeL on consumption. Columns (1) and (2) show that, at endline, all treatment groups increased real per capita consumption relative to the control group with the effect sizes larger (an approximately 10 percent increase) for the treatment groups that included both agricultural and nutrition training (T-AN and T-ANG) than the treatment that only included agriculture (a 3.6 percent increase). Four years after the ANGeL intervention ended, and a year after the worst effects of the pandemic were over, the agriculture only intervention no longer had a statistically significant impact on consumption. By contrast, in 2022, real mean per capita consumption was 4.9 percent higher in the T-AN treatment group, relative to the control group and it was 9.2 percent higher, relative to the control group, in T-ANG; the latter is significant at the 10 percent level. If we combine the two treatment arms that included both agriculture and nutrition training (without and with gender sensitization), we see that these raise real per capita consumption by 6.8 percent relative to the control group. Put differently, columns (3) and (4) show that treatments that combined training in both nutrition and agriculture led to, relative to the control group, sustained increases in real per capita consumption. Columns (5) and (6) show that while T-A had no effect on the likelihood that real per capita consumption fell by more than five percent post-program, the coefficients for T-AN and T-ANG are negative, indicating that these pre-pandemic treatment arms reduced the likelihood that consumption fell between 2018 and 2022 by approximately five percent.

[1] We chose the five percent cut-off to minimize the impact of random measurement error on the likelihood that consumption fell over this period.

Table 3: Impact of ANGeL on consumption levels and changes, endline and 2022

	(1)	(2)	(3)	(4)	(5)	(6)
	Log real per capita consumption, endline		Log real per capita consumption, 2022		Real household per capita consumption declined by more than 5%, 2018 to 2022	
Agriculture (T-A)	0.036**	0.036**	0.030	0.030	-0.005	-0.005
	(0.02)	(0.02)	(0.05)	(0.05)	(0.03)	(0.03)
Agriculture & Nutrition (T-AN)	0.102***		0.049		-0.055*	
	(0.02)		(0.03)		(0.03)	
Agriculture, Nutrition and Gender (T-ANG)	0.107***		0.092*		-0.045	
	(0.02)		(0.05)		(0.03)	
Agriculture & Nutrition or Agriculture, Nutrition & Gender		0.104***		0.068**		-0.051**
		(0.02)		(0.03)		(0.02)
P values, equality of treatments						
T-A = T-AN	<0.01		0.70		0.14	
T-A = T-ANG	<0.01		0.36		0.33	
T-AN = T-ANG	0.84		0.49		0.79	
T-A = (T-AN or T-ANG)		<0.01		0.45		0.15
Observations	2,601	2,601	2,601	2,601	2,601	2,601
R-squared	0.452	0.452	0.241	0.240	0.190	0.190

Notes. * p < 0.10; ** p <0.05; *** p < 0.01. All specifications include as independent variables listed in Table 2. Columns (1)-(4) control for baseline log per capita consumption. Columns (5)-(6) control for endline log real per capita consumption.

5.4 Impacts on diets

Table 4 shows that at ANGeL endline, the T-AN and T-ANG treatment arms increased log per capita caloric availability by 3.7 and 6.0 percent. Four years later, neither treatment had a statistically significant impact on this diet measure when included individually (column 2) or jointly (column 3). At endline, all treatment arms increased log hGDQS (column 4), with the impacts ranging from 3.7 percent (T-A) to 8.3 percent (T-ANG). We reject the null that the impacts of T-A and T-AN, and T-AN and T-ANG, are equal. Four years post-program, T-AN and T-ANG continue to have a statistically significant impact on hGDQS (column 5), but the effect size is attenuated (4.4 and 2.8 percent respectively). T-A no longer has a statistically significant impact on this outcome. When we combine these treatment arms (column 6), we reject the null that their effect size, a 3.7 percent increase, is equal to the impact of T-A.

Table 4: Impact of ANGeL on caloric availability and household GDQS

	(1)	(2)	(3)	(4)	(5)	(6)
	Log per capita caloric availability			Log hGDQS		
	Endline (2018)	2022	2022	Endline (2018)	2022	2022
Agriculture (T-A)	0.012	-0.018	-0.020	0.037***	0.006	0.006
	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
Agriculture & Nutrition (T-AN)	0.039**	0.022		0.075***	0.044***	
	(0.02)	(0.02)		(0.01)	(0.01)	
Agriculture, Nutrition and Gender (T-ANG)	0.059***	0.015		0.083***	0.028**	
	(0.02)	(0.02)		(0.01)	(0.01)	
Agriculture & Nutrition or Agriculture, Nutrition & Gender			0.02			0.037***
			(0.02)			(0.01)
P values, equality of treatments						
T-A = T-AN	0.13	0.07		<0.01	<0.01	
T-A = T-ANG	0.01	0.13		<0.01	0.10	
T-AN = T-ANG	0.28	0.74		0.58	0.15	
T-A = (T-AN or T-ANG)			0.05			<0.01
Observations	2,598	2,598	2,598	2,599	2,599	
R2	0.08	0.07	0.07	0.25	0.21	0.21

Notes. * p < 0.10; ** p <0.05; *** p < 0.01. Columns (1)-(3) controls for baseline per capita caloric availability. Columns (4)-(6) controls for baseline household GDQS.

6. DISAGGREGATIONS

We disaggregated our sample along several baseline characteristics to assess whether the impacts described above were concentrated in particular household types. This included disaggregating above or below the median of: age of the household head; household size; number of adults; mean grades of schooling of adult females; household wealth; cultivated land; and whether the household had an active homestead garden at baseline. We also disaggregated by attendance at ANGeL training. None of these disaggregations provided strong evidence of heterogenous impacts (results available on request).

However, one combination of household characteristics is suggestive of differential impacts in our sample. We disaggregated our sample by whether the household had been actively operating a homestead garden at baseline (defined as growing two or more crops on a homestead garden) and whether it owned more or less than 1.06 acres of land; 1.06 acres being the cutoff that separates households into the bottom two thirds and top third of the distribution of land owned respectively.[2] Homestead gardens are typically cultivated by women and non-homestead (or field) plots cultivated by men, reflecting the gendered division of space in rural Bangladesh. We estimated equation (1) separately for each of these four groups (Baseline homestead garden, small landholdings; Baseline homestead garden, larger landholdings; no Baseline homestead garden, small landholdings; and no Baseline homestead garden, larger landholdings) for the following outcomes: the LCSI; log per capita consumption; whether consumption fell by more than five percent between 2018 and 2022; log per capita household caloric acquisition; and log household GDQS.

Table 5 reports the impact of ANGeL across these four groups on the LCSI. Our ordered probit results show that ANGeL had an impact on the use of these coping strategies, but only for households that had an active homestead garden at baseline (see columns 1 to 4). For households with an active homestead garden at baseline but smaller land holdings (<1.06 acres), participation in either the T-AN or T-ANG treatment arms reduced the use of emergency coping strategies by 3.4 percentage points (a 33.7 percent reduction relative to the control group), reduced the use of crisis coping strategies by 6.4 percentage points (a 17.6 percent reduction relative to the control group) and increased the likelihood that no coping strategy was needed by 7.3 percentage points; see Supplementary Appendix Table A3.5. For households with an active homestead garden at baseline and larger land holdings, participation in either the T-AN or T-ANG treatment arms reduced the use of emergency coping strategies by 4.2 percentage points (a 37.2 percent reduction relative to the control group), reduced the use of crisis coping strategies by 9.4 percentage points (a 31.8 percent reduction relative to the control group) and increased the likelihood that no coping strategy was needed by 14.5 percentage points. We note that at baseline, these

[2] This disaggregation was not included in the analysis plan that we registered at RIDIE.

households had median per capita consumption below the median for the full sample; however, their median consumption was higher than households who also had small landholdings but no baseline homestead garden. Put differently, these larger impacts are found for poorer, but not the poorest, households in our sample.

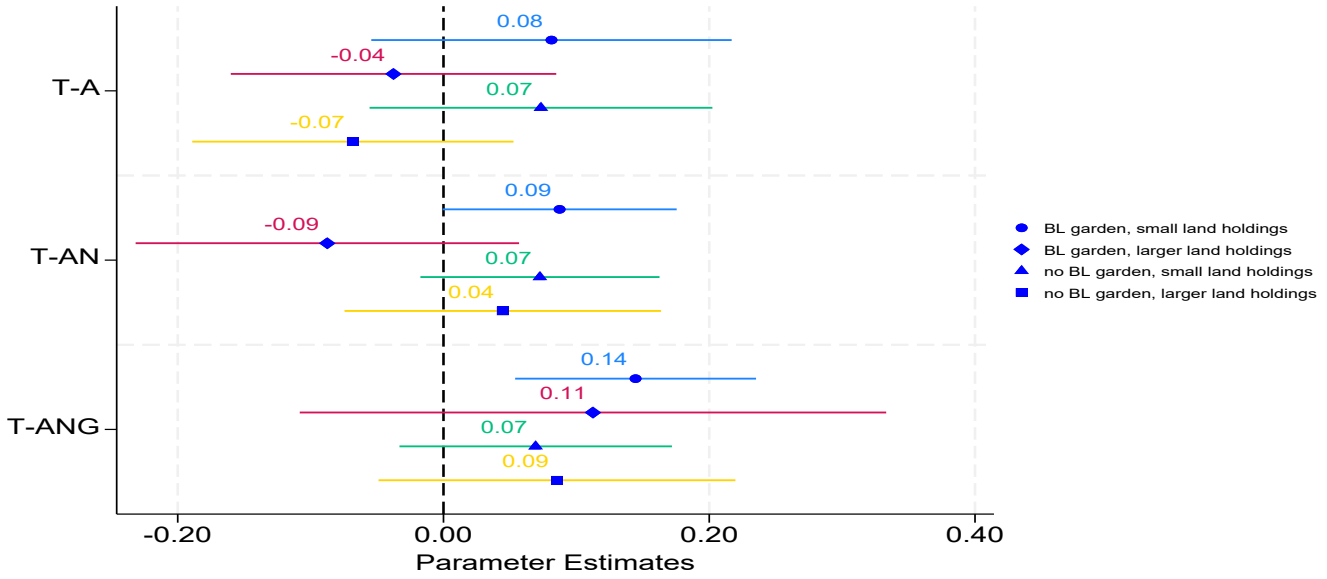
Table 5: Ordered probit estimates of the impact of ANGeL on use of Livelihood Coping Strategies, by baseline homestead garden status and land holdings

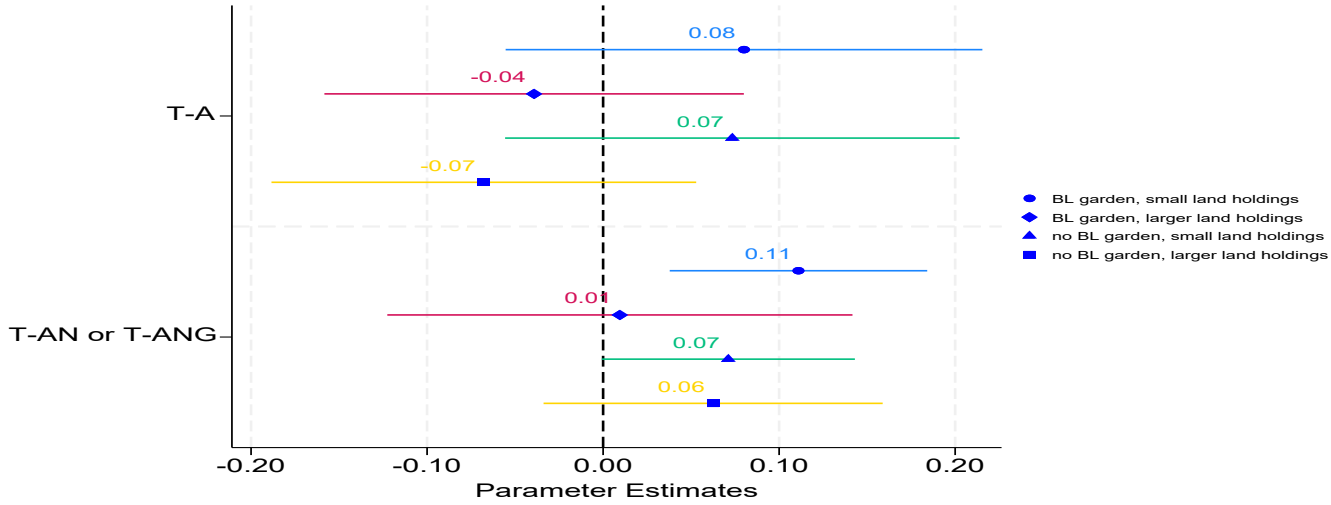
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Active homestead garden at baseline	Active	Active	Active	Active	Not active	Not active	Not active	Not active
Little, some cultivable land	Y	Y	Y	Y	Y	Y	N	N
More cultivable land	N	N	Y	Y	N	N	Y	Y
Treatment								
Agriculture (T-A)	0.105	0.104	-0.018	-0.017	0.091	0.091	0.010	0.008
	(0.13)	(0.13)	(0.13)	(0.13)	(0.10)	(0.10)	(0.13)	(0.13)
Agriculture & Nutrition (T-AN)	-0.276**		-0.300**		-0.052		-0.109	
	(0.13)		(0.14)		(0.12)		(0.15)	
Agriculture, Nutrition and Gender (T-ANG)	-0.208		-0.491***		-0.014		-0.228*	
	(0.13)		(0.14)		(0.13)		(0.14)	
T-AN or T-ANG		-0.248**		-0.392***		-0.035		-0.161
		(0.11)		(0.11)		(0.11)		(0.12)
Number of observations	690	690	434	434	1055	1055	422	422

Notes. * p < 0.10; ** p <0.05; *** p < 0.01. All specifications include as independent variables listed in Table 2. Standard errors are clustered at the unit of randomization.

Figures 1, 2, 3, and 4 report impacts across these four groups on log per capita consumption in 2022, whether households experienced a decline of more than five percent in consumption between 2018 and 2022, log per capita caloric acquisition, and log hGDQS. We first summarize these results by the four groups described above, then provide additional comments on the impacts of specific treatment arms.

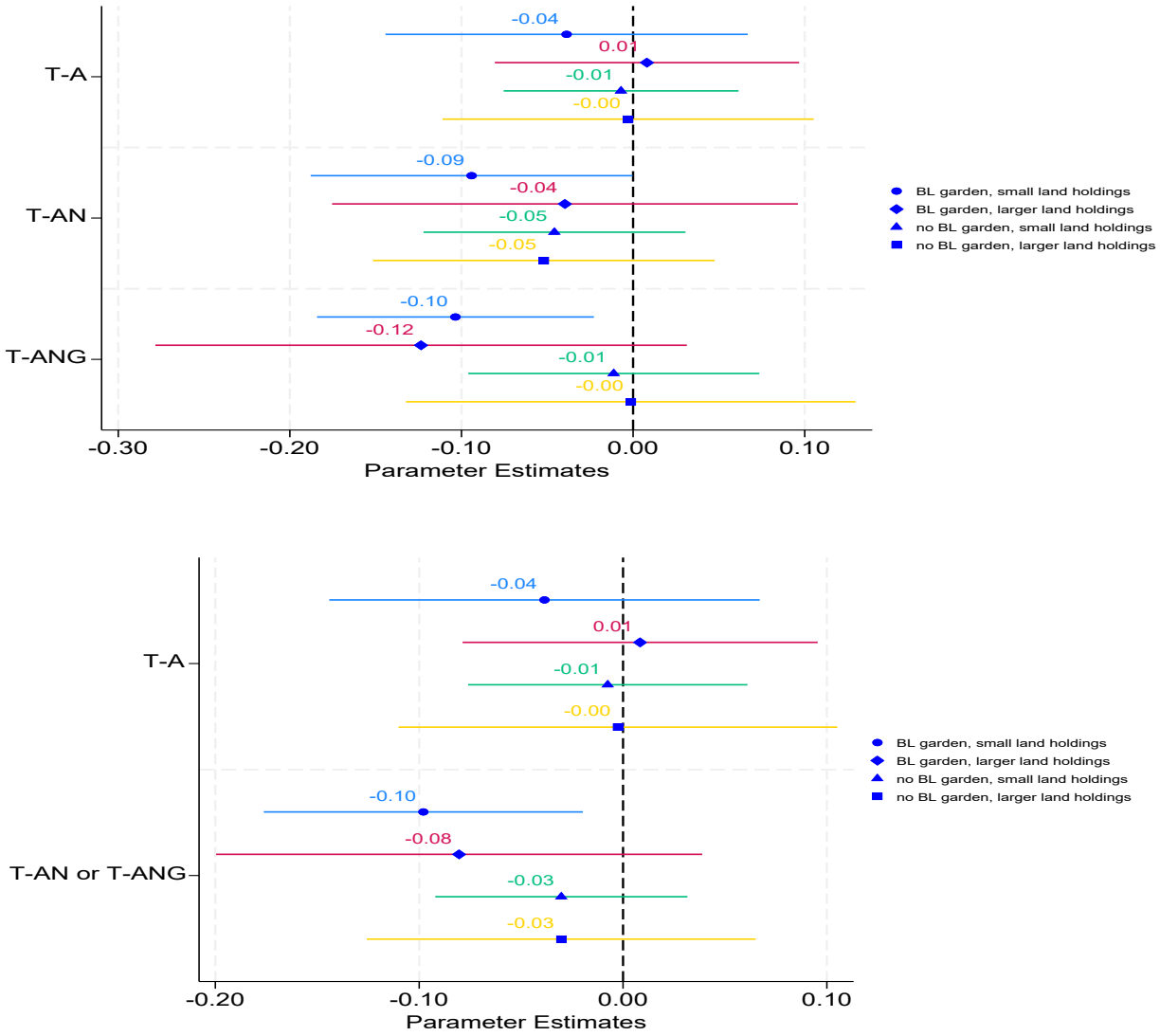
Figure 1: Impact of ANGeL on household log per capita consumption, 2022, by baseline garden and land holdings





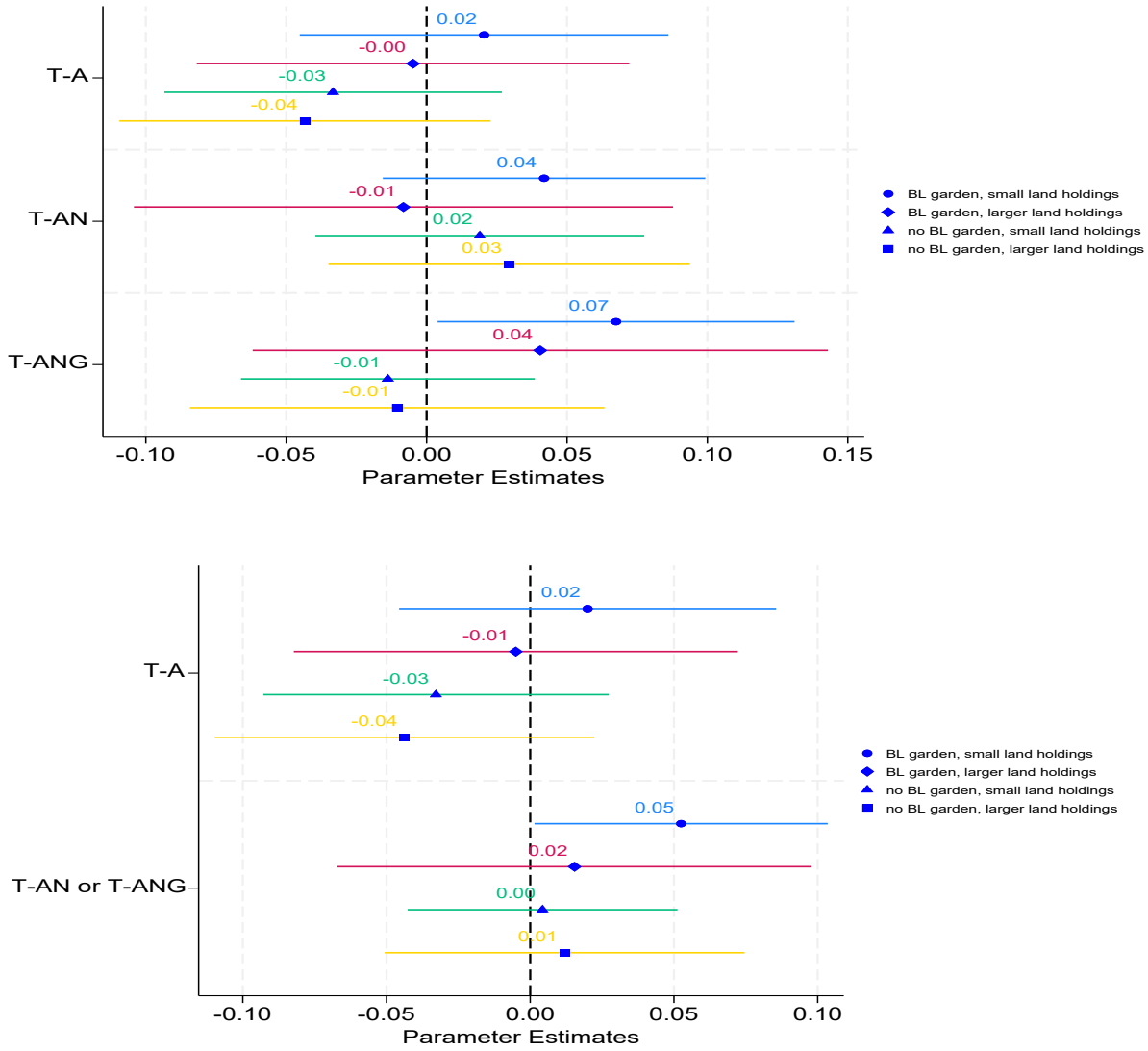
Cross-equation test of equality of (T-AN or T-ANG) coefficient	P value
BL garden, small = BL garden, larger	0.14
BL garden, small = no BL garden, small	0.41
BL garden, small = no BL garden, larger	0.41

Figure 2: Impact of ANGeL on consumption decline by more than 5%, 2018 to 2022, by baseline garden and land holdings



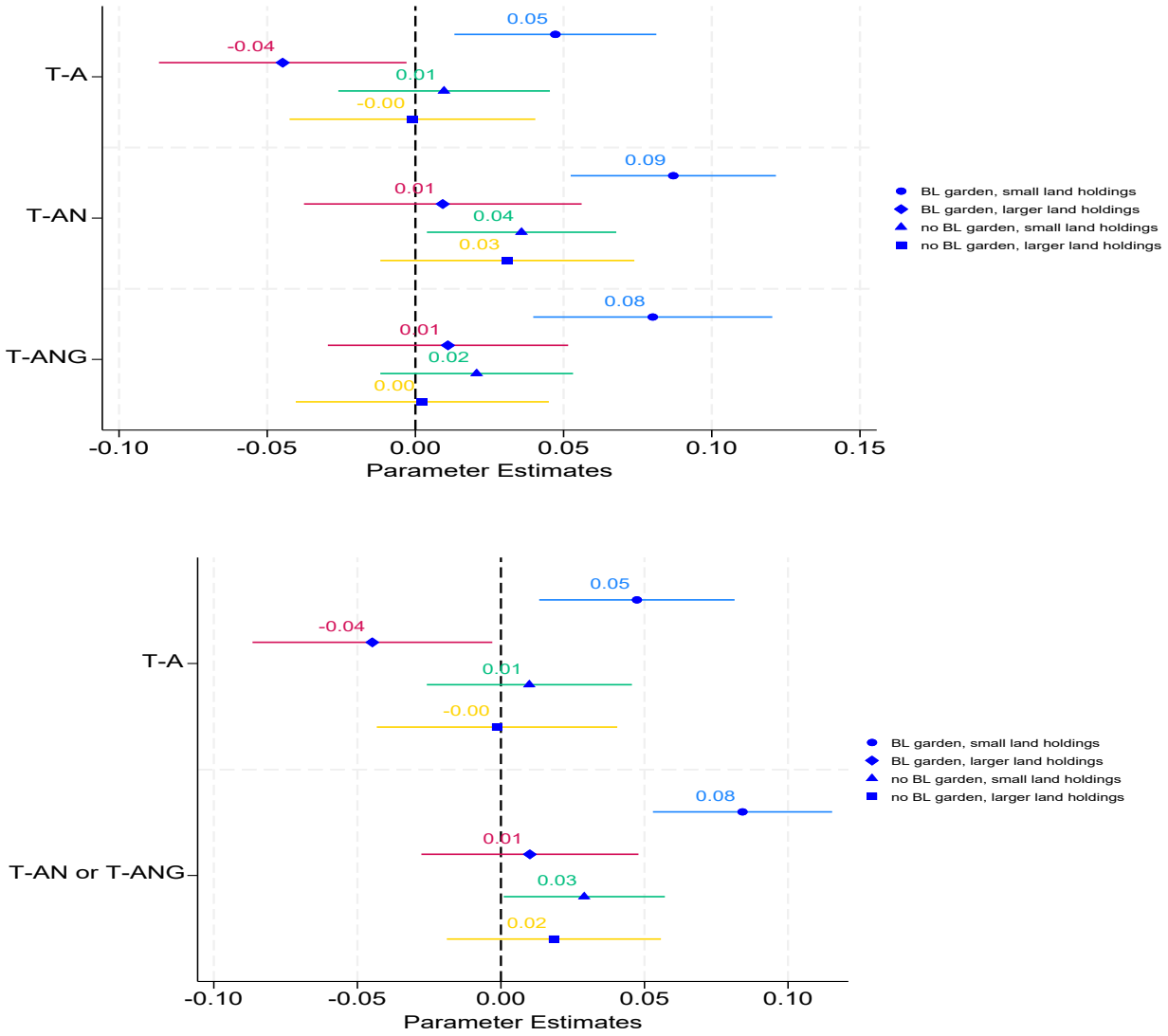
Cross-equation test of equality of (T-AN or T-ANG) coefficient	P value
BL garden, small = BL garden, larger	0.80
BL garden, small = no BL garden, small	0.19
BL garden, small = no BL garden, larger	0.27

Figure 3: Impact of ANGeL on household log per capita caloric acquisition, by baseline garden and land holdings



Cross-equation test of equality of (T-AN or T-ANG) coefficient	P value
BL garden, small = BL garden, larger	0.36
BL garden, small = no BL garden, small	0.16
BL garden, small = no BL garden, larger	0.27

Figure 4: Impact of ANGeL on hGDQS, by baseline garden and land holdings



Cross-equation test of equality of (T-AN or T-ANG) coefficient	P value
BL garden, small = BL garden, larger	<0.01
BL garden, small = no BL garden, small	<0.01
BL garden, small = no BL garden, larger	<0.01

We begin with households with larger land holdings. Across all treatment arms and outcomes, there is no evidence of statistically significant impacts for these households who operated, or did not operate, a homestead garden at baseline. Among households that had smaller land holdings at baseline, but did not operate a homestead garden, being in either the T-AN or T-ANG treatment groups increased real per capita consumption in 2022 by seven percent and increased hGDQS by three percent. Among households that had smaller land holdings at baseline and operated a homestead garden, being in either

the T-AN or T-ANG treatment groups increased real per capita consumption in 2022 by 11 percent, reduced the likelihood that consumption fell between 2018 and 2022 by 10 percentage points, increased caloric acquisition by five percent and increased hGDQS by eight percent; all of these impacts are statistically significant at the five percent level. Generally, the point estimates of impact of receiving either T-AN or T-ANG is larger for this group than it is for other groups and in the case of hGDQS, we reject the equality of impacts.

In general, agriculture training alone (T-A) has no impact for any of these four groups, the exceptions being hGDQS where this treatment arm increases hGDQS for households with a baseline homestead garden and smaller land holdings and, puzzlingly lowers hGDQS with a baseline homestead garden and larger land holdings. While we cannot reject the null that the impacts of T-ANG and T-AN are equal (results available on request), generally the point estimates for the T-ANG treatment arm tend to be larger than T-AN.

7. MECHANISMS

We explored mechanisms that underlie these results, beginning with an assessment of whether ANGeL participants learned from the agricultural training that they received and whether this learning was retained over time. We separately asked women 16 questions relating to the training they received, and we asked men 15 questions; we tallied their correct answers and converted these to percent scores.

We find that, at endline, exposure to treatments increased women's scores by about 30 percentage points with little variation across treatment arms (see top panel of Appendix Table A3.6); this was a large effect given that the control group scored 48.7 percent on this test. There is no difference in effect across our four sub-groups. Four years post-program, the impact of treatment attenuates, increasing test scores by about 14 percent relative to the control group. This attenuation largely reflects the fact that the mean score for the control group increased (to 61.8 percent); mean scores for the three treatment groups remained unchanged at around 80 percent. At endline, exposure to treatments increased men's scores by about 20 percentage points with little variation across treatment arms (see bottom panel); the male control group 47.8 percent. By 2022, scores for the male control group had increased to 65.9 percent; exposure to treatments increased this by six percent. This all suggests that knowledge was gained through the agricultural training provided by ANGeL, this knowledge was retained after the intervention ended, and that knowledge gains were especially large for women. These results are consistent with the persistent impacts that we observe four years post-program; however, because they are similar across households with little or more land at baseline and households with and without homestead gardens at baseline, they do not explain why persistent impacts were larger for some groups than others.

Our survey instrument contained questions on agency. We asked both women and men the following question, "Please imagine again a nine-step ladder, where on the bottom, the first step, are those who are totally unable to change their lives, while on step 9, the highest step, stand those who have full control over their own life. On which step are you?" At endline, the mean score for women on this ladder was 4.9 and for men it was 3.7. At endline, the T-ANG treatment arm increased this measure of women's agency by 0.22 points, a 4.8 percent increase (Appendix Table A3.7). However, at endline both the T-AN and T-ANG treatment arms had larger effects on women's agency for households that had operated a homestead garden at baseline but had relatively little land, raising this by 0.41 and 0.34 points respectively. These effects persist four years post program. In other groups, smaller (and generally non-statistically significant) effects are observed. There is no evidence that men's sense of agency was impacted by ANGeL, either at endline or four years post-program.[3]

[3] We note that we constructed a second measure of agency, based on Likert scale responses to the following questions: "When I make plans, I am almost certain/guaranteed/sure to make them work"; "I can mostly determine what will happen in my life"; "I am usually able to protect my personal interests"; "When I get what I want, It is usually because I worked hard for it"; and My

We investigate two further mechanisms: whether the increased sense of agency by women was accompanied by increases in their labor supply (Appendix Table A3.6); and whether ANGeL resulted in persistent increases in the production of agricultural commodities emphasized during training (Appendix Table A3.7). While there appears to be no impact on female (or male) labor supply at either the extensive (any income generating activities (IGA)) or intensive (number of persons, number of IGAs) margins four years post-program (Appendix Table A3.8). However, when we again disaggregate our sample, T-ANG increases the number of female IGAs by 0.36, a large effect given the mean for the control group is 1.26 (Appendix Table A3.9). By contrast, there is no impact of any treatment on men's IGAs when we disaggregate.

Appendix Table A3.10 reports on the production of agricultural products that were emphasized in the agriculture training that took place during ANGeL. Four years post-program, the T-ANG increased vegetable production by 213kg, an effect size nearly double the mean value for the control group. This was driven by an increase in vegetable production in fields, not in homestead gardens. All treatment arms had sustained impacts on fruit produced on homestead gardens; the T-ANG arm also had a large, but imprecisely measured, impact on fruit production in farmer fields. The value of poultry production, which is usually undertaken in the homestead with substantial women's involvement, also increased in the T-ANG treatment arm. When we disaggregate production of these items by baseline homestead garden and land holdings status, we find that T-ANG had a large, but imprecisely measured impact on vegetable production for households with a baseline homestead garden and smaller land holdings. (Results available on request.)

Land purchases are rare in rural Bangladesh; land is expensive. Upon marriage, men typically acquire a plot of family land to farm, with the land being formally divided among sons when the patriarch dies. Given the rarity of land purchases and the typically small land areas acquired through inter-vivos transfers and eventual inheritance (Rahman, 2010; Saha et al, 2025), we focus on land rentals, specifically sharecropping (Appendix Table A3.11), which happen with greater frequency. The parameter estimates are positive for all treatment arms, but the magnitudes are modest, ranging from 0.054 to 0.13 acres (one decimal is 1/100th of an acre.) All treatment arms increased the likelihood that households cultivated improved rice varieties by comparable magnitudes (5.3 to 6.8 percentage points) (Appendix Table A3.11).

Lastly, increasing cultivation bringing in new land for cultivation might require additional capital stock. We examine the impact of ANGeL on the holdings of productive assets. T-AN and T-ANG increased these asset holdings by 8.9 and 18.9 percent respectively at endline (Appendix Table A3.12).

life is determined by my own actions". However, there was little variation in responses (nearly all men and women agreed or strongly agreed with each statement) and so we did not find statistically significant impacts on this alternative measure of agency.

While this effect attenuates four years post-program, there remains an increase in the real total value of agricultural implements of approximately 15 percent. In the top panel of Appendix Table A3.13, we disaggregate total asset holdings by baseline homestead garden and operated land holdings, finding the largest effects for households who at baseline operated a homestead garden but had limited land holdings. In our survey instrument, we asked respondents who owned these assets, either solely or jointly with others. The bottom panel of Appendix Table A3.13 shows that in households that operated a homestead garden but had limited land holdings, female share of ownership (either solely or jointly) of productive assets increased in around five to six percentage points; in other groups, female share of productive assets was largely unchanged.

8. SUMMARY AND DISCUSSION

In the context of a nutrition- and gender-sensitive agricultural intervention in Bangladesh, this paper investigates whether an intervention aimed at improving food production diversity enhances resilience, the contribution of complementary programming, including nutrition SBC and gender sensitization, to these impacts, and whether this increased resilience is sufficient to protect consumption post-shock. We also unpack whether all participants benefit, or only some—and the mechanisms that underly both the persistence and distribution of benefits from the intervention. We use unique data, a four-year post-endline follow-up survey of households from a cluster-randomized controlled trial of a nutrition-and-gender-sensitive agricultural intervention in rural Bangladesh.

We find that treatment arms that included both agriculture and nutrition training reduced the likelihood that households undertook more severe forms of coping strategies (Crisis and Emergency). Treatment arms that included both agriculture and nutrition training reduced the likelihood that household per capita consumption fell, in real terms, by more than five percent between 2018 and 2022. The T-AN and the T-ANG treatment arms contributed to household resilience; by contrast, agriculture training alone (T-A), was not protective.

All treatment arms increased per capita consumption at endline. However, these impacts only persisted for those treatments that combined nutrition and agriculture training. The effect size is meaningful. Treatment arms that included both types of training increased per capita consumption by 6.8 percent four years after the ANGeL intervention ended. Impacts on caloric acquisition observed at ANGeL endline faded out four years post-program. However, treatments that combined nutrition and agriculture training had a persistent impact on hGDS, a measure of diet quality, raising it by 3.7 percent in 2022.

We explore whether there is evidence of heterogenous impacts. We find that across a range of outcomes - coping strategies used to address the stressors caused by the Covid-19 pandemic, whether consumption fell by more than five percent between endline and 2022), per capita consumption, household caloric acquisition, and hGDQS, the largest impacts are seen for households with a baseline homestead garden and smaller land holdings and who received the T-ANG (and for some outcomes, the T-AN) treatment. These impacts are meaningfully large. In 2022, four years after ANGeL ended, T-ANG increased caloric availability by seven percent and hGDQS by eight percent for those households with a baseline homestead garden and smaller land holdings. Households in this group were poorer than the average household in our sample at baseline, but they were not the poorest households.

Gender is at the heart of understanding why we observe these impacts, why they are larger for treatment arms that combined agriculture and nutrition training (and, sometimes with gender

sensitization), and why the effects are most pronounced for households that, while having small landholdings at baseline, operated a homestead garden. Four years post-program, women retained the knowledge they had acquired during ANGeL. However, only in the households with small baseline landholdings and a homestead garden do we observe an impact on women's sense of agency. Concurrent with this was an increase in female engagement in income generating activities and greater production of vegetables and poultry production (Appendix Table 3.10) underpinned by acquiring agricultural implements (Appendix Table 3.12) that were owned by women or owned jointly with their spouses (Appendix Table 3.13). The diversification and expansion of household productive activities are consistent with gender norms regarding the division of space: with vegetable production moving to farmer fields, such expansion would involve working in men's spaces; income generating activities and poultry raising, on the other hand, can be undertaken within the homestead, which are perceived as women's spaces. That women would conduct IGAs in close proximity to the homestead rather than work outside the home is consistent with evidence from livestock asset transfer programs in Bangladesh (Roy et al. 2015) and the diversification of women's livelihoods and increased empowerment and agency in Bangladesh more broadly (Kabeer 2024). That the diversification of women's income-earning activities occurred in the T-ANG arm could reflect messages from the gender sensitization training that emphasized women's agency and decision-making.

This follow-up study, four years after the end of an RCT that randomized different combinations of agriculture, nutrition, and gender sensitization training delivered to husbands and wives in rural Bangladesh, enabled us to assess the medium-term impact of a nutrition- and gender-sensitive agricultural intervention, specifically whether gains in per capita consumption expenditures and improvements in diets were sustained. The occurrence of both Cyclone Fani in 2019 and the onset of the Covid-19 pandemic in 2020 provided the unique opportunity to investigate whether nutrition- and gender-sensitive agricultural interventions can build resilience to shocks. The design of the RCT enabled us to ascertain which components of ANGeL were most conducive to sustained impacts over time. Detailed data on agricultural production, both on homestead and field parcels, area of land cultivated and land market transactions, individual asset ownership, employment, and nonfarm income generating activities enabled us to unpack the mechanisms that may have contributed to households' resilience and explore whether these were stronger for certain categories of beneficiaries.

Despite the richness of our data, owing to the interval between survey rounds, we were unable to track short-term changes in consumption, diets, assets, and time allocation to various activities. Thus, we do not know how diets and consumption changed in the *immediate* aftermath of the cyclone or Covid-19 related shocks. Moreover, since we did not have an ex-ante hypothesis regarding the mechanisms behind medium-term impacts, our analysis is exploratory rather than definitive. Mindful of these caveats, our

results demonstrate that nutrition and gender-sensitive agriculture programs can enhance household resilience to shocks, have sustained impacts on consumption and diets, improve the ability of women to generate income; these impacts are most pronounced for poorer (but not the poorest) households in our sample.

REFERENCES

Abadie, A., S. Athey, G. W. Imbens, and J. Wooldridge, 2023. When should you adjust standard errors for clustering? *Quarterly Journal of Economics* 138(1): 1-35.

Ahmed, A., F. Coleman, J. Ghostlaw, J. Hoddinott, P. Menon, A. Parvin, A. Pereira, A. Quisumbing, S. Roy, and M. Younus. 2024. Increasing Production Diversity and Diet Quality: Evidence from Bangladesh, *American Journal of Agricultural Economics*. 106(3): 1089-1110.

Ahmed, A., F. Coleman, J. Hoddinott, P. Menon, A. Parvin, A. Pereira, A. Quisumbing, S. Roy. 2023. Comparing delivery channels to promote nutrition-sensitive agriculture: A cluster-randomized controlled trial in Bangladesh. *Food Policy* 118, 102484, https://doi.org/10.1016/j.foodpol.2023.102484.

Ahmed, A., M. Bakhtiar, D. Gilligan, J. Hoddinott and S. Roy. 2023. Private transfers, public transfers, and food insecurity during the time of COVID-19: Evidence from Bangladesh, *Applied Economics Perspectives and Policy*, 45(4): 1901-1921. https://DOI: 10.1002/aepp.13373

Alkire, S., Meinzen-Dick, R. S. S., Peterman, A., Quisumbing, A., Seymour, G., and Vaz., A., 2013. The Women's Empowerment in Agriculture Index. *World Development* 52: 71-91.

Banerjee, A., Duflo, E., Goldberg, N., Karlan, D., Osei, R., Parienté, W., ... & Udry, C., 2015. A multifaceted program causes lasting progress for the very poor: Evidence from six countries. *Science*, 348(6236), 1260799.

Barrett, C. B., & Constas, M. A., 2014. Toward a theory of resilience for international development applications. *Proceedings of the National Academy of Sciences*, 111(40), 14625-14630.

Barrett, C., K. Ghezzi-Kopel, J. Hoddinott, N. Homami, E. Tennant, J. Upton, and T. Wu, 2021. A Scoping Review of the Development Resilience Literature: Theory, Methods and Evidence, *World Development* 146: 105612.

Bold, T., Kimenyi, M., Mwabu, G., Ng'ang'a, A., & Sandefur, J. (2018). Experimental evidence on scaling up education reforms in Kenya. *Journal of Public Economics*, 168, 1-20.

Blattman, C., Fiala, N. and Martinez, S., 2020. The long-term impacts of grants on poverty: Nine-year evidence from Uganda's youth opportunities program. *American Economic Review: Insights*, *2*(3), pp.287-304.

Bromage, S., C. Batis, S. N. Bhupathiraju, Wafaie W. Fawzi, Teresa T. Fung, Yanping Li, Megan Deitchler et al. 2021. "Development and validation of a novel food-based Global Diet Quality Score (GDQS)." *Journal of Nutrition* 151(12, S2): 75S-92S.

Constas, M., T. Frankenberger, and J. Hoddinott. 2014. Resilience Measurement Principles, Food Security Information Network Technical Series. Technical Report 1. Rome: Food and Agriculture Organization and World Food Programme.

Daily Star. 9 May, 2019. "Fani damaged crops worth Tk 38.5 cr: Agriculture Minister." Accessed September 9, 2019. https://www.thedailystar.net/country/news/fani-damaged-crops-worth-tk-385-cr-agriculture-minister-1740052

Davis, B., Handa, S., Hypher, N., Rossi, N. W., Winters, P., & Yablonski, J. (Eds.), 2023. *From evidence to action: The story of cash transfers and impact evaluation in sub-Saharan Africa*. Oxford University Press.

Fanzo, J., Carducci, B., Louis-Jean, J., Herrero, M., Karl, K. and Rosenzweig, C., 2025. Climate Change, Extreme Weather Events, Food Security, and Nutrition: Evolving Relationships and Critical Challenges. *Annual Review of Nutrition*, *45*.

FAO (2014). The State of Food and Agriculture 2014: Innovation in family farming. Food and Agriculture Organization of the United Nations, Rome.

Global Diet Quality Project, *Measuring What the World Eats: Insights from a New Approach* (Geneva: GAIN; Boston, MA: Harvard T.H. Chan School of Public Health, Department of Global Health and Population, 2022).

Hertel, T., Elouafi, I., Tanticharoen, M. and Ewert, F., 2023. Diversification for enhanced food systems resilience. *Science and innovations for food systems transformation*, pp.207-215.

Kabeer, N., 2024. *Renegotiating Patriarchy: Gender, Agency and the Bangladesh Paradox*. London: LSE Press. Available at: https://doi.org/10.31389/lsepress.rpg.

Kim, S.S., P.H. Nguyen, L.M. Tran, S. Alayon, P. Menon, and E.A. Frongillo, 2020. Different Combinations of Behavior Change Interventions and Frequencies of Interpersonal Contacts Are Associated with Infant and Young Child Feeding Practices in Bangladesh, Ethiopia, and Vietnam, *Current Developments in Nutrition* 4, 2: nzz140.

Lowder, S. K., Skoet, J., & Raney, T., 2016. The number, size, and distribution of farms, smallholder farms, and family farms worldwide. *World Development*, 87, 16-29.

Malapit, H., E. Sraboni, A. Quisumbing, and A. U. Ahmed. 2019. Intrahousehold empowerment gaps in agriculture and children's well-being in Bangladesh. *Development Policy Review* 37(2): 176-203.

Malapit, H., Quisumbing, A., Meinzen-Dick, R., Seymour, G., Martinez, E.M., Heckert, J., Rubin, D., Vaz, A., Yount, K.M., Phase, G.A.A.P. and Team, S., 2019. Development of the project-level Women's Empowerment in Agriculture Index (pro-WEAI). *World Development*, 122, pp.675-692.

Morton, J. F., 2007. The impact of climate change on smallholder and subsistence agriculture. *Proceedings of the National Academy of Sciences*, 104(50), 19680-19685.

Muralidharan, K., & Niehaus, P., 2017. Experimentation at scale. *Journal of Economic Perspectives*, 31(4), 103-124.

Pratap, B. and J. Hazrana, 2019. Crop diversification and resilience of agriculture to climatic shocks: Evidence from India, *Agricultural Systems*, 173: 345-354.

Quisumbing, A., Ahmed, A., Hoddinott, J., Pereira, A. and Roy, S., 2021. Designing for empowerment impact in agricultural development projects: Experimental evidence from the Agriculture, Nutrition, and Gender Linkages (ANGeL) project in Bangladesh. *World Development*, *146*, p.105622.

Quisumbing, A. R.; Kumar, N.; and Behrman, J. A. 2018. Do shocks affect men's and women's assets differently? Evidence from Bangladesh and Uganda. *Development Policy Review* 36 (1): 3-34. https://doi.org/10.1111/dpr.12235

Rahman, S., 2010. Determinants of agricultural land rental market transactions in Bangladesh. *Land use policy*, *27*(3), pp.957-964.

Ricciardi, V., Ramankutty, N., Mehrabi, Z., Jarvis, L., & Chookolingo, B., 2018. How much of the world's food do smallholders produce? *Global Food Security*, 17, 64-72.

Roy, S., J. Ara, N. Das, and A.R. Quisumbing. 2015. "Flypaper effects" in transfers targeted to women: Evidence from BRAC's Targeting the Ultra-poor Program in Bangladesh. *Journal of Development Economics* 117: 1-17.

Saha, S., Alam, M.J., Al Abbasi, A.A., Begum, I.A., Parikh, P. and Rola-Rubzen, M.F., 2025. The Effect of Rural Land Mortgaging on Rural Transformation at the Regional Level in Bangladesh. *Land Degradation & Development*. 36(6): 1977-1992.

Singh, B.K., Delgado-Baquerizo, M., Egidi, E. *et al.* 2023. Climate change impacts on plant pathogens, food security and paths forward. *Nat Rev Microbiol* 21: 640–656.

Sraboni, Esha, Hazel Malapit, Agnes Quisumbing, and Akhter U. Ahmed, 2014. Women's Empowerment in Agriculture: What Role for Food Security in Bangladesh? *World Development* 61: 11-52.

Vernooy, R., 2022. Does crop diversification lead to climate-related resilience? Improving the theory through insights on practice. *Agroecology and Sustainable Food Systems*, *46*(6), pp.877-901.

World Food Programme, 2023. Livelihood Coping Strategies Indicator for Food Security: Guidance Note. World Food Programme: Rome.

Appendix 1: The Agriculture, Nutrition, and Gender Linkages (ANGeL) project

Here we provide a summary of the design and implementation of the Agriculture, Nutrition, and Gender Linkages (ANGeL) project. Further details can be found in Ahmed et al (2024).

ANGeL was a multi-arm, cluster randomized controlled trial. Treatment consisted of training on nutrition, agriculture, and gender-sensitization attended by both husbands and wives. Nutrition training consisted of 19 sessions held monthly over a 17-month period. Topics included an introduction to the functional roles played by different types of foods, the importance of a balanced diet, micronutrients (vitamin A, iron, iodine, and zinc) and sources of food containing these, age-appropriate complementary foods, optimal breastfeeding practices, maternal nutrition and care, safe food preparation and preservation, hygiene, and handwashing. Activities included lectures, interactive discussions, games, and cooking demonstrations. Helen Keller International (HKI) developed the curriculum and training materials for the nutrition behavior change communication (BCC) with the Bangladesh Institute of Research and Training on Applied Nutrition (BIRTAN) and IFPRI. Training was delivered by sub-assistant agricultural officers (SAAOs) – also referred to as agricultural extension agents – who are permanent employees of the Bangladesh Ministry of Agriculture.

Agriculture training consisted of 17 sessions, also held monthly over a 17-month period. Topics covered an introduction to the cultivation of high-value crops (fruit and vegetables), using crop calendars to design a year-round system of cultivation, preparation of small plots and homestead gardens, water, pest and fertilizer management, harvest techniques, post-harvest storage, and marketing. Raising poultry, sheep and goats was also discussed, with attention to breed selection, feeding, vaccination, and diseases. The curriculum also included training on fishpond cultivation as fish is an important protein source in Bangladesh, and many Bangladeshi households have small fishponds in their homesteads or cultivate seasonal fishponds. Although these training sessions focused on agriculture, nutrition content was integrated by building competencies in identifying and cultivating nutrient-dense crops for household consumption. The curriculum and materials for the agricultural production training were developed by HKI in collaboration with the Bangladesh Agricultural Research Institute (BARI) and the Bangladesh Rice Research Institute (BRRI). Sessions included initial training, refresher training on key topics, and opportunities for participants to discuss their experiences applying their training. Training was delivered by SAAOs.[4]

For households who were in the treatment arm receiving both training in nutrition and agriculture, there were 19 nutrition sessions, and 17 agriculture sessions, held biweekly over 17 months.

[4] An additional treatment arm had nutrition training delivered by trained community nutrition workers; this is assessed in Ahmed et al (2023).

One treatment arm received the agriculture and the nutrition trainings and eight additional sessions on gender sensitization. Topics were based on HKI's *Nurturing Connections* curriculum (Helen Keller International Bangladesh 2017) and facilitated by staff hired by HKI. The gender sensitization sessions included structured activities aimed at improving intra-family respect, appreciation, and communication, as well as improving negotiation skills. These highly interactive sessions focused on gender relations, power dynamics, communication, and empowerment. The gender sensitization sessions invited mothers-in-law to participate along with husbands and wives, recognizing the role they play in decision-making around food and diets in rural Bangladesh. Supplementary Appendix Table A1.1 summarizes the topics covered in the three types of treatment.

Each training session conducted as part of ANGeL - lectures, interactive discussions, practical demonstrations, and question-answer sessions - lasted approximately 1.5 hours. Training took place either in meeting rooms or open courtyards in the villages where study participants resided; approximately 90 percent of participants reported that training sites were within one kilometer of their homes. Both husbands and wives were expected to attend each session, and care was taken to encourage active participation from both men and women. Participants received a small allowance for each training session to cover incidental costs of attending: 125 taka (approximately USD 1.50 at the time of the study) for one participant or 250 taka per household if both the husband and wife participated. Across the three treatment arms that were followed-up in 2022, the median woman attended between 79.5 and 94.4 percent of trainings; the median man attended between 75.0 and 94.0 percent of trainings. Approximately 90 percent of women reported attending training with their husbands. Work obligations were the most frequently cited reason for not attending a training session, followed by illness.

Appendix Table A1.1. Summary of ANGeL intervention components

	Agriculture training	Nutrition training	Gender training
Length of training period	17 months	17 months	17 months
Number of sessions	17	19	8
Topics covered	• cultivation of high value crops (fruit and vegetables) • using crop calendars to design a year-round cultivation system • preparation of small plots and vegetable gardens • water, pest, and fertilizer management • harvest techniques • post-harvest storage and marketing • raising poultry and small livestock (sheep and goats) • animal breed selection, feeding, vaccination, and diseases •fishpond cultivation	• the importance of a balanced diet, micronutrients (vitamin A, iron, iodine, and zinc) and sources of food containing these • age-appropriate complementary foods • optimal breastfeeding practices • maternal nutrition and care • safe food preparation and preservation, hygiene, and handwashing	• building trust • listening and communication skills • gendered perspectives • power relations and negotiation • shared decision making and assertiveness
Training format	Introductory lectures, practical demonstrations, and interactive question and answer sessions	Lectures, interactive discussions, games, and cooking demonstrations	Interactive activities, games, and group/pair discussions
Trainers	Agricultural extension agents from Bangladesh Ministry of Agriculture	Agricultural extension agents from Bangladesh Ministry of Agriculture	Women from the community hired and trained by Helen Keller International
Who was invited to attend	Husbands and wives	Husbands and wives	Husbands and wives and mothers in law

Appendix 2: Measurement of consumption, caloric availability and the hGDQS[5]

The survey modules used to measure consumption were comprehensive. They allow us to measure real household per capita consumption, daily per capita caloric availability, and to construct the household Global Diet Quality Score (hGDQS).

Consumption is the sum of the value of total food consumption and total nonfood (nondurable and durable) expenses. The value of food consumption is calculated based on a seven-day recall module that asked questions about the quantity of food purchased, price of purchased food, quantity consumed from home production, food received from other sources. Quantities consumed out of own production and food received from other sources are valued using price data collected at the village level at the same time as the household survey. The food consumption module was exhaustive in scope, covering 321 food items. Non-food expenses are sub-divided into two categories. A one-month recall period was used for items that are purchased with some frequency: fuel and lighting; washing, cleaning and cosmetics; transport/travel. Items that were purchased with less frequency, or items whose purchases tended to be lumpy were asked with a one-year recall: clothing and footwear (male and female); housing expenses; medical expenses (male and female); education expenses (male and female); remittances sent, gifts, ceremonies; recreation and leisure; taxes, fees, insurance; cooking equipment; furniture and appliances; jewelry; and other household durables. The non-food consumption module included 225 items in total. The total value of food consumption and non-food expenses is converted to monthly values, then divided by the number of household members to obtain consumption expenditure per person per month. Note that: (a) lumpy and infrequent expenditures such as dowry, wedding costs, pilgrimage, etc. are excluded from these aggregates; (b) identical food and non-food consumption modules were used in all survey years, as were the methods for producing the consumption aggregates; and (c) we use the rural general consumer price index (RGCPI) estimated by the Bangladesh Bureau of Statistics (BBS), to deflate all values to 2016 (baseline) Taka.

We extract the quantities of food available for consumption from our detailed food consumption module (with a recall period of the last seven days). Using food composition tables specific to Bangladesh, we convert these quantities to calories, divide by household size and then by seven. This gives us daily per capita caloric availability.

Our household Global Diet Quality Score is an adaptation of a recently developed indicator of diet quality (Bromage et al. 2021) called the Global Diet Quality Score (GDQS). The GDQS is designed to be sensitive to diet-related outcomes associated with both undernutrition and overnutrition. It consists of 25 food groups: 16 healthy food groups, 7 unhealthy food groups, and 2 food groups (red meat, high-

[5] This draws heavily on Ahmed et al (2024).

fat dairy) that are unhealthy when consumed in excessive amounts. For 24 food groups, three ranges of quantity of consumption are defined (in grams/day) and used in scoring the metric: low, medium, and high. For the final group, high-fat dairy, four ranges are used: low, medium, high, and very high. The points associated with the healthy GDQS food groups increase for each higher quantity of consumption category. The points associated with the unhealthy GDQS food groups decrease for each higher quantity of consumption category. For the two food groups that are unhealthy in excessive consumption (red meat, high-fat dairy), the points associated with the GDQS food group increase up to a certain threshold of quantity of consumption, then decrease. The overall GDQS is the sum of points across all 25 GDQS food groups. GDQS scores ≥23 are associated with a low risk of both nutrient adequacy, scores ≥15 and <23 indicate moderate risk, and scores below 15 indicate high risk (Bromage et al. 2021).

Because our analysis of ANGeL is at the household level, and our household-level food consumption data are based on 7-day recall, we construct a variation of the GDQS at the household level, the household-level GDQS (hGDQS). We calculate household consumption of these 25 food groups, converting these quantities into daily per adult equivalent amounts and apply the scoring method described above. This gives a hGDQS score that ranges 0 to 49.

Appendix 3: Additional tables and figures

Appendix Table A3.1: Correlates of attrition

	(1)	(2)
	Treatment status only	Treatment status and control variables
Treatment		
Agriculture (A)	0.006	0.003
	(0.014)	(0.010)
Agriculture & Nutrition (AN)	-0.013	-0.010
	(0.014)	(0.010)
Agriculture, Nutrition and Gender (ANG)	-0.012	-0.006
	(0.015)	(0.012)
R-squared	0.002	0.051
Sample size	2,749	2,749

Notes: Estimates are linear probability models where the dependent variable equals one if the household attrited between baseline and 2022. Standard errors adjusted for clustering at block level are in parentheses. *p<.10; **p<.05; ***p<.01. All specifications include as independent variables the treatment indicators. Column (2) also includes the following control variables: age and sex of household head, mean education levels of males and females 18 and older, number of adults, dependency ratio, wealth index, land owned at baseline, fishpond owned at baseline, baseline access to information as measured by (baseline) number of mobile phones owned, ownership of television, received extension visit for crop production, received extension visit for livestock or fish production, household has access to electricity, and baseline *upazila*.

Appendix Table A3.2: Means and standard deviations of baseline household characteristics, by treatment arm

	Control	Agriculture (T-A)	Agriculture and Nutrition (T-AN)	Agriculture, Nutrition and Gender (T-ANG)
Demographic				
Age, household head	41.37 (13.84)	40.80 (13.49)	41.77 (14.30)	41.11 (13.79)
Number of adults (>=18 years)	3.21 (1.44)	3.09 (1.40)	3.26 (1.54)	3.16 (1.41)
Average years of education, adult males	4.79 (3.88)	4.68 (4.03)	4.19 (3.68)	4.73 (3.57)
Average years of education, adult females	5.17 (2.87)	5.38 (2.99)	4.54 (2.75)	5.15 (2.68)
Dependency ratio	1.00 (0.62)	0.96 (0.57)	1.03 (0.65)	0.96 (0.59)
Female headed, percent	3.03	3.77	3.99	5.24
Wealth and productive assets				
Wealth index	0.30 (2.50)	0.37 (2.51)	0.02 (2.50)	-0.08 (2.38)
Land operated, acres	1.08 (1.09)	1.15 (1.24)	1.09 (1.19)	0.96 (0.80)
HH has fishpond, percent	27.52	29.16	21.13	19.59
Mobile phones, number	1.65 (1.25)	1.66 (1.12)	1.75 (1.22)	1.70 (1.15)
Household has electricity, percent	76.00	73.07	72.71	79.05
Access to information				
Owns television, percent	36.00	34.31	33.44	32.43
Received visit from extension agent in last 12 months to discuss crops, percent	19.64	24.87	22.13	19.26
Received visit from extension agent in last 12 months to discuss livestock, poultry, fish, percent	6.42	6.35	4.33	2.36
Sample size	825	583	601	592

Notes: Dependency ratio is the ratio of dependents to number of working age adults

Appendix Table A3.3: Impact of Cyclone Fani

Conditional on reporting any damage from Cyclone Fani, household reported:	Percent
Crop Loss	73.6
House Damaged	46.4
House Destroyed	18.8
Livestock Loss	6.4
Agricultural equipment damaged or destroyed	6.4
Equipment used in non-agricultural enterprises damaged or destroyed	5.2
Number of households reporting damage from Cyclone Fani	330

Note: Percentages do not add up to 100 because households may report multiple types of damage.

Appendix Table 3.4: Median monthly real (2016) per capita consumption, by round, treatment group

	Median monthly per capita consumption, 2016 Taka			Real household per capita consumption declined by more than 5% (percent)
	Baseline (2016)	Endline (2018)	Four year post-program (2022)	Between 2018 and 2022
Control	2707	2955	3420	31.3
		(9.2)	(14.4)	
Agriculture	2748	3022	3492	33.3
		(10.0)	(15.0)	
Agriculture & Nutrition	2751	3396	3647	35.5
		(22.9)	(7.7)	
Agriculture, Nutrition & Gender	2772	3146	3615	31.8
		(13.5)	(15.6)	
All households	2741	3120	3547	32.8

Notes: Sample size: 2,601. Growth rates between endline and baseline and four-year post program and endline in parentheses

Appendix Table A3.5: Marginal effects of ANGeL treatment arms on the use of Livelihood Coping Strategies, by baseline homestead garden status and land holdings

Household had active homestead garden at baseline but small land holdings

Treatment		None	Stress	Crisis	Emergency
T-A	Marginal effect	-0.030	-0.012	0.027	0.015
	Standard error	(0.036)	(0.016)	(0.032)	(0.019)
T-AN	Marginal effect	0.085**	0.023**	-0.074**	-0.034**
	Standard error	(0.041)	(0.009)	(0.035)	(0.015)
T-ANG	Marginal effect	0.063	0.018*	-0.056	-0.027***
	Standard error	(0.043)	(0.010)	(0.036)	(0.016)

Treatment		None	Stress	Crisis	Emergency
T-A	Marginal effect	-0.030	-0.012	0.027	0.015
	Standard error	(0.036)	(0.016)	(0.032)	(0.019)
T-AN or T-ANG	Marginal effect	0.073**	0.025**	-0.064**	-0.034**
	Standard error	(0.033)	(0.011)	(0.028)	(0.015)
Mean, control group		24.5	29.0	36.4	10.1

Household had active homestead garden at baseline, larger land holdings

Treatment		None	Stress	Crisis	Emergency
T-A	Marginal effect	0.006	-0.001	-0.004	-0.002
	Standard error	(0.048)	(0.002)	(0.031)	(0.014)
T-AN	Marginal effect	0.114**	-0.012	-0.072**	-0.029**
	Standard error	(0.054)	(0.011)	(0.034)	(0.012)
T-ANG	Marginal effect	0.187***	-0.028*	-0.115***	-0.044***
	Standard error	(0.053)	(0.015)	(0.032)	(0.012)

Treatment		None	Stress	Crisis	Emergency
T-A	Marginal effect	0.006	-0.0002	-0.004	-0.002
	Standard error	(0.047)	(0.002)	(0.030)	(0.014)
T-AN or T-ANG	Marginal effect	0.145***	-0.008	-0.094***	-0.042***
	Standard error	(0.042)	(0.007)	(0.029)	(0.013)
Mean, control group		33.3	25.8	29.6	11.3

Household did not have active homestead garden at baseline and had small land holdings

Treatment		None	Stress	Crisis	Emergency
T-A	Marginal effect	-0.025	-0.011	0.021	0.015
	Standard error	(0.029)	(0.014)	(0.024)	(0.018)
T-AN	Marginal effect	0.015	0.006	-0.012	-0.008
	Standard error	(0.034)	(0.013)	(0.029)	(0.018)
T-ANG	Marginal effect	0.004	0.002	-0.003	-0.002
	Standard error	(0.037)	(0.015)	(0.031)	(0.021)

Treatment		None	Stress	Crisis	Emergency
T-A	Marginal effect	-0.025	-0.011	0.021	0.015
	Standard error	(0.029)	(0.014)	(0.024)	(0.018)
T-AN or T-ANG	Marginal effect	0.010	0.004	-0.008	-0.005
	Standard error	(0.031)	(0.013)	(0.026)	(0.018)
Mean, control group		24.5	29.0	36.4	10.1

Household did not have active homestead garden at baseline but had larger land holdings

Treatment		None	Stress	Crisis	Emergency
T-A	Marginal effect	-0.003	-0.0002	0.002	0.002
	Standard error	(0.045)	(0.003)	(0.026)	(0.022)
T-AN	Marginal effect	0.037	0.001	-0.021	-0.018
	Standard error	(0.051)	(0.002)	(0.029)	(0.023)
T-ANG	Marginal effect	0.079	-0.0002	-0.044*	-0.035
	Standard error	(0.049)	(0.005)	(0.027)	(0.020)

Treatment		None	Stress	Crisis	Emergency
T-A	Marginal effect	-0.003	-0.0002	0.001	0.001
	Standard error	(0.045)	(0.003)	(0.026)	(0.022)
T-AN or T-ANG	Marginal effect	0.054	0.003	-0.031	-0.027
	Standard error	(0.041)	(0.003)	(0.023)	(0.021)
Mean, control group		24.5	29.0	36.4	10.1

Appendix Table A3.6: Knowledge of improved agricultural practices, by survey round, baseline garden and land holdings, and sex

WOMEN	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
			Endline					2022		
	All	By baseline garden and land holdings				All	By baseline garden and land holdings			
Homestead garden		Active	Not active	Active	Not active		Active	Not active	Active	Not active
Land holdings		Little, Some	Little, Some	More	More		Little, Some	Little, Some	More	More
(T-A)	0.293***	0.316***	0.274***	0.320***	0.279***	0.135***	0.171***	0.132***	0.116***	0.113***
	(0.012)	(0.019)	(0.015)	(0.023)	(0.021)	(0.016)	(0.022)	(0.020)	(0.023)	(0.027)
(T-AN)	0.315***	0.331***	0.324***	0.313***	0.282***	0.140***	0.147***	0.142***	0.106***	0.157***
	(0.012)	(0.018)	(0.014)	(0.024)	(0.019)	(0.013)	(0.024)	(0.015)	(0.019)	(0.024)
(T-ANG)	0.301***	0.292***	0.306***	0.318***	0.297***	0.143***	0.174***	0.145***	0.123***	0.137***
	(0.014)	(0.022)	(0.020)	(0.025)	(0.022)	(0.015)	(0.025)	(0.020)	(0.020)	(0.024)
Constant	0.456***	0.451***	0.471***	0.435***	0.280***	0.470***	0.486***	0.417***	0.531***	0.353***
	(0.030)	(0.039)	(0.042)	(0.062)	(0.100)	(0.032)	(0.049)	(0.049)	(0.058)	(0.083)
Observations	2,601	690	1,055	434	422	2,589	688	1,047	433	421
R-squared	0.534	0.583	0.566	0.512	0.536	0.335	0.363	0.339	0.364	0.362

MEN	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
			Endline					2022		
	All	By baseline garden and land holdings				All	By baseline garden and land holdings			
Homestead garden		Active	Not active	Active	Not active		Active	Not active	Active	Not active
Land holdings		Little, Some	Little, Some	More	More		Little, Some	Little, Some	More	More
(T-A)	0.200***	0.187***	0.199***	0.217***	0.190***	0.040**	0.061*	0.031	0.068**	-0.010
	(0.014)	(0.026)	(0.018)	(0.022)	(0.022)	(0.018)	(0.032)	(0.020)	(0.033)	(0.043)
(T-AN)	0.200***	0.185***	0.201***	0.210***	0.229***	0.061***	0.062*	0.060**	0.050*	0.066
	(0.014)	(0.024)	(0.021)	(0.029)	(0.022)	(0.017)	(0.034)	(0.023)	(0.027)	(0.041)
(T-ANG)	0.197***	0.176***	0.211***	0.208***	0.229***	0.066***	0.069**	0.062**	0.087**	0.100**
	(0.014)	(0.025)	(0.020)	(0.031)	(0.031)	(0.018)	(0.030)	(0.027)	(0.035)	(0.044)
Constant	0.479***	0.394***	0.483***	0.547***	0.539***	0.721***	0.683***	0.739***	0.696***	0.760***
	(0.036)	(0.047)	(0.047)	(0.063)	(0.069)	(0.047)	(0.075)	(0.063)	(0.072)	(0.107)
Observations	2,601	690	1,055	434	422	2,601	690	1,055	434	422
R-squared	0.254	0.302	0.256	0.257	0.291	0.158	0.206	0.179	0.126	0.144

Notes. * p < 0.10; ** p <0.05; *** p < 0.01. All specifications include as independent variables listed in Table 2. Standard errors are clustered at the unit of randomization. (T-A): Agriculture training only; (T-AN): Agriculture and nutrition training; (T-ANG): Agriculture, nutrition training and gender sensitization.

Appendix Table A3.7: Agency, by survey round, baseline homestead garden and land holdings, and sex

WOMEN	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
			Endline					2022		
	All	By baseline garden and land holdings				All	By baseline garden and land holdings			
Homestead garden		Active	Not active	Active	Not active		Active	Not active	Active	Not active
Land holdings		Little, Some	Little, Some	More	More		Little, Some	Little, Some	More	More
(T-A)	0.060	0.100	0.188	-0.135	-0.066	0.149	0.283	-0.063	0.392**	0.085
	(0.09)	(0.17)	(0.15)	(0.15)	(0.13)	(0.10)	(0.20)	(0.15)	(0.19)	(0.19)
(T-AN)	0.177*	0.411**	0.103	-0.126	0.164	0.211**	0.363**	0.019	0.482*	0.208
	(0.09)	(0.16)	(0.13)	(0.17)	(0.14)	(0.10)	(0.15)	(0.16)	(0.28)	(0.19)
(T-ANG)	0.224**	0.334*	0.219*	0.187	0.032	-0.012	0.342*	-0.146	-0.149	-0.068
	(0.09)	(0.18)	(0.13)	(0.17)	(0.14)	(0.11)	(0.19)	(0.18)	(0.19)	(0.22)
Constant	3.449***	3.312***	3.409***	3.508***	3.550***	3.618***	3.594***	3.390***	3.490***	5.381***
	(0.26)	(0.29)	(0.38)	(0.48)	(0.61)	(0.24)	(0.37)	(0.39)	(0.51)	(0.62)
Observations	2,598	690	1,054	433	421	2,588	688	1,047	433	420
R-squared	0.220	0.265	0.220	0.264	0.209	0.201	0.200	0.203	0.266	0.231

MEN	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
			Endline					2022		
	All	By baseline garden and land holdings				All	By baseline garden and land holdings			
Homestead garden		Active	Not active	Active	Not active		Active	Not active	Active	Not active
Land holdings		Little, Some	Little, Some	More	More		Little, Some	Little, Some	More	More
(T-A)	-0.101	0.024	-0.087	-0.369**	0.027	0.007	-0.035	0.139	-0.087	-0.006
	(0.074)	(0.126)	(0.111)	(0.158)	(0.200)	(0.131)	(0.267)	(0.176)	(0.192)	(0.272)
(T-AN)	-0.037	0.020	-0.005	-0.190	0.115	0.098	0.178	0.122	0.091	0.096
	(0.076)	(0.122)	(0.105)	(0.177)	(0.195)	(0.116)	(0.210)	(0.164)	(0.173)	(0.261)
(T-ANG)	-0.038	0.228	-0.066	-0.328*	0.242	0.022	0.032	0.279*	-0.130	-0.323
	(0.084)	(0.141)	(0.126)	(0.183)	(0.191)	(0.128)	(0.235)	(0.154)	(0.201)	(0.286)
Constant	2.908***	2.764***	2.884***	3.190***	4.218***	3.920***	3.709***	3.763***	3.931***	4.957***
	(0.160)	(0.272)	(0.274)	(0.444)	(0.866)	(0.277)	(0.491)	(0.456)	(0.674)	(1.102)
Observations	2,497	639	1,010	430	418	2,343	611	940	406	386
R-squared	0.330	0.323	0.305	0.339	0.349	0.166	0.192	0.145	0.204	0.201

Notes. * p < 0.10; ** p <0.05; *** p < 0.01. All specifications include as independent variables listed in Table 2. Standard errors are clustered at the unit of randomization. (T-A): Agriculture training only; (T-AN): Agriculture and nutrition training; (T-ANG): Agriculture, nutrition training and gender sensitization.

Appendix Table A3.8: Impact on household labor supply, 2022, by sex

	Female			Male		
	(1)	(2)	(3)	(4)	(5)	(6)
	Any IGA	**Num persons**	**Num IGAs**	**Any IGA**	**Num persons**	**Num IGAs**
Agriculture (T-A)	-0.023	-0.034	-0.069	0.003	-0.004	-0.104
	(0.037)	(0.053)	(0.099)	(0.018)	(0.044)	(0.086)
Agriculture & Nutrition (T-AN)	-0.041	-0.062	-0.043	0.010	0.064	0.059
	(0.037)	(0.058)	(0.098)	(0.016)	(0.045)	(0.091)
Agriculture, Nutrition and Gender (T-ANG)	0.015	0.010	0.077	0.015	-0.034	0.033
	(0.038)	(0.059)	(0.112)	(0.018)	(0.045)	(0.091)
Control mean	0.712	0.852	1.223	0.886	1.160	2.051
Number of obs	2,886	2,886	2,886	2,886	2,886	2,886
p: T-A = T-AN	0.67	0.65	0.82	0.68	0.14	0.08
p: T-A = T-ANG	0.42	0.51	0.26	0.53	0.51	0.18
p: T-AN = T-ANG	0.19	0.33	0.37	0.78	0.03	0.78

Notes. IGA = Income generating activity. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$. All specifications include as independent variables listed in Table 2. Standard errors are clustered at the unit of randomization.

Appendix Table A3.9: Impact of ANGeL on number of female economic activities by baseline homestead garden status and land holdings

	(1)	(2)	(3)	(4)
	By baseline garden and land holdings			
Homestead garden	Active	Not active	Active	Not active
Land holdings	Little, Some	Little, Some	More	More
Agriculture (T-A)	-0.033	-0.065	-0.225	0.060
	(0.192)	(0.099)	(0.158)	(0.178)
Agriculture & Nutrition (T-AN)	-0.029	-0.049	-0.167	0.123
	(0.144)	(0.120)	(0.159)	(0.184)
Agriculture, Nutrition and Gender (T-ANG)	0.358**	0.074	-0.313*	0.007
	(0.176)	(0.133)	(0.166)	(0.203)
Control mean	1.263	1.123	1.386	1.255
Number of obs	689	1,055	434	422
p: T-A = T-AN	0.98	0.89	0.76	0.74
p: T-A = T-ANG	0.10	0.30	0.67	0.83
p: T-AN = T-ANG	0.03	0.48	0.50	0.66

Notes. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$. All specifications include as independent variables the treatment indicators, upazila fixed effects and baseline control variables. Standard errors are clustered at the unit of randomization.

Appendix Table A3.10: Production of vegetables, fruit, and poultry products

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Vegetables (kg)			Fruit (kg)			Poultry (Taka)
	All production	Homestead production	Non-homestead production	All production	Homestead production	Non-homestead production	
Agriculture (T-A)	-21.283	-0.093	-21.190	111.660	85.069**	26.591	81.986
	(56.015)	(5.729)	(55.747)	(75.216)	(40.818)	(52.978)	(124.955)
Agriculture & Nutrition (T-AN)	63.918	0.752	63.166	22.013	61.431*	-39.418	185.010
	(109.726)	(8.043)	(107.354)	(76.687)	(32.744)	(72.932)	(119.416)
Agriculture, Nutrition and Gender (T-ANG)	213.029*	12.653	200.376*	192.002	63.156**	128.846	511.913***
	(119.348)	(10.96)	(119.801)	(192.933)	(31.243)	(184.676)	(189.168)
Control mean	260.6	35.2	241.3	257.6	182.9	74.6	1471.0
p: T-A = T-AN	0.02	0.91	0.40	0.31	0.65	0.32	0.47
p: T-A = T-ANG	0.01	0.23	0.03	0.69	0.67	0.58	0.04
p: T-AN = T-ANG	0.33	0.30	0.41	0.27	0.96	0.25	0.06

Notes. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$. All specifications include as independent variables listed in Table 2. Standard errors are clustered at the unit of randomization. Sample size is 2,886.

Appendix Table A3.11: Impact on land sharecropped (decimals) and rice production

	(1) Amount of land sharecropped (Decimals)	(2) Grew rice	(3) Grew improved rice variety
Agriculture (T-A)	13.070**	0.053*	0.059**
	(6.330)	(0.027)	(0.028)
Agriculture & Nutrition (T-AN)	5.469	0.049	0.053*
	(4.955)	(0.030)	(0.030)
Agriculture, Nutrition and Gender (T-ANG)	6.896*	0.071**	0.068**
	(3.551)	(0.032)	(0.033)
Control mean	12.58	0.74	0.73
p: T-A = T-AN	0.27	0.90	0.84
p: T-A = T-ANG	0.24	0.59	0.81
p: T-AN = T-ANG	0.71	0.56	0.70

Notes. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$. All specifications include as independent variables listed in Table 2. Standard errors are clustered at the unit of randomization.

Appendix Table A3.12: Impact of ANGeL on (log) productive assets

Panel A	Log real total value of household assets		Log real total value of agricultural implements		Log real total value of livestock	
	Endline (2018)	2022	Endline (2018)	2022	Endline (2018)	2022
Agriculture (T-A)	0.048	-0.049	0.140**	0.064	0.118	0.038
	(0.045)	(0.059)	(0.055)	(0.065)	(0.080)	(0.114)
Agriculture & Nutrition (T-AN)	0.089*	0.051	0.112*	0.149**	0.110	-0.041
	(0.051)	(0.061)	(0.062)	(0.063)	(0.108)	(0.129)
Agriculture, Nutrition and Gender (T-ANG)	0.189***	0.115	0.217***	0.159**	0.380***	0.164
	(0.054)	(0.072)	(0.064)	(0.067)	(0.121)	(0.140)
Control mean	4.334	4.484	1.014	1.531	2.705	2.848
p: T-A = T-AN	0.481	0.117	0.662	0.267	0.937	0.540
p: T-A = T-ANG	0.012	0.027	0.235	0.225	0.013	0.379
p: T-AN = T-ANG	0.085	0.359	0.135	0.889	0.038	0.149
Panel B						
T-A	0.048	-0.050	0.140**	0.064	0.116	0.037
	(0.046)	(0.059)	(0.055)	(0.065)	(0.081)	(0.115)
T-AN or T-ANG	0.134***	0.080	0.159***	0.153***	0.231**	0.051
	(0.044)	(0.056)	(0.053)	(0.054)	(0.093)	(0.112)
Control mean	4.334	4.484	1.014	1.531	2.705	2.848
p: T-A = T-AN or T-ANG	0.086	0.031	0.716	0.191	0.168	0.905

Notes. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$. All specifications include as independent variables listed in Table 2. Standard errors are clustered at the unit of randomization. Sample size is 2,601.

Appendix Table A3.13: Productive asset holdings and female share of holdings, 2022, by homestead garden and cultivable land holdings

(Log) productive assets

	(1)	(2)	(3)	(4)
Homestead garden at baseline	Active	Not active	Active	Not active
Land holdings	Little, Some	Little, Some	More	More
Agriculture (T-A)	0.119	-0.159*	-0.070	-0.011
	(0.088)	(0.081)	(0.109)	(0.139)
Agriculture & Nutrition (T-AN)	0.235***	0.003	-0.091	-0.022
	(0.073)	(0.097)	(0.113)	(0.149)
Agriculture, Nutrition and Gender (T-ANG)	0.194*	0.047	0.217*	0.085
	(0.105)	(0.085)	(0.130)	(0.175)
Control mean	4.301	4.324	4.892	4.776
Observations	690	1,055	434	422
R-squared	0.315	0.316	0.375	0.298

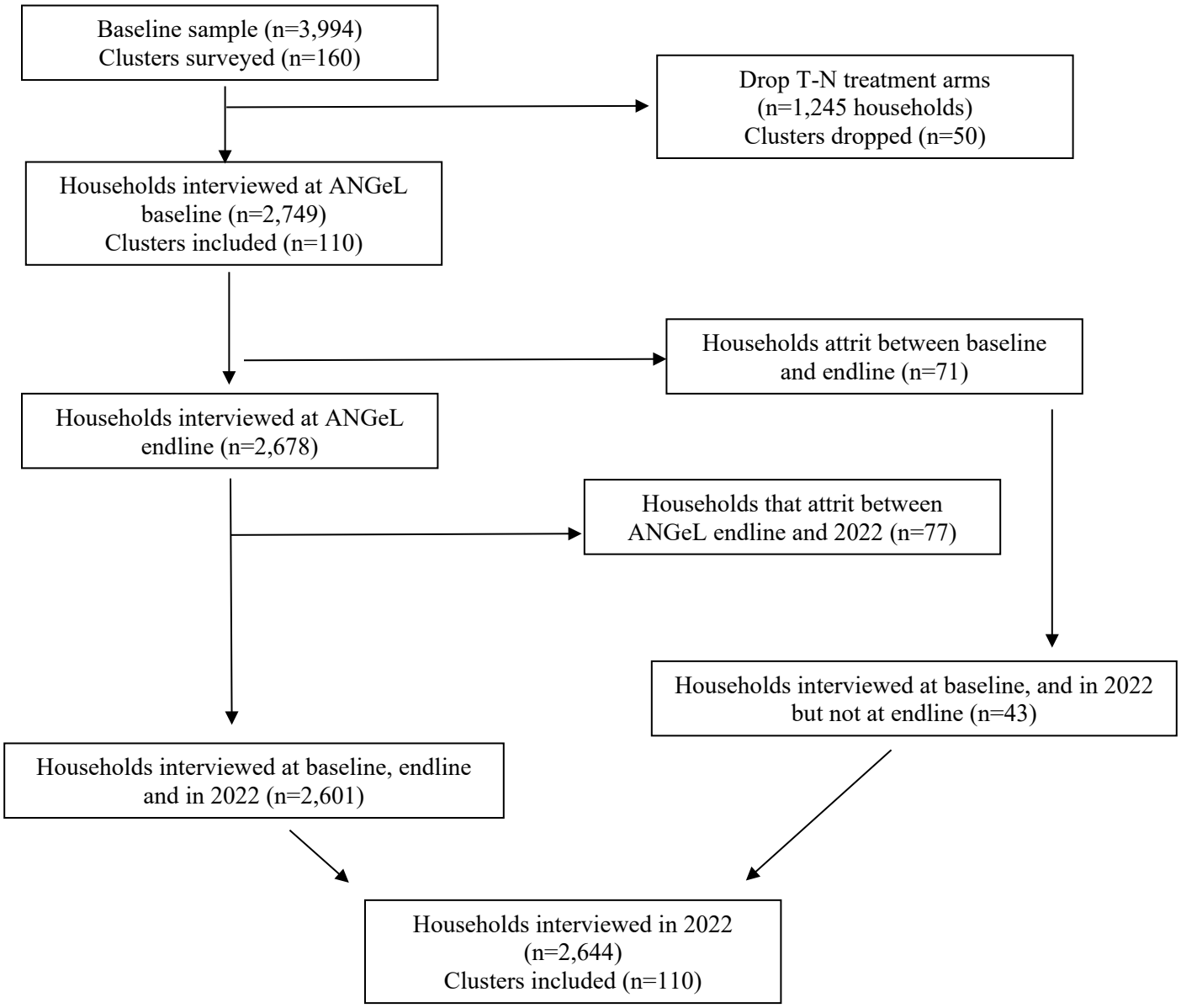
Notes. * p < 0.10; ** p <0.05; *** p < 0.01. All specifications include as independent variables listed in Table 2. Standard errors are clustered at the unit of randomization.

Female share of productive assets

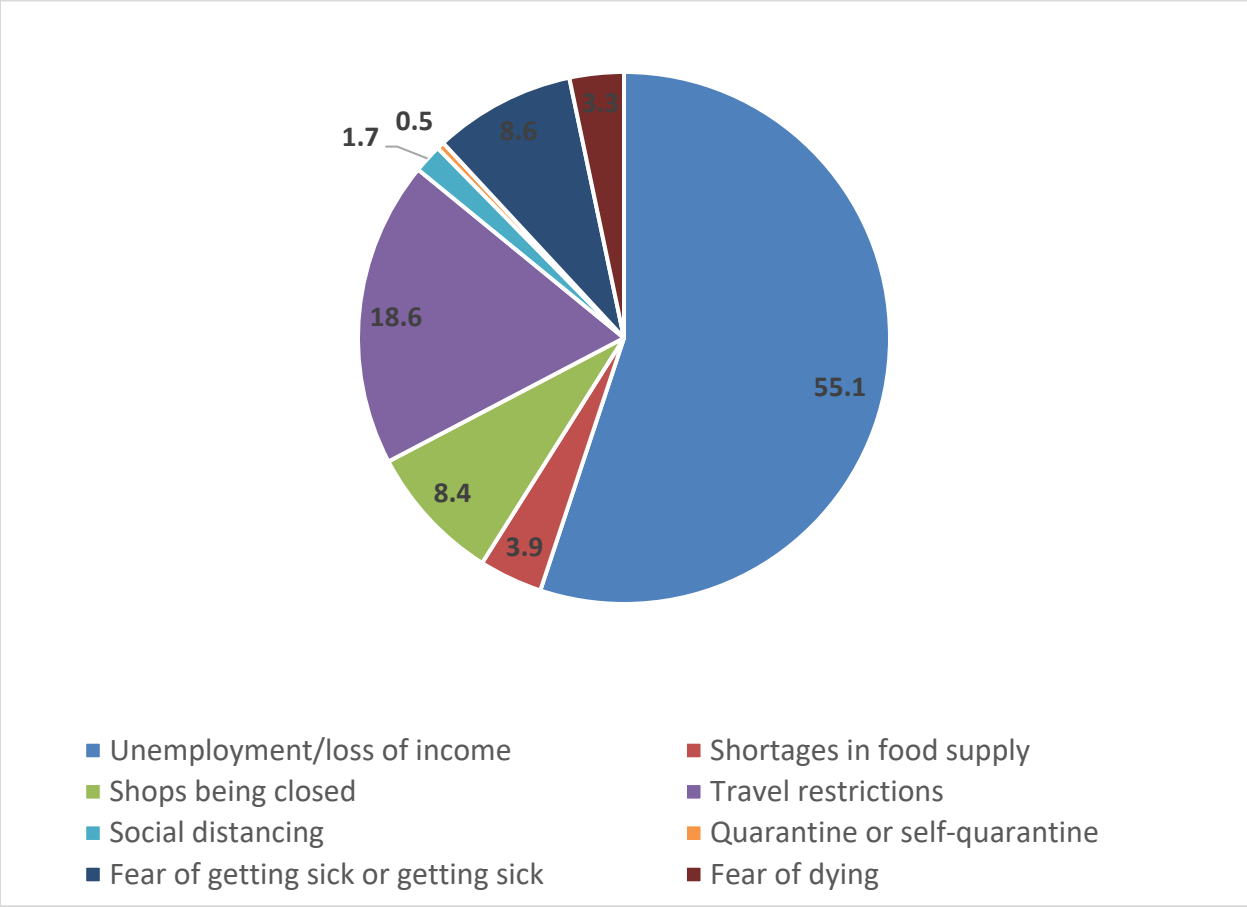
	(1)	(2)	(3)	(4)
Homestead garden at baseline	Active	Not active	Active	Not active
Land holdings	Little, Some	Little, Some	More	More
Agriculture (T-A)	5.037	4.420	4.400	-4.382
	(3.300)	(3.045)	(3.820)	(5.589)
Agriculture & Nutrition (T-AN)	6.639	2.241	0.805	-3.857
	(4.046)	(3.436)	(4.954)	(4.785)
Agriculture, Nutrition and Gender (T-ANG)	6.821*	-2.231	1.197	-0.687
	(3.981)	(3.076)	(4.595)	(5.757)
Constant	45.126***	25.686***	55.406***	19.823
	(7.291)	(7.567)	(9.908)	(18.240)
Observations	690	1,055	434	420
R-squared	0.244	0.167	0.244	0.138

Notes. * p < 0.10; ** p <0.05; *** p < 0.01. All specifications include as independent variables listed in Table 2. Standard errors are clustered at the unit of randomization.

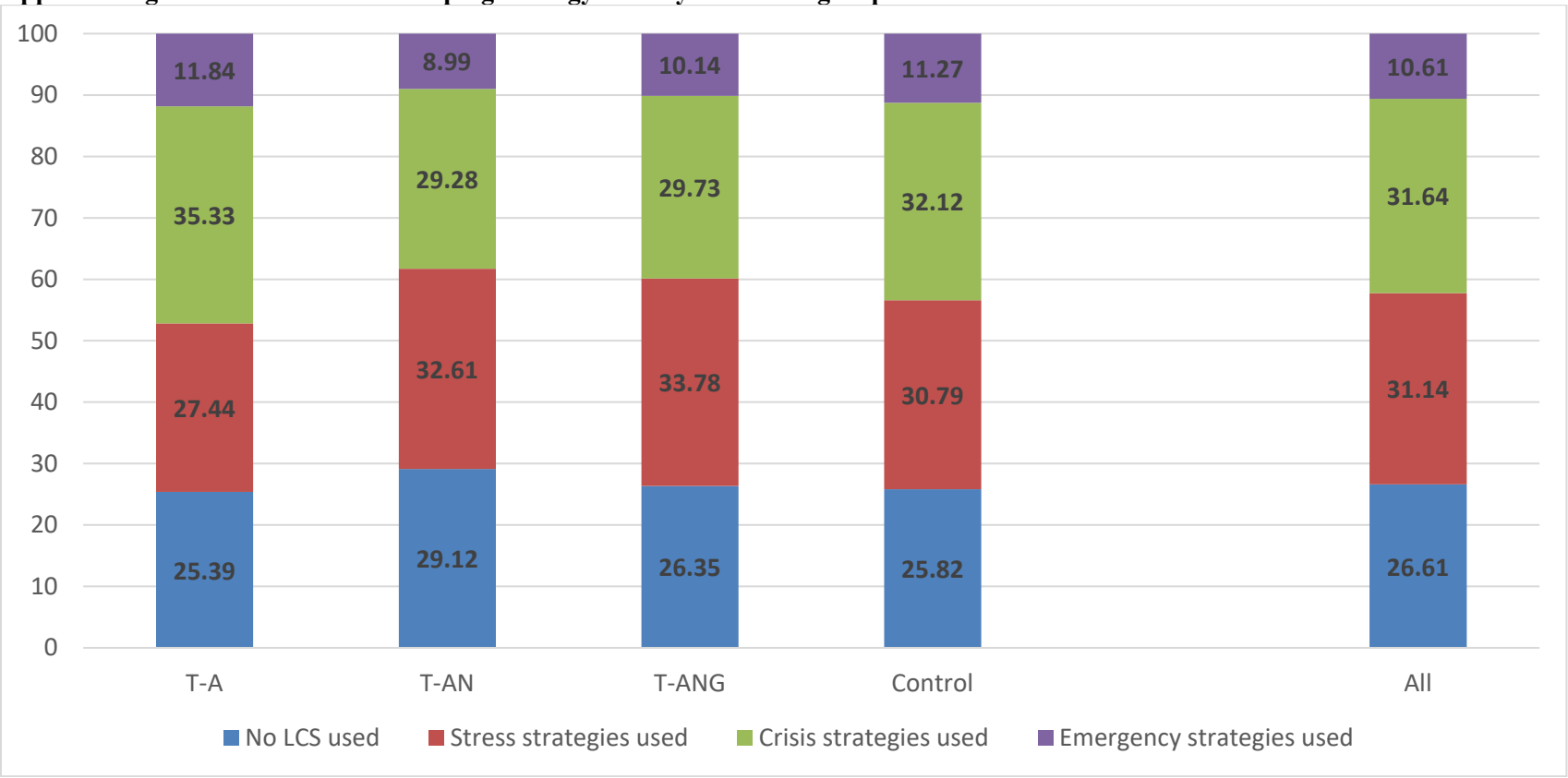
Appendix Figure A3.1: ANGeL2, Participant Flow Diagram



Appendix Figure A3.2: Aspect of the Covid-19 pandemic crisis that households reported as having the greatest impact



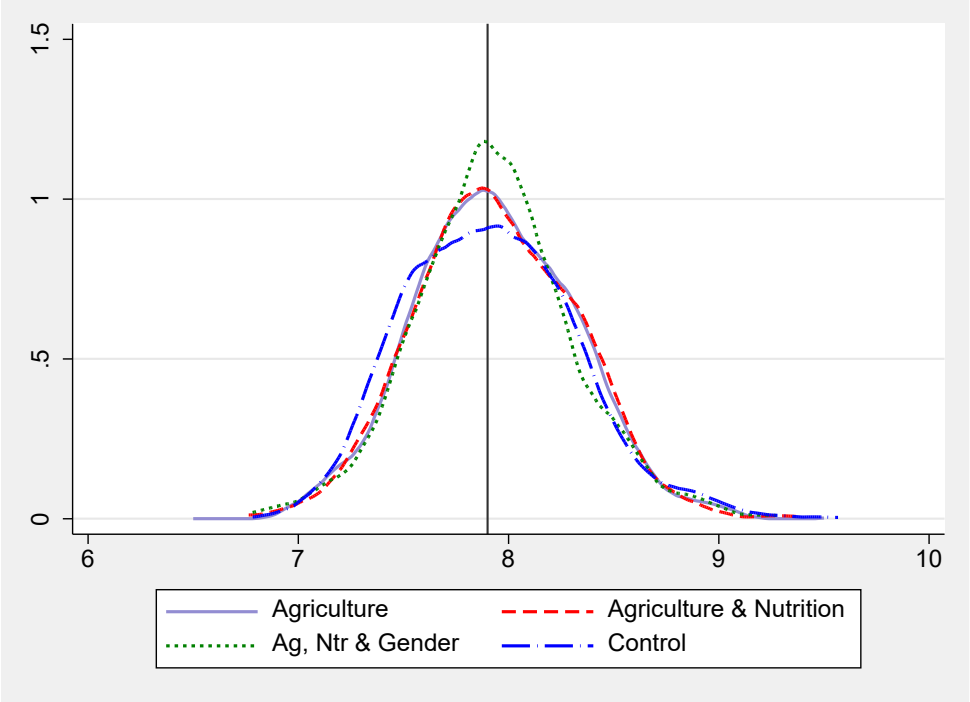
Appendix Figure A3.3: Most severe coping strategy used by treatment group



Appendix Figure A3.4: Use of Livelihood Coping Strategies, by strategy and frequency of use

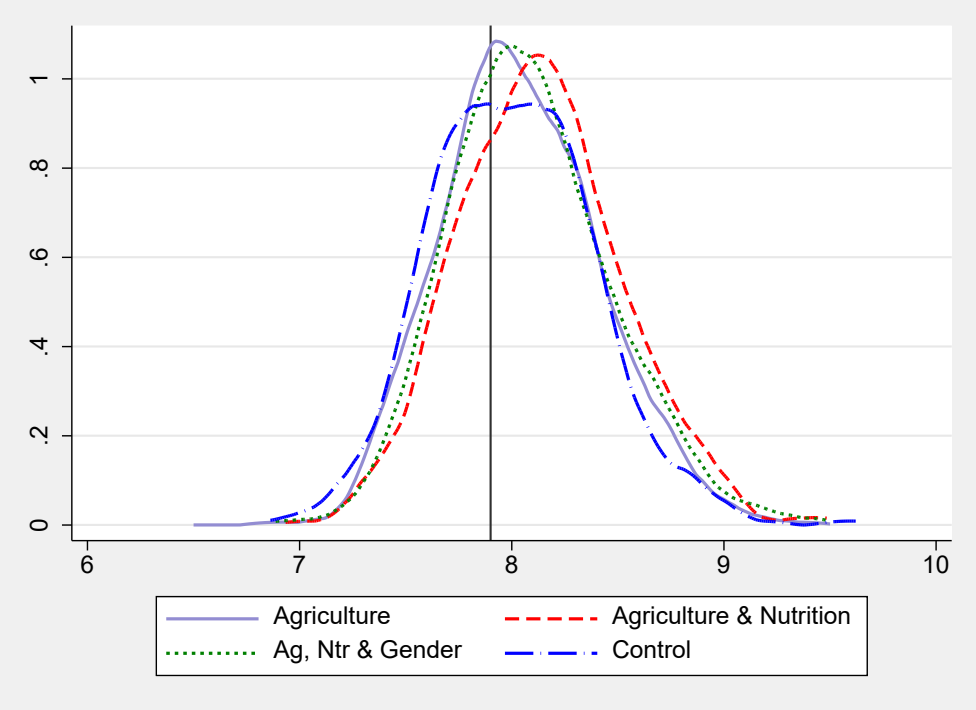
Appendix Figure A3.5: Density plots of log real per capita consumption, by survey round and treatment group

Baseline (January 2016)



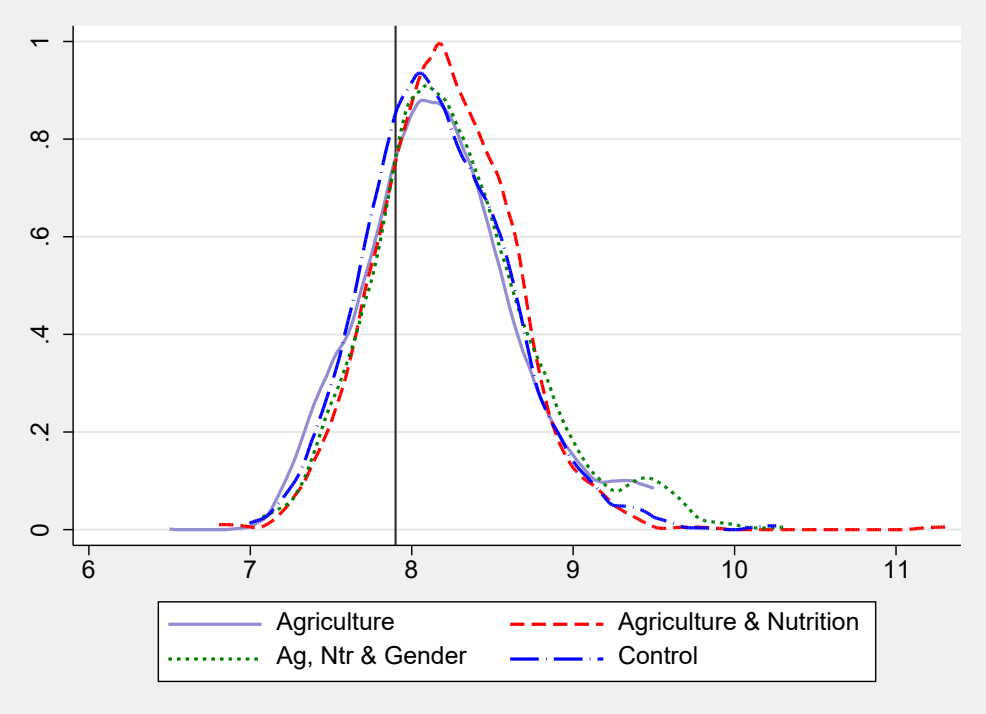
Exact Kolmogorov–Smirnov test of equality of distributions	P value
Agriculture = Agriculture & Nutrition	0.99
Agriculture = Agriculture, Nutrition & Gender	0.24
Agriculture & Nutrition = Agriculture, Nutrition & Gender	0.24
Agriculture = Control	0.23
Agriculture & Nutrition = Control	0.14
Agriculture, Nutrition & Gender = Control	0.04

Endline (January 2018)



Exact Kolmogorov–Smirnov test of equality of distributions	P value
Agriculture = Agriculture & Nutrition	<0.01
Agriculture = Agriculture, Nutrition & Gender	0.22
Agriculture & Nutrition = Agriculture, Nutrition & Gender	0.02
Agriculture = Control	0.04
Agriculture & Nutrition = Control	<0.01
Agriculture, Nutrition & Gender = Control	<0.01

Four year post-program follow-up (February 2022)



Exact Kolmogorov–Smirnov test of equality of distributions	P value
Agriculture = Agriculture & Nutrition	0.12
Agriculture = Agriculture, Nutrition & Gender	0.25
Agriculture & Nutrition = Agriculture, Nutrition & Gender	0.09
Agriculture = Control	0.33
Agriculture & Nutrition = Control	0.03
Agriculture, Nutrition & Gender = Control	0.03

Notes: Sample consists of households surveyed in 2016, 2017 and 2022. Sample size: 2,601. Vertical rule at 7.90 is median baseline consumption of the control group.

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