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Strengthening Nutrition and Improving Livelihoods through Linking Women Farmers to Markets

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Highlights

- Impact of production extension services and collective marketing were assessed.
- Production extension services improved food insecurity and dietary diversity.
- Collective marketing, along with extension services, mostly shared similar impacts.
- It had a larger increase in marketing, human capital expenditure, and women’s empowerment.

Abstract

This article examines the impact of linking small-scale women farmers to markets and production-oriented extension services on income, nutrition, farm production and marketing, and women's empowerment in Bangladesh. This study is based on a quasi-experimental design with three groups, including the experimental group that received homestead food production advisory services and collective marketing; the comparison group that recieved only production-oriented advisory service; and the control group with no intervention. This design allows us to compare treatment effect estimates between multiple treatments. We find that collective marketing combined with production-oriented extension services particularly had a greater and positive impact on income and expenditure on education and transportation, and dietary diversity scores, as well as a substantial increase in marketing poultry and vegetables, and some outcomes of women's empowerment.

Keywords: small-scale women farmers, collective marketing, food security, dietary diversity

1. Introduction

Over the past several decades, we have witnessed that agricultural growth and development are recognized as an important strategy to reduce poverty in most developing countries, and agricultural development does not occur without engaging smallholder farmers (Mellor, 1999; World Bank, 2007). Besides building up farmers' production capabilities, more recently linking smallholder farmers to markets has gained popularity as an emerging policy. Proponents for market-oriented interventions suggest that smallholders, by acting collectively, can reduce transaction costs and information asymmetry in markets, as well as integrate into high-value markets, which enhance their marketing performance and are associated with an increase in bargaining power, income opportunities, and food security (Devaux et al., 2009; Fischer and Qaim, 2012a; Markelova et al., 2009; Wiggins et al., 2010). Collective action also benefits buyers by reducing transaction costs through obtaining stable supplies of quality products (Okello, Narrod, and Roy, 2007; Shiferaw, Hellin, and Muricho, 2011; Vorley, Fearne, and Ray, 2016).

For example, Holloway et al. (2000) show that marketing cooperatives for dairy products in Ethiopia reduced transaction costs of smallholders, enhancing the marketable milk surplus. Okello, Narrod, and Roy (2007) examine the impact of food safety

requirements in green bean export sectors in the three Africa countries of Kenya, Ethiopia, and Zambia, and a coping strategy of smallholder farmers, excluded from green bean supply chain due to inability to comply quality standards. The authors find that smallholder producers, through collective action in farmers' organizations, were able to resolve their constraints and access to agricultural exports market opportunities. Additional empirical evidence of collective action and marketing can be found in studies of Roy and Thorat (2007), Wollni and Zeller (2007), and Fischer and Qaim (2012a). More recently, Fischer and Qaim (2012b) address the gender issues in collective marketing and show that women's group participation not only prevents males from having control over women-controlled products, but also increases their income share.

However, women often face socioeconomic and cultural constraints that impede them from taking advantage of group participation. Specifically, women may have limited opportunities, motivation, and capabilities (Pandolfelli, Meinzen-Dick, and Dohrn, 2008). Previous agricultural extension studies provide consistent evidence of gender-specific constraints in access to extension services of poor rural women (Doss, 2001; Quisumbing and Pandolfelli, 2010; Swanson, Farner, and Bahal, 1989). Also, women in poor households have higher opportunity costs of time due to their

various livelihood activities and responsibilities, which may reduce their incentives for group membership (Godquin and Quisumbing, 2008; Meinzen-Dick and Zwarteveen, 1998; Zaman, 1995). Furthermore, in Bangladesh, restrictions on women's physical mobility beyond her homestead or community and on selling homestead products in markets are often described in the literature as major barriers that limit women's control of household resources, technology adoption, and marketing engagement (Quisumbing and Maluccio, 2003; Quisumbing et al., 2013).

As of January 2013, Caritas Bangladesh and Catholic Relief Services have partnered in implementing the Egiye Jai ("Move Forward") and Nijera Gori ("We Build It Ourselves") projects in two vulnerable districts of Bangladesh. The Egiye Jai project has been implemented in eight villages in Rajihar Union of Barisal district, and the Nijera Gori project has been implemented in eight villages in Dinajpur Sadar and Birgonj Upazilas of Dinajpur districts. The projects intend to increase quality homestead food production and improve food security and nutrition through enhancing women farmers' access to new technologies and production-oriented advisory services. Additionally, since early 2016, the Nijera Gori project has adopted a collective marketing strategy to overcome women's marketing barriers while avoiding cultural conflict within the household and community. Specifically,

instead of taking women farmers to markets, the project has established multiple collective markets close to women's homes in each village and connects them to local traders twice a week. Additionally, in order to incentivize traders' participation, farmers sell slightly below market price, so that traders earn the difference, varying with the sales' quantity.

This article examines the impact of linking women farmers to markets, in addition to production-oriented extension services, on various dimensions of households' livelihoods, classified into four categories: (*i*) income and expenditure patterns, (*ii*) farm production and sale, (*iii*) food security and dietary diversity, and (*iv*) women's empowerment. The data were collected from 36 villages in two districts where extension services have been offered in eight villages in Rajihar Union of Barisal district with 10 nearby villages serving as a control area, and, similarly, eight treatment villages in Dinajpur Sadar and Birgonj Upazilas in Dinajpur district with 10 nearby control villages. More specifically, this study is based on a quasi-experimental design, interviewing 2,000 rural farm households in three groups – experimental group: eight treatment villages with homestead food production (advisory) services and collective marketing (500 households); comparison group: eight treatment villages with only production-oriented advisory services (500 households); and control group: 13 control villages with no

intervention (1,000 households). This design allows us to compare treatment effect estimates between multiple treatments.

Also, in Bangladesh, during the pre-harvest period of amen rice (September-November), rural households often suffer from seasonal food deprivation, locally known as Monga, and lack of adequate employment and income. During this period, overall food consumption is much lower in Rangpur region – where the experimental group villages are located (Dinajpur district) – than in the rest of country. Also, the food consumption falls sharply in all regions – and more for Rangpur region – indicating that seasonality in food consumption is an acute issue for Rangpur (Khandker, 2011). Our surveys were collected between September and October (2016) during this lean season, and this analysis allows us to answer whether or not an approach, catalyzing women's marketing activities with through freeing cultural and structural marketing barriers that women need to bear, could improve income, nutrition, and women's empowerment outcomes in Bangladesh.

2. Project Design

2.1. Homestead Food Production Extension Services

The Egiye Jai (Barisal district) and Nijera Gori (Dinajpur district) projects deliver similar production-oriented extensive agricultural training that provides a strong basis for sustainable and

quality homestead production of vegetable, poultry, large animals, and fisheries as well as post-harvest management and financial skills. The projects use a cluster-level training approach to promote women farmers' participation in agricultural training programs through overcoming women's restrictions on physical mobility beyond her homestead or community. Specifically, in each village, the projects define geographical boundaries for each cluster of households, ensuring that households within proximity to each other are in the same cluster, and then bring extension agents to a gathering space close to two or three village clusters. Project participation is voluntary for farmers in a treatment area, but the delivered technologies are shown to farmers in the cluster through organized demonstration plots and field days. This approach facilitates replication for improved agricultural practices through sharing knowledge and experiences among farmers in a neighborhood, thereby strengthening the impacts that extension services have on the targeted clusters and villages.

According to CRS's 2015 report, the Egiye Jai project served 118 village clusters in eight project villages, reaching 3,018 households, and the Nijera Gori project served 119 village clusters in eight villages and reached 3,633 households. The report also shows that 2,090 households (69.3%) had attended Egiye Jai cluster-level training between June 2013 to June 2014, and 92% were

women. Similarly, 1,916 households (52.7%) attended Nijera Gori cluster-level training between February 2014 and July 2014. 88% were women.[1] These results indicate the fact that the cluster-level training approach appears to be an effective way to reach women farmers with improved agricultural practices.

2.2. Collective Marketing

Women in Bangladesh face many structural and cultural constraints. Specifically, cultural norm do not favor women's marketing activities, and women often face particularly severe time constraints on marketing because, for example, some regions open a local market from 4 pm to 8 pm, and it is women's busy time of the day for cooking, childcare, and house chores. Also, markets lack women-only facilities. However, if a woman decides to sell her homestead products at the door to a local trader, she may face the 'unjust price' issue, receiving a lower price than what it could be sold for at the local market (OECD, 2006). Since March 2016, the Nijera Gori project (Dinajpur district) has adopted a collective marketing approach, linking smallholder women farmers to markets via local traders. The project first establishes a collective market,

[1] The number of Nijera Gori training attendees (and percent reaching project population) would be recorded relatively less, compared to Egiye Jai training attendees, due to the short data collection period. Also, since extension training was provided from mid-2013 to December 2016, the cumulated number of training attendees through the life of the projects would be more than the recorded estimates.

located in proximity to multiple clusters in the village, and then brings a local trader to the collective market site twice a week to buy collected homestead food products. Indeed, prior to collective marketing, the local traders had to visit door-to-door to buy homestead products, and it often took much time and effort to collect the targeted amounts of products. The traders might also take advantages of women's cultural constraints by suggesting lower prices for products than what women would receive from the local market. After collective marketing, the traders could reduce transaction costs from obtaining a stable supply of quality homestead products; however, they also lose bargaining power over small-scale producers since a price is already determined under the project control – market price information must be notified in the collective market sites, and a farmer receives 2 tk less per kilogram than the listed market price.

3. Data

Survey respondents were randomly selected at the cluster level in the treatment villages. Specifically, the projects assigned a project identification number to entire households, and, based on the population size in a cluster, the size of sampling was determined. The surveys were collected from 36 villages in two districts where extension services have been offered in eight villages in Rajihar

Union of Barisal district with 10 nearby villages serving as a control area, and similarly eight treatment villages in Dinajpur Sadar and Birgonj Upazilas in Dinajpur district with 10 nearby control villages. We also surveyed rural households in the control villages; however, unlike the treatment village's sampling scheme, control village respondents were randomly chosen at the village-level, based on ad hoc list of village households with the help of Catholic Relief Services, Caritas Bangladesh, and community authorities. We randomly chose 50 respondents from each of the 20 control villages. Altogether in each project, we collected 1,000 surveys including 500 surveys from the treatment villages and 500 surveys from the control villages. In other words, according to this study's analysis framework, the experimental group (production-oriented extension services and collective marketing) had 500 households, the comparison group (production-oriented extension services only) had 500 households, and the control group (no intervention) had 1,000 households. For the purpose of this study, we limited our analysis samples to married households (dropped 7.4% of the entire sample). Also, we excluded surveys completed by son, daughter, parents, or other relationships to the head of household (1%) since they would increase the likelihood of measurement errors in data. The number of sampled households and their treatment status by villages and districts are detailed in Table 1.

[Table 1 here]

The survey questionnaire collects extensive information on household socio-economic characteristics, farm livelihoods, food security, dietary diversity, and dwelling characteristics. For dependent variables, we construct an overall household wealth index value, estimated by the principal component (PCA) with 15 types of assets, which provide plausible and defensible weights for an index of assets to serve as proxy for wealth (Filmer and Pritchett, 2001; Labonne, Biller, and Chase, 2007; McKenzie, 2005). We also include changes in household expenditure patterns for six categories (food, energy, clothe, healthcare, education, and transportation). One thing to note about expenditure pattern variables is that we make a binary variable, assigning 1 if household maintained or increased expenditure on the corresponding category, and 0 if otherwise. This is because the surveys were collected during the lean season, and the majority of rural households often face seasonal food deprivation and economic inactivity, reducing the overall food consumption and expenditures (Khandker, 2011). Therefore, by maintaining, or even increasing, the level of expenditure on food and others may deliver some insight into how the treatments could contribute to coping with seasonality. Also, we use five outcome variables to measure a farm livelihood strategy – the quantity of large animals (cows and goats), quantity of poultry (chickens and

ducks), vegetable production, and sale of poultry and vegetables. Furthermore, we include household food insecurity assess score (Coates, Swindale, and Bilinsky, 2007) and dietary diversity score (Swindale and Bilinsky, 2006). Lastly, to measure women's empowerment, we use four outcome variables, including a number of community groups in which women are active members; whether a woman has a large animal (often recognized as men-specific asset); and whether the women can make an autonomous decision on marketing poultry and vegetables. The control variables include a set of household characteristics, landholding (residential and cultivation), cultivated land holding, access to markets, and dwelling characteristics. Description of variables used in this analysis is detailed in Table 2.

[Table 2 here]

Table 3 presents descriptive statistics and a balance test that compared the difference in control covariates – statistical significance tests on equality of means for continuous variables and equality of proportion for binary variables – between treatment and control groups. If the control group is well established, we would expect that none of the coefficient would statistically differ from zero. Table 3 reports that most variables show a statistical difference with some degree between groups, and greater differences between

comparison group and control group.[2] These results indicate a need for statistical adjustment for group differences to correct for potential bias in treatment effect estimates.

[Table 3 here]

4. Conceptual Model

4.1. Balancing Group Differences

A completely randomized experiment posits the difference in mean outcomes between treatment and control group as unbiased treatment effect estimates if the entire population is counterfactually assigned to the treatment. In a quasi-experimental study, treatment assignment is often a result of individual or site selection due to pre-existing differences in individual traits and preferences, correlated with a voluntary nature of program participation or the effects of interventions. Also, Catholic Relief Services might rely on Caritas Bangladesh to select treatment districts and villages, considering the level of beneficiaries' interest in the treatment schemes, site accessibility, and relationships Caritas Bangladesh had maintained with the sites (Allcott, 2015). In this case, the composition of control (or pre-treatment) covariates of a treatment group tends to be systematically different from those in the average potential

[2] We report descriptive statistics and mean difference test results between treatment and control groups in each district in Appendix A1.

population, more likely causing biased effect estimates of the treatment.

In order to correct selection bias, social science scholars and practitioners have utilized propensity score matching (PSM) and stratification methods; however, the use of methods is mostly restricted to a binary treatment (Joffe and Rosenbaum, 1999). Alternatively, some have adopted inverse probability weighting (IPW) for multiple treatments that assign to each sample a weight inverse to the estimated propensity scores of receiving the treatment (Robins, 2000; Rosenbaum, 1987). However, IPW is sensitive to misspecification of the functional form of the propensity score models, and in the case of limited overlap in the (control) covariate distributions of the treatment and control group, the method may lead to bias in the treatment effect estimation (Imbens, 2004; Hong, 2010).

In this article, we adopted the marginal mean weighting through stratification (MMW-S) method that is a nonparametric adjustment strategy, combining key elements of propensity score stratification and IPW. A consistent simulation-based evidence of statistical validation and performance, comparing with IPW and other often-used regression-based models, are established in the studies of Hong (2010) and Linden et al. (2015). In general, MMW-S calculates propensity scores to predict the probability of receiving multiple

treatments and stratify the analytic sample into quantiles of the propensity scores (Hong, 2011). Since the project has two treatment designs in which one treatment (Nijera Gori) included collective marketing components in addition to the other treatment (Egiye Jai), we modeled an ordinal treatment as a function of control covariates through an ordinal logistic regression. Also, a unit that did not have counterparts in an alternative treatment group, known as a common support condition, was excluded from the analysis sample since it had no counterfactual information in the observed data, in turn, lacking an empirical basis for the causal inference. Then we computed a weight for each unit, based on their corresponding stratum and treatment assignment. We report results from covariate balancing tests to ascentain whether the statistical differences in the propensity scores of covariate composition between treatment groups have been eliminated after weighting.

However, the aforementioned approach may produce biased treatment effect estimators if the models do not control for regional heterogeneity. Indeed, both project regions have served vulnerable farm households, but they might have a quite different living environment in terms of agro-ecological characteristics, labor opportunities, government assistances, and so forth. The survey data, unfortunately, do not contain village or Upazila-level characteristics, which make a strong assumption of regional

homogeneity across treated and control villages in the treatment effect estimation. This limitation makes our regression estimates as suggestive, but not definitive. In order to address concerns of regional heterogeneity, as a supportive evidence, we conduct additional analyses, using the PSM approach to create a statistical sample of control within each treatment region (Dehejia and Wahba, 2002; Heckman et al., 1998). Since the treated and control villages within the region are geographically close enough to share the similar regional characteristics, potential bias in the effect estimates, derived from regional heterogeneity across villages, would substantially decrease with an appropriate matching. However, in this case, unlike the MMW-S method, we cannot compare the impact size between the two treatments. Since both approaches have trade-offs, we utilized both regression results to draw the conclusion of treatments' impact on various outcomes of interest.

Several matching methods have been developed to match the treatment and control group households of similar propensity scores, but asymptotically, all matching methods should yield the same results (Caliendo and Kopeinig, 2008). In this article, we utilize the nearest neighbors matching (NNM) and kernel-based matching (KM) approaches. Additionally, we report several balancing test statistics. Specifically, we report a comparison of the pseudo R^2 and *p*-values of the likelihood ratio (LR) test of joint significance of all

regressors before and after the match. The pseudo R^2 should be low, and *p*-values of the LR test should be insignificant accepting the hypothesis of joint significance after the match. Moreover, we report the mean and median absolute standardized bias between the treatment and control group.

4.2. Estimation

The objective of this article is to estimate impacts of multiple treatments on various outcomes of interest. Applying the MMW-S approach, the treatment effect estimation can be modeled in two stages. In the first stage, we generated the marginal mean weights, following steps in the previous section, and then we calculated the average treatment effect (ATE) for multiple treatments (we include two treatment dummy variables, differentiating the experimental and comparison groups from control group) on an outcome variable in the second stage by estimating the difference in the weighted mean outcome between each treatment group and the control group. For the second stage estimation, we adopt a multilevel mixed-effects model. The distinct feature of the model is to capture village's random effects, and it also accounts for the correlation between households nested within the village. If we denote by y the outcome variable of household i ($i = 1,\ldots, m$) in village j ($j = 1,\ldots, J$), a

typical multilevel mixed-effects model with random intercept can be expressed as:

$$y_{ij} = \beta_0 + \beta_{1j}T1_{ij} + \beta_{2j}T2_{ij} + \beta_{3j}X_{ij} + u_{0j} + \varepsilon_{ij}. \quad (1)$$

In Eq. (1), u_{0j} is a random intercept for villages, distributed independently from the residual error ε_{ij}. The random village intercept captures unobserved heterogeneity across villages that may affect treatment outcome variables, for example village leaders, loan opportunities, and social capital. Regarding fixed effects part of the model, we include treatment dummy variables (*T1* – experimental group; *T2* – comparison group) and household-specific charateristics (*X*). The model can be extended to include further village-level characteristics or by relaxing fixed coefficent such that the effect of an explanatory variable can be different in each geographical level. One may prefer to add village-level fixed effects instead of random intercept in the estimation; however, the use of many dummy variables (35 village dummies in our study) would decrease degrees of freedom, and multicollineariry problem may arise.

5. Findings

The ordinal logistic estimates for multiple treatments' propensity are presented in Table 4. Several variables are statistically significantly associated with treatment status

particularly for wife's education, household size, and own landholdings. Table 5 compares the between-treatment-group differences in the distribution of estimated propensity scores before and after weighting.[3] The results show that, after weighting, the mean propensity score becomes equal across the three groups. Additionally, we report three multiple comparison tests, and all test statistics provide consistent evidence of statistical indifference across groups. Furthermore, we generate a histogram of the estimated propensity score with a kernel density overlay to illustrate the considerable overlap among the three groups (Figure 1).

[Table 4 here]

[Table 5 here]

[Figure 1 here]

Table 6 reports descriptive statistics for study outcome variables, applying estimated marginal mean weights on data.[4] The results show that both treatment groups increased monthly income and maintained or increased household's expenditure on healthcare, education, and transportation, compared to those in the control groups; and the experimental group had greater mean values for income, education, and transportation than the comparison group.

[3] We report the result of stratifying the analytic sample on the balancing score in Appendix A2. 12 observations that did not satisfy a common support condition were excluded from the analysis sample due to no counterfactual information in the observed data.

[4] In addition, Appendix A3 reports the same descriptive statistics but with a comparison between treatment and control groups in each district.

We also observe that both treatment groups tended to have a greater number of poultry and increase sale of poultry and vegetables, but more marketing activities occurred in the experimental group. Furthermore, both treatment groups tended to have a smaller score for household's food insecurity, compared to the control group, while the dietary diversity score seemed to be similar across groups. The results also show that women in the experimental group tended to participate in a greater number of community groups, have own large animal, and make marketing decisions by self on poultry and vegetables.

[Table 6 here]

In order to have better understanding on the impact of linking women farmers to markets and production-oriented extension services on the outcome variables, controlling for household-specific characteristics and heterogeneous village effects, we used multilevel mixed-effects models with the marginal mean sample weights to calculate the average treatment effect estimates (Table 7).[5] The estimates show that the experimental group and comparison group increased wealth index values by 0.34 and 0.32 points, and had increased a chance of income increase in 6 months by 39.4 and

[5] In case of a binary outcome variable, we used mixed-effect probit regression and calculated the average marginal effect estimates for treatment variables. Authors also ran weighted OLS regressions with village-level fixed effects, and most variables showed similar coefficient sign and statistical significance. Regression results will be available by request.

16.1 percentage points.[6] The projects' income effects can be partly explained by an increase in vegetable production by 1.09 and 1.18 natural logarithm points in the experimental group and comparison group, respectively, and by an increase in sale of poultry and vegetables, compared to those in the control group, and a substantial increase in marketing on poultry and vegetable in the experimental group. For expenditure, we find that both treatment groups increased the likelihoods of maintaining or increasing expenditures on clothing, healthcare, education, and transportation, and the experimental group had a particularly greater estimate size for education and transportation spending. On the other hand, in terms of food spending, we only find such an effect from the comparison group. Also, the results showed that, on average, the experimental group decreased food insecurity by 2.64 points and increased the dietary diversity scores by 0.38 points while the comparison group decreased food insecurity scores by 1.35 and increased dietary diversity by 1.11 points. Furthermore, women's empowerment estimates showed that women in the experimental group increased the membership of community groups by 1.3; and increased the likelihoods of having a large animal by 33.3 percentage points; and increased self-decision-making on marketing poultry and vegetables by 22.3 and 17.9 percentage points; while the comparison group

[6] All estimates in Table 7 and Table 9 are compared to the control group.

increased participating group memberships by 0.75, and poultry and vegetable marketing decisions by 6.6 and 9.7 percentage points, respectively.

[Table 7 here]

However, as discussed in section 4.1., the above approach may produce biased treatment effect estimators if the models do not control for regional heterogeneity. In order to address concerns of regional heterogeneity, we conducted additional analyses, using PSM to create a statistical sample of control groups within each treatment region. Table 8 reports test-statistics to compare the level of bias before and after propensity score matching. The standardized mean difference for overall covariates used in the propensity score (13.1% for the Egiye Jai project and 28.3% for the Nijera Gori project) is reduced to less than 1%, based on different PSM specifications after matching. The LR test results lead us to accept the hypothesis of joint significance of matching variable after matching in both projects. Moreover, the mean and median standardized bias decrease significantly after matching. Therefore, the results of low pseudo-R^2, mean and medium standardized bias, and the insignificant *p*-values of the LR test after matching suggest that the proposed specification of the propensity score is fairly

successful regarding balance of the distribution of covariates between the treatment and control group in each project.[7]

[Table 8 here]

Table 9 summarizes the project impact by treatment status and district, using PSM. Nijera Gori project estimates, depending on the specific matching algorithm used, report a statistically significant and positive project impact on outcomes of wealth, monthly income, and expenditure on clothing, healthcare, education, and transportation while the project decreased likelihoods of maintaining or increasing food and energy expenditures. The results also show a positive impact on the quantity of poultry, vegetable production, and sale of poultry and vegetable, dietary diversity scores, and all outcome variables under women's empowerment. On the other hand, the results from Egiye Jai show a statistically significant treatment impact on wealth, monthly income, expenditure on food and healthcare, vegetable production, and sale of poultry and vegetables, as well as household food insecurity scores and dietary diversity scores, and membership, sale of poultry and vegetable decisions under women's empowerment. Based on regression results from Table 7 and Table 9, we draw a conclusion of multiple treatment effects, reported in Table 10. We find that

[7] As a supportive matching evidence, in Appendix A3, we display scatterplots of the standardized differences versus Rubin's residual variance ratio, illustrating the level of covariate imbalance by binary treatment indicator, before and after matching (Rubin, 2001).

collective marketing, combined with production-oriented extension services, particularly had a greater and positive impact on income, and expenditure on clothing, healthcare, education, and transportation, as well as a substantial increase in marketing poultry and vegetables. The results also suggest that receiving homestead food production advisory services significantly reduced food insecurity and improved dietary diversity in the comparison group, while only dietary diversity effect in the experimental group existed. This result can be explained by already lower level of food insecurity scores in the control group villages in Dinajpur (Appendix A.3.). Furthermore, the estimates show that both treatment groups revealed statistically significant improvement on women's empowerment outcomes, and greater impact on membership, own large animals, and marketing poultry decisions for the experimental group.

[Table 9 here]

[Table 10 here]

6. Conclusion

This article provides empirical evidence of the impact of linking small-scale women farmers to markets and production-oriented extension services on the set of study outcome variables. We find that implementing collective marketing along with production-

oriented extension services may provide smallholder farmers the secured marketing outlet for enhanced food production, positively associated with income and expenditure patterns particularly on healthcare, education, and transportation, as well as intake of diverse nutrition. Additionally, project interventions (cluster approach) effectively reached out to women farmers, and increased women's empowerment as a pathway to improve dietary diversity (Sraboni et al., 2014).

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Tables

Table 1: Number of Study Samples and Treatment Status by Villages and Districts (N = 1,832)

Dinajpur				Barisal			
Treatment (AG+ML)	*N*	Control	*N*	Treatment (AG)	*N*	Control	*N*
Dabra Jineshwari	92	Badla Para	50	Boro Bashail	79	Ahuti Battra	41
Fajilpur	15	Bashudebpur	50	Coto Bashail	59	Ambari	43
Khorikadam	41	Bochapukur	49	Coto Dumuria	33	Bahadupur	43
Mohadebpur	70	Dakeswari	48	Paschim Goail	19	Bakal	54
Nagri Sagri	91	Durlovpur	49	Paschim Razihar	67	Battra	47
Salbari Dabra	68	Kathgor	50	Razihar	94	Chengutia	42
Pochwim Paragon	27	Koikuri	50	Sutar Bari	28	Dumuria	30
Sundori Hatgachh	42	Mahatabpur	50	Valuksi	80	Kandirpar Cenguitia	44
		Moricha	49			Noapara	45
		Satkhamar	49			Uttor Sajuria	44
Total	446	Total	494	Total	459	Total	433

Table 2: Description of Variables

Variable	Description
Dependent Variable	
Income and Assets	
Wealth	= Wealth index value estimated by the principal component analysis (PCA) with 15 types of assets (radio, cell phone, bicycle, motorcycle, refrigerator, large animals, poultry, vegetable garden, fish pond, camera, fans, television, sewing machine, and clock)
Monthly Income	= 1 if a household has increased monthly income, compared to 6 months ago; 0 if otherwise
Expenditure	
Food	= 1 if a household has maintained or increased the level of monthly expenditure on food and beverage, compared to 6 months ago; 0 if otherwise
Energy	= 1 if a household has maintained or increased the level of monthly expenditure on energy (cooking, heating, lighting), compared to 6 months ago; 0 if otherwise
Clothe	= 1 if a household has maintained or increased the level of monthly expenditure on clothes and footwear, compared to 6 months ago; 0 if otherwise
Healthcare	= 1 if a household has maintained or increased the level of monthly expenditure on healthcare, compared to 6 months ago; 0 if otherwise
Education	= 1 if a household has maintained or increased the level of monthly expenditure on education, compared to 6 months ago; 0 if otherwise
Transportation	= 1 if a household has maintained or increased the level of monthly expenditure on transportation, compared to 6 months ago; 0 if otherwise
Farm Livelihood Strategy	
Quantity of Large Animal	= Number of cows and goats
Quantity of Poultry	= Number of chickens and ducks
Sale of Poultry	= 1 if a household has increased sales of poultry, compared to 6 months ago; 0 if otherwise
Vegetable Production	= total vegetable production in kilogram
Sale of Vegetable	= 1 if a household have sold vegetables during the growing season; 0 if otherwise
Food Security and Dietary Diversity	
HFIS	= Household Food Insecurity Score
DDS	= Dietary Diversity Score
Women's Empowerment	
Membership	= Number of community groups woman is an active member of
Own Large Animal	= 1 if a woman owns a cow or goat; 0 if otherwise
Sale of Poultry Decision	= 1 if a woman makes a decision over sales of poultry; 0 if otherwise
Sale of Vegetable Decision	= 1 if a woman makes a decision over sales of vegetables; 0 if otherwise
Treatment Indicator	
AG + ML	= 1 for treatment villages with production-oriented agricultural extension services and collective marketing (linkage); 0 for otherwise
AG	= 1 for treatment villages with production-oriented agricultural extension services only
Control Variables	
Husband Age	= Husband's age
Wife Age	= Wife's age
Husband Primary Education	= 1 if a husband had some primary education or less (0-5 years of education)
Wife Primary Education	= 1 if a wife had some primary education or less (0-5 years of education)

Muslim	= 1 for having Muslim religion; 0 for otherwise
Household Size	= Number of household members
Own Land	
Less than 49 decimals or no land	= 1 for having land less than 49 decimals or no land; 0 for otherwise
50-98 decimals	= 1 for having land between 50-98 decimals; 0 for otherwise
Cultivated Land	
Less than 49 decimals	= 1 for having cultivated land less than 49 decimals or less; 0 for otherwise
50-98 decimals	= 1 for having cultivated land between 50-98 decimals; 0 for otherwise
Agriculture/Farming	= 1if a household member is involved in agriculture or farming activity; 0 if otherwise
Non-Agricultural Day Labor	= 1 if a household member is involved in non-agricultural day labor activity; 0 if otherwise
Access to Markets	= Distance in kilometer to the closest market
Dwelling Characteristics	
Individual house (Structure)	= 1 for living in an individual house; 0 for otherwise
Earth or Sand (Floor)	= 1 if the floor is made of earth or sand; 0 for otherwise
Firewood (Cooking fuel)	= 1 for using firewood for cooking; 0 for otherwise

Table 3: Descriptive Statistics for Household and Dwelling Characteristics, and Tests for Differences in Means across Groups

	Treatment Group		Control Group	Difference		
	(1) Experimental Group AG+ML	(2) Comparison Group AG	(3) Control Group No Intervention	(4) |(1)-(3)|	(5) |(2)-(3)|	(6) |(1)-(2)|
Husband Age	43.917	48.053	45.188	1.271*	2.865***	4.136***
	(12.890)	(11.589)	(12.588)	(0.734)	(0.728)	(0.838)
Wife Age	35.765	38.272	36.355	0.591	1.917***	2.508***
	(11.112)	(9.737)	(10.686)	(0.626)	(0.616)	(0.714)
Husband Primary Education	0.717	0.489	0.620	0.097***	0.131***	0.228***
	(0.451)	(0.500)	(0.486)	(0.027)	(0.029)	(0.032)
Wife Primary Education	0.706	0.492	0.582	0.125***	0.090***	0.214***
	(0.456)	(0.501)	(0.494)	(0.028)	(0.029)	(0.033)
Muslim	0.502	0.528	0.382	0.120***	0.146***	0.025
	(0.501)	(0.500)	(0.486)	(0.028)	(0.029)	(0.034)
Household Size	4.509	5.217	4.836	0.327***	0.381***	0.708***
	(1.476)	(1.856)	(1.610)	(0.091)	(0.100)	(0.114)
Own Land: Less than 49 decimals or no land	0.628	0.595	0.762	0.134***	0.166***	0.033
	(0.484)	(0.491)	(0.426)	(0.026)	(0.027)	(0.033)
Own Land: 50-98 decimals	0.193	0.265	0.141	0.052**	0.124***	0.072**
	(0.395)	(0.442)	(0.349)	(0.021)	(0.023)	(0.029)
Cultivated Land: Less than 49 decimals	0.509	0.492	0.558	0.050*	0.067**	0.017
	(0.500)	(0.501)	(0.497)	(0.029)	(0.030)	(0.034)
Cultivated Land: 50-98 decimals	0.316	0.345	0.315	0.002	0.030	0.028
	(0.465)	(0.476)	(0.465)	(0.027)	(0.028)	(0.032)
Agriculture/Farming	0.910	0.651	0.876	0.034*	0.226***	0.260***
	(0.286)	(0.477)	(0.329)	(0.018)	(0.023)	(0.027)
Non-Agricultural Day Labor	0.726	0.475	0.640	0.086***	0.165***	0.252***
	(0.446)	(0.500)	(0.480)	(0.027)	(0.029)	(0.032)
Access to Markets	0.950	0.959	0.806	0.143***	0.152***	0.009
	(0.831)	(0.636)	(0.515)	(0.037)	(0.033)	(0.051)
Individual house (Structure)	0.733	0.212	0.703	0.030	0.491***	0.521***
	(0.443)	(0.409)	(0.457)	(0.026)	(0.026)	(0.029)
Earth or Sand (Floor)	0.910	0.935	0.948	0.038***	0.013	0.025
	(0.286)	(0.247)	(0.222)	(0.014)	(0.013)	(0.018)
Firewood (Cooking fuel)	0.950	0.959	0.806	0.099***	0.440***	0.539***
	(0.831)	(0.636)	(0.515)	(0.029)	(0.026)	(0.027)
N	446	415	906	1,352	1,321	861

Notes: 65 out of 1,832 observations (3.54%) were excluded from the analyses due to missing responses for the dependent and control variables. Column (1)-(3) report standard deviations in parenthesis, and column (4)-(6) report standard errors in parenthesis. * denotes significance at 10%, ** at 5%, and *** at 1% level.

Table 4: Ordered Logit Regression to Balance the Multiple Treatments Groups

	Multivalued Treatments (0 = No Intervention; 1 = AG; 2 = AG+ML)
Husband Age	-0.018
	(0.012)
Wife Age	0.008
	(0.012)
Husband Primary Education	0.233*
	(0.122)
Wife Primary Education	0.431***
	(0.162)
Muslim	0.520
	(0.496)
Household Size	-0.099**
	(0.041)
Own Land: Less than 49 decimals or no land	-1.082***
	(0.342)
Own Land: 50-98 decimals	-0.197
	(0.247)
Cultivated Land: Less than 49 decimals	0.002
	(0.248)
Cultivated Land: 50-98 decimals	-0.157
	(0.207)
Agriculture/Farming	-0.149
	(0.208)
Non-Agricultural Day Labor	0.260
	(0.187)
Access to Markets	0.341
	(0.352)
Individual house (Structure)	-0.369
	(0.241)
Earth or Sand (Floor)	-0.354
	(0.293)
Firewood (Cooking fuel)	0.020
	(0.453)
$\boldsymbol{\alpha_1}$	-1.334*
	(0.957)
$\boldsymbol{\alpha_2}$	-0.217
	(1.183)
Log-Likelihood	-1739.881
Pseudo R^2	0.044
N	1,767

Notes: Estimates are calculated by bootstrapping using 1,000 resampling iterations. Robust standard errors, clustered at village-level, are reported in parenthesis. * denotes significance at 10%, ** at 5%, and *** at 1% level.

Table 5: Between Treatment Group Difference in Estimated Propensity Scores before and after Weighting

	Before Weighting				After Weighting		
	N	Mean	Std. Dev		*N*	Mean	Std. Dev
No Intervention	906	0.557	0.120	No Intervention	906	0.521	0.128
AG	415	0.481	0.139	AG	410	0.517	0.135
AG + ML	446	0.467	0.141	AG + ML	439	0.517	0.135
F test of Mean Differences		91.06				0.23	
		(<0.001)				(0.798)	
Multiple Comparison Tests							
Bonferroni							
		No Intervention	AG			No Intervention	AG
AG		-0.075		AG		-0.004	
		(< 0.001)				(1.000)	
AG + ML		-0.090	-0.014	AG + ML		-0.004	$-2.23 \times e^{-4}$
		(< 0.001)	(0.322)			(1.000)	(0.322)
Scheffe							
		No Intervention	AG			No Intervention	AG
AG		-0.075		AG		-0.004	
		(< 0.001)				(0.871)	
AG + ML		-0.090	-0.014	AG + ML		-0.004	$-2.23 \times e^{-4}$
		(< 0.001)	(0.273)			(0.852)	(1.000)
Sidak							
		No Intervention	AG			No Intervention	AG
AG		-0.075		AG		-0.004	
		(< 0.001)				(0.936)	
AG + ML		-0.090	-0.014	AG + ML		-0.004	$-2.23 \times e^{-4}$
		(< 0.001)	(0.289)			(0.921)	(1.000)

Notes: AG + ML denotes the experimental group; AG denotes the comparison group. *p*-value is reported in parenthesis.

Table 6: Descriptive Statistics for Dependent Variables after MMW-S

	Experimental Group AG+ML	Comparison Group AG	No Intervention
	(1)	(2)	(3)
Income and Assets			
Wealth	-0.013	0.466	-0.244
	(1.551)	(0.148)	(1.496)
Monthly Income	0.771	0.488	0.379
	(0.421)	(0.500)	(0.485)
Expenditure			
Food	0.173	0.340	0.181
	(0.378)	(0.474)	(0.385)
Energy	0.638	0.598	0.712
	(0.481)	(0.491)	(0.453)
Clothe	0.196	0.293	0.113
	(0.397)	(0.456)	(0.316)
Healthcare	0.257	0.352	0.154
	(0.438)	(0.478)	(0.631)
Education	0.342	0.254	0.164
	(0.475)	(0.436)	(0.370)
Transportation	0.503	0.465	0.217
	(0.501)	(0.499)	(0.412)
Farm Livelihood Strategy			
Quantity Large Animals	3.382	1.122	2.089
	(3.786)	(1.742)	(2.344)
Quantity Poultry	8.711	10.875	7.201
	(9.260)	(10.238)	(38.304)
Sale of Poultry	0.394	0.192	0.120
	(0.489)	(0.395)	(0.325)
Vegetable Production [a]	2.860	3.093	1.881
	(2.479)	(1.875)	(2.209)
Sale of Vegetable	0.311	0.291	0.186
	(0.463)	(0.455)	(0.389)
Food Security and Dietary Diversity			
HFIS	1.966	2.239	4.093
	(3.881)	(3.343)	(5.252)
DDS	7.220	8.122	6.882
	(1.628)	(1.414)	(1.611)
Women's Empowerment			
Membership	2.074	1.492	0.717
	(1.006)	(0.879)	(0.737)
Own Large Animal	0.424	0.051	0.101
	(0.495)	(0.220)	(0.302)
Sale of Poultry Decision	0.632	0.138	0.126
	(0.481)	(0.346)	(0.332)
Sale of Vegetable Decision	0.280	0.160	0.097
	(0.450)	(0.367)	(0.296)
N	439	410	906

Notes: Standard deviations are reported in parenthesis. a: values are expressed in logarithm term.

Table 7: Summary of Impact of Production-Oriented Extension Services and Collective Marketing (N = 1,755)

	AG + ML		AG	
	Coefficient	*dy/dx*	Coefficient	*dy/dx*
Income and Assets				
Wealth	0.344***		0.316**	
	(0.132)		(0.128)	
Monthly Income	1.161***	0.394	0.453**	0.161
	(0.180)		(0.186)	
Expenditure				
Food	-0.078	-0.017	0.795***	0.241
	(0.101)		(0.182)	
Energy	-0.315	-0.094	-0.358	-0.107
	(0.222)		(0.229)	
Clothe	0.602***	0.130	0.738***	0.168
	(0.176)		(0.218)	
Healthcare	0.489***	0.126	0.633***	0.171
	(0.167)		(0.202)	
Education	0.676***	0.202	0.253**	0.066
	(0.151)		(0.119)	
Transportation	1.293***	0.398	0.576**	0.163
	(0.272)		(0.230)	
Farm Livelihood Strategy				
Quantity Large Animals	1.208***		-0.844***	
	(0.251)		(0.280)	
Quantity Poultry	1.916		2.666	
	(1.179)		(2.391)	
Sale of Poultry	0.938***	0.271	0.374**	0.086
	(0.090)		(0.151)	
Vegetable Production [a]	1.087***		1.176***	
	(0.188)		(0.314)	
Sale of Vegetable	0.471***	0.134	0.424***	0.119
	(0.136)		(0.156)	
Food Security and Dietary Diversity				
HFIS	-2.644***		-1.349*	
	(0.808)		(0.704)	
DDS	0.381***		1.108***	
	(0.140)		(0.197)	
Women's Empowerment				
Membership	1.331***		0.750***	
	(0.105)		(0.150)	
Own Large Animal	1.307***	0.333	-0.146	-0.018
	(0.169)		(0.203)	
Sale of Poultry Decision	0.826***	0.223	0.306**	0.066
	(0.119)		(0.138)	
Sale of Vegetable Decision	0.778***	0.179	0.483***	0.097
	(0.142)		(0.169)	

Notes: Robust standard errors, clustered at the village-level, are reported in parenthesis. The estimates are calculated by multilevel mixed effects models, controlling for village effects, with control variables described in Table 3. The average marginal effects (*dy/dx*) are calculated if mixed-effect probit model is used. * denotes significance at 10%, ** at 5%, and *** at 1% level.

Table 8: A Comparison of Matching Quality Results of Before and After Propensity Score Matching

	Regression Type	Pseudo R^2 before matching	Pseudo R^2 after matching	LR chi-square before matching	LR chi-square after matching	Mean standardized bias before matching	Mean standardized bias after matching	Median standardized bias before matching	Median standardized bias after matching	*N*
AG + ML										
NNM	Probit	0.283	0.008	367.81***	8.74	25.8	4.6	10.9	4.0	800
KM	Probit	0.283	0.008	367.81***	8.57	25.8	5.1	10.9	5.1	900
AG										
NNM	Probit	0.131	0.008	150.27***	8.98	17.0	5.5	9.7	4.9	755
KM	Probit	0.131	0.008	150.27***	8.86	17.0	5.1	9.7	3.2	829

Notes: * denotes significance at 10 percent, ** at 5 percent, and *** at 1 percent level.
NNM = five nearest neighbor matching with replacement and common support
KM = kernel-based matching with a bandwidth 0.06 and common support

Table 9: Summary of Impact of Production-Oriented Extension Services and Collective Marketing by Treatments and District Using Propensity Score Matching Approach

	AG + ML vs No Intervention Dinajpur		AG vs No Intervention Barisal	
	NNM	KM	NNM	KM
Income and Assets				
Wealth	0.561***	0.431***	0.172*	0.174*
	(0.166)	(0.155)	(0.095)	(0.100)
Monthly Income	0.993***	0.982***	0.861***	0.857***
	(0.240)	(0.230)	(0.200)	(0.198)
Expenditure				
Food	-0.457**	-0.479**	1.095***	1.172***
	(0.232)	(0.228)	(0.213)	(0.194)
Energy	-0.868***	-0.856***	0.174	0.264
	(0.223)	(0.205)	(0.288)	(0.286)
Clothe	1.326***	1.263***	0.234	0.275
	(0.242)	(0.216)	(0.209)	(0.205)
Healthcare	1.190***	1.221***	0.295*	0.297**
	(0.174)	(0.163)	(0.152)	(0.140)
Education	1.056***	0.0977***	-0.035	0.023
	(0.219)	(0.209)	(0.105)	(0.107)
Transportation	2.142***	1.851***	-0.031	-0.022
	(0.332)	(0.386)	(0.133)	(0.130)
Sales of Poultry and Vegetable				
Quantity Large Animals	-0.150	-0.111	-0.027	-0.001
	(0.286)	(0.285)	(0.199)	(0.191)
Quantity Poultry	2.222***	2.169***	2.833	4.114***
	(0.788)	(0.798)	(2.546)	(1.741)
Sale of Poultry	0.680***	0.681***	0.562**	0.605**
	(0.096)	(0.099)	(0.265)	(0.238)
Vegetable Production [a]	1.008***	1.036***	1.254***	1.289***
	(0.275)	(0.284)	(0.292)	(0.297)
Sale of Vegetable	0.602***	0.611***	0.379**	0.374**
	(0.167)	(0.178)	(0.166)	(0.166)
Food Security and Dietary Diversity				
HFIS	0.020	0.036	-4.257***	-4.109***
	(0.499)	(0.521)	(0.535)	(0.510)
DDS	0.398**	0.372**	1.401***	1.357***
	(0.186)	(0.188)	(0.219)	(0.226)
Women's Empowerment				
Membership	1.314***	1.315***	0.853***	0.863***
	(0.098)	(0.097)	(0.168)	(0.168)
Own Large Animal	1.003***	1.021***	0.467	0.380
	(0.228)	(0.214)	(0.384)	(0.354)
Sale of Poultry Decision	0.569***	0.574***	0.546**	0.545***
	(0.127)	(0.117)	(0.214)	(0.191)
Sale of Vegetable Decision	0.719***	0.732***	0.717***	0.770***
	(0.154)	(0.161)	(0.214)	(0.213)

Notes: Robust standard errors, clustered at the village-level, are reported in parenthesis. The estimates are calculated by multilevel mixed effects models, controlling for village effects, with control variables described in Table 3. * denotes significance at 10%, ** at 5%, and *** at 1% level.

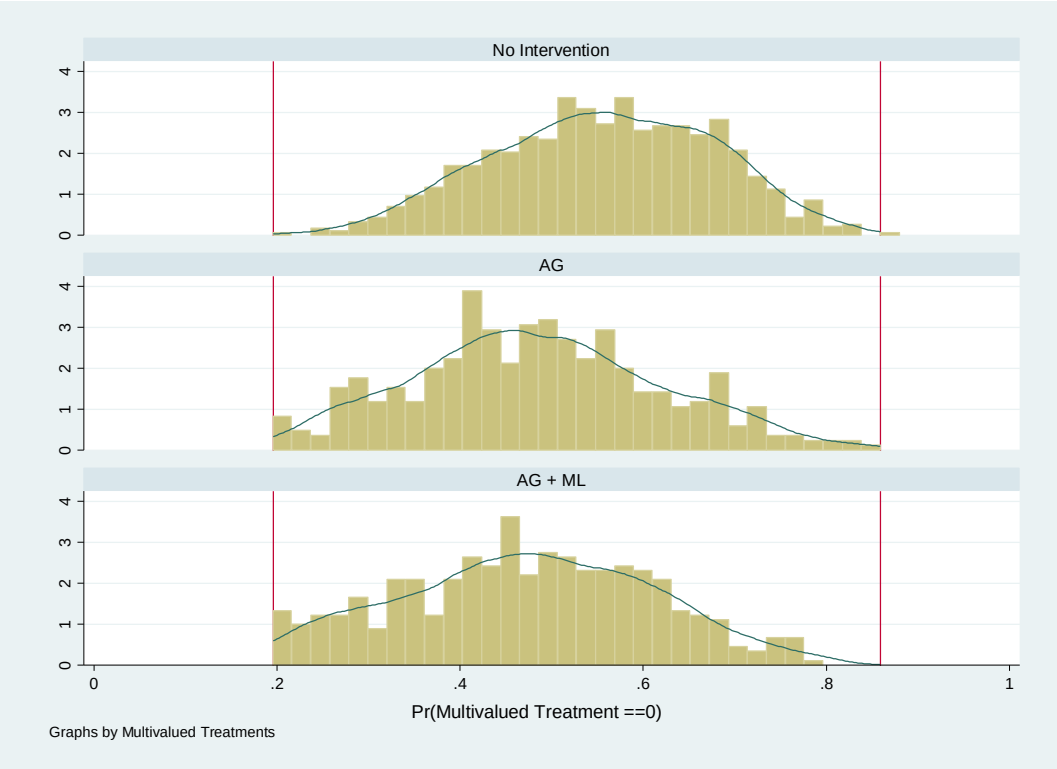
Table 10: Summary of Impact of Production-Oriented Extension Services and Collective Marketing from Different Econometric Model Results

	Experimental Group AG + ML (1)	Comparison Group AG (2)	Impact Size (3)
Income and Assets			
Wealth	(+)	(+)	>
Monthly Income	(+)	(+)	>
Expenditure			
Food		(+)	
Energy			
Clothe	(+)		
Healthcare	(+)	(+)	C
Education	(+)		
Transportation	(+)		
Sales of Poultry and Vegetable			
Quantity Large Animals			
Quantity Poultry			
Sale of Poultry	(+)	(+)	>
Vegetable Production	(+)	(+)	<
Sale of Vegetable	(+)	(+)	>
Food Security and Dietary Diversity			
HFIS		(–)	
DDS	(+)	(+)	<
Women's Empowerment			
Membership	(+)	(+)	>
Own Large Animal	(+)		>
Sale of Poultry Decision	(+)	(+)	>
Sale of Vegetable Decision	(+)	(+)	C

Notes: Denote (+) if we observe a statistically significant and positive coefficient from both Table 7 and Table 9, and (-) if we observe a statistically significant and negative coefficient from both Table 7 and Table 9. Column (3) compares the impact size of the treatment effects, using estimates from Table 7 and Table 9, and denotes 'C' if the results are opposite between two tables. For example, in Table 7 the healthcare result from the experimental group is less than the result from the comparison group. However, in Table 9, the experimental group result is larger than comparison group. Hence the "C" shown in column 3.

Figures

Figure 1: Common Support for Multiple Treatments



Appendix

Appendix A1: Descriptive Statistics for Household and Dwelling Characteristics, and Tests for Differences in Means, by Treatment Status and Districts

	Dinajpur			Barisal		
	(1) AG+ML	(2) No Intervention	(3) Difference	(4) AG	(5) No Intervention	(6) Difference
Husband Age	43.917	43.750		48.053	46.896	
	(12.890)	(11.621)		(11.589)	(13.465)	
Wife Age	35.765	35.939		38.272	36.850	*
	(11.112)	(10.039)		(9.737)	(11.399)	
Husband Primary Education	0.717	0.750		0.489	0.466	
	(0.451)	(0.433)		(0.500)	(0.499)	
Wife Primary Education	0.706	0.679		0.492	0.466	
	(0.456)	(0.467)		(0.501)	(0.499)	
Muslim	0.502	0.484		0.528	0.261	***
	(0.501)	(0.500)		(0.500)	(0.440)	
Household Size	4.509	4.661		5.217	5.043	
	(1.476)	(1.489)		(1.856)	(1.722)	
Own Land: Less than 49 decimals or no land	0.628	0.957	***	0.595	0.529	*
	(0.484)	(0.202)		(0.491)	(0.500)	
Own Land: 50-98 decimals	0.193	0.033	***	0.265	0.271	
	(0.395)	(0.178)		(0.442)	(0.445)	
Cultivated Land: Less than 49 decimals	0.509	0.591	**	0.492	0.519	
	(0.500)	(0.492)		(0.501)	(0.500)	
Cultivated Land: 50-98 decimals	0.316	0.335		0.345	0.290	*
	(0.465)	(0.473)		(0.476)	(0.454)	
Agriculture/Farming	0.910	0.939	*	0.651	0.802	***
	(0.286)	(0.240)		(0.477)	(0.399)	
Non-Agricultural Day Labor	0.726	0.888	***	0.475	0.345	***
	(0.446)	(0.315)		(0.500)	(0.476)	
Access to Markets	0.950	0.895		0.959	0.700	***
	(0.831)	(0.537)		(0.636)	(0.466)	
Individual house (Structure)	0.733	0.919	***	0.212	0.447	***
	(0.443)	(0.274)		(0.409)	(0.498)	
Earth or Sand (Floor)	0.910	0.978	***	0.935	0.913	
	(0.286)	(0.148)		(0.247)	(0.282)	
Firewood (Cooking fuel)	0.950	0.138	***	0.959	0.935	
	(0.831)	(0.345)		(0.636)	(0.247)	
N	446	492	938	415	414	829

Notes: 65 out of 1,832 observations (3.54%) were excluded from the analyses due to missing responses for the dependent and control variables. Standard deviations are reported in parenthesis. Column (3) and (6) report level of statistical significance of difference between the treatment and control group. * denotes significance at 10 percent, ** at 5 percent, and *** at 1 percent level.

Appendix A2: Marginal Mean Weight through Stratification (MMW-S) for Multiple Treatments

	AG + ML		AG		No Intervention		
Stratum	*n*	MMWS	*n*	MMWS	*n*	MMWS	Total
1	99	0.556	72	0.714	49	2.317	220
2	59	0.928	72	0.711	88	1.285	219
3	66	0.834	56	0.918	98	1.159	220
4	52	1.053	59	0.867	108	1.047	219
5	47	1.166	43	1.190	129	0.876	219
6	50	1.101	38	1.353	132	0.860	220
7	39	1.405	30	1.705	150	0.754	219
8	27	2.029	40	1.279	152	0.744	219
Total	439		410		906		1,755

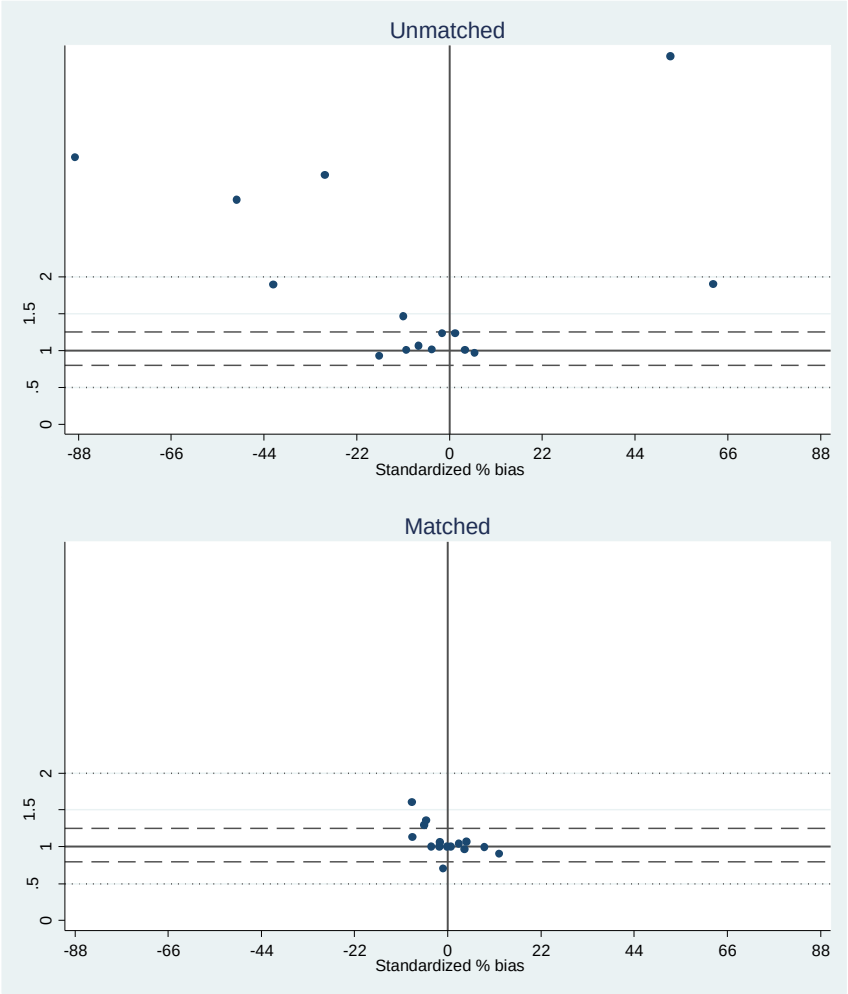
Appendix A3: Descriptive Statistics for Dependent Variables after MMW-S by District

	Dinajpur		Barisal	
	Experimental Group AG+ML	Control Group No Intervention	Comparison Group AG	Control Group No Intervention
	(1)	(2)	(3)	(4)
Income and Assets				
Wealth	-0.013	-0.742	0.466	0.334
	(1.551)	(1.073)	(0.148)	(1.697)
Monthly Income	0.771	0.523	0.488	0.220
	(0.421)	(0.500)	(0.500)	(0.415)
Expenditure				
Food	0.173	0.258	0.340	0.095
	(0.378)	(0.438)	(0.474)	(0.294)
Energy	0.638	0.870	0.598	0.536
	(0.481)	(0.336)	(0.491)	(0.499)
Clothe	0.196	0.033	0.293	0.201
	(0.397)	(0.178)	(0.456)	(0.401)
Healthcare	0.257	0.048	0.352	0.272
	(0.438)	(0.213)	(0.478)	(0.446)
Education	0.342	0.123	0.254	0.208
	(0.475)	(0.329)	(0.436)	(0.407)
Transportation	0.503	0.056	0.465	0.395
	(0.501)	(0.229)	(0.499)	(0.489)
Farm Livelihood Strategy				
Quantity Large Animals	3.382	2.992	1.122	1.090
	(3.786)	(2.236)	(1.742)	(2.038)
Quantity Poultry	8.711	5.913	10.875	8.626
	(9.260)	(6.397)	(10.238)	(55.196)
Sale of Poultry	0.394	0.165	0.192	0.071
	(0.489)	(0.372)	(0.395)	(0.257)
Vegetable Production [a]	2.860	1.740	3.093	2.039
	(2.479)	(2.176)	(1.875)	(2.237)
Sale of Vegetable	0.311	0.147	0.291	0.230
	(0.463)	(0.354)	(0.455)	(0.422)
Food Security and Dietary Diversity				
HFIS	1.966	2.262	2.239	6.121
	(3.881)	(3.898)	(3.343)	(5.792)
DDS	7.220	6.711	8.122	7.071
	(1.628)	(1.557)	(1.414)	(1.652)
Women's Empowerment				
Membership	2.074	0.792	1.492	0.634
	(1.006)	(0.684)	(0.879)	(0.784)
Own Large Animal	0.424	0.169	0.051	0.026
	(0.495)	(0.375)	(0.220)	(0.160)
Sale of Poultry Decision	0.632	0.187	0.138	0.058
	(0.481)	(0.391)	(0.346)	(0.233)
Sale of Vegetable Decision	0.280	0.119	0.160	0.072
	(0.450)	(0.323)	(0.367)	(0.259)
N	439	492	410	414

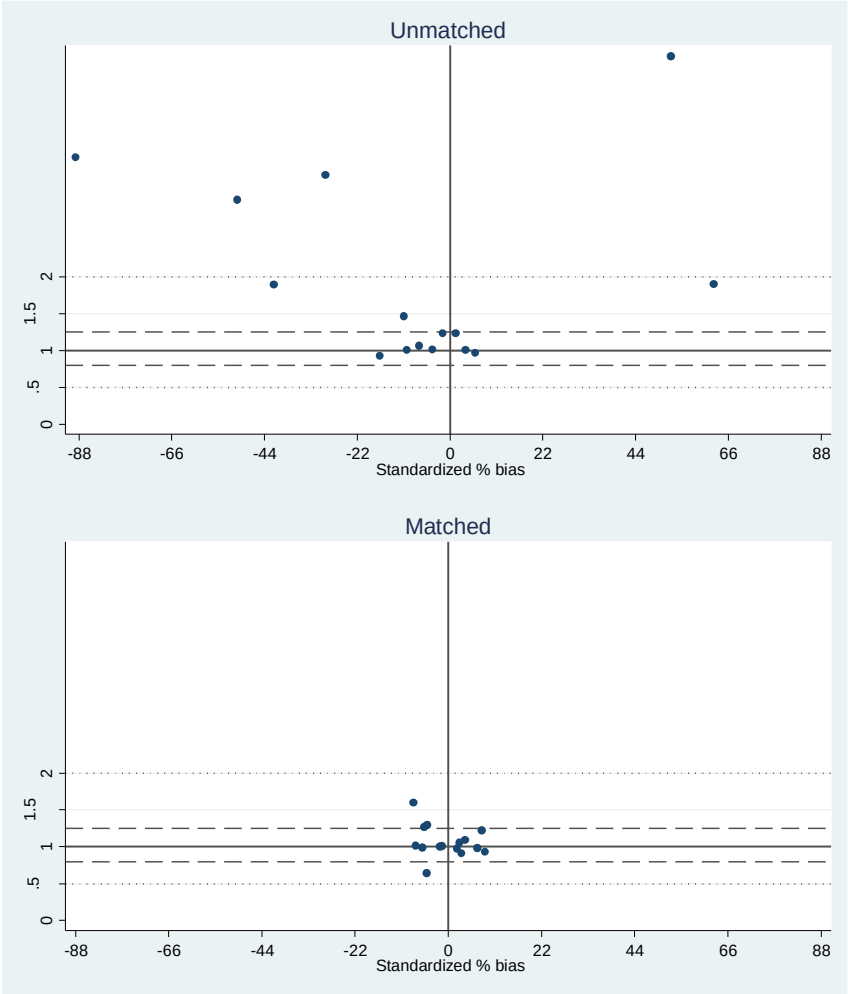
Notes: Standard deviations are reported in parenthesis. a: values are expressed in logarithm term.

Appendix A4: Propensity Score Matching Quality Results Before and After Matching by District

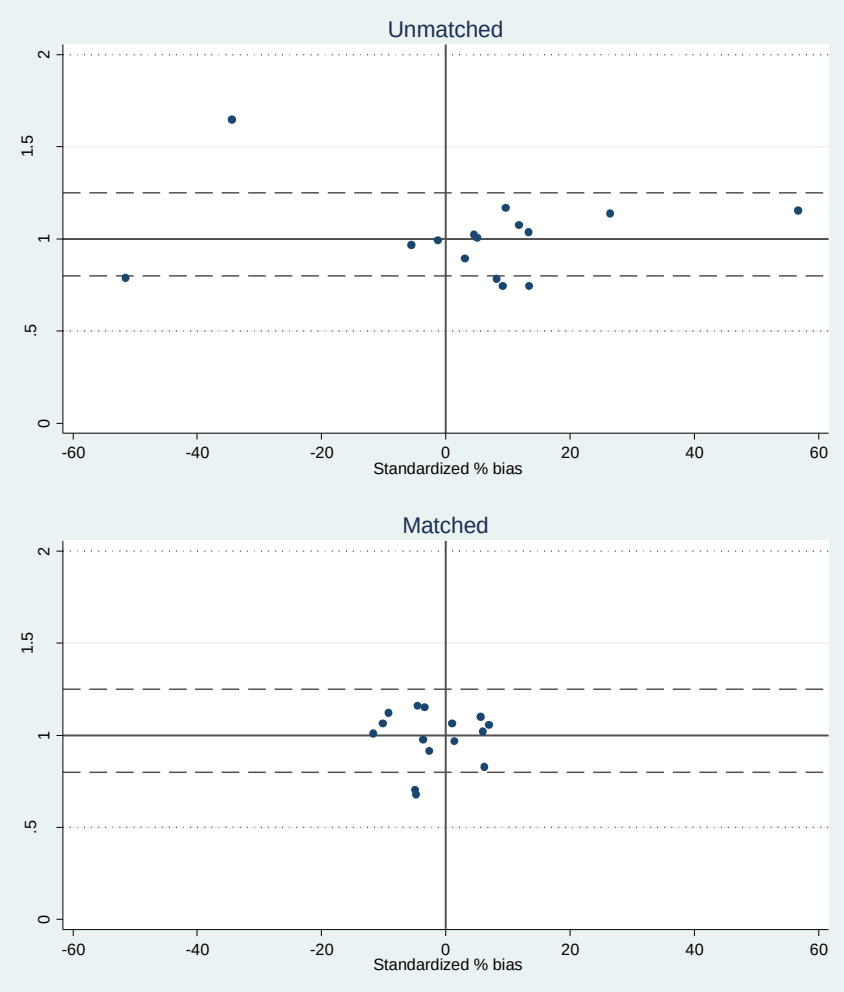
(a) Dinajpur: NNM



(b) Dinajpur: KM



(c) Barisal: NNM



(b) Barisal: KM