Competitive Research Grant

Sub-Project Completion Report

on

Impact of Aquaculture on Agricultural Production in Greater Noakhali District

Project Duration

May 2017 to September 2018

Department of Fisheries and Marine Science
Noakhali Science and Technology University

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

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Acronyms

AFS	Ammonium Ferous Sulphate	Meq	milliequivalent
BARC	Bangladesh Agricultural Research Council	NGO	Non-Government Organization
BDT	Bangladesh Taka	NL	Near Land
B	Boron	NATP	National Agricultural Technology Program
Co-PI	Co- Principal Investigator		
CRG	Comprehensive Research Grant	nm	nanometer
DoF	Department of Fisheries	N	Nitrogen
DO	Dissolved Oxygen	OC	Organic Carbon
Degree Centigrade	^{0}C	OM	Organic Matter
DL	Distance Land	ON	Organic Nitrogen
dS	Unit of Electrical Conductivity	P	Phosphorus
DMSP	Dimethylsulphonioproprionate	PAA	Prepared Phenylanthranilic Acid
EC	Electrical conductivity	PI	Principal Investigator
et. al	and others	ppt	Parts Per Thousand
FAO	Food and agricultural Organization	ppm	Parts per million
FF	Fish Farm	S	Sulfur
FGD	Focus Group Discussion	SD	Standard Deviation
FRSS	Fisheries Resource Survey Systems	SRDI	Soil Resource Development Institute
		SPSS	Statistical Packages for Social Science
pH	Negative Logarithms of Hydrogen Ion	PP	Project proposal
PHY	Physical	FIN	Financial
Gov	Government	TK	Taka
HYV	High Yield Variety	TN	Total Nitrogen
K	Potassium	T	Temperature
		TV	Television
Kg	Kilogram	USAID	United States Agency for International Development
L	Large	WHO	World Health Organization
mg/l	Miligram Per Litre	WIF	Water Logged Farm
MT	Metric Ton	μ	micron
mm	Millimeter	±	plus minus sign
AFS	Ammonium Ferous Sulphate	%	Percentage

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Executive Summary

Laboratory experiment and field survey were conducted to find out the influence of aquaculture on agricultural farms in grater Noakhali (Noakhali, Feni and Luxmipur) district during July 2017 to March 2018. Data on soil - water samples and socio-economic condition of aquafarms and nearby agriculture farms (before and after the establishment of aquaculture farms) were collected from 240 farms under different upazillas in Greater Noakhali district. Soil and water samples were collected from 4 locations; fish pond, near agricultural land (within 50m), distance agricultural land (within 250m) and control data (>250 m) from each farms. A total 240 Soil and water samples (pH, temperature, salinity and nutrients) of the fish farms (FF), near agricultural land (NL), distance agricultural land (DL) and control site (where there is no effect of nutrient leaching) were collected and were analyzed at Soil Resource Development Institute (SRDI) Noakhali following standard methods. Socio-economic conditions of aquafarms and nearby agriculture farms (before and after the establishment of aquaculture farms) were performed through questionnaire survey.

Soil and water quality parameters particularly salinity, organic matter, organic carbon observed in the present study were always higher in fish farms compared to nearland, distance land and control sites (except total nitrogen). Although there is no study to date on the organic matter content in water and soil of greater Noakhali district, a published study on two areas of Noakhali of newly constructed ponds soil showed 2.21 ± 1.43% which was almost three times lower than the present study. Continuous application of feed and fertilizers with high doses in the fish farms might result the higher values of organic matter in the present study. Compared to other reported values, observed soil and water quality parameters were found suitable for fish production in the coastal region of Bangladesh. Soil phosphorus ranged from (8.02±0.22) to 15.69±22.22 while phosphorus in water ranged from 0.58±0.87 to 2.06±2.75 in fish farm and their surrounding agricultural lands of the study areas. Mean pH and phosphorus content in water was significantly low in Feni district compared to other two districts. Soil pH, OC, OM, TN, P and salinity of Noakhali district significantly (TuKey's HSD post hoc test P <0.05) varied from Feni district and K, S and B were significantly different in three districts. Stepwise multiple regression model (ANOVA) suggested that if OC% is increased by 1% then OM% will be increased by 1.726%. On the other hand when OC% increased, total nitrogen (%) also increased by 0.083%.

Aquaculture activities in greater Noakhali district not only positively impacted agricultural farmers with increased crop production and better livelihood but also to the nearby surrounding agriculture farmers with increased crop production (only rice) and better livelihood, however patterns of agricultural crops (-80%) disappeared and/ about to disappear after the establishment of fish farms. Activities of the large scale aquaculture farms with >15 acres areas impacted negatively on the near land agriculture in terms of cropping patterns (-72%). Cultivation of groundnut (-100%) completely disappeared in the near land of fish farms in greater Noakhali district whereas Helon (-80%) and vegetables (-67%) were about to disappear in the same area. Finally, 4 crops such as Helon, Ground nut, vegetable and others disappeared and only high yielding variety (HYV) rice became dominant and being cultivated in the areas under investigation after the establishment of aquaculture farms. Not only large aquaculture farms, but also the medium and small farms have negative impacts on cropping patterns of nearby agricultural land in greater Noakhali district.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. **Title of the CRG sub-project:** Impact of aquaculture on agricultural Production in Greater Noakhali District, Bangladesh

2. **Implementing organization:** Department of Fisheries and Marine Science, Noakhali Science and Technology University.

3. **Name and full address with phone, cell and E-mail of PI/Co-PI (s):** Professor Dr. Md. Jahangir Sarker, Cell: 01733910237, e-mail: sarker35@gmail.com

4. **Sub-project budget (Tk):** 40,55,745.00
    Total: Forty lac fifty five thousand seven hundred forty five taka
    Revised (if any): Not Applicable

5. **Duration of the sub-project:** 1 year 5 months
    Start date (based on LoA signed): May 2017
    End date: 30 September 2018

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

Fish culture in ponds and lakes in Bangladesh was founded by Dr. Nazir Ahmed (1947–1960), the then Director of Fisheries in East Pakistan. Dr. Ahmed initiated the carp culture in ponds and lakes between late 60s and early 70s (FAO, 2014) but commercial aquaculture started in 80s. Aquaculture gained popularity in the last 20 years due to it's profitably. Inland close water (culture) fish production increased annually by about 3%, however total production by the last 8 years became more than doubled (1351979 MT in 2009-10 & 2405415MT in 2016-17) (Year book of Fisheries Statistics of Bangladesh, 2009-10; 2016-17). This indicates the unanimous establishment of aquafarms in Bangladesh. As a result, a large number of aqua farms had been established in different parts of the country. In most of the cases, the aqua farmers don't follow the scientific aquaculture guidelines in their farms. Moreover, the government of Bangladesh has no specific guidelines as well for establishing the aquaculture farms and it may play a negative role on agricultural production and productivity which may hamper the supply chain of our food source (Figure 1).

There are 1,465 commercial fish farms (631 in Noakhali district, 521 in Laxmipur district and 313 in Feni district) under current operations in the greater Noakhali regions (personal communication, district fishery officer). Though these aqua farms are licensed sometimes they don't comply with the Government rule. The aquafarms pay much attention to increase their fish production and profit rather than considering any scientific and legal guidelines. Such professional intentions might impact negatively on nearby agriculture land and/agriculture farms. For example, during the construction of an aqua farm it is needed to surround the selected area by wall or fence that are not maintained and as a result the nearby agricultural land get hampered.
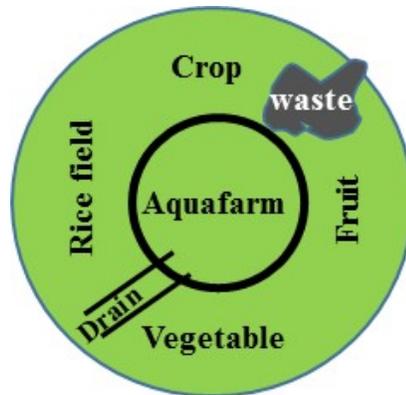
Figure 1: Diagrammatic concept of proposed study

Different construction materials are usually kept beside the agriculture farms or sometimes fish farming waste materials are also thrown on nearby agriculture land. As a result agricultural activities are hampered. When aqua-farmers dig land for constructing ponds, tanks or hatcheries, their waste materials also affect nearby agricultural land. Sometimes their outlets or drainage systems may overflow and the waste materials spread throughout the surrounding agriculture land resulted serious damage to agricultural lands and crops (changes in soil organic matter, soil pH, salinity, micro/macro nutrients etc.). In integrated farming, metabolic waste product of fish, cattle and poultry also damage crops. Normally cow dung or poultry bi-product may be used as fertilizer for crops. But excessive of such waste causes destruction of crops. Sometimes these wastes carry different harmful pathogens/diseases to crops. The aqua farms placed on upper landmass than the level of agriculture land to prevent flood or other natural disaster, also may deteriorate the fresh agricultural land through runoff from aqua-farms. Therefore, the present research was designed to assess the impact of aqua-farming on agriculture due to unscientific and illegal farming practices. Normally, most of the farmers don't understand the extent of damage in terms of human health hazard, food quality and safety, land pollution, water pollution etc. although they watch lower crop production. Purpose of this research is to find out the factors which are responsible for decreasing and/increasing crops production due to mismanagement of aqua farms and develop mitigation strategy to protect both fisheries and agriculture resources in the country.

7. **Sub-project goal:** To identify the present status of aquaculture production and productivity and its impacts on nearby non-aquaculture farmers' livelihood.

8. **Sub-project objective (s):**
    - To determine soil and water quality of aquafarms and adjacent agriculture land.
    - To identify the status of agricultural productions and productivity of the adjacent aquaculture farm.
    - To assess the impact of aquaculture farming on livelihood status of non-aquaculture farmers.

9. **Implementing location (s): Greater Noakhali districts (Noakhali, Feni, Luxmipur).**

10. **Methodology :**
The study was conducted in greater Noakhali during May 2017 to September 2018 (Figure 2). Two types of activities were performed under the project: i) Laboratory analysis of soil and water samples of aqua-farms and non-aqua farms to achieve objective I; and ii) Questionnaire based interviewing of aqua-farmers and non-aqua farmers were performed. Non-aqua farmers who were farming adjacent to the aqua farms were included in the research to achieve objectives II and III. Both qualitative and

quantitative data were collected through individual interview and detail farm survey of the target farmers. To cross check the information collected from farm survey, focus group discussion (FGD) were performed in each selected study area.
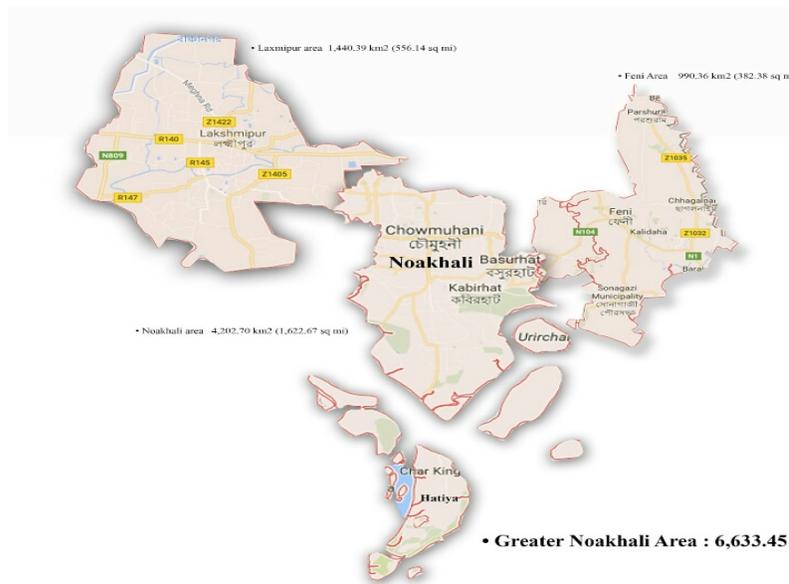
Figure 2. Map of Greater Noakhali District.

A total of 240 sites were selected for this study covering three districts of greater Noakhali (Noakhali, Luxmipur and Feni). In each district, 80 sites were selected from 4 categories: fish farms - 20, FF; near land agriculture farms - 20, NL; distant land agriculture farms - 20, DL; and control land - 20, CL (Table 1). The selected farms were categorized as small (<10 acre), medium (10-50 acre) and large (>50 acre). Based on farm size, stratified random sampling technique was followed to select farm sites (Table 1).

Table 1. Tabular presentation of sampling design

	Aquafarms	Non Aquafarms		
District	Fish farm (FF)	Near land (NL)	Distant land (DL)	Control land (CL)
Noakhali	20	20	20	20
Luxmipur	20	20	20	20
Feni	20	20	20	20
Total	60	60	60	60
Total number of samples during the study= 60+60+60+60= 240				

(a)   (b)

(c)   (d)

(f)   (e)

Plate 1. Selected sites for soil and water samples collection; (a-b) fish farm, FF; (c-d) near land agriculture farm, NL; (e) distant land agriculture farm, DL (f) control land.

Investigation of soil and water quality parameters in aquafarms and non-aquafarm sites

Soil and water samples were collected from 4 categories of sites as per design during the experimental period. Each soil sample was collected from five places forming Z-shape and mixed together. In case of non-aquafarm sites, water samples were collected from fish farm and adjacent water bodies. In some cases (distance land, DL; and control sites, CL), an area of land was dug using a spade and after 30 minutes waters were accumulated to those burrowed areas. The probe of the multi parameter was emerged in to burrowed areas of water and the readings from the display was recorded when it became stable. Likewise water pH, temperature (^{O}C), salinity (ppt), dissolved oxygen (DO, mg/L) were measured directly. Soil and water samples were collected in plastic container/bottles and carried to Regional laboratory of SRDI, Noakhali for estimating pH, organic matter, organic carbon, total nitrogen, available phosphorus, potassium, sulfur and boron contents using standard method as described in SRDI manual.

Plate 2: Water sample analysis

Preparation of soil sample for analysis

The samples were air dried, ground, mixed thoroughly and sieved through 10 mesh sieve. The composite soil samples were stored in clean plastic container for the analysis of soil nutrients.

Determination of soil temperature (^{O}C)

An area was dug in each of the sampling sites using a spade and after a couple of minutes waters were accumulated to those burrowed areas. The probe of the multi parameter was emerged in to burrowed areas of water and the readings from the display was recorded when it became stable.

Determination of pH

Soil pH was determined with the help of a Glass Electrode pH meter, the soil-water ratio was maintained as 1:2.5 (Jackson, 1962). Measurement was done with ADWA AD1000 H/mV temperate pH meter.

Plate 3. pH meter

Determination of Electrical Conductivity and Salinity (dS/m)

The electrical conductivity indicates the amount of soluble (salt) ions in soil. The determination of electrical conductivity (EC) is made with a conductivity cell by measuring the electrical resistance of a 1:5 soil: water suspension. After preparing a 1:5 soil: water suspension by weighing 10g air-dry soil (<2mm) into a 200ml plastic bottle where 50ml deionized water was added. This was mechanically shacked at 250 rpm for 1 hour to dissolve soluble salt. Then, the suspension was filtered by Whatman No-1 filter paper. The EC meter was calibrated according to the manufacturer's instructions using the KCl reference solution (1413μS) to obtain the cell constant. Then the cell was rinsed thoroughly. The electrical conductivity of the 0.01M KCl is measured at the same temperature as the soil filtrate. The conductivity cell was rinsed with the soil filtrate. The value indicated on the EC meter was recorded. At last the EC was calculated with the help of following equation described by Petersen (2010).

$$EC = \frac{EC\ meter\ value \times 3}{1000}\ dS/m$$

Calculation of salinity from EC value:

When the value of EC is between 0-1.9 dS/m then equation of,
Salinity (ECe) = 1.323 $\times$ EC value + 0.122

When the value of EC is between 2.0- 14.0 dS/m then equation of,
Salinity (ECe)= 1.267 $\times$ EC value + 1.269

When the value of EC is between > 14.0 dS/m then equation of,
Salinity (ECe) = 0.895 $\times$ EC value + 8.31

Plate 4. EC meter

Determination of organic matter and organic carbon

Organic carbon in soil sample was determined volumetrically by wet oxidation method of Walkley and Black (1934). The underlying principle is to oxidize the organic matter with an excess of 1N $K_2Cr_2O_7$ in presence of conc. H_2SO_4 and Citrate the residual $K_2Cr_2O_7$ solution with 1N NH_4FeSO_4. The amount of soil organic matter was calculated by multiplying the value of organic carbon with the Van Bemmelen factor, 1.724 (Piper CS. 1950).

Determination of Total Nitrogen (%):

Total Nitrogen in the soil was determined by Kjeldahl method by digesting soil sample at 390°C in a digestion tube with 5 ml 98% conc. H_2SO_4 and 1.0 g catalyst mixture (K_2SO_4:$CuSO_4.5H_2O$ =10:1) by a

digestion unit. Nitrogen was digested by distillation with 33% NaOH followed by titration of the distillate trapped in 0.05M HCl with 0.05M NaOH [54].

Determination of Phosphorus (µg/g):

Available phosphorus of soil was determined by using 2 methods (Olsen *et. al.,* 1964 and Bray and Kurtz, 1945). For Olsen method, 1.25g soil was taken into a 200ml plastic bottle. After adding 25 ml 0.5 M sodium bicarbonate solution, it was shaken exactly for 30 minutes in an orbital shaker. Then immediately bottles were taken out and samples were filtered into a dry beaker by using Whatman No.1 filter paper. It was transferred 5 ml filtrate by fine pipette into a 50ml volumetric flask. 5 ml 0.3 M H_2SO_4 was added, and was shaken by hand up to the bubble completely dissolved or up to 30 minutes and 25 ml distilled water was added. After adding 10 ml ammonium molybdate L-ascorbic acid (immediately prepared), volume was made by adding distilled water up to 50ml and was shaken carefully by hand. After 15 minutes, the absorbance was measured on a spectrophotometer at 890 nm wave length. Same procedure was followed for phosphorus standard solution, 0.0-0.1-0.2-0.3-0.4 mg/L P. For Bray and Kurtz, (1945) method: 3.50g soil was taken into a dry 200ml plastic bottle. Then 25 ml 0.03M ammonium fluoride extracting solution was added with a pipette. The ammonium fluoride extracting solution was stored at 25˚C and the solution was removed from the cabinet immediately before use. The bottle in an orbital shaker was immediately placed and was shacked for exactly 5 minutes. After completion of the shacking immediately the bottle was removed from the shaker and immediately filtered into a dry volumetric flask by using Whatman no.1 filter paper. It was transferred 5 ml filtrate by fine pipette into a 50ml volumetric flask. Approx. 30ml distilled water was added and mixed, 10 ml ammonium molybdate L-ascorbic acid solution was added, and the volume was made with water upto 50ml and mix. After 15 minutes, the absorbance was measured on a spectrophotometer at 890 nm wave length. Same procedure was followed for phosphorus standard solution, 0.0-0.1-0.2-0.3-0.4mg/LP.

Determination of available soil sulfur (µg/g)

Available S content of soil was determined by extracting the soil with sulphur extracting solution. The extractable sulfur content was determined by developing turbidity by adding acid seed solution [150 ml conc.HNO_3, 550 ml glacial acetic acid and 7 ml sulfur stock solution-1 (1000 mg L^{-1} S) was mixed and added water to volume 2 L and turbidimetric reagent [20 g polyvinylpyrolidone and 300 g $BaCl_2.2H_2O$ up to 2 L volume with distilled water (Fox et al., 1964).

Plate 5. Spectrophotometer

Determination of Potassium (meq/100g)

Exchangeable potassium (K) of soil was determined by extraction with 1N ammonium acetate (CH_3COONH_4 (pH 7.0) and K was determined from the extract by using flame photometer (Black CA. 1965). After weighing 2.50g soil into a 200ml plastic bottle, 25 ml 1M Ammonium Acetate was added. It was shacked for 30 minutes and was left for overnight. Care was taken to avoid evaporation from the bottle. On a dry funnel into a dry beaker or flask was filtered with No.42 filter paper. Measurement of the contents of K was taken directly in the soil extract using a flame photometer. Same procedure was followed for potassium standard solution, 0.000-0.025-0.050-0.075-0.100 cmol (+) K per L (Schollenberger and Simon, 1945).

Plate 6: Flame Photometer

Determination of Boron (µg/g)
Turned on the nitrogen digester and was adjusted it to 150°C. The soil was digested with 0.01 M CaCl$_2$ solution in the ratio 1:2 into clean and dry digestion tubes with glass stopper in each. After first bubble, the temperature setting was reduced to 110°C and boiled for exactly 5 minutes from the time was start. The digester was turned and placed the tubes in a vessel with cold water for 15 minutes and filtered on a dry filter into a dry plastic bottle and then Transferred 2.0 ml undiluted filtrate into another dry plastic bottle, added 4 ml buffer solution and 4 ml azomethyl-H reagent and mixed. After 30 minutes the absorbance was measured at 420 nm on a spectrophotometer and calculated by using a standard curve (Petersen, 2010).

Plate 7: Spectrophotometer

Plate 8: Boron / Nitrogen digestion unit & procedure

Plate 9: Sample preparation and analysis of soil and water samples in SRDI, Noakhali

Analysis of water samples
Sample collection
Water samples were collected during 10 to 11 am from subsurface layer using plastic bottles, carried to the laboratory and stored in a refrigerator for analysis. Before analysis, samples were filtered using dry Whatman No. 42 into dry screw cap bottle and stored in refrigerator for pH, EC, salinity, organic matter, organic carbon, total nitrogen, total phosphorus, potassium, sulfur and boron.

Temperature (^{O}C)
After taking the surface water sample from each location of each farm, multi parameter (HACH) was used to take the measurement of temperature (^{0}C), dissolved oxygen (DO, mg/l) of water on the spot. Water samples were collected in plastic bottles and the probe of the multi parameter was emerged in the sampled water. The readings from the display was recorded when it became stable.

pH (Jackson, 1962). Electrical conductivity (Petersen 2010), salinity (refractometer), organic matter, organic carbon, total nirogen (Walkley and Black, 1934), total phosphorus (Bray and Kurtz, 1945) when soil pH was <7.0 and (Olsen *et al*., 1964) when pH was >7.0), Potassium (meq/100g, Black 1965), sulfur (µg/g , Fox *et al*., 1964) [29] and Boron (µg/g, Petersen 2010) of the water samples were measured following the methods given in parenthesis similar to that of soil quality parameters.

10.2. Aquaculture productivity in aquafarms and non-aquafarms (agro-farms) and their impacts on agriculture
This chapter discussed how the fish farms (FF) with their culture activities impact on the near land and distant land non aquafarmers (agriculture) production, productivity in greater Noakhali district. Present study also assessed the livelihood & socioeconomic status & constraints faced by the fishermen in Greater Noakhali by questionnaire based survey.

Plate 10: Focus group discussion and questionnaire interview with farm representatives.

Collection of Data:

The study was based on primary data collection directly from the farm owner. Before collecting primary data, a precise questionnaire (Appendix 1) was developed which was pre-tested in some nearby fish farms. In this test much endeavor was given in order to reach the objectives of the study. The selected farms were categorized as small (0-5 acre, medium (5-15 acre) and large (> 15 acre). Based on farm size, the stratified random sampling technique was followed to select farm households.

Based on the knowledge gained during pre-testing, the final questionnaire was re-arranged, modified & improved. Data were collected from the farmers of selected farms / sites (FF, NL, DL and control sides) and respective soil and water samples were collected for analysis (Plate H-K).

Data Analysis:

All the collected data were scrutinized & summarized carefully before final tabulation. Some of the data were collected instantly in local units but finally converted to international units. The data were first tabulated into a preliminary data sheet of a computer & compared with computer spread sheets to ensure the accuracy of the data entry. Statistical analyses were performed using SPSS.

11.   Results and discussion:

11.1. Soil and water quality parameters of selected farms/sites

pH

Soil pH ranged 5.19±0.3 - 6.25±0.5 in all sites of (Table 2) Feni district (FF, NL, DL and control sites) showed the acidic condition compared to other two districts (Noakhali and Luxmipur) particularly in fish farms (FF). The ideal range of pH in soil is 6.0 to 6.5 because most of the plants' nutrients are available in this stage (Vossen , 2012). To measure the degree of soil acidity and alkalinity, soil pH is a very important variable and it helps to know about soil properties such as chemical, biological and indirectly physical environment including nutrients. The Central Institute of Brackish Water Aquaculture (CIBA) reported that the optimum value of soil pH is 6.5 -7.5 for aquaculture. Soils are referred to as being acidic, neutral, or alkaline (basic), depending on their pH values on a scale of 0 to 14. A pH of 7.0 is neutral; less than 7.0 is acidic; and greater than 7.0 is alkaline (McCauley *et al*., 2017). In the present study, acidic soil was observed in Feni district while alkaline soil with pH more than 7.0 were recorded in other two (Noakhali and Luxmipur district) districts in every sites (Table 2) which had a good agreement with the findings of (Tapader *et al*., 2017) for Noakhali district. Water pH in 3 districts were similar to that of soil pH (Table 2). Water with low alkalinity, results low pH cause shortage of inorganic phosphorus and carbon dioxide for plant growth (Boyd and Tucker, 1998) suggesting lower fish and agricultural production potentials in Feni district compared to other two districts (Table 3). Boyd and Tucker (1998) also pointed out that optimum pH for good health and high growth rate of freshwater animals are in the range of 6.5 - 9.0 which were similar to the findings of the present study (Boyd and Tucker, 1998). pH values of both soil and water in fish farm (FF), near land (NL), distance land (DL) were always higher than the controls in all of the three districts (Table 2 & 3). Ranges of water pH in the present study were from 6.49±0.9 to 7.86±0.3. The Central Institute of Brackish Water Aquaculture (CIBA, 2001) reported that the optimum value of pH for aquaculture in soil is 6.5 -7.5. Another study in the Gher of shatkhira, Bangladesh region measured pH values ranged from 7.8 to 8.2 (CIBA 2001). Therefore present findings of pH in soil and water in greater Noakhali districts were within the range of common aquaculture farms excepting Feni (Table 2 & 3).

Table 2. Soil quality parameters observed in different sites of 3 different districts.

District		Soil quality parameters				
	Sites	pH	P	K	S	B
Noakhali	FF	7.09±0.7	12.77±9.0	0.28±0.08	42.04±13.8	0.40±0.2
	NL	7.09±0.8	15.21±9.9	0.29±0.0	50.12±19.1	0.37±0.2
	DL	7.00±0.6	14.02±11.3	0.29±0.1	42.04±16.6	0.42±0.2
	Control	6.49±0.6	9.79±4.3	0.20±0.0	51.92±18.2	0.54±0.2
Feni	FF	6.25±0.5	13.55±0.6	0.002±0.0	1.65±1.3	0.50±0.4
	NL	5.92±0.5	12.38±0.2	0.002±0.0	1.69±1.1	0.51±0.4
	DL	5.83±0.7	9.02±0.5	0.02±0.0	1.63±1.1	0.55±0.4
	Control	5.19±0.3	8.02±0.2	0.02±0.0	1.83±0.5	0.43±0.37
Lakshmipur	FF	7.33±0.5	15.69±22.2	0.17±0.0	16.26±19.3	0.18±0.1
	NL	6.83±0.6	13.10±13.3	0.19±0.0	15.38±13.6	0.36±0.3
	DL	6.96±0.5	8.29±5.3	0.17±0.0	14.24±11.4	0.34±0.35
	Control	5.20±0.29	8.24±2.20	0.23±0.12	19.56±4.23	0.43±0.34

Salinity (ppt)
In the present study, salinity ranged from 0.02 ± 0.05 to 0.69 ± 0.41 (Figure 3). Salinity is a major leading factor that affects the consistency and growth of aquatic organism's population (Jamabo, NA., 2008). Both soil and water salinity of FF, NL and DL were significantly ($P<0.05$) higher than the control sites of the entire study areas suggesting fish farms showed potential influence on its nearby agricultural lands. Garg and Bhatnagar (1996) recommended desirable range up to 2 ppt for common carp that supported the present findings for aquaculture in the selected areas.

Dissolved oxygen DO (mg/L) and Temperature (^{O}C)
During the present investigation DO ranged from 6.30 ± 1.04 to 8.88 ± 1.75 in FF, NL, DL and control sites of three districts which were in the optimum level (Table 3) for aquaculture practices as recommended by Cheng *et al*. (2003). Maintenance of an adequate level of DO in pond water is very important for aquaculture and prolonged exposure of low oxygen concentration can inhibit the fish growth. Water samples from Noakhali and Luxmipur were collected in May-June 2018 while samples from Feni were collected during heavy rainfall (July-September 2018) which made the variation of temperature almost 2^{O}C in the study areas. The growth, survival, distribution, behavior and physiology of shrimps and other aquatic organisms are greatly affected by dissolved oxygen (Solis, 1988). The principal source of oxygen in water is atmospheric air and photosynthetic planktons (Bhatnagar and Garg, 2000). Temperature is the parameter which revealed that as the degree of hotness or coldness in the body of a living organism either in aquatic or terrestrial environment (Lucinda and Martin, 1999). Temperature in the present study ranged from 30.90 ± 0.89 to (32.53 ± 1.16) and the recommended temperature for tropical major carps is 28-32^{0}C (BARC, 2005) which supported the current findings. Average or good production of DO should be above 5.0 ppm, if it is between 3.0-5.0 ppm in ponds will be considered as unproductive (BARC, 2005) which supported the results revealed from the present study.

Table 3. Water quality parameters (Mean± SD) observed in different sites of 3 different districts.

Districts		Water						
	Sites	pH	DO	Temp	P	S	K	B
Noakhali	FF	7.68±0.0	6.51±0.9	32.53±1.01	2.06±2	0.01±0.0	2.89±0.8	0.77±1.1
	NL	7.68±0.3	6.30±1.0	32.53±1.1	2.03±2	0.01±0.0	3.28±1.0	0.72±0.5
	DL	7.70±0.3	6.68±1.0	32.53±1.1	1.95±2	0.01±0.0	2.78±0.9	0.75±0.5
	Contr	7.86±0.3	6.73±1.0	32.40±1.0	2.17±2	0.01±0.0	2.64±0.9	0.64±0.53
Feni	FF	6.70±0.4	7.94±2.1	30.9±0.9	0.59±0	0.01±0.0	1.43±1.0	0.31±0.2
	NL	6.84±0.4	7.66±2.5	30.9±0.9	0.47±0	0.02±0.0	2.48±3.8	0.30±0.1
	DL	6.84±0.4	8.09±2.1	30.9±0.9	0.54±0	0.01±0.0	1.82±2.4	0.24±0.1
	Cont.	6.58±0.4	9.01±1.8	30.97±0.8	0.34±0	0.01±0.0	1.12±0.9	0.24±0.1
Lakshmipur	FF	7.62±0.4	8.88±1.7	31.07±0.9	0.97±1	0.01±0.0	3.25±3.1	0.07±0.0
	NL	7.45±0.7	8.72±1.5	31.15±1.0	0.88±1	0.01±0.0	3.53±3.2	0.08±0.1
	DL	7.71±0.5	8.63±1.4	31.14±0.9	0.58±0	0.01±0.0	2.95±1.8	0.1±0.0
	Cont.	6.49±0.9	8.82±1.7	30.92±0.8	0.34±0	0.02±0.1	0.11±0.0	1.01±0.9

Organic matter (OM%) and Organic carbon (OC%)
The mean value of OM% ranged from 1.19 ± 0.35 to 2.98 ± 1.46 in fish farm and their surrounding agricultural lands during the current investigation (Figure 4). Soil organic matter is a key factor in maintaining long-term soil fertility since it is the reservoir of metabolic energy, which drives soil biological processes involved in nutrient availability (Ekubo and Abowei, 2011). A good soil should

have at least 2.5% organic matter (Banerjea, 1967), but in Bangladesh most of the soils have less than 1.5%, and some soils even less than 1% organic matter (BARC, 2005). The concentrations of organic matter in aquaculture pond soils range from less than 1% in highly leached mineral soils from extensive pisciculture ponds to over 20% in ponds constructed on organic soils (Boyd CE, 1995). Although there is no study to date on the OM content in water and soil of greater Noakhali district, a small study on two areas of Noakhali (Tapader *et al*, 2017) of newly constructed ponds soil showed 2.21 ± 1.43% which was almost three times lower than the present study. Continuous application of feed and fertilizers with high doses in the fish farms might result the higher values of OM in the present study. Haque, SA (2006) estimated OM ranging 0.8- 3.1% had a very good agreement with the current research findings. Organic matter content (%) both in the soil and water of FF, NL and DL were significantly higher than the control sites in all the 3 districts suggesting significant influence of fish farms on its surrounding agricultural lands. The mean value of OM% in water was always found little bit higher than the soil in the entire study areas. On the other hand, organic matter content (OM%) in FF, NL and DL showed significantly higher values in control sides for both in soil and water in 3 districts further confirmed the use of fish feed and fertilizers in fish farms that leached to the NL and DL gradually.

Organic carbon acts as the source of energy for bacteria and other microbes that release nutrients through various biochemical processes. Pond soils with less than 0.5% organic carbon are considered unproductive while those in the ranges of 0.5 - 1.5% and 1.5 - 2.5% have medium and high productivity, respectively. Banerjea (1967) suggested that the acceptable range of organic carbon for aquaculture ponds is 0.5 to 2.5%. The optimal range is 1.5 to 2.5%. According to Boyd (1995), when soil pH is below 7.0 and organic carbon concentrations are above 2.5% (around 5% organic matter) within the S horizon, natural productivity that supports fish growth decreases in ponds Boyd, 1995). The mean value of soil (0.8-2.6%) and water organic carbon (0.9-3.1%) in three districts although did not differ much (slightly higher in water), however, FF, NL and DL showed significantly higher values in all districts compared to control sites (Figure 5). Mean value of soil organic carbon was recorded (1.47 ± 0.53%) in newly constructed pond in Noakhali by Tapader *et al*. (2017) was almost 3 times lower than the present findings. Bacterial decomposition of artificial feed and fertilizers applied to the fish farms of the study areas might be the causes of higher organic carbon content in the present study areas (Tapeder *et al.,* 2017).
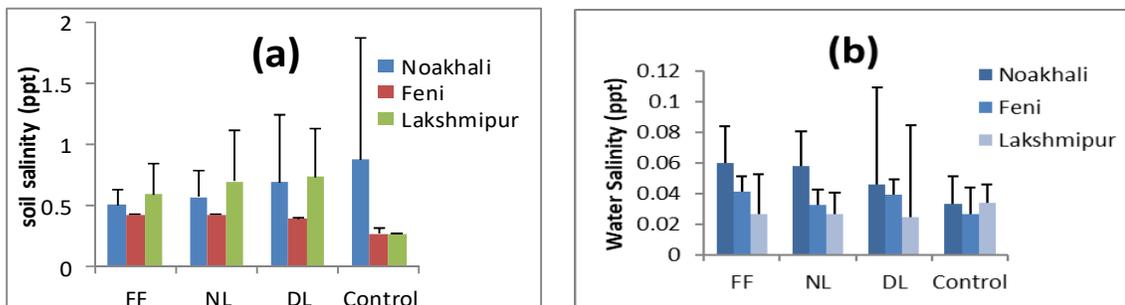

Figure 3. Variation of soil (a)   and water (b) salinity (ppt) in Fish Farm (FF), Near Land(NL), Distance Land (DL) and control side among Noakhali, Feni and Laskmipur observed in Greater Noakhali district.
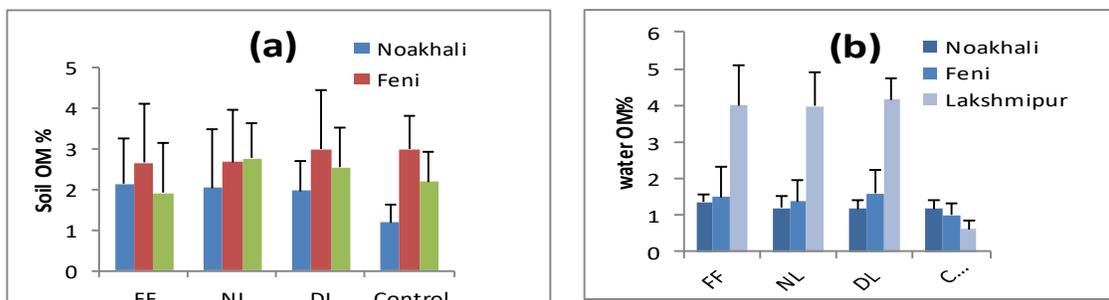
Figure 4. Variation of soil (a) and water (b) organic matter (%) in Fish Farm (FF), Near Land(NL), Distance Land (DL) and control side among Noakhali, Feni and Lakshmipur observed in Greater Noakhali district.

Total Nitrogen (TN%)

The average value of total nitrogen (TN%) ranged 0.12-0.45 in soil and 0.03-0.36 in water of the three districts. Total Nitrogen enters water in numerous forms, including both inorganic (ammonia, ammonium, nitrate, and nitrite) and organic forms. Boyd and Tucker (1998) stated that application of nitrogen to fertilize ponds is usually in the form of urea, which rapidly hydrolyzes to ammonia, salts of ammonium and nitrate, or organic nitrogen in manure. Denitrification is an important pathway of nitrogen removal from ponds. Higher values of TN in the control sites of soil indicated high concentration of NO_3-N in FF, NL and DL in three district while lower values in the control sites of water suggested lower value of NO_3- nitrogen in three districts (Figure 6) as Heiskary et al., (2010) suggested that when TN increases above 2 mg/l, nitrate-N becomes an important component to TN and When TN concentrations exceed 3 to 4 mg/l, nitrate-N will usually be higher than the organic-N. TN% concentration of FF, NL and DL in the study area was found to be ranged from 0.09±0.06 to 0.16±0.12. FF, NL and DL values were found significantly higher than the control sites for soil TN% of the entire study areas suggesting significant influence of fish farms on its nearby agricultural lands, but opposite scenario were observed for water TN%. Application of nitrogen to fertilize ponds is usually in the form of urea, which rapidly hydrolyzes to ammonia, salts of ammonium and nitrate, or organic nitrogen in manure (Boyd and Tucker, 1998). Denitrification is an important pathway of nitrogen removal from ponds. Observed soil nitrogen content (0.2 to 0.5%) was found suitable for fish production in the coastal region of Bangladesh Heiskary et al., 2010; Hickling, 1971). The present study results were found within this referenced range. But for Noakhali and Feni water TN% showed the lower value because of collecting samples in the peak rainy season (Figure 5 & 6).
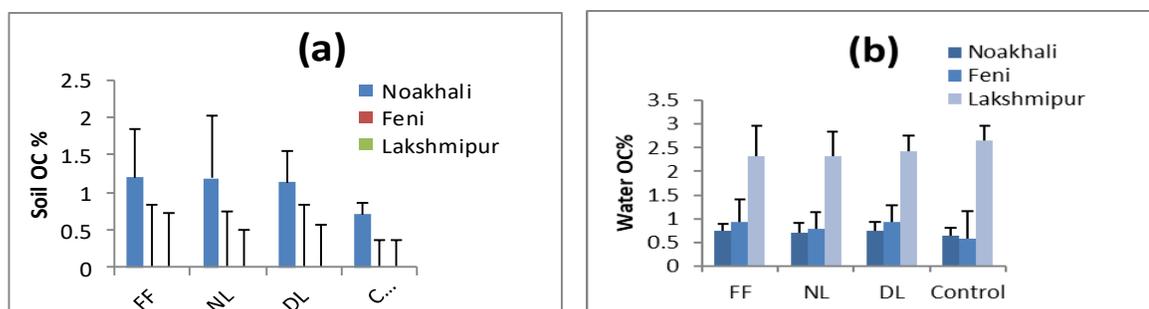

Figure 5. Variation of soil (a) and water (b) organic carbon (%) in Fish Farm (FF), Near Land(NL), Distance Land (DL) and control side among Noakhali, Feni and Laskmipur observed in Greater Noakhali district.
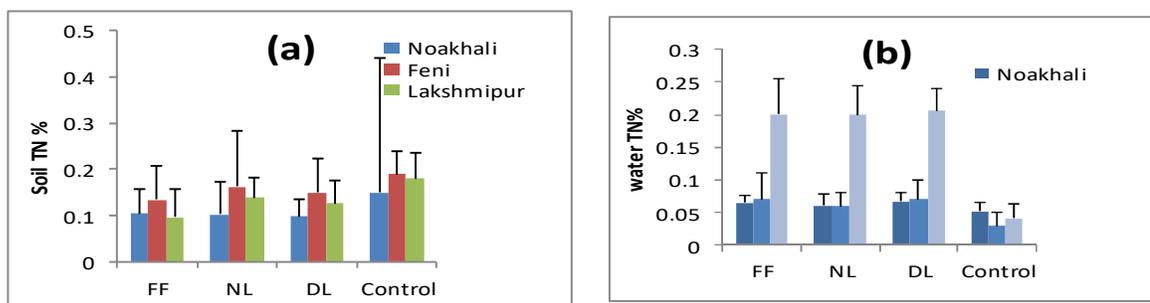
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Figure 6. Variation of soil (a) and water (b) total nitrogen (%) in Fish Farm (FF), Near Land (NL), Distance Land (DL) and control side among Noakhali, Feni and Laskmipur observed in Greater Noakhali district.

Phosphorus (µg/g)

Soil phosphorus ranged from 8.02±0.22 to 15.69±22.22 while phosphorus in water ranged from 0.34±0.1 to 2.17±2.1 in fish farm and their surrounding agricultural lands (Table 2 & 3) of the study areas. Mean phosphorus content in water was significantly low in Feni district compared to other two districts. However, control sites in all districts for both soil and water phosphorus contents were significantly lower than the FF, NL and DL respectively suggesting application of fish feed and fertilizers might yielded the high concentrations. Pond soil interact with the water column affecting the phosphorus cycle in natural waters (Reddy *et al.*, 1999). This interaction is also a major factor in pond aquaculture (Boyd and Musig, 1981; Boyd, 1995). Range of mean concentration of phosphorus in the present study was similar to the ranges described by (Heiskary *et al.,* 2010). Phosphorus 0.05-0.07 ppm is optimum and productive and 1.0 ppm (1µg/g) is considered very suitable because it influenced plankton and shrimp production (Bhatnagar *et al.,* 2004). Interestingly higher value of phosphorus in the present study might be due to the use of excess supplementary feed containing phosphorus into the fish pond.

Sulfur (µg/g)

Soil sulfur ranged from 1.63 ± 1.18 to 50.12±19.15 and the higher value was very near to 65.2 µg/g which was suggested by Rahman and Ahsan (2006) (Table 2 & 3). The sulfur values in water were found remarkable lower than the referenced value. The samples were collected in the peak rainy season and this can be the main reason behind the lower experimental value of water. There was no influence of fish farm soil sulfur (µg/g) on the nearby agricultural lands in all of the 3 districts. Similarly, sulfur content in fish farm did not show any influence in Noakhali and Feni districts except in Luxmipur. Total sulfur content of 0.1-0.5% in the ponds soil is included in the medium productive pond (Boyd, 1995). Total sulfur concentration increases linearly with the age of the ponds (Munsiri *et al.,* 1996).

Potassium (meq/100g)

Potassium (meq/100g) ranged from 0.002±0.001 to 0.29±0.10 and 0.34±0.16 to 2.17±2.10 in soil and water respectively during the current study. Potassium from dead phytoplankton and zooplankton due to application of fish feed might mix with clay materials and bound in soil but before it dissolves in water resulting higher values in water. Heiskary *et al.,* (2010) found potassium ranging from 0.1-0.5 meq/100g supports the current investigation done for soil and water in 3 districts showed no significant influence of fish farms on its surrounding agricultural lands. Potassium is readily absorbed by plant tissues and effects the growth of aquatic flora. The mean concentration of potassium in water was much higher than the contents of soil in all of the three districts (Table 2 & 3). Accordingly, fish farm (FF), Nearland (NL) and Distance land (DL) showed higher values of potassium compared to controls.

Boron (μg/g)

Bron (μg/g) ranged from 0.18±0.14 to 0.55±0.4 and 0.07± 0.0 to 1.01± 0.9 in soil and water respectively (Table 2 and Table 3). Study conducted by SRDI (1996) Noakhali revealed that soil mean boron concentration ranged from 0.49-1.6μg/g which is similar to the present findings. Mean concentration of boron in soil in the present study was higher than the water. No significant influence of fish farms for both soil and water boron (μg/g) was found on its surrounding agricultural lands during the study period. Boron concentration depends on the type of soil as well as on the amount of organic matter. In surface water, concentrations of boron depend on the amount of boron present in the soils and rocks of the drainage area (Smitha *et al*., 2015).

Multiple comparison in the mean values of soil quality parameters (TuKey's HSD post hoc test *P* <0.05) were performed to find out the district wise variation. Soil pH, OC, OM, TN, P and salinity of Noakhali districts significantly varied from Feni district and K, S and B were significantly different in three districts.

Table 4. Variation in the soil quality parameters observed during the present study.

Multiple comparisons of soil quality parameters (TuKey's HSD post hoc test)			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
Dependent Variable						Lower Bound	Upper Bound
pH	Noakhali	Feni	1.06683*	.12117	.000	.7805	1.3531
		Luxmipur	.02067	.11624	.983	-.2540	.2953
OC%	Noakhali	Feni	-.43177*	.12992	.003	-.7388	-.1248
		Luxmipur	-.21661	.12464	.194	-.5111	.0779
OM%	Noakhali	Feni	-.72786*	.22494	.004	-1.2594	-.1964
		Luxmipur	-.35756	.21579	.225	-.8674	.1523
TN%	Noakhali	Feni	-.04791*	.01282	.001	-.0782	-.0176
		Luxmipur	-.01900	.01230	.273	-.0481	.0101
P (μg/g)	Noakhali	Feni	9.70380*	2.12409	.000	4.6849	14.7227
		Luxmipur	1.81183	2.03768	.648	-3.0029	6.6265
K (meq/100g)	Noakhali	Feni	.05480*	.01961	.016	.0085	.1011
		Luxmipur	.10936*	.01881	.000	.0649	.1538
S (μg/g)	Noakhali	Feni	28.14032*	2.73890	.000	21.6687	34.6119
		Luxmipur	29.39148*	2.62747	.000	23.1832	35.5998
B (μg/g)	Noakhali	Feni	-.11739	.06154	.139	-.2628	.0280
		Luxmipur	.10163	.05903	.200	-.0379	.2411
Salinity (ppt)	Noakhali	Feni	.55671*	.05474	.000	.4274	.6861
		Luxmipur	-.08665	.05251	.227	-.2107	.0374
*. The mean difference is significant at the 0.05 level.							

Correlation matrix among soil quality parameters

Soil pH in three districts were found highly negatively correlated with OC, OM, TN and positively correlated with phosphorus and salinity while organic carbon showed highly positively correlated with organic matter and total nitrogen (TN) with negative correlation with salinity (Table 5). The composition of the soil bottom is related to organic matter means organic carbon and nitrogen. Organic matter of the soil releases organic carbon after the bacterial degradation showed the highly positive relation with total nitrogen and negative relation with salinity. Phosphorus showed highly significant positive relationship with potassium, sulfur and salinity with significant negative relationship with Boron. Potassium was highly correlated with the concentration of sulfur and was found different in each districts and locations. Soil salinity in each sites (FF, NL, DL and control) were significantly different from each districts.

Table 5. Pearson´s correlation matrix of soil quality parameters observed in the entire study areas (3 districts) during the present study.

Correlations											
	pH	OC	OM	TN	P	K	S	B	Sal.	Dist.	sites
pH	1										
OC	-.388[**]	1									
OM	-.390[**]	.998[**]	1								
TN	-.391[**]	.831[**]	.829[**]	1							
P	.328[**]	.017	.013	-.016	1						
K	-.070	.096	.092	.036	.212[**]	1					
S	.122	-.039	-.040	-.061	.241[**]	.536[**]	1				
B	.003	.034	.030	.051	-.186[*]	.028	-.026	1			
Sal.	.597[**]	-.150[*]	-.152[*]	-.179[*]	.278[**]	.050	.268[**]	-	1		
District	.036	.109	.103	.091	-.036	-.395[**]	-.589[**]	-	.140	1	
Locatio	-.015	.135	.129	.114	-.066	-.392[**]	-.565[**]	-	.166	.949	1
**. Correlation is significant at the 0.01 level (2-tailed).											
*. Correlation is significant at the 0.05 level (2-tailed).											

Relationship between soil organic matter, organic carbon and total nitrogen

There have been a lot of studies conducted in different countries and different regions in the world to elucidate the relationship between soil organic matter, organic carbon and total nitrogen. Unfortunately, no study was conducted to find out their relationship with huge number of samples in Bangladesh. Stepwise multiple regression model (ANOVA) was developed using 186 soil samples data from the present study. Regression model suggested that if OC% is increases by 1% then OM% increases by 1.726%. On the other hand, if OC% increases, total nitrogen (%) increases by 0.083% (Table 6 & 7).

Table 6. ANOVA Regression model for soil quality parameters in greater Noakhali district.

	Sum of Squares	Df	Mean Square	F	Sig.	Unstandardized Coefficients	Standardized Coefficients	T	
							Std. Error		
						B	r	Beta		Sig.
Regression	281.378	1	281.378	51947.968	.000[b]					
Residual	1.002	185	.005			.003	.012		.258	.796
Total	282.380	186				1.726	.008	.998	227.921	.000

Dependent Variable: OM%; b. Predictors: (Constant), OC%; p<0.05

Table 7. ANOVA Regression model for soil quality parameters in greater Noakhali district.

	Sum of Squares	Df	Mean Square	F	Sig.	Unstandardized Coefficients	Standardized Coefficients	T	Sig.
							Std. Error	Beta		
Regression	.646	1	.646	412.23	.000[b]					
Residual	.290	185	.002			.008	.006		1.298	.196
Total	.936	186				.083	.004	.831	20.303	.000

a. Dependent Variable: TN%; b. Predictors: (Constant), OC%; p<0.05
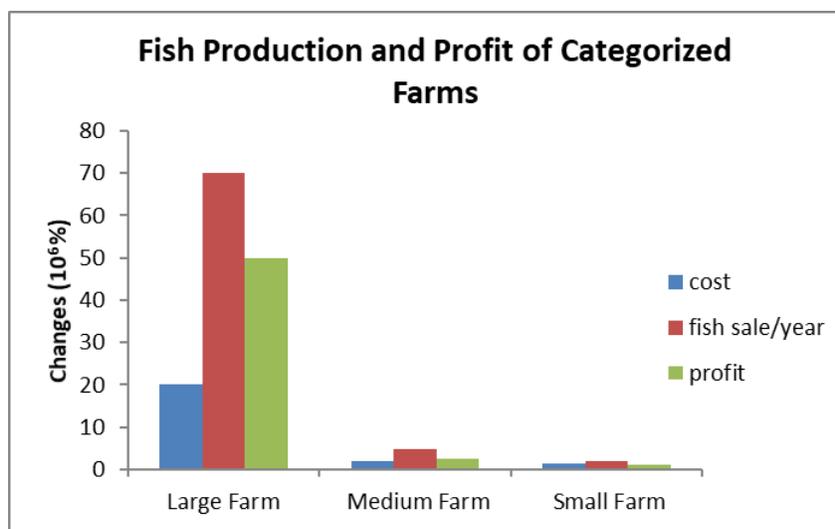
11.2 Agricultural Productivity and Profitability Analysis

Fish Farm Productivity and Income:

As mentioned earlier that the fish farm owners converted their agricultural crop land in to fish farms for more profit in the studied areas. Therefore the total productions from fish farms and agricultural crops (rice, halon, vegetables etc.) nearby the fish farm areas (agricultural land) before and after the establishment of fish farm's were studied. Nine (9) large fish farms, 16 medium fish farms and 42 small fish farms were studied in greater Noakhali district. Results from the greater Noakhali district revealed that the gross profit (%) was found higher in large fish farms (238.24%) compared to medium (160.79%) and small (66.69%) fish farms (Table 8 & Figure 7).

Table 8. Total cost (Lac Taka), fish production (MT) and profitability (%) analyzed in different categories of fish farms in greater Noakhali district.

Sl#	Farm Category	No of Fish Farm	Fish Farm Total Fixed Cost (Lac Taka)/Year		Fish Farm Temporary Cost (Lac Taka)/Year		Fish production (MT)/Year		Total Fish Sale (Lac Taka)/Year		% of Profit
			Total	Average	Total	Average	Total	Average	Total	Average	
1.	Large Farm (>15 acre)	9	301.26	33.47	1572.41	174.71	32.19	3.58	6337.50	704.17	238.24
2.	Medium Farm (5-15 acre)	16	24.11	1.51	228.34	14.27	3.76	0.23	658.36	41.15	160.79
3.	Small Farm (<5 acre)	42	24.72	0.59	213.44	5.08	2.25	0.05	397.00	9.45	66.69

Figure 7. Fish Farm Productivity and profitability observed in greater Noakhali district.

11.3 Impact of Aquaculture on Agricultural productions and profitability:

Similar to the fish production and gross profit in fish farms nearby large farm's agricultural crop production (NL) after the establishment of fish farms were also found to be the highest (17.01%) compared to small and medium fish farms in greater Noakhali district (Table 9). Therefore, it is further confirmed that aquaculture activities impacted positively to the nearby surrounding areas

with fish production and profit as well as agricultural crop production along with gross profit in greater Noakhali district. Aquaculture farm's activities by supplying huge volumes of nutrient rich waters might be the impact of increased total crop production and gross profit.

Table 9. Changes in average Crop Production (%) & Profitability (%) of Near Land after the establishment of aquaculture farms in greater Noakhali district.

Sl#	Farm Category	No of Fish Farm	Total Crop Production			Gross Profit		
			Before	After	% Change	Before	After	% Change
1.	Large Farm (>15 acre)	9	126.89	151.11	19.09	63,216.67	73,972.22	17.01
2.	Medium Farm (5-15 acre)	16	54.13	60.69	12.12	15,546.88	16,828.13	8.24
3.	Small Farm (<5 acre)	42	43.83	45.29	3.31	17,670.83	18,023.93	2.00

Less positive impact of large fish farms on their nearby agricultural crop production (gross profit change 17.01%; Table 9) was found compared to their distance agricultural production (gross profit change 17.96%; Table 10). Statement from the focus group revealed that continuous draining out of nutrient rich water to its nearby agricultural land made the area water logged. Rice plant after the seedling grows very fast with those excessive nutrients but they can't withstand and finally production fall. On the other hand, maximum gross profit was achieved by the small (43.19%) and medium farms (42.80%) of the distance land (Table 10 and Figure 8). This indicates small and medium fish farms impacted more benefit by the aquaculture activities such as continuous leaching of nutrient rich waters gradually decreased from near land to distant land through moving from waterlogged area to dry land and might develop the distance land suitable for more variety of agricultural crops.

Table 10. Changes in average Crop Production (%) & Profitability (%) of Distance Land after the establishment of aquaculture farms in greater Noakhali district.

Sl#	Farm Category	No of Fish Farm	Total Crop Production			Gross Profit		
			Before	After	% Change	Before	After	% Change
1.	Large Farm (>15 acre)	9	217.00	255.56	17.77	116,066.67	136,911.11	17.96
2.	Medium Farm (5-15 acre)	16	49.38	59.81	21.14	11,843.75	16,912.50	42.80
3.	Small Farm (<5 acre)	42	45.81	55.71	21.62	15,075.60	21,586.90	43.19
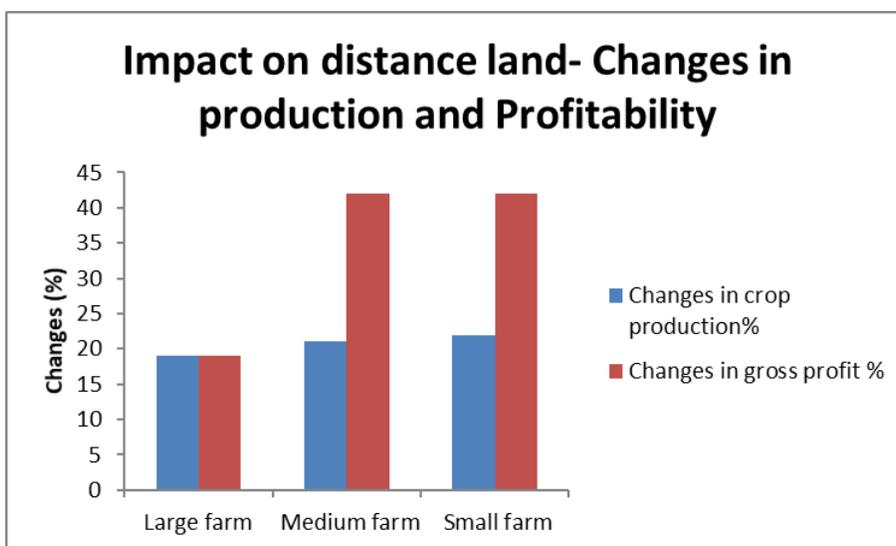
Figure 8. Impact aquaculture on distance lands crop productivity and profitability.

Crop Variety:

In both near land and distance land, High Yield Variety (HYV) of rice showed an increasing rate of farming in every case after fish farm establishment. Variety of agricultural crops in nearby agriculture areas (near land and distance agriculture land) of large, medium and small fish farm In greater Noakhali district were found to be remarkably changed (Table 11.) due to the huge nutrient leaching as well as making the near land areas water logged after the establishment of fish farms. Seven (7) near land agriculture land after the establishment of large fish farms (9); 8 near land agriculture land after the establishment of medium fish farms (16) and 18 near land agriculture land after the establishment of small farms (42) were found to cultivate only rice. On the other hand, 5 distance agriculture land after the establishment of large fish farms (9); 11 distance agriculture land after the establishment of medium fish farms (16) and 33 distance agriculture land after the establishment of small farms (42) were found to be cultivated only rice (Table 11). Both near and distance agricultural lands showed a little decrease or no change of rice production after the fish farm establishment but the highest decreasing rate in rice production (all types) was found in small farms of near agricultural land (Table 11).

Table 11. Changes in the variety of crops after the fish farms establishment in greater Noakhali district.

Sl#	Farm Category	No of Fish Farm	Change	Near Land crop					Distant Land crop				
				HYV	WIF	Hybrid	Both	None	HYV	WIF	Hybrid	Both	None
1.	Large Farm (>15 acre)	9	Increase	6	1	0	0	0	5	0	0	2	0
			Decrease	0	2	2	1	4	0	0	1	0	7
2.	Medium Farm (5-15 acre)	16	Increase	8	0	0	0	0	11	0	0	2	0
			Decrease	0	5	5	0	8	0	0	0	1	15
3.	Small Farm (<5 acre)	42	Increase	18	0	0	1	0	33	0	0	5	0
			Decrease	2	10	6	7	18	0	2	2	1	6

Changes in soil and water color:

Large fish farm water color showed no change but the medium (93.75%) and small (88.10%) farms showed increasing rate of change in near land than distance land after fish farm establishment. Percentage of soil color change showed slightly different pattern. The highest soil color change was

found in large farms (100%) of distance land but medium (93.75%) and small (92.86%) fish farms of near lands showed the higher change than distance lands' medium (50%) and small (83.33%) farms (Table 12).

Table 12. Changes in of soil and water color after the fish farms establishment in greater Noakhali district.

No.	Farm Category	No of Fish Farm	Near Land				Distant Land			
			Soil Color Change	Soil Color Change %	Water Color Change	Water Color Change (%)	Soil Color Change %	Soil Color Change %	Water Color Change	Water Color Change %
1.	Large Farm (>15 acre)	9	8	88.89	8	88.89	9	100	9.00	88.89
2.	Medium Farm (5-15 acre)	16	15	93.75	15	93.75	8	50	13	81.25
3.	Small Farm (<5 acre)	42	39	92.86	37	88.10	35	83.33	34	80.95

Changes in use of fertilizers:

The present study result showed that the application of inorganic fertilizers in the near land areas of aquafarms were increased after the establishment of all sizes of fish farms in the studied area (Table 13) which might lead this area hypertrophic causing water logged and less crop production.

Table 13. Changes in the use of fertilizers in agricultural farms after the fish farms establishment in greater Noakhali district

Sl#	Farm Category	Fish Farm	Time	Near Land				Distant Land			
				Organic	Inorganic	Both	None	Organic	Inorganic	Both	None
1.	Large Farm (>15 acre)	9	Before	0	2	7	0	0	2	7	0
			After	0	2	7	0	0	3	6	0
2.	Medium Farm (5-15 acre)	16	Before	1	2	13	0	0	6	10	0
			After	1	1	13	0	0	6	10	0
3.	Small Farm (<5 acre)	42	Before	8	9	25	0	2	9	31	0
			After	2	8	30	0	0	8	3	1

Changes in cropping pattern:

Activities of the large scale aquaculture farms with >15 acres areas impacted negatively on the near land agricultural in terms of cropping patterns (-72%). Cultivation of groundnut (-100) was completely disappeared in the near land of fish farms in greater Noakhali district whereas Helon (-80%) and vegetable (-67) were about to disappear in the areas (Table 14). Not only large aquaculture farms, but also medium and small farms have also negative impact on the cropping patterns of its nearby agricultural land (Table 14) in greater Noakhali district.

Table 14. Changes in cropping patterns after the fish farms establishment in greater Noakhali district.

Sl. #	Farm Category	No of Fish Farm	Time	Near Land					Distant Land				
				Rice	Helon	Groundnut	Vegetable	Other	Rice	Helon	Groundnut	Vegetable	Other
1.	Large Farm (>15 acre)	9	Before	9	5	1	3	1	9	2	2	1	1
			After	8	1	0	1	0	9	0	1	4	0
			Change (%)	-11	-80	-100	-67	-100	0	-100	-50	+400	-100
			Total change	72%					130%				
2.	Medium Farm (5-15 acre)	16	Before	16	3	3	6	1	16	2	2	6	1
			After	16	1	0	2	0	16	1	0	3	0
			Change (%)	0	-67	-100	-67	-100	0	-50	-100	-50	-100
			Total change	67%					60%				
3.	Small Farm (<5 acre)	42	Before	39	11	4	9	1	41	3	3	14	2
			After	42	3	0	2	1	42	1	0	6	1
			Change (%)	+108	-73	-100	-78	0	+102	-67	100	-57	-50
			Total change	72%					75%				

Changes in Income:

The present study result showed that the annual income of the fish farm owners were gradually increased after fish farm establishment than before but a dramatically increasing rate was observed in large fish farm owners. Large fish farm owner annual income was found 124.17 Lac BDT and 376.33 Lac BDT before and after fish farm establishment. Again, in case of average increase of income (%) in the experimental area showed a gradual decrease from large fish farm to small farm yearly. The highest value (203.09%) was found for large fish farm, 146.22%for medium farms and the lower (122.48%) stands for small farms (Table 15).

Table 15. Changes in annual income (Lac Taka) after the fish farms establishment in greater Noakhali district.

Sl No.	Farm Category	No of Fish Farm	Previous Annual Income		Annual Income after Farm Established		Average Increase of Income (%)	No. of Owner Taken Loan	% of Owner Taken Loan
			Total	Mean	Total	Mean			
1.	Large Farm (>15 acre)	9	1,117.5	124.2	3,387	376.3	203.0	5	55.6
2.	Medium Farm (5-15 acre)	16	172	10.75	423.5	26.47	146.2	4	25
3.	Small Farm (<5 acre)	42	120.3	2.86	267.6	6.37	122.5	13	30.9

Changes in educational status:

Education has significant impact on the society. It is the key determinant of the lifestyle & status in a society. Educational attainment has strong effects on reproductive behavior, family planning & knowledge about contagious diseases, occupation, income, sanitation system & issues related to family health & hygiene. In the present study result the educational facilities of the large fish farm

owners were found almost same (100%) as before but in medium (100%) and small size farm (97.62%) a dramatically increasing rate was observed after the fish farm establishment (Table 16).

Changes in medical facilities:
The present study result also revealed the increasing rate of medical facility in fish farm owners after the farm establishment. Increasing rate in medical facility was observed almost same in the large fish farm owners as before but in medium (100%) and small size farm (100%) slightly increasing rate was observed after the fish farm establishment (Table 16).

Table 16. Changes in education, medical, drinking water & sanitation facilities after the establishment of fish farm in greater Noakhali district.

Sl No.	Farm Category	No. Fish Farm	Education Facility			Medical Facility			Sanitation Facility		
			Before	After	% availed after	Before	After	% availed after	Before	After	% availed after
1.	Large Farm (>15 acre)	9	9	9	100	9	9	100	9	9	100
2.	Medium Farm (5-15 acre)	16	12	16	100	15	16	100	16	16	100
3.	Small Farm (<5 acre)	42	38	41	97.62	41	42	100	40	42	100

Changes in Sanitary facilities:
 Fish farmer are the productive group of people in the country. In the present study result the sanitation facilities of large and medium fish farm owner was found almost same (100%) as before but in small size farm (100%) slightly increasing rate was observed after the fish farm establishment (Table 17).

Table 17. Sanitation facilities categories for the fisherman in the study area:

Sanitation Facilities	Description
Katcha	Made of bamboo with leaf shelter& very poor drainage disposal
Semi-building	Made of brick with leaf or in tin shelter & inadequate drainage disposal
Building	Made of brick with good drainage disposal

Changes in Electrical Equipment & Motor Vehicle Usages
Dramatically increasing rate was observed in using electrical equipment & motor vehicle among the fish farm owners after the fish farm establishment in the experimental area. From the present study result, the increasing rate in electrical equipment use was found 75% in large farm owners and 600% and 433.33% in medium and small farm owners respectively. On the other hand, the changing (increase) rate of using motor vehicles was observed 125%, 175% and 222.22% in large, medium and small fish farm respectively (Table 18).

Table 18. Changes in Electrical Equipment & Motor Vehicle Uses after the establishment of fish farm in greater Noakhali district

Sl #	Farm Category	No of Fish Farm	All of TV, Fridge & Mobile			Motor Vehicle		
			Before	After	% Change	Before	After	% Change
1.	Large Farm (>15 acre)	9	4	7	75	4	9	125
2.	Medium Farm (5-15 acre)	16	2	14	600	4	11	175
3.	Small Farm (<5 acre)	42	6	32	433.33	9	29	222.22

Future planning

Present study result also revealed about the future plan of the fish farmers related to their farms of the study area. Out of 9 large fish farm owners 2 of them are interested to establish new farms and 7 of them wanted to extent the prevailing one but not interested in other business. Medium fish farmers are also not interested in other business rather than fish farming but out of 42, 2 small scale fish farmers showed interest in other business (Table 19).

Table 19. Future Plan related to fish farm establishment and extension in greater Noakhali district.

Sl#	Farm Category	No of Fish Farm	New Farm Establishment	Extension	Other Business
1.	Large Farm (>15 acre)	9	2	7	0
2.	Medium Farm (5-15 acre)	16	2	14	0
3.	Small Farm (<5 acre)	42	4	36	2

Production and Profitability

Average crop production & profitability of near land and distance land

A comparative scenario of average crop production & profitability of surrounding agricultural lands (near and distance) of the fish farms of the study area resulted that near agricultural lands, total crop production was higher 19.09% in larger fish farm and lower 3.31% in small fish farm. Along with this, the gross profit (%) was also showed the same pattern of increase. On the other hand, the opposite pattern was observed for total crop production (%) and gross profit (%) in distance land. Total crop production was found higher 21.62% in small fish farm and lower 17.77% in large fish farm. Along with this, the gross profit (%) was also showed the same pattern of increase in distance land.

As the fish farm owners discharged their pond water to the surrounding agricultural lands the area was water-logged all year round. The area of the near land small farms which was considered <5 acre maybe water-logged all of the time but the full area of large agricultural farm (>15 acre) may not water-logged so the production rate was found higher than the small agricultural farms of near land.

Along with the discharged water of the fish farms huge amount of nutrients are transported to the near agricultural land and slightly to the distance agricultural lands. So the influence of these nutrients can be found in small farms (<5 acre) of distance land but not on the large farms (>15 acre). This can be the reason behind the production of the small farms is found higher than the larger farm of distance land. Along with increasing production the gross profit (%) is getting increased.

Impact on Agricultural Production of surrounding lands after Fish Farm Establishment
Present study result also revealed that, in both near land and distance land High Yield Varity (HYV) rice was showed an increasing rate in every case after the fish farm establishment.

In both near and distance agricultural lands showed little bit decrease or no change of rice production after the fish farm establishment but the highest decreasing rate in rice production (all types) was found in small farms of near agricultural land. But only in the small farm of near land, farmers increased the using rate of fertilizers after the fish farm establishment.

The highest soil color change was found in large farms (100%) of distance land but in near land medium (93.75%) and small (92.86%) fish farms showed the higher changing value. The area of the near land small farms (<5 acre) maybe water-logged all year round and nutrients load is also very high as the water had come from the adjacent fish farm. These small farms of near agricultural lands in most of the cases are established in un-planned manner and drainage facility is also very poor. So, this can be the reason behind the highest decreasing rate of all type of rice production and higher soil color change in small farms of near agricultural land. Most of the farmers of our country have lack of knowledge about nutrient load and the use of fertilizers in cultivable lands. So, present study result showed that they were using more fertilizers in small farms of near agricultural land of the study area for increasing the production which ultimately increasing the level of nutrients and making the agri-land more unproductive. This can be also the cause of lower production of small farms than large farms of near agricultural land.

But the lower production and higher soil color change in large farms of distance agricultural land may not be related to fish farm establishment. Changing cropping patterns, use of different fertilizers and pesticides can be the reason behind it.

The current study result also revealed that, a great negative impact was found on production of helon and ground nuts after fish farm establishment in the both near and distance land. The areas mainly remain water-logged in the nearby agricultural lands of fish farm where the drainage facilities is very poor which can be the main reason of crop diversification and reduce the production of these crops (helon, groundnuts).

Changes in livelihood patterns
The present study result revealed that the annual income of the fish farm owners were gradually increased after fish farm establishment than before but a dramatically increasing rate was observed in large fish farm owners' income. Along with the increasing income the educational, medical and sanitation facilities also showed an increasing pattern of the fish farm owners in the study area. Different modern facilities such as use of mobile phone, various electrical devices and motor vehicles made the lifestyle of the fish farm owners more and more advanced and digitalized. These modern and advanced facilities updated the socio-economic status of the fish farmers especially the large farm owners.

Fish farmers of the studied area are more interested in making extension of their own fish farm and some of them are interested in starting new fish farms as their income is increasing day by day. In most of the cases they are not interested in other business.

12. Research highlight/findings:
- Aquaculture influenced in changing soil color, water color and rich in nutrients significantly on its nearby water logged areas in greater Noakhali district.
- Aquaculture activities in greater Noakhali district not only positively impacted fish farmers with increased fish production, gross profit and better livelihood but also to the nearby

surrounding agriculture farmers with increased crop production (only rice) and better livelihood, however 80% agricultural crops were disappeared and/ about to disappear after the establishment of fish farms.

- Among 5 major crops only High Yield Varity (HYV) of rice became dominant and being cultivated in both near land and distance land after the establishment of each fish farms in greater Noakhali district.

- Along with the livelihood changes, socio-economic status of the fish farmers especially around the large farm owners were improved although major crops were disappeared.

- Fish farms having very small facilities of used water drainage and those were established in an unplanned way become a great threat particularly for nearby agriculture farms in terms of food security because of the disappearance and/reduction of cropping patterns and diversity in greater Noakhali areas.

- Activities of the large scale aquaculture farms with >15 acres areas impacted negatively on the near land agricultural in terms of cropping patterns (-72%). Cultivation of groundnut (-100%) was completely disappeared in the near land of fish farms in greater Noakhali district whereas Helon (-80%) and vegetable (-67%) were about to disappear in the areas. 4 crops (local name Helon, English name cowpea; *Vigna unguiculata*, ground nut, vegetable and others), were disappeared and only High Yield Varity (HYV) rice became dominant and being cultivated in the studied areas after the establishment of aquaculture farms. Not only large aquaculture farms, but also medium and small farms have also negative impact on the agriculture cropping patterns of its nearby agricultural land in greater Noakhali district.

B. Implementation Position

1. **Procurement:**

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment	Nil	Nil	Nil	Nil	
(b) Lab &field equipment					
1. laptop-01	50,000	50,000	50,000	50,000	
2. Desktop-01	40,000	40,000	40,000	40,000	
3. UPS-01	3000	3000	3000	3000	
4. Scanner-01	5000	5000	5000	5000	
5. Lesser Jet Printer-01	16,000	16,000	16,000	16,000	
6. Digital Camera-01	20,000	20,000	20,000	20,000	100%
7.Water filtration with pump	1,48,000	1,48,000	1,48,000	1,48,000	
8.Refractometer-01	34,000	34,000	34,000	34,000	
9. pH meter	39,000	39,000	39,000	39,000	
10. Chemical	7,00000	7,00000	7,00000	7,00000	
Total	**10,55,000**	**10,55,000**	**10,55,000**	**10,55,000**	
(c) Other capital items					

2. **Establishment/renovation facilities: N/A**

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

3. **Training/study tour/ seminar/workshop/conference organized: N/A**

Description	Number of participant			Duration	Remarks
	Male	Female	Total	(Days/weeks/ months)	
(a) Training					N/A
(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	330745	330745	330745	0	100	
B. Field research/lab expenses and supplies	2678808	2610480	2613580	0		
C. Operating expenses	254135	225346	225346	0	100	
D. Vehicle hire and fuel, oil & maintenance	302476	271218	272476			
E. Training/workshop/ seminar etc.	0	0	0	0	100	
F. Publications and printing	80000	13950	13950	0	100	
G. Miscellaneous	56581	41970	48315			
H. Capital expenses	353000	353000	353000	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	Output (i.e. product obtained, visible, measurable)	Outcome (short term effect of the research)
To determine the soil and water quality of the aquafarms and adjacent agriculture land.	The soil and water samples were analyzed for both physical and chemical properties in the regional laboratory of Soil Resource Development Institute, Mrettika Bhaban, Gabua, Noakhali (SRDI). The samples were analyzed following the standard methods as SRDI (2012).	Soil and water quality in the fish farms were suitable for fish farming but their concentrations particularly organic matters were significantly higher than nearby agricultural land and control sides.	Soil and water quality of the fish farms were suitable for fish production but their near lands remained water logged due to drained waters with very high concentrations of nutrients all the year round.
To identify the status of agricultural production and productivity of the adjacent aquaculture farm.	Collected data were accumulated & analyzed using SPSS, MS-Excel & general calculation methods & then presented in textual, tabular & graphical forms.	Changing the color of water and soil in the near land and distance land were observed and increased amount of organic matter and was found in the near land and distance land areas.	Aquaculture farm's activities by supplying huge volumes of fertilized waters helped increased total agricultural crop production after the fish farm establishment.

To assess the impacts of aquaculture farming on livelihood status of non-aquaculture farmers.	Primary data collection was collected directly from the farm owner. Before collecting primary data, a precise questionnaire (Annexure) was developed which is tested in some nearby fish farms. In this test much endeavor was placed in order to reach the objectives of the study. According to the knowledge gained in the test, the final questionnaire was re-arranged, modified & improved.	Including better livelihood (education, use of various electrical devices, motor vehicles, mobile phones and other modern facilities), crop production and gross profit (%) was found to be increased in near land (43 %), distance land (42.8 %) agriculture farmers of the small and medium farm owners respectively after the establishment of fish farm. Least gross profit was observed (17.1%) in near land agriculture farmers compared to distance land farmers after the establishment of large fish farms in the study area.	Although establishment of 3 categories of (large, medium and small) fish farms impacted positively on their surrounding agriculture farmers in terms of gross profit and crop production, however activities of the large scale aquaculture farms with >15 acres areas showed negative impact on the near land agricultural cropping patterns (-72%). Cultivation of groundnut (-100) was completely disappeared in the near land of fish farms in greater Noakhali district whereas Helon (English name cowpea; *Vigna unguiculata* (-80%) and vegetable (-67) were about to disappear in the areas. Not only large aquaculture farms, but also medium and small farms have also negative impact on the cropping patterns of its nearby agricultural land.

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.			
Journal publication	Under preparation		
Information development			
Other publications, if any		Abstract published in Hiroshima University of Biosphere Science at International Summer School Program, 2018.	

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

    i.   Generation of technology (Commodity & Non-commodity)

> Necessitation of proper guidelines on the design and construction of aquaculture farms on the aquaculture engineering point of view. Water re-circulatory aquaculture system is very much essential to develop so as to re-use of drained water from the large farms to its nearby agriculture farms/land in the areas.

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

> Aquaculture helped increasing fish productions as well as those of their nearby agriculture productions revealing positive impact on agriculture crop production and livelihood however cropping diversity of agricultural land are decreased significantly which will affect the sustainable aquaculture-agriculture productions in greater Noakhali district as crop land is limited.

    iii.   Technology transferred that help increased agricultural productivity and farmers' income

> N/A

    iv.   Policy Support

> Needs to policy support to bring all the fish farms under specific rules and regulations particularly on the future prescribed design of aquafarms including proper drainage system and/ establishing water re-circulatory aquaculture system so as to maintain sustainable agriculture-aquaculture farming system.

G. Information regarding Desk and Field Monitoring

   i)   Desk Monitoring:
- Monitoring workshop held on 15 May 2018 at BARC auditorium with satisfactory output.
- Annual Review Workshop held in 20 September, 2018 at BARC and comments from rapporteurs were complied.

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

Monitoring team	Date(s) of visit	Total visit till date (No.)	Output
PIU-BARC, NATP-2	10, January, 2019	01	Satisfactory

H. Lesson Learned/Challenges (if any)
- The respondents mainly the agricultural farm owners were not pleased to provide actual information about their incomes and problems they were facing due to the establishment of fish farm.

I. Challenges (if any)
- Very challenging to get real data from agricultural farm owners since they were scared and grasped by the rich and powerful aqua farm owners.

Signature of the Principal Investigator
Date ………………………….
Seal

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

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Appendices

Appendix 1. Questionnaire

Fisheries & Marine Science Department, Noakhali Science and Technology University, Noakhali
Sub-Project: Impact of aquaculture on agricultural production in greater Noakhali district
Project ID: 587
Questionnaire-1:Fish farm

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1. Identity of the farm owner:

Owner name:………………………………..   Age:……………….. Years
Owner's Address: Village:……………………   Union:…………………….
*   Thana:……………. Zilla:………………. Mobile No:…………………..*
Ownership Type: a) Single = 1   b) Partnership = 2
What is your proportion of share in the farm? (In %)

Basic Information of the fish farm:

Does the farm have government approval?	☐	1 = "Government Approved Farm" 2 = "Government Disapproved Farm"
2.2 Year of Farm Establishment………	☐	
2.3 Staff number during farm establishment	☐	*In Number*
2.4 Stuff number at present	☐	*In Number*
2.5 Permanent staff number	☐	*In Number*
2.6 Temporary staff number	☐	*In Number*

Physical condition of the fish farm:

3.1 *Area of the fish farm…….*	☐ ☐	1 = "Area in acre" 2= "Area in Decimal"
3.2 What was the water area of your pond?	☐	Area in decimal
Farm Area Category……	☐	1 = "Small Farm" < 5 acre 2 = "Medium Farm" 5-15 acre 3= " Large Farm" > 15 acre
3.4 Distance of fish farm from main road…	☐	1 = "Near" < 0.5 km 2 = "Far" 0.5-2.0 km 3= " More Far" > 2 km 4 = Adjacent Beside main road
3.5 Road condition to reach the farm…………	☐	1 = "Paka" 2 = "Adhapaka" 3= " Kacha"
3.6 Boundary around the farm	☐	1 = "Yes" 2 = "No"
3.7 Number of ponds in the farm	☐	
3.8 Drainage facility	☐	*1= Yes 2= No*
3.9 Drainout ways	☐	1 = "Paka nala" 2 = "Pipe" 3= "Adhapaka nala" 4 = "Kacha nala"

3.10 Drained to		1 = Adjacent land 2 = Distant land 3= Drainage system 4 = River 5= Canal
3.11 Storage facility		1= Yes 2= No

Biological condition of the fish farm:

4.1 In which year did you started fish culture?	
4.2 Which species were cultured when you started Fish culture?	1= Rui 2= Mrigel 3= Catla 4= Grass carp 5= Mirror carp 6 = "Two species" 7 = "Three species" 8 = "Four species" 9 = "Five species" 10 = "Others"
4.4 Which species do you culture now?	1= Rui 2= Mrigel 3= Catla 4= Grass carp 5= Mirror carp 6 = "Two species" 7 = "Three species" 8 = "Four species" 9 = "Five species" 10 = "Others"
4.5 Yearly feed application………	In kg/farm
4.6 Yearly fish production …………	In kg/farm
4.7 Crops prior to farm establishment beside the farm area-	1= Rice 2= Vegetable 3= Pulse 4= Oilseed 5= Maize 6 = Wheat 7 = Fish 8 = Uncultivable 9 = Others
4.8 Crops after farm establishment beside the farm area-	1= Rice 2= Vegetable 3= Pulse 4= Oilseed 5= Maize 6 = Wheat 7 = Fish 8 = Uncultivable 9 = Others

Chemical condition of the fish farm:

5.1 Preventive medication…….	1= Lime 2= Potass 3= Geolite 4= Oxygold 5= Multuiple 6 = None
5.2 If you use fertilizer in your pond, how many times do you use fertilizer?	per month Price
5.3 When you established the farm, how many times did you used fertilizer?	per month Price
5.4 Quantity of feed apply in the farm (at present)	per day
5.5 Quantity of fish feed applied in the farm during the time of farm establishment	per day
5.6 Soil color before the farm establishment……	
5.7 Soil Color Change after Farm Establishment……	a) Yes=1 b) No=2
5.8 Water color before the farm establishment……	
5.7 Water Color Change after Farm Establishment….	a) Yes=1 b) No=2
5.8 If the soil and water color changed, what is the reason behind it?	a) b)

6. Investment/ expenditures for culturing fish (in last 1 year)

6.1 Fixed Cost/year/farm:

SI	Cost Type	Value (BDT)
1.	Leasing costs (if applicable)	
2.	Preparatory costs Leveling (site clearing), excavation, compaction, building of fence and pond construction etc.	
3.	Initial stocking of pond	
4.	Insurance cost/loan	
5.	Generator	
6.	Pump	
7.	Hapa preparation	
8.	Paddle wheel	
9.	Cast Net	
10.	Others	

6.2 Temporary cost/year/farm:

SI	Items	Cash Taka (BDT)
	Cost of fish fry/fingerling	
	Maintenance cost	
	Netting & fencing cost	
	Lime	
	Fertilizers (Urea/TSP/MP/DAP)	
	Compost/ manures	
	Feed cost	
	Labor costs (..........)	
	Other cost (..........)	

Production and Income from Fish/year/farm

Sl. No	Quantity produced (kg)	Price/ Unit (BDT)	Sl. no	Quantity produced (kg)	Price/ Unit (BDT)
1= Rui			6 = "Two species		
2 = Mrigel			7 = "Three species"		
3 = Catla			8 = "Four species"		
4 = Grass carp			9 = "Five species"		
5= Mirror carp			= "Others"		

Others-

8.1 What is the public feedback do you get from people? ☐	1= Good 2= Average 3= Bad 4= Affect rice production 5= Crop production increase 6= Crop production decrease 7= Soil fertility increase 8= Soil fertility decrease
8.2 Did you receive any training regarding fish culture? (from where you get the training) ☐	1= Yes 2= No
8.3 What were the major challenges did you face with your fish culture in last 6 months? ☐	1=Lack of money or capital for culturing fish 2=Lack of technical knowledge and experience on fish culture 3=Unavailability of desired fish fingerlings,

	size and price also matter 4=Joint ownership of the ponds 5=Low level water in the homestead ponds 6=Lack of water during dry season 7=High turbid water during flood and rainy season 8=Lack of sunlight at the pond water 9= Others (specify)

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Questionnaire-2 (Livelihood of farm owner)

1. Family Information

1.1 Farm owners Name	
1.2 Partners Name	
1.3 Age (Years)	1.4 Gender (Male=1, Female=1)
1.5 Educational quality	1.6 Main Occupation
1.7 Total Family Member	1.8 Male Member
1.9 Female Member	1.10 Religion

[1] Educational Qualification: Illiterate=0; Maximum Classes in School = 1-9; S.S.C= 10; H.S.C=12; Graduation=14, Post-Graduation= 16, No Institutional Knowledge= 17

[2] Occupation: Agriculture=1; Job Holder=2; Agri-Business=3, Fish Culture=4; Fish business=5; Fish Farmer=6, Fingerling business=7, Nursery Manager=8, Agro/Aqua Equipment Seller=9; Other Business=10, others =12

[3] Religion: Muslim=1, Hindu=2, Christian=3, Buddha=4, Tribal=5.

Address: Village:…………………… Union:…………………….
            Thana:……………. Zilla:………………. Mobile No:…………………..

Family members Educational Qualification: < SSC   SSC/HSC   honors/Masters
Previous Occupation…………
a) Business=1   b) Labor =2   c) Agriculture=3   d) Foreigner=4   e) Others=5   f) Unemployed=6   g) Business and job both=7   h) Job=8
Previous Annual Income……………… (lac)
Annual Income after Farm Establishment…………………… (LAC)
Initial Capital to Start Farm……………….. (lac)
Have you face any problem to establish the farm?   a) Yes =1   b) No=2
Loan Taken from.. a) GO=1   b) NGO=2   c) Others=3   d) No loan taken=5   e) Bank & NGO=5
Influence Person……..
        a) Self =1   b) Other Fish Farmer =2   c) Friends/relatives=3   d) Go=4   e) NGO =5   f) Others=6

Family Supported before Farm Establishment……. a) Yes=1   b) No=2
Family Supported after Farm Establishment……. a) Yes =1   b) No=2
Family member's education facility before farm establishment fulfilled? … a) Yes =1   b) No=2
Family member's education advancement after farm establishment…. a) Yes=1   b) No=2
Housing

15.1 Type of Main House		15.2 Room number in house	

[4] House Type: Paka (Concrete floor, ceiling, wall) =1
Adha Paka (Concrete floor and wall) = 2
Kacha (Floor-soil, Ceiling=Tin or straw, Wall= Tin, wood or bamboo) = 3
Hut (Jhupri) = (Floor= Soil, Ceiling=Straw, Wall= Hay/straw/bamboo/jute stick/dry leaves) = 4
16. Medical Eligibility before Farm Establishment……. a) Yes=1   b) No=2
17. Medical Eligibility after Farm Establishment……… a) Yes =1   b) No=2
18. Drinking Water Facility before Farm Establishment…..
          a) Pump=1   b) Tube well=2   c) Pond =3   d) River =4   e) No facility=5
Drinking Water Facility after Farm Establishment……
a) Pump=1   b) Tube well=2   c) Pond =3   d) River=4   e) No facility=5
Sanitation Facility before Farm Establishment… a) Yes=1   b) No=2
Sanitation Facility after Farm Establishment…. a) Yes =1   b) No=2
Electronic Appliances before Farm Establishment-
a) TV=1   b) Freeze =2   c) Mobile =3   d) TV & Freeze=4   e) TV & Mobile=5
f) Freeze & Mobile=6   g) TV, Freeze & Mobile =7   h) Others =8   i) None=9
Electronic Appliances after Farm Establishment-
a) TV=1   b) Freeze =2   c) Mobile =3   d) TV & Freeze=4   e) TV & Mobile=5
f) Freeze & Mobile=6   g) TV, Freeze & Mobile =7   h) Others =8   i) None=9
Number of Motor Vehicles before Farm Establishment…… a) Yes =1   b) No=2
Number of Motor Vehicles after Farm Establishment……… a) Yes=1   b) No=2
 Association with Political/Social Parties before Farm Establishment…. a) Yes=1   b) No=2
Association with Political/Social Parties after Farm Establishment… a) Yes=1   b) No=2
Future Planning with Profit………..
a) New farm establishment=1   b) Extension of present farm =2   c) Other business =3
d) Charity=4   e) Others=5
Family's income and spending: (May 2016- April 2017)

29.1 Family's total income		29.2 Family's total spending	
29.3 Income from agriculture (Tk)		29.4 Spending for agriculture	
29.5 Income from aquaculture (Tk)		29.5 Spending for aquaculture	
29.6 Income from horticulture (Tk)		29.6 Spending for horticulture	
29.7 Income from livestock (Tk)		).8 Spending from livestock	
29.9 Others income (Tk)		).10 Others spending	

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Questionnaire-3: Agriculture (Near Land)

Respondent Name: Age:
Address:
Distance from fish farm…………. (km)
Land Area before Farm Establishment................ (decimal)
Land Area after Farm Establishment.................... (decimal)

| **6. Information before the farm establishment:** |

Crops prior to farm estabishment-
a) Rice=1   b) Helon=2   c) Groundnut=3   d) Vegetable=4   e) Others=5
Total Crop Production before Farm Adoption............ (ton)
Crop production cost before farm establishment……   ☐   (Taka)
Selling value of crops before farm establishment…   ☐   (Taka)
Gross Profit before Farm Establishment........... (taka)
Fertilizers used before farm establishment- ☐
a) Organic=1   b) Inorganic=2   c) Both=3   d) None=4
Pesticide used before farm establishment...... ☐
a) Furadan=1   b) Basudin=2   c) Sumithion=3   d) Ondrin=4
e) Furadan & Basudin=5   f) Furadan & Sumithion=6   g) Furadan & Ondrin =7
h) Basudin & Sumithion =8   i) Basudin & Ondrin=9=10   j) Sumithion & Ondrin=11
k) More than two=12   l) None=13
Problems before Farm Establishment (Please specify)-
        a)   b)   c)
Soil color before the farm establishment-
Water color before the farm establishment-

| **7. Information after the farm establishment:** |

Crops after farm establishment-
a) Rice=1   b) Helon=2   c) Groundnut=3   d) Vegetable=4   e) Others=5
Total Crop Production after Farm Adoption............ (ton)
Crop production cost after farm establishment…… ☐   (Taka)
Selling value of crops after farm establishment…   ☐   (Taka)
Gross Profit after Farm Establishment.............. (taka)
Fertilizers used after farm establishment-
a) Organic=1   b) Inorganic=2   c) Both=3   d) None=4
Pesticide used after farm establishment......
a) Furadan=1   b) Basudin=2   c) Sumithion=3 d) Ondrin=4   e) Furadan & Basudin=5
f) Furadan & Sumithion=6   g) Furadan & Ondrin =7 h) Basudin & Sumithion =8
i) Basudin & Ondrin=9=10   j) Sumithion & Ondrin=11   k) More than two=12   l) None=13
Problems after Farm Establishment..... ....
a) Waterlogged field=1   b) Human movement=2   c) Trashes left on field=3
        d) Others=4   e) No problem faced=5
Increased agricultural Production after Farm Establishment.....
a) HYV=1   b) WIF=2   c) Hybrid=3   d) Both=4
Decreased agricultural Production after Farm Establishment.....
a) HYV=1   b) WIF=2   c) Hybrid =3   d) Both=4   e) No=5
If the production increase or decrese what is the reason behind it?

a)   b)

Soil Color Change after Farm Establishment....   a) Yes=1   b) No =2

Water Color Change after Farm Establishment....   a) Yes=1   b) No=2

Facilities taken from farm owner.....   a)   b)   c)

Problems created by farm owner.......   a)   b)   c)

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Questionnaire-4: Distant Land

Respondent Name: Age:
Address:
Distance from fish farm…………. (km)
Land Area before Farm Establishment................ (decimal)
Land Area after Farm Establishment.................... (decimal)

| 6. Information before the farm establishment: |

Crops prior to farm estabishment-
 a) Rice=1   b) Helon=2   c) Groundnut=3   d) Vegetable=4   e) Others=5
Total Crop Production before Farm Adoption............ (ton)
Crop production cost before farm establishment……   [   ] ka)
Selling value of crops before farm establishment…   [   ] ka)
Gross Profit before Farm Establishment........... (taka)
Fertilizers used before farm establishment-   [   ]
 a) Organic=1   b) Inorganic=2   c) Both=3   d) None=4
Pesticide used before farm establishment……   [   ]
       a) Furadan=1   b) Basudin=2   c) Sumithion=3   d) Ondrin=4
       e) Furadan & Basudin=5   f) Furadan & Sumithion=6   g) Furadan & Ondrin =7
       h) Basudin & Sumithion =8   i) Basudin & Ondrin=9=10   j) Sumithion & Ondrin=11
       k) More than two=12   l) None=13
Problems before Farm Establishment (Please specify)-
  a)   b)   c)
Soil color before the farm establishment-
Water color before the farm establishment-

| 7. Information after the farm establishment: |

7.1 Crops after farm establishment-
   a) Rice=1   b) Helon=2   c) Groundnut=3   d) Vegetable=4   e) Others=5
7.2 Total Crop Production after Farm Adoption............ (ton)
7.3 Crop production cost after farm establishment……   [   ] (Taka)
7.4 Selling value of crops after farm establishment…   [   ] (Taka)
7.5 Gross Profit after Farm Establishment.............. (taka)
7.6 Fertilizers used after farm establishment-
     a) Organic=1   b) Inorganic=2   c) Both=3   d) None=4
7.7 Pesticide used after farm establishment……
       a) Furadan=1   b) Basudin=2   c) Sumithion=3   d) Ondrin=4
       e) Furadan & Basudin=5   f) Furadan & Sumithion=6   g) Furadan & Ondrin =7
       h) Basudin & Sumithion =8   i) Basudin & Ondrin=9=10   j) Sumithion & Ondrin=11
       k) More than two=12   l) None=13
7.8 Problems after Farm Establishment..... ....
       a) Waterlogged field=1   b) Human movement=2   c) Trashes left on field=3
       d) Others=4   e) No problem faced=5
Increased agricultural Production after Farm Establishment.....
     a) HYV=1   b) WIF=2   c) Hybrid=3   d) Both=4

Decreased agricultural Production after Farm Establishment.....

    a) HYV=1   b) WIF=2   c) Hybrid =3   d) Both=4   e) No=5

7.11 If the production increase or decrese what is the reason behind it?

        a)   b)

7.12 Soil Color Change after Farm Establishment....   a) Yes=1   b) No =2

7.13 Water Color Change after Farm Establishment....   a) Yes=1   b) No=2

8.1 Facilities taken from farm owner.....   a)   b)   c)

9.1 Problems created by farm owner....... a)   b)   c)

Appendix 2. List of Respondents

List of Interviewed Personnel

A) Luxmipur District

Sl. No.	Name of Farm Owner/ Farmer	Address	Mobile Number
	Abdul Hai Mafiz	Char Ruhita, 4 no Char Ruhita, Luxmipur Sadar	01718338286
	Abdul Haque	South Mojupur, 10 no South Mojupur, Luxmipur Sadar	
	Abu Sufian	South Mojupur, 10 no South Mojupur, Luxmipur Sadar	01853030555
	Abul Kalam	Char Ali Hasan, 5 no Char Ali Hasan, Luxmipur Sadar	
	Ahsan Ullah	Modhupur, 5 no Padmabazar, Ramganj, Luxmipur	
	Ali Hossain	Balashpur, 7 no Bashikpur, Luxmipur Sadar	
	Ali Hossain Haoladar	Char Ramani, 20 no Char Ramani, Luxmipur Sadar	
	Ali Ullah	Char Ruhita, 4 no Char Ruhita, Luxmipur Sadar	
	Anowar Chadri	Khilbaicha, Luxmipur Sadar, Luxmipur	
	Anower Hosen	Modhupur, 5 no Padmabazar, Ramganj, Luxmipur	
	Babor Mia	Tumchar, 21 no Tumchar, Luxmipur Sadar	
	Bahar Uddin	Ashnabad, 2 no South Hamchadi, Luxmipur Sadar	
	Bashir Ullah	Balashpur, 7 no Bashikpur, Luxmipur Sadar	
	Bashir Ullah	Char Afjal Fakira, 7 no Char Ramij, Ramgati, Luxmipur	
	Doha Uddin	Moddho Char Ramani, Shahpur, 7 no Char Ramani, Luxmipur Sadar	
	Dulal Chandra Dash	Korunanagar, 9 no Char Jangalia, Komolnagar, Luxmipur	01712981694
	Enayet Ullah	Ashnabad, 2 no South Hamchadi, Luxmipur Sadar	
	Faruk Hossain	Shakchar, 6 no Char Ali Hasan, Luxmipur Sadar	
	Faruk Ur Rahman	Balashpur, 7 no Bashikpur, Luxmipur Sadar	01684890325
	Gazi Mohammad Belal Hossain	North Chandkhali, 15 no Laharkandi, Luxmipur Sadar	01815349932
	Gofur Mia	Korunanagar, 9 no Char Jangalia, Komolnagar, Luxmipur	
	Hanif Munshi	South Mojupur, 10 no South Mojupur, Luxmipur Sadar	
	Hazi Abdul Latif	Korunanagar, 9 no Char Jangalia, Komolnagar, Luxmipur	
	Hazi Md. Delower Hossain	Char Afjal Fakira, 7 no Char Ramij, Ramgati, Luxmipur	01822194218
	Hazi Nazrul Islam	Balashpur, 7 no Bashikpur, Luxmipur Sadar	
	Jahangir Alam Joy	Shahpur, 1 no Luxmipur Sadar, Luxmipur	01911616151
	Jamal Uddin	Char Afjal Fakira, 7 no Char Ramij, Ramgati, Luxmipur	
	Kamrul Alam Chowdhury	Shakchar, 6 no Char Ali Hasan, Luxmipurmipur Sadar	01749405971
	Kashim	Char Ruhita, 4 no Char Ruhita, Luxmipur Sadar	

Sl. No.	Name of Farm Owner/ Farmer	Address	Mobile Number
	Malek Mia	Tumchar, 21 no Tumchar, Luxmipur Sadar	
	Md. Abul Kashem	Shakchar, 6 no Char Ali Hasan, Luxmipur Sadar	
	Md. Billal	Char Ali Hasan, 7 no Char Ali Hasan, Luxmipur Sadar	01715355936
	Md. Farid	Char Ramani, 20 no Char Ramani, Luxmipur Sadar	
	Md. Harun	Char Ahsan, 20 no Char Romanimohon, Luxmipur Sadar	
	Md. Harun	Char Ruhita, 4 no Char Ruhita, Luxmipur Sadar	
	Md. Hasan	Tumchar, 21 no Tumchar, Luxmipur Sadar	01821158113
	Md. Jalal Mia	Char Ali Hasan, 7 no Char Ali Hasan, Luxmipur Sadar	
	Md. Jinnah	Char Ahsan, 20 no Char Romanimohon, Luxmipur Sadar	
	Md. Latif	Shahpur, 1 no Luxmipur Sadar, Luxmipur	
	Md. Ledu Mia	Modhupur, 5 no Padmabazar, Ramganj, Luxmipur	0171951590
	Md. Liton	Tumchar, 21 no Tumchar, Luxmipur Sadar	
	Md. Liton	Char Ali Hasan, 7 no Char Ali Hasan, Luxmipur Sadar	
	Md. Mahim Uddin	Char Ruhita, 4 no Char Ruhita, Luxmipur Sadar	01712761311
	Md. Mohim	Shahpur, 1 no Luxmipur Sadar, Luxmipur	
	Md. Monowar Hossain	Char Ali Hasan, 5 no Char Ali Hasan, Luxmipur Sadar	01629616266
	Md. Parvej	Char Afjal Fakira, 7 no Char Ramij, Ramgati, Luxmipur	
	Md. Rafique	Korunanagar, 9 no Char Jangalia, Komolnagar, Luxmipur	
	Md. Reaz	Char Afjal Fakira, 7 no Char Ramij, Ramgati, Luxmipur	
	Md. Shapan	Shakchar, 6 no Char Ali Hasan, Luxmipurmipur Sadar	
	Md. Shipon	Moddho Char Ramani, Shahpur, 7 no Char Ramani, Luxmipur Sadar	01749043030
	Md. Shiraj	Char Ruhita, 4 no Char Ruhita, Luxmipur Sadar	
	Md. Shobuj Mia	Shahpur, 1 no Luxmipur Sadar, Luxmipur	
	Md. Taiyab	Khilbaicha, Luxmipur Sadar, Luxmipur	
	Mejbaur Rahman Chisti	Char Ahsan, 20 no Char Romanimohon, Luxmipur Sadar	01821158113
	Mia Md. Kamal	Moddho Char Ramani, Shahpur, 7 no Char Ramani, Luxmipur Sadar	
	Mohammad Arman Hossain	Char Afjal Fakira, 7 no Char Ramij, Ramgati, Luxmipur	01812612572
	Mohammad Parvej	North Chandkhali, 15 no Laharkandi, Luxmipur Sadar	
	Moktar Uddin	Tumchar, 21 no Tumchar, Luxmipur Sadar	
	Mostak Ahmed	Khilbaicha, Luxmipur Sadar, Luxmipur	01716494324
	Neyamot Patowary	Balashpur, 7 no Bashikpur, Luxmipur Sadar	
	Oahid Uddin Chowdhury	Shakchar, 6 no Char Ali Hasan, Luxmipur Sadar	01846116646

Sl. No.	Name of Farm Owner/ Farmer	Address	Mobile Number
	Rafiqul Islam	Korunanagar, 9 no Char Jangalia, Komolnagar, Luxmipur	
	Rahim Mia	Char Ali Hasan, 5 no Char Ali Hasan, Luxmipur Sadar	
	Rehana Akhter	North Chandkhali, 15 no Laharkandi, Luxmipur Sadar	
	Sajjad Al Maruf	Tumchar, 21 no Tumchar, Luxmipur Sadar	01728931187
	Sharif Molla	Char Ramani, 20 no Char Ramani, Luxmipur Sadar	01816264064
	Shujit Roy	Ashnabad, 2 no South Hamchadi, Luxmipur Sadar	01708427701
	Toslim Uddin	Shakchar, 6 no Char Ali Hasan, Luxmipurmipur Sadar	

B) Noakhali District

Sl. No.	Name of Farm Owner/ Farmer	Address	Mobile Number
	Abdul Karim	Noakhali Mouja, 6 no Nowa, Sudharam, Noakhali	
	Abdul Rashid Mollah	Khanpur, 15 no Sharifpur, Bagumganj, Noakhali	
	Abul Kashem	Hazipur, Begumganj, Noakhali	
	Akter Uj Jaman	Khanpur, 15 no Sharifpur, Bagumganj, Noakhali	01831046499
	Ali Akbar	Islampur, Badol Court, Chatkhil, Noakhali	
	Anowar Hossain	North Manikpur, 5 no Arjuntola, Shanbug, Noakhali	01854511199
	Atik Ullah	Koishoarbag, 1 no Sonaimuri, Sonaimuri, Noakhali	
	Chan Mia	Rampur, 6 no Rampur, Companiganj, Khanpur, Noakhali	
	Hazi Shruj Mia	North Manikpur, 5 no Arjuntola, Shanbug, Noakhali	
	Jafor Imam	Hazipur, Begumganj, Noakhali	
	Jamal Uddin	South Manikpur, 5 no Arjuntola, Shanbug, Noakhali	
	Jesmin	Char Guliakhali, 6 no. Dhanshalik, Kabir Hat, Noakhali	
	Kamal Uddin	South Manikpur, 5 no Arjuntola, Shanbug, Noakhali	
	Kamal Uddin	Fulahari, Noroompu, Kabir Hat, Noakhali	
	Kulsum	Sholla, Pak Kishorgonj, Noakhali Sadar, Noakhali	
	Maruful Haque	Koishoarbag, 1 no Sonaimuri, Sonaimuri, Noakhali	01791612781
	Md. Abdul Khalek	Sholla, Pak Kishorgonj, Noakhali Sadar, Noakhali	01816449816
	Md. Abdul Mannan	South Nironjonpur, 2 no Sundolpur, Kabir Hat, Noakhali	01815699509
	Md. Abul Kashe	Char Neyamot, Char Aalag, Ramgati, Noakhali	
	Md. Alamgir	Sholla, Pak Kishorgonj, Noakhali Sadar, Noakhali	
	Md. Bahar	Islampur, Badol Court, Chatkhil, Noakhali	01710951117
	Md. Humaiun Kabir	Noakhali Mouja, 6 no Nowa, Sudharam, Noakhali	
	Md. Idris Mia	Islampur, Badol Court, Chatkhil, Noakhali	01710703427

Sl. No.	Name of Farm Owner/ Farmer	Address	Mobile Number
	Md. Jamal Uddin	South Nironjonpur, 2 no Sundolpur, Kabir Hat, Noakhali	
	Md. Jashim Uddin	Char Neyamot, Char Aalag, Ramgati, Noakhali	
	Md. Jashim Uddin	South Nironjonpur, 2 no Sundolpur, Kabir Hat, Noakhali	
	Md. Kamal Uddin	Birahimpur, Sirajpur, Companiganj, Noakhali	01838365167
	Md. Kamrul Hasan	Madla, 7 no Batia, Kabir Hat, Noakhali	01840849882
	Md. Mujammal	Birahimpur, Sirajpur, Companiganj, Noakhali	
	Md. Nasir Uddin	Sholla, Noakhali Sadar, Noakhali	01638030075
	Md. Nurul Islam	Char Neyamot, Char Aalag, Ramgati, Noakhali	01747327279
	Md. Nurul Islam	Char Guliakhali, 6 no. Dhanshalik, Kabir Hat, Noakhali	
	Md. Rafik	North Manikpur, 5 no Arjuntola, Shanbug, Noakhali	01813961603
	Md. Rocky	Rampur, 6 no Rampur, Companiganj, Khanpur, Noakhali	01632228834
	Md. Saiful Islam	Char Guliakhali, 6 no. Dhanshalik, Kabir Hat, Noakhali	01929097350
	Md. Shafi ullah	Sholla, Noakhali Sadar, Noakhali	
	Md. Shahed Chowdhury	Hazipur, Begumganj, Noakhali	01718854027
	Md. Shahid	Rampur, 6 no Rampur, Companiganj, Khanpur, Noakhali	
	Mejbah Uddin Shujon	Fulahari, Noroompu, Kabir Hat, Noakhali	01925832996
	Mia Nurul Haque	North Manikpur, 5 no Arjuntola, Shanbug, Noakhali	
	Najmul Hasan	Islampur, Badol Court, Chatkhil, Noakhali	
	Nasir Uddin	Sholla, Noakhali Sadar, Noakhali	
	Nazimul Hasan	Madla, 7 no Batia, Kabir Hat, Noakhali	
	Nur Jamal	Islampur, Badol Court, Chatkhil, Noakhali	
	Nur Nabi	Birahimpur, Sirajpur, Companiganj, Noakhali	
	Nuruj Jaman	Khanpur, 15 no Sharifpur, Bagumganj, Noakhali	
	Rafik ul Haidar	Fulahari, Noroompu, Kabir Hat, Noakhali	
	Rafiq Mia	Islampur, Badol Court, Chatkhil, Noakhali	
	Rahmat Ali	Koishoarbag, 1 no Sonaimuri, Sonaimuri, Noakhali	
	Ruhul Amin	North Manikpur, 5 no Arjuntola, Shanbug, Noakhali	
	Shahadur Rahman	Noakhali Mouja, 6 no Nowa, Sudharam, Noakhali	01729473622
	Sikandar Badshah	South Manikpur, 5 no Arjuntola, Shanbug, Noakhali	01825296555
	Somir Mollah	Madla, 7 no Batia, Kabir Hat, Noakhali	

C) Feni District

Sl. No.	Name of Farm Owner/ Farmer	Address	Mobile Number
	Abdul Hai	Chitolia, Pashuram, Feni	01822859021
	Abdul Karim	Kuhuwa, Boxmahamud, Pashuram, Feni	

Sl. No.	Name of Farm Owner/ Farmer	Address	Mobile Number
	Abdul Khalek	Boraiya, Dormopur, Feni Sadar, Feni	
	Abdul Mannan	Nawabpur, Sonagazi Sadar, Feni	01848113787
	Abdul Motaleb	Shibpur, 2 no Rajapur, Dagonbuiya, Feni	
	Abdullah Al Mamun	Dawhia, Char Dorbesh, Sonagazi, Feni	
	Abdur Rahman	Dawhia, Char Dorbesh, Sonagazi, Feni	01753131700
	Abdur Rahman	Nawabpur, Sonagazi Sadar, Feni	
	Abrur Rahman	Bhabanipur, 2 no Rajapur, Dagonbuiya, Feni	
	Abu Sufian	Jugir Gao, Phachgaciya, Feni Sadar, Feni	
	Abu Sufian	Boraiya, Dormopur, Feni Sadar, Feni	
	Abul Hashem	Boraiya, Dormopur, Feni Sadar, Feni	01834443233
	Ali Ashraf	Hechachara, Chagalnaiya, Feni	
	Ali Hannan	Chitolia, Pashuram, Feni	
	Aminul Haque	Boraiya, Dormopur, Feni Sadar, Feni	
	Anowar Hossain	Chandrapur, Dagonbuiya Sador, Feni	
	Belal Hasan	Banaglabazar, Silonia, Fulgazi, Feni	
	Bishwajit Dash	Boraiya, Dormopur, Feni Sadar, Feni	
	Dilip	Hechachara, Chagalnaiya, Feni	
	Golam Arshad	Chandia, Char Chanddia, Sonagazi, Feni	01821840433
	Imdat Hossain	Chandia, Char Chanddia, Sonagazi, Feni	
	Iqbal Khan	Chitolia, Pashuram, Feni	
	Jahir Ahamed	Shibpur, 2 no Rajapur, Dagonbuiya, Feni	
	Jamal Mia	South Joyloshkor, Joyloshkor, Dagonbuiya, Feni	
	Jamil Islam	Amirabad, Sonagazi, Feni	
	Kabir Ahamed	Dawhia, Char Dorbesh, Sonagazi, Feni	
	Khairul Hasan	Abupur, Shorshodi, Feni Sadar, Feni	
	Khairul Islam	Amirabad, Sonagazi, Feni	01822859121
	Lokman Hazi	Abupur, Shorshodi, Feni Sadar, Feni	
	Lokman Khan	Goniyamora, Fulgazi, Feni	
	Mahmud Hossain	Kuhuwa, Boxmahamud, Pashuram, Feni	
	Md. Abdul Kalam	Boraiya, Dormopur, Feni Sadar, Feni	01813169066
	Md. Abdullah Al Faisal	Abupur, Shorshodi, Feni Sadar, Feni	01834779676
	Md. Abul Kalam	Chandrapur, Dagonbuiya Sador, Feni	01813169060
	Md. Ahsan Ullah	Shundarpur, Dagonbuiya Sador, Feni	
	Md. Ajijul Haque	South Joyloshkor, Joyloshkor, Dagonbuiya, Feni	01773958950
	Md. Anowar Hossain	Goniyamora, Fulgazi, Feni	01839922930
	Md. Arafat Hossain	Shundarpur, Dagonbuiya Sador, Feni	01856035787
	Md. Daud Hossain	Mokamia, Radhanagor, Chagalnaiya, Feni	01829603745
	Md. Golam Faruk	Jugir Gao, Phachgaciya, Feni Sadar, Feni	01823859022
	Md. Hanif	Salamnagar, 7 no. Matbuiya, Dagonbuiya, Feni	01815821938
	Md. Hossain	Nijpanua, Janglemia, Nawabpur, Chhagalnaiya, Feni	
	Md. Ibrahim	Hechachara, Chagalnaiya, Feni	01819450664
	Md. Iqbal Hossain	Chandrapur, Dagonbuiya Sador, Feni	01830336596
	Md. Jamal	Jugir Gao, Phachgaciya, Feni Sadar, Feni	
	Md. Khairul Hasan	Abupur, Shorshodi, Feni Sadar, Feni	01823772438
	Md. Khoka	South Batania, Pathannagor, Chhagalnaiya, Feni	
	Md. Khokon	Chandia, Char Chanddia, Sonagazi, Feni	
	Md. Milon	South Joyloshkor, Joyloshkor, Dagonbuiya, Feni	

Sl. No.	Name of Farm Owner/ Farmer	Address	Mobile Number
	Md. Nur karim Liton	Kuhuwa, Boxmahamud, Pashuram, Feni	01825291241
	Md. Nurul Islam	Abupur, Shorshodi, Feni Sadar, Feni	
	Md. Osman	Mokamia, Radhanagor, Chagalnaiya, Feni	
	Md. Rafikul Islam	Bhabanipur, 2 no Rajapur, Dagonbuiya, Feni	
	Md. Rahim	South Batania, Pathannagor, Chhagalnaiya, Feni	01819795581
	Md. Rahman	Kuhuwa, Boxmahamud, Pashuram, Feni	01825291241
	Md. Sadek	South Batania, Pathannagor, Chhagalnaiya, Feni	
	Md. Saiful Islam	Shibpur, 2 no Rajapur, Dagonbuiya, Feni	01814410193
	Md. Selim	Salamnagar, 7 no. Matbuiya, Dagonbuiya, Feni	
	Md. Shahadat	Salamnagar, 7 no. Matbuiya, Dagonbuiya, Feni	
	Md. Shajahan	Shundarpur, Dagonbuiya Sador, Feni	
	Md. Shiraj	Mokamia, Radhanagor, Chagalnaiya, Feni	
	Md. Tofael Ahmed	Nijpanua, Janglemia, Nawabpur, Chhagalnaiya, Feni	0184276421
	Mokbul Ahamed	Bhabanipur, 2 no Rajapur, Dagonbuiya, Feni	01819795581
	Nikhil Chandra Dash	Chandrapur, Dagonbuiya Sador, Feni	
	Nur Karim	Chandrapur, Dagonbuiya Sador, Feni	
	Nur Mohammad	Kuhuwa, Boxmahamud, Pashuram, Feni	
	Rabiul Haque	Kuhuwa, Boxmahamud, Pashuram, Feni	
	Rashedul Islam	Banaglabazar, Silonia, Fulgazi, Feni	
	Shahadat Khan	Goniyamora, Fulgazi, Feni	
	Sharif	Amirabad, Sonagazi, Feni	
	Sirajul Haque	Nijpanua, Janglemia, Nawabpur, Chhagalnaiya, Feni	
	Tohidul Islam	Banaglabazar, Silonia, Fulgazi, Feni	01860596990
	Umesh Chandra Dash	Chandrapur, Dagonbuiya Sador, Feni	
	Zahir Ahmed	Abupur, Shorshodi, Feni Sadar, Feni	