Project ID 462

Competitive Research Grant

Sub-Project Completion Report

on

The study on environmental and socio-economic impact of *Daudkandi* model floodplain fisheries management

Project Duration

May 2017 to December 2018

[Sustainable Development Associates
180/6/12A, 1st floor, Titas Road (near water pump)
East Rampura, Dhaka 1219. www.susdeva.com]

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

House of development consultants

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Project Implementation Unit
National Agricultural Technology Program-Phase II Project (NATP-2)
Bangladesh Agricultural Research Council (BARC)
New Airport Road, Farmgate, Dhaka – 1215
Bangladesh

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Project Implementation Unit
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Published in: September, 2018

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Acronyms

ABNJ	Area Beyond National Jurisdiction
7th FYP	Seventh Five Year Plan
APHA	American Public Health Association
ASA	Association for Social Advancement
BBS	Bangladesh Bureau of Statistics
BFRI	Bangladesh Fisheries Research Institute
BFRI	Bangladesh Fisheries Research Institute
BOD	Biological Oxygen Demand
BRAC	Bangladesh Rural Advancement Committee
CBFM	Community Based Fisheries Management
CO_2	Carbon di oxide
COD	Chemical Oxygen Demand
CPUE	Catch Per Unit Effort
CSS	Christian Social Services
DFID	Department for International Development
DGM	Deputy General Manager
DO	Dissolved Oxygen
DoE	Department of Environment
DoF	Department of Fisheries
EC	Electrical conductivity
EEZ	Exclusive Economic Zone
FAD	Fish Aggregation Device
FGD	Focus Group Discussion
FGD	Focus Group Discussion
FY	Fiscal Year
GDP	Gross Domestic Product
GED	General Economics Division
GoB	Government of Bangladesh
GPS	Global Positioning System
HACCP	Hazard Analysis and Critical Control Point
HH	Household
ITLOS	International Tribunal for the Law of the Sea
IUCN	International Union for the Conservation of Nature
Kg	Kilogram
LOQ	Limit of Quantification
MACH	Management of Aquatic Ecosystems through Community Husbandry
MCS	Monitoring, Control and Surveillance System

MT	Metric Tonne
NGO	Non-Governmental Organization
PCR	Polymer Chain Reaction
PL	Post Larvae
SDA	Sustainable Development Associates (SDA).
SIS	Small Indigenous Specis
SPF	Specific Pathogen Free
SRO	Self-Regulatory Organization
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
UFO	Upazila Fisheries Officer
USAID	United States Agency for International Development
VGD	Vulnerable Group Development
VGF	Vulnerable Group Feeding
WHO	World Health Organization
YRG	Year Round Gear

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Executive Summary

Fish catch

Fish production of the sampled FPAs was calculated from the partial and final harvest data. It was observed that average fish production was approximately twenty metric tons per hectare.

The amount of fish caught by ber jal, chandi jal and puchuni jal was very close and was higher over current net, cast net, drag net and fish traps in the controlled floodplains. It was measured that in an average the fish catch by ber jal was 6.9 Kg, 10.65 Kg and 12.5 Kg during the 1st quarter of moon, new moon and full moon in the main river. According to the survey data fish catch was found more in deep water (Main River) comparing to shallow waters. However, significant amount of fishes were caught in Katha in shallow water.

In the same time the average amount of fish caught by chandi jas was found 5.2 Kg, 12.73 Kg and 10.2 Kg during the 1st quarter of moon, new moon and full moon in the main river. The sating jal (encircled net) are usually used for catching kaski fish. In an average, the catch of sating jal was recorded as 6.25 Kg, 11.24 Kg and 11.84 Kg during the 1st quarter of moon, new moon and full moon in the main river.

Water quality and limnological survey

Samples were collected from six different selected points for the water quality and limnological survey.

Phytoplankton

In the present study, 14 species under 4 groups were encountered**.** Among which 5 species belongs to both in Bacillariophyceae and Chlorophyceae followed by 3 species to Cyanophyceaeand and 1 species to Euglenophyceae. *Chlorella,* under Chlorophyceae group was found most governing genera (180ind./L) followed by *Ulothrix* (163 ind./L), *Melosira (*120ind./L) under Bacillariophyceae . The plankton compositions based on total amount count at six sites are mainly dominated by Chlorophyceae (50.25%). The order Cyanophyceae encountered to be lowest (5.91%) compared to the six orders.

Zooplankton

In the present study, 7 species under three zooplankton groups were identified of which 3 species belong to Cladocera followed by 2 species of Rotifera and 2 species of copepods**.** *Keratella* under the group Rotifera (69ind./L) followed *Moina* under the Cladocera (51ind./L) were found dominant taxa, respectively. The maximum zooplankton encountered was at SW1 (405ind./L) followed by SW6 (330ind./L) and the lowest number of zooplankton estimated at SW4 (165ind./L).

Benthos

In the present study, a total of 5 groups of benthos were recorded**.** The benthos that found in six different sampling sites of Meghna River were *Chironomus* larvae, *Lamellidens marginalis, Pilaglobosa, Unio* and *Sartorianas pinigera* (TeloKakra). The dominant group was*Pilaglobosa*, followed by *Chironomus* larvae and *Unio*.*Pilaglobosa* was present in all sampling sites followed by *Chironomus* larvae. Among the six sampling the sites the benthos (*Pilaglobosa*) was found to be dominating (40.91%) followed by *Chironomus* larvae (36.36%), *Lamellidens marginalis* (9.09%)*, ,Unio* (8.09%) and *Sartoriana spinigera* (TeloKakra, 4.55%).

Environmental parameter analysis

In the present study, the BOD of the study areas found to be fluctuated from 1.0 (SW2, SW3 and SW6) to 2.0 (SW1, SW4, and SW5) with a mean value of 1.5±0.55. COD values found same in all the sampling stations and it was 4 ppm. In the present study the EC of the sampling sites fluctuated between 73 µS/cm (SW1, SW5 and SW6 to 110 µS/cm (SW4), with an average value of 79.67± 14.88µS/cm. The phosphate level of the sampling areas in the present study fluctuated between 1.19 (in SW4) *to* 1.85 mg/l (in SW6) with an average value of 1.48±0.22 mg/l. Salinity in the study area varied from 0.03 ppt (in SW1, SW2 and SW6) to 0.05 ppt (in SW4) with a mean value of 0.033±0.008 mg/L. Sulphate ranged between <LOQ(SW1 and SW5) to 2 mg/l (SW2 and SW4) with a mean value 1.0±0.896 in this present study.

TDS of the investigated area oscillated from 35.0 (in SW1 and SW6) to 52.0 mg/L (in SW4) with a mean value of 40.0±7.24 mg/L. In the present study, the minimum amount of TSS was found both in SW1 and SW2 (5.0 mg/l) and maximum in SW4 (8.0 mg/l).

The surface water temperature of the scrutinized study area found to be varied from 28.5°C to 30.0°C with a mean value 29.25±0.52°C. The value of transparency in six discrete sites found to be varied from 23.5 cm (in SW2) to 66 cm (in SW4) with a mean value of 43.92±15.48 cm. The pH of the study areas found to be fluctuated from 6.5 (in SW2) to 7.25 (in SW4) with a mean value of 6.87±0.25.

Dissolved Oxygen ranges from 3.0 mg/l (in SW4) to 5.0 mg/L (in SW2, SW3, SW5 and SW6), with a mean value of 4.5±0.84mg/L. Carbon di oxide varied with the sampling sites of the present study. It oscillated from 6 (in SW5) to 12.0 mg/L (in SW2) with a mean value of 8.42±2.01 mg/L. The values of chloride found to be varied between 60 mg/l (in SW1, SW5 and SW6) to 90 mg/L (in SW2, SW3 and SW4) with a mean value of 75.0±16.43 mg/l in present study.

Socio-economic survey

This survey was done by using questionnaire survey, conducting Focus Group Discussion (FGD), Key Informants Interview (KII) and literature review.

Among the respondents about 51.5% are male in contrast to 48.5% female. The literacy rate among the household heads was found only 46%. Out of 1695 household heads, 24% have primary level of education, 17% have secondary level of education, 5% higher secondary and only 1% of each have got graduation and post- graduation level of education. The overall literacy rate among the household members (>5years), was found 66.78%.

The main primary occupation of the household members are fishing (9.76%), fish trading (3.21%), agriculture farming (3.09%), wage laborer (2.97%), industrial labour (2.55%), salaried job (1.64%), rickshaw/van pulling (1.46%), running small shop (1.33%), working abroad (1.27%), business (1.03%), petty trader (0.85%), driving (0.79%), disabled (0.61%), teacher (0.3%), tailoring (0.24%), poultry/fisheries/livestock farming (0.18%), welding (0.06%), homeopath doctor (0.06%), house maker (25.65%), student (25.41%), children (10.43%) and others (1.21%).

The average household's income per month was calculated as Taka 17540, which is above national average household income (Taka 11479) and also significantly higher from the baseline survey (Taka 14155). The average household expenditure was found as taka 13514 per month. The main expenditure was observed for purchasing food items (54%) followed by education of their children (12%), clothing (10%), traveling (8%), health care of family members (7%), cooking fuel (6%), etc.

Only 27.9% have mentioned that the FPAs has some negative impact on their livelihoods. Interestingly about 11.4% of the respondents noticed increasing trends of fish production

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. Title of the CRG sub-project: The study on environmental and socio-economic impact of Daudkandimodel floodplain fisheries management
2. Implementing organization: Sustainable Development Associates (SDA)
   180/6/12A, 1st floor, Titas Road (near water pump)
   East Rampura, Dhaka 1219. www.susdeva.com
3. Name and full address with phone, cell and E-mail of PI/Co-PI (s):

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Co-Principal Investigator:

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4. Sub-project budget (Tk):
   Total: : TK. 49,99,275(Taka Forty Nine Lac Ninety Nine Thousand Two Hundred and Seventy Five Only).

Revised (if any): _____

5. Duration of the sub-project:
   Start date (based on LoA signed): May 2017 to

   End date: December 2018
6. Justification of undertaking the sub-project:
   In Bangladesh, floodplain fisheries, particularly the inland open water fisheries, have been affected seriously due to the Flood Control, Drainage and Irrigation (FCDI) Project which led the serious consequences causing reductions in fish production i.e. reducing catch per unit area, biodiversity and livelihood of poor fishers (Craig et al., 2004; Ali and Alam, 2005). Historically, inland open water was the major source of fish production in the country, which contributed about 90% of country's fish production in the 1960's. But due to manmade causes, such as destruction of natural habitat by water pollution through agricultural and industrial intensification, over-fishing in the absence of fisheries management and conservation measures, implementation of flood control and drainage projects, fish production in the inland open water, particularly in the rivers and seasonal floodplains, has declined significantly during the last four decades (Ali, 1995; Mazid and Hossain, 1995; Shelly, 2004). The degradation of floodplains resulting from human interferences due

to construction of roads, embankments, deforestation, encroachment for agricultural production, indiscriminate use of pesticides and natural causes such as siltation, drought, cyclone and intrusion of saline water have negative impacts on fish diversity in Bangladesh. On the other hand, the indiscriminant use of different fishing gears, harmful techniques of fishing threatens the biodiversity of the seasonal floodplains. It has been reported that the Chalan Beel fishery is one of the largest, most important watersheds in North Central floodplain in Bangladesh and during 2005-2006 fish production was reduced to 50% of what was in 1982. It was also stated that gradual habitat degradation and over exploitation were the key drivers of biodiversity degradation which were connected to increased siltation rates, construction of flood control embankments and roads, uncontrolled use of pesticides and chemical fertilizers in the croplands, excessive removal of surface water and extraction of ground water for irrigation, diversion of water courses, unregulated discharge of untreated industrial and aqua farms effluents, fish harvesting by dewatering (Hossain et al., 2009).

In this context, floodplain aquaculture (FPA) is a recent development in Bangladesh, and a WorldFish study (Belton et al. 2011) attributed its introduction to a local non-governmental organization (NGO) named SHISUK (*Shikhya Shastha, Unnayan Karjakram* in Bengali, which can be translated into English as Education, Health and Development Programme). This FPA management system, developed by SHISUK with community collaboration, was started as an independent pilot project without support of any government body in 1996 in the Daudkandi *upazila* (sub-district) of the Comilla district. The management system later gained popularity as the '*Daudkandi Model*' of community fishery/aquaculture or FPA regionally and nationally. The Daudkandi model has been adopted by more than 90 similar FPA projects and companies around Daudkandi *upazila* (Toufique and Gregory 2008). Sultana (2012) also mentioned that the model received considerable policy attention in the context of an annual 30–100% rise in enclosure-based private seasonal FPAs in subsequent decades in different parts of Bangladesh.

7. Sub-project goal: The goal of the sub-project is to provide solid evidence to the policy planners and researchers working in the fisheries sector of Bangladesh to replicate *Daudkandi* model of community floodplain aquaculture considering environmental and socio-economic impacts.

8. Sub-project objective**(s):**

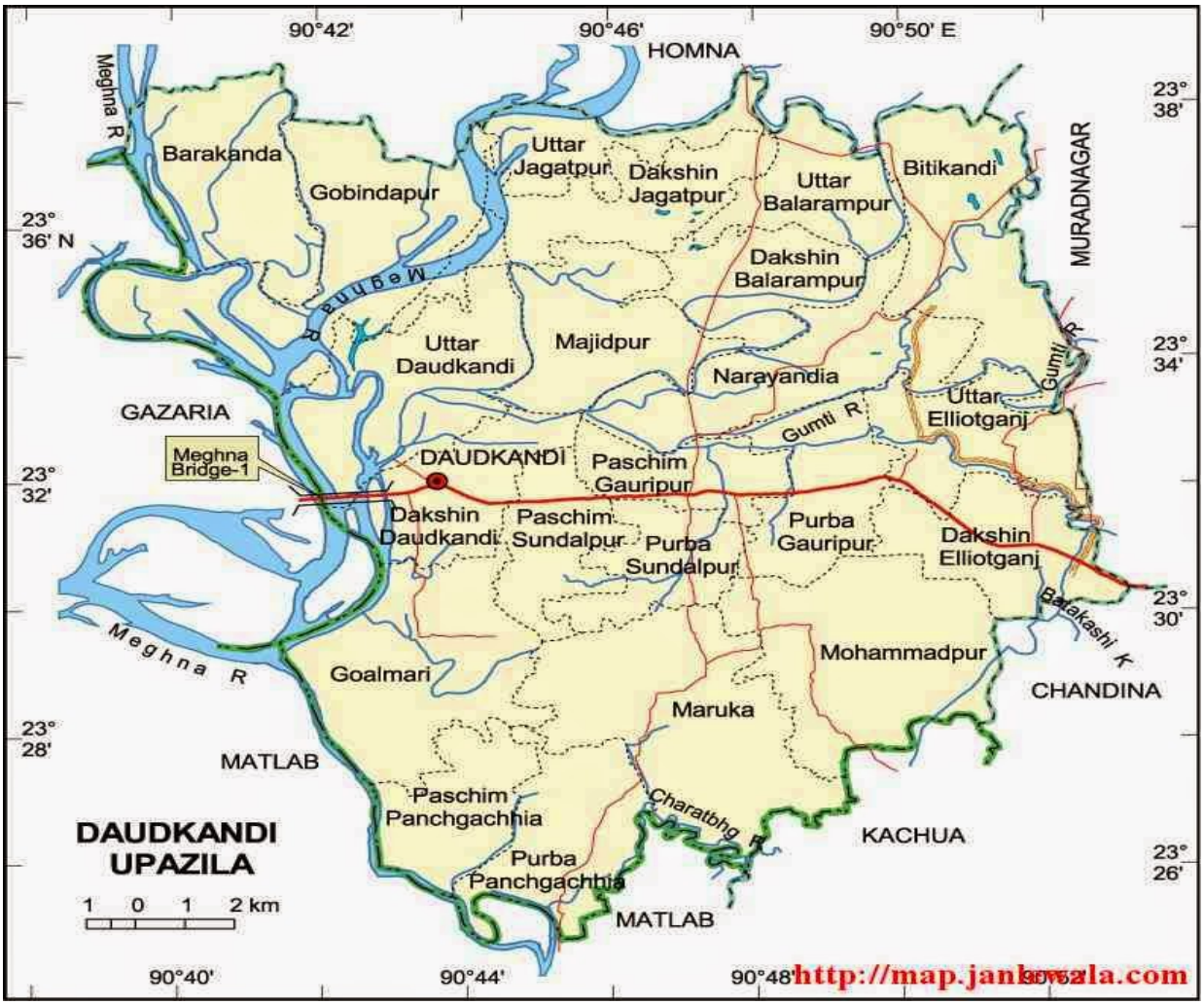
The purpose of the sub-project is to assess the socio and environmental impact of Daudkandi model of community floodplain aquaculture of Comilla district for future replication of this model. The specific objectives of the project are to:

a. Assess the impact of Daudkandi model of community floodplain aquaculture on fish population.
b. Assess the impact of Daudkandi model of community floodplain aquaculture on water quality and cropping system
c. Assess the impact Daudkandi model of community floodplain aquaculture on the livelihood of fishing community.

9. Implementing location (s):

The sub-project will be implemented in the Daudkandi Upazila of Comilla district. The total area of Daudkandi Upazila is 208.66 sq Km, located in between 23°24' and 23°35' north latitudes and in between 90°41' and 90°53' east longitudes. It is bounded by the Meghna and Titas upazilas on the north, Matlab Dakshin and Kachua upazilas on the south, Chandina and Muradnagar upazilas on the east, Matlab Uttar and Gazaria upazilas on the west (please see map-1). The total population is 284031; male 143305, female 140726 (Source: Bangladesh Population Census 2001, BBS).

The study will be conducted covering three community managed flood plain projects, open flood plain areas and in the main river. A map of Daudkandi upazila is shown below:



Map-1: Political map of daudkandi upazila

Because of the low-lying nature of its land, most of which remains under water due to frequent floods, Comilla district long had been recognized as a food deficit area, with its lowest-lying areas growing only one crop of rice (BWDB 1994). The farming households, including well-off land owner families, experienced lack of employment, shortages of food, especially during the September–November period, and the resultant urban migration. Thus subsistence fishing became the most important occupation to marginal farming households with lack of formal

activities. In 1992 the Bangladesh Water Development Board (BWDB) put an embankment on the Gumti River - the main cause of recurrent floods - to protect villages from recurrent flooding, and this changed the landscape of the area by enclosing an area about 327 sq. km by a 45.5 km long embankment (including Daudkandi upazila) (Toufique and Gregory 2008). The entire floodplain takes the appearance of a vast water-body during the summer monsoon (June-September) by getting inundated because of its low-lying landmass, which filled with depressions like other low-lying areas of the surrounding upazilas. The low lying landmass was traditionally cultivated for winter crops, like onions, garlic, pulses and sweet potatoes. In other seasons the lands were used for Aus (April-August) and Aman (April–December) rice production. However, this farming was mainly dependent on natural weather and most times production was damaged by excessive rain, floods or sometimes droughts (CIRDAP 2002).

The first attempt, although unsuccessful, of utilizing seasonally flooded private lands for aquaculture was made by a group of landowners in Daudkandi upazila in 1987 (Toufique and Gregory 2008). After construction of the embankment new attempts were made without involvement of any NGO. Most of these attempts failed on account of technical or organizational/financial grounds. Only after introduction of the Pankowri Fisheries project did the area found a successful management system for floodplain aquaculture in the technical, organizational and financial aspects.

Samples were collected from the sites stated below:

Sl. #	Location address	Code	Waterbody type	GPS coordinates	
				X	Y
01	Tamta floodplain	SW1	Open floodplain	90.85251819640	23.52512095150
02	Lokhaitoli	SW2	Open floodplain	90.84148340240	23.49899689340
03	Saliakandi floodplain	SW3	Open floodplain	90.88632334600	23.56017909240
04	Shaibal Fisheries Ltd.	SW4	Semi-closed floodplain	90.83678526130	23.53278363400
05	Khirai Fisheries	SW5	Semi-closed floodplain	90.85620436630	23.51232085580
06	Chargram Fisheries Ltd.	SW6	Semi-closed floodplain	90.84746917130	23.51144870050

10. Methodology in brief:

10.1 Approach

The study will include three cooperative based managed floodplain aquaculture projects to observe the spatial variation of biodiversity at Daudkandi. Moreover, three open floodplain areas will be selected as control system. Besides, primary data will be collected from the main river to compare the aquatic diversity together with socio-economic conditions of fishermen community. Five (05) important and basic surveys will be essentially required to obtain the primary data and information with a view to make a qualitative and quantitative assessment of the project areas about aquatic diversity, open water capture fisheries together with socio-economic conditions of fishermen community, fish landing and marketing network, fish migration and fish spawning ground. Survey Process Modules will be applied to the following 'Field Study Components':-

10.1.a Fish catch surveys

This survey will include catch and effort, species composition, migration behavior, etc. at the project's impact zone to obtain data and information in the Study Area. The catch and effort will be estimated by using a model equation developed by de Graff and Chinh (1992),

$$Y_d = \sum_g CPUE_g . f_g$$

Where, Yd= total daily catch for gear (g)

CPUEg= daily mean catch per unit effort for gear, fg= mean effort (gears,hour-1).

Daily fish catch data will becollected from at least 10% of the fishermen of the main river adjacent to the study area, fish production data of three floodplain aquaculture project collected annually.

10.1.b Limnological and Water Quality Parameters surveys

Monthly limnological data (Dissolved oxygen, BOD, COD, Conductivity, TDS, TSS and pH, Phyto/ zooplankton, benthos) will be collected and analyzed in reputed laboratories.

i. Limnological and Water Quality Parameters surveys

Water sample for testing water quality and primary productivity from the selected sampling points will be collected once in a month.

a) Benthos

Benthos will be collected by Ekman dredge at about 1-3m depth (shallow region) from each sampling point. Containers were labeled indicating the station code, the sample code, sampling date etc.The sieved material will then fix as a whole in the plastic container having a 10% formalin solution and preserved until use.

b) Phytoplankton

Phytoplankton samples will be collected at each sampling points for once in a month during the survey period. Monofilament nylon plankton net of 25 μm mesh size will be used to collect the sample. Analyses will be done on a Sedgewick-Rafter counting cell, under a compound binocular microscope. The plankton density is estimated by-

N = (Ax1000xC)/(VxFxL)

Where,

N = No. of phytoplankton cells or units per litre of original river water.

A = Total No. of phytoplankton counted.

C = Volume of final concentrate of the samples in ml.

V = Volume of a field in cubic mm.

F = No. of fields counted.

L = Volume of original river water in liters.

c) Zooplankton

Zooplankton samples will be collected at each sampling points for once in a month during the survey period. Monofilament nylon plankton net of 50 μm mesh size will be used for this purpose.

The cell counts will be used for compute the cell density using the Striling (1985) formula where the zooplankton density is estimated by-

N = (Ax1000xC)/(VxFxL)

Where,

N = No. of zooplankton cells or units per litre of original river water.

A = Total No. of zooplankton counted.

C = Volume of final concentrate of the samples in ml.

V = Volume of a field in cubic mm.

F = No. of fields counted.

L = Volume of original river water in liters.

ii. Water Quality Parameter:

A centigrade thermometer will be used to measure water temperature. Transparency (cm) will be measured with a Secchi disc of 24cm diameter. Dissolved oxygen (DO), BOD, COD, conductivity, TDS, TSS and pH will be measured by HACH Freshwater Kit. Moreover, the survey will include oil/ grease test.

iii. Socio-economic survey

Fishermen Community Households surveys under Study Villages will be done by using the survey questionnaire. The following formula will be used to estimate the required sample size:

$$n = \frac{Z^2 * N * p * q}{C2*(N-1) + Z^2 * p * q}$$

Where,

n = The desired sample size

Z^2 = chi-square as the standard normal deviate (3.841) - for 1 degree of freedom.

p = Desired probability level, the portion in the population estimated to have a particular characteristics (i.e. the probability in percentage).

q = 1.0 – p

N = Given Population size

C = Degree of desired error level (considered here error level at 3.5% for more accuracy)

iv. Fish Landing and Marketing Network survey

This survey will be done following a pre-designed checklist to obtain data on fish landing and marketing network including fish pricing strata, marketing structure and distribution system occurring in different season within the Study Area;

10.1.c Fishermen Community Households surveys

Fishermen household survey with pre designed questionnaire and focus group discussion (FGD) will be done. About 600 respondents will be interviewed, 8 FGD and 8-10 KIIs will be conducted.

10.1.d Fish Landing and Marketing Network surveys

This survey will be based on review of secondary information and where possible through observation of occurrences and discussion with different professional related to fisheries activities prevalent in upstream and downstream.

11. Results and discussion:

11.1 Introduction to fisheries resources

Fish is the second most valuable agricultural crop in Bangladesh and its production contributes to the livelihoods and employment of millions of people. The culture and consumption of fish therefore has important implications for national income and food security. Bangladeshi people are popularly referred to as "*Mache Bhate Bangali*" or "fish and rice makes a Bengali". The fisheries sector in Bangladesh is broadly divided into four sub-sectors- inland capture, inland culture, mari-culture (artisanal fisheries) and marine industrial fisheries.

Bangladesh is one of the world's leading inland fisheries producers and has a huge water resource all over the country in the form of small ponds, ditches, lakes, canals, small and large rivers, and estuaries covering about 4.34 million hectares. Freshwater aquaculture involves pond aquaculture especially the polyculture of native and exotic species.

The fisheries activities can broadly be classified under three categories: inland capture fisheries, inland culture fisheries, and marine fisheries, where the former is the dominant part making up around 40% of total production of this sector. Fisheries sector plays a very important role in the national economy having a share in GDP of about 4.37 percent and engaging about 13% of rural labour force. Contribution of fisheries sub-sector over the last 10 years (FY04 to FY13) varied between 4.37 to 5.11 percent. There had been several actions undertaken for increasing fish production. These included increasing total water area for aquaculture, augmenting open water capture fishery, ensuring access of the poor and genuine fishers to fish cultivation, accelerating aquaculture farming, developing technologies through supporting fishery research, disseminating evolved technologies through strengthening extension services, promoting private sector, improving fish marketing and processing system, quality control and so on. The sub-sector experienced more or less consistent in growth, varying from 7.33% growth in FY10 to 4.55% growth in FY13. Last 10 years average growth performance of this sector was around 5.5%. The sub sector's contribution to the national economy is significant, as it provides about 60% of the animal protein intake and more than 17 million people are engaged with this sub sector on full time and part time basis (GED, Planning Commission, 2015).

A combination of export and buoyant domestic demand has spurred profitability and growth of fisheries activities. Real prices have been increasing providing incentives for further investment and expansion in this important agricultural activity.

There has also been a structural change within this sector as the importance of small-scale open water fisheries declined while close water culture fisheries grew. The current good practices of open water fisheries management such as replenishing stock and developing and implementing fisheries management regulations; preserving fish sanctuaries; banning fish catch during certain periods and ensuring community based fisheries management; protecting dry season water flows, restoration of habitat and fish species; integrated Coastal Fisheries Resource Management; maintenance of ecosystem health and management of pollution; coping with climate changes has yielded positive results. The recent success in Hilsa management programme, and the achievement of a number of other aquaculture programmes as MACH, CBFM-II and others, point to the way forward for management of the inland and coastal/marine capture fisheries.

Recently the Government of Bangladesh has adopted its seventh five years pan. Regarding the fisheries sector, the target for fish production has set to 45,52,000 MT from various sources (Table 11.1).

Table 11.1: Projected Production and Demand

Sl. #	Source	Baseline (2012-13)			Projection (2020-21)		
		Water area ('000 ha	Total production ('000 MT)	Production (kg/ha)	Water area ('000 ha)	Total production ('000 MT)	Production (kg/ha)
1	River, estuaries	854.00	147.00	172.00	854.00	169.05	197.95
2	Sundarbans	177.00	16.00	90.00	177.00	21.28	120.23
3	Beel	114.00	88.00	770.00	114.00	104.72	918.60
4	Kaptai Lake	69.00	9.00	131.00	69.00	11.25	163.04
5	Floodplain/Haor	2702.00	701.00	260.00	2617.00	841.20	311.32
	Total open water	**3916.00**	**961.00**		**3831.00**	**1147.50**	
6	Pond/Dighi	371.00	1447.00	3896.00	393.00	1982.39	5044.25
7	Baor	5.00	6.00	1120.00	5.00	8.10	1620.00
8	Seasonal cultured water-body	131.00	201.00	1539.00	211.00	492.45	2333.89
9	Shrimp/prawn Farm	275.00	206.00	749.00	275.00	226.60	824.00
	Total aquaculture	**782.00**	**1860.00**		884.00	**2709.54**	
10	Marine Artisanal	0.00	516.00			603.72	
11	Trawler	0.00	73.00			91.25	
	Total marine		**589.00**			**694.97**	
	Grand total		**3410.00**			**4552.01**	
	Total Demand		**3792.00***			**4528.00****	

Source: Department of Fisheries background paper.

** Including other uses fish (export + fish meal + wastage); ** Considering 60 gram per capita consumption and BBS projected population growth*

Bangladesh has extensive and highly diversified fisheries resources. The available fisheries resources can be broadly classified into the following four sub-sectors:

i. Inland freshwater culture fisheries.
ii. Inland open water capture fisheries.
iii. Coastal fisheries and brackish-water aquaculture (shrimp culture) and
iv. Marine fisheries

The total fish production of Bangladesh in 2012-13 is given in the table 11.2 below:

Table 11.2: Species/Group-wise Annual Fish Production in Inland and Marine Fisheries *2012-2013*

[Unit: Metric Ton]

Species/Group	Inland Fisheries	Marine Fisheries	Total	%
Major Carp	729362		729362	*21.39*
Other Carp	54131		54131	*1.59*
Exotic Carp	402858		402858	*11.81*
Cat Fish	360745		360745	*10.58*
Snake Head	53370		53370	*1.56*
Live Fish	102670		102670	*3.01*
Other Inland fish	834208		834208	*24.46*
Hilsa/Illish *(Tenualosa ilisha)*	98648	252575	351223	*10.30*
Shrimp/Prawn	185274	46568	231842	*6.80*
Sardine *(Sardinella fimbriata)*		29636	29636	*0.87*
Bombay Duck (*Harpondon nehereus)*		71745	71745	*2.10*
Indian Salmon (*Polydactylus indicus)*		2445	2445	*0.07*
Pomfret (*Rup/ Hail/ Foli Chanda)*		29693	29693	*0.87*
Jew Fish (*Poa, Lambu, Kaladatina* etc.)		30600	30600	*0.90*
Sea Cat Fish (*Tachysurus spp.)*		8594	8594	*0.25*
Shark/ Skate / Ray		5017	5017	*0.15*
Other Marine Fish		112115	112115	*3.29*
Total				
Metric Ton	2821266	588988	3410254	*100.00*
%	82.73%	17.27%	100%	

Note: 1. Major Carp - Rui, Catla, Mrigal
2. Other Carp - Kalibaus, Bata, Ghania
3. Exotic Carp - Silver Carp, Grass Carp, Common Carp, Mirror Carp, Big Head Carp, Black Carp
4. Cat Fish - Boal, Air, Pangas, Silon, Rita
5. Snake Head - Shol, Gazar, Taki
6. Live Fish - Koi, Singhi, Magur
7. Prawn - Galda and Other Inland Chingri
8. Shrimp - Bagda and Other Coastal/ Marine Chingri
9. Other Fish (Inland and Marine) - Includes all other fishes except those mentioned above.

Bangladesh is working with close collaboration with the World Bank, USAID, Department for International Development (DfID), World Fish Center and other international organization to develop the sector by building research partnerships and increasing investment. Community based management of fisheries is proving its potential to avert the longstanding political challenges farmers have been facing. The country, however, faces urgent imperatives to strengthen environmental laws to curb pollution which is significantly compromising the performance of the fisheries sector.

11.2 Policy, legal and administrative framework of fisheries sector

Bangladesh is a country of submerged with numerous wetlands. This is the blessing of nature that enriches the country with a rich aquatic biodiversity. About 265 Freshwater fish species are inhabitant in the water bodies of Bangladesh (Rahman, 2005), among which about 200 species

are of small fishes (SIS fishes). According to IUCN Bangladesh (2000), Fifty four species are endangered. Such issues are occurring due to natural and man-made disturbance of wetlands. But there are various rules and regulations for conserving and protecting our enormous fisheries resources that should be informed and abide by the people of our country. Because, not only it is the duty of the people to abide by the rules and regulations of the republic, but also it is a part of patriotism. As a responsible citizen of Bangladesh, everybody should know and follow the rules and regulations to conserve, protect and develop our threatened natural aquatic resources.

Table 11.3: Provisions related to fisheries accordingly to NEP of 1992

Sector		Implementing Agencies
Fish and Livestock Resources:		
1. Steps will be taken to rehabilitate wetlands such as *haors, baors*, and *beels* and declare them as protected areas for pisciculture. Wetland areas will not be encroached upon.		a. Ministry of Fisheries and Livestock b. *Haor* Development Board c. Department of Fisheries
2. Pisciculture will be encouraged in all ponds and tanks. Over extraction of fish from ponds and wetlands will be prohibited. Similar prohibition will be effected for shrimp fry and other fish resources.		a. Ministry of Fisheries and Livestock b. Department of Fisheries c. Upazilas Administration
3. Ministry of Environment and Forest will advise on the environmental aspects of protection and augmentation of shrimp cultivation. The government will delineate appropriate coastal areas for.		a. Ministry of Fisheries and Livestock b. Ministry of Environment and Forest c. Department of Environ-shrimp cultivation d. Department of Fisheries
4. Necessary research and programs for prevention of fish disease and epidemics will be strengthened.		a. Ministry of Fisheries and Livestock b. Fish Research Institute c. Agriculture University
5. Regular monitoring and research will be conducted on the state of wetlands like *haors*, *baors*, and *beels* etc.		a. Ministry of Fisheries and Livestock b. Ministry of Defense c. SPARRSO d. Survey of Bangladesh

With a view to overcome the problems of fisheries sector, the Government of Bangladesh has passed several fisheries laws and policies. Three categories of fisheries laws have been developed, each aiding the development and administration of different water bodies: inland open water, inland closed water, and brackish and marine water.

11.3 Summary of fisheries law and policy in Bangladesh

The following is a summary of Bangladesh laws and policies relevant to compliance and enforcement issues in the fisheries sector.

A. Penal Provisions of the Existing Fisheries Laws

Approximately twelve fisheries laws (both substantive and procedural in nature) as well as some policies have been passed for fisheries resource management and administration in Bangladesh. The penal provisions of some of these laws are very insignificant such as one month or three months or a fine which may extend to five hundred taka or both. Dr. Mohiuddin Farooque, an expert on the environmental laws in Bangladesh, pointed out that the incorporated penal provision is very insignificant because the Act was written around one hundred years ago and it is almost outdated and colonial (Mohiuddin Farooque, 1996). These laws do not meet the present needs.

B. Relevant Procedural Laws of Fisheries in Bangladesh

Section 145 of the Criminal Code of Procedure deals with the fisheries related disputes.

Disputes associated with the use of water and water bodies such as *haors, baors, beels*, lakes, wetlands etc. that shall be settled by the Magistrate of the first class for sustainable fisheries conservation and development. By settling disputes of fisheries, the fish environment is possible to develop. It seems that through the implementation of the relevant provisions of this Code, fisheries resources may be conserved for the environment and development of Bangladesh.

C. Relevant Constitutional Provisions of Fisheries in Bangladesh

The Constitution of Bangladesh also discusses the fisheries environment as a part of natural resources in Bangladesh. The article 16 of the Bangladesh Constitution is one of the sub sectors that pertain to agriculture. This section states that State shall adopt effective measures to bring about a radical transformation in the rural areas through the promotion of an agricultural revolution. Article 16 ensures agriculture development and encourage to take different measures such as introduce modern technologies, seeds, chemical fertilizers, pesticides for increasing agriculture production to meet up food and fiber shortage, poverty reduction and to uplift the rural economy. Consequently, agriculture production in Bangladesh gradually increases in three or four times at present after independence. Fishery production, as sub sector of the agriculture, also increases tremendously, but in this respect it mentionable that production of cultured fish is increased around 10 times in 1990s. On the other hand, fresh water fish production is deceased alarmingly due to various causes created from the present agriculture systems. These are converted of wetlands to agriculture land resulting decrease the habitation of fish and other aquatic resources, adverse impact of pesticides and chemical fertilizers, etc. Unfortunately, the constitution does provide provisions to overcome these unexpected problems create due to modern agriculture systems.

D. Biodiversity Issues

In order to protect the biodiversity of the fisheries in Bangladesh, the government has passed the Bangladesh National Biodiversity Strategy and Action Plan which establishes a policy framework.

Some important fisheries rules and regulations are briefly described below.

A. <u>The East Bengal Protection and Conservation of Fish Act, 1950</u>

Some amendments, rules, ordinances and SRO (Statutory Regulatory Order) were done depending on the above act, are as follows-

a. The East Bengal Protection and Conservation of Fish (Amendment) Act- 1950

b. The Protection and Conservation of Fish (Amendment) Ordinance- 1982

c. The Protection and Conservation of Fish Rules- 1985
d. The Protection and Conservation of Fish Rules- 1985… under this SRO –

1. The Protection and Conservation of Fish (Amendment) Act, 1995

The main characteristics of the above act, rules and SRO are as follows-

- To harvest fish creating permanent structures in rivers, canals and marshes is prohibited and in this case of seizure, removal and confiscation of the permanent structure can be done.
- To build temporary or permanent dams or structure in rivers, canals and marshes, except irrigation, flood protection and drainage are prohibited.
- It is prohibited to harvest fish in inland waters and coastal water bodies using different explosives and weapons.
- It is prohibited to kill fishes through destructive ways such as poisoning, making pollution, disposing commercial waste materials in inland waters.
- It is prohibited to catch fry and brood of snakeheads and to take measures which are destructive to snakehead in water bodies which have connection with rivers, canals and marshes except the catching of fry and brood for culture.
- It is prohibited to catch fry, fingerlings, and brood of Rui, Catla, Mrigel, Kalbaus and Gonia during specific period from selected 27 rivers and canals etc.
- Without the purpose of culture, nobody can catch, transport or sell the following fishes during the specific period and under specific size:
- Rui, Catla, Mrigel, Kalbaus and Gonia under the size of 23cm during November to May.
- 'Jatka' under the size of 23cm during November to May.
- Pangus under the size of 23cm during November to April.
- Shilong under the size of 30cm during February to June.
- Shol under the size of 30cm during February to June.
- Ayre under the size of 30cm during February to June.
- It is prohibited to catch fry and fingerling and PL (Post Larvae) of fish and spawn in the coastal region.
- Confiscated fish can be sold in auction.
- It is prohibited to catch fish using current net of mesh size 4.5cm or less.
- A person, who will disobey the above rule for the first time will have to suffer the punishment of rigorous imprisonment of minimum 1 month to maximum 6 months and a maximum fine of the Tk. 1000.
- After the first time, the convicted person will have to suffer the punishment of rigorous imprisonment of minimum 2 months to maximum 1 year.
- A person who will disobey the rules of Fish Act, in special cases can be arrested without warrant.

  The complaint or report on a person for disobeying the rules of Fish Act by a Fisheries Officer or a Police Officer is considered as cognizable offence.

2. The Protection and Conservation of Fish (Amendment) Act, 2002

The characteristics of the above Fish (Amendment) Act- 2002 are as follows:

- In case of current net, nobody can produce, weave, import, market, stock, carry, transport and keep under his possession and use them.

- If anybody disobeys the above rule, then he will be punished according to the following rules-
- The user of current nets will be punished an imprisonment of minimum 1 year and maximum 2 years or will be fined Tk. 5000 or both of imprisonment and fine.
- The producer, weaver, importer, marketing officer and stockiest of current nets will be punished rigorous imprisonment of minimum 3 years, extending up to 5 years and a fine of maximum Tk. 10,000.
- A person, who will carry, transport, keep under his possession and use current nets, will be punished rigorous imprisonment of minimum 1 year extending up to 2 years or will be fined Tk. 5000 or both of imprisonment and fine.
- The authorities who will take action against the persons who will disobey 'The Protection and Conservation of Fish Act- 2002':
- All Fisheries Officers, Officers empowered by the Government and Police Officers can search, investigate and seize the banned current nets.
- Legal suit cannot be filled in lower courts below those of First Class Magistrate or Metropolitan Magistrate under 'The Protection and Conservation of Fish Act-2002'.
- The above courts can finalize the law suit through brief hearing.

B. The Fish and Fish Products Rules- 1997

The main characteristics of the above Ordinance and Rules are as follows:

1. Processing, marketing, supply and export of fish and fish products can not be done without license.
2. For fish processing, export, fish depot, fish arat and supplier one will have to pay fixed fee and ice plant, related to above organizations, must have license.
3. HACCP procedure must be maintained in every step of fish processing and fish marketing.
4. According to conditions of ordinance rule nos. 1, 2 and 3 fish processing plant construction and management can be done and this through fulfilling the conditions fish processing plant will get license.
5. Processing, export and supply of unhygienic rotten fish on polluted fish cannot be done.
6. Preliminary treatment of fish and prawn in unhygienic depot is prohibited.
7. Preliminary treatment of fish and prawn must be done in hygienic service center, landing center and depot.
8. Dressing of prawn and fish cannot be done outside the factory.
9. For every lot of processed fish and fish product hygienic certificate must have to be taken.
10. In fish and prawn culture, such kind of antibiotic, pesticide, hormone and chemical substances, cannot be used, which will destroy food value of fish and prawn.
11. Any kind of ingredient in fish processing which will destroy the quality of fish and fish product cannot be used.
12. Export of fish cannot be done without hygienic certificate.
13. Every box or pot of processed fish and fish product must be labeled in English.
14. All activities on steps of fish processing are under the legal purview of inspection.
15. For giving hygienic certificate, sample of fish and fish product must be collected.
16. The period of the license will be for a calendar year or for a part of it.
17. Unhygienic fish or fish product, unsuitable for giving license, must be destroyed.

C. Fish Hatchery Act- 2010

- The Fish Hatchery Act- 2010 has been enforced to produce good quality fertilized fish egg, post larvae of prawn and fish fry and fingerling through constructing appropriate quality fish/prawn hatchery and for better.

Though Bangladesh is a developing country, but the land has plenteous natural resources. Now it is our responsibility to conserve these valuable environmental resources. There are many rules and regulations besides the aforementioned, but all the rules and regulations may fall into decline if we are not aware and abide by. Our enriched aquatic biodiversity is declining gradually due to our regardless and indifference. Therefore, everybody regarding to fisheries sector should come forward to protect, conserve and develop this important agriculture sub-sector without any delay. Awareness and respect to follow the rules and regulations should build up nationwide by both the government and mass-media. Moreover, law enforcing authorities have to enforce the laws strictly. If everybody becomes aware of the fisheries sector, Bangladesh can achieve her protein supply and food security target, no doubt.

The main rules, regulations, ordinances, acts as well as laws relevant to fisheries sector of Bangladesh are-

- The Tanks Improvement Act, 1939
- THE PROTECTION AND CONSERVATION OF FISH ACT, 1950
- THE GOVERNMENT FISHERIES (PROTECTION) ORDINANCE, 1959
- East Pakistan Government Fisheries (Protection) Ordinance, 1959
- THE BANGLADESH FISHERIES DEVELOPMENT CORPORATION ACT, 1973
- Bangladesh Civil Service (Agriculture:Fisheries) Composition and Cadre Rules, 1980
- THE FISH AND FISH PRODUCTS (INSPECTION AND QUALITY CONTROL) ORDINANCE, 1983
- THE MARINE FISHERIES ORDINANCE, 1983
- The Marine Fisheries Rules, 1983
- The Fish and products (Inspection and Quality Control) ordinance, 1983
- THE FISHERIES RESEARCH INSTITUTE ORDINANCE, 1984
- The Protection and Conservation of Fish Rules, 1985
- THE PRIVATE FISHERIES PROTECTION ACT, 1889
- National Fisheries Policy, 1998
- Animal and Fish Act, 2010
- Fishery Feed Rules, 2011
- Hatchery Rules 2012
- FIsh Hatchery Rules-2012
- Fish Hatchery Act, 2010

11.4 Government strategies to improve fisheries sector

4.2.1 Goals and Strategies for Fisheries Sub-Sector during 7th FYP Period

The vision 2021 of the government targeted to achieve its goals of self-sufficiency in food and thus increased food security, which includes attaining self-sufficiency in production of fish and shrimp and generate surplus for export, along with improvement in food safety standard of fish production. The 7th plan will also promote increased participation of women in fish cultivation.

These require achieving a dual objective of enhancing productivity, livelihoods security and equitable distribution of benefits side by side with the conservation of potential fisheries resources and aquatic biodiversity of rivers, beel, haor, baor, flood plains and other water bodies. The strategies for achieving the goals and objectives will be as follows:

a. Open water fisheries management

- Control of pollution of the rivers in which the main actor will be the Ministry of Environment in collaboration with other concerned agencies.
- Prevent further deterioration of water logging, blockade of water-flows and shrinkage of water-bodies by infrastructures like embankment, roads, urban housing projects and industrialization. Such projects must follow the environmental rules and regulations (including EIA, SIA, etc.) and incorporate adequate mitigation measures in consultation with the Ministry of Fisheries and Livestock.
- In the case of such problems created by existing infrastructure, projects and programmes will be implemented to construct and maintain fish-passes, fish-friendly regulators, re-excavate canals and rivers restoring and conserving productivity as much as possible.
- Establish and maintain fish and wetland sanctuaries which will comprise complete ban on fishing in certain eco-sensitive areas like Sundarbans, parts of Kaptai Lake, and several sections of the river Halda, selected beels and haor areas and certain sections of the Bay of Bengal etc. Similarly, along the major rivers having parallel channels, selected ones will be preserved.
- The conservation strategy will specially include seasonal ban, gear restriction, identifying genuine fishers by providing ID Cards, species restriction, and alike.
- Besides strict implementation of the Fish Act, 1950; government will look into the possibility of making available insurance schemes for the fish farmers, and will assist the fisher folk accessing Social Safety Nets like VGD and VGF and alternative livelihoods support during the restriction period of fish catching.
- The fishermen will be organized in sustainable community based organizations and such organizations will be given management responsibility of khas jolmohal on long term basis so that they conserve rather than just exploit resources. Present short term leasing system, often benefiting the influential elite and the leaseholder not taking any effort to conserve, will gradually be replaced by the long term lease to organizations of genuine fishermen who will be trained in sustainable management and provided other support.
- Daudkandi model of seasonal floodplain aquaculture will be further promoted to expand all over the country but with added emphasis to combine maintaining sanctuaries in the important beel and haor areas; keeping enough opportunities to free flow of water between rivers and beels; rearing fries of various indigenous species in nurseries and supplementing natural stock.

b. Inland aquaculture

- Maintain purity of brood stock of indigenous carp and other indigenous fish species conserving the natural breeding, spawning, nursery and grow-out areas to complete the whole lifecycle and natural reproduction process.
- Purebred brood fish of commercially important indigenous fish species will be maintained in the selected Fish Seed Multiplication Farms of the DOF, research stations of the BFRI, other

GoB establishments and promoting private and NGO hatcheries with facilitation and monitoring support by the DOF and BFRI.

- Brood fish from the above source will be distributed to the GoB hatcheries and selected private and NGO hatcheries to produce good quality fish seed and fries of commercially important and endangered species.
- Operation of hatcheries, nurseries and supply of spawn and fry, in which private sector is the key player, will be constantly monitored by GO-NGO collaboration and public private partnership. Compliant hatcheries will be awarded quality certification. Advertising in the printed and electronic media must contain such reference of quality certification. Gradually, marketing of fish fry and spawn without holding quality certificate will be banned, initially in the selected districts and then all over the country.
- Production, import and marketing of fish and shrimp feed, feed ingredients, minerals and vitamin premix, and other inputs, in which private sector is the key player, will be constantly monitored by GO-NGO. Compliant feed mills and other enterprises will be awarded quality certification.
- Aquaculture and conservation will be restructured to reinforce the strengths of each other, sustainable and community based flood plain aquaculture will be combined with maintaining sanctuaries and restocking of indigenous species
- Pen culture and Cage culture will be further promoted but guided and monitored for species selection, location, target group identification, and feed and input use etc. Special care will be taken to restrict pen and cage culture of exotic carnivorous species like piranha. Species promoted for cage and pen culture will include all indigenous carp species, mono-sex tilapia, shorputi, shrimp, prawn, and selected exotic carps etc.

c. Shrimp and coastal aquaculture

- Government defined shrimp farming zones in the coastal region based on natural advantages of shrimp and prawn farming with restitution of water management infrastructure in each zone to optimize production and environmental sustainability. Different methods of aquaculture and farming system will be promoted in different zones depending on suitability-such as shrimp with salt limited to south eastern Cox's Bazar district, shrimp with paddy in Khulna and Satkhira districts, mono-crop improved extensive shrimp farming in limited areas of both southeast and southwest regions, improved traditional golda farming in areas like Bagerhat, northern Khulna and banning extensive shrimp farming in low-saline and non-saline areas.
- Introduction of Specific Pathogen Free (SPF) shrimp by private sector, which is duly facilitated by the government.
- Production of virus-free shrimp PL requires availability of virus free mother shrimp which is becoming scarce. Conservation of shrimp and prawn parent stock and their harvest by stress-free trawling, transportation and rearing in the hatcheries will be facilitated. To ensure supply of virus-free shrimp PL, all hatcheries will ensure PCR test of both mother shrimp and shrimp PL and DoF will provide certification of PL quality of both golda and bagda hatcheries.
- Import of both golda and bagda PL will be controlled, including illegal border trading.
- Extension support and research extension linkage will be strengthened.
- Community organizations of shrimp farmers and other primary stakeholders will be supported with technology, input, financing and market linkage by contract growing system run by the processing plants and monitored by the DOF and partner NGOs.

- Traceability of supply source, with e-Traceability and subsequently screening throughout the supply chain, will be ensured by contract growing and marketing system which will also ensure supply of virus-free PL, good quality and contamination-free feed and other inputs at reasonable price.

d. Marine Fisheries and Exploring Blue Economy

The marine fisheries resources of Bangladesh play a crucial role in the economy of Bangladesh contributing about 18% of the total fisheries production of 3.41 million MT during FY13. The entire industry of shrimp aquaculture depends upon on marine sector for steady supply of berried penaeid shrimp to ensure supply of post larvae. The recent verdict given by the International Tribunal for the Law of the Sea (ITLOS) and International Arbitration Tribunal over dispute of maritime boundary with Myanmar and India legitimately settles the EEZ of Bangladesh up to 200 nautical miles from the baseline comprising 118,813 sq. km of maritime waters. In order to establish a comprehensive plan for sustainable conservation, management and exploitation of resources from the sovereign marine waters as well as explore the new opportunities of Blue Economy the present status of fisheries resources and its future potential for the national economy will be framed out. The strategies and actions shall include:

- Rapid assessment of fisheries stocks by species in recently resolved South-West waters of EEZ (19,467 sq.km)
- Formulation of National Marine Fisheries Policy during the 7th Plan
- Restrict and control pouching of resources and illegal entry of foreign trawlers
- Identify conservation needs and methods that can be effectively administered and regularly monitored
- Cooperate with the Coast Guard and Navy on the control of encroachment and breach of regulation, also by local vessels.
- Institutional capacity building of the concerned agencies, strengthening of monitoring, Control and Surveillance System (MCS) in the Bay of Bengal.
- Promote development of technology for production of seed for culturing marine fish, and seaweed.
- Collaborative effort for distant water fishing (beyond 200 miles of EEZ and Area Beyond National Jurisdiction (ABNJ)) to explore and exploit tuna and large pelagic fishes.

11.5 Result and discussion of the study

Section 1: Fish catch

a. Gear used

The Meghna river is one of the largest rivers in Bangladesh (Hossain et al., 2009, Hossain, 2011) and sustains country's important multi-species commercial fishery. A large number of fishing crafts and gears are operated in the Meghna and its estuary for commercial exploitation of the fishery resources (Moula et al., 1993; Das and Banargii, 2000). Fishing gear is any form of equipment, implement, tool or mechanical device used to catch, collect or harvest fish (Banglapedia, 2006). The principal categories of fishing gears that are traditionally used in Bangladesh can be enumerated as the following: fishing nets, fishing traps, hooks and lines, wounding gears and fish aggregation device (Chakraborty et al., 1995). Various types of materials are used to make these fishing gears include netting, twine, plastic structural and fasteners, clips and swivels, ropes, steel wire ropes, combination wire ropes, purse rings,

polyester, polyethylene, nylon, cotton, polypropylene, mixed fibers, floats and sinkers, bamboo, wood etc. (Hameed and Boophendranath, 2000). The shape and size of the gear depends on the use of gears and the environmental condition of the water body. The fish catch assessment survey in the project area identified the types of fishing gears and their mode of operation

Table 1: Nature of fishing gears operation in the study area

Type of fishing gear	English name	Local name	Target species	Operation period	Size	# of persons involved	Catch
Current jal	Monofilament gill net	Current jal (YRG)	Puti, tengra, koi, shingi, juvenile of carps	June-September	40-50 m	1 persons	1.5-2 Kg/ day
	Gill net	Chandi jal	Hilsa	February-August	500- 750 m	3 persons	5-25 Kg/ day
		Chapila jal	Chapila, bele	February-October	200-250 m	3 persons	10-15 Kg/day
Ber jal (SG)	Seine net	Carps, catfish	Carps, catfish	January- May	75-100 m	15-20	50-60 Kg/day
Bag net	Set bag net	Dhur jal	Chewa, kaski, chapila, hilsa, silon, etc.		150 m	3 persons	
Moi jal (YRG)	Drag net	Moi jal	Prawn		4-5 m	2 persons	
	Pull net	Puchuni jal	Prawn, small fishes		3-4 m	1 persons	
Hook (YRG)	Long line	Hazari borshi	Boal, ayre, rui, bele, shole, gozar		2-3K hooks	2 persons	
Chai	Fish trap	Rabani chai	Bujuri, eel, puti	June- October			
		Dhar chai	Prawn	June- October			
		Box chai	Prawn	June- October			
Fish aggregating devices (FADs)	Brush pile	Katha	Major and minor carps, cat fishes, snake heads, prawn, etc.	August-February	Avg. size 0.5 Hectare		700-800 Kg/yr.

b. Diversity of fishing gears surveyed

Fish catch- effort data was collected August 2017 to October 2018 in the controlled floodplains, it covered 1st quarter of moon, new moon and full moon. In every stages of moon, data were collected for three days. A total of 121 fishermen and their fishing gears were surveyed during the study period (Table 2). As this was not a good fishing season, number of fishermen, fishing gears and amount of fish catch was less. In the Focus Group Discussion, fishermen mentioned that the main fishing period is from July to October.

Table 2: Sample size of fishermen and fishing gears

Local name of fishing gears	English name of fishing gears	# of gear sampled		
		Canal/ river (Deep water)	Floodplains (Shallow water)	Total no. of gears
Ber Jal	Encircled net	7	0	7
Chandi jal	Gill net	3	0	3
Current net	Monofilament gill net	6	22	28
Jhaki Jal	Cast net	0	4	4

Moi Jal	Drag net	18	23	41
Puchuni Jal	Pull net	0	1	1
Sating Net	Encircled net	6	0	6
Chai	Fish trap	7	24	31
Total		40	81	121

The survey was conducted in the main canal/ river (deep water) and in the floodplains (shallow water). Among the surveyed fishing gears, there was seven (07) ber jal (encircled net) three (03) Chandi jal (gill net), six current nets, 18 moi jal (drag net), six sating jal (encircled net) and seven chai (fish traps) operated in the deep water. However, in the shallow water, 22 current jal, four cast nets, twentythree drag nets, 1 pull net and twenty four fish traps were surveyed.

c. 11.4.2 Fishing hours

Fishing hours differed from gear to gear, their mode of operation, types of fish caught, etc. It was found in the study the highest amount of time that the current nets were soaked under water. In an average they were soaked about 10.28 hours, 13.14 hours and 13.34 hours during the 1st quarter of moon, new moon and full moon respectively (Table 3). This was because, the fishermen used to set the net under water for couple of hours and then lift it to collected the entangled fishes. Also the puchuni jal (encircled nets) were also operated in the shallow water for 12, 13.3 and 13.5 hours during the 1st quarter of moon, new moon and full moon respectively. The table… also stated that the gear operation duration was larger during the new and full moon comparing to the 1st quarter of moon.

Table 3: Hours of fishing by gears

Types of gears	**Deep water**			**Shallow water**		
	Ist quarter	New moon	Full moon	1stquarter	New moon	Full moon
	Total fishing hour					
Ber jal	9	11.6	11.8	0	0	0
Chandi jal	12	12.5	12	0	0	0
Current jal	0	0	0	10.28	13.14	13.34
Cast net	0	0	0	2.41	3.2	3.5
Drag net	7.8	7.5	7.75	8.7	8.05	8.3
Puchuni Jal	0	0	0	12	13.3	13.5
Sating jal	6.5	7.6	7.2	0	0	0
Chai	7.3	6.3	14	7.2	7.33	14.3

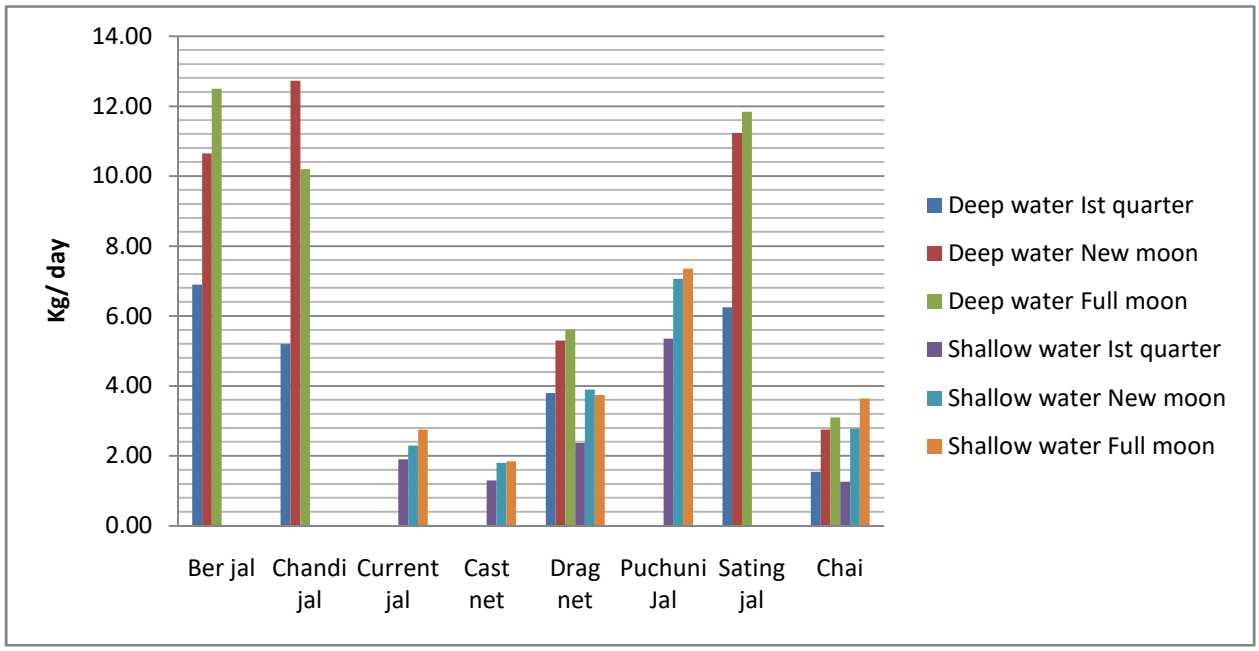
d. Amount of fish catch

Fish production of the sampled FPAs was calculated from the partial and final harvest data. It was observed that average fish production was approximately twenty metric tons perhactor. It is clearly evident that the fishing efficiency of different gears differed significantly..

Again, it is marked that the moon has direct influence over the amount of fish caught. The chart 1 shows that the amount of fish caught by ber jal, chandi jal and puchuni jal was very close and was higher over current net, cast net, drag net and fish traps. It was measured that in an average the fish catch by ber jal was 6.9 Kg, 10.65 Kg and 12.5 Kg during the 1st quarter of moon, new moon and full moon in the main river (Chart 5.1). According to the survey data fish catch was found more in deep water (main river) comparing to shallow water.

Chart1: Amount of daily fish catch by different gears

In the same time the average amount of fish caught by chandi jas was found 5.2 Kg, 12.73 Kg and 10.2 Kg during the 1st quarter of moon, new moon and full moon in the main river. The sating jal (encircled net) are usually used for catching kaski fish. The river Meghna is famous for the abundance and taste of kaski fish. In an average, the catch of sating jal was recorded as 6.25 Kg, 11.24 Kg and 11.84 Kg during the 1st quarter of moon, new moon and full moon in the main river. The cast nets are not used for commercial fishing and drag nets are used for subsistence level of fishing. However, fish traps were also found subsistence level of fishing.



The fishing efficiency or per hour catch by gears shows that, about 1.06 Kg of fish were caught by ber jal during the full moon, 0.92 Kg in new moon and 0.77 Kg during 1st quarter of moon. The fishing efficiency was found highest among the sating jal during the study period (Table 4). This net is mainly used for kaski fish catching.

Table 4: Daily fish catch by different gears at different loner stage

Types of gears	Deep water			Shallow water		
	Ist quarter	New moon	Full moon	Ist quarter	New moon	Full moon
	Catch (Kg/Hr.)	Catch (Kg/Hr.)	Catch (Kg/Hr.)	Catch (Kg/Hr.)	Catch (Kg/day)	Per hour fishing (Kg)
Ber jal	0.77	0.92	1.06	0	0	0
Chandi jal	0.43	1.02	0.85	0	0	0
Current jal	0	0	0	0.18	0.18	0.21
Cast net	0	0	0	0.54	0.56	0.53
Drag net	0.49	0.71	0.73	0.27	0.48	0.45
Puchuni Jal	0	0	0	0.45	0.53	0.55

Sating jal	0.96	1.48	1.64	0	0	0
Chai	0.21	0.44	0.22	0.18	0.38	0.25

e. Species Composition

A wide range of fish species are caught here. Their variations are also season depended. Usually, late monsoon (September-October) is the peak time for fishing. In that period water starts to recede. Juvenile and adult fishes also come to main river from the adjacent floodplain areas. Again, fish species and their amount of catch usually differ from gear to gear. According to the fish catch-effort monitoring survey, a wide range of fish species were caught by the fishermen. These are Ayre, Bele, Baim, Boal, Bujuri tengra, Batashi, Chanda, Chela, Common carp, Chapila, Garua, Hilsa, Kaski, Kalbasu, Katla, Kakila, Kholisa, Koi, Meni, Mola, Prawn, Pabda, Puti, Rui, Shorputi, Shingi, Shol, Taki, Rayek bata and Tengra.

Further, the data was analyzed for percentage of fish caught by gears. In the ber jal the highest percentage of fish caught by weight was Puti (17.1%), Boal (12.8%), Rayek bata (12.8%), Prawn (8.3%), Hilsa (6.6%), Chapila (6.5%), Mola (5.9%), Garua (5.6%), Chela (5.4%), Katla (3.5%), Shol (3.2%), Shorputi (3.0%), Bele (2.2%), Rui (2.1%), Pabda (1.8%), Kakila (1.4%), Chanda (1.2%), Batashi (0.7%), and Kalbasu (0.1%). However, by puchuni jal about 90% of catch was prawn and about 93% was kaski by sating jal (Table 5).

Table 5: Percentage of fish caught by weight by gears

Name of fish	**% of fish caught by different types of gears**							
	Ber Jal	Chai	Chandi	Current net	Cast net	Drag net	Puchuni Jal	Sating Net
Ayre	0	0	0	3.6	6.5	3.9	0	0
Bele	2.2	12.1	3.0	11.7	9.7	15.3	0	0
Baim	0	6.7	0	2.2	2.5	1.1	0	0
Boal	12.8	0	12.0	0.4		0.1	0	0
Bujuri tengra	0	6.0	0	8.6	3.2	1.2	0	0
Batashi	0.7	0	0			0.4	0	0
Chanda	1.2	0.5	0	0.2	2.5	0.6		3.6
Chela	5.4		0	0	0	0.4	0	0
Common carp	0	0	0	2.8		0	0	0
Chapila	6.5	0	20.0	9.5	0	6.2	0	0
Garua	5.6	0	8.0	0.2	0	0	0	0
Hilsa	6.6	0	22.0	0	0	2.6	0	0
Grass carp	0	0	0	0.3	0	0	0	0
Kaski		0	0	0	0	1.0	0	93.3
Kalbasu	0.1	0	22.0	0.2	0	0.6	0	0
Katla	3.5	0	0		0	0.9	0	0
Kakila	1.4	0	0	1.7	0	0	0	0
Kholisa	0	5.3	0	2.4	4.9	4.1	0	0
Koi	0	0	0	5.3	0	0	0	0
Meni	0	0.2	0	1.0	0	1.6	0	0

Mola	5.9	0	0	0	0	0	0	0
Prawn	8.3	40.1	4.0	19.3	18.3	24.8	90.0	0
Pabda	1.8	0	0	0.1	0	0	0	0
Puti	17.1	22.3	3.0	14.5	32.2	22.9	10.0	3.1
Rui	2.1	0	6.0		0	0	0	0
Shorputi	3.0	0	0	1.2	0	0	0	0
Shingi	0	0.1	0	4.1	0	2.7	0	0
Shol	3.2	0	0	0	0	0	0	0
Taki	0	0	0	0	2.5	0.2	0	0
Rayek bata	12.8	0	0	0.4	0	0.6	0	0
Tengra	0	6.8	0	10.4	17.8	8.8	0	0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total no. of species caught	19	10	9	22	9	21	2	3

A fairly large number of types and forms of gear are being operated in the floodplains to exploit wild fishes since time immemorial. The intensity of use of any form of gear in the open water dependent on the intensity of target fish population presumed to be available in that waterbody. Among them, many of these have been known to catch carp fingerlings before they grow to legal size and many of these are responsible for sharp decline in the population of wild species of the floodplain.

During the Focus Group Discussion (FGD) and the baseline report it was found that many types of gears are operated in the study areas depending on seasonality. The table… states about the types of gears, their mode of operation, seasonality and efficiency operated in the study area-

f. Aquatic Fauna

A large number of aquatic fauna was observed in the project area. Many are totally dependent on wetlands and some species are partially dependent on wetlands. The wetlands are intensively exploited and the habitat is heavily disturbed. Despite this, some species have adapted to the altered environment, and others have even flourished.

Among the amphibians the skipper frog (*Rana cyanophyctis*) is common, being found in most of the wetland habitats; it has been the most successful in adapting to the altered environment. Among the reptiles, the roof turtle (*Kachuga tecta*) and the flat-shelled spotted turtle (*Lissemys punctata*) are also found in few numbers. These freshwater turtles face problems of migration during summer when water levels are inadequate. Common aquatic snakes include the checkered keelbaek (*Xenochrophis piscator*) and the smooth water snake (*Enhydris enhydris*). The freshwater dolphin (*Platanista gangetica*) is seen very rarely in the Meghna during the monsoon season.

Most of the fish species were found in the Rainy season while some Major Fish species like Hilsha were found in the early winter and also in the early monsoon. In case of floodplain fish catch, small indigenous fish species were available especially in the monsoon season. This an important protein source for the poor people and during discussion with the fishermen community it was revealed that most of the Subsistence and Part-time fishermen depend on these

small fishes not only as a protein source in their diet but also a part of their major income which comes from sale of these fishes. Due to its availability in the floodplains and easily accessible by the poor people, these important fish species are called 'Poor man's fish' (RCC 2002).

Table 6: Available aquatic fauna of the study area

Order	Local name	Scientific name	Deep-water	Shallow water	Abundance
Siluriformes	Ayre	*Mystus aor*	√		July to December
	Bacha	*Eutropiichthys vacha*		√	July to September
	Batashe	*Batasio batasio*		√	July to September
	Boal	*Wallago attu*	√		July to September, November to January
	Bujuri	*Mystus bujuri*		√	July to September
	Garua	*Clupisoma garua*		√	July to September
	Kajali	*Ailia Coila*		√	July to September
	Pabda	*Ompok pabda*		√	July to September
	Rita	*Rita rita*	√		July to November
	Shingi	*H. fossilies*		√	July to September, October to November
	Tengra	*Mystus vittatus*		√	July to September
Cypriniformes	Bata	*Labeo bata*		√	July to September
	Common carp	*Cyprinus carpio*		√	October- March
	Chela	*Chela cachius*		√	April to September
	Ghonia	*Labeo gonius*	√		July to September
	Grass carp	*Ctenopharyngodon idella*		√	October- March
	Kalbashu	*Labeo calbashu*	√		June to November
	Katla	*Catla catla*	√		June to November
	Mrigala	*Cirrhina mrigala*	√		June to October
	Puti	*Puntius stigma*		√	July to September, January to March
	Rayek bata	*Cirrhinus reba*		√	July to November
	Rui	*Labeo rohita*	√		June to November
	Sar Puti	*Puntius sarana*		√	July to September
Perciformes	Bele	Glossogobius giuris		√	July to September
	Chewa	Pseudapocryptes elongatus	√		July to September
	Koi	*Anabas testudineus*		√	October to December, July to September
	Kholisa	*Colisa fasciata*		√	July to September
	Meni	*Nandus nandus*		√	July to September
	Mola	*Amblypharyngodon mola*		√	April to January

	Nama Chanda	*Chanda nama*		√	April to February
	Taki	*Channa punctatus*		√	April to January
Osteoglossiformes	Chital	*Notopterus Chitala*	√		July to November
	Foli	*Notopterus notopterus*		√	July to November
Synbranchiformes	Baim	*Mastacembelus armatus*	√		July to September
	Gutum	*Lepidocephalus guntia*		√	July to September
Clupiformes	Hilsa	*Tenualosa ilisha*	√		June to October and sometimes up to December
	Chapila	*Gudusia chapra*		√	June to October
Mugiliformes	Kaski	*Corica sobrona*		√	July to September
Beloniformes	Kakila	*Xenentodon cancila*		√	July to September
Decapoda	Golda Icha	*Macrobrachium rosenbergii*	√		April to February
	Dima Icha	*Macrobrachinm villosimanus*		√	April to February
	Chatka Icha	*Macrobrachinm malcolmsonii*	√		April to February
	Gura Icha	*Palaemon styliformes,*			April to February
	(small prawns)	*Macrobrachium lamarrei, Macrobrachium dyanus, Macrobrachium lichodactylus*		√	April to February
	Small fish, snails and crabs			√	April to February

Among the most vulnerable fish species that are seldom seen in the study area are the Chaca chaca (Chaga) and Badis badis (Napit Koi). During the study period, none of these fish species were found in any types of the water body of the Study area. But local fishermen confirmed that they still exist in the study area (table 7).

Table 7: Endangered Fish Species of the Study Area

Sl. No.	Endangered Fish Species of the study area	
	Local Name	Scientific Name
1.	Chital	*Notopterus Chitala*
2.	Kalbaus	*Labeo calbasu*
3.	Gonia	*Labeo gonius*
4.	Dhela	*Osteobrama cotio*
5.	Rita	*Rita rita*
6.	Pabda	*Ompok Pabda*

7.	Gajal/Gagar	*Channa Marulius*
8.	Sarputi	*Puntius sarana*
9.	Darkina	*Rasbora rasbora*
10.	Silong	*Silonia Silondia*
11.	Baghair	*Bagarius bagarius*
12.	Chaga	*Chaca chaca*
13.	Nama Chanda	*Chanda nama*
14.	Napit Koi	*Badis badis*
15.	Tara Baim	*Macroganthus aral*

g. Fish Marketing Network

The fish market survey for this assignment was conducted for six days at four nearby market/ fish landing centres. These are Bottala, Tentultola, Boiduer Bazar and New Town fish markets. Structured questionnaire interview and Focus Group Discussions (FGDs) were conducted with the fish traders and representatives of their associations of four fish landing centers to understand the fish marketing network, seasonal variation of catch, employment generation, etc.

Major aspects of the Landing Centers are described below:

1. Rate of commission taken by the Aratdar/ commission agents is more or less same i.e., 2%-5%. General practice is taking a part of the catch instead of taking money. Locally, it is called "**Khoraki Money**" or in English "**fish for the day**".
2. The smallest landing centre is the Bottola Ghat fish landing centre. It is normally operated in 5-6 months in a year (Feb- June). However, due to the presence of some fishermen, it is just open rest of the year as a low activity.
3. In case of timing, the Tentultola and Bottola fish markets open early in the morning and continue for aboput two hours. However, the fish market at Boidyer Bazar operates at the noon time
4. In the fish landing Centers, there was little or no infrastructure except Boidyer Bazar. Only some Kaccha houses built for the Aratdars. There are no fish processing or preservation facilities in these Centres. The fish are sold on the open sky.

Employment in fish marketing

Fishery is labor intensive and, at all stages, generates employment. An example of this is multi harvesting, which improves the yield and income and increases the labor requirement. According to the Economic Census (2001 & 2003) of BBS, there are 61829 establishments engaged in the sale of fish and seafood in the country. The total establishments comprise of 20561 permanent, 38676 temporary and 2592 household based establishments. In other words, there are 33.25% permanent, 62.55% temporary and 4.2% household based establishments. Total number of persons engaged in the sale of fish and seafood is 93377 of which 92809 (98%) are males and 1568 (2%) are females. Of the total establishments engaged in the sale of fish and seafood, 37730 (61%) are in the urban area and the rest 24099 (39%) are in the rural area.

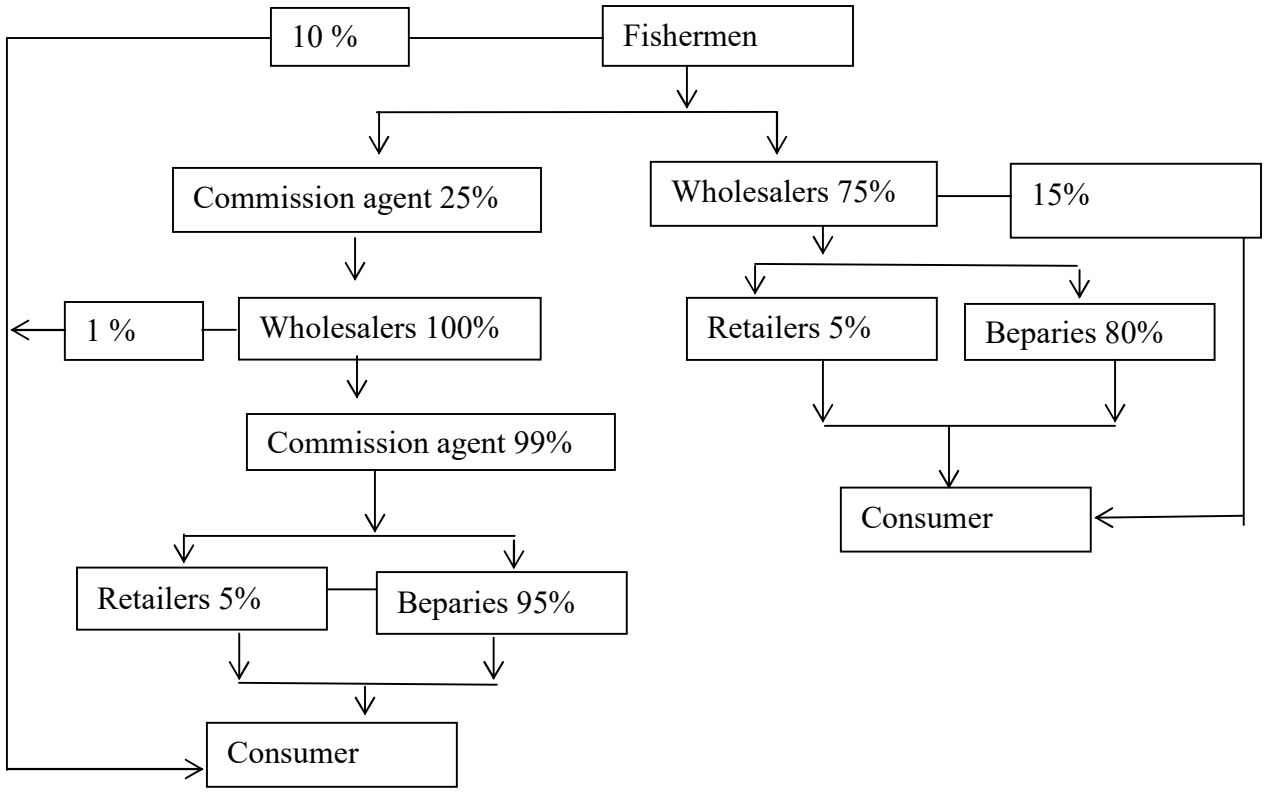
An overview of the people involved at different levels for different fish marketing activities at Tamta, Khiraitola and Daudkandi Bazzar fish landing centres is shown in the table 8.

Table 8: People involved in fish marketing and their main responsibilities

Local name	English	Brief description/responsibilities	Persons involved in fish market			
			Tamta	Khiraitola	Daudkandi Bazzar	
Matsyajibi	Fishermen	Catch fish from river and adjacent floodplains	40-50	100-150	400-500	100-150
Nikari	Middlemen	These people are the front line fish traders who actually buy fishes on behalf of the Aratdar / Mohajan. They Collect (buy) fish from fishermen and sell at auction and retail markets. Usually Nikari buy fish within own village and neighboring villages.	15-20	50-60	100-150	30-35
Arot	Auction house/market	Usually in the established markets there is fixed place for auctioning fish. There are few to several auction houses in a market. The individual auction house is called Arot		22	35	
Arotder	Auctioneer	Owner of individual auction house and runs the auction process. Arotders are the main investors in fish marketing.		22	35	
Paiker	Retailer	Buy fish from auction markets by bidding and retails to consumers at retail markets.	20-25	70-80	200-250	25-30
Sharker	Manager Employee of auctioneer and is paid monthly	Maintain records of all kind as required by auctioneer mainly financial records such as payments, providing credit, recovery etc.		22	35	
Kuli	Laborer	Unload and load fish. Carry fish from vehicle to auction place and vice-versa.		20-22	30-40	

Marketing Channel in the study area

In the study area, the fish marketing channel from fishers to consumers passes through a number of intermediaries like local fish traders, agents, wholesalers and retailers (Fig 6.1). Sometimes, a single person was found to perform a dual job depending on the supply and availability of fish and season. Rokeya *et al.* (1997) found that there were five different groups such as- Local agent (*dalal*), money lender (*Mahajans*), retailers (*nicary*), wholesalers (*paiker*), distributors (*bapary*) and commission agent (*aratdar*) involved as intermediaries in the distribution network from producer to consumer in the fish market.



Pricing System of the entire fish value chain with the seasonality aspects including Marketing Margins

Based on the literature review, conducting interviews and FGDs with Arotders and fish traders at selected four fish landing centers, it is evident that the prices of fishes has increased many folds for some species (Table 9). On the other hand, the traders and fishermen claimed that the fish catch has declined by more than 50% within last decade.

The fish price differs from market to market depending on their quality, size, market segment, etc. The table 9 shows the different market price of fishes at different markets.

Table 9: different market price of fishes at different markets

Fish species	Tamta			Khiraitola			Daudkandi Bazzar		
	Large	Medium	Small	Large	Medium	Small	Large	Medium	Small
	Tk/ Kg	Tk/ Kg	Tk/ Kg	Tk/ Kg	Tk/ Kg	Tk/ Kg	Tk/ Kg	Tk/ Kg	Tk/ Kg
Ayre				950	700	600			
Baim				600	427	373			
Bele				550	377	273		373	263
Bacha									
Bighead									
Boal				750	650	523			
Chapila				333					
Chewa		277			250		273	220	163
Chital				850	523	373			
Foloi				390	223	173			
Gazaer		275		350	240	173			
Garua				390	223	173			
Hilsa				950	650	550		600	423
Kaski			133			130			133
Katala				160	137	110	627	367	223
Kajali					823				
Koi	273		163						
Meni				423	370	273	373	263	220
Pangas	177	130	118				173	133	110
Prawn	850	647	560	800	550	450	750	550	400
Puti								223	
Rui								323	173
Silver carp	157	140	120				173	133	110
Taki								170	133
Tilapia	217	167	113	150	130	110	163	140	113
Rayek bata								273	220
Tengra					227				223

Section -2:Water quality and limnological survey

a. Introduction

Water quality refers to the chemical, physical, biological, and radiological characteristics of water.[1] It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose.[2] It is most frequently used by reference to a set of standards against which compliance can be assessed. The most common standards used to assess water quality relate to health of ecosystems, safety of human contact and drinking water

Environmental water quality, also called ambient water quality, relates to water bodies such as lakes, rivers, and oceans. Water quality standards for surface waters vary significantly due to different environmental conditions, ecosystems, and intended human uses. Toxic substances and high populations of certain microorganisms can present a health hazard for non-drinking purposes such as irrigation, swimming, fishing, boating, and industrial uses. These conditions may also affect wildlife, which use the water for drinking or as a habitat. Modern water quality laws generally specify protection of fisheries and recreational use and require, as a minimum, retention of current quality standards.

Limnology is the study of inland waters. It is often regarded as a division of ecology or environmental science. It covers the biological, chemical, physical, geological, and other attributes of all inland waters (running and standing waters, both fresh and saline, natural or man-made). This includes the study of lakes and ponds, rivers, springs, streams and wetlands.

Limnology has greatly influenced the field of freshwater fisheries science, particularly fisheries biology.

b. Findings of limnological and water quality tests

b.1 Plankton composition

The plankton community is consisted of the primary producers or phytoplankton and the secondary producers or zooplankton (Battish, 1992). The rate of gross primary productivity is important for assessing the fisheries yield (Mridula and Rajesh, 2002).

b.1.a Phytoplankton

In the present study, 14 species under 4 groups were encountered **(Table 11.1).** Among which 5 species belongs to both in Bacillariophyceae and Chlorophyceae followed by 3 species to Cyanophyceaeand 1 species to Euglenophyceae. *Chlorella,* under Chlorophyceae group was found most governing genera 180ind./L followed by *Ulothrix* 163 ind./L, *Melosira*120ind./L under Bacillariophyceae **(Table 11.2).**The number of phytoplankton species identified was a little bit low. It may be due to the opaqueness of the water. As the growth and proliferation of phytoplankton merely depends on sunlight penetration in any waterbody. Dredging in the around the sampling sites also could have bad impact in the transparency of the river water around the sampling station. On the other hand, the extent of phytoplankton per liter was maximum at SW1 (total 1020 ind./L) followed by SW3 (total 960 ind./L), SW6 (total 945 ind./L and the minimum was at SW4 (465ind./L) **(Figure 1).**

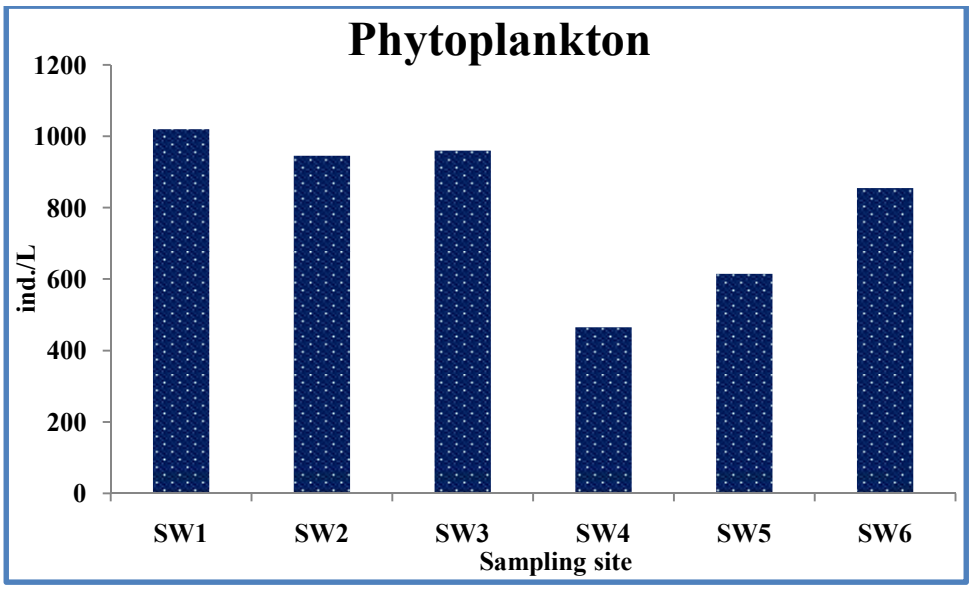


Fig. 1: Station basedphytoplankton abundance (%) in Meghna River.

The presence of low phytoplankton can be due to presence of more planktivore fish in the River. Due to overgrazing by planktivore fish on phytoplankton may be there amount is diminishing.

Table 1: Qualitative assessment ofphytoplankton in Meghna River.

Phytoplankton	Genus	SW1	SW2	SW 3	SW4	SW 5	SW6
Bacillariophyceae	*N. forcipata*	P	P	P	P	P	P
	Cymbella	P	P	P	A	A	P
	Melosira	P	P	P	P	P	P
	Tabellaria	P	P	P	A	P	P
	Microspora	A	P	P	P	P	P
Chlorophyceae	*Ankistrodesmus*	P	P	A	A	P	P
	Chlorella	P	P	P	P	P	P
	Spirogyra	P	A	P	P	P	P
	Tetraedon	P	P	P	A	P	P
	Ulothrix	P	P	P	P	A	P
Cyanophyceae	*M. aeruginosa*	P	P	P	A	A	P
	Gleocapsa	A	P	P	P	A	P
	O. germinata	P	P	P	A	P	A
Euglenophyceae	*Euglena*	P	P	P	P	P	P

Table 2: Quantitative assessment ofphytoplankton (ind./l) in Meghna River.

Phytoplankton	Genus	SW1	SW2	SW 3	SW4	SW 5	SW6	Total (mean)	Order (Total)
Bacillariophyceae	*N. forcipata*	120	75	135	60	45	135	95	301 ind./L
	Cymbella	30	30	45	15	0	15	23	
	Melosira	165	105	105	135	120	90	120	
	Tabellaria	60	45	60	0	60	45	45	
	Microspora	0	15	30	15	30	15	18	
Chlorophyceae	*Ankistrodesmus*	15	30	0	0	45	30	20	408 ind./L
	Chlorella	210	315	165	90	120	180	180	
	Spirogyra	30	0	45	30	30	15	25	
	Tetraedon	15	15	30	0	45	15	20	
	Ulothrix	285	210	180	60	0	240	163	
Cyanophyceae	*M. aeruginosa*	15	15	15	0	0	15	10	48 ind./L
	Gleocapsa	0	30	30	30	0	15	18	
	O. germinata	15	15	45	0	45	0	20	
Euglenophyceae	*Euglena*	60	45	75	30	75	45	55	55 ind./L
Point based (Total)		1020	945	960	465	615	855		

Species Richness	11	12		8				

he plankton compositions based on total amount count at six sites are mainly dominated by Chlorophyceae (50.25%) **(Figure 1).** The order Cyanophyceae encountered to be lowest (5.91%) compared to the six orders. The species richness was maximum 12 in SW2, SW3 and SW6 and lowest was 8 in SW4.

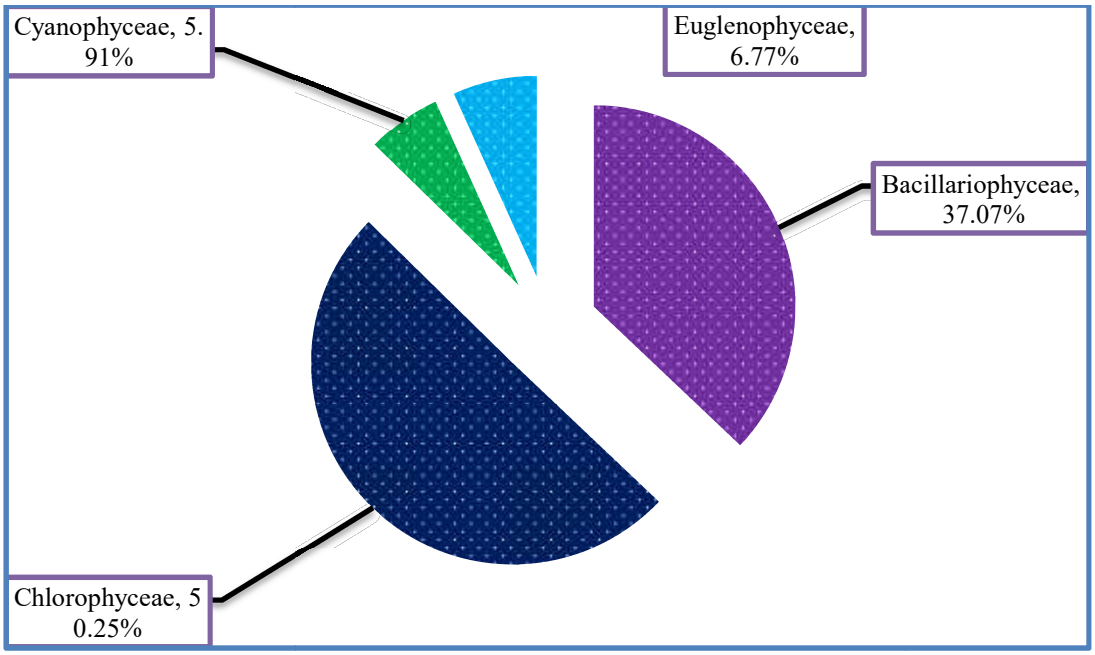
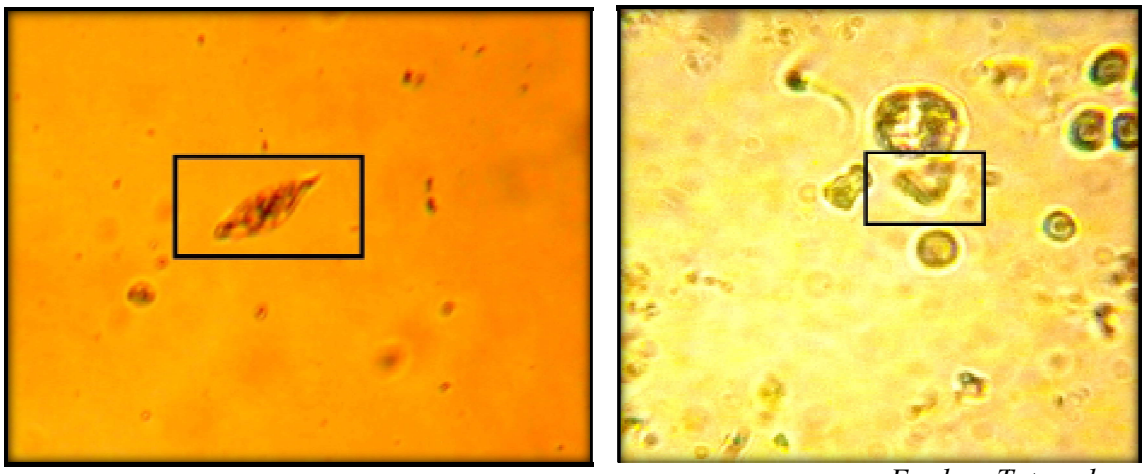
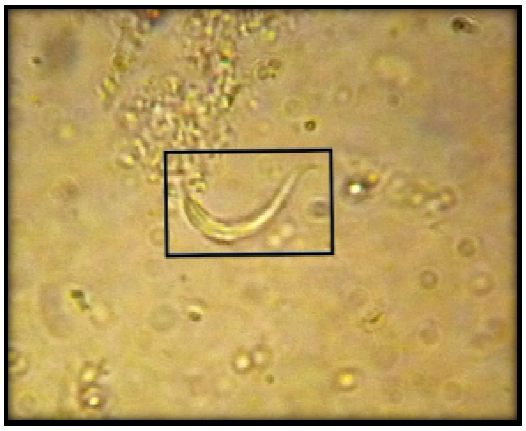


Fig. 1: Order basedphytoplankton (%) in Meghna River.

Plate 1: Phytoplankton and zooplankton study of the study area in the laboratory



EuglenaTetraedon



Ankistrodesmus

Plate 2: Images of some identified phytoplankton of the study area.

Diversity index of Phytoplankton

The Shannon-Weaver diversity index (H') of the survey area found to be oscillated from 1.96 (SW4) to 2.33(SW3) with mean value of 2.09±0.14 **(Fig. 3).** The results suggesting that the overall condition of the sampling points for phytoplankton found to be pretty good.

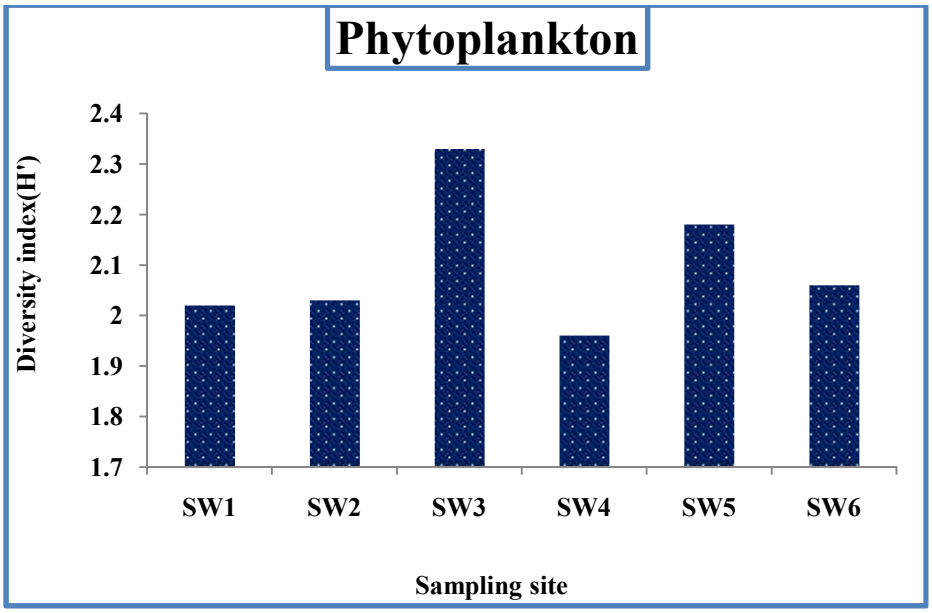


Fig. 3: Diversity index (H′) value of phytoplankton of different sampling of the study area.

b.1.b Zooplankton

Freshwater zooplankton is an important component in aquatic ecosystems as primary and secondary links in the food chain (Hutchinson, 1967; Lind 1985; Wetzel 1975). In the present study, 7 species under three zooplankton groups, of which 3 species belong to Cladocera followed by 2 species ofRotifera and 2 species of copepods were identified **(Table 3).** *Keratella* under the group Rotifera 69ind./L followed *Moina* under the Cladocera 51ind./L (**Table 4)** were found dominant taxa, respectively.

Table 3: Qualitative assessment ofzooplanktons in Monu River.

Zooplankton	Genus	SW1	SW2	SW 3	SW4	SW 5	SW6
		P	P	P	P	P	P
	Asplanchna	P	A	P	A	P	P
Cladocera	Sida	P	P	P	P	A	P
	Moina	P	P	P	A	P	P
	Diaphanosoma	P	A	P	A	P	P
Copepods	Cyclops	P	P	P	P	P	P
	Diaptomus	A	P	P	P	P	P

Table 4: Quantitative assessment of zooplanktons (ind./l)in Monu River.

Zooplankton	Genus	SW1	SW2	SW 3	SW4	SW 5	SW6	Total (mean)	Order (Total)
Rotifer	*Keratella*	90	60	90	45	75	75	69	93 ind/l
	Asplanchna	60	0	45	0	30	45	24	
Cladocera	*Sida*	30	45	45	30	0	30	30	128 ind/l
	Moina	135	75	105	0	45	30	51	
	Diaphanosom	45	0	30	0	45	60	27	

	a								
Copepods	*Cyclops*	45	45	30	45	30	30	36	84 ind/l
	Diaptomus	0	30	45	45	60	60	48	
Point based (Total)		405	255	390	165	285	330		
Species Richness		6	5	7	4	6	7		

The abundance of zooplankton was assessed based on sampling station **(Figure 4).** The maximum zooplankton encountered was at SW1 (405ind./L) followed by SW6 (330ind./L) and the lowest number of zooplankton estimated at SW4 (165ind./L). As the number of phytoplankton wasthe lowest in SW4 (465 ind/L) may be because of this reason the number of zooplankton was also low in number at the same sampling site.

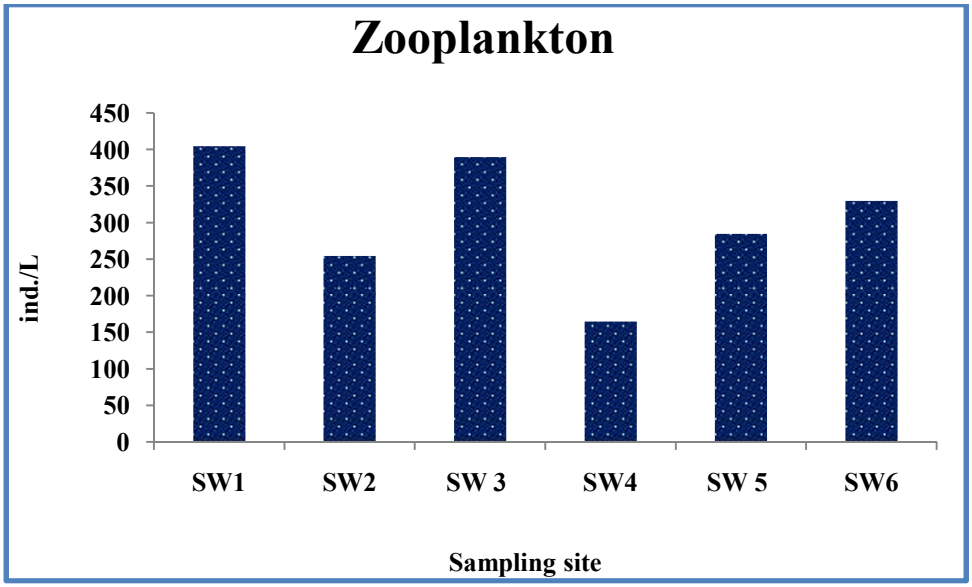


Fig. 4: Station basedzooplankton abundance (ind./L) in Meghna River.

Among the three orders observed in Meghna river at six sampling points, the dominating group encountered was Cladocera (41.97%) followed by Rotifer (30.49%) and Copepods (27.54%) **(Figure 5).** The species richness was maximum both at SW3 and SW6 (7) and lowest was found at SW4 (4). The less amount of zooplankton presence can be due to the presence of more zooplankton feeder fishes in the study area.

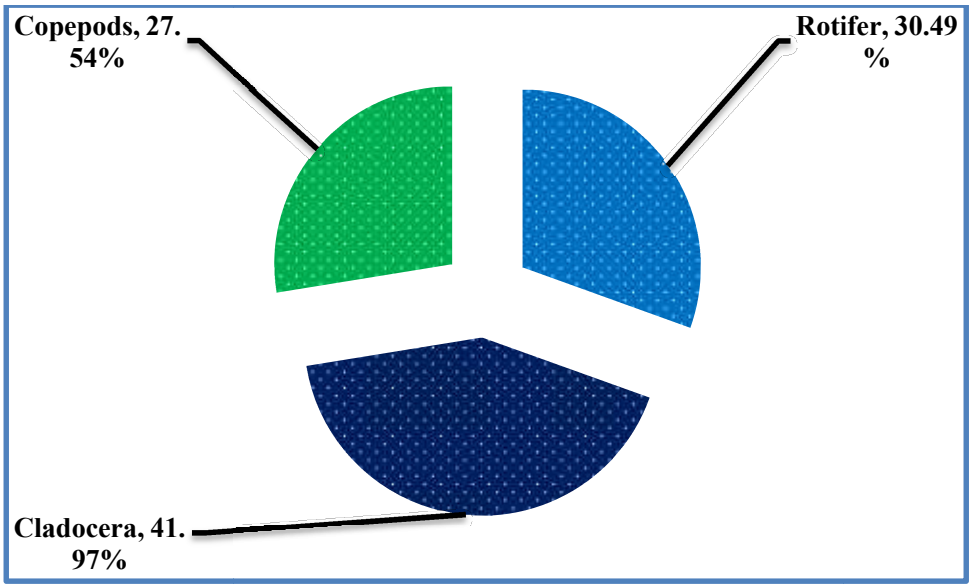
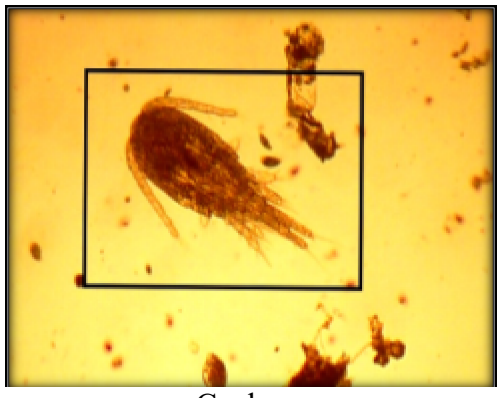


Fig. 5: Order basedzooplankton (%) in Meghna River.

Diaphanosoma *Moina*



Cyclops

Plate 3: Images of some identified Zooplankton in Meghna River.

Diversity index of zooplankton

The Shannon-Weaver diversity index (H') of zooplankton of the survey area found to be oscillated from 1.37 (SW4) to 1.88(SW6) with mean value of 1.67±0.18 **(Fig. 6).** The results suggesting thatthe overall condition of the sampling sites for zooplankton found to be pretty good.

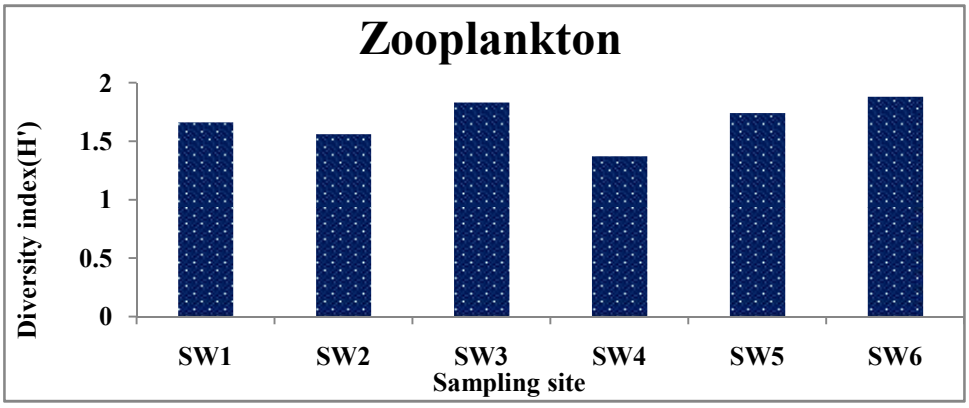


Fig. 6: Diversity index (H′) value of zooplankton of different sampling sites of Meghna River.

Benthos

For the assessment of benthic community of Meghna River at six discrete sampling stations Ek-man Dredge was used. Both qualitative and quantitative assessment was done in six selected sampling sites **(Table 11.5).** In the present study, total of 5 groups of benthos were recorded **(Table 11.6).** The benthos that found in six different sampling sites on Meghna River were*Chironomus* larvae, *Lamellidensmarginalis, Pilaglobosa, Unio*and*Sartorianaspinigera* (TeloKakra). The dominant group was*Pilaglobosa*,followed by *Chironomus* larvae and *Unio*.*Pilaglobosa* was present in all sampling sites followed by*Chironomus* larvae (4.6). The highest number of benthos was encountered at SW3 followed by SW1**(Figure 7).**

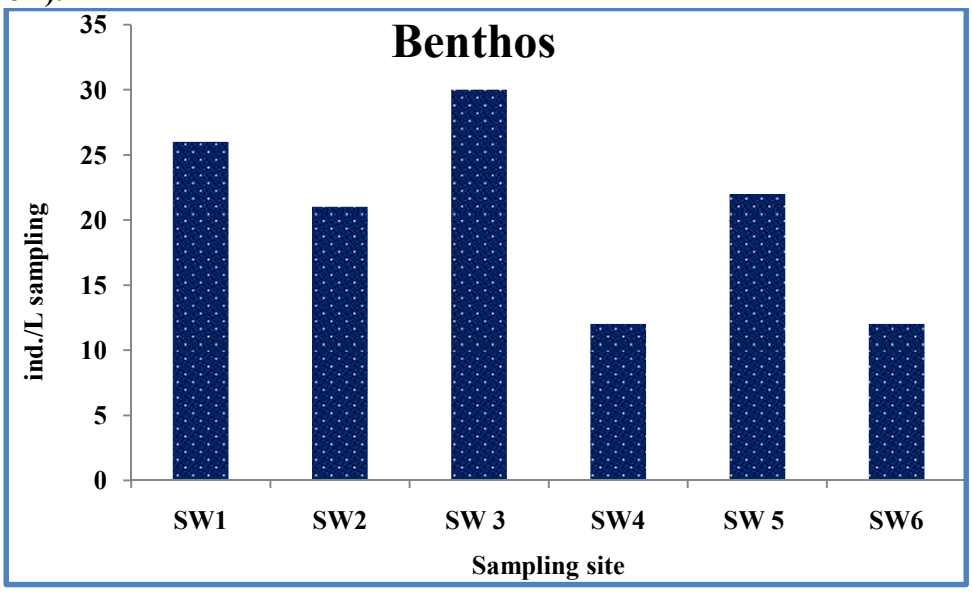


Fig. 7: Station based benthos abundance (ind./sampling) in Meghna River.

Among the six sampling the sites the benthos (*Pilaglobosa*) was found to be dominating (40.91%) followed by *Chironomus* larvae (36.36%), *Lamellidens marginalis* (9.09%), ,*Unio* (8.09%) and *Sartoriana spinigera* (TeloKakra, 4.55%) **(Figure 8).**

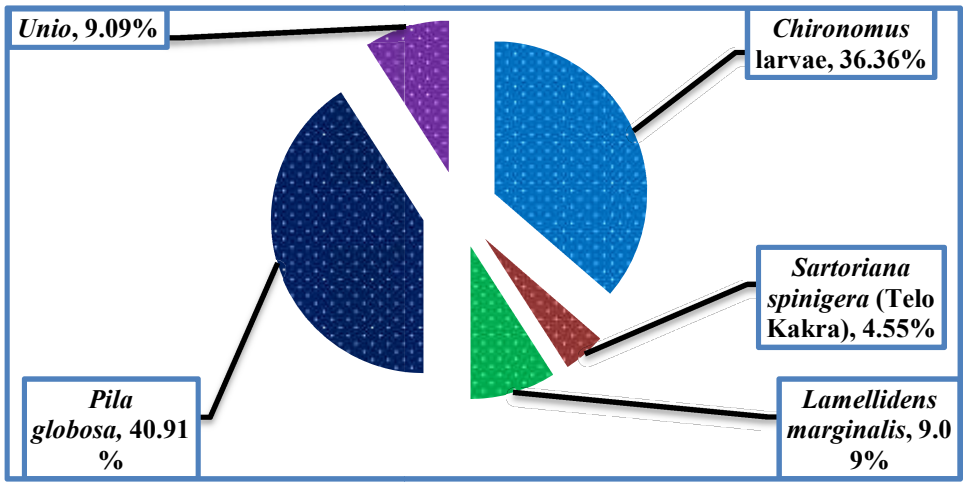
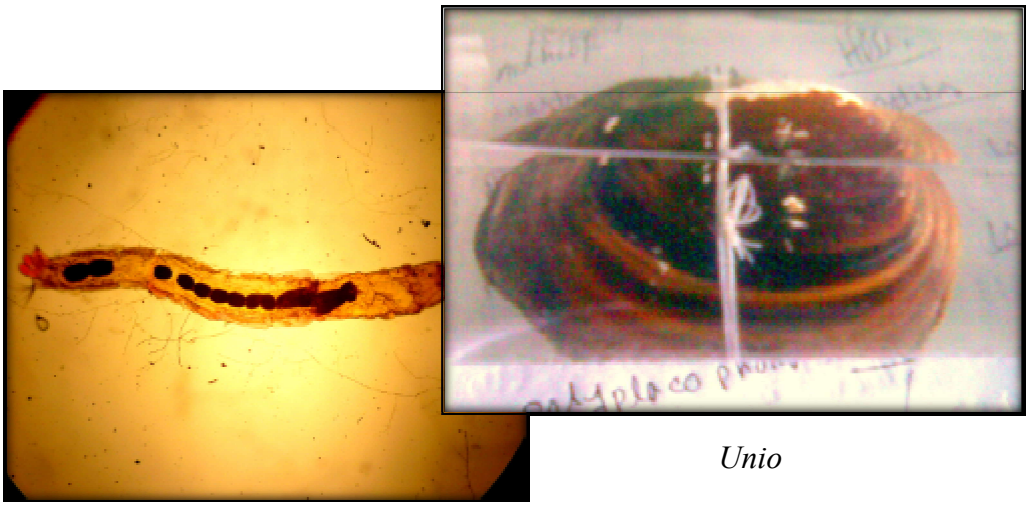
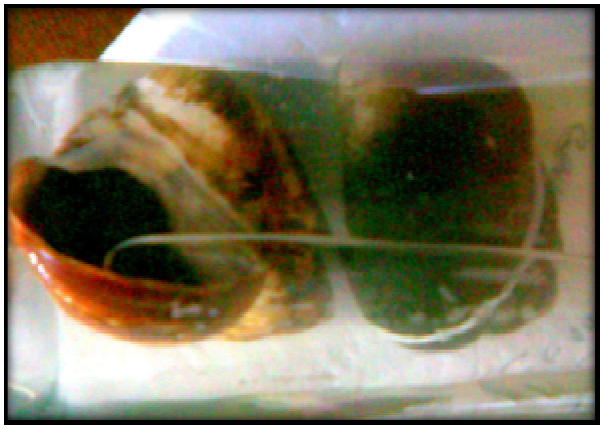


Fig. 8: Genus based benthos (%) in Meghna River.



*Chironomus*larvae

Unio



Pilaglobosa

Plate 1: Images of some identified benthos in Meghna River.

But the number of benthos was low at SW4. It may be due to discharging industrial effluents in the sampling (SW4) area. Availability of *Chironomus* larvae and gastropod (*Pila globosa, Unio*) indicate the good condition of the water body. Species diversity of benthos in the present study was relatively low. This may be due to unfavorable condition for the organism in the sampling sites. There were some draggers in the Meghna River near the sampling sites. This may adversely affect the total benthos population. Benthic invertebrates play an important role in transitional ecosystems, by filtering phytoplankton and then acting as a food source for larger organisms such as fish, thereby linking primary production with higher trophic levels. They also structure and oxygenate the bottom by reworking sediments and play a fundamental role in breaking down organic material before bacterial re-mineralization. So, care should be taken not to disturb their habitat.

Table 5: Qualitative identification of benthos in the study area

Benthos	SW1	SW2	SW 3	SW4	SW 5	SW6
Chironomus larvae	P	P	P	P	P	P
Sartorianas pinigera (TeloKakra)	P	A	A	0	P	0
Lamellidens marginalis	P	P	P	0	P	P
Pilaglobosa	P	P	P	P	P	P
Unio	P	P	P	P	P	P

Table 6: Quantitative identification of benthos of the study area.

Benthos	SW1	SW2	SW 3	SW4	SW 5	SW6	Total (mean)	Genus (%)
Chironomus larvae	11	8	13	5	8	2	8	36.36
Sartorianas pinigera (TeloKakra)	1	0	0	0	1	0	1	4.55
Lamellidens marginalis	3	2	3	0	2	2	2	9.09
Pila globosa	9	9	11	6	9	7	9	40.91
Unio	2	2	3	1	2	1	2	9.09

Point based (Total)	26	21	30	12	22	12	22	
Species richness	5	4	4	3	5	4		

Diversity index of Benthos

The Shannon-Weaver diversity index (H') of benthos of the sampling area found to be fluctuated between 0.92 (SW4) to 1.44(SW3) with mean value of 1.21±0.18 **(Figure 9).** The results suggesting that, the overall condition of the sampling points for benthos found to be moderate.

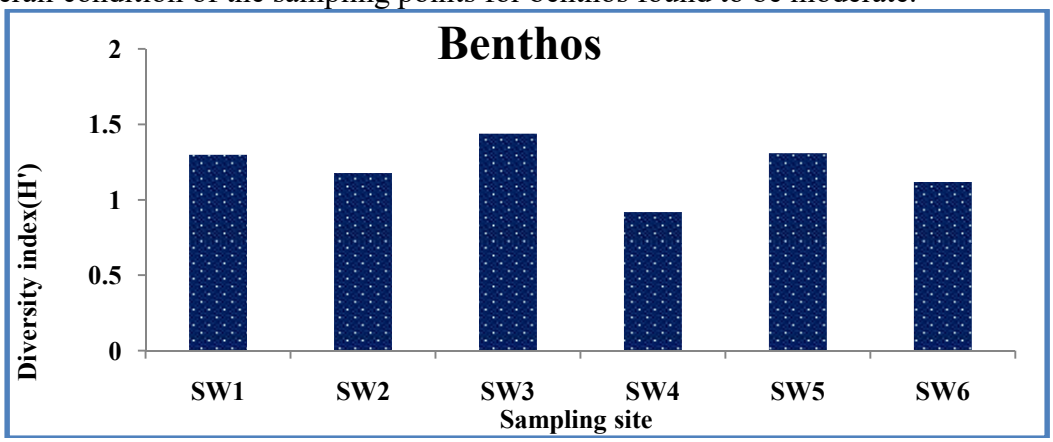


Fig. 9: Diversity index (H′) value of benthos of different sampling sites of Meghna River.

b.1.d Environmental parameter analysis

Environmental factors have influence on the occurrence and the distribution of fish and shellfish in any aquatic system. These parameters are considered as the most important in the identification of the nature, quality and type of the water (fresh, brackish, saline) for any aquatic ecosystem (Iwama e*t al.,* 2000). Several physico-chemical or biological factors could act as stressors and adversely affect fish growth and reproduction. Industrial effluents of different origins containing toxic metals, pesticides, etc and anthropogenic sources (Hatje, *et al.,* 1998) create water pollution problems through discharges into river water. The utility of river water for various purposes is governed by physico-chemical and biological quality of the water. The assessment of the changes in river communities as a result of the impact of pollution is particularly interesting issue within the frame work of aquatic ecology, since running waters are becoming increasingly affected by anthropogenic discharge (Whitton *et al.,* 1991). Therefore, it is necessary to know the environmental parameters in the study area. Ecological parameters like temperature, transparence, DO and pH vary season to season. Some of water parameters were determined *in-situ* during sampling and the rest of the parameters were determined in the laboratory. *In-situ* measurements are the following: Water temperature (Celsius thermometer), water pH (Titration method), transparency (Secchi disc), DO (Titration method), CO_2(Titration method), chloride (Titration method), total hardness (Titration method), nitrite (Titration method), NH_3(Titration method). Titration methods were done by using HACH Test Kit (Model: FF-2, Cat No. 2430-01). Rests of the parameters were determined in the laboratory. The recorded hydrological parameters of six points in the Meghna River have been shown in **(Table 7).**

BOD (Biological Oxygen Demand)

Unpolluted natural waters will have a BOD of 5 mg/l or less. BOD has direct influence on the amount of dissolved oxygen in rivers and streams. In the present study, the BOD of the study areas found to be fluctuated from 1.0 (SW2, SW3 and SW6) to 2.0 (SW1, SW4, and SW5) with a mean value of 1.5±0.55. The amount of BOD in all the locations except SW4 was more or less same as the base line study

conducted by SGS India Private Limited (ESIA Report). From the study it can be said that, the water quality of the study area is unpolluted and suitable for aquatic organisms **(Table 11.7).**

COD (Chemical Oxygen Demand)
The measure of COD determines the quantities of organic matter found in water. The COD test is helpful in indicating toxic conditions and the presence of biologically resistant organic substances (Sawyer *et al.*, 2003). In present study, COD values found same in all the sampling stations and it was 4 ppm **(Table 7).** The amounts of COD in all the locations were lower than those of base line study conducted by SGS India Private Limited (ESIA Report).

Electrical conductivity
The value of electrical conductivity depends on the concentration and degree of dissociation of the ions as well as the temperature and migration velocity of the ion in the electric filed. The electrical conductivity measures the concentration of ions in water. Specific conductance of most natural water generally ranges from about 50 to 1500 µS/cm. But in the present study the EC of the sampling sites fluctuated between 73 µS/cm (SW1, SW5 and SW6to 110 µS/cm (SW4), with an average value of 79.67± 14.88µS/cm **(Table 7).** The EC values in all the locations wereless than those of the base line study conducted by SGS India Private Limited (ESIA Report). The EC of these sampling sites were within the permissible limit.

Phosphate (mg/l)
The phosphate level of the sampling areas in the present study fluctuated between 1.19 (in SW4) to 1.85 mg/l (in SW6) with an average value of 1.48±0.22 mg/l **(Table 7).** But according to BBS (2013),the standard level of phosphate in drinking water is 6. So it is clear that the phosphate level of the Meghna river was within the conformity of BBS.

Salinity
Salinity in the study area varied from 0.03 ppt (in SW1, SW2 and SW6) to 0.05 ppt (in SW4) with a mean value of 0.033±0.008 mg/L **(Table 7).** Detected salinity level was found permissible.

Sulphate
Major source of sulphate of rivers are effluents from certain sorts of industries and acid rain in the industrial areas. Sulphate can also be produced by bacterial or oxidizing action as in the oxidation of organo-sulphur compounds. The more common sinks are pyrite, gypsum, and sulphate reduction. In the present study sulphate ranged between <LOQ(SW1 and SW5) to 2 mg/l (SW2 and SW4) with a mean value 1.0±0.896 **(Table 7).** In contrast to baseline study (ESIA Report), there is a little increase in sulphate in the sampling sites which is negligible for any river having connection with industries.

TDS (Total Dissolved Solids)
Total Dissolve Solids (TDS) refers to the sum of all the components dissolved in water. TDS of the investigated area oscillated from 35.0 (in SW1 and SW6) to 52.0 mg/L (in SW4) with a mean value of 40.0±7.24 mg/L **(Table 7).** Although the TDS value of the study areas found satisfactory, there were fluctuation in values between SW1 and SW4.In contrast to baseline study (ESIA Report), there was huge decrease in TDS level in the sampling sites.

TSS (Total Suspended Solids)

TSSs are solid materials, including organic and inorganic, that are suspended in the water. These would include silt, plankton and industrial wastes. In the present study, the minimum amount of TSS was found both in SW1 and SW2 (5.0 mg/l) and maximum in SW4 (8.0 mg/l) **(Table 7).** According to BSS (2013) and WHO (2011),the standard value of TSS is 10.0mg/l **(Table 7)**. So the TSS value of Meghna River was within the conformity of BBS (1013) and WHO (2011). However TSS values of all sampling sites of the present study were less than those of base line study (ESIA Report).

Water Temperature

The fluctuation in river water temperature usually depends on the season, geographic location, sampling time and temperature of effluents entering the stream (Ahipathy, 2006). The surface water temperature of the scrutinized study area found to be varied from 28.5°C to 30.0°C with a mean value 29.25±0.52°C **(Table 7).** Lowest value of temperature was observed 28.5 in SW1 and the maximum value 30.0°C in SW6. There was a little difference in water temperature among the sampling sites. Water temperature of the sampling sites of the present study was somehow lower than those of base line study (ESIA Report). This may be due to variation of sampling time or season.

Transparency

In the present study, the value of transparency in six discrete sites found to be varied from 23.5 cm (in SW2) to 66 cm (in SW4) with a mean value of 43.92±15.48 cm **(Table 7).** The minimum value of water transparency was observed where there was a continuous water supply from the outlay of the power plant. But water transparency was found maximum at SW4, because there was no water turbulence.

pH

Fish survive and grow best in waters with a pH between 6 and 9 (Iwama e*t al.,* 2000). In the present study, the pH of the study areas found to be fluctuated from 6.5 (in SW2) to 7.25 (in SW4) with a mean value of 6.87±0.25 **(Table 7).** But pH level of SW1 was found to be 6.8 and 7.0 in SW6. But the present study differs with the base line study (ESIA Report) at SW4 sampling site, where pH was found 7.25. But SGS India Private Limited reported 3.6 pH at the same sampling site. Anyway, as the value of pH ranges from 6.5 to 7.25, this seems almost neutral in nature and favorable for any kind of aquatic organisms.

Dissolved Oxygen (DO)

Oxygen is the single most important gas for most aquatic organisms; free oxygen (O_2) or DO is needed for respiration. DO levels below 1 ppm would not support fish; levels of 5 to 6 ppm are usually required for most of the fish population. The average value of DO levels (6.5mg/l) indicates the average quality of river water (APHA, 1995). Dissolved Oxygen ranges from 3.0 mg/l (in SW4) to 5.0 mg/L (in SW2, SW3, SW5 and SW6), with a mean value of 4.5±0.84mg/L **(Table 11.7)** in the present study. The lowest DO was found in SW4 sampling site. This result is relevant with the base line study conducted by SGS India Private Limited (ESIA Report). Standard value of DO for sustaining aquatic life is 4 ppm whereas for drinking purposes it is 6 ppm (Ahmed and Rahman, 2000). However, amount of DO found in all the sampling sites except SW4 is pretty good for the fish community in the river.

CO_2

Carbon di oxide varied with the sampling sites of the present study. It oscillated from 6 (in SW5) to 12.0 mg/L (in SW2) with a mean value of 8.42±2.01 mg/L **(Table 7).** Respiration by plankton and other organisms may be one of the probable cause of relatively higher concentration of CO_2 in the study area.

Chloride

Chloride is an inorganic ion found in all natural waters. Sources of chloride include septic systems, wastewater treatment plant effluent, animal waste, potash fertilizer and drainage from road-salting chemicals. The values of chloride found to be varied between 60 mg/l (in SW1, SW5 and SW6) to 90 mg/L (in SW2, SW3 and SW4) with a mean value of 75.0±16.43 mg/lin present study **(Table 7).** For public health, chlorides up to 250 mg/l are not harmful but values greater than this are indication of pollution (Nahar, 2000). From the present study it is clear that, the presence of chloride was within the permissible limit. However, this result does not co-relevant to that of base line study conducted by SGS India Private Limited. Their minimum and maximum values were 7.24 and 180.97 at SW3 and SW4 sites, respectively.

Total hardness

The maximum documented hardness in the study area SW4 51.3 mg/L and lowest value was 34.2 mg/L in rest of the sampling sites with a mean value of 37.05±6.98mg/L **(Table 7).** This result is co-relevant with the base line study conducted by SGS India Private Limited.

Nitrite

Nitrite is thetoxic by-product of nitrifying bacteria. It is only mildly less toxic than ammonia but still can kill aquatic animals if its levels get too high. The toxicity of this product is pH dependent and as the pH decreases nitrite form prevails and is therefore more toxic. The lethal dosage of nitrite is 10-20 mg/l. Nitrite of the scrutinized area oscillated from <LOQ (both in SW4 and SW6) to 1.26 mg/L (in SW3 and SW5) with a mean value of 0.72±0.59 mg/L **(Table 7).** This result indicates that nitrite levels in all the sampling sites are satisfactory.

Ammonia

Ammonia in water may be taken up by aquatic plants as nutrient or oxidized by bacteria into nitrate or nitrite. Amount of ammonia in freshwater is also dependent on pH and temperature. It is however, toxic to freshwater organisms at concentrations ranging from 0.53-22.8 mg/l. Although the ammonia molecule is a nutrient required for aquatic plants, excess ammonia may accumulate in the aquatic animals and cause alteration of metabolism or increases in body pH.The ammonia values in the investigated sampling points were found varying from 0.0035 (in SW1) to 0.244 mg/L (in SW2) with a mean value of 0.07±0.09 mg/l **(Table 7).** This result also indicates that ammonia molecule in all the sampling sites are quite acceptable.

Oil and Grease

Industrial applications mainly causes oil enters in the wastewater stream may include vehicle wash bays, workshops, fuel storage depots, transport hubs and power generation. Typical contaminants can include solvents, detergents, grit. lubricants and hydrocarbons. Toxicity varies among different types of oils and greases. Refined oils are generally more toxic than crude oils. Low levels of oil pollution can reduce aquatic organisms' ability to reproduce and survive. 0.3-0.6 mg/l of certain aromatic hydrocarbons can be lethal to aquatic organisms while chronic concentrations over 50 µg/l may be harmful to estuarine species. Oil can also create chemical oxygen demand. In the present investigation oil and grease was 0.1-0.2 mg/l in all the sampling sites **(Table 7).** It indicates accebtable level. While the same was <2 mg/l in the base line study conducted by SGS India Private Limited.

Table 7: Environmental parameters assessed and methods deployed in the study.

Parameters	SW1	SW2	SW3	SW4	SW5	SW6	Analytical method
BOD (mg/l)	2	1	1	2	2	1	5 days incubation

COD (mg/l)	4	4	4	4	4	4	CRM
EC (µS/cm)	73	74	75	110	73	73	EC meter
Phosphate (mg/l)	1.48	1.48	1.36	1.19	1.54	1.85	UVS
Salinity (0%)	0.03	0.03	0.03	0.05	0.03	0.03	Multimeter
Sulphate (mg/l)	1	2	<LOQ	2	1	<LOQ	UVS
TDS (mg/l)	35	36	36	52	46	35	multimeter
TSS (mg/l)	5	5	6	8	7	6	Gravimetric Method
Water Temperature (^oC)	28.5	29.5	29	29	29.5	30	Celsius thermometer (div = 0.10C)
Transparency (cm)	39	23.5	58	66	41	36	Secchi disc (25 cm)
pH	6.8	6.5	6.9	7.25	6.8	7	Titratiion Method
DO (mg/l)	4	5	5	3	5	5	Titratiion Method
CO_2 (mg/l)	9	12	8	7.5	6	8	Titratiion Method
Chloride (mg/l)	60	90	90	90	60	60	Titratiion Method
Total Hardness (mg/l)	34.2	34.2	34.2	51.3	34.2	34.2	Titratiion Method
Nitrite (mg/l)	1.115	0.66	1.26	0	1.26	0	Titratiion Method
NH_3 (mg/l)	0.0035	0.244	0.12	0.0072	0.029	0.0102	Titratiion Method
Oil and Grease(mg/l)	0.01	0.01	0.02	0.01	0.01	0.02	Spectrum 100 FT-IR spectrometer

BOD (Biological Oxygen Demand); COD (Chemical Oxygen Demand); EC (Electrical conductivity)

b.1.e Heavy metals

The value of toxic heavy metals like Chromium (Cr), Iron (Fe), Lead (Pb), and Manganese (Mn) in Meghna River were found more or less conformity with the WHO, World Health Organization**(Table 8).**Chromium was almost absent in the study area except SW2 (0.003 mg/l). But Fe was found to cross bit the standard level of WHO, although the amount of all sampling sites were less than those of the base line study conducted by SGS India Private Limited (ESIA Report). On the other hand, Mn and Pb were within the permissible limit of WHO standards.The amounts of these two heavy metals in all the locations were more or less same as the base line study conducted by SGS India Private Limited (ESIA Report).

Table 8: Heavy metals in different sampling sites of Meghna River

Parameters	SW1	SW2	SW3	SW4	SW5	SW6	WHO standard limit	Analytical method
Cr (mg/l)	<LOQ*	0.0003	<LOQ	<LOQ	<LOQ	<LOQ	0.05	AAS
Fe(mg/l)	0.69	0.85	0.73	0.64	0.68	0.71	0.3	AAS
Pb (mg/l)	0.004	0.003	<LOQ	0.003	<LOQ	<LOQ	10.0	AAS
Mn (mg/l)	<LOQ	0.03	<LOQ	0.07	<LOQ	<LOQ	0.05	AAS

***LOQ-Limit of quantitation**

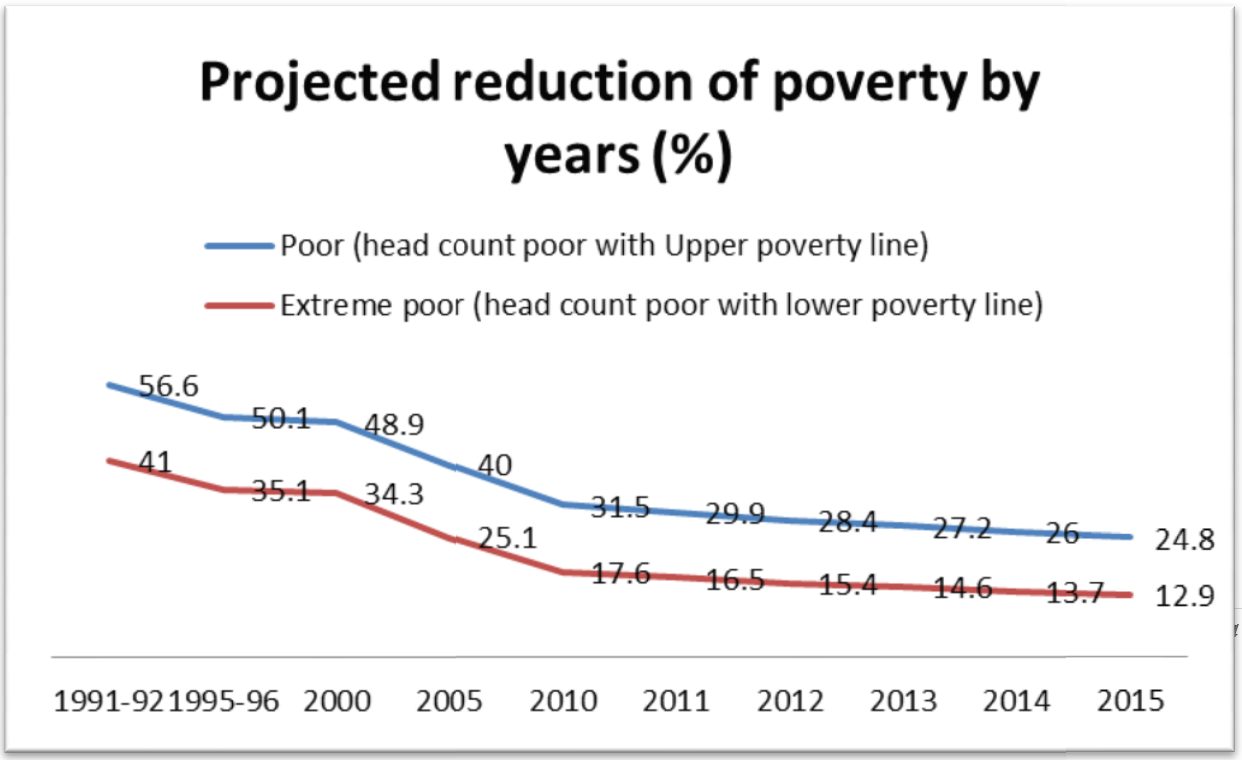
Table 9: Some physico-chemical parameters recommended by different organizations.

Parameters	Standard (DOE, 2001)	Bangladesh Standard for Fisheries (EQS, 1997)	Domestic Standards (De, 2005)	Drinking Standards (ADB, 1994)	Irrigation Standard (Ayers and Westcot, 1976)	Bangladesh Bureau of Statistics (2013),	World Health Organization (WHO, 2011)
BOD	5	(-) or below 2 (mg/l)	NA	NA	NA	-	-
COD	4	-	-	-	-	-	-
EC	300	800-1000	NA	NA	NA	-	-
Sulphate	22	-	-	-	-	-	
Phosphate (mg/l)						6	-
TDS (mg/l)	165	500	500	1000	450	-	-
TSS (mg/l)						10	10
Water Temperature (^oC)	30.5	25	-	-	-	-	-
pH	7.25	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	-	-
DO (mg/l)	6.5	4.0-6.0	4.0-6.0	NA	NA	-	-
Chloride (mg/l)	13	-	-	-	-	-	-
Nitrite (mg/l)	0.1	-	-	-	-	-	-
NH_3 (mg/l)	0.05	-	-	-	-	-	

Section -3: Socio-economic survey

a. Introduction on socio-economic survey

According to the 2005 Household and Income and Expenditure Survey, 25.1% of households in Bangladesh lived in extreme poverty. By 2010, the figured had fallen to 17.6% and in 2015 to 12.9%. This reduction confirms that Bangladesh continues to make meaningful progress to reduce



levels of poverty in the country.

Source: GED, Planning Commission, GoB (2015)

An average household in Bangladesh consists of 4.5 household members and have an overall income of BDT 9648, or about BDT 2130 per head. The average per capita income level of consumers below the upper poverty line is BDT 1271 per month, for those below the lower poverty line its only BDT 1102.84 per month on national level. According to the 2010 survey, the number of earners per household is 1.31 at national level, 1.27 in rural area and 1.40 in urban area. Since, 1995-96, number of earner per household shows a declining trend and has a positive correlation with the declining changing pattern of household size. The income per earner was found to be BDT 8795 for the country as a whole in 2010. In rural areas, this was BDT 7592 and in the urban BDT 11778. Income per earner increased to BDT 8795 in 2010 from BDT 5145 in 2005, an increase of BDT 3650 (70.94%) during this period. The average income per household in turn was found to be 9648tk in rural areas and 16477tk in urban areas, on a national level the average amounts to 11480tk.

The present study tried to capture basic socio-economic aspects of seven selected fisheries villages adjacent to the power plant.

b. Sampling Design and Sample Size

For the purpose of fisheries resource survey, consistent with the objectives, the detailed basic information was collected from sample households. Therefore, primary concentration was given to collect the necessary and relevant qualitative and quantitative primary information/data from the targeted sample project area.

The households survey under study villages were done by using the baseline survey questionnaire. The following formula was used to estimate the required sample size:

$$n = \frac{Z^2 * N * p*q}{C2*(N-1) + Z^2*p*q}$$

Where,

n = The desired sample size

Z^2 = chi-square as the standard normal deviate (3.841) - for 1 degree of freedom.

p = Desired probability level, the portion in the population estimated to have a particular characteristics (i.e. the probability in percentage).

q = 1.0 – p

N = Given Population size

C = Degree of desired error level (considered here error level at 3.5% for more accuracy)

Total number of the sampled size was determined at 1695 during the baseline survey. The current fisheries resource survey tried to collect data from the same respondents. However, in some cased the same respondents were not available. In this situation the survey team interviewed every 6th number of households from each village. Thus, 351 samples were covered from the field (Table 13.1)

Table 13.1: Actual Number of Samples Covered

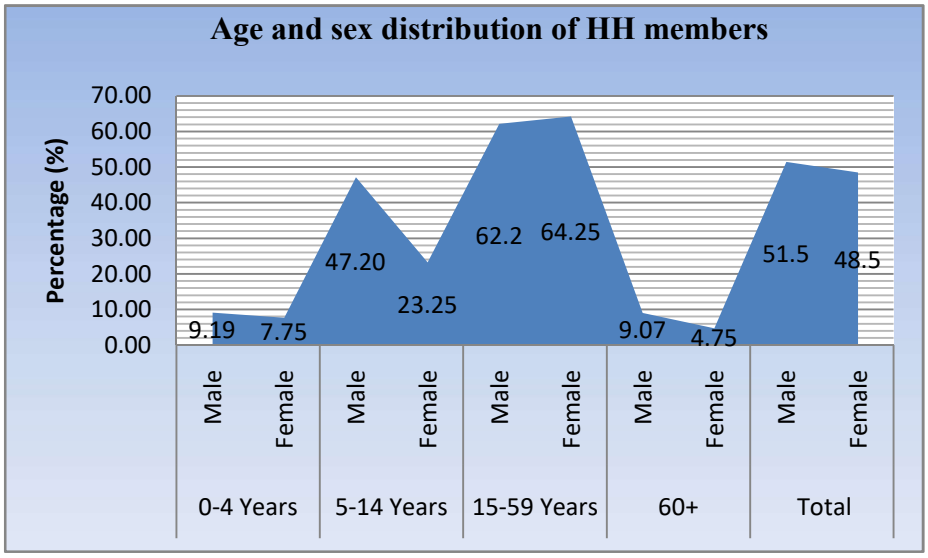
S. No.	Name of the village	Number of Household
1.	Tamta	70
2.	Lokhaitoli	330
3.	Saliakandi	598
4.	Shaibal	149
5.	Khirai	315
6.	Chargram	233
	Total	1695






c. Findings

c.1 Demography of the respondents



The chart left shows that there are total of 1649 household members distributed among 351 surveyed household. Among them 51.5% are male in contrast to 48.5% female. The female and male ratio is 106.13, which is slightly larger than the national average (100.25, BBS 2011). The baseline survey suggests that there was male 56.1% and female 43.9%, female and male ratio was 127.83. The data also reveals that about 62.2% of the male and 64.255 of the female fall into the 15-59 years age group, which means the capable workforce is more than 60% in the study area

Table 1: Age and Sex of the Household Members

Name of the vill.	0-4 Years		5-14 Years		15-59 Years		60+	
	Male	Female	Male	Female	Male	Female	Male	Female
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Tamta	18.97	4.44	24.14	24.44	46.6	66.67	10.34	4.44
Lokhaitoli	7.19	5.56	41.90	30.86	64.7	56.79	4.58	6.79
Saliakandi	8.91	10.13	45.30	19.83	65.9	66.24	10.08	3.80
Shaibal	10.94	11.29	47.60	17.74	65.6	67.74	7.81	3.23
Khirai	8.87	5.56	45.00	26.19	60.5	63.49	8.87	4.76
Chargram	9.68	5.81	54.50	17.44	58.1	70.93	12.90	5.81
Total	9.19	7.75	47.20	23.25	62.2	64.25	9.07	4.75

The survey tried to get information from the household heads. In absence of them capable person of the household was interviewed. The sex ratio among the respondents of the questionnaire survey was male 92% and female 8% (Table 2).

Table 2: Sex of the respondent

Name of the village	Male	Female
	Percentage (%)	Percentage (%)
Tamta	100.0	0.0
Lokhaitoli	96.8	3.2
Saliakandi	97.1	2.9
Shaibal	76.7	23.3
Khirai	77.4	22.6
Chargram	95.0	5.0
Total	92.0	8.0

Household size

The average household size in the study villages was found 4.7 persons, which is similar to the national average.

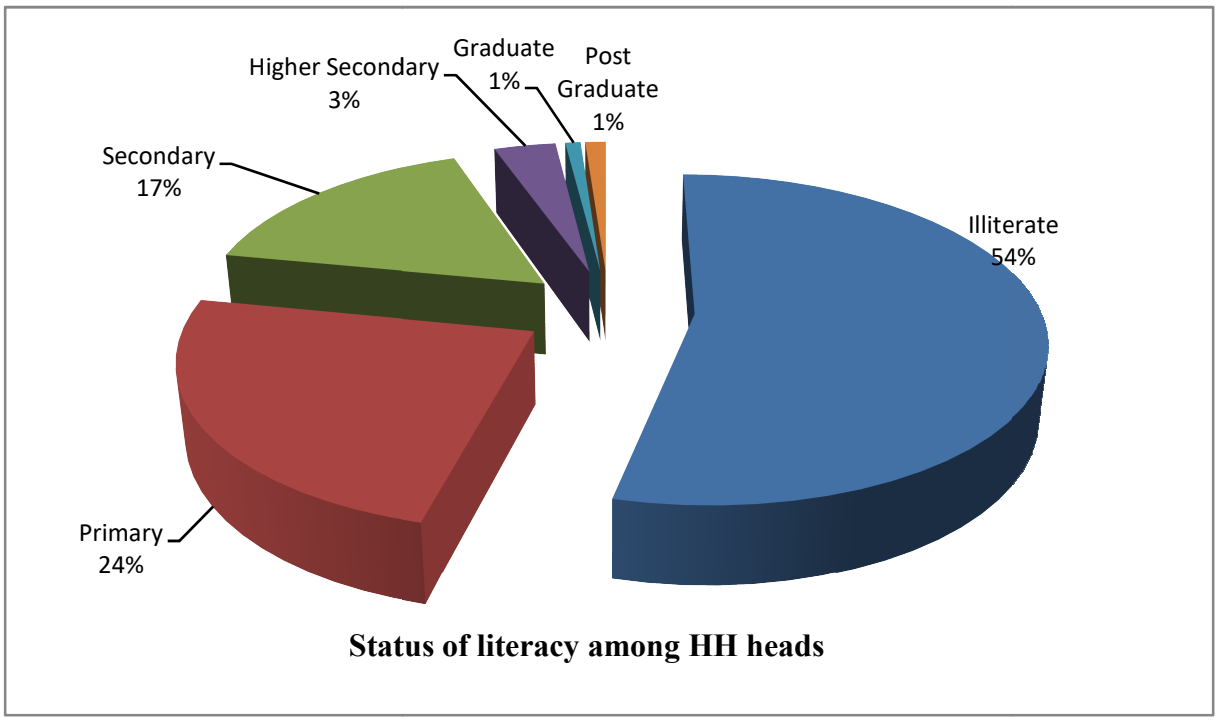
Table 3: Household size of the study villages

Name of the villages	HH size (Person/HH)
Tamta	5.72
Lokhaitoli	5.00
Saliakandi	4.76
Shaibal	4.20
Khirai	4.72
Chargram	4.48
Total	4.70

Educational status of household heads

The literacy rate among the household heads was found only 46%. Out of 351 household heads, 24% have primary level of education, 17% have secondary level of education, 5% higher secondary and only 1% of each have got graduation and post- graduation level of education. The rate of education among the female household heads is very poor, only 40% of them has some kind of literacy (Chart4).

Chart 4: Status of literacy of the HH heads



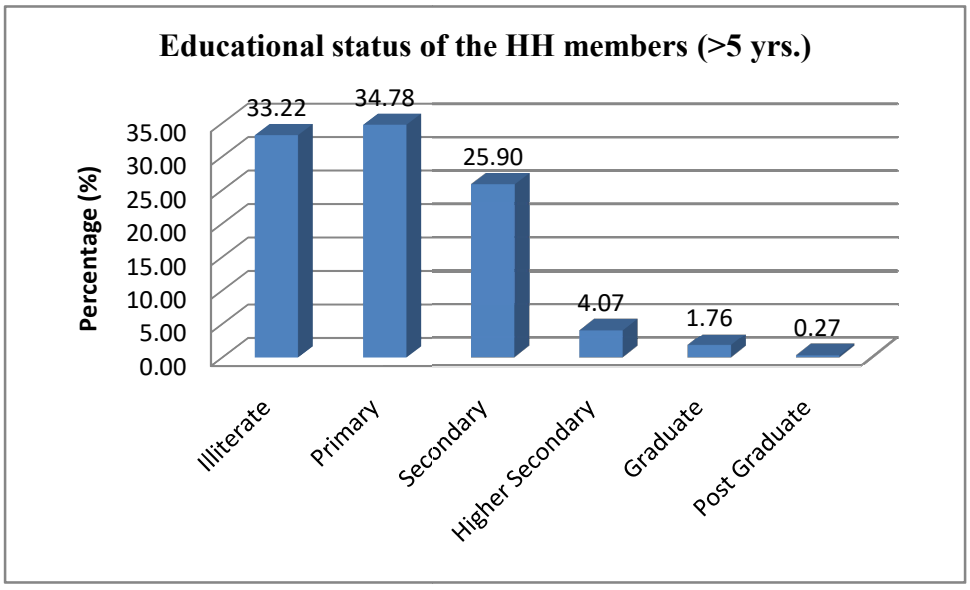
Durin g the Focus Group Discussion, they have mentioned that earlier there few educational institutions and the communication system was also very poor. However, after the industrialization of this area road

communication system has developed significantly. The Government and NGOs are running schools. Besides, some industries are providing financial supports to the schools and students. Also the parents realized that unless their children get proper education they would not get jobs in future. In this fact, parents are more aware about the education of their children.

Table5: Status of literacy of the household heads by gender segregation

Educational Status	Male	Female	Total
	Percent (%)	Percent (%)	Percent (%)
Illiterate	53.6	60.0	53.8
Primary	24.4	20.0	24.2
Secondary	16.7	13.3	16.5
Higher Secondary	3.3	6.7	3.4
Graduate	0.9	0.0	0.9
Post Graduate	1.2	0.0	1.1
Total	100.0	100.0	100.0

The overall literacy rate among the household members (>5years), was found 66.78% which is very much higher to the national average (51.77%, BBS 2011).



Among the household members, 34.77% have got primary level of education, 25.9% have secondary level of education, 4.07% have higher secondary level of education, while only 1.76% are graduate and 0.27% are post-graduate (Chart 3).

Separating the data by male and female, it was found that the literacy rate among the male (67.1%) is slightly bigger than female (66.5%). Out of 756 male members only 4 (0.5%) have got post-graduation level of education, while none of the female have got post-graduation level of education (Table5)..

Table5: Educational status of household members (>5 years)

Educational Status	Male	Female
	Percent (%)	Percent (%)
Illiterate	32.9	33.5
Primary	35.4	34.1
Secondary	24.1	27.8
Higher Secondary	5.2	2.9
Graduate	1.9	1.7
Post Graduate	0.5	0.0
Total	100.0	100.0

Occupations

Among the surveyed households, the heads are engaged in various types of professions to maintain their livelihoods. Among the household heads, fishing is their main means of livelihoods (31.9%) followed by agriculture (11.4%), fish trading (10.54%), wage labour (6.27%), rickshaw/ van pulling (5.41%), Running small shop (4.27%), salaried job (4.27%), business (3.99%), industrial labour (3.42%), driving (2.85%), petty trader (2.85%), unemployed (2.28%), working abroad (2.28%), house maker (1.71%), teacher (0.85%), disabled (0.85%), poultry / fisheries / livestock farming (0.57%), tailoring (0.57%) and homeopath doctor (0.28%) (Table 6).

Table 6: Primary occupation of the Household Heads

Types of occupation	Male	Female	Total
	Percentage (%)	Percentage (%)	Percentage (%)
Fisherman	33.75	10.71	31.91
Agriculture	12.07	3.57	11.40
Fish trader	11.46	0	10.54
Wage laborer	6.19	7.14	6.27
Rickshaw/van puller	4.95	10.71	5.41
Small Shop	4.33	3.57	4.27
Salaried job	3.41	14.29	4.27
Business	4.02	3.57	3.99
Industrial labour	2.79	10.71	3.42
Driver	3.1	0	2.85
Petty trader	3.1	0	2.85
Unemployed	2.48	0	2.28
Working Abroad	1.86	7.14	2.28
House maker	0.31	17.86	1.71
Teacher	0.93	0	0.85
Disabled	0.93	0	0.85
Poultry / fisheries / livestock farming	0.62	0	0.57
Tailoring	0.31	3.57	0.57
Homeopath doctor	0.31	0	0.28
Others	3.1	7.14	3.42
Total	100.00	100.00	100.00

However, the primary occupation of the household members is also diverse. The main primary occupation of the household members are fishing (9.76%), fish trading (3.21%), agriculture farming (3.09%), wage laborer (2.97%), industrial labour (2.55%), salaried job (1.64%), rickshaw/van pulling (1.46%), running small shop (1.33%), working abroad (1.27%), business (1.03%), petty trader (0.85%), driving (0.79%), disabled (0.61%), teacher (0.3%), tailoring (0.24%), poultry/fisheries/livestock farming (0.18%), welding (0.06%), homeopath doctor (0.06%), house maker (25.65%), student (25.41%), children (10.43%) and others (1.21%) (Table7). Nevertheless, about 5.88% of the household members were found unemployed.

Table 7: Primary occupation of the Household Members

Types of occupation	Male	Female	Total
	Percentage (%)	Percentage (%)	Percentage (%)
Fisherman	18.61	0.4	9.76
Unemployed	5.18	6.6	5.88
Fish trader	6.24	0	3.21
Farmer	5.77	0.3	3.09
Wage laborer	4.95	0.9	2.97
Industrial labour	4.36	0.6	2.55
Salaried job	2.71	0.5	1.64
Rickshaw/van puller	2.83	0	1.46
Small Shop	2.36	0.3	1.33
Working Abroad	2.47	0	1.27
Others	2	0.4	1.21
Business	2	0	1.03
Petty trader	1.65	0	0.85
Driver	1.53	0	0.79
Disabled	0.59	0.6	0.61
Teacher	0.47	0.1	0.3
Tailor	0.12	0.4	0.24
Poultry/fisheries/livestock Firm	0.35	0	0.18
Welder	0.12	0	0.06
Homeopath	0.12	0	0.06
House maker	0.35	52.5	25.65
Student	24.26	26.6	25.41
Children	10.95	9.9	10.43
Total	100	100	100

As most of the household members are engaged in non-formal sectors, they have to uphold secondary occupations to maintain their livelihoods. In several occasions, the occupations are seasonal. Among the

surveyed households, the secondary occupations of the heads are mainly agriculture farming (31.03%), fishing (25.86%), wage labor (14.66%), etc. (Table8)

Table8: Secondary occupation of the household heads

Types of occupation	Male		Female		Total	
		Percentage (%)		Percentage (%)		Percentage (%)
Agriculture farming		31.58		0		31.03
Fisherman		26.32		0		25.86
Wage laborer		14.91		0		14.66
Industrial labour		1.75		50		2.59
Rickshaw/van puller		2.63		0		2.59
Poultry/fisheries/livestock farming		2.63		0		2.59
Fish trading		2.63		0		2.59
Small Shop		2.63		0		2.59
Business		2.63		0		2.59
Driver		1.75		0		1.72
Petty trader		1.75		0		1.72
Working abroad		0.88		0		0.86
Others		7.89		50		8.62
Total		100		100		100

Like as the household heads, the household members also have secondary occupations. These are mainly agriculture farming (31.8%), fishing (19.9%), wage labor (14.6%), etc. (Table9)

Table9: Secondary occupation of the household members

Types of occupation	Percentage (%)		Percentage (%)		Percentage (%)	
	Percentage (%)	Percentage (%)	Percentage (%)	Percentage (%)	Percentage (%)	Percentage (%)
Agriculture farming	48	34	0	0	48	31.8
Fisherman	30	21.3	0	0	30	19.9
Wage laborer	22	15.6	0	0	22	14.6
Industrial labour	4	2.8	1	10	5	3.3
Poultry/fisheries/livestock farming	3	2.1	2	20	5	3.3
Small Shop	5	3.5	0	0	5	3.3
Fish trader	4	2.8	0	0	4	2.6
Business	4	2.8	0	0	4	2.6
House maker	0	0	3	30	3	2
Rickshaw/van puller	3	2.1	0	0	3	2
Tailor	0	0	3	30	3	2
Driver	2	1.4	0	0	2	1.3
Petty trader	2	1.4	0	0	2	1.3
Salaried job	1	0.7	0	0	1	0 .7
Working abroad	1	0 .7	0	0	1	0.7
Student	0	0	1	10	1	0.7
Others	12	8.5	0	0	12	7.9

The survey found that in every household more than one person is engaged in earning activities. In an average 1.55 persons are engaged in earning activities per household.

Table 10: Household earning members, fishing months and years of involvement

Name of the villages	Average numbers of earning member	Engage in fishing per year			
		1-3 months	4-6 months	7-9 months	10+ months
		f %	%	%	%
Tamta	1.39	0.0	5.9	17.6	76.5
Lokhaitoli	1.65	5.2	15.5	29.3	50.0
Saliakandi	1.60	21.6	8.1	13.5	56.8
Shaibal	1.50	-	-	-	-
Khirai	1.66	0.0	0.0	50.0	50.0
Chargram	1.35	25.0	50.0	8.3	16.7
Total	1.55	9.7	17.9	22.1	50.3

In the survey, it was found that 145 people are engaged in fishing activities, seasonal to year round. Out of them more than 50% are engaged in fishing round the year, about 9.7% are engaged in fishing only for 1 to 3 months and about 40% are engaged in fishing for 4 to 9 months.

Table11: Years of engagement

Name of the villages	Years of engagement in fishing activities									
	1-5 yrs		6-10 yrs		11-20 yrs		21-30 yrs		30+	
		%		%		%		%		%
Tamta		0.0		0.0		52.9		23.5		23.5
Lokhaitoli		5.2		20.7		39.7		17.2		17.2
Saliakandi		10.8		10.8		29.7		21.6		27.0
Shaibal		0.0		0.0		0.0		50.0		50.0
Khirai		0.0		33.3		33.3		8.3		25.0
Chargram		5.3		15.8		31.6		36.8		10.5
Total		5.5		15.9		36.6		21.4		20.7

Fishing is a traditional and unorthodox occupation in Bangladesh. The study also reveals that in the study villages, the people are engaged in fishing for long period. About 36.6% of the fishers are engaged in fishing for about 11 to 20 years and about 42.1% of are engaged in fishing for more than 20 years. It is interesting to know that only 5.5% of the fishers are engaged in fishing activities for about 1 to 5 years (Table…). It means that the recruitment in fishing activities is reducing in number. This may due to reduction of fishes in open water, fishing has become expensive and there are alternative income sources prevailing in the area.

Income and expenditure

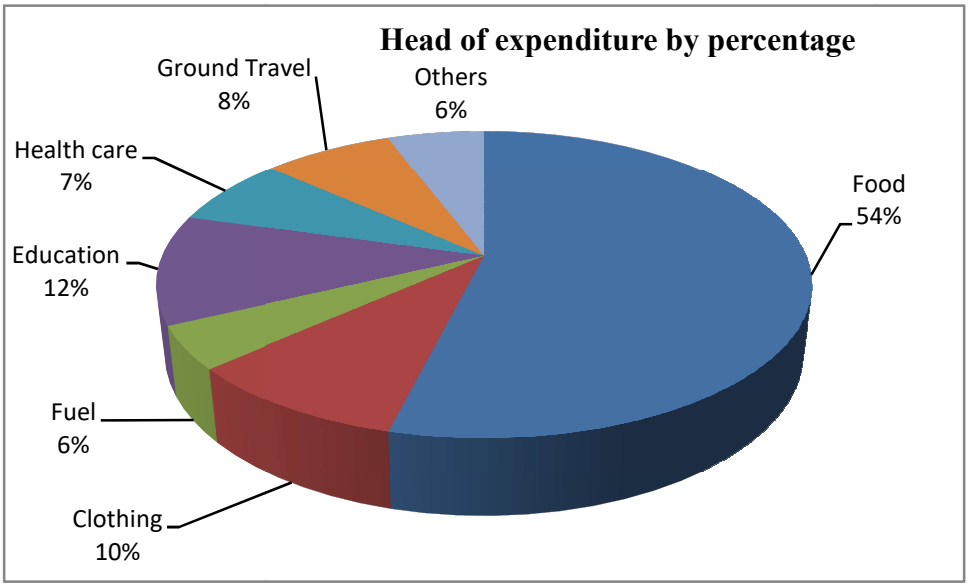
The average household's income per month was calculated as Taka 17540 (Chart…), which is above national average household income (all, Taka 11479 and rural, Taka 9648, BBS 2010) and also significantly higher from the baseline survey (Taka 14155). The amount of average monthly income depends on the number of earning members in a household, their nature of job, duration of employment in a year, commodity price, etc. (Table12).

Table 12: Household's monthly income

Name of the	Income range by HH	Max.	Min.

villages	<6000 Tk		6001-9000 Tk		9001-12000 Tk		12001-15000 Tk.		15001-18000 Tk.		8001-24000 Tk		24000+		(Tk.)	(Tk.)
		%		%		%		%		%		%		%		
Tamta		0.0		0.0		5.6		33.3		11.1		33.3		16.7	40000	9500
Lokhaitoli		0.0		7.9		14.3		22.2		15.9		25.4		14.3	50000	6500
Saliakandi		1.9		15.4		23.1		21.2		6.7		13.5		18.3	89001	6000
Shaibal		0.0		16.7		26.7		6.7		6.7		23.3		20.0	54000	7500
Khirai		0.0		13.2		22.6		17.0		9.4		17.0		20.8	40650	7000
Chargram		2.5		15.0		35.0		22.5		2.5		10.0		12.5	33000	5500
		2.3		11.6		23.3		25.6		9.3		16.3		11.6	55000	5000

Household members spent their money for various purposes; these are mainly for purchasing food, cloth, fuel, education of their children, health care, travelling, etc. The main expenditure was observed for purchasing food items (54%) followed by education of their children (12%), clothing (10%), traveling (8%), health care of family members (7%), co0king fuel (6%), etc. (Chart….). The expenditure on food item purchase indicates that the respondents have lack of opportunity to grow their own food.



The structure of housing indicates the status of poverty and hygiene condition of a household. The housing status of the respondents has improved with their increased income. During the current survey about 38% respondents have noticed that they have kuchha houses, while it was observed about 44.5% households had kuchha houses during baseline survey (Table14.14). Also the data reveals that about 7.1% of the respondents have constructed pucca houses, however, it was only 3.28% during the baseline survey.

About 86.6% respondents have mentioned that they have homesteads, meaning a space for housing including a small piece of land for home gardening, cow-shades or poultry rearing. About 23.9% have mentioned they have agriculture land (Table15) and only 9.4% have noticed that they do not have land either for house making or agriculture purpose.

Table 15: Ownership of lands

Name of the villages	Ownership of lands							
	Homestead		Ag. Lands		Others		No lands	
		%		%		%		%
Tamta		94.4		22.2		5.6		5.6
Lokhaitoli		100.0		7.9		3.2		0.0
Saliakandi		96.2		35.6		2.9		2.9
Shaibal		80.0		0.0		0.0		20.0
Khirai		34.0		1.9		28.3		39.6
Chargram		100.0		62.5		2.5		0.0
Total		86.6		23.9		8.8		9.4

The fishermen need boat, net, traps, etc. for fishing. Usually, the poor fishermen possess small boat, cheap net, fish traps for fishing. In case of large commercial fishing they need to hire it from rich people. The survey data shows that out of 145 fishermen about 86.9% have their own boat, 80% have nets and about 17.9% have fishing traps or hooks for long-line fishing.

Access to water sanitation

The Government of Bangladesh is working hard for total sanitation. However, the condition of latrines has slightly declined in the study area. The data shows that about 95.4% of the respondents have latrines, while it was 99.4% during baseline survey and the national average is 93% (BBS, 2011). About 100% of the respondents of Ashariar Char and Dudhghata have latrines (Table17). At Char Balaki about 87.3% have their latrines and rest of them still go for open defecation.

Table 17: Water and Sanitation Status of the Households

Name of the village	Have latrine		Types of latrine			
	Yes		Sanitary		Non-sanitary	
		%		%		%
Tamta		100.0		72.2		27.8
Lokhaitoli		87.3		67.3		32.7
Saliakandi		100.0		67.3		32.7
Shaibal		90.0		66.7		33.3
Khirai		98.1		65.4		34.6
Chargram		92.5		75.7		24.3
Total (Current survey)		95.4		69.0		31.0%

Most of the respondents of the study area have sanitary latrines either with water seal or without water seal and about 16.2% have non-sanitary latrines.

About 6.8% of the latrines are in brick buildings, about 74.6% are with ring slabs with tin fence and about 6% latrines are with ring slabs with bamboo fence (Table18).

Table18: Construction materials of latrines

Name of the village	Construction materials							
	Brick building		Ring slab with tin fence		Ring slab with bamboo fence		Others	
		%		%		%		%
Tamta		22.2		66.7		5.6		5.6
Lokhaitoli		1.6		61.9		14.3		22.2
Saliakandi		5.8		81.7		4.8		7.7
Shaibal		6.7		76.7		0.0		16.7
Khirai		9.4		84.9		3.8		1.9
Chargram		7.5		70.0		5.0		17.5
Total		6.8		74.6		6.0		12.5

Access to Drinking Water

The respondent of the study area mostly use hand tube-well for their drinking water. They collect drinking water either from their own tube-well or from neighbors hand tube-wells.

Table19: Status of access to drinking water

Name of the village	Access to Drinking Water							
	Own hand tube well		Neighbor's hand tube well		Tap water		Pond/River Water	
		%		%		%		%
Tamta		100.0		5.6		0.0		0.0
Lokhaitoli		49.2		49.2		0.0		1.6
Saliakandi		78.8		19.2		5.8		0.0
Shaibal		70.0		30.0		0.0		0.0
Khirai		58.5		43.4		0.0		0.0
Chargram		82.5		20.0		0.0		0.0
Total		69.8		30.2		1.7		0.3

The mighty river Meghna has great influence over the people dwelling adjacent to this river. They use this river water for various purposes, e.g. for bathing, cleaning utensils, bathing animals, irrigation, etc. According to the survey data about 56.1% of the respondent households use river water for household works and 27% use for irrigation purpose (Table20). According to the survey data those who possess lands adjacent to the power plant have an average of 37 decimal of agriculture land, the maximum amount of land is 120 decimal, while the minimum is two decimal (Table21)

Table 21: Average landholding adjacent to power plant

Name of the village	The amount of agriculture land holding (Decimal) close to power plant			
	No. of HHs have lands	Maximum (Dec.)	Minimum (Dec.)	Average (Dec.)
Tamta	1	37	37	37
Lokhaitoli	1	90	90	90
Saliakandi	4	82	10	41
Shaibal	4	30	2	14
Khirai	1	20	20	20
Chargram	6	75	9	33

Electricity and gas connection for cooking are the essential utilities for modernization of the society. The survey data reveals that about 95.4% of the respondent households have electricity connection at their homes. This helps them to use light, fan, mobile phone and other electrical instruments. This also helps the children to study more hours at night. During the baseline period there was no gas connection at household level. Meanwhile about 49.6% households have gas connection for cooking (Table22).

Table 22 : Access to utilities

Name of the village	Have electricity connection		Have gas connection		Type of cooking fuel used					
	Yes		Yes		LPG		Fire wood		Others	
		%		%		%		%		%
Tamta		94.4		55.6		16.7		27.8		55.6
Lokhaitoli		90.5		1.6		0.0		98.4		1.6
Saliakandi		93.3		48.1		0.0		51.0		49.0
Shaibal		100.0		96.7		0.0		3.3		96.7
Khirai		96.2		60.4		0.0		37.7		62.3
Chargram		100.0		62.5		0.0		37.5		62.5
Total (Current survey)		95.4		49.6		2.6		48.7		49.3

During the sickness of the household member, they use to visit various places to get health services; these are including public hospital, private clinic, private practitioners, village doctor, community clinic, etc. Sometime they use to visit multiple places to get better treatment. However, the survey data shows that regarding health services, village doctors are mostly visited (21.4%) (Table 23). They live close to the villagers and provide services at cheap price. About 11.4% visit the public hospital, although they have noticed that the services of the public hospital are not up to the mark.

Table 23: Access to Health Services

Access to Health Services	Current survey		Baseline	
	Frequency (f)	Percent (%)	Frequency (f)	Percent (%)
Public hospital	40	11.4	35	10.45
Private clinic	25	7.1	22	6.57
Private practitioner	10	2.8	5	1.49
Village doctor	75	21.4	73	21.79
Community Clinic	12	3.4	8	2.39
Public & Private hospital	35	10.0	34	10.15
Public hospital + Private Practitioner	13	3.7	10	2.99
Public hospital + Village doctor	73	20.8	71	21.19
Public hospital + community clinic	13	3.7	11	3.28
Private clinic+ Practitioner	7	2.0	6	1.79
Private clinic+ village doc	10	2.8	7	2.09
Private practitioner + village doc	10	2.8	7	2.09
Village doctor + community clinic	28	8.0	29	8.66

Affiliation with NGOs

NGOs play a greater role in rural poverty eradication through micro-credit operation, skill base training, rights claiming, disaster preparedness, combating domestic violence, etc. The survey data shows that about 52.7% of the respondent households are the member of local or national NGOs. The highest number of respondents of Ashariar char (61.1%) is attached with NGOs (Table 24).

Table 24: Attachment with any organization

Name of the village	Member of any social organization (NGOs)/ cooperatives	
		Percentage (%)
Tamta		61.1
Lokhaitoli		57.1
Saliakandi		54.8
Shaibal		36.7
Khirai		52.8
Chargram		52.5
Total		52.7

Table 25: Percentage of borrowers from NGOs by study villages

Name of the villages	Taken loan
	Percentage (%)
Tamta	84.6
Lokhaitoli	72.0
Saliakandi	82.1
Shaibal	37.9
Khirai	59.6
Chargram	52.5
Total	64.8

In an average the respondent households have borrowed taka 47530 in the last year (Chart

Impacts of the FPAs

Only 27.9% have mentioned that the FPAs has some negative impact on their livelihoods (Table 14.29).

Table14.29: Perception about the impacts of the FPAs

Name of the villages	Observed impact due to operation of the FPAs	
		Percentage (%)
Tamta		22.2
Lokhaitoli		28.6
Saliakandi		44.2
Shaibal		16.7
Khirai		7.5
Chargram		22.5
Total (Current survey)		27.9

After keeping all the assumptions that the operation of power plant might have negative impact on fish production in the natural water-body, surprisingly about 11.4% of the respondents rather noticed increasing trends of fish production (Table 26).

Table 26: Types of impact due to the operation of the power plant

Name of the villages	Types of impact													
	Increased fish production		Reduce of fish in kata unit		Reduced fish availability in the study area		Increased fish disease		Suffering skin disease		Less production of crops		Others	
		%		%		%		%		%		%		%
Tamta		11.1		5.6		5.6		0.0		0.0		0.0		16.7
Lokhaitoli		12.7		3.2		19.0		4.8		3.2		1.6		7.9
Saliakandi		24.0		4.8		23.1		16.3		1.0		5.8		8.7
Shaibal		3.3		0.0		0.0		0.0		6.7		13.3		0.0
Khirai		5.7		0.0		0.0		0.0		0.0		0.0		1.9
Chargram		0.0		2.5		0.0		0.0		0.0		10.0		10.0
Total		11.4		2.6		12.3		5.7		1.7		5.1		7.4

12. Research highlight/findings:

Fish production of the sampled FPAs was calculated from the partial and final harvest data. It was observed that average fish production was approximately twenty metric tons per hectare.

The amount of fish caught by ber jal, chandi jal and puchuni jal was very close and was higher over current net, cast net, drag net and fish traps in the controlled floodplains. It was measured that in an average the fish catch by ber jal was 6.9 Kg, 10.65 Kg and 12.5 Kg during the 1st quarter of moon, new moon and full moon in the main river. According to the survey data fish catch was found more in deep water (Main River) comparing to shallow waters. However, significant amount of fishes were caught in Katha in shallow water.

In the present study, 14 species under 4 groups were encountered**.** Among which 5 species belongs to both in Bacillariophyceae and Chlorophyceae followed by 3 species to Cyanophyceaeand and 1 species to Euglenophyceae. *Chlorella,* under Chlorophyceae group was found most governing genera (180ind./L) followed by *Ulothrix* (163 ind./L), *Melosira (*120ind./L) under Bacillariophyceae . The plankton compositions based on total amount count at six sites are mainly dominated by Chlorophyceae (50.25%). The order Cyanophyceae encountered to be lowest (5.91%) compared to the six orders.

In the present study, 7 species under three zooplankton groups were identified of which 3 species belong to Cladocera followed by 2 species of Rotifera and 2 species of copepods**.** *Keratella* under the group Rotifera (69ind./L) followed *Moina* under the Cladocera (51ind./L) were found dominant taxa, respectively. The maximum zooplankton encountered was at SW1 (405ind./L) followed by SW6 (330ind./L) and the lowest number of zooplankton estimated at SW4 (165ind./L).

In the present study, a total of 5 groups of benthos were recorded**.** The benthos that found in six different sampling sites of Meghna River were *Chironomus* larvae, *Lamellidens marginalis, Pilaglobosa, Unio* and *Sartorianas pinigera* (TeloKakra). The dominant group was*Pilaglobosa*, followed by *Chironomus* larvae and *Unio*.*Pilaglobosa* was present in all sampling sites followed by *Chironomus* larvae. Among the six sampling the sites the benthos (*Pilaglobosa*) was found to be dominating (40.91%) followed by *Chironomus* larvae (36.36%), *Lamellidens marginalis* (9.09%)*, ,Unio* (8.09%) and *Sartoriana spinigera* (TeloKakra, 4.55%).

In the present study, the BOD of the study areas found to be fluctuated from 1.0 (SW2, SW3 and SW6) to 2.0 (SW1, SW4, and SW5) with a mean value of 1.5±0.55. COD values found same in all the sampling stations and it was 4 ppm. In the present study the EC of the sampling sites fluctuated between 73 µS/cm (SW1, SW5 and SW6 to 110 µS/cm (SW4), with an average value of 79.67± 14.88µS/cm. The phosphate level of the sampling areas in the present study fluctuated between 1.19 (in SW4) *to* 1.85 mg/l (in SW6) with

an average value of 1.48±0.22 mg/l. Salinity in the study area varied from 0.03 ppt (in SW1, SW2 and SW6) to 0.05 ppt (in SW4) with a mean value of 0.033±0.008 mg/L. Sulphate ranged between <LOQ(SW1 and SW5) to 2 mg/l (SW2 and SW4) with a mean value 1.0±0.896 in this present study.

TDS of the investigated area oscillated from 35.0 (in SW1 and SW6) to 52.0 mg/L (in SW4) with a mean value of 40.0±7.24 mg/L. In the present study, the minimum amount of TSS was found both in SW1 and SW2 (5.0 mg/l) and maximum in SW4 (8.0 mg/l).

The surface water temperature of the scrutinized study area found to be varied from 28.5°C to 30.0°C with a mean value 29.25±0.52°C. The value of transparency in six discrete sites found to be varied from 23.5 cm (in SW2) to 66 cm (in SW4) with a mean value of 43.92±15.48 cm. The pH of the study areas found to be fluctuated from 6.5 (in SW2) to 7.25 (in SW4) with a mean value of 6.87±0.25.

Dissolved Oxygen ranges from 3.0 mg/l (in SW4) to 5.0 mg/L (in SW2, SW3, SW5 and SW6), with a mean value of 4.5±0.84mg/L. Carbon di oxide varied with the sampling sites of the present study. It oscillated from 6 (in SW5) to 12.0 mg/L (in SW2) with a mean value of 8.42±2.01 mg/L. The values of chloride found to be varied between 60 mg/l (in SW1, SW5 and SW6) to 90 mg/L (in SW2, SW3 and SW4) with a mean value of 75.0±16.43 mg/l in present study.

Among the respondents about 51.5% are male in contrast to 48.5% female. The literacy rate among the household heads was found only 46%. Out of 1695 household heads, 24% have primary level of education, 17% have secondary level of education, 5% higher secondary and only 1% of each have got graduation and post- graduation level of education. The overall literacy rate among the household members (>5years), was found 66.78%.

The main primary occupation of the household members are fishing (9.76%), fish trading (3.21%), agriculture farming (3.09%), wage laborer (2.97%), industrial labour (2.55%), salaried job (1.64%), rickshaw/van pulling (1.46%), running small shop (1.33%), working abroad (1.27%), business (1.03%), petty trader (0.85%), driving (0.79%), disabled (0.61%), teacher (0.3%), tailoring (0.24%), poultry/fisheries/livestock farming (0.18%), welding (0.06%), homeopath doctor (0.06%), house maker (25.65%), student (25.41%), children (10.43%) and others (1.21%).

The average household's income per month was calculated as Taka 17540, which is above national average household income (Taka 11479) and also significantly higher from the baseline survey (Taka 14155). The average household expenditure was found as taka 13514 per month. The main expenditure was observed for purchasing food items (54%) followed by education of their children (12%), clothing (10%), traveling (8%), health care of family members (7%), cooking fuel (6%), etc.

Only 27.9% have mentioned that the FPAs has some negative impact on their livelihoods. Interestingly about 11.4% of the respondents noticed increasing trends of fish production
It is recommended that like other important fishing regulation should be implemented to protect and conserve the existing important fin fish.

There should be a coordinating body among the FPA operators in the study area.

A regular and systematic survey on population composition, seasonal variation of Phyto and Zooplankton and benthos in the demarcated study area could be continued year round to observe the seasonal variations

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement	
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)
(a) Office equipment	Purchase completed through RFQ process	79,500	100%	100%
(b) Lab &field equipment	Purchase completed through RFQ process	4,01,100	100%	100%
(c) Procurement of Computer and accessories	Purchase completed through RFQ process	1,73,400	100%	100%

2. Training/study tour/ seminar/workshop/conference organized:

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(b) Workshop	-	-	25	1 day	-

C. Financial and physical progress

(*Fig in Tk)*

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)
A. Contractual staff salary	1,047,794	1,047,794	1,047,794	-	100%
B. Field research/lab expenses and supplies	2,657,300	2,657,300	2,657,300	-	100%
C. Operating expenses	389,241	389,241	389,241	-	100%
D. Vehicle hire and fuel, oil & maintenance	250,000	250,000	250,000	-	100%
E. Training/workshop/seminar etc.	75,000	75,000	75,000	-	100%
F. Publications and printing	-	-	-	-	-
G. Miscellaneous	163,175	163,175	163,175	-	100%
H. Capital expenses	356,700	356,700	356,700	-	100%
	4,939,210	**4,939,210**	**4,939,210**	-	100%

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

Generation of technology (Commodity & Non-commodity) and Policy Support:

- Fish production, income, employment, rice production and diversification of business have been increased while rice production cost has been reduced.
- Disparity, shifting occupation and social conflict (due to control over water) etc. have increased.
- Environmental degradation as well as loss of biodiversity have been happened due to use of pesticides and industrial affluent.
- Fish production, income, employment, rice production and diversification of business have been increased while rice production cost has been reduced.

Signature of the Principal Investigator
Date …….
Seal

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