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PRACTICE CHANGE IN DRY SEASON CROPPING OF NON-SALINE AREAS IN SOUTHERN BANGLADESH: PERSPECTIVE ON PROJECT INTERVENTION

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ABSTRACT

Australian Centre for International Agricultural Research (ACIAR) seeks to introduce pulse production as alternative of rice cropping and thus improve the socioeconomic status of the farm households in Southern Bangladesh. This study was carried out to assess the changes on agronomic practices, crop diversification and profitability, women empowerment, and food security and livelihood of non-saline areas' farmers after the ACIAR project intervention (both cash and kind) at the end-line period. A total of 240 farmers (i.e., 120 focal and 120 control) was investigated during 2020-2021 following stratified random sampling technique from Patuakhali, Barisal, Jhalokathi, and Barguna districts. The collected data were analyzed using a combination of descriptive statistics (sum, averages and percentages) and mathematical analyses (Simpson's index of cropping diversity, partial budget analysis, women's empowerment index, food group consumption frequency score and German correlation sensitive poverty index). The majority of the farmers were found to follow the cropping patterns of Fallow – *Aman* rice – Pulses, *Boro* rice – *Aman* rice – Fallow and *Aus* rice – *Aman* rice – Pulses. Pulses covered around 37.0 and 33.0 percent of the total cropped area of focal and control farmers, respectively. The average cropping diversity was at medium level for both categories of farmers. The revenue from pulses production was found much higher than rice farming for both focal and control farmers. The extent of women empowerment was increasedat the end-line period by 2.8 and 0.8 percent for focal and control farmers, respectively after adopting the project intervention. The study found focal farm households more food secure compared to control farm households at the end-line period. As a response to the project support, the livelihood of focal farm households improved more than control farm households at the end-line period based on poverty dimensions (71.0 and 65.2 percent, respectively). The study concludes that the project intervention resulted in enhanced crop diversification and farm enterprise profitability, women empowerment, and food security, and livelihood improvement through poverty reduction in the non-saline areas of Southern Bangladesh. The study recommends direct input provision by the government to motivate the farmers continuing pulse production over rice monocropping, and time-to-time monitoring for bringing efficiency in cropping system.

Keywords: Non-saline agriculture; project intervention; practice change; food security; livelihood; Bangladesh.

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I. INTRODUCTION

Agriculture is the mainstay of the economy of Bangladesh. The economic development is inextricably linked with the performance of this sector (Uddin and Nasrin, 2013). The coastal zone of Bangladesh has a significant place in the country's economy (Ahsan, 2013). About 40 million people in the coastal areas of Bangladesh depend on agriculture (BBS, 2020) which is the most important livelihood option for the coastal people of Bangladesh (GoB and UNDP, 2009). The Government of Bangladesh has prioritized the coastal zone as the zone of most in need of development (MoWR, 2005). Within Australia's Sustainable Development Investment Portfolio (SDIP) coordinated by the Department of Foreign Affairs and Trade (DFAT), Australian Centre for International Agricultural Research (ACIAR) seeks to improve the livelihoods and resilience of smallholder farmers to climate variability by facilitating the adoption of more productive, profitable and lower-risk farming systems in the Eastern Gangetic Plains. Specifically, in Bangladesh, ACIAR has shared priorities to improve food security and poverty in light of its high vulnerability to the impacts of climate variability. The project aims contributing to the performance framework of the DFAT by promoting prosperity and poverty reduction through increased farm household incomes in the project region. Additionally, it anticipates additional benefits to rural women flowing from the increased pulse production through increased household dietary diversity, more employment opportunities and reduced state of poverty.

In Southern Bangladesh, agricultural activity centres around the annual cropping of monsoonal rice. Harvest of traditional long-duration rice extends from December to February where soils remain wet. Cropping in the dry *Rabi* season is economic (ACIAR, 2011) but it is conditioned by land topography, drainage, soil salinity and irrigation availability. As a result, households' income becomes lower which falls under the poverty line. In the rain-fed lands, dry-season cultivation is limited by the profitability of traditional cultivation of pulses (Uddin *et al.*, 2019). Around one third of the farmers in the coastal areas are now cultivating only one crop in a calendar year, i.e., *Aman* rice during monsoon while most of the cultivable lands remain almost barren in dry season (Hossain, 2016). Thus, the cropping intensity in the coastal area is only around 133 compared to the national average around 200 (UNB, 2017). Many people in Southern Bangladesh do not have a balanced diet, remain undernourished and become easily susceptible to diseases (Müller and Krawinkel, 2002). For socioeconomic constraints, the majority of the region can't afford animal protein and as such, have to depend on plant protein, bulk of which comes from pulses. The excellent nutrition value of pulses is highly complementary to a cereal-based diet in developing countries (UNB, 2017). Pulses are affordable source of protein, minerals and energy in a human diet for the largest population in Bangladesh while it contains about 23.7% protein as against 7.5% of rice and at the same time it

also contains amino acid lysine which is in short supply in food grains (Coles *et al.*, 2016; Rebello *et al.*, 2014).

The target of the project is that smallholder livelihoods in Southern Bangladesh are improved through increased dry-season cropping productivity and profitability through the replacement of rice fallows with pulses. The farm households would also have a higher disposable income as a consequence of adopting new profitable cropping practices in pulses and expanding their cropped areas of pulses. Such measures can provide a steppingstone out of poverty by generating a small capital surplus that can be used to send children to school and/or allowing access to better health care. In the dry season when seasonal male out-migration is most pronounced in the coastal districts of Bangladesh, farm activities are commonly managed and led by women. Hence, it is plausible that the gain from higher productivity and increased farm income will mostly be realized by women farmers by enhancing women's empowerment through greater access to income and thus higher decision-making power. Further, the availability of an additional crop will enhance nutritional security by increasing access to a high protein diet and greater dietary diversity especially of women and children who commonly suffer from malnutrition (Pandey *et al.*, 2016; Sibhatu *et al.*, 2015).

The importance of this modality has been portrayed in a good number of literatures. A modest effort has been made here to appraise the previous research studies which are as follows: Uddin *et al.* (2019) examined the livelihood status of farm households in Southern Bangladesh and revealed that the farm households in saline areas were more prone to poverty than the farm households in non-saline areas; Hasan *et al.* (2018) investigated the impact of Climate-Smart Agriculture (CSA) adoption on the food security of coastal farmers in Southern Bangladesh and found that adoption of CSA practices was positively associated with households' food security in terms of per capita annual food expenditure; Hossain and Majumder (2018) constructed a review on impact of climate change on agricultural production and food security in coastal regions of Bangladesh and found that existing gender-poverty nexus along with socioeconomic and political aspects made women more endangered to climate vulnerability and food security; Nahar and Hamid (2016) made an attempt to examine the impact of soil salinisation on paddy production in Khulna and Bagerhat districts of Bangladesh and concluded that salinity had an adverse impact on paddy production that reduced paddy yield as well as profit margin of the paddy farmers; Ahmed and Haider (2014) quantified the impact of salinity on rice production in the South-West region of Bangladesh and found that *kharif* was the dominant crop season in that region; and Shoaib (2013) conducted a study of major cropping patterns and crops in saline areas of Bangladesh and found that land type, soil texture, soil and water salinity, and water recession regulated the cropping intensity in the coastal zone of Bangladesh.

It is evident that most of the studies dealt with the impact of climate change on either farmers' cropping system or their livelihood, especially food security status and the severity of salinity in the Southern areas of Bangladesh. But there is a lack of study that assessed the farming practices and profitability of farm enterprises, employment opportunities, food security issue and overall poverty situation of farmers particularly in the non-saline Southern areas of Bangladesh. In light of this research gap, the objectives of this end-line study were to assess the practice changes (i.e., before-after situation) on the following issues after the ACIAR project intervention adopted by the farmers: i) agronomic practice changes; ii) crop diversification and profitability; iii) women empowerment; and iv) food security and livelihood of non-saline areas' farmers.

II. MATERIALS AND METHODS

Study areas, sample selection and data collection

The end-line study was conducted at four upazilas under four districts of non-saline areas in Southern Bangladesh which were: Patuakhali, Barisal, Jhalokathi, and Barguna. Two categories of farmers were targeted for investigation which were: focal farmers (farmers receiving technical and logistic support from the project and having regular contact with project staff) and control farmers (farmers receiving no training and technical support from the project). A total of 240 farmers (i.e., 120 focal and 120 control) was surveyed during the period of 2020-21 with the help of personnel from Bangladesh Agricultural Research Institute (BARI) and Department of Agriculture Extension, Bangladesh (DAE) for primary data collection using a structured questionnaire following the stratified random sampling technique. Different books, publications, published and unpublished documents of the Government of Bangladesh (GoB), etc. were also considered as the sources of secondary data and information to accomplish the study.

Intervention under the project

To improve smallholder incomes in Southern Bangladesh through improved productivity and profitability of dry-season cropping of non-saline land, a limited amount of input support in the form of both cash and kind (i.e., seeds/planting materials, fertilizers, pesticides, care and management, field demonstrations, etc.) was provided to the selected focal farmers at free of cost. Necessary technical advices were provided by the research team and local extension agents; and the Principal Investigator, Co-investigator and Research Assistant monitored the implementation of practice change time to time in the farmers' fields.

Data analysis

For analyzing the end-line data, a combination of descriptive statistics (i.e., sum, averages and percentages), mathematical and statistical techniques were used to achieve the objectives.

Simpson's index of cropping diversity

To measure the change in diversification of crop production, Simpson's index of diversity was used as follows (Basavaraj *et al*., 2016):

$$SI_C = 1 - \sum \left(\frac{a_i}{A}\right)^2$$

Where, SI_C = Simpson's crop diversification index value; a_i = Area devoted to a particular crop in a given year; and A = total annual cultivated area (equal to the sum of all cropped areas in each season).

The value of SI_C ranged between 0 and 1, where, SI_C = 1 represented infinite diversity and SI_C = 0 represented no diversity.

Partial budget analysis

Partial budget analysis was used to compare the costs and benefits of the on-going farming practice situation and alternative crop production as a means of project intervention, rather than comparing the crop profitability of focal and control farmers. The following mathematical expression was used for partial budgeting of alternative crops (Tigner, 2006):

Debits:	Revenue forgone for not cultivating rice crops	=	Gross return from rice crop production after project intervention
	Additional cost for pulses production	=	Total cost of pulse production after project intervention
Credits:	Additional revenue for pulses production	=	Gross return from pulse production after project intervention
	Cost saved for not cultivating rice crops	=	Total cost of rice crop production after project intervention
Decision:	Credit > Debit = Increase in net return; Profit		
	Credit <Debit = Decrease in net return; Loss		

Women's empowerment index

The women's empowerment index (WEI) was used to measure development in the multi-dimensional aspects of women's empowerment (THP, 2014) by aggregating results across five key domains (i.e., agency, income, leadership, resources and time). WEI was composed of two parts: i) women's achievement ratio (WAR), and ii) gender parity ratio (GPR). The WEI was scored out of a total of 100 possible points with each domain counting for up to 20 points. THP (2014) had set a threshold score of 80 points as a mark of an adequate level of empowerment. The overall WEI was constructed by calculating the sum of 11 indicators' weighted WAR and GPR as follows:

$$WEI = \sum_{i=1}^{11} [(0.6 \times WAR + 0.4 \times GPR) \times Weight]$$

Where, WEI = Women's empowerment index; WAR = Women's achievement ratio; and GPR = Gender parity ratio.

Measurement of food security

To identify the impact of intervention on farm households' food security, households' dietary diversity and food group consumption frequency score (FGFS) was calculated. Households' dietary diversity was measured on the basis of the number of food groups consumed within the daily, weekly and monthly period of recall from the total of 17 food groups. FGFS for different food categories was calculated using the consumption frequency scores (Table 1) (adopted from Saaka and Osman, 2013). This composite index of dietary diversity takes into account food frequency and it varied from a minimum of 0 to a maximum of 34. The households were classified into two categories: food insecure (if FGFS < 17) and food secure (if FGFS ≥ 17). The cutoff of 17 was chosen because that was the mean FGFS in this study.

Table 1. Food consumption frequency scores

Food categories	Consumption frequency	Score
Highly consumed (rice/wheat, pulses, vegetables, leafy vegetables, tea/coffee)	Not consumed during a whole day	0
	Consumed once a day	1
	Consumed at least twice a day	2
Moderately consumed (fish, chicken meat, mutton/beef meat, eggs, milk, spicy fast food, confectionery fast food)	Not consumed during a week	0
	Consumed 1-3 times per week	1
	Consumed at least 4 times per week	2
Less consumed (fruits, sweets/curd, juice/ice cream/chocolate, cake/cookies, honey/butter)	Not consumed during a month	0
	Consumed 1-2 times per month	1
	Consumed at least 3 times per month	2

German correlation sensitive poverty index

The German correlation sensitive poverty index (GCSPI) is an index designed to measure the intensity of poverty as a mode of livelihood status (Rippin, 2016). It comprises six equally weighted poverty dimensions; health (weighted indicators: health condition and health impairments), education (weighted indicators: schooling and graduation), employment (weighted indicators: activity status, minimum wage and time poverty), housing (weighted indicators: housing condition, amenities and living space), mobility (weighted indicators: transport and crime) and income (weighted indicator: households' monthly income). The following formula was used to address the intensity of poverty of focal and control farm households:

$$\text{Intensity of poverty} = \Sigma d(w) \times 100$$

Where, d = Households deprived of the indicators; andw = Weighted score of the indicators.

III. RESULTS AND DISCUSSION

Major agronomic and cropping practices

The change in farmers' agronomic and cropping practices at the end-line period in the non-saline areas after adopting the project intervention is demonstrated in Table 2. It was found that the majority of the farmers followed the cropping patterns of Fallow – *Aman* rice – Pulses, *Aus* rice – *Aman* rice – Fallow and *Aus* rice – *Aman* rice – Pulses which remained same before and after the project intervention. Rather, the percentage of focal farmers cultivating pulse crops increased compared to control farmers after adopting the project intervention (particularly, mungbean in Patuakhali and Jhalokathi, grasspea in Barisal, and cowpea in Barguna). The farmers stated that the field remained wet even after the harvest of *Aman* rice, which hindered pulses and *Rabi* crop production. Shahidullah *et al.* (2006) stated that only a single cropping pattern of single Fallow – Fallow – T. *Aman* rice occupied 35% of total cropped area in the Southeast coastal region of Bangladesh.

After the project intervention available, all focal farmers were provided with appropriate knowledge through field demonstration on adopting improved crop varieties and seed density control, which helped them to increase their monetary income at the end-line period through enhanced crop productivity. This situation was similar to the discussion by Garbero *et al.* (2018) where the authors highlighted that adopting improved crop varieties could help increasing income by 35%, increasing expenditure by 14%and reducing poverty by 4% in rural areas globally. Nearly four-fifth of focal farmers also responded that their fertilizer and insecticide use was increased efficiency at the end-line period because of applying these energy inputs at the appropriate time. Nevertheless, Kumar *et al.* (2020) recommended to use nano-fertilizers (e.g., nano-nitrogen, nano-copper and nano-zinc) at the right time with the optimum application rate for increasing the yield of dry season crops as well as minimizing the nutrient footprint induced by the loss from the applied fertilizers during the food production process (Dhar *et al.*, 2021).

Analysis of crop diversification

Different types of crops were produced by the farmers in the study areas like rice crops (*Aus*, *Aman* and *Boro*), cash crops (jute, cotton, etc.), vegetables (potato, sweet potato, bean, tomato, cabbage, cauliflower, etc.), spices (onion, garlic, chili, etc.), pulses (mungbean, grasspea, cowpea, lentil, etc.) and other crops (wheat, maize, etc.). It is evident from Table 3 that cropping diversity, varied by a great extent from low to moderate based on the agronomic seasons, the reason of which was the amount of land used to grow different seasonal crops. Before adopting project intervention, the level of crop diversification was similar for both focal and control farmers (average SI_C = 0.4). Though the average cropping diversity of focal farmers was increased slightly after the project intervention, it was on medium level for both categories of farmers (with an average SI_C of 0.5 and 0.4 for focal and control farmers, respectively) at the end-line period. On an average, before adopting the project

intervention, 71.2 and 73.8 percent of total cropped area of focal and control farmers were found to be under pulses production.

Table 2. Major agronomic and cropping practices (% of farmers responded)

Study areas	Particulars		Focal farmers		Control farmers	
			Before	After	Before	After
Patuakhali	Major cropping patterns	*Fallow – Aman* rice – Mungbean	69.5	81.7	63.0	65.0
		Aus rice – *Aman* rice – Fallow	25.0	10.3	32.3	30.5
		Aus rice – *Aman* rice – Mungbean	5.5	8.0	4.7	4.5
	Cropping systems	Monocropping	100.0	92.3	100.0	100.0
		Mixed/Relay cropping	0.0	7.7	0.0	0.0
	Sowing methods	Broadcasting	100.0	66.5	100.0	100.0
		Line sowing	0.0	33.5	0.0	0.0
	Adoption of improved variety and seed density control		0.0	100.0	0.0	5.0
	Timely application of fertilizer and insecticide		10.0	80.0	9.0	12.0
Barisal	Major cropping patterns	*Aus* rice – *Aman* rice – Grasspea	34.5	48.5	49.0	52.2
		Fallow – *Aman* rice – *Boro* rice	30.3	21.0	38.4	40.2
		Fallow – *Aman* rice – Mungbean	35.2	30.5	12.6	7.6
	Cropping systems	Monocropping	72.3	22.5	83.6	75.0
		Relay cropping	28.7	77.5	16.4	25.0
	Sowing methods	Broadcasting	100.0	100.0	100.0	100.0
		Line sowing	0.0	0.0	0.0	0.0
	Adoption of improved variety and seed density control		0.0	100.0	0.0	5.0
	Timely application of fertilizer and insecticide		10.0	80.0	6.0	8.0
Jhalokathi	Major cropping patterns	Fallow – *Aman* rice – Mungbean	48.3	76.3	42.5	45.3
		Fallow – *Aman* rice – *Boro* rice	37.6	10.0	39.1	34.0
		Aus rice –*Aman* rice– Mungbean	14.1	13.7	18.4	20.7
	Cropping systems	Monocropping	100.0	96.0	100.0	100.0
		Mixed/Relay cropping	0.0	4.0	0.0	0.0
	Sowing methods	Broadcasting	100.0	76.4	100.0	100.0
		Line sowing	0.0	23.6	0.0	0.0
	Adoption of improved variety and seed density control		0.0	100.0	0.0	4.0
	Timely application of fertilizer and insecticide		10.0	80.0	4.0	6.0
Barguna	Major cropping patterns	Fallow – *Aman* rice – Cowpea	43.6	72.8	25.2	18.7
		Fallow – *Aman* rice – *Boro* rice	35.3	13.7	30.0	27.3
		Aus rice – *Aman* rice – Mungbean	21.1	13.5	44.8	54.0
	Cropping systems	Monocropping	100.0	98,0	100.0	100.0
		Mixed/Relay cropping	0.0	2.0	0.0	0.0
	Sowing methods	Broadcasting	100.0	100.0	100.0	100.0
		Line sowing	0.0	7.0	0.0	0.0
	Adoption of improved variety and seed density control		0.0	100.0	0.0	0.0
	Timely application of fertilizer and insecticide		10.0	80.0	0.0	5.0

Source: Field Survey, 2020-21.

After adopting the project intervention, the cropped area covered by pulses production for focal farmers was increased to 80.9% but it remained almost unchanged for control farmers. By analyzing division wise crop diversification in

Bangladesh, Islam and Hossain (n.d.) found the highest magnitude of crop diversification (0.5) in Rajshahi division and the lowest magnitude of crop diversification (0.2) in Sylhet division.

Table 3. Simpson's crop diversification index

Farmers' categories	Agronomic seasons	Area under crop production (ha)							SI_C	Average SI_C
		Rice crops	Cash crops	Vegetables	Spices	Pulse crops	Other crops	Total cropped area		
Before adopting project intervention										
Focal farmers	*Kharif-I*	0.20	0.35	0.06	0.03	-	0.02	0.66	0.6	0.4
	Kharif-II	0.58	0.02	0.03	0.01	-	0.02	0.66	0.2	
	Rabi	0.09	0.02	0.03	0.02	0.47	0.03	0.66	0.5	
Control farmers	*Kharif-I*	0.17	0.33	0.05	0.04	-	0.02	0.61	0.6	0.4
	Kharif-II	0.51	0.02	0.03	0.03	-	0.02	0.61	0.3	
	Rabi	0.05	0.01	0.04	0.02	0.45	0.04	0.61	0.4	
After adopting project intervention										
Focal farmers	*Kharif-I*	0.15	0.40	0.06	0.04	-	0.03	0.68	0.6	0.5
	Kharif-II	0.49	0.05	0.09	0.02	-	0.03	0.68	0.5	
	Rabi	0.06	0.01	0.02	0.01	0.55	0.03	0.68	0.3	
Control farmers	*Kharif-I*	0.17	0.33	0.05	0.04	-	0.02	0.61	0.6	0.4
	Kharif-II	0.51	0.02	0.03	0.03	-	0.02	0.61	0.3	
	Rabi	0.05	0.01	0.04	0.02	0.45	0.04	0.61	0.4	

Source: Authors' Estimation, 2020-21.

Comparative profitability of rice crops and pulses

To assess the comparative profitability of producing rice crops and pulses for both focal and control farmers, partial budget analysis was used which is portrayed in Table 4. Based on the profitability analysis which affirmed focal farmers to be more profitable than control farmers in crop production after receiving the project intervention (Table A1), it was found that on an average, change in net return was Tk. 897 and Tk. 2458 per hectare for rice crops with pulses for focal and control farmers, respectively at the end-line period. Revenue from pulses production was much higher than rice farming for both focal and control farmers. If the focal and control farmers would replace rice crops production with pulses cultivation, they could obtain additional Tk. 897 and Tk. 2458, respectively from the same one hectare of land. So, it is evident from the partial budget analysis that farmers who produced pulses were more profit earners than those who cultivated rice crops. Kumar and Bourai (2012) found the similar result where the authors stated that pulse production was 13.0% more profitable than rice cultivation in Uttarakhand, India.

Table 4. Partial budgeting of rice crops with pulses (Tk./ha)

Farmers' categories	Debit		Credit		Change in net return
	Particulars	Rice crop with pulses	Particulars	Rice crop with pulses	
Focal farmers	Additional cost for pulses production/Total cost of pulse production after project intervention	20019	Additional revenue for pulses production/Gross return from pulse production after project intervention	39243	897
	Revenue forgone for not cultivating rice crops/Gross return from rice crop production after project intervention	88816	Cost saved for not cultivating rice crops/Total cost of rice crop production after project intervention	70489	
	Total	108835	Total	109732	
	Decision		Increase in net return; Profit		
	Particulars	Rice crop with pulses	Particulars	Rice crop with pulses	
Control farmers	Additional cost for pulses production/Total cost of pulse production after project intervention	22250	Additional revenue for pulses production/Gross return from pulse production after project intervention	40718	2458
	Revenue forgone for not cultivating rice crops/Gross return from rice crop production after project intervention	88783	Cost saved for not cultivating rice crops/Total cost of rice crop production after project intervention	72773	
	Total	111033	Total	113491	
	Decision		Increase in net return; Profit		

Source: Authors' Estimation, 2021.

Evaluation of women empowerment status

It is evident from Table 5 that the WEI score for focal and control farmers before the project intervention was 79.6 and 79.2, indicating low women empowerment for both categories of the farmers. But after the project intervention, the WEI score was estimated at 85.9 and 79.8, which confirmed that to some extent, women empowerment was increased at the end-line period by 7.9% and 0.8% for focal and control farmers, respectively. The empowered women were able to make decisions and exercise control over resources and were free to exercise the decisions without fear of repercussion. Moreover, they had the ability to benefit from economic activities, and enhanced access to markets and financial resources. In addition, they had the ability to participate in community activities, and were encouraged to speak in and for their communities. Furthermore, women and girls had access to the

resources and skills they needed to become equal participants in the society. Also, they were reducing domestic drudgery (i.e., time spent on hard, menial or dull work) freeing up time to pursue productive endeavours, education, childcare and leisure activities. The findings were supported by UNB (2018) where the study reported that Bangladesh hold the 47th position among 144 countries in term of securing women empowerment based on the gender gap index (GGI) whereas India, Sri Lanka, Nepal, Bhutan and Pakistan remained at 108th, 109th, 111th, 124th and 143rd positions, respectively.

Table 5. Women's empowerment index

Domains	Indicators	Weight	Focal farmers			Control farmers		
			WAR	GPR	Indicator score	WAR	GPR	Indicator score
Agency	Men and women jointly share responsibility for making community decisions	7	0.8 (0.9)	0.8 (0.9)	5.6 (6.3)	0.8 (0.8)	0.7 (0.8)	5.3 (5.6)
	Men and women jointly share responsibility for making household decisions	7	0.9 (0.9)	0.8 (0.8)	6.0 (6.0)	0.8 (0.9)	0.9 (0.9)	5.9 (6.3)
	Perceptions on violence against women	6	0.8 (0.9)	0.9 (0.9)	5.0 (5.4)	0.9 (0.9)	0.9 (0.7)	5.4 (4.9)
Income	Owning and operating business	10	0.9 (0.9)	0.8 (0.9)	8.6 (9.0)	0.8 (0.8)	0.8 (0.8)	8.0 (8.0)
	Access to financial services	10	0.8 (0.9)	0.8 (0.8)	8.0 (8.6)	0.9 (0.8)	0.7 (0.9)	8.2 (8.4)
Leadership	Membership in community organizations or groups	10	0.7 (0.8)	0.6 (0.8)	6.6 (8.0)	0.7 (0.9)	0.8 (0.8)	7.4 (8.6)
	Comfortable speaking in public	10	0.7 (0.9)	0.7 (0.9)	7.0 (9.0)	0.8 (0.8)	0.7 (0.9)	7.6 (8.4)
Resources	Literacy rate	10	0.8 (0.9)	0.8 (0.8)	8.0 (8.6)	0.9 (0.7)	0.8 (0.7)	8.6 (7.0)
	Minimum prenatal care visits	10	0.7 (0.8)	0.8 (0.8)	7.4 (8.0)	0.8 (0.8)	0.7 (0.7)	7.6 (7.6)
Time	Time spent gathering cooking fuel	10	0.8 (0.8)	0.9 (0.8)	8.4 (8.0)	0.7 (0.8)	0.9 (0.7)	7.8 (7.6)
	Household division of labour on domestic drudgery tasks	10	0.9 (0.9)	0.9 (0.9)	9.0 (9.0)	0.7 (0.7)	0.8 (0.8)	7.4 (7.4)
WEI score			79.6 (85.9)			79.2 (79.8)		
Increase in women's empowerment (%)			7.9			0.8		

Source: Authors' Estimation, 2021.

Note: Values for WAR, GPR, indicator score and WEI score without and in the parentheses indicate the context before and after adopting the project intervention, respectively.

Households' food security status

Food security was estimated from the viewpoint of three perspectives, such as, availability of safe and nutritious food, access to food and utilization of food. Analyzing the dietary diversity for focal and control farm households, it was found that farm households of both categories had access to a varied range of foods in their daily, weekly or monthly meals, which were denoted as 'highly consumed', 'moderately consumed' and 'less consumed' foods, respectively. The study revealed that at the end-line period, more focal farm households compared to control farm households ensured a slight increase in the consumption of rice/wheat, leafy vegetables, fish, chicken meat, milk, fruits, sweets/curd, cake/cookies, etc. (Table 6). Though majority of both focal and control farm households were found to be more food secure at the end-line period than the baseline period on the basis of FGFS criteria, the extent was higher for the focal farm households compared to the control farm households (88.5% and 64.6% focal and control farm households, respectively) (Table 7). Relevant to this finding, Shams and Sohel (2016) reported that homestead/community-based cage fishing, cash grant and training on non-farm activities could be viable options to ensure food security of vulnerable people living in coastal areas of Bangladesh.

Table 6. Dietary frequency of foods consumed by farm households (% of responses)

Food categories	Food items	Focal farm households			Control farm households		
		D_0	D_1	D_2	D_0	D_1	D_2
Highly consumed	Rice/wheat	0.0 (0.0)	0.0 (0.0)	100.0 (100.0)	0.0 (0.0)	0.0 (0.0)	100.0 (100.0)
	Pulses	5.9 (3.1)	32.8 (34.1)	61.3 (62.8)	5.3 (5.8)	31.6 (30.4)	63.1 (63.8)
	Vegetables	0.0 (0.0)	12.3 (10.3)	87.7 (89.7)	0.0 (0.0)	13.2 (12.4)	86.8 (87.6)
	Leafy vegetables	16.4 (12.7)	75.0 (70.8)	8.6 (16.5)	15.7 (17.0)	73.6 (71.2)	10.7 (11.8)
	Tea/coffee	10.5 (8.5)	16.2 (16.0)	73.3 (75.5)	12.0 (11.4)	15.1 (17.1)	72.9 (71.5)
Food categories	Food items	Focal farm households			Control farm households		
		W_0	W_1	W_2	W_0	W_1	W_2
Moderately consumed	Fish	0.0 (0.0)	15.3 (11.2)	84.7 (88.8)	0.0 (0.0)	17.5 (18.3)	82.5 (81.7)
	Chicken meat	21.4 (19.5)	71.5 (68.2)	7.1 (12.3)	20.8 (19.5)	70.6 (71.7)	8.6 (8.8)
	Mutton/beef meat	63.9 (58.0)	35.0 (40.6)	1.1 (1.4)	63.2 (65.0)	36.1 (32.4)	0.7 (2.6)
	Eggs	0.0 (0.0)	68.0 (72.3)	32.0 (27.7)	0.0 (0.0)	68.7 (69.6)	31.3 (30.4)
	Milk	9.2	32.7	58.1	9.5	31.9	58.6

Food categories	Food items	Focal farm households			Control farm households		
		D_0	D_1	D_2	D_0	D_1	D_2
		(5.1)	(40.9)	(54.0)	(8.0)	(33.0)	(59.0)
	Spicy fast food	52.9	41.0	6.1	51.8	41.7	6.5
		(49.8)	(40.0)	(10.2)	(50.2)	(41.0)	(8.8)
	Confectionery fast food	43.5	38.3	18.2	44	39	17.0
		(42.8)	(37.1)	(20.1)	(43.1)	(40.3)	(16.6)
Food categories	Food items	Focal farm households			Control farm households		
		M_0	M_1	M_2	M_0	M_1	M_2
Less consumed	Fruits	0.0	9.0	91.0	0.0	8.9	91.1
		(0.0)	(7.2)	(92.8)	(0.0)	(10.2)	(89.8)
	Sweets/curd	14.6	62.8	22.6	15.2	61.7	23.1
		(17.2)	(64.0)	(18.8)	(16.3)	(62.7)	(21.0)
	Juice/ice cream/ chocolate	32.1	36.7	31.2	33.6	38.0	28.4
		(31.5)	(38.2)	(30.3)	(31.0)	(37.2)	(31.8)
	Cake/cookies	5.3	34.5	60.2	5.9	34.1	60.0
		(8.3)	(40.5)	(51.2)	(6.0)	(35.0)	(59.0)
	Honey/butter	73.3	12.4	14.3	71.4	11.3	17.3
		(70.3)	(16.4)	(13.3)	(70.8)	(13.2)	(16.0)

Source: Field Survey, 2020-21.

Note: D_0, D_1 and D_2 indicate 'not consumed during a whole day', 'consumed once a day' and 'consumed at least twice a day'; W_0, W_1 and W_2 indicate 'not consumed during a week', 'consumed 1-3 times per week' and 'consumed at least 4 times per week'; and M_0, M_1 and M_2 indicate 'not consumed during a month', 'consumed 1-2 times per month' and 'consumed at least 3 times per month', respectively.

Values without and in the parentheses indicate the context before and after adopting the project intervention.

Table 7. Food security level of the farm households

Particulars	Criteria	Focal farm households		Control farm households	
		Before	After	Before	After
Food insecure	FGFS < 17	37.0	11.5	36.3	35.4
Food secure	FGFS ≥ 17	63.0	88.5	63.7	64.6

Source: Authors' Estimation, 2020-21.

Farmers' state of poverty

To evaluate the state of poverty of focal and control farm households, German correlation sensitive poverty index (GCSPI) was constructed on the basis of six poverty dimensions: health, education, employment, housing, mobility and income. The proportion of deprived focal and control farm households was 29.0 and 34.8 percent, respectively; and the proportion of privileged focal and control farm households was 71.0 and 65.2 percent, respectively (Table 8), The households were deprived or privileged based on all the indicators of a single dimension or at a combination of the indicators across dimensions. The reason for a better livelihood condition of focal farm households at the end-line period was that they could save money from crop production inputs (i.e., the inputs provided with by the project) and further employ it in other income generating activities. This result is quite similar

with Uddin and Dhar (2018) where the authors observed improved livelihood circumstances of the government input supported farmers for *Aus* rice production compared to the non-supported farmers.

Table 8. German correlation sensitive poverty index

Indicators	Focal (n = 120)		Control (n = 120)		Weights
	No. of households deprived (√) or privileged (×) based on the indicators				
	√	×	√	×	
Health					
Subjective health condition, either poor or bad	44/120	76/120	54/120	66/120	1/12
Lack of physical and mental health condition due to health impairments	18/120	102/120	16/120	104/120	1/12
Education					
Less than nine years of schooling	66/120	54/120	82/120	38/120	1/12
Neither graduation nor training qualification	90/120	30/120	108/120	12/120	1/12
Employment					
Unemployed status of activity	0/120	120/120	0/120	120/120	1/18
Working with below minimum wage	26/120	94/120	18/120	102/120	1/18
Working hour at least eight hours	56/120	64/120	72/120	48/120	1/18
Housing					
In urgent need of complete renovation to avoid the danger of breaking down	10/120	110/120	26/120	94/120	1/18
Lack of comfortable amenities	88/120	32/120	112/120	8/120	1/18
Living space below minimum requirement (45 sq. metre)	20/120	100/120	34/120	86/120	1/18
Mobility					
No personal vehicle available and public transport more than 20 minutes away	40/120	80/120	34/120	86/120	1/12
Insecure or dangerous neighbourhood	12/120	108/120	0/120	120/120	1/12
Income					
Monthly household income below breadline (Tk. 11479)	6/120	114/120	16/120	104/120	1/6
Score of the households	0.290	0.710	0.348	0.652	
Intensity of poverty (%) Deprived (√) households	29.0		34.8		-
Intensity of poverty (%) Privileged (×) households	71.0		65.2		-

Source: Authors' Estimation, 2020-21 and HIES, 2016.

Note: Score of deprived focal farm households = (44/120 × 1/12) + (18/120 × 1/12) + (66/120 × 1/12) + (90/120 × 1/12) + (0/120 × 1/18) + (26/120 × 1/18) + (56/120 × 1/18) + (10/120 × 1/18) + (88/120 × 1/18) + (20/120 × 1/18) + (40/120 × 1/12) + (12/120 × 1/12) + (6/120 × 1/6) = 0.290.
Score of privileged focal farm households = (76/120 × 1/12) + (102/120 × 1/12) + (54/120 × 1/12) + (30/120 × 1/12) + (120/120 × 1/18) + (94/120 × 1/18) + (64/120 × 1/18) + (110/120 × 1/18) + (32/120 × 1/18) + (100/120 × 1/18) + (80/120 × 1/12) + (108/120 × 1/12) + (114/120 × 1/6) = 0.710.
Scores of deprived or privileged control farm households were calculated accordingly.
Percentage of deprived focal farm households = 0.290 × 100 = 29.0.
Percentage of privileged focal farm households = 0.710 × 100 = 71.0.
Percentages of deprived or privileged control farm households were calculated accordingly.

IV. CONCLUSION

The study came to a conclusion that the intervention of ACIAR project to bring agronomic practice change into farmers' dry season cropping in the non-saline areas of Southern Bangladesh resulted in enhanced crop diversification and farm enterprise profitability, women empowerment, and food security; and livelihood improvement through poverty reduction at the end-line period. Based on the observations from the end-line assessment, it is recommended that farmers should produce the best-suited pulse crop/variety for production in each study areas based on the soil topography and geographical condition, discussing with the local extension agents (e.g., mungbean in Patuakhali and Jhalokathi, grasspea in Barisal, and cowpea in Barguna). The farmers should be provided with direct input support from the government (either cash, kind or both) to motivate them producing pulses over rice-monocropping which would lead to not only higher cropping diversity but also higher income from crop production, and the support outcome should be monitored by a strong vigilance team. The dissemination of modernized dry-season agriculture will be successful only when the local government and non-government extension agents should maintain a regular extension contact with the farmers in the non-saline areas of Southern Bangladesh.

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APPENDIX

Table A1. Profitability of major crops

Particulars			Focal farmers						Control farmers					
			Rice crops			Pulses			Rice crops			Pulses		
			Unit/ha	Tk./ unit	Tk./ha	Unit/ha	Tk./ unit	Tk./ha	Unit/ha	Tk./ unit	Tk./ha	Unit/ha	Tk./ unit	Tk./ha
Cost of production														
Variable costs	Human labor		67 man-days (66 man-days)	500 (500)	33500 (33000)	21 man-days (20 man-days)	500 (500)	10400 (10000)	68 man-days (68 man-days)	500 (500)	34000 (34000)	22 man-days (22 man-days)	500 (500)	10750 (11000)
	Power tiller		-	-	10246 (9971)	-	-	2516 (1504)	-	-	10726 (10800)	-	-	2532 (2346)
	Seed/seedlings		48 kg (50 kg)	100 (90)	4800 (4500)	26 kg (24 kg)	60 (70)	1560 (1680)	49 kg (51 kg)	100 (95)	4900 (4845)	25 kg (25 kg)	65 (70)	1625 (1750)
	Fertilizers	Urea	213 kg (200 kg)	20 (20)	4260 (4000)	69 kg (60 kg)	20 (20)	1380 (1200)	216 kg (218 kg)	20 (20)	4320 (4360)	72 kg (74 kg)	20 (20)	1440 (1480)
		TSP	130 kg (125 kg)	20 (18)	2600 (2250)	28 kg (25 kg)	20 (18)	560 (450)	126 kg (130 kg)	20 (18)	2520 (2340)	28 kg (28 kg)	20 (18)	560 (504)
		MoP	74 kg (71 kg)	25 (25)	1850 (1775)	-	-	-	75 kg (70 kg)	25 (25)	1875 (1750)	-	-	-
		Total	-	-	8710 (8025)	-	-	1940 (1650)	-	-	8715 (8450)	-	-	2000 (1984)
	Herbicides and insecticides		-	-	5434 (4541)	-	-	-	-	-	3505 (4245)	-	-	-
	i. Total variable cost		-	-	62690 (60037)	-	-	16416 (14834)	-	-	61846 (62340)	-	-	16907 (17080)
Fixed costs	Land use cost		-	-	6454 (6666)	-	-	3259 (3335)	-	-	6454 (6666)	-	-	3259 (3335)
	Interest on operating capital		-	-	3748 (3786)	-	-	1873 (1850)	-	-	3794 (3767)	-	-	1841 (1835)
	ii. Total fixed cost		-	-	10202 (10452)	-	-	5132 (5185)	-	-	10248 (10433)	-	-	5100 (5170)
iii. Total cost			-	-	72892	-	-	21548	-	-	72094	-	-	22007

Particulars		Focal farmers						Control farmers					
		Rice crops			Pulses			Rice crops			Pulses		
		Unit/ha	Tk./ unit	Tk./ha	Unit/ha	Tk./ unit	Tk./ha	Unit/ha	Tk./ unit	Tk./ha	Unit/ha	Tk./ unit	Tk./ha
				(70489)			(20019)			(72773)			(22250)
Change in total cost (%)		-	-	-3.3	-	-	-7.1	-	-	0.9	-	-	1.1
		Return from production											
iv. Gross return	Main product	104 maund (105 maund)	800 (800)	83320 (84022)	37 maund (37 maund)	1050 (1070)	38571 (39243)	102 maund (105 maund)	800 (800)	81758 (83973)	38 maund (38 maund)	1050 (1070)	39613 (40718)
	By-product	-	-	4879 (4794)	-	-	-	-	-	4755 (4810)	-	-	-
	Total	-	-	88199 (88816)	-	-	38571 (39243)	-	-	86513 (88783)	-	-	39613 (40718)
v. Gross margin (iv - i)		-	-	25509 (28779)	-	-	22155 (24409)	-	-	24667 (26443)	-	-	22706 (23638)
vi. Net return (iv - iii)		-	-	15307 (18327)	-	-	17023 (19224)	-	-	14419 (16010)	-	-	17606 (18468)
vii. Benefit cost ratio (BCR) (iv ÷ iii)		-	-	1.21 (1.26)	-	-	1.79 (1.85)	-	-	1.20 (1.22)	-	-	1.80 (1.83)
Change in gross return (%)		-	-	0.7	-	-	1.7	-	-	2.6	-	-	2.8
Change in gross margin (%)		-	-	12.8	-	-	10.2	-	-	7.2	-	-	4.1
Change in net return (%)		-	-	19.7	-	-	12.9	-	-	11.0	-	-	4.9

Source: Authors' Estimation, 2018-19.

Note: Values without and in the parentheses indicate the context before and after adopting the project intervention.