Project ID: 429

Competitive Research Grant

Sub-Project Completion Report

on

Impact of Improved Aquaculture Technologies on Productivity and Livelihood of Fish Farmers in Bangladesh

Project Duration

May 2017 to September 2018

Department of Development & Poverty Studies
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka 1207

Submitted to
Project Implementation Unit-BARC, NATP 2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

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Project Implementation Unit
National Agricultural Technology Program-Phase II Project (NATP-2)
Bangladesh Agricultural Research Council (BARC)
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Acronyms

ATT	:	Average treatment on treated
BMP	:	Better management practices
DAE	:	Department of Agricultural Extension
DoF	:	Department of Fisheries
et al.	:	And others
IPWRA	:	Inverse probability weighted regression adjustment
MAEP	:	Mymensingh Aquaculture Extension Project
MT	:	Metric ton
PCR	:	Project Completion Report
PSM	:	Propensity Score Matching
SE	:	Standard error
Tk.	:	Taka, Bangladeshi currency

Table of Contents

List of Tables

Executive Summary

The fisheries sector plays a particularly crucial role among poor as a main or additional source of employment, livelihood and income in Bangladesh. The remarkable achievement has been possible disseminating the improved fisheries technologies to the fish farmers. The present study assessed the impact of improved aquaculture technologies on the productivity and livelihood of fish farmers in Bangladesh. The study was conducted in 25 upazillas under 11 districts based on the highest contributors in the fish production in Bangladesh. Six aquaculture technologies were taken into consideration to achieve the objectives. A total of 1747 fish farm households were interviewed to represent the improved aquaculture technologies users covering the control fish farms in Bangladesh. The study used descriptive statistics, poisson regression and inverse probability weighted regression adjustment (IPWRA) to analyse the data.

The findings indicate that most of the respondents adopted improved practices to some extent. In the case of carp culture, highest 44% of the carp farmers adopted 4 improved practices out of six. Carp farmers' spouse education, training, and contact with extension were positive and significantly influenced the adoption of improved aquaculture practices. Due to higher productivity, per hectare gross and net return was significantly ($P<0.01$) higher for adopters compared to non-adopters. Treatment effect analysis suggested that adoption of improved practices significantly affect the productivity, profitability and consumption expenditure of the adopters. Most of the pangus farmers adopted four practices out of six. Family members, spouse education, training, and farm size were found to be positive and significantly influenced the adoption of improved practices of pangus cultivation. Productivity and net return was found significantly higher for adopters compared to non-adopters. IPWRA analysis suggested that adoption of improved practices significantly affected the productivity and profitability of the adopters. In the case of cage culture highest 48% of the respondents adopted 3 improved practices. Among the different variables, farmers' education, societal membership status, contact with extension and number of family members working person in the cage farm were positive and significantly influenced the adoption of improved practices while farm size of the respondents has negative effect on adoption. IPWRA analysis suggested that adoption of improved practices significantly affected the productivity and profitability. Findings also indicate that farmers who adopted improved practices also received significantly higher productivity and profitability in the case shrimp and prawn farming, respectively. In the case of crab fattening about 21% of the farmers adopted 3 improved practices out of six. Crab farmers' age, education, training, contact with extension and pond ownership were positive and significantly influenced the adoption of improved practices. Treatment effect analysis suggested that adopters of improved practices received significantly higher productivity, profitability and consumption expenditure. Over all, the findings indicate that adopters of improved practices have both yield and profitability advantage for all the six selected aquaculture technologies. Although most of the respondents already adopted improved practices but there is scope to improve the situation by bringing more farmers under adoption by providing effective extension policies. Most of the farmers opined that frequent attack of diseases is the main constraints which hampered the production for all the technologies. Availability of extension services, more training and inputs at subsidized price were suggested by the farmers to further improve the production level.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. **Title of the CRG sub-project:** Impact of Improved Aquaculture Technologies on Productivity and Livelihood of Fish Farmers in Bangladesh

2. **Implementing organization:**

   Department of Development & Poverty Studies

   Sher-e-Bangla Agricultural University

   Sher-e-Bangla Nagar, Dhaka 1207, Bangladesh

3. **Name and full address with phone, cell and E-mail of PI/Co-PI (s):**

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4. **Sub-project budget (Tk):**

   4.1 Total:Tk. 24,99,945 (Taka Twenty FourLack Ninety Nine Thousand Nine Hundred Fourty Five)

   4.2 Revised (if any): N/A

5. **Duration of the sub-project:**

   5.1 Start date (based on LoA signed): 07 May 2017

   5.2 End date: 30 September 2018

6. **Justification of undertaking the sub-project:**

Bangladesh is considered one of the most suitable regions for fisheries in the world, with the world's largest flooded wetland and the third largest aquatic biodiversity in Asia after China and India (Shamsuzzaman *et al.,* 2017). The fisheries sector plays a particularly crucial role among poor as a main or additional source of employment, livelihood and income in Bangladesh. Being one of the leading fish producing countries of the world Bangladesh had produced a total of 4.134million metric tonnes (MT) in the year of 2016-17 which was more than the targeted production level of 4.05 million metric tonnes. Through this remarkable achievement Bangladesh become a self-sufficient country in fish production proving 62.58 gram of fish per person in daily dietary consumption (DoF, 2017). An estimated 1.2 million people of Bangladesh are fishers and earn their livelihood from fishing. A further 12 million people indirectly earn their livelihood from fisheries and aquaculture and related

activities and employed in the backward and forward linkages of the value chain such as the downstream activities of fish trading, fish seed production, collection of shrimp and prawn seed, fish handling, processing and marketing, net making, input supply and processing. The number of fish farmers and shrimp/prawn farmers presently are 13.86 million and 0.83 million, respectively. Among the people involved in the sector 10% are women (Hossain, 2014). In this perspective, aquaculture in Bangladesh has expanded rapidly over the last three decades. Aquaculture has increasingly been playing a major role in total fish production (3.26 million tons) of the country and presently more than half of the total production (52.92 %) comes from aquaculture (1.73 million tons). Horizontal expansion of aquaculture has been taking place on the riverine floodplains which have been enclosed to facilitate the intensification of production (Belton and Azad 2012; Hossain, 2014). Aquaculture is the farming of fish and other aquatic organisms, with 'farming' implying - some form of intervention to increase productions, and some form of private rights of the stock under intervention (Beveridge and Little 2002). The performance of the aquaculture sector of Bangladesh has become the fifth-largest producer of aquaculture products in the world in recent years. It is a clear sign of its increasingly important role in the nation's social and economic development. The steady growth of aquaculture has tremendously contributed in the fish production and livelihood of fish farmers' in Bangladesh. The remarkable achievement has been possible disseminating the improved fisheries technologies to the fish farmers. The fish farmers are utilizing the fisheries technologies for improving their livelihood and also contributing the employment generation in fisheries sector. The improved aquaculture technologies are carp polyculture, intensive aquaculture, small scale cage culture, shrimp farming, prawn farming, crab farming etc. these technologies has already created a wide range of socio-economic impacts on the fish farmers which need to be evaluated. But rigorous impact assessment is very limited in Bangladesh. Following are the few studies conducted on different technologies in Bangladesh and abroad;

Islam *et al.* (2016) conducted a study to evaluate the production performance and economics of different carp polyculture systems in Gangni upazila under Meherpur district from July to November 2015. Average fish production of the farmers was 6,274 kg/ha/yr. Fish production was found to be 7,904 kg/ha/yr and net income was Tk. 2,42,060/ha/yr, respectively in carp-tilapia polyculture system.

Kassam and Dorward (2016) assessed the potential poverty impacts of small-scale pond aquaculture and cage aquaculture in Ghana, comparing the relative significance of their direct and indirect impacts. Non-poor small-scale pond fish farmers who had been trained and/or use better management practices (BMPs) were found to hold the most potential to impact poverty indirectly through generating economic growth. These indirect impacts were higher than the direct impacts on poor small-scale fish farmers and the indirect impacts from cage aquaculture.

Gurung*et al.,* (2016) showed that commercial aquaculture increased both farm income and income inequality, brought in new sources of employment, changed gender roles and relations, altered women's access to and control of resources, altered household food consumption patterns, and increased market dependence for staple food.

Chandra *et al.,* (2013) studied the impact of technology intervention on the production and productivity of floodplain wetlands. Annual fish production of the wetlands increased significantly after the adoption of pen culture technology for stocking of fingerlings raised *in situ*. Fish productivity increased from 300, 417, 425, and 125 kg/ha/yr to 1050, 1030, 850 and415 kg/ha/yr in Haribhanga, Damal, Raumari and Puthimari wetlands, respectively. The benefit cost ratio of fish production in wetland ranged between 2.85 and 3.94 for the selected wetlands.

Rand and Trap (2009) estimated the impact of Mymensingh Aquaculture Extension Project (MAEP) in Bangladesh. The authors found a positive short-run impact on pond productivity and the value of fish production per capita among participants. However, in the long run no similar well-determined effect emerges. Second, MAEP appears to have had no significant impact on socioeconomic status as measured by consumption expenditure of participating households.

Ofuoku et al., (2008) was conducted to isolate the determinants of improved fish production technologies in Delta State, Nigeria. The level of adoption was low. The grand mean adoption score and adoption index are 1.02 and 0.10, respectively. The low level of adoption was attributed to cost of the technologies, their complexities and lack of extension contact. The level of education, age of farmers, farm size, farm income and extension contact were the major determinants of fish production technologies adoption.

Saha and Islam (2005) conducted a study to determine the factors affecting adoption of pond polyculture in three districts namely Mymensingh, Bogra and Narshingdi in Bangladesh and found thatin Mymensingh, 75% pond owners adopted carp polyculture technology whereas in Bogra and Narshingdi only 16% and 25% pond owners, respectively adopted this technology for fish production. The production of fish per unit area was found to be 5 to 10 times higher in Mymensingh compared to that of Bogra and Narshingdi.

The systems and technology used in aquaculture has developed rapidly in the last fifty years. They vary from very simple facilities (e.g. family ponds for domestic consumption in tropical countries) to high technology systems (e.g. intensive closed systems for export production). Much of the technology used in aquaculture is relatively simple, often based on small modifications that improve the growth and survival rates of the target species, e.g. improving food, seeds, oxygen levels and protection from predators (FAO, 2018). Simple systems of small freshwater ponds, used for raising herbivorous and filter feeding fish, account for about half of global

aquaculture production. In Bangladesh, numerous aquaculture technologies have been used by fish farmers and other related stakeholders. A significant number of improved aquaculture technologies has also been developed researchers and scientists to facilitate these production practices. Among those pond carp polyculture, intensive aquaculture of pangus, small scale cage culture, shrimp farming in gher, fresh water prawn farming, crab farming etc. are mostly mentionable. Aquaculture production comprises different systems depending upon the applied level of technology. In aquaculture production, any change in the practice of feeding (e.g. from traditional/extensive to intensive feeding practice) represents a technological innovation and this is assumed to generate increases in aquaculture production and income. (Ahmed, 2007). Rahman et al. (2011) agreed that fishermen can increase their production if they found training regarding production technologies. Belton and Thilsted (2014) found that technological changes in aquaculture have dramatically increased fish supply, lowered relative fish prices, and reigned in price volatility. Based on the assessment of impacts of training and aquaculture extension on livelihoods of rural fish farmers in Bangladesh Rahman et al. (2015) concluded that the training and extension support could have increased the fish production and livelihood significantly. Farmers' adoption of technology such as industrially produced complete feed for aquaculture production result in higher outputs, higher costs and improved financial returns (Ahmed, 2007). That's why aquaculture technologies have a very crucial role in the livelihoods of fish farmers and other stakeholders. Though enormous research works has been conducted regarding aquaculture technologies but unfortunately an important aspect of the improved aquaculture technology issues has been remained untouched. That's why we attempt to investigate the impacts of improved aquaculture technologies on the livelihoods of fish farmers in Bangladesh.

From the above discussion, it is clear that impact of aquaculture technologies adoption has not been addressed well in Bangladesh. Most of the Studies used very simple technique to measure the treatment effect without considering the selectivity bias. Besides most of the studies are at regional level which are not representative for the nation as a whole. Thus, the questions like what is the causal effect of improved technologies adoption on productivity and livelihood? What are factors affecting the adoption? are yet to be studied empirically in Bangladesh. The present study is, therefore, a moderate effort to examine the above research questions and fulfill the gap to some extent.

7. **Sub-project goal:** The goal of the proposed project is to assess the impacts of improved aquaculture technologies on productivity and livelihood of fish farmers in Bangladesh.

8. **Sub-project objective (s):**
   - To compare productivity and profitability of fish farming between traditional and improved aquaculture technologies users;

- To identify the determinants of adopting improved aquaculture technologies at farm level;
- To assess the impact of improved aquaculture technology on fish yield and livelihood of fish farmers.

9. Implementing location (s):

List of technology and study districts based on technology

Sl. No.	Technology	Study Districts
1	Carp Culture (Polyculture)	Mymensingh, Jessore, Rajshahi
2	Intensive aquaculture of Pangus	Mymensingh, Brahmanbaria, Jessore
3	Cage Culture	Chandpur, Chapai Nawabganj, Laxmipur
4	Shrimp farming in gher	Khulna, Bagherhat, Coxsbazar
5	Fresh water prawn farming in gher	Khulna, Satkhira, Bagherhat
6	Fattening of crabs	Khulna, Bagherhat and Satkhira

10. Methodology in brief:

10.1 Data sources and sampling design

The fish farm survey was carried out for different aquaculture technologies by applying the multistage stratified random sampling technique for selecting fish producers. At the first stage, the 11 districts were selected based on the highest contributors in the fish production in Bangladesh. At stage two, selected aquaculture technologies adopting upazillas were selected through district fisheries office. Thus, a total of 25 upazillas were selected for data collection. Then, the highest aquaculture technologies concentrated area was surveyed applying cluster sampling approach for collecting information through primary survey from technologies adopter fish farmers and control fish farmers in the same area. The unions and blocks were selected as the primary sampling unit based on the highest aquaculture technologies concentration for the selected technologies. Finally, the fish farmers were selected randomly from the village level.

The list of fish farm households in each upazilla was collected from upazilla Fisheries Office, which serves as the population for the present study. Then 50 fish farmers were surveyed in each upazilla for each of the selected technologies. Thus from each district 100 fish farmers were interviewed randomly for each of the selected aquaculture technologies. For each technology we have selected three districts, thus for each of the selected aquaculture technology total sample size stood at 300. But due to lack of respondents of cage culture we only managed to survey 247 farmers from the selected three districts. Thus, a total of 1747 fish farm households were interviewed to represent the improved aquaculture technologies users covering the control fish farms in Bangladesh. Out of the 300 carp farmers, 2 farmers did not provide any production related data due to severe production loss, those were dropped from the analysis. Similarly, 3 pangus farmers, and 13 prawn farmers were also

dropped from the analysis due to non-availability of data. Finally, data of 1729 fish farmers were used to achieve the objectives of the study.
Area wise sample distribution is as follows:

Name of the districts	Name of the upazilla	Name of Technology	No. of sample
Khulna	Dumuria	Shrimp farming in gher	50
		Fresh water prawn farming in gher	50
		Fattening of crabs	50
	Paikgacha	Shrimp farming in gher	50
		Fresh water prawn farming in gher	50
		Fattening of crabs	50
Bagerhat	Bagerhat Sadar	Shrimp farming in gher	50
		Fresh water prawn farming in gher	50
		Fattening of crabs	50
	Rampal	Shrimp farming in gher	50
		Fresh water prawn farming in gher	50
		Fattening of crabs	50
Sathkhira	Sathkhira Sadar	Fresh water prawn farming in gher	50
	Kolaroa	Fresh water prawn farming in gher	50
	Kaligonj	Fattening of crabs	50
	Shamnagor	Fattening of crabs	50
Jessore	Jessore Sadar	Carp Culture (Polyculture)	50
	Jhikorgacha	Carp Culture (Polyculture)	50
		Intensive aquaculture of Pangus	50
	Monirampur	Intensive aquaculture of Pangus	50
Mymensingh	Trishal	Carp Culture (Polyculture)	50
		Intensive aquaculture of Pangus	50
	Vhaluka	Carp Culture (Polyculture)	50
		Intensive aquaculture of Pangus	50
Rajshahi	Mohanpur	Carp Culture (Polyculture)	50
	Paba	Carp Culture (Polyculture)	50
Chapai Nawabganj	Sader & Gomostapur	Cage Culture	21
	Godagari	Cage Culture	06
Chandpur	Chandpur Sadar	Cage Culture	50
	Haimchar	Cage Culture	50
Laxmipur	Laxmipur Sadar	Cage Culture	50
	Raipur	Cage Culture	50
Brahmanbaria	Brahmanbaria Sadar	Intensive aquaculture of Pangus	50
	Akhaura	Intensive aquaculture of Pangus	50
Cox's Bazar	Cox's Bazar Sadar	Shrimp farming in gher	50
	Chakaria	Shrimp farming in gher	50
Total sample			**1747**

10.2 Selection of adopters

Adopters of improved aquaculture technologies were selected based on the following indicators:

1. Carp culture (polyculture): use improved variety of fingerlings, maintain appropriate stocking density, provide food according to body weight of the fish, change water of the pond when necessary, apply lime according to soil ph, and have proper drainage facility.
2. Intensive aquaculture of pangus: use improved variety of fingerlings, maintain appropriate stocking density, provide food according to body weight of the fish, change water of the pond when necessary, apply lime according to soil ph, and have proper drainage facility.
3. Cage culture: use improved variety of fingerlings, maintain appropriate stocking density, provide food according to body weight of the fish, and apply lime in the nursery pond.
4. Shrimp farming in gher: use improved variety of fingerlings, maintain appropriate stocking density, provide food according to body weight of the fish, change water of the pond when necessary, apply lime according to soil ph, and have proper drainage facility.
5. Fresh water prawn farming in gher: use improved variety of fingerlings, maintain appropriate stocking density, provide food according to body weight of the fish, change water of the pond when necessary, apply lime according to soil ph, and have proper drainage facility.
6. Fattening of crabs: maintain appropriate stocking density, provide food according to body weight of the fish, change water of the pond when necessary, apply lime according to soil ph, proper drainage facility, and maintain male-female ratio.

10.3 Analytical techniques

10.3.1 Productivity and profitability of the improved aquaculture technologies

To achieve the first objective mostly descriptive statistics like mean, percentage was used. To test the difference between the mean of the outcome variables of improved technology adopters and non-adopters, t-test was conducted for the independent group of the sample with the hypothesis is that there is no difference between the population mean of the two groups of farmers. In this study the following formula was used to test the difference between two groups.

$$t = \frac{(X_{IA} - X_{INA})(\mu_{IA} - \mu_{INA})}{\delta_{X_{IA-X_{INA}}}}$$

Where, X_{IA} and X_{INA} is the mean of the improved technology adopters and non-adopters respectively. $\mu_{IA}$and $\mu_{INA}$is the population mean of the adopters and non-adopters. $\delta_{IA\text{-}INA}$ is the standard error of the difference between adopters and non-adopters mean.

10.3.2 Factor affecting the adoption

Poisson regression model was used to examine the factors affecting the adoption of improved aquaculture practices. The Poisson regression model, suitable for the

estimation of count data (Greene 1997), was selected for the estimation of the farmers' decisions on the number of improved aquaculture practices to adopt. The fish farmers made a series of discrete household decisions that was computed across an aggregation of choices to a Poisson distribution. The Poisson regression model is the development of the Poisson distribution to a non-linear regression model of the effect of independent variables, *xi*, on a scalar dependent variable *y*.

$E\ (y / x_i) = \mu = exp(x^{'}\beta)$ *and* $y = 0\text{-}6$

Where,

$$exp(x^{'}\beta) = exp\ (\beta_0) + exp\ (\beta_1 x_1\ ) + exp(\beta_2 x_2\ ) + \ldots\ldots + exp\ (\beta_k x_k)$$

The coefficients of the marginal effects of the Poisson model can be interpreted as theproportionate change in the conditional mean if the i^{th}regressor changes by one unit.

$$\beta_i = \frac{\delta E(\frac{y}{x_i})/\delta x_i}{E(\frac{y}{x_i})} = \frac{\delta \log E(\frac{y}{x_i})}{\delta x_i}$$

The Poisson model sets the variance as equal to the mean, as follows:

$$v(\frac{y}{x_i}) = \mu(x_i, \beta) = \exp(x^{'}\beta)$$

To identify the factors affecting the adoption the following explanatory variables were used;

X_1 = Number of family members

X_2= Age of the respondent (years)

X_3 = Education (year of schooling)

X_4 = Spouse education (year of schooling)

X_5 = Training received on selected aquaculture technology (days)

X_6 = Farm size (in ha)

X_7 = Societal membership (yes/no)

X_8 = Extension contact (yes/no)

X_9 = Pond ownership (yes/no)

X_{10} = Number of family members working in the fish farm

10.3.3 Estimation of impacts of adoption

Causal effects estimation of improved aquaculture practices on potential outcome indicators is not easy due to selection bias problem. True measurement of impacts requires controlling of sample selection bias through random assignment of individuals into treatments. If the sample selection procedure is not completely random, several studies (Gautam et al., 2017; Schreinemachers et al., 2016; Gitonga et al., 2013; Khan et al., 2012; Abebaw et al., 2010) suggested to use propensity score matching (PSM) to estimate the average treatment on treated (ATT).

However, ATT from PSM can still produce biased results in the presence of mis-specification in the propensity score model (Robins et al., 2007; Wooldridge, 2010). To overcome the problem, the present study used IPWRA which provides consistent results in the presence of mis-specification in the treatment or outcome model, but not both. IPWRA estimator has the double-robust property that ensures consistent results as it allows the outcome and the treatment model to account for mis-specification. Following Imbens and Wooldridge (2009), ATT in the IPWRA model was estimated in two steps. In the first step, we estimate the propensity scores using multinomial logistic regression and in second step, linear regression was used to estimate the ATT. ATT was computed as follows;

$$ATT = \frac{1}{N_t}\sum_{1}^{N_t}\{(\alpha'1 - \alpha'2) - (\delta'1 - \delta'2)x_i\}$$

Where, ($\alpha'1$ and $\delta'1$) are estimated inverse probability weighted parameters for treated households (adopters) while ($\alpha'2$ and $\delta'2$) are estimated inverse probability weighted parameters for untreated households (non-adopters), N_t indicates the total number of treated households.

11. Results and discussion:

11.1. Carp Culture (Poly culture)

11.1.1 Descriptive statistics of the variables used in the models

Differences in selected characteristics of adopters and non-adopters are presented in Table 1. The mean difference suggested that there are some differences between adopters and non-adopters in terms of selected household characteristics. The characteristics of adopters and non-adopters were similar in terms of family members, age, training, farm size, societal membership, and fishing experience. But significant differences exist between adopters and non-adopters with respect to education ($p<0.01$), and extension contact ($p<0.01$) which indicates that the two groups are not directly comparable and justifies the use of treatment effect model.

Table 1. Descriptive statistics of the socio-economic characteristics of the respondents

Characteristics	Number of technologies adopted						All adopters	Non adopters	Mean diff.
	01	02	03	04	05	06			
Family member (No.)	4.04	3.67	4.03	4.13	5.00	--	4.09	3.73	0.36
Age (yrs)	40.45	37.17	42.76	40.38	42.44	--	40.51	42.47	-1.96
Education (yrs)	9.08	9.00	8.90	10.02	8.56	--	9.48	6.07	3.41***
Training (days)	0.94	1.22	3.79	7.10	16.44	--	4.66	2.27	2.39
Farm size (ha.)	0.54	0.33	0.75	0.76	0.84	--	0.66	0.76	-0.1
Societal membership (%)	04	11	31	16	22	--	13	07	6
Extension contact (%)	70	67	75	82	79	--	76	33	43***

Characteristics	Number of technologies adopted						All adopters	Non adopters	Mean diff.
	01	02	03	04	05	06			
Pond ownership (%)	71	72	83	67	67	--	70	60	10
FMWCF (No.)	1.23	1.17	1.28	1.25	1.33	--	1.24	1.27	-0.03
Experience in carp farming (yrs)	9.01	8.11	10.83	11.16	14.44	--	10.33	8.87	1.46

Note: *** indicates significant at 1% level; FMWCF indicates family members working in carp farming

11.1.2 Adoption status of improved practices

It is evident from the Table 2 that most of the farmers (44.97%) adopted 4 practices out of the selected 6 improved carp cultivation practices followed by 31.21% of farmers who adopted 1 practice. No farmers were found to be adopted all the 6 selected practices while only around 5% of the farmers did not adopted any of the selected improved carp cultivation practices.

Table 2. Adoption status of different improved technologies (n = 298)

Items	Number of practices						
	1	2	3	4	5	6	0
No. of farmers	93	18	29	134	9	--	15
Percent of total	31.21	6.04	9.73	44.97	3.02	--	5.03

11.1.3 Factors affecting adoption

It is revealed from Table 3 that the estimated pseudo R-squared value is low (0.08), but the overall significance of the Poisson model, reported by the Wald chi-squared value, is satisfactory. Non-significant value of goodness of fit also indicating the good fit of the model.

Carp farmers' spouse education, training, and contact with extension were positive and significantly influenced the adoption of improved aquaculture practices. The positive and significant association of the extension contact and training suggested that exposing farmers to agricultural extension advice and training could help to increase the adoption of improved practices confirms the findings of DeGraft-Johnson et al., (2014) and Mensah-Bonsu et al., (2017). Adoption of new technologies require some level of technical knowledge, direct contact with extension services and training increases the acquisition of relevant knowledge. Efforts are warranted to increase the number of extension personnel's in the rural areas to increase the adoption level. Positive and significant value of spouse education indicates that the farmers who have educated spouse were adopted more.

Table 3. Factors affecting adoption decision: Poisson estimates

Variables	Unit	Coefficient	Robust SE	z
Family member	Number	0.028	0.023	1.19
Age	Years	0.003	0.003	0.91
Education	Years	0.003	0.009	0.34
Spouse education	Years	0.024***	0.009	2.69
Training	Days	0.011***	0.003	3.74
Farm size	Hectare	0.002	0.031	0.06
Societal membership	Dummy (yes/no)	0.088	0.074	1.18
Extension contact	Dummy (yes/no)	0.227***	0.083	2.73
Pond ownership	Dummy (yes/no)	0.045	0.068	0.66
FMWCF	Number	0.053	0.057	0.94
Constant		0.179	0.222	0.80
Log likelihood	-526.23			
LR chi square	54.49***			
Pseudo R^2	0.08			
Goodness of fit	224 ns			
No. of observations	298			

Note: FMWCF indicates Family members working in carp farm; *** indicates significant at 1% level; ns indicates not significant

11.1.4 Cost and return of carp cultivation

On an average, the total cost of carp cultivation was found higher who adopted the improved aquaculture practices compared to the farmers who did not adopted but these differences were not statistically significant (Table 5). Among the cost items, feed cost was the major cost item followed by carp fingerlings cost (Table 4).

Table 5 Indicates that total cost of production was almost similar for both adopters (Tk 387110/ha) compared to non-adopters (Tk. 374022/ha). Per hectare production was also found to be significantly ($P<0.05$) higher for adopters (3443 kg/ha) than that of non-adopters (2884 kg/ha). As a result of higher productivity, per hectare gross and net return was also significantly ($P<0.01$) higher for adopters compared to non-adopters. The findings indicate that adoption of improved practices need marginally higher capital investment but at the same time it provided significantly higher income which may be useful in reducing poverty and malnutrition to some extent in the rural areas.

Table 4. Per hectare cost structure of carp cultivation (in Taka)

Cost items	No. of technology adopted						Non adopters
	1	2	3	4	5	6	
A. Fixed costs							
Land rent	51835	53062	50811	56210	40208	--	61371
Pond preparation	14100	11234	12155	13353	13489	--	12345
Netting	1350	2206	1709	1487	2867	--	823
Guard	1314	1779	1236	1272	2168	--	1551
Equipment	910	932	2549	966	2093	--	1105
Total fixed cost	69509	69213	68460	73288	60825	--	77195
B. Variable cost							
Fingerlings	79348	49314	64156	87441	59899	--	70279
Feed cost	156341	152651	130876	149010	133947	--	138567
Human labor	56571	46312	40222	43186	38141	--	29839
Fertilizer cost	27467	21723	22530	26771	39510	--	39537
Lime cost	3560	3141	3543	4189	2760	--	3458
Pesticide cost	637	189	247	735	409	--	399
Pond repair	10906	10359	14580	11959	13879	--	12242
Water treatment	1411	2245	2217	1892	4367	--	2506
Total variable cost	336241	285934	278371	325183	292912	--	296827
Total cost (A+B)	405750	355147	346831	398471	353737	--	374022

Table 5. Per hectare return from carp cultivation

Items	Number of technology adopted						All adopters	Non adopters	Mean diff.
	1	2	3	4	5	6			
Production (kg/ha)	3305	3034	3138	3512	5623	--	3443	2884	559**
Ave. price (Tk/kg)	213	192	182	230	215	--	216	168	48***
Gross return (Tk/ha)	703965	582528	571116	807760	1208945	--	743688	579264	164424***
TVC	336241	285934	278371	325183	292912	--	322466	296827	25639
TFC	69509	69213	68460	73288	60825	--	64644	77195	-12551
Total cost (Tk/ha)	405750	355147	346831	398471	353737	--	387110	374022	13088
Net return (Tk/ha)	292038	227573	210635	398249	855208	--	356578	205242	151336***
BCR	1.73	1.64	1.65	2.03	3.42	--	1.92	1.55	--

Note: ** and *** indicates significant at 5% and 1% level.

11.1.5 Impact of improved aquaculture technology adoption

Impact on productivity

It is evident from the Table 6 that the adoption of improved practices significantly affected the productivity of carp. It is clear from the results that farmers who adopted 2 and 3 number of improved practices received higher per hectare yield compared to non-adopters but these differences are not statistically significant. The farmers who adopted 1, 4, and 5 number of improved practices were received significantly ($p<0.01$) higher per hectare yield (445 – 2248 kg) compared to non-adopters which is

similar to the findings of Rand and Tarp (2009) indicated that technology adoption significantly affected the productivity.

Table 6. Impact of improved technologies on productivity of carp

Number of technology adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	445.38***	169.13	2.63
2	0	176.15	181.29	0.97
3	0	122.04	230.05	0.53
4	0	623.07***	179.70	3.47
5	0	2248.45***	302.45	7.43

Note: *** indicates significant at 1% level

Impact on profitability

Findings of the table 7 indicates that all category of adopters of improved practices received higher per hectare profit compared to non-adopters due to higher productivity but these differences were not significant for the farmers who adopted 2 and 3 number of improved practices. Amankwah and Quagrainie (2017) also found that improved fish technology adoption increases the income from fish cultivation. Farmers who adopted more number of improved practices received more income compared to the farmers who adopted less number of practices as well as non-adopters. The values of ATT were ranged from Tk. 48883 – Tk. 450127 based on different number of adopted improved practices. More awareness building programs and trainings are warranted to augment the adoption process since adoption enhanced the productivity and income.

Table 7. Impact of improved technologies on profitability of carp cultivation

Number of technology adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	162992.50***	63583.74	2.56
2	0	91330.34	72957.02	1.25
3	0	48883.72	74149.98	0.66
4	0	236480.00***	64635.16	3.66
5	0	450127.60***	62701.77	7.18

Note: *** indicates significant at 1% level

Impact on consumption expenditure

The positive and significant values of ATT indicate that consumption expenditure of the farmers who adopted improved practice was higher (Tk. 1139 – 26310) compared to non-adopters (Table 8). Sahu and Das (2015) also indicated that agriculture related technology adoption have significant and positive effect of the consumption expenditure used as a proxy of well being of the farmers. The findings of the present

study may indicate that adoption improved practices can play a vital role in the anti-poverty policies of Bangladesh.

Table 8. Impact of improved technologies on consumption expenditure of carp farmers

Number of technology adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	12807.65**	5016.46	2.55
2	0	15238.81	9264.61	1.64
3	0	1139.09	5146.09	0.22
4	0	26310.55***	6113.57	4.30
5	0	19080.64***	4000.48	4.77

Note: ** and *** indicates significant at 5% and 1% level

Impact on household assets

The findings indicate that adoption of improved practices have mixed effect on the household assets position of the adopters. This may be due to the fact that purchases of household assets depend on many other factors apart from fish income. The findings also indicate that the farmers who adopted more practices were purchased more asset compared to other farmers may be due to higher income received from carp cultivation (Table 9).

Table 9. Impact of improved technologies on household assets of carp farmers

Number of technology adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	35882.91	49987.85	0.72
2	0	61155.44	56220.82	1.09
3	0	-9760.69	53819.42	-0.18
4	0	165773.40***	53465.81	3.10
5	0	103539.00*	64718.42	1.60

Note: * and *** indicates significant at 10% and 1% level

Impact on livestock

The positive value of ATT indicates that the farmers who adopted 1 and 2 practice owned more livestock compared to non-adopters which is marginally significant (Table 10). Apart from that there was no significant differences between the two categories of farmers indicated adoption did not have any significant effect on the livestock assets. This may be due to the fact that rearing livestock is labor intensive and time consuming which may prevent the fish farmers to purchase livestock.

Table 10. Impact of improved technologies on livestock asset of carp farmers

Number of technology adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	20750.89*	12107.83	1.71
2	0	52635.22*	29197.60	1.80
3	0	-13505.04	10506.53	-1.29
4	0	-4026.76	10454.40	-0.39
5	0	-12510.17	22339.00	-0.56

Note: * indicates significant at 10% and 1% level

Impact of fishing equipment

It is evident from table 11 that the farmers who adopted improved practices spend more money (Tk. 826 – 2655) to purchase different fishing equipments. This is due to the fact that adopters received higher net return compared to non-adopters and may spend extra amount of money to purchase fishing equipments. These differences were significant at 1% and 5% level for the farmers who adopted 1 and 4 practices, respectively.

Table 11. Impact of improved technologies on purchase of fishing equipments

Number of technology adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	2655.50***	835.38	3.18
2	0	779.53	860.82	0.91
3	0	692.06	1432.93	0.48
4	0	2623.30**	1315.64	1.99
5	0	826.10	1235.91	0.67

Note: ** and *** indicates significant at 5% and 1% level

Impact on educational expenses

The ATT value of the educational expenses for the farmers who adopted 1 practice out of 6 were significant indicates that farmers spending more money on child education compared to non-adopters (Table 12). The findings also indicate that the differences in ATT values were not significant for other category of adopters. This may be for the fact that apart from technology adoption, education depends on many other factors like no. of child in the family, child age etc. which were not considered in the analysis. The farmers who adopted more practices may not have enough school going child in the family which may resulted as non-significant effect.

Table 12. Impact of improved technologies on educational expenses

Number of technology adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	3236.67***	1124.68	2.88
2	0	744.32	1307.78	0.57
3	0	-117.98	941.77	-0.13

Number of technology adopted		ATT	SE	z
Adopters	Non-adopters			
4	0	1572.33	1140.50	1.38
5	0	1072.61	1107.75	0.97

Note: *** indicates significant at 1% level

11.1.6 Problems in carp culture

Yet carp cultivation is profitable and improves the livelihood status of the farmers but it has some constraints which should not be ignored. Among the constraints, frequent attack of diseases was the major barrier and about 42% farmers' responses regarding this problem. Besides, about 23% farmers opined that unavailability of improved fingerlings is another constraint which hampers the carp cultivation at field level. Lack of transportation facilities (17.11%), lack of training (11.74%) and lack of capital (12.42%) are few other concerns for the farmers (Table 13).

Table 13. Problems of carp cultivation

Sl #	Problems	No. of farmers	Percentage
01	Frequent attack of diseases	125	41.95
02	Lack of training	35	11.74
03	Lack of improved fingerlings	67	22.48
04	Lack of capital	37	12.42
05	Lack of transportation facilities	51	17.11

11.1.7 Suggestions

To overcome the barriers of production about 36% of the farmers mentioned that concerned authorities may take initiatives to supply different inputs like medicine, fingerlings etc. at subsidized rate as well as extension services to reduce the disease attack. To increase the knowledge of improved technologies of the farmers more training (19.80%) should be arranged. Government should take necessary action to ensure reasonable price of carp so that the carp farmers can continue their operation in future (Table 14).

Table 14. Suggestions for improvement

Sl #	Suggestions	No. of farmers	Percentage
01	More training	59	19.80
02	Supply of subsidized inputs and services	107	35.91
03	Ensure good price	72	24.16

11.2 Intensive aquaculture of Pangus

11.2.1 Descriptive statistics of the variables used in the models

Socio-economic characteristics of adopters and non-adopters are presented in Table 15. The socio-economic characteristics of adopters and non-adopters were similar in terms of age, farm size, pond ownership, number of working family members and experience. But significant differences exist between adopters and non-adopters in

terms of family member, education, training, societal membership and extension contact. These differences indicate that in spite of careful selection of the sample, the two groups are not directly comparable which in one sense justify the use of treatment effect model.

Table 15. Descriptive statistics of the socio-economic characteristics of the respondents

Characteristics	No. of practices adopted						All adopters	Non adopters	Mean diff.
	01	02	03	04	05	06			
Family member (No.)	3.91	4.39	4.11	4.59	4.17	--	4.26	3.88	0.38**
Age (yrs)	41.21	40.86	41.34	40.30	40.33	--	40.82	43.04	-2.22
Education (yrs)	7.23	8.49	7.61	9.11	8.50	--	8.25	7.60	0.65*
Training (days)	1.94	1.92	2.39	4.53	9.07	--	3.90	3.00	0.90**
Farm size (ha.)	0.39	0.59	0.65	0.71	0.86	--	0.63	0.53	0.10
Societal membership (%)	11	08	20	26	26	--	19	12	7*
Extension contact (%)	85	67	48	83	81	--	73	52	21***
Pond ownership (%)	71	90	66	67	73	--	73	64	9
FMWCF (No.)	1.19	1.24	1.29	1.20	1.19	--	1.21	1.24	-0.03
Experience in pangus farming (yrs)	7.87	9.12	8.25	9.61	8.12	--	8.70	9.20	-0.50

Note: * and *** indicates significant at 10% and 1% level; FMWCF indicates number of family members working in pangus farm

11.2.2 Adoption status of improved practices

It is evident from the Table 16 that about 24% of the farmers adopted 4 practices out of the selected 6 improved pangus cultivation practices followed by 18.86% of farmers who adopted 3 practices. No farmers were found to be adopted all the 6 practices while around 8% of the farmers did not adopted any of the selected improved pangus cultivation practices.

Table 16. Adoption status of different improved technologies (*n* = 297)

Items	Number of practices						
	1	2	3	4	5	6	0
No. of farmers	53	51	56	70	42	0	25
Percent of total	17.85	17.17	18.86	23.57	14.14	0	8.42

11.2.3 Factors affecting adoption

It is revealed from table 17 that the estimated pseudo R-squared value is low (0.20) and the overall significance of the Poisson model, reported by the Wald chi-squared

value, is satisfactory. Non-significant value of goodness of fit also indicating the good fit of the model.

Coefficient of farmers' family members, spouse education, training, and farm size were found to be positive and significantly influenced the adoption of improved aquaculture practices. The positive and significant association of training ($p<0.01$) suggested that exposing farmers to training could help to increase the adoption of improved practices because training help the farmers to come in touch with experts which enhanced the knowledge of the farmers. Efforts are warranted to increase the number of trainings on pangus farming in the rural areas to increase the adoption level. Farm size ($p<0.01$) positively influenced adoption decision may be due to economics of scale confirms the findings of Ofuoku et al., (2008). The farmers who have educated spouse were adopted more. Number of family members also influenced the adoption.

Table 17. Factors affecting adoption decision: Poisson estimates

Variables	Unit	Coefficient	Robust SE	z
Family member	Number	0.039*	0.023	1.69
Age	Years	-0.004	0.003	-1.18
Education	Years	-0.003	0.010	-0.27
Spouse education	Years	0.006***	0.002	3.59
Training	Days	0.019***	0.004	4.68
Farm size	Hectare	0.080***	0.024	3.39
Societal membership	Dummy (yes/no)	0.091	0.076	1.19
Extension contact	Dummy (yes/no)	0.054	0.073	0.74
Pond ownership	Dummy (yes/no)	-0.006	0.072	-0.08
FMWCF	Number	0.026	0.066	0.39
Constant		0.744***	0.201	3.70
Log likelihood	-537.97			
LR chi square	81.27***			
Pseudo R^2	0.20			
Goodness of fit	234 ns			
No. of observations	297			

Note: FMWCF indicates Family members working in pangus farm; * and *** indicates significant at 10% and 1% level; ns indicates not significant

11.2.4 Cost and return of pungas cultivation

On an average, the total cost of pangus cultivation was found to be gradually increased from lower to higher number of practices. Among the cost items, feed cost was the major cost item followed by pangus fingerlings cost (Table 18).

Table 19 indicates that total cost of production was higher for adopters (Tk 631399/ha) compared to non-adopters (Tk. 518340/ha) but the difference was not statistically significant. Per hectare production was also found to be significantly ($P<0.01$) higher for adopters (12377 kg/ha) than that of non-adopters (7409 kg/ha). As a result of higher productivity, per hectare gross and net return was also significantly

higher for adopters compared to non-adopters. The findings indicate that adoption of improved practices need higher capital to some extent but at the same time it also provided significantly higher income which may be useful in reducing poverty and malnutrition in the rural areas.

Table 18. Per hectare cost structure of pangus cultivation

Cost items	Adopters						Non adopters
	1	2	3	4	5	6	
A. Fixed costs							
Land rent	73972	78015	78680	78319	81496	--	76247
Pond preparation	12681	20032	14622	17504	17532	--	10473
Netting	1951	1559	6283	2127	1847	--	2193
Guard	1680	1868	1073	1690	2541	--	1341
Equipment	473	352	425	339	553	--	445
Total fixed cost	90757	101826	101083	99979	103969	--	90699
B. Variable cost							
Fingerlings	92150	86472	97248	120478	106870	--	73018
Feed cost	316574	335372	397114	366957	367790	--	293623
Human labour	45389	50407	55412	49710	59496	--	34671
Fertilizer cost	3791	4556	8373	3337	4636	--	5283
Lime cost	3765	4062	4145	5160	4866	--	3880
Pesticide cost	451	1701	653	2510	471	--	1219
Pond repair	12467	11772	13784	11373	16602	--	12686
Water treatment	4283	3576	3705	2443	3046	--	3261
Total variable cost	478870	497918	580434	561968	563777	--	427641
Total cost (A+B)	569627	599744	681517	661947	667746	--	518340

Table 19. Per hectare return from pangus cultivation

Items	Adopters						All adopters	Non adopters	Mean diff.
	1	2	3	4	5	6			
Production (kg)	10636	11347	12520	13778	15614	--	12377	7409	4968***
Ave. price (Tk/kg)	87	88	86	82	81	--	85	88	-3
Gross return (Tk/ha)	925332	998536	1076720	1129796	1264734	--	1052045	651992	400053*
TVC	478870	497918	580434	561968	563777	--	534046	427641	106405
TFC	90757	101826	101083	99979	103969	--	97352	90699	6653
Total cost (Tk/ha)	569627	599744	681517	661947	667746	--	631399	518340	113059
Net return (Tk/ha)	355705	398792	395203	467849	596988	--	420646	133652	286994**
BCR	1.62	1.66	1.58	1.71	1.89	--	1.67	1.26	--

Note: *, ** and *** indicates significant at 10%, 5% and 1% level.

11.2.5 Impact of improved aquaculture technology adoption

Impact on productivity

It is evident from the table 20 that the adoption of improved practices significantly affected the productivity of pangus. It is revealed from the results that farmers who adopted improved practices received significantly ($p<0.01$) higher per hectare yield compared to non-adopters. The ATT values were increased as the farmers adopted more number of improved practices compared to less. The values of ATT were ranged 3615 - 8164 kg/ha. Thus, improved technology adoption significantly affected the productivity which confirm the findings of Rand and Tarp (2009).

Table 20. Impact of improved technologies on productivity of pangus

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	3615.34***	670.57	5.39
2	0	6186.51***	1662.86	3.72
3	0	5556.20***	739.88	7.51
4	0	6657.32***	821.68	8.10
5	0	8164.66***	780.54	10.46

Note: *** indicates significant at 1% level

Impact on profitability

Findings of the table 21 indicates that all category of adopters of improved practices received significantly higher profit compared to non-adopters due to higher productivity consistent with the findings of Amankwah and Quagrainie (2017), which indicated that improved fish technology adoption increases the income from fish cultivation. It is also evident that the income of the farmers increases as more improved practices are adopted compared to less. The values of ATT were ranged from Tk. 185126 – Tk. 400794 based on different number of adopted improved practices. Training and awareness building programs are warranted to augment the adoption process since adoption enhanced the productivity and income.

Table 21. Impact of improved technologies on profitability of pangus cultivation

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	185126.80***	42839.39	4.32
2	0	354744.60***	129088.40	2.75
3	0	242003.00***	55711.34	4.34
4	0	273816.10***	53480.63	5.12
5	0	400794.30***	48355.26	8.29

Note: *** indicates significant at 5% and 1% level

Impact on consumption expenditure

The positive and significant values of ATT indicate that consumption expenditure of the farmers who adopted 1, 2 and 5 number of improved practice was higher (Tk. 7278 – 11167) compared to non-adopters (Table 22). Technology adoption have significant and positive effect on the consumption expenditure which was used as a proxy of wellbeing of the farmers (Sahu and Das, 2015). Due to higher income and increase in the capacity of spending more, adoption of improved practices may play a vital role in the anti-poverty programmes in Bangladesh.

Table 22. Impact of improved technologies on consumption expenditure of pangus farmers

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	19465.60	7278.44***	2.67
2	0	15101.62	8539.37*	1.77
3	0	23324.00	15207.05	1.53
4	0	13087.65	8439.76	1.55
5	0	33035.38	11167.57***	2.96

Note: * and *** indicates significant at 10% and 1% level

Impact on household assets

The findings indicate that adoption of improved practices did not have any significant effect on the household assets position of the adopters. This may be due to the fact that purchases of household assets need higher investment which depends on many other factors.

Table 23. Impact of improved technologies on household assets of pangus farmers

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	-49849.15ns	76825.02	-0.65
2	0	37216.85ns	99481.86	0.37
3	0	-64892.71ns	91734.52	-0.71
4	0	68285.60ns	104681.10	0.65
5	0	147058.20ns	130562.00	1.13

Impact on livestock

The positive and significant value of ATT indicates that the farmers who adopted 6 practice owned more livestock compared to non-adopters (Table 24). Like household assets position adoption of improved practices did not affect the livestock assets position. This may be due to the fact that rearing livestock is labor intensive and need more time, which may prevent the fish farmers to purchase livestock.

Table 24. Impact of improved technologies on livestock asset of pangus farmers

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	3964.10	13020.87	0.30
2	0	11850.63	14950.70	0.79
3	0	17840.44	14317.92	1.25
4	0	11244.81	17147.09	0.66
5	0	31319.78*	16545.17	1.89

Note: * indicates significant at 10% level

Impact of fishing equipment

The findings indicate that adoption of improved practices did not have any significant effect on the purchase of fishing equipments. This may be due to the fact that the adopters may already have the required number of fishing equipments which may prevent them to buy the new one during the last one year (Table 25).

Table 25. Impact of improved technologies on purchase of fishing equipments

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	-434.87ns	453.05	-0.96
2	0	-272.91ns	476.65	-0.57
3	0	-223.63ns	523.97	-0.43
4	0	-29.97ns	515.04	-0.06
5	0	496.99ns	812.90	0.61

Impact on educational expenses

The ATT values of the educational expenses for the farmers who adopted 1 and 3 number of improved practices were positive and significant while the other values of ATT were not statistically significant. This may indicate that education expenses not only depend on adoption but also on many other factors like no. of child in the family, child age etc., which were not considered in the analysis (Table 26).

Table 26. Impact of improved technologies on educational expenses

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	2543.10**	1159.80	2.19
2	0	1646.51	1215.66	1.35
3	0	2042.92**	892.71	2.29
4	0	3429.24	2329.43	1.47
5	0	820.57	699.22	1.17

Note: ** indicates significant at 5% level

11.2.6 Problems in pangus culture

Most of pangus farmers (29.63%) opined that high price of feed is the major problem of pangus cultivation. Besides, about 12% farmers opined that low market demand is an another important constraint which hampers the pangus cultivation at field level (Table 27).

Table 27. Problems of pangus cultivation

Sl #	Problems	No. of farmers	Percentage
01	High price of feed	88	29.63
02	Low market demand	37	12.46

11.2.7 Suggestions

To overcome the barriers of production about 35% of the farmers mentioned that the market price of feed should be controlled by the concern authority which may enhance their profitability. About 20% of the farmers mentioned that concerned authorities may take initiatives to supply different inputs at subsidized rate to reduce the disease attack (Table 28).

Table 28. Suggestions for improvement

Sl #	Suggestions	No. of farmers	Percentage
01	Ensure low feed price	104	35.02
02	Supply of subsidized inputs and services	61	20.54

11.3. Cage Culture

11.3.1 Descriptive statistics of the variables used in the models

Differences in selected characteristics of adopters and non-adopters are presented in Table 29. The mean difference suggested that adopters are younger and more educated compared to non-adopters. There also significant differences exist between adopters and non-adopters with respect to societal membership, and extension contact. The characteristics of adopters and non-adopters were statistically similar in terms of training, farm size and fishing experience (Table 29).

Table 29. Descriptive statistics of the socio-economic characteristics of the respondents

Characteristics	No. of practices adopted				All adopters	Non adopters	Mean diff.
	01	02	03	04			
Family member (No.)	--	4.65	4.38	4.57	4.46	3.85	0.61*
Age (yrs)	--	38.94	37.38	40.74	38.78	43.71	-4.92*
Education (yrs)	--	7.29	7.35	7.92	7.63	4	3.63***
Training (days)	--	2.59	3.19	6.07	4.40	2.42	1.97^{ns}
Farm size (ha.)	--	0.51	0.26	0.39	0.33	0.36	-0.03^{ns}
Societal membership (%)	--	58.82	34.45	55.67	44.21	7.14	37***
Extension contact (%)	--	82.35	86.55	92.78	89.27	50.00	39***
FMWCF (No.)	--	1.59	1.45	1.46	1.45	1.14	0.31**
Experience in cage	--	8.53	4.74	5.92	5.48	5.42	0.05^{ns}

Characteristics	No. of practices adopted				All adopters	Non adopters	Mean diff.
	01	02	03	04			
farming (yrs)							

Note: * and *** indicates significant at 10% and 1% level respectively; FMWCF indicates Family members working in cage farm

11.3.2 Adoption status of improved practices

It is evident from the Table 30 that most of the farmers (48.18%) adopted 3 practices followed by 39.27% who adopted all the 4 selected improved practices, respectively. No farmers adopted 1 practice and around 6% of the farmers did not adopt any of the selected improved cage cultivation practices.

Table 30. Adoption status of different improved technologies (*n* = 247)

Items	Number of technologies				
	1	2	3	4	0
No. of farmers	0	17	119	97	14
Percent of total	0	6.88	48.18	39.27	5.67

11.3.3 Factors affecting adoption

It is revealed from table 31 that the estimated pseudo R-squared value is fairly low (0.15), but the overall significance of the Poisson model, reported by the Wald chi-squared value, is satisfactory. Non-significant value of goodness of fit also indicating the good fit of the model.

Findings indicates that farmers' education, societal membership status, contact with extension and number of family members working person in the cage farm were positive and significantly influenced the adoption of improved practices while farm size of the respondents has negative effect on adoption. The negative association of farm size ($p<0.10$) may implies that the farmers who have larger amount of land for crop cultivation may not get enough time to involved in cage farming. The positive and significant association of the extension contact ($p<0.01$) suggested that exposing farmers to agricultural extension advice could help to increase the adoption of improved practices confirms the findings of DeGraft-Johnson et al., (2014) and Mensah-Bonsu et al., (2017). Adoption of new technologies requires some level of technical knowledge, direct contact with extension services increases the acquisition of relevant knowledge. Efforts are necessary to increase the number of extension personnel's in the rural areas to increase the adoption level. Societal membership ($p<0.05$) also positively influenced the adoption may be due to the fact that farmers who are engaged with different societal membership get the opportunity to meet with different peoples which may influence them to adopt new technologies.

Table 31. Factors affecting adoption decision: Poisson estimates

Variables	Unit	Coefficient	Robust SE	z
Family member	Number	0.007	0.019	0.370
Age	Years	0.001	0.003	0.470
Education	Years	0.015*	0.008	1.840
Spouse education	Years	-0.003	0.009	-0.280
Training	Days	0.011	0.007	1.600
Farm size	Hectare	-0.032*	0.020	-1.620
Societal membership	Dummy (yes/no)	0.086**	0.038	2.230
Extension contact	Dummy (yes/no)	0.227**	0.094	2.430
FMWCF	Number	0.050*	0.030	1.660
Constant		0.614	0.166	3.700
Log likelihood	-411.08			
LR chi square	30.68***			
Pseudo R^2	0.15			
Goodness of fit	104^{ns}			
No. of observations	247			

Note: FMWCF indicates Family members working in cage farm; *, ** and *** indicates significant at 10%, 5% and 1% level

11.3.4 Cost and return of cage cultivation

The findings revealed that on an average, the total cost of cage cultivation was found higher who adopted the improved practices compared to the farmers who did not adopted. These differences were statistically significant at 1% level (Table 33). Feed cost was found to be the major cost item followed by fingerling cost (Table 32).

Table 33 indicates per hectare production was significantly (P<0.01) higher for adopters (4798 kg/ha) compared to non-adopters (2634 kg/ha). As a result of higher productivity, per hectare gross and net return was also significantly (P<0.01) higher for adopters compared to non-adopters. Adoption of improved practices is capital intensive but at the same time it generates higher productivity and return, which may be useful in reducing poverty and malnutrition to some extent in the rural areas.

Table 32. Cost structure of cage cultivation (per 10 cage)

Cost items	Adopters				Non adopters
	1	2	3	4	
A. Fixed costs					
Cage preparation	--	13412	11485	9558	9963
Netting	--	4471	2094	2115	5407
Guard	--	555	691	883	558
Total fixed cost	--	18438	14270	12556	15928
B. Variable costs					
Fingerlings	--	43382	51565	47630	26596
Feed cost	--	281075	358284	447770	272075

Cost items	Adopters				Non adopters
	1	2	3	4	
Human labour	--	24173	19657	24670	22389
Fertilizer cost	--	753	742	810	1013
Lime cost	--	676	141	465	429
Cage repair	--	2412	1429	1213	1488
Total variable cost	--	352471	431818	522558	323990
Total cost (A+B)	--	370909	446088	535114	339918

Table 33. Return from cage cultivation

Items	Adopters				All adopters	Non adopters	Mean diff.
	1	2	3	4			
Production (kg)	--	3338	4549	5421	4798	2634	2164***
Ave. price (Tk/kg)	--	132	122	122	123	133	-10***
Gross return (Tk/ha)	--	440843	555412	658944	590154	350322	239832***
TVC	--	352471	431818	522558	453829	323990	129839***
TFC	--	18438	14270	12556	14720	15928	-1208ns
Total cost (Tk/ha)	--	370909	446088	535114	468548	339918	128630***
Net return (Tk/ha)	--	69934	109324	123830	121606	10404	111202***
BCR	--	1.19	1.25	1.23	1.26	1.03	--

Note: *** indicates significant at 1% level.

11.3.5 Impact of improved aquaculture technology adoption

Impact on productivity

It is evident from the table 34 that the adoption of improved practices significantly affected the productivity of cage farming. Farmers who adopted the improved practices received significantly higher per hectare yield (869 – 2668 kg/ha) compared to non-adopters which is similar to the findings of Rand and Tarp (2009) indicated that technology adoption significantly affected the productivity. The ATT values indicates that farmers who adopted more practices received higher yield compared to the farmers adopted less number of improved practices.

Table 34. Impact of improved technologies on productivity of cages

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	--	--	--
2	0	869***	172	5.06
3	0	2102***	198	10.60
4	0	2668***	339	7.88

Note: *** indicates significant at 1% level

Impact on profitability

Findings of the table 35 indicates that adopters of improved practices received significantly higher profit compared to non-adopters due to higher productivity. Farmers who adopted more number of improved practices received more income compared to the farmers who adopted less number of practices as well as non-adopters (Table 35). The values of ATT were ranged from Tk. 88111 – Tk. 119226 based on different number of adopted improved practices, which indicates that improved technologies adoption increases income. More awareness building programs along with extension services are warranted to augment the adoption process since adoption enhanced the productivity and income.

Table 35. Impact of improved technologies on profitability of cage cultivation

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	--	--	--
2	0	119226**	47275	2.52
3	0	86557*	48786	1.77
4	0	88111*	47218	1.87

Note: ** and * indicates significant at 5% and 10% level

Impact on consumption expenditure

The positive and significant values of ATT indicate that consumption expenditure of the farmers who adopted improved practice was significantly higher (Tk. 2978 – 58583) compared to non-adopters (Table 36). Sahu and Das (2015) also indicated that agriculture related technology adoption has significant and positive effect of the consumption expenditure used as a proxy of wellbeing of the farmers. The results also indicate that there were no significant differences in the consumption expenditure for the farmers who adopted 1 practice compared to who did not adopt any practice.

Table 36. Impact of improved technologies on consumption expenditure of cage farmers

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	--	--	--
2	0	2978	6481	0.46
3	0	34554***	9258	3.73
4	0	58583***	13051	4.49

Note: *** indicates significant at 1% level

Impact on household assets

The findings indicate that adoption of improved practices did not affect the household assets position of the adopters. This may be due to the fact that purchases of household assets depend on many other factors apart from aquaculture income.

Table 37. Impact of improved technologies on household assets of cage farmers

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	--	--	--
2	0	-36144 ns	65324	-0.55
3	0	41459 ns	68468	0.61
4	0	-1686 ns	57537	-0.03

Note: ns indicates not significant

Impact on livestock assets

The findings indicate that adoption of improved practices did not significantly affect the livestock assets position of the adopters. This may be due to the fact that rearing livestock is labour intensive and time consuming which may prevent the farmers to purchase livestock (Table 38).

Table 38. Impact of improved technologies on livestock asset of cage farmers

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	--	--	--
2	0	-52322 ns	33563	-1.56
3	0	-39310 ns	33764	-1.16
4	0	-20351 ns	35226	-0.58

Note: ns indicates not significant

Impact of fishing equipment

The positive values of ATT indicate that the farmers who adopted improved practices spend more money to purchase different fishing equipment (Table 39). These differences were significant at 5% level for the farmers who adopted 4 practices. This may be due to the fact that adopters received higher income compared to non-adopters which enable them to spend extra amount of money to purchase fishing equipment.

Table 39. Impact of improved technologies on purchase of fishing equipments

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	--	--	--
2	0	475	1807	0.26
3	0	1690	1559	1.08
4	0	3890**	1668	2.33

Note: ** indicates significant at 5% level

Impact on educational expenses

The ATT value of the educational expenses for the farmers who adopted 2 practices out of 4 were not significant while differences in ATT values were marginally

significant for the farmers who adopt 3 and 4 practices compared to non-adopters. It implies that farmers who adopted improved practices were spend more money on child education compared to non-adopters (Table 40).

Table 40. Impact of improved technologies on educational expenses

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	--	--	--
2	0	393	1492	0.26
3	0	1862*	990	1.88
4	0	1999*	1231	1.62

Note: * indicates significant at 10% level

11.3.6 Problems of cage culture

Among the different problems most of farmers (24.29%) opined that as cage culture is relatively a new dimension of aquaculture in Bangladesh, lack of proper technical knowhow prevented them to receive higher yield and return. Among the other barriers, flack of improved fingerlings reduced the production. Besides, about 18% farmers opined that unavailability of capital is another constraint which hampers the cage cultivation at field level (Table 41).

Table 41. Problems of cage cultivation

Sl #	Problems	No. of farmers	Percentage
01	Lack of training	60	24.29
02	Lack of improved fingerlings	55	22.27
03	Lack of capital	44	17.81

11.3.7 Suggestions

To overcome the barriers of production about 33% of the farmers mentioned the need of more training regarding production technology. About 17% of the farmers mentioned that concerned authorities may take initiatives to supply different inputs like medicine, fingerlings etc. at subsidized rate as well as extension services to reduce the disease attack. As cage culture is capital intensive, loan with low interest may influence the farmers to cultivate in future (Table 42).

Table 42. Suggestions for improvement

Sl #	Suggestions	No. of farmers	Percentage
01	More training	81	32.79
02	Supply of subsidized inputs and services	41	16.60
03	Loan with low interest	53	21.46

11.4 Shrimp farming in gher

11.4.1 Descriptive statistics of the variables used in the models

Differences in selected characteristics of adopters and non-adopters are presented in Table 43. The mean difference suggested that there are some differences between adopters and non-adopters in terms of selected household characteristics. The characteristics of adopters and non-adopters were similar for most of variables apart from societal membership ($p<0.10$), and extension contact ($p<0.01$) which indicates that the two groups are not directly comparable and justifies the use of treatment effect model.

Table 43. Descriptive statistics of the socio-economic characteristics of the respondents

Characteristics	No. of practices adopted						All adopters	Non adopters	Mean diff.
	01	02	03	04	05	06			
Family member (No.)	4.93	4.50	4.31	4.74	4.22	4.51	4.48	4.20	0.28ns
Age (yrs)	44.53	44.47	43.00	42.53	42.17	42.00	42.77	42.88	-0.11ns
Education (yrs)	8.47	5.47	7.12	7.67	7.28	8.08	7.35	6.52	0.83ns
Training (days)	10.53	0.59	2.16	4.98	5.64	6.03	4.61	1.40	3.21ns
Farm size (ha.)	0.60	0.48	0.51	0.69	0.58	0.73	0.62	0.57	0.05ns
Societal membership (%)	40	44	43	45	52	51	47	28	19*
Extension contact (%)	33	23	59	67	78	84	65	28	37***
Pond ownership (%)	47	71	58	74	60	49	61	76	-15ns
FMWCF (No.)	1.13	1.32	1.29	1.28	1.48	1.64	1.40	1.32	0.08ns
Experience in shrimp farming (yrs)	13.00	12.82	13.22	14.48	14.55	14.20	13.92	13.80	0.12ns

Note: * and *** indicates significant at 10% and 1% level; ns indicates not significant; FMWCF indicates Family members working in shrimp farm

11.4.2 Adoption status of improved practices

It is evident from the Table 44 that most of the farmers (20.33%) adopted all the 6 practices followed by 19.33% of farmers who adopted 4 and 5 practices. Around 8% of the farmers did not adopt any of the selected improved shrimp cultivation practices.

Table 44. Adoption status of different improved technologies (*n* = 300)

Items	Number of technologies						
	1	2	3	4	5	6	0
No. of farmers	15	34	49	58	58	61	25
Percent of total	5	11.33	16.33	19.33	19.33	20.33	8.33

11.4.3 Factors affecting adoption

It is revealed from table 45 that the estimated pseudo R-squared value is low (0.05), but the overall significance of the Poisson model, reported by the Wald chi-squared value, is satisfactory. Non-significant value of goodness of fit also indicating the good fit of the model.

Prawn farmers' farm size, contact with extension and number of family members working person in the farm were positive and significantly influenced the adoption of improved practices The positive and significant association of the extension contact ($p<0.01$) suggested that exposing farmers to agricultural extension advice could help to increase the adoption of improved practices confirms the findings of DeGraft-Johnson et al., (2014) and Mensah-Bonsu et al., (2017). Adoption of new technologies requires some level of technical knowledge, direct contact with extension services increases the acquisition of relevant knowledge. Efforts are necessary to increase the number of extension personnel's in the rural areas to increase the adoption level. Positive association of farm size ($p<0.10$) indicates that the large farmers were readily accepted the new technologies may be due to the fact that large farmers have enough amounts of resources to cover the risk associated with adoption of new technology. The farms which have more family supplied manpower to work in the farm also adopted more ($p<0.01$).

Table 45. Factors affecting adoption decision: Poisson estimates

Variables	Unit	Coefficient	Robust SE	z
Family member	Number	-0.017	0.017	-0.99
Age	Years	-0.002	0.003	-0.86
Education	Years	0.004	0.009	0.5
Spouse education	Years	-0.002	0.009	-0.27
Training	Days	0.003	0.004	0.79
Farm size	Hectare	0.063*	0.038	1.66
Societal membership	Dummy (yes/no)	0.045	0.051	0.88
Extension contact	Dummy (yes/no)	0.423***	0.067	6.32
Pond ownership	Dummy (yes/no)	-0.055	0.051	-1.08
FMWCF	Number	0.164***	0.037	4.45
Constant		0.913***	0.169	5.39
Log likelihood	-589.13			
LR chi square	79.10***			
Pseudo R^2	0.05			
Goodness of fit	227 ns			
No. of observations	300			

Note: FMWCF indicates Family members working in shrimp farm; * and *** indicates significant at 10% and 1% level.

11.4.4 Cost and return of shrimp cultivation

The findings revealed that on an average, the total cost of shrimp cultivation was higher for adopters compared to non-adopters (Table 47). The costs of production were gradually increased as the farmers adopted more practices than less. Among the cost items, feed cost was the major cost item followed by rental value of gher (Table 46).

Table 47 indicates that productivity was higher for adopters (421 kg/ha) than that of non-adopters (290 kg/ha). As a result of higher productivity, per hectare gross and net return was also significantly ($P<0.01$) higher for adopters compared to non-adopters. Higher production cost indicates improved practices adoption need higher capital but can generates higher production and income, which may be useful in country like Bangladesh to reduce poverty to some extent in the rural areas.

Table 46. Per hectare cost structure of shrimp cultivation

Cost items	Adopters						Non adopters
	1	2	3	4	5	6	
A. Fixed costs							
Land rent	31432	48710	50638	42862	48057	50280	46595
Gher preparation	9906	11675	13896	13696	16046	22801	15499
Netting	1593	1683	2071	2579	3740	4432	1119
Guard	1422	1130	1562	1632	1328	2202	1690
Total fixed cost	44353	63198	68167	60769	69171	79715	64903
B. Variable costs							
Fingerlings	34817	34265	33053	31866	43507	42311	20362
Feed cost	26905	41134	39296	46559	43696	60439	32781
Human labour	15637	12440	11361	13721	21828	21588	22757
Fertilizer cost	3141	1860	3587	2949	3816	3725	2568
Lime cost	915	1222	1620	1427	1702	1988	1178
Gher repair	4426	9754	5504	8919	8974	6259	6582
Water treatment	1556	619	1108	636	384	571	373
Total variable cost	87397	101294	95529	106077	123907	136881	86601
Total cost (A+B)	131750	164492	163696	166846	193078	216596	151504

Table 47. Per hectare return from shrimp cultivation

Items	Adopters						All adopters	Non adopters	Mean diff.
	1	2	3	4	5	6			
Production (kg)	233	403	398	400	456	481	421	290	131***
Ave. price (Tk/kg)	658	639	654	640	628	628	639	658	-19
Gross return (Tk/ha)	153314	257517	260292	256000	286368	302068	269019	190820	78199***
TVC	87397	101294	95529	106077	123907	136881	113445	86601	26844**

Items	Adopters						All adopters	Non adopters	Mean diff.
	1	2	3	4	5	6			
TFC	44353	63198	68167	60769	69171	79715	67236	64903	2333
Total cost (Tk/ha)	131750	164492	163696	166846	193078	216596	180681	151504	29177**
Net return (Tk/ha)	21564	93025	96596	89154	93290	85472	88338	39316	49022***
BCR	1.16	1.57	1.59	1.53	1.48	1.39	1.49	1.26	--

Note: ** and *** indicates significant at 5% and 1% level.

11.4.5 Impact of improved aquaculture technology adoption

Impact on productivity

It is evident from the table 48 that the farmers who adopted 1 improved practice out of the 6 selected practices received similar per hectare yield compared to non-adopters. Farmers who adopted 2-6 number of improved practices received significantly higher per hectare yield (142 – 175 kg/ha) compared to non-adopters which is similar to the findings of Rand and Tarp (2009) indicated that technology adoption significantly affected the productivity. The ATT values indicates that farmers who adopted more practices received higher yield compared to the farmers adopted less number of improved practices.

Table 48. Impact of improved technologies on productivity of shrimps

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	-17.11	31.42	-0.54
2	0	163.08***	35.60	4.58
3	0	149.44***	33.10	4.52
4	0	165.56***	40.89	4.05
5	0	142.98***	35.37	4.04
6	0	175.74***	52.11	3.37

Note: *** indicates significant at 1% level

Impact on profitability

Findings of the table 49 indicates that apart from the adopters of 1 improved practices, all the other category of adopters received significantly higher per hectare profit compared to non-adopters due to significantly higher productivity. Amankwah and Quagrainie (2017) also found that improved fish technology adoption increases the income from fish cultivation. Farmers who adopted more number of improved practices received more income compared to the farmers who adopted less number of practices as well as non-adopters. The values of ATT were ranged from Tk. 25321 – Tk. 75351 based on different number of adopted improved practices. More awareness building programmes along with extension services are warranted to augment the adoption process since adoption enhanced the productivity and income.

Table 49. Impact of improved technologies on profitability of shrimp cultivation

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	5150.61	9994.45	0.52
2	0	56626.05***	10916.82	5.19
3	0	75351.41***	13387.76	5.63
4	0	69277.57***	16726.07	4.14
5	0	36718.29*	21135.73	1.74
6	0	25321.29**	11239.11	2.25

Note: *, ** and *** indicates significant at 10%, 5% and 1% level

Impact on consumption expenditure

The positive and significant values of ATT indicate that consumption expenditure of the farmers who adopted 1 improved practice was significantly higher (Tk. 20776) compared to non-adopters (Table 50). Sahu and Das (2015) also indicated that agriculture related technology adoption has significant and positive effect of the consumption expenditure used as a proxy of well being of the farmers. The findings of the present study may indicate that adoption improved practices can play a vital role in the anti-poverty policies of Bangladesh. The other ATT values were found to be positive but not significant. May be the shrimp farmers spend their fish income for different purposes which were not considered in the analysis.

Table 50. Impact of improved technologies on consumption expenditure of shrimp farmers

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	20776.84*	12011.87	1.73
2	0	973.13	10240.12	0.10
3	0	9616.04	9945.79	0.97
4	0	14207.64	13293.89	1.07
5	0	1138.31	8230.73	0.14
6	0	10969.11	10889.45	1.01

Note: * indicates significant at 10% level

Impact on household assets

The findings indicate that adoption of improved practices positively affected the household assets position of the adopters. The ATT values were ranged from Tk. 43674 – 193465 (Table 51). These differences were significant for the farmers who adopted 1, 3 and 4 numbers of practices. The findings may also imply that the shrimp farmers were more interested to spend their income on household assets rather than on consumption.

Table 51. Impact of improved technologies on household assets of shrimp farmers

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	102807.10**	41750.46	2.46
2	0	177839.90	123732.20	1.44
3	0	193465.40***	50573.71	3.83
4	0	123586.90***	40630.88	3.04
5	0	100898.90	73041.42	1.38
6	0	43674.23	37176.43	1.18

Note: ** and *** indicates significant at 5% and 1% level

Impact on livestock assets

The findings indicate that adoption of improved practices did not affect the livestock assets position of the adopters. This may be due to the fact that rearing livestock is labor intensive and time consuming which may prevent the fish farmers to purchase livestock.

Table 52. Impact of improved technologies on livestock asset of shrimp farmers

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	-25893.03ns	29254.53	-0.89
2	0	-26333.12ns	31848.68	-0.83
3	0	-8667.59ns	30591.39	-0.28
4	0	-19800.64ns	27080.32	-0.73
5	0	-8449.93ns	32408.18	-0.26
6	0	-4901.99ns	27292.90	-0.18

Impact of fishing equipment

The findings indicate that adoption of improved practices did not have any significant effect on the purchase of fishing equipments. This may be due to the fact that the adopters may already have the required number of fishing equipments which may prevent them to buy the new one during the last one year (Table 53).

Table 53. Impact of improved technologies on purchase of fishing equipments

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	352.05ns	2264.58	0.16
2	0	-282.61ns	2529.18	-0.11
3	0	-2031.13ns	2240.29	-0.91
4	0	2920.91ns	2847.22	1.03
5	0	431.53ns	2759.94	0.16
6	0	-867.04ns	2191.18	-0.40

Impact on educational expenses

The ATT values of the educational expenses were negative for the farmers who adopted 1 - 4 number of improved practices but statistically not significant (Table 54). Similarly, educational expenses for adopters of 5 and 6 numbers of practices were positive and higher compared to non-adopters but statistically not significant. This may indicate that education expenses depend on diversified factors which were not considered in the analysis. The farmers who adopted more practices may not have enough school going child in the family which may resulted as non-significant effect.

Table 54. Impact of improved technologies on educational expenses

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	-1733.29ns	4916.90	-0.35
2	0	-7049.56ns	5322.39	-1.32
3	0	-6490.97ns	5507.94	-1.18
4	0	-3314.36ns	5436.66	-0.61
5	0	2068.05ns	8068.75	0.26
6	0	1266.26ns	7230.81	0.18

11.4.6 Problems in shrimp culture

Yet shrimp cultivation is profitable and improves the livelihood status of the farmers but it has some constraints which should not be ignored. Among the constraints, frequent attack of diseases was the major barrier and about 36% farmers' responses regarding this problem. Besides, 30 % farmers opine that unavailability of improved fingerlings is another constraint which hampers the prawn cultivation at field level. Low yield (9.67%) and lack of training (9.33%) are few other concerns for the farmers (Table 55).

Table 55. Problems of shrimp cultivation

Sl #	Problems	No. of farmers	Percentage
01	Frequent attack of diseases	109	36.33
02	Low yield	29	9.67
03	Lack of training	28	9.33
04	Lack of improved fingerlings	90	30.00
05	High price of feed	19	6.33

11.4.7 Suggestions

To overcome the barriers of production about 35% of the farmers mentioned that concerned authorities may take initiatives to supply different production inputs at subsidized rate as well as extension services to reduce the disease attack and increase yield. To increase the yield and knowledge of the farmers regarding production technology more training (27%) should be arranged. Government should take necessary action to ensure reasonable price so that the shrimp farmers can continue their operation in future (Table 56).

Table 56. Suggestions for improvement

Sl #	Suggestions	No. of farmers	Percentage
01	More training	81	27.00
02	Supply of subsidized inputs and services	99	34.49
03	Ensure good price of shrimp	53	17.67

11.5. Fresh water prawn farming in gher

11.5.1 Descriptive statistics of the variables used in the models

Differences in selected characteristics of adopters and non-adopters are presented in Table 57. The mean difference suggested that there are some differences between adopters and non-adopters in terms of selected household characteristics. The characteristics of adopters and non-adopters were similar in terms of family members, age, training, societal membership, and fishing experience. But significant differences exist between adopters and non-adopters with respect to farm size ($p<0.10$), and extension contact ($p<0.01$) which indicates that the two groups are not directly comparable and justifies the use of treatment effect model.

Table 57. Descriptive statistics of the socio-economic characteristics of the respondents

Characteristics	No. of practices adopted						All adopters	Non adopters	Mean diff.
	01	02	03	04	05	06			
Family member (No.)	3.85	3.84	4.82	4.52	4.27	4.33	4.32	3.95	0.37
Age (yrs)	45.74	43.19	44.33	40.71	43.49	36.63	41.85	41.10	0.75
Education (yrs)	6.07	7.54	8.06	8.07	7.18	7.62	7.52	8.43	-0.91
Training (days)	2.41	3.70	3.65	2.43	4.12	5.63	3.88	3.69	0.19
Farm size (ha.)	0.72	0.97	1.00	0.73	0.78	0.87	0.85	0.48	0.37*
Societal membership (%)	22	38	43	45	65	62	49	43	6.00
Extension contact (%)	7	24	41	60	61	77	50	19	31.00***
Pond ownership (%)	70	57	71	55	53	67	62	57	5.00
FMWCF (No.)	1.30	1.16	1.29	1.31	1.63	1.60	1.41	1.33	0.08
Experience in prawn farming (yrs)	10.52	12.68	11.65	11.83	11.82	14.22	12.32	9.29	3.03

Note: * and *** indicates significant at 10% and 1% level; FMWCF indicates family members working in prawn farm

11.5.2 Adoption status of improved practices

It is evident from the Table 58 that most of the farmers (20.91%) adopted all the 6 practices followed by 17.77% and 17.07% of farmers who adopted 5 and 3 practices, respectively. Around 7% of the farmers did not adopted any of the selected improved prawn cultivation practices.

Table 58. Adoption status of different improved technologies (*n* = 287)

Items	Number of practices						
	1	2	3	4	5	6	0
No. of farmers	27	37	49	42	51	60	21
Percent of total	9.41	12.89	17.07	14.63	17.77	20.91	7.32

11.5.3 Factors affecting adoption

It is revealed from table 59 that the estimated pseudo R-squared value is low (0.10), but the overall significance of the Poisson model, reported by the Wald chi-squared value, is satisfactory. Non-significant value of goodness of fit also indicating the good fit of the model.

Prawn farmers' societal membership status contact with extension and number of family members working person in the prawn farm were positive and significantly influenced the adoption of improved practices while age of the respondents has negative effect on adoption. The negative association of age may be implied that the older farmers are unwilling to accept improved technologies, because they are afraid of risks involved with new technologies which confirms the findings of Maduakor (2001) and Ofuoku et al., (2008). This may also indicate that extension approach of trained the older farmers may not be useful rather younger farmers may be selected for training as they ready to accept any new technology. The positive and significant association of the extension contact ($p<0.01$) suggested that exposing farmers to agricultural extension advice could help to increase the adoption of improved practices confirms the findings of DeGraft-Johnson et al., (2014) and Mensah-Bonsu et al., (2017). Adoption of new technologies requires some level of technical knowledge, direct contact with extension services increases the acquisition of relevant knowledge. Efforts are necessary to increase the number of extension personnel's in the rural areas to increase the adoption level. Societal membership ($p<0.05$) also positively influenced the adoption may be due to the fact that farmers who are engaged with different societal membership get the opportunity to meet with different peoples which may influence them to adopt new technologies.

Table 59. Factors affecting adoption decision: Poisson estimates

Variables	Unit	Coefficient	Robust SE	z
Family member	Number	-0.008	0.022	-0.38
Age	Years	-0.007***	0.002	-3.10
Education	Years	-0.007	0.008	-0.82
Spouse education	Years	-0.002	0.010	-0.16
Training	Days	0.001	0.002	0.60
Farm size	Hectare	0.009	0.030	0.29
Societal membership	Dummy (yes/no)	0.138**	0.061	2.28
Extension contact	Dummy (yes/no)	0.409***	0.062	6.56
Pond ownership	Dummy (yes/no)	0.016	0.055	0.29
FMWCF	Number	0.100**	0.040	2.50
Constant		1.209	0.157	7.69

Variables	Unit	Coefficient	Robust SE	z
Log likelihood	-562.76			
LR chi square	103.49***			
Pseudo R^2	0.10			
Goodness of fit	232 ns			
No. of observations	287			

Note: FMWCF indicates Family members working in prawn farm; ** and *** indicates significant at 5% and 1% level; ns indicates not significant

11.5.4 Cost and return of prawn cultivation

The findings revealed that on an average, the total cost of prawn cultivation was found higher who adopted the improved practices compared to the farmers who did not adopted. These differences were statistically significant at 5% level (Table 61). Among the cost items, feed cost was the major cost item followed by rental value of gher (Table 60).

Table 61 indicates per hectare production was found significantly (P<0.01) higher for adopters (630 kg/ha) than that of non-adopters (376 kg/ha). As a result of higher productivity, per hectare gross and net return was also significantly (P<0.01) higher for adopters compared to non-adopters. The findings indicate that although the adoption of improved practices need higher capital investment but at the same time it provided significantly higher income which may be useful in reducing poverty and malnutrition to some extent in the rural areas.

Table 60. Per hectare cost structure of prawn cultivation

Cost items	Adopters						Non adopters
	1	2	3	4	5	6	
A. Fixed costs							
Land rent	66048	75712	65223	55304	55091	57317	56547
Gher preparation	11020	21454	13972	20475	25664	31904	14345
Netting	1625	1811	1926	3295	3655	7760	2070
Guard	2929	2504	1666	1627	2194	1866	1565
Equipment	1840	2495	3313	2763	2515	3236	1821
Total fixed cost	83462	103976	86100	83464	89119	102083	76348
B. Variable cost							
Fingerlings	31890	38404	38882	46100	57942	48036	36329
Feed cost	63584	94106	67339	67412	80743	84726	42181
Human labour	40408	60001	38431	35003	56126	31153	26243
Fertilizer cost	9612	7300	8833	5266	4252	4521	9361
Lime cost	3749	3371	3478	3094	3090	2628	3724
Pesticide cost	2313	1706	742	1254	1629	3073	1027
Gher repair	9524	7707	9166	7186	11959	7732	10383
Water treatment	1508	2920	1373	1745	1584	1475	1619
Total variable cost	162588	215515	168244	167060	217325	183344	130867
Total cost (A+B)	246050	319491	254344	250524	306444	285427	207215

Table 61. Per hectare return from prawn cultivation

Items	Adopters						All adopters	Non adopters	Mean diff.
	1	2	3	4	5	6			
Production (kg)	482	654	546	601	700	711	630	376	254***
Ave. price (Tk/kg)	640	706	647	633	635	621	643	627	16
Gross return (Tk/ha)	308480	461724	353262	380433	444500	441531	405090	235752	169338***
TVC	162588	215515	168244	167060	217325	183344	186344	130867	55477**
TFC	83462	103976	86100	83464	89119	102083	93180	76348	16832*
Total cost (Tk/ha)	246050	319491	254344	250524	306444	285427	279525	207215	72310**
Net return (Tk/ha)	62430	142233	98918	129909	138056	156104	125565	28537	97028***
BCR	1.25	1.45	1.39	1.52	1.45	1.55	1.45	1.14	--

Note: *, ** and *** indicates significant at 10%, 5% and 1% level.

11.5.5 Impact of improved aquaculture technology adoption

Impact on productivity

It is evident from the table 62 that the adoption of improved practices significantly affected the productivity of prawn. Farmers who adopted the improved practices received significantly higher per hectare yield (115 – 602 kg/ha) compared to non-adopters which is similar to the findings of Rand and Tarp (2009) indicated that technology adoption significantly affected the productivity. The ATT values indicates that farmers who adopted more practices received higher yield compared to the farmers adopted less number of improved practices.

Table 62. Impact of improved technologies on productivity of prawns

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	115.30***	26.38	4.37
2	0	195.46**	80.65	2.42
3	0	162.74***	36.55	4.45
4	0	217.32***	42.06	5.17
5	0	369.01***	51.80	7.12
6	0	602.29***	83.49	7.21

Note: ** and *** indicates significant at 5% and 1% level

Impact on profitability

Findings of the table 63 indicates that all category of adopters of improved practices received significantly higher per hectare profit compared to non-adopters due to higher productivity. Amankwah and Quagrainie (2017) also found that improved fish technology adoption increases the income from fish cultivation. Farmers who adopted

a greater number of improved practices received more income compared to the farmers who adopted less number of practices as well as non-adopters. The values of ATT were ranged from Tk. 34658 – Tk. 245789 based on different number of adopted improved practices. More awareness building programs along with extension services are warranted to augment the adoption process since adoption enhanced the productivity and income.

Table 63. Impact of improved technologies on profitability of prawn cultivation

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	34658.40**	17926.27	1.93
2	0	79785.00***	30345.00	2.63
3	0	79955.84***	20848.44	3.84
4	0	125197.00***	29723.55	4.21
5	0	143284.40***	30242.96	4.74
6	0	245789.50***	32389.30	7.59

Note: ** and *** indicates significant at 5% and 1% level

Impact on consumption expenditure

The positive and significant values of ATT indicate that consumption expenditure of the farmers who adopted improved practice was significantly higher (Tk. 11440 – 25116) compared to non-adopters (Table 64). Sahu and Das (2015) also indicated that agriculture related technology adoption has significant and positive effect of the consumption expenditure used as a proxy of well being of the farmers. The findings of the present study may indicate that adoption improved practices can play a vital role in the anti-poverty policies of Bangladesh.

Table 64. Impact of improved technologies on consumption expenditure of prawn farmers

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	11440.98***	3270.73	3.50
2	0	19944.23***	3326.52	6.00
3	0	17785.28***	5966.42	2.98
4	0	25116.73***	6725.06	3.73
5	0	11679.10**	4895.10	2.39
6	0	24224.71***	6298.65	3.85

Note: ** and *** indicates significant at 5% and 1% level

Impact on household assets

The findings indicate that adoption of improved practices did not affected the household assets position of the adopters. This may be due to the fact that purchases of household assets depend on many other factors apart from fish income (Table 65).

Table 65. Impact of improved technologies on household assets of prawn farmers

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	64132.85ns	44956.25	1.43
2	0	57179.05ns	52967.77	1.08
3	0	-2456.90ns	56350.09	-0.04
4	0	-48062.91ns	40837.99	-1.18
5	0	-15638.21ns	57126.44	-0.27
6	0	-54882.59ns	44857.73	-1.22

Impact on livestock

The positive value of ATT indicates that the farmers who adopted improved practices owned more livestock compared to non-adopters (Table 66). This also implies that prawn farmers are investing their income to other agricultural sector which may further improve their standard of living and this diversification may also work as a risk reduction strategy for the prawn cultivars.

Table 66. Impact of improved technologies on livestock asset of prawn farmers

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	51380.50***	19921.80	2.58
2	0	42476.30***	16122.04	2.63
3	0	41104.80**	16281.32	2.52
4	0	13861.36	19033.44	0.73
5	0	25746.16*	15268.65	1.69
6	0	51543.22**	20624.30	2.50

Note: *, ** and *** indicates significant at 10%, 5% and 1% level

Impact of fishing equipment

The positive values of ATT indicate that the farmers who adopted improved practices spend more money to purchase different fishing equipments (Table 67). These differences were significant at 5% level for the farmers who adopted 3 practices. This may be due to the fact that adopters received higher net return compared to non-adopters which enable them to spend extra amount of money to purchase fishing equipments.

Table 67. Impact of improved technologies on purchase of fishing equipments

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	1279.11	853.01	1.50
2	0	810.06	979.65	0.83
3	0	1901.52**	894.46	2.13
4	0	465.71	473.49	0.98

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
5	0	71.52	354.04	0.20
6	0	350.18	405.98	0.86

Note: ** indicates significant at 5% level

Impact on educational expenses

The ATT value of the educational expenses for the farmers who adopted 1 practice out of 6 were significant indicates that farmers spending more money on child education compared to non-adopters. The findings also indicate that the differences in ATT values were not significant for other category of adopters (Table 68). This may be for the fact that apart from technology adoption, education depends on many diversified factors which were not considered in the analysis. The farmers who adopted more practices may not have enough school going child in the family which may resulted as non-significant effect.

Table 68. Impact of improved technologies on educational expenses

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	4603.19*	2511.03	1.83
2	0	2912.40	2364.70	1.23
3	0	1242.22	1561.55	0.80
4	0	620.15	1172.24	0.53
5	0	977.03	815.62	1.20
6	0	382.22	1407.52	0.27

Note: * indicates significant at 10% level

11.5.6 Problems in prawn culture

Yet prawn cultivation is profitable and improves the livelihood status of the farmers, but it has some constraints which should not be ignored. Among the constraints, frequent attack of diseases was the major barrier and about 44 % farmers' responses regarding this problem. Besides, 23 % farmers opine that unavailability of improved fingerlings is another constraint which hampers the prawn cultivation at field level. Low market price (21%) is also creates difficulty in production. In addition, lack of training (12.20%) and lack of capital (12.89%) are few other concerns for the farmers (Table 69).

Table 69. Problems of prawn cultivation

Sl #	Problems	No. of farmers	Percentage
01	Frequent attack of diseases	125	43.55
02	Lack of capital	37	12.89
03	Lack of training	35	12.20
04	Lack of improved fingerlings	67	23.34
05	Low market price	61	21.25
06	Lack of transportation facilities	45	15.68

11.5.7 Suggestions

To overcome the barriers of production about 45% of the farmers mentioned that concerned authorities may take initiatives to supply different inputs like medicine, fingerlings etc. at subsidized rate as well as extension services to reduce the disease attack. To increase the knowhow of the farmers more training (35.89%) should be arranged. Government should take necessary action to ensure reasonable price so that the prawn farmers can continue their operation in future (Table 70).

Table 70. Suggestions for improvement

Sl #	Suggestions	No. of farmers	Percentage
01	More training	103	35.89
02	Supply of subsidized inputs and services	128	44.59
03	Ensure good price of prawn	72	25.09
04	Loan with low interest	25	8.71

11.6. Fattening of crabs

11.6.1 Descriptive statistics of the variables used in the models

Differences in selected characteristics of adopters and non-adopters are presented in Table 71. The socio-economic characteristic indicates that adopters are more experienced and educated compared to non-adopters. The analysis also suggested that the farmers who have own pond are adopted more. The mean difference also suggested that adopters and non-adopters were similar in terms of family members, training, farm size, societal membership, extension contact and experience.

Table 71. Descriptive statistics of the socio-economic characteristics of the respondents

Characteristics	No. of practices adopted						All adopters	Non adopters	Mean diff.
	01	02	03	04	05	06			
Family member (No.)	4.36	3.95	3.89	3.93	4.02	4.30	4.04	3.92	0.12^{ns}
Age (yrs)	38.82	40.57	38.30	38.50	40.95	42.79	40.02	32.19	7.82***
Education (yrs)	5.82	6.33	5.89	7.45	8.04	10.15	7.36	6.04	1.32*
Training (days)	0.91	0.79	0.98	1.45	2.80	5.79	2.21	1.15	1.05^{ns}
Farm size (ha.)	0.79	0.45	0.25	0.42	0.54	0.70	0.49	0.46	0.03^{ns}
Societal membership (%)	27	48	34	45	65	66	49	58	-9^{ns}
Extension contact (%)	50	67	58	84	84	87	73	65	8^{ns}
Pond ownership (%)	68	55	59	64	64	68	61	23	38***
FMWCF (No.)	1.45	1.50	1.67	1.77	1.67	1.53	1.62	1.62	0.0^{ns}
Experience in crab farming (yrs)	7.05	8.00	6.89	6.41	7.76	8.00	7.36	7.35	0.01^{ns}

Note: * and *** indicates significant at 10% and 1% level; FMWCF indicates family members working in crab farming

11.6.2 Adoption status of improved practices

It is evident from the Table 72 that most of the farmers (21.33%) adopted 3 practices out of the selected 6 improved crab cultivation practices followed by 18.33% of farmers who adopted 5 practices. About 16% of the farmers adopted all the 6 practices while only around 9% of the farmers did not adopted any of the selected improved crab cultivation practices.

Table 72. Adoption status of different improved technologies (n = 300)

Items	Number of practices						
	1	2	3	4	5	6	0
No. of farmers	22	42	64	44	55	47	26
Percent of total	7.33	14	21.33	14.67	18.33	15.67	8.67

11.6.3 Factors affecting adoption

It is revealed from table 73 that the estimated pseudo R-squared value is low (0.06), but the overall significance of the Poisson model, reported by the Wald chi-squared value, is satisfactory. Non-significant value of goodness of fit also indicating the good fit of the model.

Crab farmers' age, education, training, contact with extension and pond ownership were positive and significantly influenced the adoption of improved aquaculture practices. The positive and significant association of the extension contact and training suggested that exposing farmers to agricultural extension advice and training could help to increase the adoption of improved practices. Extension contact and training enable the crab farmers to acquire knowledge, which may augment the adoption decision (DeGraft-Johnson et al., 2014; Mensah-Bonsu et al., 2017). Positive and significant value of age indicates that older farmers were the one most likely to adopt improved practices which confirm the findings of Isoto et al. (2014). This may be due to the fact that crab farming is comparatively new technology in Bangladesh which requires experience. Educated farmers were adopted more. The farmers who have their own pond also adopted more. The extension approach may need modification targeting owners of pond rather than lease farmers to increase adoption.

Table 73. Factors affecting adoption decision: Poisson estimates

Variables	Unit	Coefficient	Robust SE	z
Family member	Number	-0.021	0.026	-0.810
Age	Years	0.007***	0.003	2.910
Education	Years	0.040***	0.009	4.600
Spouse education	Years	0.004	0.008	0.470
Training	Days	0.031***	0.006	5.430
Farm size	Hectare	0.007	0.032	0.210
Societal membership	Dummy (yes/no)	-0.018	0.058	-0.320
Extension contact	Dummy (yes/no)	0.202***	0.072	2.820
Pond ownership	Dummy (yes/no)	0.135**	0.056	2.410

Variables	Unit	Coefficient	Robust SE	z
FMWCF	Number	0.047	0.034	1.410
Constant		0.315*	0.170	1.850
Log likelihood	-575.18			
LR chi square	136.17***			
Pseudo R^2	0.06			
Goodness of fit	228.9^{ns}			
No. of observations	300			

Note: FMWCF indicates Family members working in crab farm

11.6.4 Cost and return of crab cultivation

On an average, the total cost of crab cultivation was found higher who adopted higher number of improved practices compared to the farmers who adopted less. Among the cost items, feed cost was the major cost item followed by crab fingerlings cost (Table 74).

Table 75 indicates that total cost of production was significantly (P<0.01) higher for adopters (Tk 548946/ha) compared to non-adopters (Tk. 289959/ha), which indicate adoption of improved practices is cost intensive. Per hectare production was also found to be significantly higher for adopters (1427 kg/ha) than that of non-adopters (767 kg/ha). As a result of higher productivity, per hectare gross and net return was also significantly (P<0.01) higher for adopters compared to non-adopters. Higher income may play a vital role in increasing the livelihood status of the crab farmers in the study areas.

Table 74. Per hectare cost structure of crab cultivation

Cost items	Adopters						Non adopters
	1	2	3	4	5	6	
Fixed costs							
Land rent	79683	82920	75616	83521	78045	76198	69173
Pond preparation	20298	20798	20945	26873	25940	31149	14709
Netting	19213	17932	15031	15506	18686	14106	15600
Bamboo fencing	22666	29734	33191	23627	37844	38334	36374
Guard	2805	9761	2114	5494	8158	4303	3940
Equipments	795	2768	1103	2493	2753	1545	922
Total fixed cost	145462	163914	148000	157514	171425	165635	140718
Variable costs							
Crabs	71774	151751	207063	248610	233084	313519	60091
Feed cost	117153	75703	106155	163830	190076	131991	60327
Human labour	43862	32872	60179	33301	76418	75765	10655
Fertilizer cost	558	344	302	675	1405	344	583
Lime cost	2483	1686	1586	2009	3150	2122	1788
Electricity	--	122	234	127	119	365	--
Pond repair	6495	9510	11369	13530	17500	8250	14093
Water treatment	1586	1226	1827	2028	7770	1885	1703
Total variable cost	243909	273214	388715	464110	547522	534241	149241
Total cost (A+B)	389371	437128	536715	621624	700947	699876	289959

Table 75. Per hectare return from crab cultivation

Items	Adopters						All adopters	Non adopters	Mean diff.
	1	2	3	4	5	6			
Production (kg)	973	1054	1404	1438	1677	1701	1427	767	705***
Ave. price (Tk/kg)	681	640	654	681	669	684	667	688	-21^{ns}
Gross return (Tk/ha)	662441	674658	918653	979576	1122215	1164131	943871	528186	415685***
TVC	243909	273214	388715	464110	547522	534241	387882	149241	238641***
TFC	145462	163914	148000	157514	171425	165635	161064	140718	20346^{ns}
Total cost(Tk/ha)	389371	437128	536715	621624	700947	699876	548946	289959	259351***
Net return (Tk/ha)	273070	237530	381938	357952	421268	464255	394925	238227	156698***
BCR	1.70	1.54	1.71	1.58	1.60	1.66	1.72	1.82	--

Note: *** indicates significant at 1% level.

11.6.5 Impact of improved aquaculture technology adoption

Impact on productivity

It is evident from the table 76 that the adoption of improved practices significantly affected the productivity of crab. Adoption of 1 and 2 number of improved practices did not affected the productivity but the farmers who adopted 3, 4, 5 and 6 number of improved practices received significantly higher per hectare yield (473 – 942 kg) compared to non-adopters, which is similar to the findings of Rand and Tarp (2009) indicated that technology adoption significantly affected the productivity. The values of ATT were significant at 1% level.

Table 76. Impact of improved technologies on productivity of crabs

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	9.41	116.69	0.08
2	0	105.53	106.93	0.99
3	0	473.21***	112.36	4.21
4	0	696.08***	166.13	4.19
5	0	822.11***	153.60	5.35
6	0	942.55***	230.59	4.09

Note: *** indicates significant at 1% level

Impact on profitability

Findings of the table 77 indicates that all category of adopters of improved practices received significantly higher per hectare profit compared to non-adopters due to higher productivity. It is also evident that the farmers who adopted more number of improved practices received more income compared to the farmers who adopted less number of practices as well as non-adopters. The values of ATT were ranged from

Tk. 74063 – Tk. 332319 based on different number of adopted improved practices. More awareness building programs and trainings are warranted to augment the adoption process since adoption enhanced the productivity and income.

Table 77. Impact of improved technologies on profitability of crab cultivation

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	74063.00*	44007.10	1.68
2	0	103871.80**	45358.27	2.29
3	0	230736.00***	50928.04	4.53
4	0	235519.70***	53200.76	4.43
5	0	332319.70***	118565.70	2.80
6	0	203136.50***	58960.27	3.45

Note: *, ** and *** indicates significant at 10%, 5% and 1% level

Impact on consumption expenditure

The positive and significant values of ATT indicate that consumption expenditure, used as proxy of wellbeing, of the farmers who adopted improved practice was higher (Tk. 14403 – 25357) compared to non-adopters (Table 78). The findings of the present study may indicate that adoption improved practices can play a vital role in improving the wellbeing and livelihood of the crab farmers in Bangladesh.

Table 78. Impact of improved technologies on consumption expenditure of crab farmers

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	17585.87**	7580.52	2.32
2	0	21777.97***	8440.12	2.58
3	0	25357.71***	7176.20	3.53
4	0	14403.76*	7793.73	1.85
5	0	18368.18***	6955.85	2.64
6	0	28183.15**	13292.16	2.12

Note: *, ** and *** indicates significant at 10%, 5% and 1% level

Impact on household assets

The findings indicate that adoption of improved practices did not have any significant effect on the household assets position of the adopters. This may be due to the fact that purchases of household assets need higher investment which depends on many other factors (Table 79).

Table 79. Impact of improved technologies on household assets of crab farmers

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	15451.98^{ns}	32568.98	0.47
2	0	26178.94^{ns}	31500.29	0.83
3	0	1806.63^{ns}	16498.38	0.11
4	0	6842.80^{ns}	16460.93	0.42
5	0	23305.11^{ns}	30478.59	0.76
6	0	22531.10^{ns}	29206.21	0.77

Note: ns indicates not significant

Impact on livestock

The positive value of ATT indicates that the farmers who adopted 1 practice owned more livestock compared to non-adopters which is marginally significant (Table 80). Apart from that there were no significant differences between the two categories of farmers indicated adoption did not have any significant effect on the livestock assets.

Table 80. Impact of improved technologies on livestock asset of crab farmers

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	31645.97*	16438.82	1.93
2	0	18994.95^{ns}	11910.14	1.59
3	0	17481.92^{ns}	11298.34	1.55
4	0	7246.61^{ns}	12423.62	0.58
5	0	7984.31^{ns}	10793.49	0.74
6	0	44160.73^{ns}	32108.52	1.38

Note: * indicates significant at 10% level; ns indicates not significant

Impact of fishing equipment

It is evident from table 81 that the farmers who adopted improved practices spend more money (Tk. 885 – 2857) to purchase different fishing equipment (Table 81). This is due to the fact that adopters received higher net return compared to non-adopters and may spend extra amount of money to purchase fishing equipment.

Table 81. Impact of improved technologies on purchase of fishing equipments

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	1108.26*	569.95	1.94
2	0	885.54*	518.71	1.71
3	0	885.86*	471.58	1.88
4	0	1813.84*	1046.85	1.73
5	0	2857.22***	910.84	3.14
6	0	1875.99***	689.38	2.72

Note: *, and *** indicates significant at 10% and 1% level

Impact on educational expenses

The ATT values of the educational expenses for the farmers who adopted 5 and 6 number of practices were not significant whereas the farmers who adopted less number practices significantly spend more amount of money on child education compared to non-adopters. Expenses on education depends on many other factors which were not considered in the analysis. The farmers who adopted more practices may not have enough school going child in the family which may resulted as non-significant effect (Table 82).

Table 82. Impact of improved technologies on educational expenses

Number of practices adopted		ATT	SE	z
Adopters	Non-adopters			
1	0	2509.95*	1435.13	1.75
2	0	1391.40*	865.93	1.60
3	0	3355.35**	1399.78	2.40
4	0	2971.53**	1348.03	2.20
5	0	1501.92^{ns}	1309.49	1.15
6	0	1078.98^{ns}	1333.13	0.81

Note: *, and ** indicates significant at 10% and 5% level; ns indicates not significant

11.6.6 Problems in crab fattening

Yet crab fattening is profitable at farm level, but it has some constraints which should not be ignored. Among the constraints, frequent attack of diseases was the major barrier and about 53 % farmers' responses regarding this problem. Besides, about 20% farmers opine that lack of improved crab fingerlings is another constraint, which hampers the adoption of crab improved practices at field level. In addition, lack of training (10.67%) and lack of capital (12%) are few other concerns for the farmers (Table 83).

Table 83. Problems of crab cultivation

Sl #	Problems	No. of farmers	Percentage
01	Frequent attack of diseases	158	52.67
02	Lack of capital	36	12.00
03	Lack of training	32	10.67
04	Lack of improved fingerlings	59	19.67

11.6.7 Suggestions

To overcome the barriers of production about 34% of the farmers mentioned that supply of different production inputs along with extension services are necessary to reduce the frequent disease attack. Training may also play a vital role in improving the situation as opined by 28% of the respondents. According to the farmers' opinion, loan with low interest (7%) may also augment the adoption of crab culture since adoption of improved practices are cost intensive (Table 84).

Table 84. Suggestions for improvement

Sl #	Suggestions	No. of farmers	Percentage
01	More training	85	28.33
02	Supply of subsidized inputs and services	102	34.00
03	Availability of diseases free improve fingerlings	27	9.00
04	Loan with low interest	21	7.00

12. Research highlight/findings:

- The study found that adopters were more educated and comparatively younger than non-adopters for most of the selected technologies.
- Although most of farmers adopted the selected improved practices but still there is an ample scope to improve the situation converting the non-adopters into adopters. This warranted for more awareness building programmes, training and field days.
- Among the different variables' education, training and extension contact positively influenced the adoption decision.
- Total cost of production was higher for adopters. But, at the same time, productivity and net return was also found higher for adopters compared to non-adopters. This indicates that adopters may not have the cost advantage but higher productivity and net return augmented the adoption process.
- Treatment effect analysis also suggested that adopters were received significantly higher productivity and profitability.
- The findings of the study also indicate that consumption expenditure, used as a proxy of wellbeing of a farmer, is significantly higher for adopters, compared to non-adopters.
- ATT values of household and livestock assets were positive but not significant indicates that fish farmers were not much interested to spend their income for household asset and livestock.
- Among the different constraints, farmers of all the technologies faced few common constraints such as, unavailability of improved fingerlings, lack of technical knowhow, unavailability of field level extension services, low price of fish.

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment	Procured	**118000**	100%	**117119**	All capital items have been procured prior approval of
Furniture					
(i) Executive Chair	01	10000			
(ii) Visitor Chair	06	24000			
(iii) Computer Table	02	10000			
iv) Computer Chair	02	6000			

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
v) File Cabinet	01	20000			procurement plan by PIU-BARC, NATP-2 and SAURES
vi) Steel Almira	02	48000			
Computer and Accessories		**230000**		**229000**	
i) Desktop Computer	02	120000			
ii) Laptop	01	60000			
iii) Laser Printer	01	20000			
iv) UPS	02	20000			
iv) Scanner	01	10000			
(b) Lab &field equipment					
(c) Other capital items					

2. Establishment/renovation facilities: Not applicable

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	

3. Training/study tour/ seminar/workshop/conference organized: Not applicable

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training					
(b) Workshop					

C. Financial and physical progress

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	681545	668307	668307	0	100	
B. Field research/lab expenses and supplies	780000	778978	778978	0	100	
C. Operating expenses	284400	273436	273436	0	100	
D. Vehicle hire and fuel, oil & maintenance	160000	140402	140402	0	100	
E. Training/workshop/seminar etc.	100000	0	0	-	Nil	
F. Publications and printing	101000	202675	202675	0	100	
G. Miscellaneous	45000	40247	40247	0	100	
H. Capital expenses	348000	346119	346119	0	100	

D. Achievement of Sub-project by objectives: (Tangible form)

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Outputi.e. product obtained, visible, measurable)	Outcome(short term effect of the research)
1. To compare productivity and profitability of fish farming between traditional and improved aquaculture technologies users;	Socio-economic and cost-return data analysis	Descriptive statistics, cost and return analysis, t-test	Higher productivity and profit for adopters from fish cultivation.
2. To identify the determinants of adopting improved aquaculture technologies at farm level;	Econometrics modeling using field level data collected from fish farmers	Descriptive statistics, poisson regression results	More training and extension contact influenced the adoption decision.
3. To assess the impact of improved aquaculture technology on fish yield and livelihood of fish farmers.	Treatment effect analysis using field level data collected from fish farmers	ATT estimation	Due to higher productivity and profitability livelihood status of the adopters increased to some extent compared to non-adopters.

E. Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.	**N/A**		
MS Thesis		O4	1. Profitability and Efficiency of Mud Crab Fattening in Bangladesh 2. Profitability of Shrimp Farming: A Study in Some Selected Areas of Bangladesh 3. A Study on Pangus Cultivation at Farm Level in Some Selected Areas of Mymensingh District 4. Profitability Analysis of Cage

			Fish Culture: A Study in Chandpur District, Bangladesh
Journal publication	06	02	Adoption and Impact of improve crab fattening practices on the productivity and wellbeing of the coastal farmers in Bangladesh, Journal: Ocean and Coastal Management (Under reviewed, Elsevier) Determinants and impact of improve practices adoption: case of freshwater prawn farming in Bangladesh, Journal: Aquaculture (Under reviewed, Elsevier)
Conference Article		01	River-based Tilapia Cage culture in Bangladesh: Impacts and Determinants of Adoption, Applied Statistics and Policy Analysis Conference,2019 Charles Sturt University, Australia
Information development			
Other publications, if any			

F. Technology/Knowledge generation/Policy Support (as applied):

i. **Generation of technology (Commodity & Non-commodity): N/A**

ii. **Generation of new knowledge that help in developing more technology in future:**

- Education, training and extension contact positively influenced the adoption of improved aquaculture practices.
- Adoption of improved aquaculture technologies significantly enhance productivity and profitability of fish farming.

- Due to adoption of improved aquaculture technologies, wellbeing and livelihood of the fish farmers increases to some extent.

iii. Technology transferred that help increased agricultural productivity and farmers' income: N/A

iv. Policy Support:

- More field level extension workers are warranted to increase the adoption. Department of fisheries may arrange field days, demonstration and trainings to augment the adoption decision.
- Crab fattening is relatively a new dimension of aquaculture in Bangladesh. It also has export potentiality and can be used as a useful adaptation strategy of climate change. Government and concern authorities may take initiative to encourage the farmers to adopt the technology, specially in coastal areas where climate change effects are severe.
- More research on developing improved practices as a package is necessary.
- Adoption of improved practices need capital. Since most of the fisherman in Bangladesh is poor, credit facility with low interest may provide them the capital they need to adopt improved technologies. Selected improved aquaculture technologies may play a vital role in anti-poverty policies of the country as it increases the income and wellbeing of the fish farmers.

G. Information regarding Desk and Field Monitoring

i) Desk Monitoring [description & output of consultation meeting, monitoring workshops/seminars etc.):

Date	Activity	Place	Organizer
21.12.2017	Review Workshop	BARC Auditorium	PIU-BARC, NATP2
05.03.2018	Progress Review Workshop	Seminar Room, BARC	AERS Division
15/16.05.2018	Monitoring Workshop	BARC Auditorium	PIU-BARC, NATP2
16.09.2018	Annual Review Workshop	BARC Auditorium	PIU-BARC, NATP2

ii) Field Monitoring (time& No. of visit, Team visit and output):

Date	No. of Visit	Team	Remarks
13.12.2017	01	Representatives of PIU-BARC, NATP 2	Satisfactory
15.02.2018	01	M & E Members of AERS Division, BARC	Satisfactory

I. Lesson Learned/Challenges (if any)

i) Social survey: Social research is based on primary survey data which is very difficult to collect the information from field level farmers. In general, farmers were provided the information based on memorizing which inflated the proper cost and return data. It creates problem to achieve good results. Social survey has been conducted very cautiously with proper supervision and monitoring.

ii) Account Management: It was very difficult to materialize the research activities according to proposed line items budget. It needs flexibility for spending the research budget to conduct the research activities efficiently, effectively and appropriately. Account management system should be developed easier way.

iii) Fund Release: Fund release was not in timely manner which obstruct to maintain the research work schedule. Conducting research properly, it is very important to release the fund timely.

J. Challenges (if any): Data collection from the filed level at different study districts was most challenging task of the research project.

Signature of the Principal Investigator	Counter signature of the Head of the
Date …….	organization/authorized representative
	Date ……...
Seal	Seal

Appendix-1

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Appendix 2

প্রকল্প আইডি : ৪২৯ এল.এ.টি.পি - ২ কোড নং: | | | | | | | | |

জরীপ প্রশ্নমালা

ডেভেলপমেন্ট এন্ড পোভার্টি স্টাডিজ বিভাগ

শেরেবাংলা কৃষি বিশ্ববিদ্যালয়, ঢাকা-১২০৭

Impact of Improved Aquaculture Technologies on Productivity and Livelihood of Fish Farmers in Bangladesh

এই তথ্য সংগ্রহের মূল উদ্দেশ্য মৎস্য চাষ প্রযুক্তির মাধ্যমে জীবনযাত্রার উন্নয়ন, মৎস্য উৎপাদনশীলতায় পরিবর্তন, মৎস্য চাষের সমস্যা ও সমাধানের পথ নিরুপন করা। আপনার প্রদানকৃত তথ্য কেবলমাত্র গবেষণার কাজে ব্যবহার হবে এবং তথ্যের গোপনীয়তা রক্ষা করা হবে। আপনার সহযোগীতা একান্ত কাম্য।

১। মৎস্য চাষ পদ্ধতির নাম

১) কার্প চাষ ☐ ২) পাঙ্গাস চাষ ☐ ৩) খাচায় মাছ চাষ ☐

৪) ঘেরে লবন পানির চিংড়ি চাষ ☐ ৫) ঘেরে স্বাদুপানির চিংড়ি চাষ ☐ ৬) কাঁকড়া মোটাতাজাকরণ ☐

২। মৎস্য প্রযুক্তি গ্রহণের অবস্থা : ১) প্রযুক্তি গ্রহণকারী ☐ ২) প্রযুক্তি গ্রহণকারী নয় ☐

A. মডিউল-১: কৃষকের পারিবারিক তথ্য

১. নাম: .....

২. ঠিকানা: গ্রাম: ..... উপজেলা: .....

জেলা: ..... মোবাইল: | | | | | | | | | | |

৩. পরিবারের সদস্য সংখ্যা ....., পুরুষ ....., মহিলা .....

৪. আর্থ-সামাজিক তথ্য:

ক্রমিক নং	তথ্য প্রদানকারীর সাথে সম্পর্ক	লিঙ্গ	বয়স (বৎসর)	বৈবাহিক অবস্থা	শিক্ষাগত যোগ্যতা	কত বছর স্কুলে পড়েছেন	পেশা	
							প্রধান	অপ্রধান
১	২	৩	৪	৫	৬	৭	৮	৯
১	1							
২								
৩								
৪								
৫								
৬								
৭								
৮								
৯								

কোড:

সম্পর্ক: প্রধান কৃষক =1, স্বামী/স্ত্রী =2, ছেলে/মেয়ে = 3, মা/বাবা= 4, ভাই/বোন = 5, ছেলে বৌ =6, ভাই এর স্ত্রী =7, ভাই এর ছেলে/মেয়ে =8, অন্যান্য = 9, **লিঙ্গ:** পুরুষ =1, মহিলা =2

বৈবাহিক অবস্থা: অবিবাহিত =1, বিবাহিত = 2, বিধবা =3, তালাকপ্রাপ্ত =4, আলাদা বসবাস =5

শিক্ষাগত যোগ্যতা: স্বাক্ষর =1, প্রাথমিক =2, মাধ্যমিক =3, উচ্চ মাধ্যমিক =4, ডিগ্রী/অনার্স =5, অশিক্ষিত =6

পেশা: কাজ করে না =0, কৃষি =1, মাছচাষ =2, পশুপালন =3, শ্রমিক =4, ব্যবসা =5, চাকুরী =6, ছোট ব্যবসা/দোকান =7, গৃহিনী =8, ছাত্র = 9, অন্যান্য = 10

৫. পরিবারের সদস্যদের মধ্যে নিয়মিত মৎস্য খামারে কাজ করে কতজন? .....

৬. পরিবারে অর্থ উপার্জনকারী সদস্য সংখ্যা কত: .....

৭. মৎস্য/ কাঁকড়া চাষে অভিজ্ঞতা: ..... বৎসর

৮. কৃষি কাজে অভিজ্ঞতা: ..... বৎসর

৯. a) আপনি কি মৎস্য/ কাঁকড়া চাষের জন্য কোন প্রশিক্ষণ পেয়েছেন? ১) হ্যাঁ ☐ ২) না ☐

b) যদি হ্যাঁ হয়, কত বার? ....., c) মোট কত দিন : .....

কোন প্রতিষ্ঠান থেকে (কোড ব্যবহার করুন) ☐

(কোড: গবেষনা প্রতিষ্ঠান = 1, জেলা মৎস্য অফিস = 2, এনজিও = 3, উপজেলা মৎস্য অফিস = 4, NATP প্রকল্প =5, যুব উন্নয়ন অফিস = 6, অন্যান্য = 7)

১০. জমির পরিমান (শতাংশ):

ক্রম নং	জমির ধরন		পরিমান (শতাংশে)
১	নিজস্ব চাষের জমি		
২	বর্গা নেয়া		
৩	বর্গা দেয়া		
৪	বন্ধক নেয়া		
৫	বন্ধক দেয়া		
৬	বসতবাড়ি		
৭	পুকুর	নিজস্ব	
৮		লীজ নেয়া	

১১. বিভিন্ন সামাজিক প্রতিষ্ঠানের অংশ গ্রহণ:

a) আপনি কি কোন সামাজিক প্রতিষ্ঠানের সদস্য? (টিক চিহ্ন দিন) ১) হ্যাঁ ☐ ২) না ☐

b) যদি হ্যাঁ হয়, তাহলে উক্ত প্রতিষ্ঠানের নাম. ---------- (কোড ব্যবহার করুন)

কোড: গ্রাম্য সমবায় সমিতি=1, কৃষক সমবায় সমিতি=2, ইউনিয়ন কাউন্সিল=3, বয়স্ক শিক্ষা কমিটি=4, যুব উন্নয়ন কমিটি=5, রাজনৈতিক দল=6, এনজিও=7, স্কুল ব্যবস্থাপনা কমিটি=8, মসজিদ কমিটি=9, বাজার উন্নয়ন কমিটি=10, মৎস্য চাষী কল্যান সমিতি=11, অন্যান্য=12

c) আপনি কত বছর যাবত উপরোক্ত সামাজিক প্রতিষ্ঠানের সাথে জড়িত: ..... বছর

B. মডিউল ২: উন্নত মৎস্য চাষ প্রযুক্তিসমূহের তথ্য

১২. প্রযুক্তি সংক্রান্ত তথ্য:

১	আপনি কি পদ্ধতিতে মাছ/ কাঁকড়া চাষ করেন? (এক্সটেনসিভ =1, সেমি ইনটেনসিভ =2, ইনটেনসিভ =3)	
২	আপনার কতগুলো পুকুর/ঘের / খাঁচা রয়েছে? (সংখ্যা)	
৩	পুকুর/ঘেরের মোট আয়তন কত? (শতাংশ)	
৪	জরিপকৃত পুকুর/ঘেরের / খাঁচার আয়তন (দৈর্ঘ্য×প্রস্থ×উচ্চতা) কত? (শতাংশ)	
৫	জরিপকৃত পুকুর/ঘেরের/ খাঁচার মালিকানার ধরণ (একক =1, যৌথ =2, লীজ/ভাড়া =3)	
৬	যদি যৌথ মালিকানা হয়, তাহলে মোট আয় ব্যয়ের কত শতাংশ আপনি প্রদান করেন?	
৭	জরিপকৃত পুকুর/ঘেরের গভীরতা কত? (ফুট)	
৮	বছরে কত মাস জরিপকৃত পুকুর/ঘেরে পানি থাকে?	
৯	পানি সরবরাহের উৎস কি? (শ্যালো=1, ডীপ টিউবওয়েল=2, বৃষ্টির পানি=3, নদী =4, অন্যান্য=5)	
১০	জরিপকৃত পুকুর/ঘেরের / খাঁচার মাটির ধরন (বালু =1, কাদা =2, দোআঁশ=3, বালু- দোআঁশ=4, এঁটেল দোআঁশ =5, অন্যান্য=6)	
১১	আপনি বছরে কতবার পোনা অবমুক্ত করেন?	
১২	আপনি পুকুর/ঘেরে / খাঁচায় অবমুক্তের জন্য পোনা কোথায় হতে সংগ্রহ করেন? (বিএফআরআই =1, হ্যাচারী =2, খোলা বাজার =3, অন্যান্য =4)	
১৩	আপনার মতে অবমুক্তকৃত পোনাগুলো উন্নত জাতের কিনা? (হ্যাঁ =1, না =2)	
১৪	আপনি কি জানেন প্রতি শতাংশে কি পরিমান পোনা/ কাঁকড়া অবমুক্ত করতে হয়? (হ্যাঁ =1, না =2)	
১৫	যদি হ্যাঁ হয়, আপনি কি যথাযথ পরিমাণ পোনা / কাঁকড়া মজুদের ঘনত্ব মেনে চলেন? (হ্যাঁ =1, না =2)	
১৬	অবমুক্ত করার পূর্বে আপনি কি পোনাসমূহকে পরিশোধন করেন? (হ্যাঁ =1, না =2)	
১৭	আপনি কি ভাসমান খাদ্য সরবরাহ করেন? (হ্যাঁ =1, না =0)	
১৮	আপনি কি মাছের / কাঁকড়া ওজন অনুযায়ী খাদ্য সরবরাহ করেন? (হ্যাঁ =1, না =0)	
১৯	আপনি দিনে কতবার খাদ্য সরবরাহ করেন?	
২০	পরপর ২বার খাদ্য প্রদানের মধ্যবর্তী সময় কত ঘন্টা?	
২১	পুকুর/ঘেরের পানি পরিবর্তন করেন কি না? (হ্যাঁ =1, না =2)	
২২	যদি হ্যাঁ হয়, তাহলে মাসে কতবার?	
২৩	আপনি কি ঘের/পুকুর তৈরীর সময় সার প্রয়োগ করেন? (হ্যাঁ =1, না =0)	
২৪	আপনি কি চুন প্রয়োগ করেন? (হ্যাঁ =1, না =0)	
২৫	যদি হ্যাঁ হয়, আপনি কি মাটির পিএইচ অনুযায়ী চুন প্রয়োগ করেন? (হ্যাঁ =1, না =0)	
২৬	জরিপকৃত পুকুর/ঘের হতে পানি ঢোকানো বা নিষ্কাশনের ব্যবস্থা আছে কিনা? (হ্যাঁ =1, না =2)	
২৭	মাছের / কাঁকড়ার রোগ বালাই প্রতিরোধের জন্য আপনি কোন ব্যবস্থা গ্রহণ করেন? (হ্যাঁ =1, না =2)	
২৮	মাছ / কাঁকড়া চাষের একটি পূর্ণ চক্র সম্পন্ন করতে কত মাস সময় লাগে?	
২৯	আপনার বসতবাড়ি হতে জরিপকৃত পুকুর/ঘেরের দুরত্ব কত? (কিঃমিঃ)	
৩০	জরিপকৃত পুকুর/ঘের হতে বাজারের দুরত্ব কত? (কিঃমিঃ)	
৩১	আপনার বসতবাড়ি হতে উপজেলা মৎস অফিসের দুরত্ব কত? (কিঃমিঃ)	
৩২	আপনি কি প্রজাতির মাছ পুকুর/ঘেরে / খাঁচায় মজুদ করেন? (কার্পের জন্যঃ কাতলা =1, রুই =2, মৃগেল =3, গ্রাস কার্প = 4, সিলভার =5, মিরর কার্প =6, কার্ফু (জাপানি) =7, অনান্য = 8) (খাঁচার জন্যঃ তেলাপিয়া =9, সরপুটি =10, কার্প জাতীয় =10, কৈ = 11, শিং/মাগুর =12, অনান্য =8)	

৩৩	**বাগদার জন্য প্রযোজ্যঃ** আপনি কি ঘেরে পোনা অবমুক্ত করার পূর্বে নার্সারি পুকুরে বাগদার পোনা পরিচর্যা করেন? (হ্যাঁ =1, না =0)	
৩৪	নার্সারি পুকুরে রেনু ছাড়ার কতদিন পরে প্রধান ঘেরে বাগদা পোনা অবমুক্ত করেন?	
৩৫	জরিপকৃত পুকুর/ঘেরে জোয়ারের পানি ঢোকানো বা নিষ্কাশনের ব্যবস্থা আছে কিনা? (হ্যাঁ =1, না =2)	
৩৬	**কাঁকড়ার জন্য প্রযোজ্যঃ** স্ত্রী ও পুরুষ কাঁকড়া যথাযথ অনুপাতে ঘেরে অবমুক্ত করেন কিনা? (হ্যাঁ =1, না =0)	
৩৭	আপনি কি জীবন্ত খাদ্য সরবরাহ করেন? (হ্যাঁ =1, না =0)	
৩৮	কাঁকড়ার খোলস পরিবর্তনের সময় অথবা পরে আশ্রয়ের জন্য আলাদা ঘর আছে কিনা ? (হ্যাঁ =1, না =2)	
৩৯	**খাঁচার জন্য প্রযোজ্যঃ** আপনি কি খাঁচায় পোনা অবমুক্ত করার পূর্বে নার্সারি পুকুরে পোনা পরিচর্যা করেন? (হ্যাঁ =1, না =0)	
৪০	যদি হ্যাঁ হয়, আপনি কি নার্সারি পুকুরে চুন প্রদান করেন? (হ্যাঁ =1, না =0)	
৪১	যদি হ্যাঁ হয়, শতাংশে কি পরিমান চুন প্রদান করেন? (কেজি)	
৪২	আপনি কি নার্সারি পুকুরে সার প্রদান করেন? (হ্যাঁ =1, না =0)	
৪৩	আপনি কোথায় আপনার খাঁচা স্থাপন করেছেন (ক্যানাল =1, নদী =2, পুকুর= 3)	

C. মডিউল ৩: আয়-ব্যয় ও বিপনন সংক্রান্ত তথ্য

১৩. জরিপকৃত পুকুর/ঘেরে মাছের উৎপাদন খরচঃ

ক্রঃ নং	খরচের ধরন			তথ্য	
				পরিমাণ	খরচ/ইউনিট
	১			২	৩
নির্ধারিত খরচ					
১.	জমির খাজনা / লীজ মূল্য (টাকা/বৎসর)				
২.	পুকুর/ঘের তৈরী খরচ (টাকা)				
৩.	খাঁচা তৈরীর খরচ (টাকা)				
৪.	নেটিং খরচ (টাকা)				
৫.	কাকড়া চাষে বানা তৈরী খরচ (টাকা)				
৬.	গার্ড সেড (যদি থাকে) (টাকা)				
৭.	যন্ত্রপাতি (যদি থাকে) (টাকা)				
৮.	সুদের পরিমান (যদি থাকে) (টাকা/বৎসর)				
পরিবর্তনশীল খরচ (পূর্ণ বৎসরে)					
	ক) পোনা (সংখ্যা / কেজি) (টিক চিহ্ন দিন)	৯.			
		১০.			
		১১.			
		১২.			
		১৩.			
		১৪.			

ক্রঃ নং	খরচের ধরন			তথ্য	
				পরিমাণ	খরচ/ইউনিট
	১			২	৩
খ) খাদ্য (কেজি)		১৫.	বাড়িতে তৈরী		
		১৬.	কেনা		
গ) সার প্রয়োগ (কেজি)		১৭.	ইউরিয়া		
		১৮.	টিএসপি		
		১৯.	খৈল		
		২০.			
		২১.			
২২. চুন প্রয়োগ (কেজি)					
২৩. বালাইনাশক/ কীটনাশক (কেজি/ .....)					
২৪. বিদ্যুৎ বিল (টাকা)					
২৫. পুকুর পুনঃমেরামত/পাড় বাধানো (টাকা)					
২৬. পানি শোধন খরচ (টাকা) (যদি থাকে)					
২৭. অন্যান্য (উল্লেখ করুন).....					

১৪. মাছ / কাঁকড়া চাষে শ্রমিক ব্যবহারের পরিমানঃ

ক্রঃ নং	ব্যবহারের ধরণ	পরিমান		দিনের পরিমান
		পারিবারিক	ভাড়া	
	১	২	৩	৪
১	সার প্রয়োগ (ঘন্টা)			
২	খাদ্য দেওয়া (ঘন্টা)			
৩	মাছ আহরন (ঘন্টা)			
৪	বিপনন (ঘন্টা)			
৫	অন্যান্য			
৬	মুজুরী (টাকা/দিন)			
৭	গার্ডের বেতন (টাকা/বৎসর)			

১৫. মাছ / কাঁকড়া উৎপাদনের তথ্যঃ

i) আপনি বৎসরে জরিপকৃত পুকুর/ঘের থেকে কতবার মাছ সংগ্রহ করেন .....

ii) আপনি কি বিক্রয়ের পূর্বে মাছের গ্রেডিং করেন? (টিক চিহ্ন দিন): ১) হ্যাঁ ☐ ২) না ☐

iii) যদি হ্যাঁ হয়,

প্রজাতির নাম	কেজিতে মাছের সংখ্যা			গড় বিক্রয় মূল্য		
	বড়	মাঝারি	ছোট	বড়	মাঝারি	ছোট
১	২	৩	৪	৫	৬	৭

iv) যদি না হয়, গড় বিক্রয় মূল্যঃ

প্রজাতির নাম	টাকা/কেজি
১	২

v) মাছ / কাঁকড়া উৎপাদনের পরিমানঃ

ক্রঃ নং	প্রজাতি	প্রজাতি অনুযায়ী মাছের মোট উৎপাদন (কেজি)																						
		১ম			২য়			৩য়		৪র্থ			৫ম			৬ষ্ঠ			৭ম			৮ম		
		বড়	মাঝারি	ছোট	বড়	মাঝারি	ছোট	বড়	মাঝারি	ছোট	বড়	মাঝারি	ছোট	বড়	মাঝারি	ছোট	বড়	মাঝারি	ছোট	বড়	মাঝারি	ছোট	বড়	মাঝারি	ছোট
	১	২	৩	৪	৫	৬	৭	৮	৯	১০	১১	১২	১৩	১৪	১৫	১৬	১৭	১৮	১৯	২০	২১	২২	২৩	২৪	২৫
১																									
২																									
৩																									
৪																									
৫																									

vi) উপরোক্ত প্রশ্নের উত্তর জানা না থাকলে, সর্বমোট উৎপাদন কত কেজি হয়েছিলোঃ

প্রজাতির নাম	কেজি
১	২

১৬. মাছ / কাঁকড়া ভোগের ধরন (কেজি):

মোট উৎপাদন	পারিবারিক ভোগ	আত্মীয়স্বজন	বিক্রি	অন্যান্য
১	২	৩	৪	৫

১৭. মাছ বিপণন সংক্রান্ত তথ্য:

a. আপনি কার কাছে মাছ / কাঁকড়া বিক্রি করেন?

ক্রঃ নং	বিক্রয়ের মাধ্যম	বিক্রয় মূল্য (টাকা/কেজি)	শতকরা কত ভাগ (%)
	১	২	৩
১	বেপারী		
২	পাইকার		
৩	আড়তদার		
৪	খুচরা বিক্রেতা		
৫	হোটেল		
৬	গ্রামের হাট		
	অন্যান্য (উল্লেখ করুন)		

b. দাম নির্ধারন করেন কিভাবে?

১) দর কষাকষি ☐ ২) নিলাম ☐ ৩) বাজার দর ☐ ৪) পূর্বে নিধারিত মূল্য ☐

c. বাজারে দাম সম্পর্কিত তথ্য কিভাবে সংগ্রহ করেন?

১) বাজার হতে সরাসরি ☐ ২) টেলিফোন/মোবাইল ☐ ৩) প্রতিবেশীর নিকট হতে ☐ ৪) পত্রিকা ☐

৫) রেডিও/টেলিভিশন ☐ ৬) অন্যান্য .....

d. বিক্রয়ের পূর্বে আপনি কত সময় ধরে মাছ / কাঁকড়া সংরক্ষণ করেন .....ঘন্টা

e. মাছ / কাঁকড়া বিক্রি হতে সাধরনত কত সময় লাগে? ১) .....দিন অথবা ২) .....ঘন্টা

f. (১) আপনি কি সরকারের নিকট হতে মাছ / কাঁকড়া চাষের জন্য কোন ধরনের সহায়তা পেয়েছেন?

১) হ্যাঁ ☐ ২) না ☐

(২) যদি হ্যাঁ হয়, তাহলে কিভাবে এবং কত পরিমাণ.....

(৩) আপনি কি মনে করেন মাছের / কাঁকড়ার দাম সন্তোষজনক? ১) হ্যাঁ ☐ ২) না ☐

(৪) যদি না হয়, কেন .....

১৮. মাছ / কাঁকড়া আহরনের সময় কি পরিমান ক্ষতির সম্মুখীন হন?

ক্রঃ নং	ক্ষতির ধরন	ক্ষতির পরিমান	কারণসমূহ
	১	২	৩
১	পরিমাণগত ক্ষতি (কেজি)		
২	গুণগত ক্ষতি (কেজি)		
৩	মার্কেট ফোর্সজনিত ক্ষতি (টাকা)		

১৯. ক) আপনি কোথায় মাছ / কাঁকড়া বিক্রি করতে পছন্দ করেন? (টিক চিহ্ন দিন)

১) সরাসরি গ্রাম্য বাজারে / হোটেলে ☐ ২) জেলা পর্যায়ের ট্রেডার / মধ্যসত্ত্বাভোগীর কাছে ☐

৩) স্থানীয় ট্রেডার/ মধ্যসত্ত্বাভোগীর কাছে স্পটার (ঢাকা) ☐ অন্যান্য (উল্লেখ করুন): ----------

খ) পছন্দের কারণ কি? ১) মূল্য বেশী পাওয়া ☐ ২) সহজে বিক্রি করা যায় ☐ ৩) নগদ মূল্যে বিক্রি করা যায় ☐

৪) মাছ ক্ষতির পরিমাণ কম হয় ☐ অন্যান্য (উল্লেখ করুন): ☐

D. মডিউল ৪: সম্পদের পরিমাণ

২০. গৃহস্থলী সম্পদের পরিমাণ:

ক্রঃ নং	সম্পদের ধরণ	সংখ্যা	মোট মূল্য (টাকা)
	১	২	৩
	ক) বসতবাড়ি		
১	▪ টিনসেড		
২	▪ আধাপাকা বাড়ি		
৩	▪ পাকা বাড়ি		
৪	▪ কাঁচা ঘর		
	খ) আধুনিক সরঞ্জাম		
৫	▪ রেডিও		
৬	▪ টেলিভিশন		
৭	▪ মোটরসাইকেল		
৮	▪ ফ্যান		
৯	▪ মোবাইল		
	▪ অন্যান্য.....		
	গ) আসবাবপত্র		
২১	▪ আলমারী		
২২	▪ শোকেস		
২৩	▪ টেবিল ও চেয়ার		
২৪	▪ অন্যান্য.....		
	ঘ) কৃষি যন্ত্রপাতি		
২৫	▪ লাঙ্গল		
২৬	▪ স্যালো টিউবওয়েল		
২৭	▪ পাওয়ার ট্রিলার		
২৮	▪ মাড়াইযন্ত্র		
২৯	▪ স্প্রে-মেশিন		
	▪ অন্যান্য		
	ঙ) মাছচাষ জনিত যন্ত্রপাতি		
৪১	▪ মাছ ধরার জাল		
৪২	▪ নৌকা		
	▪		

ক্রঃ নং	সম্পদের ধরণ	সংখ্যা	মোট মূল্য (টাকা)
	১	২	৩
	▪		
	চ) পশু-পাখি		
৫১	▪ গরু		
৫১	▪ ষাঁড়/বলদ		
৫৩	▪ হাঁস-মুরগী		
৫৪	▪ ছাগল/ভেড়া		
	▪ অন্যান্য.....		
	ছ) খাবার পানির উৎস (টিক চিহ্ন দিন)		
৬১	▪ নিজস্ব টিউবওয়েল		
৬২	▪ প্রতিবেশীর টিউবওয়েল		
৬৩	▪ পুকুর/নদী		
৬৪	▪ কুয়া		
৬৫	▪ মোটর চালিত পাম্প		
	জ) স্যানিটেশন সুবিধা (টিক চিহ্ন দিন)		
৬৬	▪ খোলা জায়গা		
৬৭	▪ কাঁচা টয়লেট		
৬৮	▪ স্ল্যাব টয়লেট		
৬৯	▪ পাকা টয়লেট		

২১. ঋণ সংক্রান্ত তথ্য:

a) গত ১ বৎসরে ঋণের প্রাপ্যতা কি ধরনের ছিলো .....(কোড ব্যবহার করুন)

কোড: 1 = বেশী, 2 = মধ্যম, 3 = কম, এবং 4= ছিলো না

b) মাছ চাষের জন্য গত ১ বৎসরে কোন ঋণ নিয়েছেন কি না (টিক চিহ্ন দিন): ১) হ্যাঁ ☐ ২) না ☐

c) যদি হ্যাঁ হয়, তাহলে নিম্নের তথ্যগুলি প্রদান করুন;

ক্রঃ নং	ঋণের উৎস	বিবরন			
		ঋণের পরিমাণ (টাকা)	সুদের হার	কিস্তির পরিমাণ (টাকা)	কিস্তির সংখ্যা
	১	২	৩	৪	৫
১	বাণিজ্যিক ব্যাংক				
২	এনজিও				
৩	মহাজন				
৪	আত্মীয়				
	অন্যান্য.....				

২২. বাৎসরিক আয় (টাকা):

ক্রঃ নং	আয়ের উৎস	আয়ের পরিমান
	১	২
১	ফসল চাষ**	
২	গবাদি পশু চাষ**	
৩	মৎস্য / কাঁকড়া চাষ **	
৪	ব্যবসা	
৫	চাকুরী	
৬	বৈদেশিক উৎস হতে	
	অন্যান্য	

** উৎপাদন খরচ ছাড়া

২৩. বাৎসরিক ব্যয় (টাকা):

ক্রঃ নং	ব্যয়ের খাত	ব্যয়ের পরিমান
	১	২
১	কাপড়	
২	ঘরবাড়ি মেরামত	
৩	চিকিৎসা	
৪	খাদ্য	
৫	উৎসব	
	অন্যান্য	

২৪. গত এক বছরে মাছ / কাঁকড়া চাষ হতে প্রাপ্ত আয়ের ব্যবহার সংক্রান্ত তথ্য :

ক্রঃ নং	ব্যবহারের খাত	পরিমাণ (টাকা)	শতকরা হার
	১	২	৩
১	পারিবারিক ভোগ ব্যয়		
২	গৃহস্থালী সম্পদ ক্রয়		
৩	সঞ্চয়		
৪	গবাদি পশু-পাখি ক্রয়		
৫	মাছচাষ জনিত যন্ত্রপাতি		
৬	বিশুদ্ধ খাবার পানি সরবরাহ (টিউবওয়েল / পাম্প স্থাপন)		
৭	স্যানিটেশন সুবিধা বৃদ্ধি (পাকা/ স্যাব টয়লেট নির্মাণ)		
৮	পরিবারের সদস্যদের পড়াশুনায় ব্যয়		
৯	সামাজিক উন্নয়নমুলক কাজে ব্যয়		
১০	গৃহ নির্মাণ / মেরামত		
১১	ঋণ পরিশোধ		
	অন্যান্য (উল্লেখ করুন)		

২৫. গত ৭দিনে মাছ কেনার জন্য আপনি কত টাকা ব্যয় করেছেন ও কি পরিমাণ খাদ্য হিসেবে গ্রহণ করেছেন;

ক্রঃ নং	মাছের জাত (কোড)	উৎস (কোড)	কি পরিমাণে খেয়েছেন (কেজি)	প্রতি কেজি মূল্য (টাকা)	কয় বেলা খেয়েছেন
	১	২	৩	৪	৫
১					
২					
৩					
৪					

(জাত: তেলাপিয়া=1, রুই=2, কাতলা=3, শিং/মাগুর=4, মৃগেল=5, সিলভার কার্প=6, গ্রাস কার্প=7, চিংড়ী=8, কার্প=9, পাঙ্গাস=10, কৈ=11, ছোট দেশী মাছ=12, ইলিশ =13, অনান্য =14
উৎস: কেনা=1, খাল-বিল থেকে আহরণ=2, নিজস্ব চাষ=3, উপহার =4, অন্যান্য=5)

E. মডিউল ৫: সামাজিক যোগাযোগ, মাছ চাষের সমস্য ও সম্ভাবনা

২৬. মাছচাষ জনিত বিষয়ে নিম্নের ব্যক্তিবর্গের সাথে যোগাযোগের মাত্রা (টিক চিহ্ন দিন) ;

ক্রঃ নং	মাধ্যম	খুব বেশী=১	বেশী=২	মধ্যম=৩	কম=৪	নাই=৫
	১	২	৩	৪	৫	৬
১	প্রতিবেশী কৃষক					
২	মাঠ কর্মকর্তা (ডিওএফ)					
৩	উপজেলা মৎস্য অফিসার					
৪	বিএফআরআই বিজ্ঞানী					

নোটঃ মাসিক যোগাযোগ ঃ খুব বেশী=8 or above ; বেশী= 5-7; মধ্যম= 2-4; কম= 1; নাই= 0

২৭. বিভিন্ন উদ্দেশ্যে একস্থান থেকে অন্য স্থানে গমণের মাত্রা (টিক চিহ্ন দিন):

ক্রঃ নং	স্থান	সবসময়=১	প্রায়ই=২	মাঝে মাঝে=৩	হঠাৎ=৪	নাই=৫
	১	২	৩	৪	৫	৬
১	থানা সদর					
২	জেলা শহর					
৩	রাজধানী					

নোটঃ যোগাযোগের মাত্রা (মাসিক) : সবসময়= 8 or above; প্রায়ই= 6-7; মাঝে মাঝে= 3-5; হঠাৎ= 1-2; নাই= 0

২৮. কারিগরী জ্ঞানের জন্য বিভিন্ন সম্প্রসারণ কাজে অংশগ্রহণের মাত্রা (টিক চিহ্ন দিন):

ক্রঃ নং	যোগাযোগ	সবসময়	প্রায়ই	মাঝে মাঝে	হঠাৎ	নাই
	১	২	৩	৪	৫	৬
১	উপজেলা মৎস্য অফিস					
২	মাঠ দিবসে অংশগ্রহণ					
৩	গবেষণা প্রতিষ্ঠান ভ্রমণ					
৪	মাছ চাষের বই/পুস্তক পাঠ					
৫	দৈনিক পত্রিকা পাঠ					

নোটঃ যোগাযোগের মাধ্যম (মাসিক) : সবসময়=8 or above; প্রায়ই= 5-7; মাঝে মাঝে= 2-4; হঠাৎ= 1; নাই= 0

২৯. পরিবারের অন্যান্য সদস্যদের মাছচাষ ও অন্যান্য কাজে অংশ গ্রহণের মাত্রা (টিক চিহ্ন);

ক্রম নং	কাজ	অংশ গ্রহণের ধরণ			
		প্রধান কৃষক	স্বামী/স্ত্রী	উভয়	অন্যান্য
	১	২	৩	৪	৫
১	মাছ চাষ				
২	মাছ বিক্রয়				
৩	নতুন প্রযুক্তি গ্রহণ সংক্রান্ত				
৪	মাছের খাদ্য ক্রয়				
৫	ছেলে-মেয়েদের লেখাপড়া				
৬	সম্পদ ক্রয় (জমি,বাড়ি,গবাদিপশু)				

৩০.	মাছ / কাঁকড়া চাষের প্রধান সমস্যাসমূহ কি কি?
i)	
ii)	
iii)	
iv)	

৩১.	সমস্যাসমূহ সমাধানের উপায়;
i)	
ii)	
iii)	
iv)	

"সময় দেওয়ার জন্য ধন্যবাদ"

.....

তথ্য সংগ্রহকারীর স্বাক্ষর তারিখ:

নাম: মোবাইল:

Appendix 3

Few picture of the sub-project activities

Fattening of Crab at Bagerhat Sadar, Bagerhat

Research Team Visited Case Culture Technology at Chandpur

Cage culture

Data Enumerators Collecting Data

Data collection at Bagherhat

Research Team Visited an Arat at Khulna