Women Farmers' Access to Integrated Livestock Extension Services and the Impact on Livelihoods in Bangladesh

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Abstract
This paper evaluates the impacts that agricultural extension projects had on household income and farm livelihoods based on livestock, vegetable, and fisheries when they increased women farmers' access to improved technologies and advisory services. This study utilizes cross-sectional data of 1,682 households, collected in 2016, from 29 rural villages in two vulnerable districts of Bangladesh. Using a propensity score matching (PSM) method, we find that agricultural extension projects increased beneficiaries' monthly income (expenditure) and the likelihood of having poultry and planting a vegetable garden and varieties. However, we cannot find the project impact on the possession and quantity of larger animals and fisheries within the household, as both activities were often considered to be men's responsibility. Our main findings imply that reaching women farmers with advanced technologies and advisory services would improve beneficiaries' food security and dietary diversity.

***Keywords*:** Agriculture, extension services, gender, livestock livelihood, food security

Introduction
In most developing countries, the growth and development of agriculture is an important strategy to reduce poverty. Agricultural extension provides mechanisms to enhance dissemination and utilization of innovative agricultural technologies to improve agricultural productivity and farm decision making and develop a sustainable agro-industrial economy (Binswanger & Von Braun, 1991; Feder & Slade, 1986; Garforth 1982; Just & Zilberman, 1988). Agricultural extension uses various forms of delivery: (*i*) training-and-visit (T&V) extension in which field agents or specialists visit and provide appropriate technology, information and advice to selected communities (Evenson & Mwabu, 2001; Feder, Slade, & Lau, 1987; Gautam, 2000; Hussain, Byerlee, & Heisey, 1994; Owens, Hoddinott, & Kinsey, 2003); (*ii*) the use of information and communication technology (ICT) (Aker, 2010; Aker & Mbiti, 2010; Goyal, 2010); and (*iii*) learning through the sharing of knowledge and experiences between farmers or through farmer field schools (FFS) (Alene & Manyong, 2006; Feder, Murgai, & Quizon, 2004; Tripp, Wijeratne, & Piyadasa, 2005; Weir & Knight, 2004).

Despite the variety of delivery mechanisms and advisory approaches, previous evaluation studies and reviews provide consistent evidence of gender bias and gender-specific constraints in access to extension services of poor rural women. For example, Swanson, Farner, and Bahal (1990) show that women received only between 2% and 10% of all extension contacts and a mere (5%) of extension resources worldwide. Moreover, the recent studies of Gilbert et al. (2002), Katungi et al. (2008), and Madhvani and Pehu (2010) do not show any substantial improvements in gender equality in extension service delivery despite decades of efforts to integrate gender issues into economic development and poverty reduction strategies.

On the other hand, a large literature in development economics suggests that an increase in women's access to education and financial opportunities improve families' nutrition, child education, and other society-wide economic developments (Duflo, 2012; Goetz & Gupta, 1996; Hashemi, Schuler, & Riley, 1996; Panjaitan-Drioadisuryo & Cloud, 1999; Pitt & Khandker, 1998; Sharma & Zeller, 1997). In addition, recent findings from the United Nations Food and Agriculture Organization (FAO, 2011) show that women could increase yields on their farms by 20-30% if they had the same level of access to extension services and resources as men, which could, in turn, reduce hunger for 12-17% of people worldwide. However, the impact of agricultural extension differs depending on the types of technologies and delivery mechanisms, cultural and social factors, and environments (Anderson & Feder, 2004; De Janvry & Sadoulet, 2002; Norton, Alwang, & William, 2014; Todaro, 2000).

This study evaluates the impact of agricultural extension projects on households' income and farm livelihoods. Agricultural extension focused on women farmers' access to improved technologies and advisory services, and farm livelihoods were based on livestock, vegetable, and fisheries. As of January 2013, Caritas Bangladesh and Catholic Relief Services (CRS) partnered in implementing the the Egiye Jai ("Move Forward") and Nijera Gori ("We Build It Ourselves") projects, aiming to increase the yield of year-round quality homestead food production and improve household food security and nutrition [1]. In order to increase women farmers' access to extension services, the projects utilized a cluster-level training approach – extension workers provided one-on-one and group training of farmers on a variety of agricultural subjects at each village cluster – to avoid spatial constraints from the social norms, restricting women's movements outside their homesteads. This study aims to contribute to the agricultural extension and gender literature by providing empirical evidence on extension projects targeting rural women farmers to increase their access to improved technologies and advisory services.

We utilize cross-sectional household-level survey data collected in 29 villages (16 treatment and 13 control villages) in Barisal and Dinajpur districts of Bangladesh. One major difficulty in assessing the impact of the extension projects is to establish a suitable counterfactual since the treatment site selection and voluntary nature of participation would increase the likelihood to bias project impact estimates. To reduce potential sources of selection bias, we employ a propensity score matching (PSM) method, proposed by Rosenbaum and Robin (1983), to construct a statistical comparison group, which is similar to the treatment group. Our main results indicate that agricultural extension projects increased beneficiaries' monthly income (expenditure) and the likelihood of having poultry and planting a vegetable garden and varieties. However, we cannot find the project impact on the possession and quantity of larger animals and fisheries within the household, as both activities were often considered to be men's responsibility.

Additionally, according to the United Nations Children's Fund's conceptual framework of nutrition (UNICEF, 1990), these results presumably suggest that reaching women farmers with advanced technologies and advisory services would improve beneficiaries' food security and dietary diversity.

The remainder of the study proceeds as follows: Section 2 discusses the background of the Egiye Jai and Nijera Gori projects, and Section 3 details the conceptual model. Section 4 describes data and survey sampling design, and the key results and findings are discussed in Section 5. Section 6 discusses limitations of the study, and the last section summarizes and highlights the key findings and policy implications.

Background

Bangladesh, a South Asian country of approximately 160 million people, is characterized by a high population density, low per-capita income, and high poverty in which around 47 million people are below the poverty line. Also, according to the gender inequality index from the Human Development Report, Bangladesh was ranked 111 out of 148 countries, concerning factors of inequality in reproductive health, empowerment and the labor market (Malik, 2013). Agriculture accounts for 16% of the country's gross domestic product and employs nearly half of the country's workforce. Also, nearly two-thirds of Bangladesh's population live in rural areas, and over 87% of rural people depend on agriculture as an income source. The World Bank (2016) reports that agriculture played a key role in reducing Bangladesh's poverty from 48.9% in 2000 to 31.5% by 2010. However, people living in the flash flood and drought-prone districts in the northwest and the saline-affected tidal surge areas in the south still suffer from more severe food insecurity and higher poverty than the national average (Zohir, 2011). Beginning in 2013, Caritas partnered with CRS to implement agricultural extension projects in these underprivileged areas, and the Integrating Gender and Nutrition within Agricultural Extension Services (INGENAES) Project, based at the University of Illinois at Urbana-Champaign (UIUC), performed a comprehensive impact evaluation, assessing whether agricultural extension services geared to promoting rural farmers' income and farm livelihoods [2].

The Egiye Jai project was implemented in eight villages in Rajihar Union of Barisal district, and the Nijera Gori project was implemented in eight villages in Dinajpur Sadar and Birgonj Upazilas of Dinajpur districts. Both projects delivered similar extensive agricultural training that provided a strong basis for sustainable and quality homestead food production as well as post-harvest management and financial skills. In order to deliver the training, each project appointed one agriculture technical officer who collected information from government agencies (the Upazila level government agriculture officer, livestock officer, and fishery officer) and community leaders to prepare a draft training schedule and technical materials for project animators and service recipients. The animators received five days of agricultural training for improved production practices, followed by 2-3 hours of regular training bi-weekly.

The role of women in agriculture, development and poverty alleviation has emerged as an important area of investigation in Bangladesh (Abdullah & Zeidenstein, 1982; Goetz & Gupta, 1996; Hashemi et al., 1996; Safilios-Rothschild & Mahmud, 1989). Most women devote more of their time and energy to household chores and childcare than men; additionally, women spend

more than three-fourths of their time on non-income homestead food production, growing vegetables and raising small poultry and large animals (Cain, Khanam, & Nahar, 1979). Although women are involved in a variety of agricultural activities, their access to and adoption of innovative technologies is limited due to deeply embedded social norms of patriarchy and restrictions on women's movements outside their homesteads (Adato & Meinzen-Dick, 2007; van Mele, Ahmad, & Magor, 2005; Schuler & Hashemi, 1994). In order to overcome this barrier while avoiding cultural conflict within the household and community, the projects used a cluster-level training approach, which brought extension services to a gathering space close to beneficiaries' homes in each village cluster. Specifically, in each village, the projects defined geographical boundaries for each cluster of households (approximately 20 to 30 households), ensuring that households within proximity to each other were in the same cluster. Additionally, in each village cluster, the projects selected one or two community representatives (voluntary) who had roles in clarifying and informing local agriculture-related issues and challenges to project animators.

After carrying out agricultural training for developing the capacity of project animators and village leaders, the animators provided details about projects and the training schedule to all households in the village clusters prior to actual implementation. Project participation was voluntary for farmers in a designated area, but the delivered technologies were shown to farmers in the cluster through organized demonstration plots and field days. This approach aimed at facilitating 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.

Table 1: Summary of Egiye Jai and Nijera Gori Cluster-Level Training Attendance

Topic	Egiye Jai (Jun, 2013 – Jun, 2014)			Nijera Gori (Feb – Jul, 2014)		
	Men	Women	Total	Men	Women	Total
Vegetable						
First round	229	1976	2205	421	1744	2165
Second round	186	2029	2215	-	-	-
Poultry						
First round	158	1631	1789	181	2022	2203
Second round	-	-	-	122	1958	2080
Livestock	153	1652	1805	291	1755	2046
Aquaculture						
First round	165	2106	2271	172	1455	1627
Second round	149	1926	2075	149	1196	1345
Post-harvest management	137	2132	2269	-	-	-

Sources: CRS (2015) interim evaluation reports.
Notes: Period for the round of each training differs by project.

According to CRS's 2015 report, the Egiye Jai project (Barisal) served 118 village clusters in eight project villages, reaching 3,018 households. The project assigned ten animators of whom each served about 12 village clusters and 300 households. Similarly, the Nijera Gori project (Dinajpur) served 119 village clusters in eight villages and reached 3,633 households, with ten

animators each serving about 12 villages and 360 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, and 88% were women (Table 1) [3]. These results indicate the fact that the cluster-level training approach appeared to be an effective way to reach women farmers with improved agricultural practices by alleviating their mobility constraints as well as saving travel time and costs in case training was held at a distance from their homesteads. Additionally, all project beneficiaries received a Bengali version of a booklet entitled "Homestead Cultivation: Food Security and Income Sources" that contains information on all delivered agricultural practices, food security and nutrition, and financial skills with narrative pictures.

Conceptual Model

In a project evaluation context, if extension services are randomly distributed, one can estimate the extension effect by comparing outcomes of treated households to control households that have not received extension services. Assuming that an outcome of interest is a linear function of a binary treatment indicator variable, along with other control covariates (*X*), leads to the following equation:

(1) $$Y_h = \gamma X_h + \delta T_h + \varepsilon_h,$$

where *Y* represent outcome variables, *T* is a treatment indicator, γ and δ are vectors of parameters to be estimated, and ε is an error term. The treatment impact on the outcome variable is measured by the estimates of the parameter δ. Since not all of the treated households made the same decisions on farming activities based on their level of understanding, farming experiences, and financial constraints, the treatment effect estimate, δ, represents the average effect for the entire households in the treatment villages regardless of whether the treatment was actually received. However, the Egiye Jai and Nijera Gori projects were not an ideal random assignment, indicating that the treatment site selection and voluntary nature of participation were likely to be influenced by unobservable characteristics that might be correlated to the outcomes of interest, and in this case, the coefficients estimated from the Equation (1) can be biased.

In order to reduce potential source of selection bias, we use the PSM method to create a statistical sample of comparison group households that share approximately similar likelihoods of being assigned to the treatment condition based on observables in the survey data (Dehejia & Wahba, 2002; Heckman, Ichimura, Smith, & Todd, 1998). A major criticism of PSM is the assumption of selection on observables, and the presence of unobserved differences between the treatment and control groups in the propensity score estimation can create mismatching and biased estimators (Heckman & Navarro-Lozano, 2004). Nevertheless, Jalan and Ravallion (2003) assert that, in cross-sectional data analysis, the assumption of selection on observables is no more restrictive than problems of weak instruments of the instrumental variable (IV) approach [4]. Another concern of PSM is the common support condition, indicating that there are comparable observations from the treatment and control groups based on the calculated propensity scores, thereby supporting the comparison of outcomes between the two groups. Observations outside the common support region are excluded from the analyses. PSM can increase the likelihood of reasonable comparisons across treated and matched control observations with a sufficient number of control samples from which to draw matches, thereby potentially lowering bias in project impact estimates.

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. However, in practices, there are trade-offs in terms of bias and efficiency with each method (Caliendo & Kopeinig, 2008). In this study, we utilize the nearest neighbors matching (NNM) and kernel-based matching (KM) approaches. Specifically, we report four matching estimates based on the five-NNM with replacement and common support and the Epanechnikov KM estimates with a bandwidth of 0.06 and common support by logit and probit regressions. Additionally, we present results from covariate balancing tests to ascertain whether the statistical differences in control covariates between the treatment and control group have been eliminated after the match. 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 (Sianesi, 2004). 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 absolute standardized bias between the treatment and control group.

Methods

This study utilizes cross-sectional survey data collected between February and April 2016 from 29 villages in two districts where extension projects have been offered: eight treatment villages in Rajihar Union of Barisal district with ten nearby villages serving as a control area, and eight treatment villages in Dinajpur Sadar and Birgonj Upazilas in Dinajpur district with three nearby control villages. Since villages in the two districts have different household and agro-ecological characteristics, we conduct separate analyses for Barisal and Dinajpur districts.

Survey respondents were randomly selected at the cluster level in the treatment villages. Specifically, the projects assigned a project identification (ID) number to training attendees, and, based on the size of training attendees in the cluster, the projects randomly chose one to twenty respondents from each cluster. Table 2 shows that the Egiye Jai project selected an average of four respondents from each of the 120 clusters in eight treatment villages, and about five respondents from each of the 92 clusters in Nijera Gori project villages. If a selected respondent was not available, then next available respondent in the randomized list of project attendees was selected. In the meantime, we also interviewed rural farmers in the control villages located close to the project sites. However, unlike the treatment village's sampling scheme, control village respondents were randomly selected from a list of farm households in each village. Specifically, we randomly chose 50 respondents from each of the ten villages as a comparison group for evaluating the impact of the Egiye Jai project. For the Nijera Gori project, two of the three control villages were relatively larger, so we randomly selected 200 respondents from each of these villages, and another 100 from the other village. Altogether, in each project, we collected 1,000 surveys including 500 surveys from the treatment villages and 500 surveys from the control villages.

For the purpose of this study, we limited our analysis samples to married households (dropped 3.7% of the entire sample). Also, we excluded surveys completed by son, daughter, parents, or other relationships to the head of household (13.25%) since they would increase the likelihood of measurement errors in data.

Table 2: Number of Sampled Households Surveyed by Village and Districts

	# of Village Clusters	# of Sampled Households	Average # of Sampled Households in Each Cluster	Min # of Sampled Households	Max # of Sampled Households
	(1)	(2)	(3)	(4)	(5)
Egiye Jai					
Boro Bashail	40	166	4.15	1	11
Coto Bashail	9	35	3.89	1	6
Coto Dumuria	7	30	4.29	2	7
Paschim Goail	10	47	4.70	1	11
Paschim Razihar	8	29	3.63	1	8
Razihar	27	114	4.22	1	7
Sutar Bari	3	8	2.67	1	4
Valuksi	17	71	4.18	1	7
Total	121	500	4.13	1	11
Nijera Gori					
Dabra Jineshwari	25	114	4.56	1	9
Fajilpur	1	14	-	1	14
Khorikadam	10	42	4.20	2	11
Mohadebpur	15	68	4.53	2	11
Nagri Sagri	12	100	8.33	3	20
Salbari Dabra	12	50	4.17	1	8
Sundori Hatgachh	6	26	4.33	1	9
West Paragon	11	86	7.82	1	9
Total	92	500	5.43	2	11

Table 3: Number of Study Samples and Treatment Status by Villages and Districts

Egiye Jai (Barisal)				Nijera Gori (Dinajpur)			
Treatment	*N*	Control	*N*	Treatment	*N*	Control	*N*
Boro Bashail	148	Basumda	37	Dabra Jineshwari	99	Bochapukur	98
Coto Bashail	25	Batra	41	Fajilpur	12	Mahatabpur	171
Coto Dumuria	25	Changutia	37	Khorikadam	37	Moricha	172
Paschim Goail	35	Lokharmatia	36	Mohadebpur	60		
Paschim Razihar	25	Magura Bahadurpur	36	Nagri Sagri	85		
Razihar	102	Nowpara	40	Salbari Dabra	47		
Sutar Bari	7	Purbo Goail	38	Sundori Hatgachh	22		
Valuksi	52	Ramander akh	40	West Paragon	76		
		Rangta	43				
		Vazna	36				
Total	419	Total	384	Total	438	Total	441

We had a total of 803 households including 419 households from eight treatment villages, and 384 households from ten control villages in the Egiye Jai project, and we had a total of 879 households with 438 households from eight treatment villages and 441 households from three control villages in the Nijera Gori project. The number of sampled households and their treatment status by villages and districts are detailed in Table 3.

The survey questionnaire consists of extensive information on household characteristics, farm livelihoods, expenditure, land holding, labor activities, and dwelling characteristics. Description of variables used in this study is detailed in Table 4.

Table 4: Description of Variables

Variable	Description
Outcome Variable	
Monthly Expenditure	= Monthly expenditure
Livestock	
Own Cow	= 1 for having a cow; 0 for otherwise
Own Goat	= 1 for having a goat; 0 for otherwise
Number of Cows and Goats	= Number of cows and goats
Own Poultry	= 1 for having a poultry (chicken or duck); 0 for otherwise
Number of Poultry	= Number of poultry (chickens and ducks)
Vegetable	
Plant a Vegetable Garden	= 1 for planting a vegetable garden; 0 for otherwise
Type of Vegetable	= Number of vegetable types
Own Aquaculture	= 1 for rearing aquatic animals; 0 for otherwise
Control Variables	
Husband Age	= Husband's age
Wife Age	= Wife's age
Husband Education	
Primary Education	= 1 if a husband had some primary education or less (0-5 years of education)
Secondary Education	= 1 if a husband had some secondary education (6-10 years of education)
Wife Education	
Primary Education	= 1 if a wife had some primary education or less (0-5 years of education)
Secondary Education	= 1 if a wife had some secondary education (6-10 years of education)
Religion	
Muslim	= 1 for having Muslim religion; 0 for otherwise
Hindu	= 1 for having Hindu 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
Day labor	= 1 if a household member is involved in day labor activity; 0 if otherwise
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
Electricity (Lighting)	= 1 for using electricity for lighting; 0 for otherwise
Firewood (Cooking fuel)	= 1 for using firewood for cooking; 0 for otherwise

Table 5 presents summary statistics and a balance test which compared the difference in control covariates – statistical significance tests on equality of means for continuous variables and equality of proportion for binary variables – between the treatment and control groups. If the control group is well established, we would expect that none of the coefficients would statistically differ from zero. The results show that Egiye Jai treatment villages tended to have fewer households with Hindu religion and more households with less than 49 decimals (or 0.49 acre) no land while, in Nijera Gori, the treatment villages tended to have fewer households with Muslim religion, smaller household size, more households with less than 49 decimals or no land, and more households using firewood for cooking than those in the control villages [5].

Table 5: Descriptive Statistics for Household and Dwelling Characteristics

	Egiye Jai (Barisal)		Nijera Gori (Dinajpur)	
	Control (Std. Dev.)	Difference (Std. Err.)	Control (Std. Dev.)	Difference (Std. Err.)
	(1)	(2)	(3)	(4)
Husband Age	43.826	1.399	42.327	1.274
	(13.223)	(2.345)	(11.538)	(1.772)
Wife Age	35.323	2.766	33.619	1.415
	(11.532)	(2.057)	(9.773)	(1.482)
Husband Education				
Primary Education	0.458	0.087	0.710	0.018
	(0.499)	(0.108)	(0.454)	(0.071)
Secondary Education	0.430	0.029	0.265	-0.056
	(0.496)	(0.108)	(0.442)	(0.068)
Wife Education				
Primary Education	0.526	0.164	0.653	0.055
	(0.500)	(0.107)	(0.477)	(0.074)

Secondary Education	0.398	-0.137	0.331	-0.060
	(0.490)	(0.108)	(0.471)	(0.073)
Religion				
Muslim	0.396	0.051	0.771	-0.200***
	(0.490)	(0.090)	(0.421)	(0.062)
Hindu	0.604	-0.147*	0.209	0.078
	(0.490)	(0.081)	(0.407)	(0.061)
Household Size	5.104	-0.485	4.642	-0.395*
	(1.724)	(0.349)	(1.632)	(0.237)
Own Land				
Less than 49 decimals or no land	0.831	0.209**	0.712	0.198***
	(0.375)	(0.090)	(0.453)	(0.069)
50-98 decimals	0.117	-0.066	0.166	-0.071
	(0.322)	(0.074)	(0.372)	(0.058)
Cultivated Land				
Less than 49 decimals	0.654	0.125	0.506	0.073
	(0.476)	(0.105)	(0.501)	(0.074)
50-98 decimals	0.188	0.072	0.306	-0.041
	(0.391)	(0.093)	(0.461)	(0.070)
Agriculture/farming	0.497	-0.048	0.442	-0.016
	(0.501)	(0.108)	(0.497)	(0.072)
Day labor	0.180	0.061	0.261	-0.040
	(0.384)	(0.058)	(0.440)	(0.070)
Dwelling Characteristics				
Individual house (Structure)	0.739	-0.695	0.971	-0.098
	(0.440)	(0.079)	(0.169)	(0.040)
Earth or Sand (Floor)	0.930	0.062	0.939	-0.381
	(0.256)	(0.049)	(0.240)	(0.037)
Electricity (Lighting)	0.734	0.008	0.397	0.017
	(0.443)	(0.079)	(0.490)	(0.075)
Firewood (Cooking fuel)	0.977	-0.092	0.311	0.335***
	(0.151)	(0.070)	(0.463)	(0.071)
Obs.	384	803	441	879

Notes: Column (1) and Column (3) report control group means and standard deviation of covariates. Column (2) and Column (4) report the estimates obtained with the ordinary least squares (OLS) regression of each variables on treatment dummy (1 for the treatment group; 0 otherwise) with village-level fixed effects. Robust standard errors are in parenthesis. * denotes significance at 10 percent, ** at 5 percent, and *** at 1 percent level.

Table 6 compares outcomes of interest including households' monthly expenditure and farm livelihoods of livestock, vegetable, and fisheries between the treatment and control group households by districts. Specifically, we use expenditure as a proxy for income for two reasons – expenditures are considered to reflect household's permanent income more closely, as well as expenditure data are generally more reliable and stable than income data (Ahmed at al., 2013; Friedman, 1957). Therefore, we use the terms "expenditures" and "income" interchangeably in

this study. Additionally, farm livelihoods based on livestock, vegetable, and fisheries are core components of projects' agricultural training, and the difference in outcomes of service recipients to non-recipient farm households would reveal how extension projects have influenced on households' livelihood production and strategies.

Table 6: Descriptive Statistics for Outcomes of Interest

	Egiye Jai		Nijera Gori	
	Treatment	Control	Treatment	Control
	(1)	(2)	(3)	(4)
Monthly Expenditure [a]	8,295.673	9,095.031	6,299.658	5,693.878
	(3,930.919)	(6,607.961)	(2,959.648)	(2,407.221)
Livestock				
Own Cows	0.418	0.374	0.776	0.714
	(0.494)	(0.485)	(0.417)	(0.423)
Own Goats	0.088	0.050	0.634	0.494
	(0.284)	(0.218)	(0.482)	(0.501)
Number of Livestock	1.155	0.747	3.779	2.739
	(1.694)	(1.166)	(2.923)	(2.396)
Own Poultry	0.845	0.708	0.877	0.902
	(0.362)	(0.455)	(0.329)	(0.297)
Number of Poultry	10.136	5.703	8.936	5.893
	(12.610)	(7.202)	(8.753)	(6.025)
Vegetable				
Plant a Vegetable Garden	0.926	0.563	0.961	0.711
	(0.262)	(0.497)	(0.194)	(0.454)
Types of Vegetables	5.988	2.617	4.916	2.596
	(3.182)	(2.609)	(2.657)	(2.517)
Own Aquaculture	0.370	0.497	0.386	0.256
	(0.483)	(0.501)	(0.487)	(0.437)
Obs.	419	384	438	441

Notes: Standard deviations are in parenthesis. a is expressed in Bangladesh Taka.

The results show that Egiye Jai project villages relatively had more households with poultry and vegetable gardens, but had fewer households with aquaculture production than those in the control villages. Also, on average, the project villages had a greater number of poultry and types of vegetables. We also observed that the treatment villages in the Nijera Gori project tended to have more households with goats, a vegetable garden, and aquaculture production. Similarly, the project villages had a greater number of poultry and types of vegetables than those in the control villages. Further, on average, households in the Egiye Jai project had lower monthly expenditures, but Nijera Gori project households had higher expenditures than those in the control villages.

Overall, we observed that the project villages had more households with small or no land holdings, and had more households engaged in livestock rearing and vegetable production. One can expect the differential project impact on household's farm livelihood production and

strategies based on the level of land holdings, but more than three-fourths of the sampled households in our data had small plots totaling less than 49 decimals in size which reduce detection of statistical differences in outcome variables for larger landholding households.

Results

The logit and probit model estimates of the treatment propensity are presented in Table 7. Both regression models report a pseudo R^2 value of 0.21 for the Egiye Jai, and about 0.37 for the Nijera Gori project. Several variables are statistically significantly associated with treatment status. Particularly the husband's education level, cultivated landholding, the household's labor activities, and some dwelling characteristics are significant predictors to determining the treatment sites across districts. Additionally, own landholding and religion are statistically associated with the treatment status in the Nijera Gori project.

Table 7: Logit and Probit Estimates of the Propensity for Treatment Status

	Egiye Jai[a]		Nijera Gori	
	Logit	Probit	Logit	Probit
	(1)	(2)	(3)	(4)
Husband Age	0.060***	0.036***	-0.008	-0.005
	(0.015)	(0.009)	(0.016)	(0.010)
Wife Age	-0.019	-0.010	0.011	0.007
	(0.018)	(0.011)	(0.019)	(0.012)
Husband Education				
Primary Education	0.401	0.231	-1.190***	-0.696***
	(0.374)	(0.226)	(0.453)	(0.257)
Secondary Education	0.683*	0.400*	-1.084**	-0.629**
	(0.353)	(0.213)	(0.448)	(0.253)
Wife Education				
Primary Education	-0.005	0.011	-0.352	-0.178
	(0.489)	(0.293)	(0.548)	(0.326)
Secondary Education	0.740	0.468*	-0.511	-0.276
	(0.462)	(0.277)	(0.531)	(0.313)
Religion				
Muslim	0.187	0.112	-1.739***	-1.080***
	(0.171)	(0.103)	(0.423)	(0.252)
Hindu	–	–	-0.941**	-0.602**
	(–)	(–)	(0.439)	(0.262)
Household Size	-0.037	-0.019	0.025	0.015
	(0.050)	(0.030)	(0.052)	(0.031)
Own Land				
Less than 49 decimals or no land	-0.444	-0.241	-1.130***	-0.686***
	(0.400)	(0.234)	(0.308)	(0.182)
50-98 decimals	-0.197	-0.090	-0.908***	-0.553**
	(0.429)	(0.254)	(0.345)	(0.204)
Cultivated Land				
Less than 49 decimals	0.278**	0.152	0.808**	0.483**
	(0.287)	(0.170)	(0.313)	(0.185)

50-98 decimals	0.657 (0.304)**	0.387 (0.182)**	0.489 (0.300)	0.292 (0.177)
Agriculture/farming	-0.467 (0.187)**	-0.272 (0.112)**	1.298 (0.214)***	0.772 (0.126)***
Day labor	0.786 (0.223)***	0.475 (0.133)***	0.736 (0.248)**	0.435 (0.148)***
Dwelling Characteristics				
Individual house (Structure)	-1.118 (0.170)***	-0.672 (0.101)***	-1.200 (0.365)***	-0.683 (0.210)***
Earth or Sand (Floor)	1.517 (0.505)***	0.894 (0.287)***	0.370 (0.308)	0.210 (0.183)
Electricity (Lighting)	-0.008 (0.189)	-0.009 (0.113)	0.217 (0.167)	0.136 (0.099)
Firewood (Cooking fuel)	-1.001 (0.412)**	-0.612 (0.241)**	1.558 (0.170)***	0.936 (0.100)***
Constant	-2.493 (0.920)***	-1.509 (0.541)***	2.141 (0.905)**	1.258 (0.531)**
Summary statistics				
Pseudo R^2	0.208	0.207	0.365	0.365
Model chi-square	230.09***	229.23***	445.23***	444.35***
Log likelihood ratio	-467.972	-439.092	-386.655	-387.099
Obs.	803	803	879	879

Notes: Robust standard errors are in parenthesis. a: we only include Muslim variable in region category since Muslim and Hindu variables explain more than 96% of variation in the group. * denotes significance at 10 percent, ** at 5 percent, and *** at 1 percent level.

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Notes: Robust standard errors are in parenthesis. a: we only include Muslim variable in region category since Muslim and Hindu variables explain more than 96% of variation in the group. * denotes significance at 10 percent, ** at 5 percent, and *** at 1 percent level.

Table 8 reports some test-statistics to compare the level of bias before and after propensity score matching. The standardized mean difference for overall control covariates used in the propensity score (around 21% for the Egiye Jai project and 37% for the Nijera Gori project) is reduced to

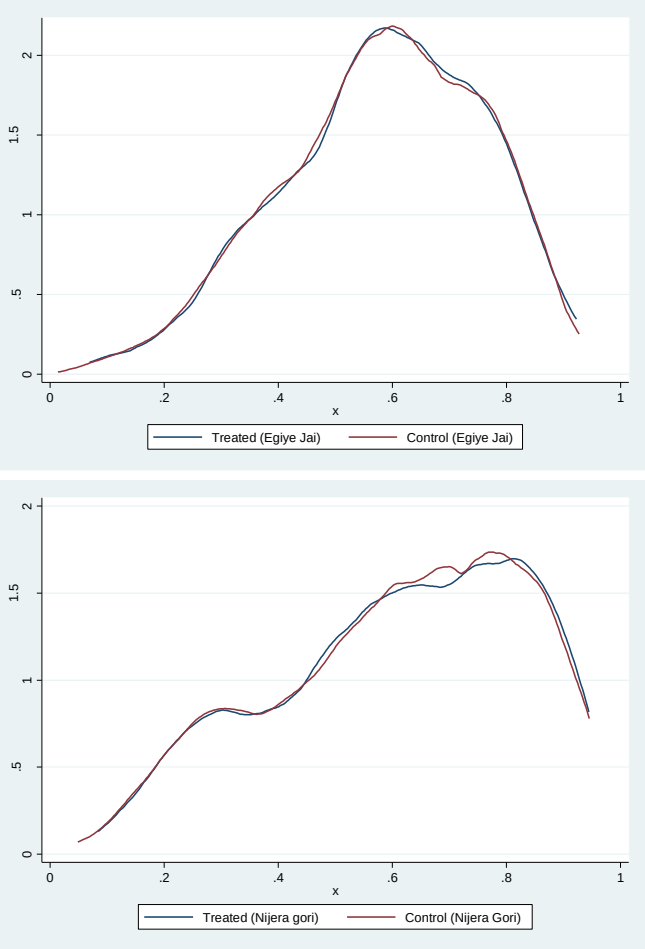
0.5%-1.0% and 1.2%-1.5%, respectively, based on different PSM specifications after matching [6]. This substantially reduces total bias, in the range of 73.8%-81.4% for the Egiye Jai, and 88.1%-92.1% for the Nijera Gori project through matching. Also, the LR test results, after propensity score matching, lead us to accept the hypothesis of joint significance of matching covariates. Moreover, the mean and median values of the standardized bias decrease significantly after matching. All these test results suggest that the proposed specification of the propensity score is fairly successful in balancing the distribution of matching covariates between the two groups. Also, Figure 1 shows the density distribution of the calculated propensity scores for the treatment and control groups after matching. We depict the propensity distribution using the KM (probit) with a bandwidth of 0.06 since it produces the lowest pseudo R^2 and mean standardized bias after matching in both districts. The more the two distributions are similar (overlapped), the larger common supports are, ensuring that the treatment observations have comparison observations nearby in the propensity score distribution (Heckman, LaLonde, & Smith, 1999).

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

Matching algorithm	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	Total % |*bias*| reduction
Egiye Jai								
NNM	Logit	0.208	0.008	170.91***	9.50	18.9	5.0	76.1
	Probit	0.208	0.010	170.91***	11.68	18.9	5.5	73.8
KM	Logit	0.208	0.005	170.91***	5.97	18.9	3.7	80.6
	Probit	0.208	0.005	170.91***	5.44	18.9	3.7	81.4
Nijera Gori								
NNM	Logit	0.365	0.015	256.76***	18.00	26.3	4.9	88.1
	Probit	0.365	0.014	256.76***	16.07	26.3	4.2	89.7
KM	Logit	0.365	0.013	256.76***	14.57	26.3	3.9	91.1
	Probit	0.365	0.012	256.76***	13.53	26.3	3.9	92.1

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

Figure 1: Density Distribution of Propensity Score after Matching:
Kernel-Based Matching (Probit) with a Bandwidth of 0.06 and Common Support



Based on propensity score matching estimation, we calculate the average treatment effect estimates for the Egiye Jai and Nijera Gori projects reported in Table 9 and 10, respectively. As a sensitivity analysis, we compute the estimates based on four different PSM specifications discussed in the previous section. All the analyses were based on the implementation of common support so that the distributions of treatment and control group households were located in the same domain [7]. Table 9 shows that the Egiye Jai project, depending on the specific matching algorithm used, increased the likelihood of having poultry by 25-30 percentage points; and enhanced the likelihood of planting a vegetable garden by 37-45 percentage points. Also, Egiye Jai increased the average monthly income (expenditures) by 2,710-3,418 taka (or 35-44 dollars). Similarly, in Table 10, the Nijera Gori project enhanced the likelihood of planting a vegetable garden by 20-21 percentage points; increased about two types of vegetables in the garden; and increased poultry by three. Moreover, Nijera Gori increased the average monthly income (expenditure) by 1,772–1,952 taka (or 23-25 dollars). However, we cannot find a statistically significant impact on the possession and quantity of larger animals and fisheries within the household, with both activities often considered to be men's responsibility, across different propensity score matching and specifications.

Table 9: Summary of Impact of the Egiye Jai Project on Households' Expenditure, and Livelihood of Livestock, Vegetable, and Fisheries

	NNM		KM	
	Logit	Probit	Logit	Probit
Monthly Expenditure	2,844.649***	3,417.650**	2,739.335**	2,709.883**
	(1,248.978)	(1,317.513)	(1,271.292)	(1,250.610)
Livestock				
Own Cows	-0.130	-0.115	-0.086	-0.092
	(0.138)	(0.135)	(0.133)	(0.135)
Own Goats	0.042	0.021	0.019	0.017
	(0.050)	(0.057)	(0.051)	(0.051)
Number of Livestock	-0.419	-0.368	-0.377	-0.384
	(0.439)	(0.398)	(0.385)	(0.383)
Own Poultry	0.251**	0.285**	0.302***	0.294***
	(0.111)	(0.126)	(0.109)	(0.110)
Number of Poultry	-1.154	-0.474	0.417	0.309
	(2.422)	(2.325)	(2.173)	(2.195)
Vegetable				
Plant a Vegetable Garden	0.373***	0.451***	0.442***	0.437***
	(0.126)	(0.128)	(0.120)	(0.122)
Types of Vegetables	4.029***	4.306***	4.093***	4.101***
	(0.647)	(0.620)	(0.645)	(0.645)
Own Aquaculture	0.119	0.160	0.158	0.144
	(0.155)	(0.150)	(0.144)	(0.145)
Obs.	724	731	794	793

Notes: Control variables listed in Table 4 and village-level fixed effects are included in the estimation. Robust standard errors are reported in parentheses. * 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 10: Summary of Impact of the Nijera Gori Project on Households' Expenditure, and Livelihood of Livestock, Vegetable, and Fisheries

	NNM		KM	
	Logit	Probit	Logit	Probit
Monthly Expenditure	1,771.550***	1,821.234***	1,951.949***	1,918.426***
	(370.857)	(366.682)	(347.240)	(347.515)
Livestock				
Own Cows	-0.029	-0.021	-0.055	-0.045
	(0.076)	(0.081)	(0.073)	(0.075)
Own Goats	-0.139	-0.176	-0.149	-0.143
	(0.102)	(0.102)	(0.095)	(0.095)

Number of Livestock	0.083	0.097	0.024	0.044
	(0.566)	(0.557)	(0.562)	(0.566)
Own Poultry	0.024	0.015	0.036	0.033
	(0.060)	(0.057)	(0.067)	(0.065)
Number of Poultry	2.780	3.019*	3.174*	3.216*
	(1.726)	(1.656)	(1.690)	(1.667)
Vegetable				
Plant a Vegetable Garden	0.207***	0.209***	0.200***	0.201***
	(0.061)	(0.059)	(0.050)	(0.050)
Types of Vegetables	2.090***	2.176***	2.036***	2.045***
	(0.465)	(0.455)	(0.446)	(0.443)
Own Aquaculture	-0.132	-0.161*	-0.135	-0.143
	(0.091)	(0.090)	(0.089)	(0.087)
Obs.	777	779	860	860

Notes: Control variables listed in Table 4 and village-level fixed effects are included in the estimation. Robust standard errors are reported in parentheses. * 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

The objectives of both projects can partly explain these results about larger animals and aquaculture, as extension projects placed more emphasis on maintaining good livestock health, for example, advising regular vaccination and animal shelter cleaning and maintenance and placing a water pot close to animal feed; however, these practices did not necessarily increase the quantity of livestock, particularly for animals with long gestation periods. Also, to cultivate fish, farmers needed a nearby pond and facilities which might increase financial and labor burdens, making the option less attractive compared to the other agricultural practices that had lower levels of fixed costs. Similarly, cows and goats tended to incur higher investments compared to small poultry or vegetable cultivation so that the initial investment costs might be a barrier [8]. Additionally, both activities are often considered to be the man's responsibility, but since the majority of project participants were women, the possibility that the wives deliver incomplete information of farm technologies for larger animals and fisheries to their husbands is higher. Further, husbands might not actively participate in the practices because they were not directly targeted. We find that the agricultural extension projects increased participants' monthly income (expenditure) and the likelihood of having poultry and planting a vegetable garden and varieties involved in the projects. Moreover, women may selectively choose training sessions concerning topics in which they are more directly involved. Indeed, the CRS's interim evaluation report (2015) shows that women's training participation was overwhelmingly higher when the topics were related to vegetable and poultry production (Table 1).

Conclusion

This study evaluates the impact of the Egiye Jai and Nijera Gori projects. These agricultural extension projects provided a strong basis for sustainable and quality homestead food production as well as aimed to increase women farmers' access to improved agricultural training in two

vulnerable districts of Bangladesh. We find that the Egiye Jai and Nijera Gori projects increased beneficiaries' monthly income and the likelihood of having poultry and planting a vegetable garden and varieties; however, we cannot find a consistent statistical evidence on the possession and quantity of larger animals and fisheries.

The projects contributed to building major pathways to strengthen household food security and nutrition status. Specifically, we employ UNICEF's nutrition framework, a widely accepted conceptual framework for the analysis of malnutrition over the past two decades, which consists of three level of determinants ("immediate," "underlying," and "basic" causes). Within the "underlying" causes, increasing food production and income can improve food security and nutrition through increasing food for a household's own consumption and purchasing more nutrient-rich foods and services or products that support nutrition. However, more recent studies have recognized nutrition as a broader concept, for example, "adequate nutritional status in terms of protein, energy, vitamins, and minerals for all household members at all time" (Quisumbing et al., 1995); and "physical, economic and social access to a balanced diet, safe drinking water, environmental hygiene, primary health care and primary education" (Swaminthan, 2008).

Our findings suggest that having poultry and vegetable gardens and varieties could promote project beneficiaries' dietary diversification through the consumption of protein (poultry meat and eggs) and a better intake of micronutrients (i.e., Vitamin A) from home vegetable gardens (Bushamuka et al., 2005; Faber et al., 2002; Gibson & Hotz, 2001). Additionally, extension services seeking to increase women farmers' access to improved technologies and advisory services may work as a channel to improve household's nutrition outcomes through an increase of women's empowerment in agriculture (Smith et al., 2003; Sraboni et al., 2014). However, field experiments may be necessary to understand gender-specific farm livelihoods, food security, and the role of agricultural extension in Bangladesh context (Doss, 2001; Kassie, Ndiritu, & Stage, 2013; Quisumbing, 2003).

Limitations

This study has two limitations. First, our findings may be limited to villages that share similar demographics and agricultural characteristics with the project villages. Since the impact of agricultural extension can differ by the types of technologies and delivery mechanisms, cultural and social factors, and environments, it is difficult to establish external validity of the findings. Second, due to the volunteer nature of participation, our project impact estimates may provide an upper limit in a case where unobservables increasing project participation are correlated with a successful adoption and utilization of improved agricultural technologies.

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This research was supported by the USAID-funded Integrating Gender and Nutrition within Agricultural Extension Services (INGENAES) projects, as well as by internal funds from Catholic Relief Services (CRS), Caritas Bangladesh (CB), and the University of Illinois. These sources of support are gratefully acknowledged. We also deeply appreciate the on the ground assistance of Caritas field staff and private enumerators who assisted with collecting field data. Furthermore, we acknowledge the contribution of CRS monitoring and evaluation staff and other in CRS who contributed to this research. Lastly, we would like to acknowledge the many grassroots farmers who provided survey responses to this study. Hopefully, our research will

illuminate policies that have a positive impact on understanding by development practitioners and funders concerning the usefulness of livelihood projects on their target population of small holder farmers.

Notes

1. Homestead food production indicates cultivating home gardens and raising small poultry, livestock, and fish to provide a rich source of vital nutrients for households.
2. Caritas Bangladesh is a national non-profit, non-governmental organization that aims to enhance human welfare and contribute to the national development operating in over 200 Upazilas in Bangladesh (http://caritasbd.org/). CRS is the official international humanitarian agency of the US Catholic community, which provides humanitarian relief and development assistance in over 90 countries on five continents (https://www.crs.org/). INGENAES is an extension strengthening project funded by USAID which works to improve gender and nutrition integration within agricultural extension services through training programs, organizational assessments, action-oriented research and the generation of evidence on what works for gender and nutrition integration (https://agreach.illinois.edu/).
3. 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.
4. IV methods are extensively discussed in Angrist, Imbense, and Rubin (1996) and Angrist and Pischke (2009).
5. The majority of the sampled households (94% or higher) had their own lands in both districts, but the project site respondents tended to have less land holdings compared to control villages.
6. Rosenbaum and Rubin (1985) suggest that a standardized difference of greater than 20% should be considered too large and an indicator that the matching process has failed.
7. Sample size differs because we exclude observations that propensity score is higher than the maximum or less the minimum of the control group (common support) depending on different PSM specifications. Ravallion (2007) asserts that a nonrandom subset of the treatment sample may need to be dropped if similar comparison units do not exist.
8. These reasons are supported by some qualitative results reported in CRS's interim evaluation report (CRS, 2015). For example, the key informant interviewees mentioned that they experienced an increase of poultry and vegetable production, and less incidence of livestock disease compared to before improved practices. Similarly, they stated that fishes were bigger and grew quickly; however, this fact may be applied to farm households that already have facilities for aquaculture production and harvest, but not necessarily increase the likelihood of non-fishing farmers to have aquaculture.

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