Project ID 674

Competitive Research Grant

Sub-Project Completion Report

on

Production and Productivity Improvement of Haor Floodplain Fisheries for Upliftment of Fishers' Livelihood

Project Duration

May 2017 to September 2018

Prof. Dr. Nirmal Chandra Roy
Department of Fish Biology and Genetics
Faculty of Fisheries
Sylhet Agricultural University
Sylhet-3100

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

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

Edited and Published by

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Acknowledgement

The execution of CRG sub-project has successfully been completed by Sylhet Agricultural University, Sylhet using the research grant of USAID Trust Fund and GoB through Ministry of Agriculture. We would like to thank to the World Bank for arranging the grant fund and supervising the CRGs by BARC. It is worthwhile to mention the cooperation and quick responses of PIU-BARC, NATP 2, in respect of field implementation of the sub-project in multiple sites. Preparing the project completion report required to contact a number of persons for collection of information and processing of research data. Without the help of those persons, the preparation of this document could not be made possible. All of them, who made it possible, deserve thanks. Our thanks are due to the Director PIU-BARC, NATP 2 and his team who extended their whole hearted support to prepare this document. We hope this publication would be helpful to the agricultural scientists of the country for designing their future research projects in order to generate technology as well as increase production and productivity for sustainable food and nutrition security in Bangladesh. It would also assist the policy makers of the agricultural sub-sectors for setting their future research directions.

Published in Septemberr 2018

Printed by

Acronyms

%	Percentage	L	Liter
≤	Less-than or equal to	LoA	Letter of Agreement
<	Less-than	LTD	Limited
±	Plus-minus	m	Meter
µm	Micrometer	mm	Millimeter
am	Ante Meridiem	MS	Master of Science
ANOVA	Analysis of Variance	NATP	National Agricultural Technology Program
BARC	Bangladesh Agricultural Research Council	NGO	Non-government organization
BD	Bangladesh	NH_3	Ammonia
BCR	Benefit Cost Ratio	PCR	Project Completion Report
BHWDB	Bangladesh Haor and Wetland Development Board	pcs	Pieces
CBO	Community Based Organization	PD	Project Director
CBFM	Community Based Fisheries Management	PI	Principal Investigator
cm	Centimeter	PIU	Project Implementation Unit
Co-PI	Co-Principal Investigator	pH	Potential hydrogen
CRG	Competitive Research Grant	Phy	Physical
DoF	Department of Fisheries	pm	Post Meridiem
DO	Dissolve Oxygen	PVT	Private
et al	Et alia (and others)	RGR	Relative Growth Rate
FCR	Food Conversion Rate	SAU	Sylhet Agricultural University
FGD	Focus Group Discussion	SAURES	Sylhet Agricultural University Research System
Fin	Financial	SD	Standard Deviation
ft	Foot	SE	Standard Error
FRSS	Fisheries Resources Survey System	SGR	Specific Growth Rate
GDP	Gross Domestic Product	SIS	Small Indigenous Species
GoB	Government of Bangladesh	SoE	Statement of Expenditure
GI	Galvanized Iron	SPSS	Statistical Package for the Social Sciences
ha	Hectare	sq	Square
IUCN	International Union for Conservation of Nature	TDS	Total Dissolved Solid
kg	Kilogram	Tk	Taka
KI	Key Informant	USAID	United States Agency for International Development
km	Kilometer	yr	Year

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Executive Summary

Haor is unique, in terms of enriched ecosystems and biodiversity. The vast area of haor floodplain is treated as the natural breeding ground of wild fishes. Haor fisheries are under great stress and their sustainability is in danger due to natural and manmade causes. The present study was undertaken to increase fish production and biodiversity in haor floodplain through technological intervention and livelihood improvement of the poor fisher folk for a period of 17 months during May 2017 to September 2018. In this study, three (03) seasonal floodplains such as, i) Tedala Huglia Chatol beel floodplain in Dekar haor, Sumanganj; ii) Chatol beel floodplain in Gopalganj and iii) Melan haor floodplain in Sylhet were selected with the help of collective management by the respective community, local administration and Department of Fisheries (DoF) at Upazila & District levels. The project had some provisions to introduce different technological interventions such as cage culture, pen culture, sanctuary establishment, SIS (small indigenous species of fish) beel nursery and stocking of carp fingerling in the selected haor floodplain. Baseline information of fish species availability, fish production and livelihood status of the fishers in each site were gathered before intervention of the technologies. To establish a beel nursery for SIS by stocking broods of 10 fish species such as Koi, Shing, Magur, Tengra, Taki, Mola, Puti, Meni, Gutum and Pabda were released. Stocking of endemic and exotic carp species with suitable stocking densities were also released in the floodplain area. Sanctuaries were established in the deeper portion of each floodplain for shelter and natural breeding of fish. Cage culture technologies introduced in the selected floodplain for 3 months culture period with the monosex male Tilapia fingerlings/other promising fish species. Pen culture technology was established in the suitable area of selected floodplain. Fish growth sampling and water quality parameters were done properly using digital machines/Kits. Fish health condition and mortality were regularly monitored in all interventions. Cost-benefit analyses were settled in every technological package.

After successful implementation of the project, fish yield and biodiversity increased in selected haor floodplain area. During technological intervention in selected haor floodplain, the number of non-stock fish species increased from 17 to 25% over the initial base level population. The highest fish yield of floodplain was recorded 497 kg/ha/yr compared to the baseline production, 200 kg/ha/yr. In cage culture, the average final length and weight of Tilapia fingerlings during harvesting were recorded 20.70±0.46 cm, 204.28±7.96g in Sunamganj site and 20.90cm, 209.00±9.18g in Golapganj site respectively. Tilapia production was recorded 160.31 and 164.50 kg/cage in Sunamganj and Golapganj site respectively during 3 months culture period. On the other hand, the highest mean final weight was recorded 781.50±4.95g with the highest production of 532.31 kg/cage for Pangus cage culture with dietary probiotic supplementation. However, the mean fish production in the haor floodplains increased against the baseline production in a year with subsequent increase in employment of fishers, medical facilities, annual expenditure and household income. Observation of socioeconomic indicators showed certain level of socio-economic upliftment of fisher's livelihood. As because the fisher's family were directly involved and they were benefited with the financial help, logistic support, and motivational and awareness supports from the project. The restriction of fishing for certain period, sanctuary arrangement focusing undisturbed habitat and guarding of the floodplains contributed to higher productivity and enhancement of fish biodiversity in the seasonal floodplains. Finally, the overall findings showed that the technological intervention under community management significantly increased annual fish yield and biodiversity of indigenous species in haor floodplain and uphold the livelihood of fishers.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. **Title of the CRG sub-project:**Production and Productivity Improvement of HaorFloodplain Fisheries for Upliftment of Fishers' Livelihood

2. **Implementing organization:**Sylhet Agricultural University, Sylhet-3100, Bangladesh

3. **i) Name and full address with phone, cell and E-mail of PI:**

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4. **Sub-project budget (Tk):**
   4.1 Total: Tk. 45,00,000.00
   4.2 Revised (if any): Tk. 45,00,000.00

5. **Duration of the sub-project:**
   5.1 Start date (based on LoA signed): 07 May 2017
   5.2 End date : 30 September 2018

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

Bangladesh has achieved remarkable progress in the fisheries sector since its independence in 1971. Now, this sector contributes 3.61% to the national GDP and almost one-fourth (24.41%) to the agricultural GDP. In recent years, this sector performs the highest GDP growth rate in comparison to other agricultural sectors (crops, livestock, and forestry) (DoF, 2018).

Bangladesh is a riverine floodplain country with three major river systems (the Ganges, Brahmaputra and Meghna) that originate from the Himalayan chain, cross the country and then join before emptying into the Bay of Bengal. Apart from rivers, there are numerous natural wetlands in the form of haors, baors, canals, beels, mangrove swamps and lands which flood seasonally for 5–6 months of the year. The floodplains are

very rich in natural productivity and support a diverse flora and fauna, among which fish is considered the most important natural resource, as it supports the livelihoods of millions of inhabitants, including many of the rural poor.

Open water fisheries including haor region floodplain fisheries that contributing bulk of fish production is very important. Open water is inundated during flood stages and isolated from main channel during the dry season. Regular flooding ensures the reproductive success of the fish species. This additional runoff with higher nutrient levels increase the floodplain area and productivity, which extend the feeding ground of fish. If the open water stocking program is introduced in the monsoon with necessary conservation measures, it can bring a revolution in the fish production.

Haor is important open water fisheries resources which are large saucer-shaped floodplain depressions located mostly in north-eastern region of the country covering about 25% of the entire region (BHWDB, 2011).It is unique, in terms of rich ecosystems and biodiversity. There are altogether 373 haors comprising an area of about 8,000 km^2 dispersed in Sylhet division including Netrokona, Kishorganj & Brahmonbaria districts. It is noted that 181 haors situated in greater Sylhet with covers an area 1,61,543 ha and average fish production is 348 kg/ha (DoF, 2015). On the other hand, 663 floodplains consisting an area of about 1,74,824 ha with an average fish production 296 kg/ha in greater Sylhet. These floodplains are close connected with haors & beels, which were enriched with various aquatic biodiversity's along with 140 species of fish (IUCN, 2000). Due to indiscriminate use and environmental degradation the fish diversity and production of the haor floodplain fisheries are degrading rapidly. So this is the time for realizing the actual situation and adaptation measures to prevent the negative effects.

Haor is known as mother fishery and vast area of haor floodplain is treated as the natural breeding ground of wild fishes. About 83% area of inland fisheries resources is inland openwater but fish production of inland closed water is significantly higher than inland open water (DoF, 2015). This is happened mainly because of massive extension works on modern aquaculture technologies since it's a profitable business. But inland open water including haor floodplain fisheries extremely neglected and Government support with existing policies did not favour its management and biodiversity conservation as per requirement of open water. It is relevant here to mention that there has been no remarkable achievement from haor floodplain fisheries currently. It is also to be particularly mentioned here that the growth in aquaculture in Sylhet region is lesser in comparison to other parts of the country because of prolonged winter season. National aquaculture contribution for the country as a whole, is about 56%, whereas, in Sylhet, contribution from aquaculture is only 27.56% and from natural waterbodies 72.48% (DoF, 2018). The above-mentioned reasons, are some of the important milieu, pinpoints the demand for underTaking an area focused & need-based project for the greater Sylhet for boosting open water fish production with maintaining biodiversity, conserving ecosystem and for generation of additional employment and income for the poor fishers community.

Some sporadic works have been done by Government development projects and donor organizations for haor fisheries development. Unfortunately, the attractive findings or appropriate technological intervention not yet established. But it is possible to increase haor floodplain fish production significantly in compare to closed water if modern management and conservation tools are properly applied. Different species of carp,

cat fish, barb and minnows, clupeid, snakehead, perch, spiny eel, featherback, loach, prawn, and other fishes are very popular native fishes whose breeding ground is haor floodplain; although the haor floodplain is now in danger due to several manmade, environmental and anthropological causes. Therefore, Government and other relevant stakeholders should take necessary initiatives immediately to protect natural breeding grounds of haor floodplain fisheries to save mother-fishery, develop livelihood of resource users, for fish biodiversity conservation and for increasing fish production those are major keys to achieve target **'Vision 2021'** in fisheries sector.

The Government of Bangladesh always gives importance to the involvement of mass-people in the development, production and conservation measures. This study attempts to find out the suitable intervention for fish production and productivity in the haor floodplain area. This study will help to better understanding of the local beneficiaries of haor floodplain area to identify the real situation on fish production and biodiversity through modification of technological intervention while offering clues into sustainable fish yield for haor fisheries development.

Haor fisheries are under great stress and their sustainability is in danger due to natural and manmade causes.Scientists reported that the fish production and diversities are gradually decreasing in the haor areas (Trina*et al*., 2016); Mahalder and Mustafa, 2013)[6,7]. Despite the economic importance of the haors, people are poorer than in any other part of the country and more than 28% of the total population here lives below the Lower Poverty Line (BHWDB, 2012). Mass of the people largely depends on the haorfisheries resources for their livelihood. So, it is now essential to increase fish production and protection of fish diversity & ecosystem through community based fisheries management approach in the haorfloodplain for livelihood of the people. Considering the above situation the research work had been undertaken.

7. **Sub-project goal:**Increase fish production in haorfloodplain and livelihood improvement of fishers' in Sylhet region

8. **Sub-project objective (s):**
   1) To improve the fish yield in haor floodplain through community based management;
   2) To assess the biodiversity of non-stocked fish species;
   3) To uplift the livelihood of community people in haor area

9. **Implementing location (s):**
   The research work was carried out by the Department of Fish Biology & Genetics, Sylhet Agricultural University, Sylhet. The location of field study areas were 3 (three) seasonal haor floodplains under two districts of Sylhet and Sunamganj.

10. **Methodology:**

(a) Approach

The research work was carried out under the Department of Fish Biology and Genetics, Sylhet Agricultural University, Sylhet. The field location of study areas were situated in two districts of Sylhet and Sunamganj. The different activities were conducted carefully for smooth functioning of the project.

One MS student was involved fully for his research of MS degree. One 'Scientific Assistant' was appointed full time for the monitoring of project activities. PI was coordinated and implemented the research projectsuccessfully. The field level research works were carried out through community based participation with the help of local administration and local Fishery Office of the Department of Fisheries (DoF). The laboratory analyses were performed in the Departmental Laboratory of Fisheries Faculty.

Figure 1: Map Showing the Experimental Site

(b) Activities done

i) Selection of floodplains

- Three (03) seasonal floodplains such as, i) Tedala Huglia beel floodplain in Sumanganj; ii) Chatol beel floodplain in Golapganj, and iii) Melan haor floodplain in Sylhet were selected from haor based two districts Sylhet and Sunamganj. The floodplains including beels under the study area was considered at the range from 10 to 22 ha.

- The Tedala Huglia beel floodplain was located 60 kilometer west away from Sylhet divisional town but it is closed to Sunamganj district town. The total area of the beel 21.85 ha and it has 6 deeper parts which containing 2.02 ha. The maximum and minimum water level of the beel was 5m and 0.75m, respectively. The total area of beel is government land. Rice production during dry months and fish production in monsoon.

- The Chatol beel floodplainnamely "Betu khal" covering an area 20.43 ha and situated at Amura Union, Golapganj. It has 'L' shaped structure and an arm is joined near Hakaluki haor which is a part of the Kushiara River. Hakaluki haor is situated in the eastern part of Bangladesh adjacent to the Assam-Bangladesh border under 5 Upzilas comprises this haor's total area. However, the research part of the floodplain is completely situated at Amura unin under Golapganj Upazila.

- The Melan haor floodplain was located 16 kilometer distance from Sylhet divisional town under Sylhet sadar Upazila. The total area of the haor floodplain is 30 ha and it has 4 deeper portions which containing 1.50 ha. The maximum and minimum water level of the beel was 5.5 m and 0.85m, respectively. The total area of beel is government land. Rice production was observed in some upper part of the floodplain during dry season and natural fish production in monsoon.

- The floodplains were selected under arrangement of collective management by the respective community (floodplain beneficiaries) with support from the local Administration and Department of Fisheries (DoF) at Upazila & District levels.

ii) Literature review and preparatory works

The following preliminary activities were carried out with the help of community people:

- ***Survey of the floodplains*** - identified the inlet and outlets, measure the volume, location areas with seasonal water availability, deeper part of the floodplain, historical background etc.
- ***Existing management of the floodplains*** - observedleasing arrangement, investment, stocking and production, and harvesting management.
- ***Experience sharing***- collected information'sfrom the local institutions and DoF about the floodplains.
- ***Pertinent literatures andpreparatory works*** - all preparatory works, pertinent literatures and related information's of the implementing project were collected in the month of May to June 2017.

iii) Structural form of CBOs and training on project activities

- A discussion meeting was held in each site before starting the project activities for organizing a structural form of CBOs. The CBO committee played vital role for implementing of project activities.After formation of CBOs committee, an agreement was signed with CBOs leader considering some term and conditions for the betterment of project and CBO's benefit.
- The training program was conducted with the community peoples in each site before starting the field research activities.

Plate 1: Group meeting for CBOs committee formation

iv) Baseline survey of floodplain & livelihood status

- Baseline data collection of fish species, production, and livelihood status of the fishers in each site was done properly. The information regarding qualitative and quantitative aspects of fish catch and abundance of non-stocked fish species in each site were collected from the people of concerned local community. Focus Group Discussion (FGD) and Key Informant (KI) interviews methods followed by structured questionnaire survey. Baseline survey & information's of floodplain were collected through a prescribed format.
- Measuring of livelihood status, the socio-demographic condition, income of fishers, family members, factors affecting the livelihood of the respondents and other relevant aspects of fishers' information's were collected.

v) Inception workshop and discussion with all stakeholders

- The project was arranged several discussion meetings with DoF officials, local administration and other stakeholders for smooth functioning of activities.
- The training programs were conducted with the community peoples in each site before starting the research activities

vi) Technological intervention (Experimentation)

Experiments 1, 2 and 4were carried out to meet up 1stobjective and 3rd experiment was conducted to fulfill the 2nd objective and 5th experiment was conducted to address 3rd objective. However, the following research experiments wereconducted during the project period as per research design.

Expt. 1: Introduction of Cage Culture Technology in Haor Floodplain for Upliftment of Fishers' Livelihood

Research Design

Selected area	Sunamganj and Golapganj
Selected haor/Waterbody	Tedala Huglia beelfloodplainand Chatol beelfloodplain
Number of cage	20 cagein each site
Cage size	32.4 m^3 (6 m x 3 m x 1.8 m)
Actual water area in cage	27 m^3 (6 m x 3 m x 1.5 m)
Fish species selected	Monosex male Tilapia (*Oreochromis niloticus*); Fingerlings size 9-10 cm
Stocking rate	30 fingerlings/m^3
Feed type	Readymade floating feed (Mega feed)
Feeding rate	8-5% body weight of fish
Rearing duration	90 days
Regular monitoring	• Water quality parameter • Fish growth sampling • Fish health condition • Mortality

Methodology

Cage culture technology was introduced in the i) Tedala Huglia beel floodplain under Dekar haor in Sumanganj and ii) Chatol beel floodplain in Golapganjfor 90 days culture period. A total of 20 cages were installed in each site. MonosexmaleTilapia (*Oreochromis niloticus*) fingerlings were stocked in the cages at the rate of 30 fingerlings per cubic meter water area of the cage.Readymade floating feed (Mega feed) were supplied three times daily at the rate of 8-5% body weight of fish. Fish sampling was done weekly for feed adjustment. Water quality parameter such as DO, Temperature, Transparency, pH, NH_3 was recorded fortnightly by digital analyzer/kit. Fish health condition and mortality was observed regularly. After 90 days rearing period, the fishes were harvested totally. The production data including final length and weight gain was recorded properly.

Construction and setting of cages

Twenty newly constructed floating cages 32.4 m^3 (6 m x 3 m x 1.8 m) were setting in each site of the haor floodplain (Plate 2). The actual water volume of each cage was 27 m^3 (6 m x 3 m x 1.5 m). Frames of cages were made by GI pipes and aluminum drums (500 L) were used to float the cages in water. Net cages were made bylong lasting nylon (plastic) net (mesh 2.0 cm). Cages were hanged with cage frame. Bamboo made platform was set up over the cages and all cages were fixed with poles of the platform. Cages were installed

at both sides of the platform for easily feed supply and intensive supervision. Open upper part of each cage was covered with another piece of nylon net (mesh 7 cm) to avoid escaping of fish and predation by bird.

Plate 2: Construction of cage frame by GI pipe, bamboo and other materials (left) and PI observed the cage unit in the haor floodplain after setting cage frame (right)

Collection and stocking of fingerlings

Monosex male Tilapia (*Oreochromis niloticus*) fingerlings were purchased from a private hatchery and were transported in canvas tank with oxygen cylinder to experimental field area (Plate 3). Before stocking, fingerlings were acclimatized to the cage water for one hour period. Initial weight and length of 30 fish fingerlings were recorded before stocking in the cage as sample basis.

Plate 3: Transportation of Tilapia fingerlings in canvas tank (left); and acclimatized to the cage water (right)

Feeding strategy

The stocked fingerlings of Tilapia were fed with commercial Mega floating feed at a decreasing rate of 8-5% of body weight thrice daily until the previous day of harvesting. Total feed for a day was divided into three equal parts and was applied in the morning between 8.00—9.00 am, in noon 12.00—1.00 pm and in evening

05.0—06.00 pm (Plate 4). Feeding rates were adjusted every 15 days intervals depending on the body weight of stocked Tilapia. Net of the cages were cleaned and checked every 15 days intervals.

Plate 4: Feed supply for stocked Tilapia fish in cage culture

Water quality monitoring

Water quality parameters such as surface temperature, transparency, dissolved oxygen (DO) concentration, pH, total alkalinity and ammonia were measured fortnightly between 9.00 and 10.00 am at the time of fish sampling. Surface water temperature was determined *in situ* using a standard centigrade thermometer. Transparency was recorded using digital Transparency meter. Dissolved oxygen was determined using a portable DO meter (YSI digital DO meter, Model 58, HANNA Company, America). P^H of cage water was recorded using pH meter (HANNA Company, America). Ammonia nitrogen was measured using ammonia test kit (Biosol, A.A. Biotech PVT LTD., Fishtech BD LTD).

Sampling of Tilapia

Fortnightly fish sampling was done to determine the growth of Tilapia fingerlings and to adjust the feed rations. Fish growth was measured in respect of weight (g) with digital balance (CAMRY digital electrical balance Model EK 3052, Bangladesh) and length by measuring scale. Sampling was continued until harvesting.

Estimation of growth, survival and yield of Tilapia

After final harvesting, all Tilapia of cages were counted and weighed individually to determine survival rate, growth and yield. Specific growth rates (SGR), food conversion ratio (FCR), and survival rate (%) were calculated following the equations.

The equations are as follows:

- Weight gain (g) =Mean final weight (g) -Mean initial weight (g)
- Survival rate (%) = (Number of fish harvested ÷ Number of fish stocked) × 100

- SGR (%/day) = {Ln (final body weight)—Ln (initial body weight)}/cultured period (day)x 100
- Feed Conversion Ratio (FCR) = Feed consumed (g dry weight)/Live weight gain (g wet weight) of fish
- Yield of fish= No. of fish caught × average final weight of fish

Economic analysis

Economic analysis of cage culture technology was calculated on the basis of purchasing prices of Tilapia fingerlings, feed, fertilizer, medicine, transport cost and the revenue from the sale of Tilapia. At the end of the study, all fishes were sold at local market. Tilapia was sold at the average rate of Tk. 120/kg. The analysis was based on market prices in Bangladesh for fish and all other items expressed in Bangladeshi taka (Tk). The net profit and Benefit-costratio (BCR) were calculated using the following formula:

Net profit = Total return – total cost
BCR=Total return/total cost

Result & Discussion

Growth and production performance of Tilapia

The growth, survival and production of monosex male Tilapia (*O. niloticus*) under cage culture in two sites are shown in Table 1.

Table 1. Growth, survival and production of Tilapia fish under Cage culture package in haorfloodplain

Site	At fish stocking		At fish harvesting		Survival (%)	SGR (%)	FCR	Production (kg/cage)	production (kg/cage m3)
	Mean length (cm)± SE	Mean weight (g)± SE	Mean length (cm) ± SE	Mean weight (g) ± SE					
Sunamganj site	9.65±0.24	29.04±0.38	20.70±0.46	204.28±7.96	96.90	2.15	1.39	160.31*	5.92
Golapganj site	9.80±0.43	30.02±0.68	20.90±0.52	209.00±9.18	97.52	2.15	1.33	164.50*	6.10

*No significant difference of fish production between two sites;

In Sunamganj site, the average initial body weight of Tilapia fingerling during stocking was 29.04±0.38 g where 30.02±0.68 g in Golapganj site. Growth of Tilapia fingerling in cage culture increased throughout the culture period. The average final weight of Tilapia during harvesting was recorded in 204.28±7.96 g and 209.00±9.18 g in Sunamganj and Golapganj site, respectively.Dev (2015) was reported that the final weight of Tilapia was 167.15—189.67 g for 99 days rearing in the nylon net cages applying floating feed without probiotics at the pond of Sylhet Agricultural University, which was lower than the present findings and Alam *et al*. (2014) estimated mean final body weight as 50.0—93.5 g using commercial Mega feed twice daily at a density of 100-200 nos/m^2 in cage at old Brahmaputra river, Mymensingh, which were much lower than the present findings.

After 90 days of cage culture, Food Conversion Ratio (FCR), Specific Growth Rate (SGR),survival and gross production of Tilapia in the present study was recorded 1.39, 2.15, 96.90% and 160.31 kg/cage, respectively in Sunamganj site where these were 1.33, 2.15, 97.52% and 164.50 kg/cage, respectively in Golapganj site. The secured FCR was more or less similar with the findings of Dev (2015) and Ahmed *et al*. (2014) who recorded FCR of Tilapia in cage culture as 1.18—1.25 and 1.11—1.41, respectively.The overall survival of Tilapia was slightly higher than the reported values in cage culture: 75.55—90.37% and SGR 2.97% use commercially available feed in Bangladesh, which was slightly lower than the present cage culture system (Ahmed *et al*., 2013).Alam *et al*. (2014) reported that the production of Tilapia was 7.7-9.4 kg/m^3cage by rearing 135 days at river, which was more or less similar with the present findings. Production of fish depends on several factors such as depending on the cage/pond size, initial size and weight of the fingerlings, quality of fish seed, stocking density, quality of feed, water environment and management practices etc.

Water quality parameters

The water quality parameters during the culture period are presented in the Table 2. Thewater quality parameters (temperature, dissolved oxygen, pH, total dissolved solids, transparency and level of ammonia) were more or less similar in two sites. All the water quality parameters of the experimental cages were found to be within the acceptable ranges for aquaculture. Water temperature is one of the most important factors for aquatic organisms. It influences other physical, chemical and biological conditions of a water body. Growth, reproduction and other biological activities of fish are controlled by temperature.However, the parameters were observed within suitable ranges of fish culture and were not significantly difference between two sites.

Table 2. Mean value of water quality parameters of Cage culture package in haorfloodplain duringstudy period

Site	Water quality parameters					
	Temperature (°C) ±SD	**Dissolved Oxygen (ppm) ±SD**	**pH**	**Total Dissolved Solid (TDS) ±SD**	**Transparency (cm) ± SD**	**Ammonia Level (mg/l) ±SD**
Sunamganj site	24.33±0.89	7.10±0.18	7.00±0.27	32.50±7.58	49.83±5.77	0.002±0.001
Golapganj site	24.17±.1.33	7.08±0.25	7.13±0.20	31.67±7.53	50.17±5.64	0.004±0.004

Economic analysis

The economic analysis of cage culture packagesare presented in Table 1.3. After 90 days of culture period, the net profit of Tilapia (*Oreochromis niloticus*) production in cage culture was recorded 5576.00±625.80 Tk/cage and Tk. 5071.94±774.18 Tk/cage in Golapganj and Sunamganj site, respectively where the benefit-cost ratio was observed 1:1.40 and 1:1.36, respectively. BCR observation indicated that the cage culture of Tilapia was not found economically feasibile due to high price of feed and fingerlings. On the other hand the fish selling price is comparatively lower. So, it needs to minimize the production cost to popularize this cage culture technology. It is noted that the economic feasibility is correlated with sustainable aquaculture. The

importance of economic analysis, as it provides a basis not only for the decision making of the individual farmers but also for the formulation of aquaculture policies.

Table 3. Economic analysis of Tilapia (*Oreochromis niloticus*) production in cage culture

Economic parameters	**Golapganj Site (Chatol beel floodplain) Value± SD (Per cage)**	**Sunamganj Site (Tedala Huglia beel floodplain) Value± SD (Per cage)**
Price of each fingerling (Tk)	4.00	4.00
Fingerlings cost (Tk) per cage	3240.00	3240.00
Price rate of feed cost (Tk/kg) per cage	45.00	45.00
Feed used (kg) in each cage	235.44±4.24	242.78±4.78
Total feed cost (Tk) in each cage	10595.00±211.20	10925.10±215.02
Production cost of each cage (Tk.)	**13835.00±210.00**	**14165.26±215.02**
Average production per cage (kg)	164.50±5.15	160.31±5.56
Average fish selling price (Tk/kg) per cage	118.00±5.10	120.00±5.20
Total income for fish crop (Tk) per cage	**19411.00±557.25**	**19236.20±667.78**
Net Profit (Tk) per cage	**5576.00±625.80**	**5071.94±774.18**
Benefit-Cost Ratio (BCR)	1:1.40	1:1.36

N.B. If we consider 20 cages, so the net benefitwas (5576.00 x20) 1,11,520.00 Tk. and (5071.94x20) 1,01,438.80 Tk. in Golapganj and Sunamganj site, respectively.

Table 3 showsthat the economic profitability was varied in some extents between two sites but there was no significant difference. The price of per kilogram feed was 45 TK. and total feed applied 252.35 kg hence the total feed cost was 11355.75 Tk/cage in Golapganj site where the total feed applied 242.78 kg hence the total feed cost was recorded 10925.26 Tk/cage in Sunamganj site. The total production cost of the cage culture represented the cost of fingerlings, feed cost and other management cost was 13835.00 Tk/cage and 14165.26 Tk/cage in Golapganj and Sunamganj site, respectively. The cost-benefit ratio was calculated 1:1.40 in Golapganj and 1:1.36 in Sunamganj site. The cost-benefit ratio was comparatively lower due to higher production cost including feed and fingerling cost. To optimize the fingerling cost nursing of Tilapia fry is very important in each site within cage culture areas.

Conclusion and recommendation

It may be mentioned that there was no remarkable change of total production shown in different floodplain areas within the same management regime. The total production of cage culture in haor floodplain is more or less similar considering other aquatic environments. From this experiment it is also clear that, cage culture of haor floodplain is encouraging of rural fishermen, because they can be involved themselves as an alternative livelihood during monsoon. But the limitations are transportation mortality was occurred high and product selling price was very low. In this consideration we have suggested the fishermen to introduce a nursery plan of Tilapia fry in separate 2-3 cages (using Rasel net) parallels within the cage culture area.

Expt.2: Observation of Fish Production and Aquatic Inhabitants through Pen Culture in Chatol Beel Floodplain

Floodplains in Bangladesh are low-lying lands, compared to the adjacent area of land, which situated near river or any other running water sources and remain as flooded by water for several months of a year. However, the floodplain is one of the major sources of fish production in Bangladesh and plays indispensable role by providing food, income and employment for huge number of people. Therefore, in 2015-16, the total area of floodplains in Bangladesh was 2,838,960 ha which included 2,704,084 ha area of capture fisheries and 134,876 ha area of culture fisheries. The total captured fish from the floodplains was 747,872 tones and the amount of cultured fish was 207,658 tones. But, the floodplain productivity from capture fisheries was 277 kg/ha, while the culture fisheries was 1,539 kg/ha (DoF, 2017). So, there are immense possibilities of culturing fish in floodplain to increase fish production and productivity. Pen is an enclosure with bottom and sides of netting or bamboo etc., whether floating at the surface or totally submerged. The pen culture system has lots of advantages including- intensive utilization of space, safety from predators, suitability for culturing many varied species, ease of harvest, the flexibility of size and economy, availability of natural food and exchange of materials with the bottom (FAO, 1987). In 2015-16, total seasonal floodplain area was 1.35 lakh ha, only 7,553 ha area of Bangladesh was utilized by pen culture system and the total production was 13,364 tones, which was 294 tones higher than the previous year (DoF, 2017). As, the fish production and productivity from pen is increasing day by day, therefore pen culture system can be an effective way to use the unused seasonal floodplains e.g. Chatol beel floodplain and make the fish production higher in relation with the demand. In fact, the pen culture technology was completely unknown to the fishers' community related to Chatol beel floodplain. By considering the present situation the objectives of this study were- to assess the growth and production of different commercially valuable stocked fish and production of non-stocked fish in Chatol beel floodplain by pen culture system, to identify the availability of other aquatic flora and fauna of the selected floodplain and to introduce the local community with the pen culture system and financial benefits compared to the natural dependency.

Methodology

Pen site and pen preparation

One unit of pen enclosure was established in the suitable place of Chatol beel floodplain, Golapganj. The name of selected seasonal floodplain was "*Kiamor ghat*" covering an area of 2.43 ha. The water availability in this floodplain is about 5-6 months generally from July to December. During dry season, this floodplain turned into dry lands and local people used this chunk of land to cultivate paddies and vegetables. However, in wet season of past years, the local people

Plate 5: Stocking carp fingerlings in Pen enclosure

occupied in this area had left this site fallow and generally depended on the local fish production. The average depth of water during July to December ranges from 1.3-2.5 m. The selected floodplain for pen site was connected to the Chatol beel through a channel of 30 m^2 (10 m × 3 m). The enclosure- bamboo-split fence (locally called *bana*) was made with easily available materials such as- bamboo split, bamboo poles and posts, nylon rope, GI wire, jute rope etc. The diameter of bamboo-split fence was 60 m^2 (15 m × 4 m) and installed at the mouth of the channel. The distance between two thin bamboo splits was maintained (≤ 1 cm) to permit the entry of larvae and hatchling of other small indigenous species but prevented the stocked fish from being escaped. Fertilization was necessary to increase the phytoplankton production of the pen. That's why organic fertilizer cowdung 5000 kg/ha and lime 250 kg/ha were being applied to the pen 10 days before stocking of fish.

Fish stocking

Mixed seven fish species- Rohu (*Labeo rohita*), Catla (*Catla catla*), Mrigal (*Cirrhinus cirrhosus*), Grass carp (*Ctenopharyngodon idella*), Sarpunti (*Puntius gonionotus*), Bighead carp (*Hypophthalmichthys nobilis*) and Gonia (*Labeo gonius*) were stocked in the pen enclosure at the ratio of 30:20:25:5:10:5:5 with the stocking density of 6,250 fingerings/ha (Plate5). The initial length of fish ranged from 12 to 17 cm and initial average weight was between 15-75 g.

Management of the pen

A mixture of rice bran (50%), wheat bran (30%) and oil cake (20%) was applied as supplementary feed in the pen at the rate of 3% fish body weight daily. In fact, equal amount of feed in the form of wet balls was distributed at the four corner of the pen two times in a day. Fish sampling was done fortnightly for feed adjustment. The whole pen including bamboo screen and net was checked regularly. The water quality parameters were measured twice in a month to understand the aquatic condition. Water quality parameters- water temperature, transparency, dissolved oxygen (DO), pH, total dissolved solid (TDS) and level of ammonia were measured by using thermometer (Hg), Secchi disc, Dissolve Oxygen meter (DO-5509), pH meter (EZDO-6011), TDS meter (EZDO-6031) and Aquasol (AE 307), respectively. In addition, depth of the water body was measured and color of the water was observed carefully. For studying growth and feed management, 10 fishes of each species were sampled randomly twice in a month. The weight was measured by digital balance and length was measured by measuring scale.

The following formulae were used to evaluate the growth of stocked fishes:

i) Length gained = Mean final length-Mean initial length

ii) Weight gained = Mean final weight-Mean initial weight

iii) % of length gained = $\frac{\text{Length gained}}{\text{Initial length}} \times 100$

iv) % of weight gained = $\frac{\text{Weight gained}}{\text{Initial weight}} \times 100$

v) Specific growth rate (SGR) = $\{(\ln W_2 - \ln W_1)/(T_2 - T_1)\} \times 100$

Where, W_1 = Initial body weight at time T_1

W_2 = Final body weight at time T_2

Observation of aquatic inhabitants

Observation of availability of aquatic inhabitants which include- phytoplankton, zooplankton, benthic fauna and aquatic weeds in different months was necessary as stocked and non-stocked fish feed on them, may use as shelter and others. For observing the availability of plankton, the samples were collected from the surface water through fine-meshed plankton nets once in a month. Less than 25 µm mesh sized net was used for phytoplankton and less than 40 µm mesh sized net was used to collect zooplankton samples. The samples were immediately preserved with 10% buffered formalin in glass bottles and brought to post-graduate laboratory of Fish Biology and Genetics department for lab assessment. Samples were taken on glass slide by a micropipette and then covered it by cover slide. Then the prepared slide was placed under a luminous microscope (XSZ21-05DN) for identification of phytoplankton and zooplankton. The phytoplankton and zooplankton were identified to at least genus level (Thompson, 2012). For observing availability of benthic fauna, clay samples containing benthic fauna were collected once in each month. Clay samples were immediately preserved in plastic container with 10% buffered formalin and brought back to laboratory for lab assessment. In the lab, clay was sieved using 0.2 mm mesh sized sieve to separate micro benthos and macro benthos. Then, the macro benthos was cleaned with distilled water and the micro benthos sample was taken in glass slide by a dropper. Afterwards, the glass slide was covered with cover slide and was placed under the luminous microscope. The benthic faunas were identified to at least genus level (except larval stage) (Robertson *et al.*, 2012). Identification of weed species at the pen was done by unaided eye observation. The weed samples were collected and brought to laboratory for further identification and the weed was identified up to species level.

Qualitative and Quantitative estimation of fish production

The fishes were finally harvested from the pen on 12 November 2017. The total production of stocked fish with their total number caught, final length and final weight, and the number and species of non-stocked fish were recorded. In the catches of non-stocked fish, the amount of small (< 25 cm) indigenous fish (SIS) was observed carefully in every catches by counting the total number of individual species in 100 fishes randomly. The non-stocked fishes were identified up to species level by the help of Encyclopedia of Flora and Fauna of Bangladesh, FAO identification sheet and other online references.

The production of fish was evaluated by following formulae:

i) Survival rate (%) = $\frac{\text{No.of fish caught}}{\text{No.of fish released}} \times 100$

ii) Total gross production of fish (kg) = gross production of stocked fish (kg) + gross production of non-stocked fish (kg)

iii) Gross production = No. of fish caught × average final weight

iv) Net production = No. of fish caught × average weight gained

Economic return

The benefit-cost analysis was done and net profit was calculated to identify the suitability and viability of culturing fish in floodplain area covering 2.43 ha through pen culture.

i) Net profit = Total output (income) - total input (cost)

ii) Benefit- cost ratio = $\frac{\text{Total output (income)}}{\text{Total input (cost)}}$

Results and discussion

Growth of stocked fish

The growth analysis of fish was done by one way analysis of variance (ANOVA) test to determine whether the growth pattern (i.e. growth of different stocked fish species at different time) and growth of stocked fishes were significantly different or not (Table 4). The growth pattern was analyzed by assessing average growth on the basis of mean weight differences and we were failed to reject null hypothesis. It delineated that the average growth pattern by weight of all stocked fish species was not significantly different from each other. However, from the result of one way ANOVA for the average total length and average weight, we were able to reject null hypothesis and it can be assumed that there were significant differences in growth of different stocked fish.

Table 4. One way ANOVA test to analyze the growth in pen

Variable	Sources of variation	Sum of Squares	degree of freedom	Mean Square	F-value	Level of significance	Remarks
Growth pattern	Between samples	67008.53	6	11168.09	1.47	0.212	$F_t > F_c$
	Within samples	319112.31	42	7597.91			
	Total	386120.84	48				
Average weight	Between samples	1195429.90	7	170775.70	3.23	0.007	$F_c > F_t$
	Within samples	2538292.11	48	52881.09			
	Total	3733722.01	55				
Average length	Between samples	827.29	7	118.18	3.33	0.006	$F_c > F_t$
	Within samples	1704.83	48	35.52			
	Total	2532.12	55				

The final length (cm), length gained (cm), weight gained (g), and specific growth rate was the highest for Grass carp (*C. idella*) due to presence of higher amount of aquatic weeds in the pen enclosure. However, the length gain (cm), length gained (%), weight gained (g), weight gained (%) and specific growth rate of Mrigal (*C. cirrhosus*) and Catla (*C. catla*) was comparatively lower because lower availability of planktons and these fishes could not compete with other fishes in feeding on supplemental diet. However, the specific growth rate of Rohu (*L. rohita*), Sarpunti (*P. gonionotus*) and Gonia (*L. gonius*) were almost similar with slight variation (Table 5).

Gorai *et al.* (2006) carried out an experiment by stocking fingerling of Indian major carp seeds (*Catla catla, Labeo rohita and Cirrhinus mrigala*) in two pens. The specific growth rate (SGR) of *C. catla* was 2.657 followed by *L. rohita* (2.639) and *C. mrigala* (2.515) at the Goruchora wetland, whereas at the 46- Morakollang wetland a better SGR was observed, *L. rohita* (2.678) followed by *C. mrigala* (2.492) and *C. catla* (2.458). In the present study, the exotic carp *C. idella* had the highest growth because of the presence of higher amount of aquatic weeds. As a result, the total number of aquatic species found was positively correlated with the SGR of *C. idella* at different time, the Pearson correlation value was 0.797 (correlation significant at 0.05 level). However, the specific growth rate of Catla, Mrigal and Bighead carp was lower as they could not compete for supplied feed with other fishes.

Table 5: Growth study of released fish species (Mean ± Standard Deviation)

Fish species	Average initial length (cm)	Average final length (cm)	Length gained (cm)	% of length gained	Average initial weight (g)	Average final weight (g)	Weight gained (g)	% of weight gained	SGR
Rohu	13.0± 0.3	23.4± 0.8	10.4± 0.8	79.7± 6.9	17.7± 3.3	283.0± 15.5	265.3± 14.4	1501.9± 267.9	2.64± 0.6
Catla	16.3± 0.4	24.5± 1.3	8.24± 1.5	50.52± 9.9	71.5± 5.1	524.6± 20.6	453.2± 24.2	633.8± 72.5	1.90± 0.4
Mrigal	15.2± 0.2	20.2± 1.0	5.13± 1.1	34.0± 7.7	24.5± 1.9	172.8± 13.2	148.3± 14.1	605.4± 92.1	1.86± 0.3
Grass Carp	16.1±0.9	45.7± 1.2	29.6± 1.2	183.88± 18.6	68.5± 3.8	1573.8± 10.3	1505.0± 11.3	2197.1± 127.6	2.98± 0.3
Sharpunti	13.7±0.4	21.2± 0.7	7.5± 1.0	54.70± 8.9	16.9± 2.2	253.3± 13.0	236.4± 13.9	1397.5± 243.8	2.58± 0.3
Bighead carp	16.8± 0.4	22.8± 0.4	6.1± 0.5	36.1± 3.5	69± 7.2	257.2± 4.3	193.2± 9.7	301.8± 45.2	1.25± 0.2
Gonia	13.2± 0.8	24.3± 0.3	11.0± 1.0	82.5± 12.7	20.5± 1.9	312.6± 7.5	292.2± 9.0	1425.2± 171.9	2.59± 0.4

Table 6: Estimation of harvested fish and fish biomass production from pen

Fish species	Harvested fish (nos.)	Survival rate (%)	Species wise Net Production (kg)	Total Net Production of stocked (kg)	Sp. Wise Gross Production (kg)	Gross Production of stocked fish (kg)	Gross Production of non-stocked fish (kg)
Rohu	3687	80.9	978.2	4232.8	1043.4	4684.9	598
Catla	2583	85.0	1170.4		1355.0		
Mrigal	3130	82.4	464.2		540.9		
Grass Carp	679	89.5	1022.1		1068.6		
Sharpunti	1224	80.7	289.4		310.0		
Bighead carp	656	86.3	123.5		168.7		
Gonia	634	83.4	185.2		198.2		

Production, productivity and survival of fish

The highest survival rate was for Grass carp (89.5%) while the survival rate for Rohu (80.9%) and Sharpunti (80.7%) have comparatively lower. However, the highest number of Rohu (3,687) was harvested from the pen because of higher stocking density. On the contrary, the lowest number of Sarpunti was recovered from the pen due to the higher mortality during and after stocking. The gross production of fish from the pen was 5282.9 kg which consisted of gross production 4684.9 kg of stocked fish (1927.94 kg/ha/135 days) and 598 kg of non-stocked fish (246.09 kg/ha/135 days) (Table 6). Therefore, the total production of fish from the Chatol beel pen was 2,174 kg/ha. Gorai *et al.* (2006) documented the production in terms of fish biomass was estimated at 2,106 kg/ha and 1780 kg/ha in Goruchora and 46-Morakollang wetlands of Assam, India respectively. These findings support to the present study.

Production of non-stocked fish within pen

The total amount of non-stocked fish production was 598 kg (246.09 kg/ha/crop). This production consisted of 497 kg (204.5 kg/ha) of SIS and 101 kg (41.6 kg/ha) of other indigenous fish species where freshwater shark (*Wallago attu*) were contributed- 70.0 kg. In the last year (2016), the natural production of fish (data obtained from the fishers' community) from the 2.43 ha floodplain was 350 kg (144.03 kg/ha/crop) (Figure 2), which was comprised of 290 kg (119.3 kg/ha)of SIS and 60 kg (24.7 kg/ha) of other indigenous fishes. Therefore, there was a massive increase in natural fish production and productivity of SIS in the *Kiamor Ghat* compared to the last year (2016) due to construction of pen which facilitated the entrance of larvae and hatchlings of other fish. SIS was observed at a lion proportion (83.1%) in the total amount of harvested non-stocked fish.

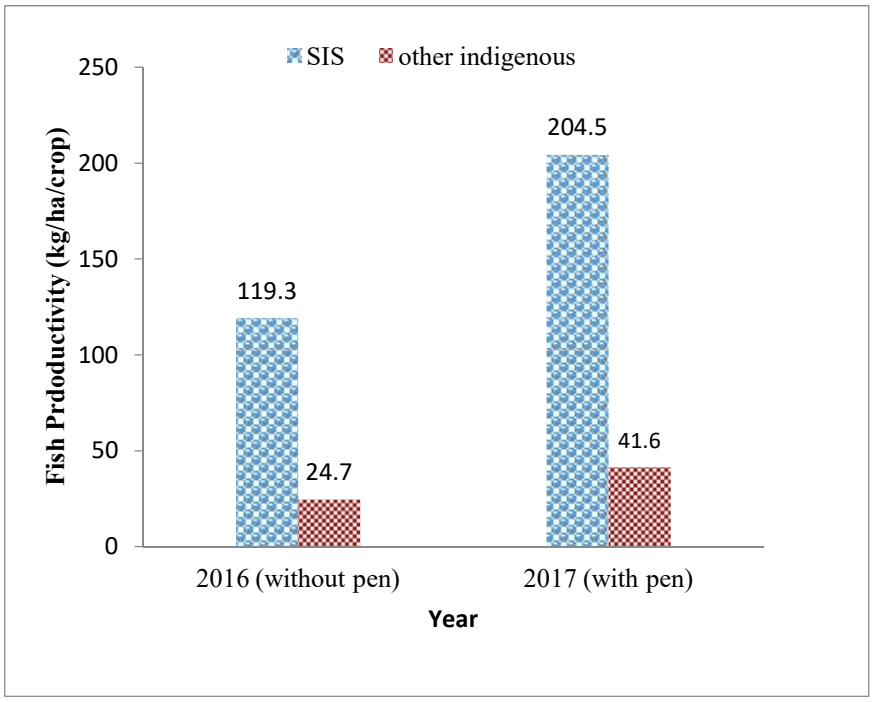


Figure 2: Comparison of productivity of non-stocked fish with the last year

Fish production from Chatol beel floodplain outside the pen

The natural production (without any technological intervention) of fish harvested by fishers' community of Amura Union, Golapgonj in 2017 was 6,132 kg from 52.5 ha area (116.8 kg/ha) of Chatol beelfloodplain (Table 7).

In the captured fishes from Chatol beel outside the pen, the production of 4,890 kg (93.14 kg/ha) of SIS and 1,242 kg (23.66 kg/ha) (Figure 3) of other indigenous fish species- freshwater shark (*Wallago attu*), Shol (*Channa striata*), Ayer (*Sperata aor*), Rohu (*Labeo rohita*), Catla (*Catla catla*), and Mrigal (*Cirrhinus cirrhosus*) etc. were observed. The natural fish productivity was higher within pen than outside of the pen site.

Table 7: Estimation of captured fish outside the pen

Captured fish (kg) in different months												Total production (kg)	Fish Productivity (kg/ ha/crop)
July		August		September		October		November		December			
SIS	Other	SIS	Other	SIS	Other	SIS	Other	SIS	Other	SIS	Other		
42	13	68	21	115	34	368	62	1311	210	2986	902	6132	116.8

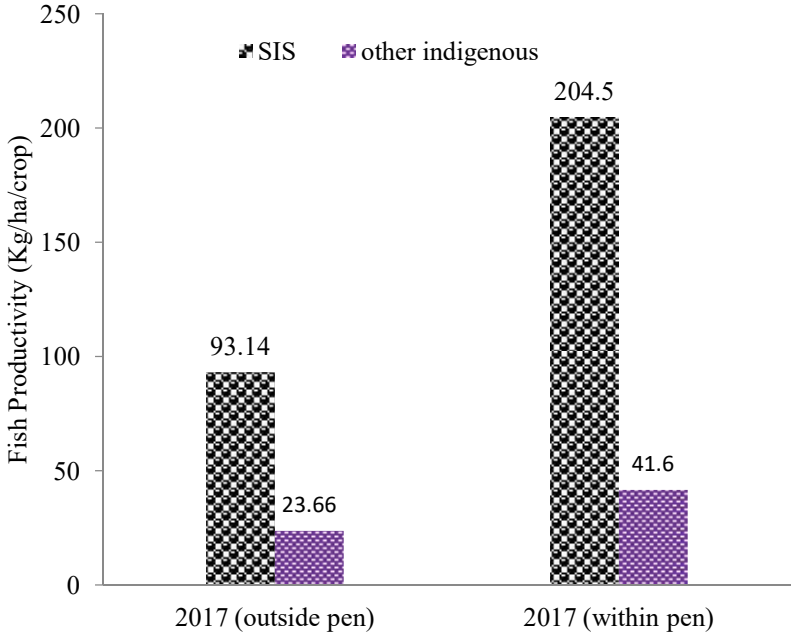


Figure 3: Comparison of productivity of non-stocked fish between outside pen and within pen

Hanif *et al*. (2016) reported 40 species from 19 families of SIS in Gorai River, Bangladesh. However, in the catches of SIS from this pen, 20 different SIS species from 12 families were being found with varying

abundance (Table 8). The total species found was lower because of water instability in seasonal floodplains. In the catches of SIS from the pen, abundance of 4 fish species was comparatively higher, 4 species were normal and 2 species were found in moderate amount. However, the maximum number of 10 fish species was found very low in amount. On the other hand, 31 species from 14 families were found outside the pen in Chatol beel floodplain (Table 8). In the catches of SIS outside the pen, abundance of 7 fish species was comparatively higher, 3 species were normal, 9 species were found in moderate amount and 12 species in very low amount.

Table 8: Abundance of SIS in catches

Family	Scientific name	Local name	Abundance in Catches (within pen)	Abundance in Catches (outside pen)
Anabantidae	*Anabus testudineus*	Koi	+	++
	Badis badis	Napit Koi	NF	+
Ambassidae	*Chanda nama*	Shada Chanda	+++	++++
	Chanda ranga	Lal Chanda	NF	++
Bagridae	*Mystus Tengra*	Bujiuri Tengra	+	+
	Mystus vitatus	Tengra	+	+
	Mystus bleekeri	Tengra	NF	+
	Mystus cavasius	Gulsha Tengra	NF	+
Belonidae	*Xenetodon cancila*	Kakila	+	++
Channidae	*Channa orientalis*	Cheng	+	+
	Channa punctatus	Taki	+	++
Clupeidae	*Gudusia chapra*	Chapila	+++	++++
	Corica soborna	Kechki	++++	++++
Cobitidae	*Lepidocephalus guntea*	Gutum	+++	+++
	Botia dario	Rani	+	++
Cyprinidae	*Esomus danricus*	Darkina	++++	++++
	Osteo brama cotio	Dhela	++	+++
	Puntius sophore	Jatpunti	++++	++++
	Amblypharyngodon Mola	Mola	++++	++++
	Puntius ticto	Titpunti	+	+
	Labeo bata	Bata	NF	+
	Labeo boga	Bhangon	NF	+
Gobiidae	*Glossogobius giuris*	Bele	NF	+
Nandidae	*Nandus nandus*	Bheda	+	++
Osphronemidae	*Colisa fasciatus*	Kholisa	+	+
Schilbeidae	*Pseudeutropius atherinoides*	Batashi	+++	+++
	Ailia coila	Baspata	NF	++
	Eutropiichthys vacha	Bacha	NF	++
Siluridae	*Ompok pabo*	MadhuPabda	++	++++
	Ompok bimaculatus	BoaliPabda	NF	+
Tetradontidae	*Tetraodon cutcutia*	Potka	NF	++

NF= Not found; +: Very low; ++: Moderate; +++: Normal; ++++: Higher

From the Figure 4, it is apparent that the family Cyprinidae contributed the maximum proportion of fish species in SIS composition within pen which accounted for 25%.Then, the second highest contributions of 10% each were from 4 families- Bagridae, Channidae, Clupeidae and Cobitidae. However, seven families contributed the least (5% each) in the species composition. On the contrary, 14 families contributed for the composition of SIS outside the pen. Among them, Cyprinidae contributed the highest proportion with 23%, while Belonidae, Gobitidae, Nandidae and Tetradontidae contributed the least of 3% each.

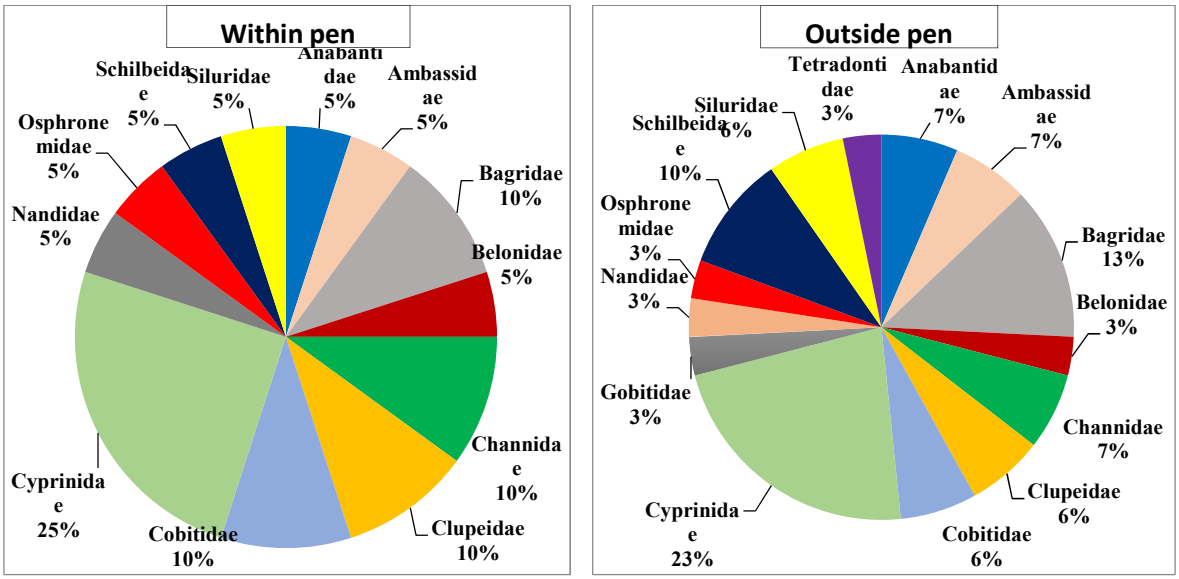


Figure 4: Contribution of different families (%) in composition of Small Indigenous Species (SIS) within pen and outside pen

Water quality parameters

The water quality parameters (water temperature, DO, pH, TDS, transparency and level of ammonia) of the pen was suitable for culturing fish, though the transparency was quite higher which indicated lower proportion of natural production (Table 9). So, the supplemental diet was a must to ensure proper growth of stocked fishes.

Table 9: Water quality parameters of different months

Date	Water temperature (°c)	DO (ppm)	pH	TDS	Transparency (cm)	Ammonia (mg/l)
Aug	27	7.3	6.9	30	64	< 0.02
Sep	26	6.9	7.1	35	60	< 0.01
Oct	26	6.2	7.2	30	59	< 0.01
Nov	25	7.2	7.8	38	50	< 0.01
Average	26± 0.82	6.9± 0.50	7.3± 0.39	33.3± 3.95	58.3± 5.91	<0.013

Availability of phytoplankton, zooplankton and benthic fauna

Total 9 genera of phytoplankton, 5 genera of zooplankton and 9 taxa of benthic fauna were observed in the study period (Table 10). However, in a study Meghna river estuary 22 different genera of phytoplankton, 32 major taxa of zooplankton and 11 major taxa of macro benthos were observed (Muhammed Sharif, 2017). The availability of phytoplankton, zooplankton and benthic fauna were lower due to the instability of water in seasonal floodplain.

Table 10: Availability of aquatic inhabitants in different months (August- November)

Inhabitant	Species/ taxa/genera	Availability of individual			
		August	September	October	November
Phytoplankton	*Pseudoanaebaena mucloi*	√	√		
	Chlorella sp.	√	√	√	
	Gyrosigma fasciola	√	√		
	Gyrosigma balticum			√	√
	Stephanopyxis sp.	√		√	
	Skeletonema sp.	√	√		√
	Ceratium sp.	√	√		
	Triceratium sp.			√	√
	Gyrodinium sp.	√			√
	Euglena sp.	√	√	√	
Zooplankton	*Brachionus sp.*	√		√	√
	Moina sp.	√	√		
	Cyclops sp.	√	√	√	√
	Sida sp.	√	√		
	Nauplius sp.			√	√
Benthic fauna	*Hirudo sp.*	√	√	√	√
	Tubifex sp.		√	√	√
	Chironomous sp.	√	√	√	√
	Dipteran pupae			√	√
	Sartoriana sp.	√	√	√	√
	Planorbella sp.	√	√	√	√
	Melonia sp.	√	√	√	√
	Viviparus sp.	√	√	√	√
	Lamillidens sp.	√	√	√	√

Availability of Aquatic weeds

The aquatic weeds can be divided into three broad groups- floating, emergent and submerged. Total 21 species of aquatic weeds from 3 groups were found in the pen (Table 11). Among the 3 groups, emergent weeds were the highest in number with 14 weed species, which followed by floating group (5 species) and the lowest submerged group (2 species). The number of aquatic weed species found in the pen site is not very low compared to other regions. According to investigation of the aquatic weeds diversity and abundance at Noakhali Sadar, Bangladesh, total 22 species of aquatic weeds were observed (Kaisar *et al*., 2016).

Economic estimation of pen

The total expenditure of pen enclosure included the cost of pen construction (Tk. 22,825), fish fry (Tk. 61,005), fertilization and liming (Tk. 24,983), fish feed (Tk. 2,39,123), transportation (Tk. 15,023) and other maintenance (Tk. 5,976) (Table 12). Therefore, the total cost of input was Tk. 368935. On the other hand, the harvested fish (5283 kg) was sold on an average of 125.33 Tk/kg and the total output was the income of Tk. 6,62,091. Therefore, the net profit from the pen was Tk. 2,93,156 and the benefit-cost ratio was 1:1.8, which was comparatively higher due to the deliberate cooperation of local fishers' community which minimized labor cost.

Table 11: Availability of aquatic weeds in different months

Group	Scientific name	Availability of weed species			
		August	September	October	November
Floating	*Eichhornia crassipes*	√	√	√	√
	Pistia stratiotes	√	√	√	
	Lemna minor	√	√		
	Wolffia arhiza	√	√	√	
	Azolla pinnata	√	√		
Emergent	*Nymphaea pubescens*	√	√		
	Nelumbo nucifera	√	√		
	Hygroryza aristata	√	√	√	√
	Trapa natans	√	√	√	√
	Enhydra fluctuans	√	√	√	√
	Polygonum glabrum	√	√	√	√
	Colocasia esculenta	√	√	√	√
	Ipomea aquatica	√	√	√	√
	Cyperus rotundus	√	√	√	√
	Scirpus actus	√	√	√	√
	Ludwigia adscendens		√	√	√
	Commerlina bengalensis	√	√	√	√
	Commelina appendiculata	√	√	√	√
	Sagittaria sp.	√	√	√	√
Submerged	*Cartophyllum demersum*	√	√		
	Najas minor	√	√	√	

Observations and comments

The study concerned about the growth and production of fishes and availability of aquatic inhabitants in Chatol beel floodplain under pen culture technology covering an area about 2.43 ha for a period of 135 days. The gross fish production of pen was 5282.9 kg, which included 4684.9 kg from stocked fish and 598 kg from non-stocked fish. The small indigenous species of fish (SIS) was dominant in the catches of non-stocked fish and total 20 different SIS species belonged to 12 families were being found with varying abundance. A total 9 species of phytoplankton, 5 species of zooplankton, 21 aquatic weeds and 9 taxa of benthic fauna were observed during study period. The net profit was 2,93,156 Tk and cost-benefit ratio was 1:1.8, which

delineate that composite fish culture through pen culture technology in floodplain area has immense possibilities for increasing fish production and financial gains. However, the decent part of river and canals in haor floodplains are suitable for the pen culture because of availability of water all the year around.

Table 12: Economic analysis of pen enclosure

Economic parameters	**Unit price**	**Total (Tk.)**
Construction of pen enclosure		22,825.00
Fish fingerlings cost (Tk)		61,005.00
Fertilizer and lime		24,983.00
Total feed cost (Tk)		2,39,123.00
Transportation cost		15,023.00
Other maintenance cost		5,976.00
Total production cost		3,68,935.00
Total income from fish selling (5283 kg)	Average price: Tk. 125.325	6,62,091.00
Net Profit		**2,93,156.00**
Benefit-Cost Ratio (BCR)		1:1.8

The present experiment revealed that utilization of seasonal floodplains through pen culture technology can be considered very significant in different aspects, mainly for increasing fish production of seasonal floodplains, financial profits and creating employment opportunities. In fact, the composite culture of other indigenous and exotic carp by the help of such a pen can facilitate the increased natural fish production. The natural production was higher compared to the previous year. In respect to the growth of fishes, *Ctenopharyngodon idella*, which is an exotic carp, had the highest length-weight gain and specific growth rate than other stocked fishes due to presence of higher amount of aquatic weeds. However, the availability of phytoplankton, zooplankton and weeds were the lowest in the month of November, while the number of species of benthic invertebrate was the lowest in October. From the economic estimation, the net profit from the pen and cost-benefit ratio was outstanding, which worth the practice of pen culture technology in unused floodplains. Further study should be carried out by changing stocking density of fish and use of commercial fish feed or quantification of plankton and weed abundance with their relationship to fish growth.

Expt. 3: Enhancement of Fish Biodiversity through Establishment of Sanctuary in Haor Floodplain

Fish sanctuary means to establish and maintain a particular demarcated protected area in the water body as a permanent shelter for the protection of fish for natural propagation, where targeted fish will not be disturbed or captured. Establishing of aquatic sanctuary is one of the effective tools for conserving fish stock, preserving biodiversity and increasing fish production. In some cases restoration as well as conservation of habitat may be possible by establishing aquatic sanctuary. Fishes congregate in the sanctuaries for shelter, lead peaceful life without any disturbance and can move independently towards the feeding and breeding ground. Impact of fish sanctuaries has been reported positive in almost all cases on fish production,

biodiversity and socioeconomic condition of the fishing community. No adverse impact on environment has been found or reported due to establishing a fish sanctuary. Moreover, as a part and form of fisheries management, sanctuaries are relatively easy for user communities to implement and enforce. Considering the above facts, fish sanctuary was established in three haor floodplain are as to enhance of fish production and biodiversity.

Research Design

Selected area	Golapganj	Sunamganj	Sylhet
Selected haor/ Water body	Chatol beel floodplain	Tedala Huglia beel floodplain	Melan haor floodplain
Number sanctuary	1	1	1
Area	100 ft x 60 ft = 6000 sq. ft	100 ft x 60 ft = 6000 sq. ft	100 ft x 60 ft = 6000 sq. ft

Methodology

Fish sanctuary was established in each site of Chatol beelfloodplain, Golapganj andTedala Huglia beel floodplain, Sunamganj and and Melan haor floodplain, Sylhet. The sanctuary was constructed at the deeper portion in each floodplain. Hizol trees, bamboos,branches of bamboos, roots and branches of other locally available trees were used in the sanctuary constructionfor fish shelter and suitable environment for natural breeding of fishes. During the lean period most of the floodplain area dried up, but the canal and deeper portion containing water round the year and that act as a source of brood-fish reservoirsfor the next breeding season. Fishing was banned during peak breeding period to promote safe breeding of indigenous fishes and up to attainment of post juvenile stage of the offspring.Sanctuary establishment and managementswere done through community participation.

Result & Discussion

3.1 Fish biodiversity observation atTedala Huglia beel floodplain, Sunamganj

Tedala Huglia beel floodplain under Dekar haor is rich in its fish diversity, where 11 rear species and 5 highly endangered species were identified. During the study period, a total number of 60 resident fish species were recorded from the beel of which 44 species were common, 11 species rear and 5 species were highly endangered (Table 13). Fish species which were highly endangered found available during study period due to sanctuary establishment as well as good management practice. The recorded fish species are categorized into 11 major groups. Of the recorded 60 fish species, 12 fish species were belong to the of Catfish, 8 fish species were belong to the barbs & minnows and perch & goramy each groups, 6 fish species were belong to the major carps, 5 fish species were belong to the murrels, 4 fish species were belong to the Eels & mud Eels and loaches & clupeids each groups, 3 fish species were belong to the exotic carps, featherbacks, glassfish and miscellaneous each groups. The related study was done by Pandit *et al.* (2015) recorded 65 species under 23 families were found available in Dekar haor. The species availability status were remarked in four categories and obtained as 26 commonly available, 18 moderately available, 21 rarely available and 19 not available species. Among the available species 9 of carps, 16 of Catfish, 10 of barbs and minnows, 1 of clupeid, 4 of snakeheads, 4 of Eels, 11 of perches, 1 of featherback, 3 of loaches and other miscellaneous 6

species including 3 species of prawns are found. Mahalder and Mustafa (2013) recoded 126 fish species from 39 families in the Sunamgonj haor area during 2008 to 2010 that clearly indicate higher fish diversity than the present study.

Table 13. Abundance of species in harvested fish from Tedala Huglia beel floodplain in Sunamganj

Sl. No.	Scientific name	Local Name	Before Intervention	after Intervention	Remarks
1	*Labeo rohita*	Rui	+	+	No change
2	*Cirrhinus cirrhosous*	Mrigel	+	+	No change
3	*Catla catla*	Catla	+	+	No change
4	*Labeo calbasu*	Kalibaus	+	+	No change
5	*Cirrhinus reba*	Lachu	+	+	No change
6	*Labeo gonius*	Gonia	+	+	No change
7	*Ctenopharyngodon idella*	Grass carp	+	+	No change
8	*Cyprinus carpio*	Carpio	+	+	No change
9	*Hypophthalmicthys molitrix*	Silver carp	+	+	No change
10	*Puntius ticto*	Tit Puti	+	+	No change
11	*Puntius sarana*	ShorPuti	-	+	change
12	*Puntius sophore*	JatPuti	+	+	No change
13	*Amblypharyngodon Mola*	Mola	+	+	No change
14	*Osteobrama cotio*	Dhela	+	+	No change
15	*Esomus danricus*	Darkina	+	+	No change
16	*Puntius terio*	Teri Puti	+	+	No change
17	*Securicula gora*	Ghora chela	-	+	change
18	*Chela cachius*	Chep chela	+	+	No change
19	*Wallago attu*	Boal	+	+	No change
20	*Ompok Pabda*	Pabda	+	+	No change
21	*Ompok pabo*	ModhuPabda	+	+	No change
22	*Ompok bimaculatus*	KaniPabda	-	+	change
23	*Heteropneustes fossilis*	Shing	+	+	No change
24	*Clarias batrachus*	Magur	+	+	No change
25	*Mystus tengara*	Gulsha Tengra	+	+	No change
26	*Mystus cavasius*	Kabashi Tengra	+	+	No change
27	*Mystus vittatus*	Tengra	+	+	No change
28	*Sperata aor*	Air	+	+	No change
29	*Rita rita*	Rita	-	+	change
30	*Bagarius bagarius*	Baga air	-	+	change
31	*Channa marulius*	Gozar	+	+	No change
32	*Channa striatas*	Shol	+	+	No change
33	*Channa punctatus*	Taki	+	+	No change
34	*Channa orientalis*	Pipla Shol	-	+	change
35	*Channa barca*	Cheng	+	+	No change
36	*Anabas testudineus*	Koi	+	+	No change
37	*Nandus nandus*	Meni	+	+	No change

Sl. No.	Scientific name	Local Name	Before Intervention	after Intervention	Remarks
38	*Colisa fasciata*	Baro Kholisha	+	+	No change
39	*Colisa lalia*	Lal kholisha	-	+	No change
40	*Colisa chuno*	ChotoKholisha	+	+	No change
41	*Glossogobius giuris*	Bele	+	+	No change
42	*Xenentodon cancila*	Kankila	+	+	No change
43	*Hyporhamphus limbatus*	EkThuita	-	+	change
44	*Macrognathus aculeatus*	Tara baim	+	+	No change
45	*Mastacembelus pancalus*	Guchi baim	+	+	No change
46	*Mastacembelus armatus*	Baim	+	+	No change
47	*Monopterus cuchia*	Kuchia	-	+	change
48	*Lepidocephalus guntea*	Gutum	+	+	No change
49	*Botia Dario*	Rani	-	+	change
50	*Gudusia chapra*	Chapila	+	+	No change
51	*Corica soborna*	Kachki	+	+	No change
52	*Notopterus notopterus*	Foli	+	+	No change
53	*Notopterus chitala*	Chitol	-	+	change
54	*Tetredon cutcutia*	Potka	+	+	No change
55	*Parambassis lala*	Lal chanda	+	+	No change
56	*Chanda nama*	Lamba chanda	-	+	change
57	*Pseudambassis baculis*	Chanda	+	+	No change
58	*Macrobrachium rosenbergi*	Galda	+	+	No change
59	*Macrobrachium rude*	Gura chinghri	+	+	No change
60	*Macrobrachium malcomsonii*	Icha	+	+	No change
Total number of non-stocked species			48	60	12 non-stocked species return due to sanctuary establishment
Increase in species abundance (%)			**25%**		

(+) indicates presence and (–) indicates absence of a particular species

In Table 13, it was found that a total of 60 species were recorded from the studied Tedala Huglia beel floodplain during the study period, among the most dominant fish species group barbs & minnows contribute 25% of total fish production. Other fish species group such as Catfishes, perch & goramy, glassfish, miscellaneous, loaches & clupeids, major carps, murrels, exotic carps, Eels & mud Eels, Featherbacks represented about 20%, 13%,8%, 7%, 6%, 5%, 5%, 4%,4%,3%, respectively (Figure 5). The more or less related result also found by Pandit *et al.* (2015) recorded 65 available fish species where the highest percentage of fishes was Catfishes (26.62%) and lowest were clupeids (1.54%) and Featherbacks (1.54%), among other group there were 16.92% perches, 15.38% barbs and minors, 13.85% carps, 6.15% snakeheads as well as Eels, 4.62% loaches and 9.23% other miscellaneous fish species. The study also shows that the most dominant resident species contribute the best part of the catch (38.48%) consist of only five species were *Puntius sophore* (Jatputi), *Pseudambassis baculis* (Chanda), *Mystus vittatus* (Tengra), *Wallago attu* (Boal), *Nandus nandus* (Meni) (Table 14); those five species were abundant due to establishment of fish sanctuary act as a breeding and nursing ground and also benefit of banning of fishing around fish sanctuary. Catfishes

are dominant in many waterbodies because they can survive in low water depth and adverse environmental condition. The opinion and findings supports to the present study.

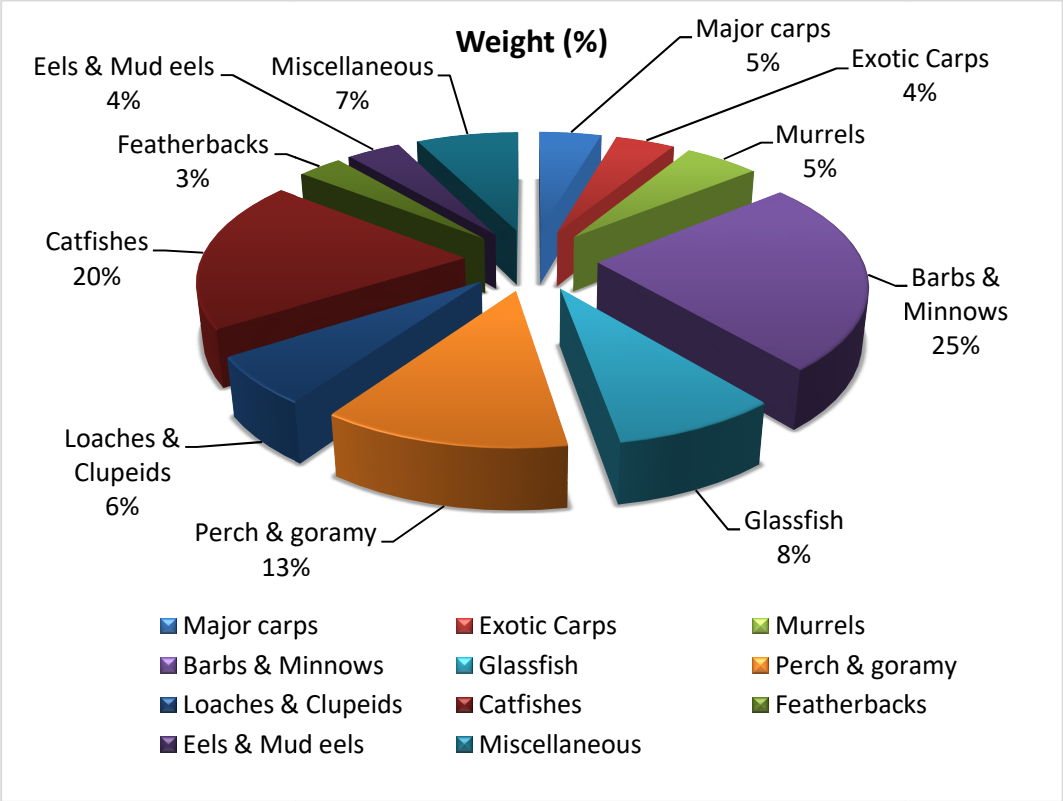


Figure 5: Major group fish contribution at Tedala Hugliabeel floodplain during partial harvesting of fish sanctuary

Species composition

During the study period, a total number of 60 resident fish species were recorded from the floodplain, while 48 fish species were recorded from baseline information which focus on a positive change of the fish biodiversity after fish sanctuary establishment in haor floodplain, the number of non-stock fish species 25% increase over the initial base level population due to well management practice and banning of fishing during breeding season. Rahman *et al.* (2010) reported that the abundance of non-stocked species increased 15% in the studies floodplainas compared to the abundance of baseline recorded species (before project intervention) which were much lower than the present findings.

Table 14. Fishcatches including top five fish species at the sanctuary area of Tedala Hugliafloodplain

Sl. No.	Scientific name	Local Name	Total weight (kg)	Weight (%)
1	*Puntius sophore*	JatPuti	452	18.04
2	*Pseudambassis baculis*	Chanda	162	6.47
3	*Mystus vittatus*	Tengra	140	5.59
4	*Wallago attu*	Boal	120	4.79
5	*Nandus nandus*	Meni	90	3.59
6	Other Species	(55 species)	1541	61.52

Total fish catches in selected sanctuary	2505	100.00

Fish biomass

Technological intervention plays a vital role for increasing fish production in floodplain fisheries. The production of stocked and non-stocked fishes in Tedala Huglia beel floodplain were recorded to be 36 kg/ha, 180 kg/ha, respectivelyin before intervention period, while these production were increased as 146 kg/ha and 315 kg/ha respectively before and after technological intervention period. The incremental production of stocked and non-stocked fish was recorded 110 kg/ha and135 kg/ha, respectively with a total production was 245 kg/ha (Figure 6).

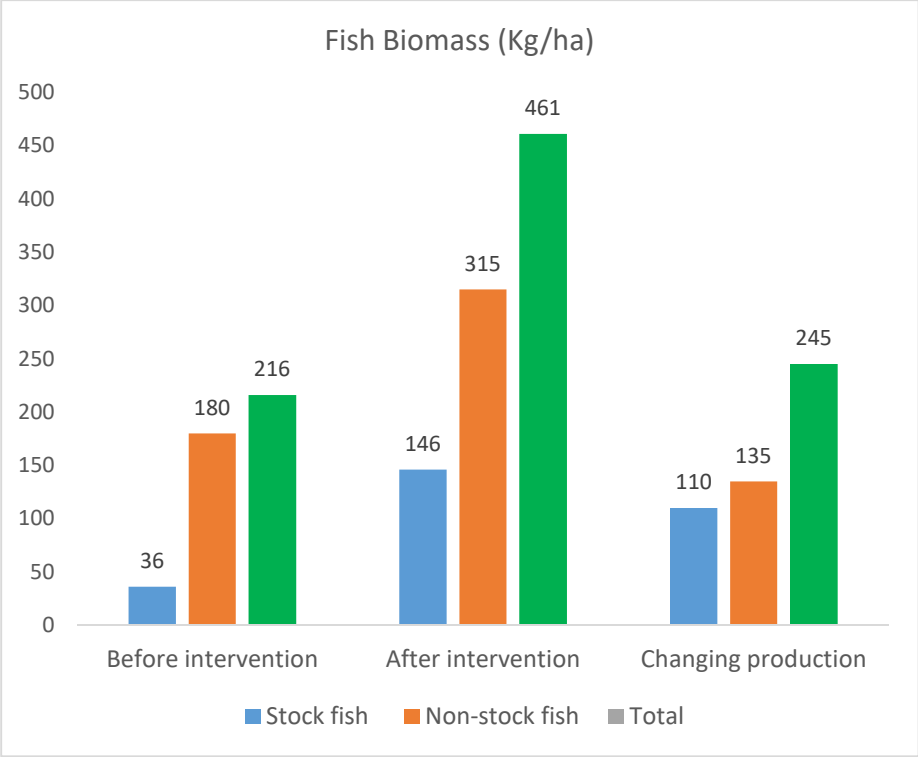


Figure 6: Scenario of fish biomass (kg/ha) at Tedala Huglia beel floodplain during before and after intervention period

The baseline (before intervention) fish production (both stocked and non-stocked) was recorded 216 kg/ha where the production was increased 461 kg/ha after technological intervention and the production uphold 245 kg/ha during the study period. The incremental fish production plays a positive role in selected floodplain due to intervention of two new technologies. It is reported that the stock fish production was increased by the introduction of new cage culture technology and management conservation of floodplain, and the abundant of non- stock fish specieswas increased due to establishment of fish sanctuary. Rahman *et al.* (2010) reported that the mean fish production in the floodplains increased to 443 kg/ha against baseline production of 124 kg/ha over a culture period of 5-6 months in a year with subsequent increase in period of employment of fishers, income and household fish consumption. Fish larvae, hatchlings and young fry of wild non-stocked fishes entered into the seasonal floodplains through large fence spacing was more or less similar with the findings.

Economic analysis of fish sanctuary

The total expenditure of fish sanctuary establishment was 65,000.00 Tk. where the construction materials such as bamboos, trees, bamboo & tree branches, roots of trees, plastic & iron wire wereincluded (Table 15). The labour cost of sanctuary establishment and small boat purchasing cost were also calculated there. Therefore, the total management cost was Tk. 65,000.00. On the other hand, the harvested fish was 2505 kg where low price small fish 2175 kg and valued fish such as Boal, Shol, Magur, Shing, Ayer, Pabda, Gulsha etc. were 330 kg. The average price of small fish was 71.00 Tk/kg and valued fish was 390.00 Tk/kg. So thatthe total output was the income of Tk. 283,125.00. Therefore, the net profit from the fish sanctuary was Tk. 218,125.00 and the cost-benefit ratio was 1:4.36, which was comparatively higher due to aggregating more fish in the a small area like sanctuary with congenial environment.

Table 15. Economic analysis of fish sanctuary in Tedala Huglia beelfloodplain

Economic parameters	**Unit price**	**Taka**
1) Construction materials		
a) Bamboo- 100 nos	250.00	25000.00
b) Hizol trees 3 pcs	550.00	1650.00
c) Branches of bamboo	1200.00	1200.00
d) Roots of different trees	3500.00	3500.00
e) Nylon (Plastic) rope 15 kg	120.00	1800.00
f) Iron wire 3 kg	90.00	270.00
2) Boat purchase-1 no	11000.00	11000.00
3) Labour cost (30 day labour)	500.00	15000.00
4) Other management cost (Signboard and others)	LS	5580.00
Total Cost		**65,000.00**
Fish selling price 2505 kg (low price small fish 2175 kg & valued fish 330 kg)	Average price: Small: 71.00 Tk Valued: 390.00 Tk	**283,125.00**
Net profit (Tk)		**218,125.00**
Benefit-cost ratio (BCR)		**1:4.36**

3.2 Fish biodiversity observation at Chatol beel fish sanctuary, Golapganj

Species Composition

Fish diversity was observed after establiShing the fish sanctuary in Chatol beel floodplain. The fish species were recorded before and after technological intervention in Chatol beel floodplain in this study. After technological intervention, a total number of 55 resident fish species were recorded (Table 16) from the floodplain; while 47 fish species were recorded before technological intervention. Therefore, the number of non-stock fish species increased 17.02%in after technological intervention periodconsidering initialbaselevelpopulationin Chatol beel floodplain.

Table 16. Abundance of species in harvested fish fromChatol beelfloodplain in Golapganj

Sl. No.	Scientific name	Local Name	Before Intervention	After Intervention
1	*Labeo rohita*	Rui	+	+
2	*Cirrhinus cirrhosous*	Mrigal	+	+
3	*Catla catla*	Catla	+	+
4	*Labeo calbasu*	Kalibaus	+	+
5	*Cirrhinus reba*	Lachu	+	+
6	*Labeo gonius*	Gonia	+	+
7	*Ctenopharyngodon idella*	Grass carp	+	+
8	*Cyprinus carpio*	Carpio	+	+
9	*Hypophthalmicthys molitrix*	Silver carp	+	+
10	*Puntius ticto*	Tit Puti	+	+
12	*Puntius sophore*	Jatputi	+	+
13	*Amblypharyngodon Mola*	Mola	+	+
14	*Osteobrama cotio*	Dhela	+	+
15	*Esomus danricus*	Darkina	+	+
16	*Securicula gora*	Ghora chela	-	+
17	*Chela cachius*	Chep chela	+	+
18	*Wallago attu*	Boal	+	+
19	*Ompok Pabda*	Pabda	+	+
20	*Ompok pabo*	ModhuPabda	+	+
21	*Ompok bimaculatus*	KaniPabda	-	+
22	*Heteropneustes fossilis*	Shing	+	+
23	*Clarias batrachus*	Magur	+	+
24	*Mystus tengara*	Gulsha Tengra	+	+
25	*Mystus cavasius*	Chuto Tengra	+	+
26	*Mystus vittatus*	Tengra	+	+
27	*Sperata aor*	Air	+	+
28	*Rita rita*	Rita	-	+
29	*Bagarius bagarius*	Baga air	-	+
30	*Channa marulius*	Gozar	+	+
31	*Channa striatas*	Shol	+	+
32	*Channa punctatus*	Taki	+	+
33	*Channa barca*	Cheng	+	+
34	*Anabas testudineus*	Koi	+	+
35	*Nandus nandus*	Meni	+	+
36	*Colisa fasciata*	Baro kholisha	+	+
37	*Colisa lalia*	Lal kholisha	-	+

38	*Colisa chuno*	Choto kholisha	+	+
39	*Glossogobius giuris*	Bele	+	+
40	*Xenentodon cancila*	Kankila	+	+
41	*Macrognathus aculeatus*	Tara baim	+	+
42	*Mastacembelus pancalus*	Guchi baim	+	+
43	*Mastacembelus armatus*	Baim	+	+
44	*Lepidocephalus guntea*	Gutum	+	+
45	*Botia dario*	Rani	-	+
46	*Gudusia chapra*	Chapila	+	+
47	*Corica soborna*	Kachki	+	+
48	*Notopterus notopterus*	Foli	+	+
49	*Notopterus chitala*	Chitol	-	+
50	*Parambassis lala*	Lal chanda	+	+
51	*Chanda nama*	Lambachanda	-	+
52	*Pseudambassis baculis*	Chanda	+	+
53	*Macrobrachium rosenbergi*	Galda	+	+
54	*Macrobrachium rude*	Gura chinghri	+	+
55	*Macrobrachium malcomsonii*	Icha	+	+
	Total number of non-stocked species		**47**	**55**
	Increase species abundance (%)		**17.02%**	

(+) indicates presence and (–) indicates absence of a particular species

In Table 16, it was found that a total of 55 resident fish species were recorded from the Chatol beel floodplain of which 41 species were common, 10 species rear and 4 species highly endangered; It was also reported that 47 fish species were available in baseline survey. Fish species which were highly endangered found available during study period due to sanctuary establishment as well as conservation management of selected floodplain. In this study, SIS was found with their abundance in major catches at Chatol beel floodplain (Table 17) where 10 species were very low, 2 species were moderate, 4 species were normal and 4 species were higher presence. Mola, JatPuti, Darkina and Kachki were higher abundant where dhela and modhu Pabda were moderate.

Fish biomass

Chatol beel floodplainis a productive haor basin adjacent to Kushiara river. The carp fingerling stocking programme, sanctuary and pen enclosure was established there. Before technological intervention the stocked and non-stocked fish production at Chatol beel floodplain, Golapgonj was recorded 80 kg/ha, 120 kg/ha,respectively with a total fish production 200 kg/ha. After successful implementation of the project activities the stocked and non-stocked fish production was recorded 209 kg/ha, 288 kg/ha, respectively with a total production was 497 kg/ha (Figure 7). After technological intervention the incremental fish production was observed as 298 kg/ha where 129 kg/ha was stocked and 169 kg/ha was non-stocked. The incremental fish production was highly appreciable that could be encouraged the community people for adopting new technology and conservation management of haor floodplain.

Table 17. SIS found in Chatol beel floodplain with their abundance in catches

Family	Scientific name	Local name	Abundance in catches
Anabantidae	*Anabus testudineus*	Koi	+
Ambassidae	*Chanda nama*	Chanda	+++
Bagridae	*Mystus Tengra*	Bujiuri Tengra	+
	Mystus vitatus	Tengra	+
Belonidae	*Xenetodon cancila*	Kakila	+
Channidae	*Channa orientalis*	Cheng	+
	Channa punctatus	Taki	+
Clupeidae	*Gudusia chapra*	Chapila	+++
	Corica soborna	Kechki	++++
Cobitidae	*Lepidocephalus guntea*	Gutum	+++
	Botia dario	Rani	+
Cyprinidae	*Esomus danricus*	Darkina	++++
	Osteobrama cotio	Dhela	++
	Puntius sophore	Jatpunti	++++
	Amblypharyngodon Mola	Mola	++++
	Puntius ticto	Titpunti	+
Nandidae	*Nandus nandus*	Bheda	+
Osphronemidae	*Colisa fasciatus*	kholisa	+
Schilbeidae	*Pseudeutropius atherinoides*	Batashi	+++
Siluridae	*Ompok pabo*	MadhuPabda	++

+: Very low (10); ++: Moderate (2); +++: Normal (4); ++++: Higher (4)

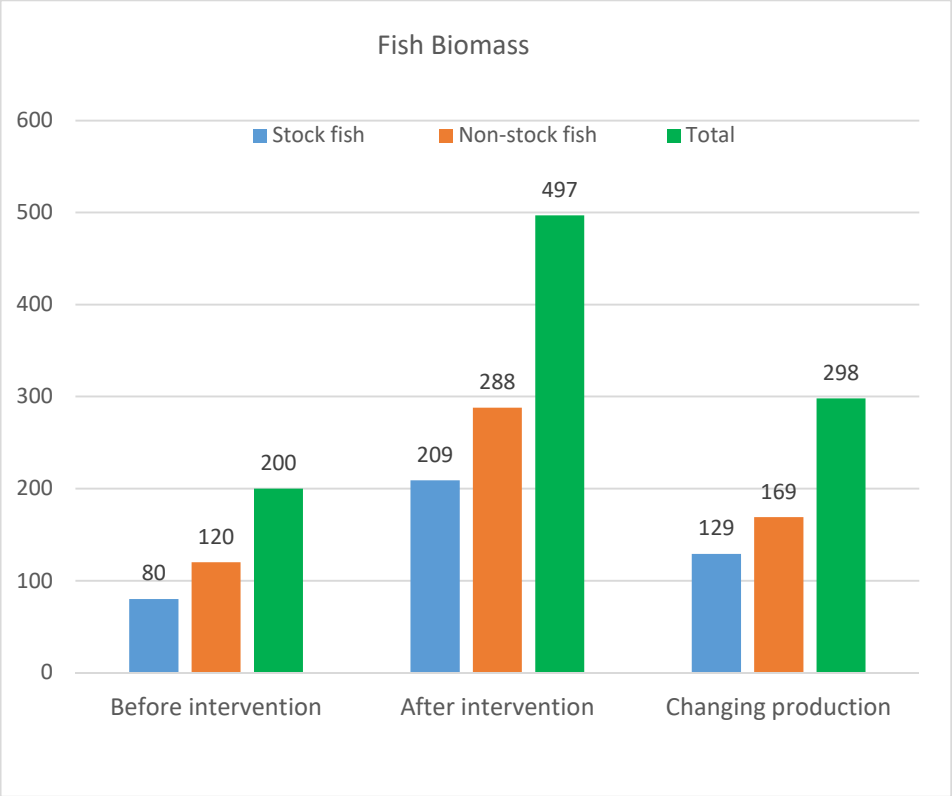


Figure 7: Scenario of fish biomass (kg/ha) at Chatol beel floodplain during before and after intervention

Table 18. Economic analysis of fish sanctuary in Chatolbeelfloodplain Golapganj

Economic parameters	**Unit price**	**Taka**
2) Construction materials		
a) Bamboo- 130 nos	240.00	31200.00
b) Hizol trees 3 pcs	620.00	1860.00
c) Branches of bamboo	1500.00	1500.00
d) Roots of different trees	3200.00	3200.00
e) Nylon (Plastic) rope 16 kg	125.00	2000.00
f) Iron wire 3 kg	100.00	300.00
2) Boat fair	4500.00	4500.00
3) Labour cost (35 day labour)	450.00	15750.00
4) Other management cost (signboard and others)	LS	4800.00
Total Cost		**65,110.00**
Fish selling price 2815 kg (low price small fish 2450 kg & valued fish 365kg)	Average price: Small: 70.00 Tk Valued: 400.00 Tk	**317,500.00**
Net profit (Tk)		**252,390.00**
Benefit-cost ratio (BCR)		**1:4.88**

Economic analysis of fish sanctuary in Chatol beel floodplain

The economic analysis of fish sanctuary in Chatol beel floodplain is presented in Table 18. The total expenditure of fish sanctuary establishment was 65,110.00 Tk. where the construction materials such as bamboos, trees, bamboo & tree branches, roots of trees, plastic & iron wire were included. The labour cost Tk. 15750.00 and boat fair 4500.00 Tk. were also calculated there. The harvested fish was 2815 kg where low price small fish 2450 kg and valued fish such as Boal, Shol, Magur, Shing, Ayer, Pabda, Gulsha etc were 365 kg. The average price of small fish was 70.00 Tk/kg and valued fish was 400.00 Tk/kg. So that the total fish selling price was Tk. 317,500.00. Therefore, the net profit from the fish sanctuary was Tk. 252,390.00 and the cost-benefit ratio was 1:4.88, which was comparatively higher due to aggregating more fish in the a small area like sanctuary with undisturbed environment.

3.3 Fish biodiversity observation at Melan haor fish sanctuary, Sylhet

Species Composition

Melan haor fish sanctuary in Sylhet sadaris very rich in fish production and other aquatic biodiversity. During the study period, a total number of 50 resident fish species were recorded (Table 19) from the beel of which 25 species were common, 15 species rear and 3 species were highly endangered. The Recorded fish species are categorized into 11 major groups. Of the recorded 50 fish species, 10 fish species are belong to the Catfish, 8 fish species are belong to the perch and goramy,5 fish species are belong to the major carps, 4 fish species are belong to the barbs and minnows, 4 fish species are belong to murrels, 6 fish species are belong to Eels and mud Eels, 7 fish species are loaches and clupeids, 3 fish species are belong to featherbacks, 3 fish species are belongs to shellfish, 2 fish species are exotic fish species, 2 fish species are belong to glassfish. A total of 50 species were recorded from the studied beel floodplain during the study period, which were included into 11 major groups. Among the most dominant fish species group Catfishes contribute 20% of total fish production. Other fish species group such as perch and goramy, major carps, barbs and minnows, murrels, Eels and mud Eels, loaches and clupedis, featherbacks, shellfish, exotic carps and glassfish represented about 16%, 10%, 10%, 8%, 8%, 8%, 6%, 6%, 4%, 4%,respectively (Figure8). The study also shows that the most dominant resident species contribute the best part of the catch consist of only five species were *Puntius sophore* (JatPuti) 20%, *Pseudambassis baculis* (Chanda) 6.47%, *Mystus vittatus* (Tengra) 5.63%, *Wallago attu* (Boal) 5.79%, *Nandus nandus* (Meni) 3.59%, and other species 58.52% to overall production. Those five species were abundant due to establishment of fish sanctuary act as a breeding and nursing ground and also benefit of banning of fishing around fish sanctuary.

Table 19. Abundance of species in harvested fish from Melan haor floodplain Sylhet

Sl. No.	Scientific name	Local Name	Outside Haor	Inside Haor
1	*Labeo rohita*	Rui	+	+
2	*Catla catla*	Catla	+	+
3	*Labeo calbasu*	Kalibaus	-	+
4	*Cirrhinus reba*	Lachu	+	+
5	*Labeo gonius*	Gonia	+	+
6	*Ctenopharyngodon idella*	Grass carp	+	+
7	*Cyprinus carpio*	Carpio	+	+
8	*Puntius ticto*	Tit Puti	+	+
9	*Puntius sarana*	ShorPuti	-	+

10	*Puntius sophore*	JatPuti	+	+
11	*Amblypharyngodon Mola*	Mola	+	+
12	*Esomus danricus*	Darkina	+	+
13	*Wallago attu*	Boal	+	+
14	*Ompok Pabda*	Pabda	+	+
15	*Ompok bimaculatus*	KaniPabda	+	+
16	*Heteropneustes fossilis*	Shing	+	+
17	*Clarias batrachus*	Magur	+	+
18	*Mystus tengara*	GulshaTengra	+	+
19	*Mystus vittatus*	Tengra	+	+
20	*Sperata aor*	Air	-	+
21	*Rita rita*	Rita	-	+
22	*Bagarius bagarius*	Bagair	-	+
23	*Channa marulius*	Gozar	+	+
24	*Channa striatas*	Shol	+	+
25	*Channa punctatus*	Taki	+	+
26	*Channa barca*	Cheng	+	+
27	*Anabas testudineus*	Koi	+	+
28	*Nandus nandus*	Meni	+	+
29	*Colisa fasciata*	Barokholisha	+	+
30	*Colisa lalia*	Lal kholisha	+	+
31	*Colisa chuno*	Chotokholisha	+	+
32	*Glossogobius giuris*	Bele	+	+
33	*Xenentodon cancila*	Kankila	+	+
34	*Hyporhamphuslimbatus*	EkThuita	-	+
35	*Macrognathus aculeatus*	Tara baim	+	+
36	*Mastacembelus pancalus*	Guchibaim	+	+
37	*Mastacembelus armatus*	Baim	+	+
38	*Monopterus cuchia*	Kuchia	-	+
39	*Lepidocephalusguntea*	Gutum	+	+
40	*Botia Dario*	Rani	-	+
41	*Gudusiachapra*	Chapila	+	+
42	*Corica soborna*	Kachki	+	+
43	*Notopterus notopterus*	Foli	+	+
44	*Notopterus chitala*	Chitol	-	+
45	*Tetredon cutcutia*	Potka	+	+
46	*Parambassislala*	Lal chanda	+	+
47	*Pseudambassis baculis*	Chanda	+	+
48	*Macrobrachium rosenbergi*	Galda	+	+
49	*Macrobrachium rude*	Gurachinghri	+	+
50	*Macrobrachium malcomsonii*	Icha	+	+
Total number of non-stocked species			41	50
Increase in species abundance (%)			**22%**	

(**+)** indicates presence and (**–)** indicates absence of a species

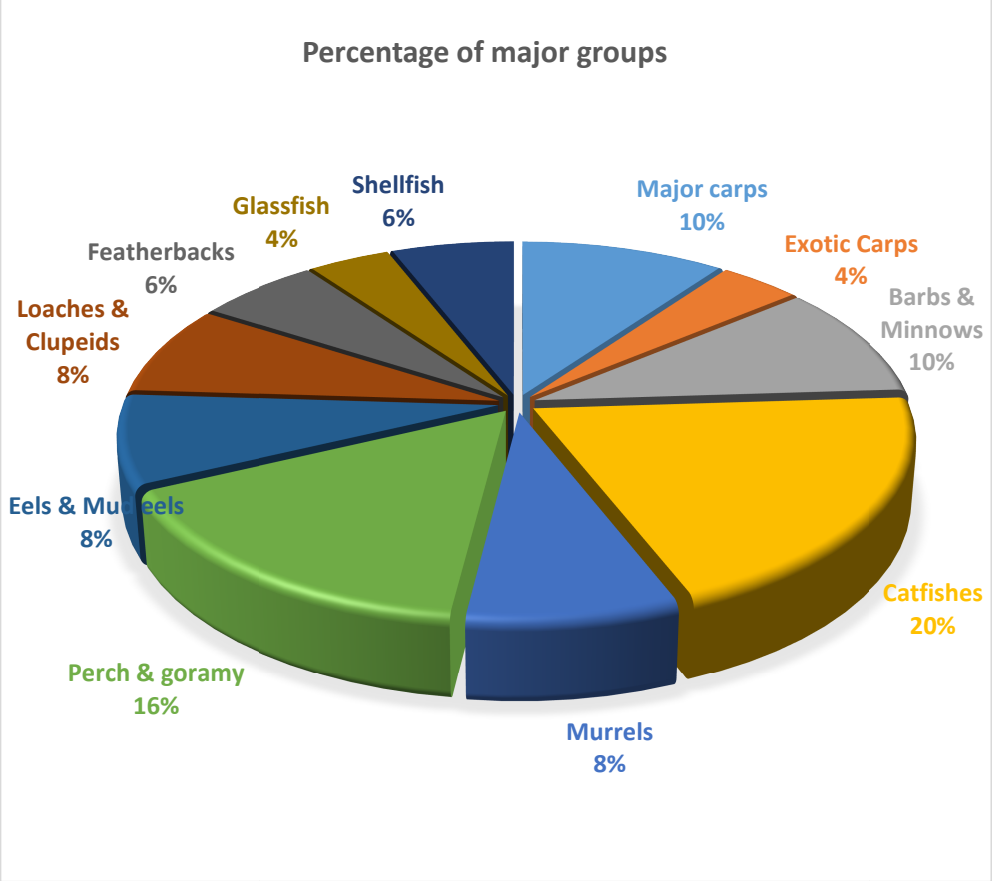


Figure 8: Contribution of the major group of fish in Melan haorfloodplain

Contribution of the major group of fish at Melan haor floodplain

From the study 50 species under 11 major groups were observed at Melanhaor floodplain of which Catfishes found 10 species which consist 20%, Perch and gorami found 8 species which consist 16 %, Major Carp found 5 species which consist 10%, Barb and Minnows found 5 species which consist 10%, Eel and mud Eels found 4 species consists 8%, Murrels found 4 species which consist 8%, Loaches and Clupeids found 4 species which consist 8%, Featherbacks found 3 species which consist 6%, Shell fish found 3 species which consist 6%, Glassfish found 2 species which consist 4% and Exotic carp found 2 species which consist 4% (Figure 8).

In Melan haor floodplain the total fish production was recorded 2781 kg (Table 20). Thetop seven fish species were dominant in catches (49%) and rest of fish species were about 51%. Among them JatPuti (*Puntius sophore)* 416 kg (14.97%), Mola (*Amblypharyngodon Mola*) 149 kg (5.34%), Kachki (*Corica soborna*) 180 kg (6.47%), Shol (*Channa striata*) 155 kg (5.57%), Boal (*Wallago attu)* 161 kg (5.79%), Tengra (*Mystus vittatus*) 157 kg (5.65%), Kankila (*Xenentodon cancila*) 157 Kg (5.65%), and other species 1417 kg (50.96%).

Table 20. Total fish production of main species (top seven) and their % composition in Melan haor floodplain

Sl. No.	Scientific name	Local Name	Total weight (kg)	Weight (%)
1	*Puntius sophore*	Jatputi	416	14.97
2	*Amblypharyngodon Mola*	Mola	149	5.34
3	*Corica soborna*	Kachki	180	6.47
4	*Channa striatas*	Shol	155	5.57
5	*Wallago attu*	Boal	161	5.79
6	*Mystus vittatus*	Tengra	146	5.25
7	Kankila (*Xenentodon cancila*)	Kaikka	157	5.65
8	Other Species	(43 species)	1417	50.96
Total			2781	100

Economic analysis of fish sanctuary in Melan haor floodplain

The economic analysis of fish sanctuary in Melan haor floodplain is presented in Table 21. The total expenditure of fish sanctuary establishment was 72,480.00 Tk. where the construction materials cost such as bamboos, trees, bamboo & tree branches, roots of trees, plastic & iron, and labour cost and boat purchasing cost were included there. The total harvested fish was 2781 kg where low price small fish 2410 kg and valued fish such as Boal, Shol, Magur, Shing, Ayer, Pabda, Gulsha etc. were 371 kg. The average price of small fish was 75.00 Tk/kg and valued fish was 395.00 Tk/kg. So that the total fish selling price was Tk. 327,295.00. Therefore, the net profit from the fish sanctuary was Tk. 254,815.00 and the cost-benefit ratio was 1:4.51, which was comparatively higher due to aggregating more fish in the a small area like sanctuary with undisturbed environment.

Table 21. Economic analysis of fish sanctuary in Melan haorfloodplain

Economic parameters	Unit price	Taka
3) Construction materials		
a) Bamboo- 120 nos	250.00	30000.00
b) Hizol trees 3 pcs	550.00	1650.00
c) Branches of bamboo	1200.00	1200.00
d) Roots of different trees	2800.00	2800.00
e) Nylon (Plastic) rope 20 kg	118.00	2360.00
f) Iron wire 3 kg	90.00	270.00
2) Boat purchase-1 no	9000.00	9000.00
3) Labour cost (40 day labour)	500.00	20000.00
4) Other management cost	LS	5200.00
Total Cost		**72,480.00**
Fish selling price 2781 kg (low price small fish 2410 kg & valued fish 371kg)	Average price: Small: 75.00 Tk Valued: 395.00 Tk	**327,295.00**
Net profit (Tk)		**254,815.00**
Benefit-cost ratio (BCR)		**1:4.51**

Expt. 4: Effect of Dietary Probiotic Supplementation on Growth and Survival of Sutchi Catfish, *Pangasius hypophthatmus* at Different Stocking Density under Cage Culture

Catfishes are hardy fish that can survive in kind of regions and they are easy to farm especially in warmer climatic conditions. Among the exotic Catfish species *Pangasius hypophthalmus* is one of the most profitable commercial Catfish species of Bangladesh. Naturally it is herbivorous fish. The growth of *P. hypophthalmus* shows a positive correlation with protein level of supplemented diet (Sarker *et al.,* 2018). However, protein quality of feed is also a vital factor for fish growth (Sayeed *et al*., 2009). The increased protein level in fish feed makes the production cost higher and increases the chance of feed waste. Probiotic supplementation could decrease the feed cost by increasing efficient nutrient uptake that ensure robust growth with lower protein level. Beside, probiotics increases the amount of beneficial gut microbiota reducing the chance of harmful bacterial attack. Probiotics also keep the watery environment healthy giving an opportunity for fish stocking at a higher density without any chance of poor water quality (Krishna *et al*., 2015). This study focuses on the intensification of *P. hypophthalmus* culture in the haor floodplain with a short term return in a cost-effective manner.

Methodology

Study area and study period

The experiment was conducted in a floodplain of Chatol beel situated in Amura Union, Golapganj Upazilla, Sylhet and necessary laboratory work was done inside the post-graduate laboratory of the Department of Fish Biology and Genetics, Faculty of Fisheries, Sylhet Agricultural University, Sylhet. However, the feed composition was analyzed from the Quality Control Laboratory, Department of Fisheries, Dhaka. The study was carried out for a period of 90 days, 1 July to 30September 2018 in 9 cages. The water availability in this floodplain is about 5-6 months generally from July to December. During dry season, this floodplain turned into dry lands and local people used this chunk of land to cultivate paddies and vegetables.

Preparation of cage and set up

Experimental cages were used for culture of *P. hypophthalmus*. Frame of cage was made of GI pipe. Plastic drum materials were used as float. Floating net cages having a volume of 6 m x 3m x 2.1 m with a water level of 1.78 m; were made of knot-less polyethylene net (mesh size 1.0 cm). Net cages were hanged with cage frame using nylon nets. Bamboo made platform was set up over the cages for horizontal movement of fishers that made the feed supply process easier and intensive observation of the cages. Cages were cleaned manually every day.

Experimental design

Cages were stocked with required quantity of fish fingerlings of pangus (*P. hypophthalmus*) at different stocking density with average 50.0 g size in each cage following the experimental design (Table 22).

Fish stocking

Healthy and uniform sized *P. hypophthalmus* fish were collected from different commercial hatchery and kept in a rectangular hapa for 2 weeks acclimatization. The total number of stocked fingerlings was 6300. The

length and weight data of fish sample was recorded properly before stocking in the pond according to the design of the experiment.

Table 22. Stocking density *P. hypophthalmus* in cage cultureunder three different treatments

Treatment	Replication	Stocking Density (fingerlings/m^2)	Feed Type	Dose of Probiotics (g/Kg)
T_1	3	25	Mega Feed (Spectra Hexa Feeds Ltd.)	2
T_2		22		
T_3		19		

Supplemental diet

The stocked fry of Tilapia were fed with commercial Mega floating feed containing about 28% protein certified by Quality Control Laboratory, Department of Fisheries, Dhaka (Table 23).

Table 23: Proximate composition of supplemented feed used in the experiment

Major composition of diet	Amount of composition (%)
Crude protein % (lowest)	27.25
Moisture % (highest)	8.75
Fat % (highest)	3.15
Fiber % (highest)	8.29
Ash % (highest)	10.87

Probiotic bacterial strains

In this experiment, Safegut was used as supplemented probiotics marketed by *Eskayef Bangladesh Ltd*. The probiotic is composed of different bacterial strain associated with digestive enzymes and vitamins (Table 24).

Table 24. Proximate composition of probiotic used in the experiment

Active Ingredient	Activity/Conc.	Active Ingredient	Activity/Conc
Lactic Acid *Bacillus*	2-3 Billion CFU/g	Vitamin B6	NLT 5 mg/g
Bacillus subtilis	0.5-1 Billion CFU/g	Vitamin C	NLT 10 mg/g
Bacillus licheniformis	0.5-1 Billion CFU/g	Amylase	NLT 100 SKB U/g
Aspergillus oryzae	0.1-0.3 Billion CFU/g	Protease	NLT 100 HUT U/g
Aspergillus niger	0.1-0.3 Billion CFU/g	Phytase	NLT 10 FTU U/g
Saccharomyces boulardii	0.2-0.5 Billion CFU/g	Cellulase	NLT 100 CMC U/g
Vitamin B_1	NLT 5 mg/g	Starch as a Diluent	

Feeding strategy

Commercial Mega floating feed was used for feeding purposes. Feeding was started at 10% of body weight of fish initially and gradually decreased up to 2% until the end of the study. Probiotics were measured in an

electrical balance and these were used at a rate of 2 g/Kg of feed. Firstly, these were mixed with water and then mixed with feed and air dried feed were broadcasted over the cages at required amount. Feeds were applied twice a day (09:00 p.m. and 03:00 a.m.). Feeding rates were adjusted every 15 days intervals depending on the body weight of stocked pangus. Net of the cages were cleaned and checked at weekly intervals. Behavior of pangus was regularly observed especially after providing feed, in the morning and in the evening to determine their conditions such as movement, infection, colorations and diseases. Sampling was continued until harvesting.

Sampling of *P.hypophthalmus*

Fortnightly sampling was done to determine the growth of pangus and to adjust the feed rations. Growth was measured with digital balance. Length of fish was measured by a measuring scale.

Estimation of growth, yield and survival of *P. hypophthalmus*

Pangus were harvested after 90 days of culture. They were caught from each cage at the same day. After harvesting, all Tilapia of each cage were counted and weighed individually to ascertain the growth, survival and production.

Growth and Survival Analysis

Specific growth rate (SGR), food conversion ratio (FCR), protein efficiency ratio (PER) and survival (%) were calculated following the equation as cited by Ricker (1975). The equations are as follows:

i. $\text{Weight Gain (g)} = \text{Final Weight} - \text{Initial Weight}$

ii. $\text{Survival Rate (\%)} = \frac{\text{Final Number of Fish}}{\text{Initial Number of Fish}} \times 100$

iii. $\text{Relative Growth Rate (RGR) (\%)} = \frac{\text{Final Weight} - \text{Initial Weight}}{\text{Initial Weight}} \times 100$

iv. $\text{Specific Growth Rate (SGR.) (\%/Day)} = \frac{\{\text{Ln (Final Weight)} - \text{Ln (Initial Weight)}\}}{\text{Duration (Days)}} \times 100$

v. $\text{Feed Conversion Ratio (FCR)} = \frac{\text{Dry Feed Consumed}}{(\text{Fish Final Weight} - \text{Fish Initial Weight})}$

Fish Yield

vi. $\text{Gross Yield} = \text{No. of Fish Caught} \times \text{Average Final Weight}$

vii. $\text{Net Yield} = \text{No. of Fish Caught} \times \text{Average Weight Gained}$

Economic analysis

viii. $\text{Net Profit} = \text{Total Return} - \text{Total Cost}$

ix. $\text{BCR} = \frac{\text{Total Return}}{\text{Total Cost}}$

Water quality monitoring

Water quality parameters of water such as temperature, transparency, dissolved oxygen (DO), pH and ammonia were recorded at fortnightly intervals at 09-10 am in each sampling. Water temperature was

measured in situ using a standard centigrade thermometer. Transparency was recorded using Secchi disc. Dissolved oxygen, pH and TDS were measured using Digital Multi Meter (Model: CPD-65N). Ammonia were measured using ammonia test kit.

Statistical analysis

Growth, survival and production parameters were analyzed using one way analysis of variance (ANOVA) to compare the treatments means. Post hoc analysis among groups after finding significant differences were carried out by Duncan's multiple-range test. The level of significance was accepted at $p<0.05$ using IBM SPSS (Statistical Package for Social Science) version 23.

Result and Discussion

Growth, yield and survival estimation

The growth, survival and production of pangus (*P. hypophthalmus*) in three treatments are shown in Table 25. However, some features of growth and production of selected species are mentioned below:

Table 25. Growth, survival and production performance (mean ± SD) of pangus in three treatments during the study period

Parameters	Treatments*		
	T_1	T_2	T_3
Stocking density (nos./m^2)	25	22	19
Average initial weight (g)	50.85 ± 0.07	51.15 ± 1.06	51.15 ± 0.92
Average final weight (g)	754.00 ± 2.83	781.50 ± 4.95	769.00 ± 5.66
Net final weight gain (g)	703.15 ± 2.76 ^{a}	730.35 ± 6.01 ^{b}	717.85 ± 6.58 ^{c}
Daily weight gain (g)	7.81 ± 0.05 ^{a}	8.12 ± 0.12 ^{b}	7.98 ± 0.12 ^{bc}
FCR	1.28 ± 0.04 ^{a}	1.21± 0.07 ^{b}	1.25 ± 0.05 ^{ac}
Survival (%)	94.63 ± 2.86 ^{a}	96.43 ± 1.65 ^{b}	95.58 ± 2.23 ^{bc}
Specific growth rate (% /day)	3.00 ± 0.03 ^{a}	3.03 ± 0.06 ^{b}	3.01 ± 0.05 ^{ac}
Gross production (kg/m^2)	18.85 ± 0.41 ^{a}	17.19 ± 0.31 ^{b}	14.62 ± 0.36 ^{c}
Net production (kg/m^2)	17.58 ± 0.41 ^{a}	16.07 ± 0.31 ^{ab}	13.65 ± 0.32 ^{c}

* Mean values in the same row with same superscript letters are not significantly different ($p<0.05$)

Average body weight (ABW) of Pangus during stocking was same of 50 g in all cages. Growth of pangus in all treatments increased throughout the culture period. The highest mean final weight was recorded in T_2 (781.50 ± 4.95 g) and the lowest in T_1 (754.00 ± 2.83 g). Significantly ($p<0.05$) higher final weight gain of Tilapia was found in T_2 (730.35 ± 6.01 g) than those of T_1 (703.15 ± 2.76 g) and T_3 (717.85 ± 6.58 g) (Table 25 and Figure 9).

In the present study, Significantly ($p<0.05$) highest weight gain of *P. hypophthalmus* was found to be 8.12 ± 0.12 g in T_2 by rearing for 90 days at 22/m^2 density and supplemented with floating feed followed by 7.98 ± 0.12 g and 7.81 ± 0.05 g in T_3 and T_1 respectively (Table 25 and Figure 10 a).

Food conversion ratio (FCR) of sutchi Catfish in the present investigation was ranged between 1.21—1.28. During the study period the FCR in three treatments were 1.28 ± 0.04, 1.21± 0.07 and 1.25 ± 0.05 in T_1, T_2, and T_3 respectively. FCR was significantly ($p<0.05$) lower in T_2 (1.21) than that of T_1 (1.28) and T_3 (1.25) but FCR was not significantly different in $T_1$and T_3 (Table 25 and Figure 10 b).

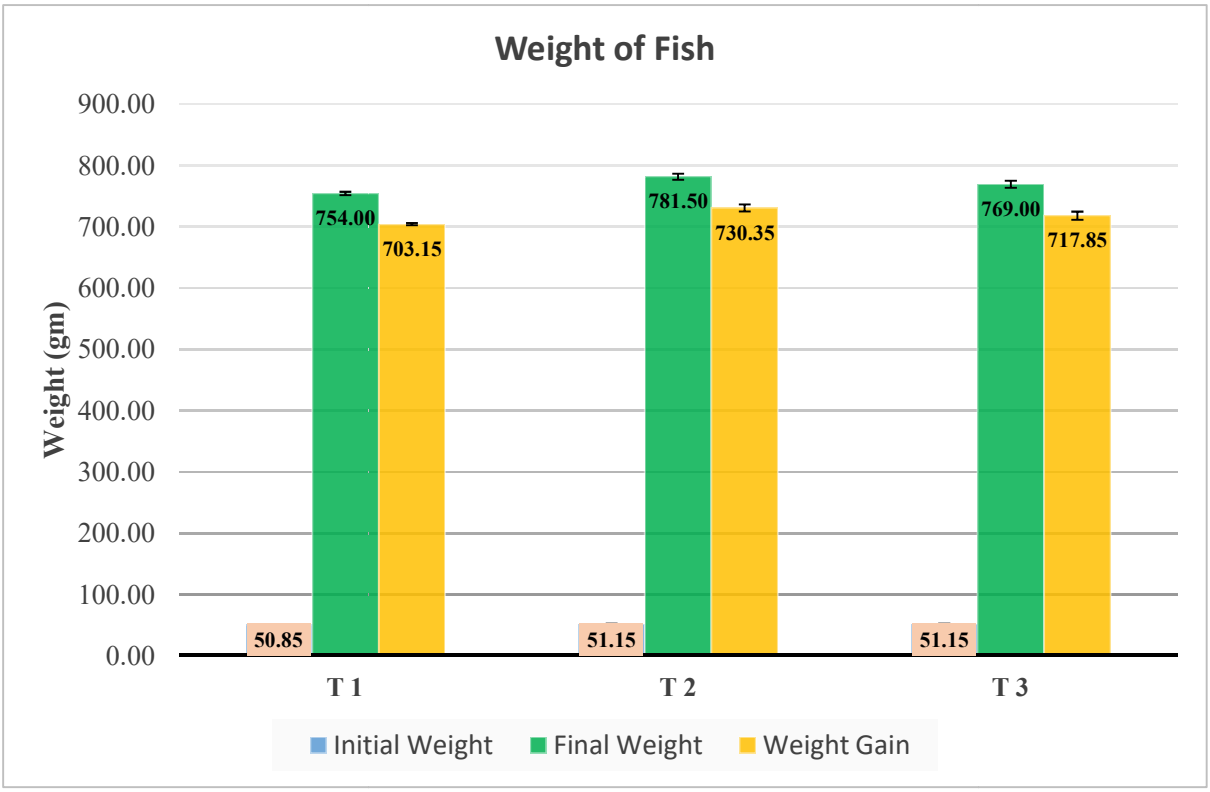
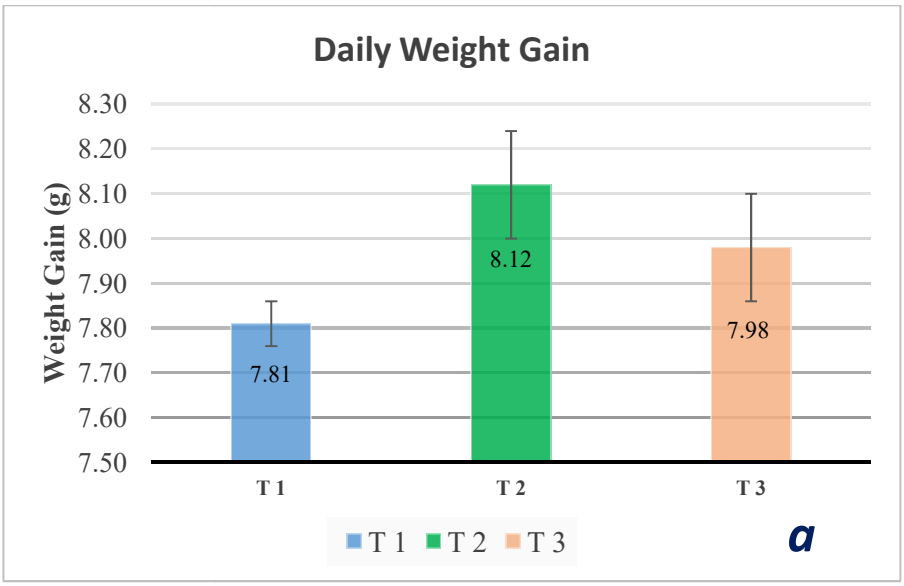


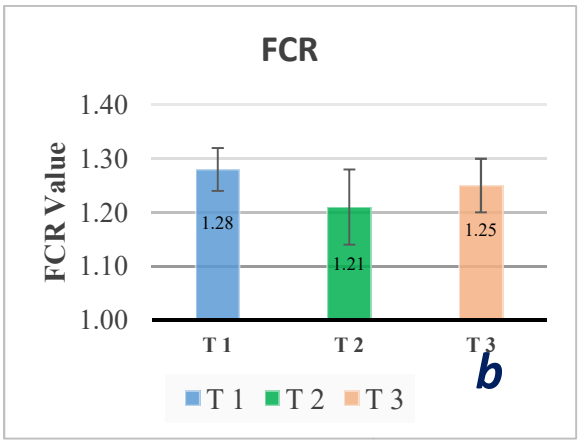
Figure 9: Weight of *P. hypophthalmus* (each of the clustered bar represents weight of fish giving a comparison between different treatments)

The survival of pangus was ranged between 94.63 to 96.43%. The survival was 94.63 ± 2.86, 96.43 ± 1.65 and 95.58 ± 2.23 in T_1, T_2 and T_3, respectively. Higher survival of pangus was found in T_2 (96.43 %) and lower in T_1 (94.63 %). Significant difference among the three treatments was not observed (Table 25).

The mean specific growth rate (SGR) of pangus in different treatments was 3.00 ± 0.03, 3.03 ± 0.06 and 3.01 ± 0.05 in T_1, T_2 and T_3 respectively. Significantly ($p<0.05$) highest SGR value (3.03) was found in T_2 whereas the lowest SGR value (3.00) was found in T_1 (Table 25 and Figure 10 c).

Previously, Sayeed *et al*. (2009) found a higher growth (838 g) of Thai pangus with commercial feed (32% protein) and moderate growth (786 g) with handmade diet (28.61% protein) in polyculture from a culture period of 11 months. That study also revealed best FCR (1.96) and SGR (1.60%) with commercial diet (32% protein). The growth pattern of pangus in our study significantly better with previous study. However, Sayeed *et al*. (2009) documented survival of Thai pangus nearly about 97% which is more or less similar with our study.





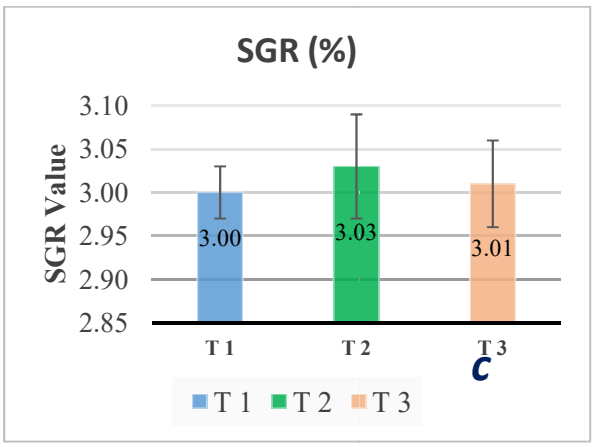


Figure 10: Growth parameters of *P. hypophthalmus* (a) The daily weight gain was ranged between 7.81 to 8.12 with a highest daily weight gain in the Treatment 2; (b) The FCR value of fishes were satisfactory with probiotic treatment. However, the FCR varied among treatments representing lowest FCR in the Treatment 2; (c) Highest specific growth rate was found in Treatment 2 while the rest of the treatment show more or less similar SGR value

Economic analysis

After 90 days of culture period, the range of profit of pangus was Tk. 11692.56 to 14259.08 in three treatments. The net profit in three treatments were Tk. 14259.08 (T_1), 14052.82 (T_2) 11692.56 (T_3), respectively. Higher profit was obtained in T_1 (Tk. 14259.08) than those of T_2 (Tk. 14052.82) and T_3 (Tk. 11692.56) but there was no significant different between $T_1$and T_2 (Table 26).

It was found from the experiment that the cost benefit ratio was 1.37, 1.45 and 1.40 in T_1, T_2 and T_3 respectively. The cost benefit ratio was highest in T_2 (1.45) and the lowest was in T_1 (1.37) (Table 26).

Table 26. Economic analysis of pangus (*P. hypophthalmus*) production/cage (32 m^3) in different treatments during the study period

Economic Parameter	Treatments		
	T_1	T_2	T_3
Price of each fingerling (Tk)	6.00	6.00	6.00
Total cost of fingerlings (Tk)	4800.00	4200.00	3600.00
Price of feed/kg (Tk)	46.40	46.40	46.40
Total feed used (kg)	685.00	600.00	515.00
Total feed cost (Tk)	31784.00	27840.00	23896.00
Total probiotic cost (Tk)	1637.92	1433.18	1228.44
Cage Making Cost Sharing	750.00	750.00	750.00
Total operational cost of each cage (Tk.)	**38971.92**	**34223.18**	**29474.44**
Average production per cage (kg)**	532.31	482.76	411.67
Average fish selling price (Tk/kg)	100.00	100.00	100.00
Total selling price of fish crop (Tk)	**53231.00**	**48276.00**	**41167.00**
Net Profit (Tk)	**14259.08**	**14052.82**	**11692.56**
Benefit-Cost ratio (BCR)	**1:1.37**	**1:1.45**	**1:1.40**

Finally, we may conclude that pangus could be stocked at 22 nos/m^2 (T_2) which was better than other treatments in all aspects. Therefore, the fish farmers may be encouraged to use the probiotics for accelerating fish production with a higher density.

Water quality parameters

Environmental parameters play an important role on the production of fish and other aquatic organisms. Suitable water quality parameters are pre-requisite for a healthy aquatic environment and for the production of sufficient fish and fish food. The water quality parameters are shown in Table 27.

Table 27. Water quality parameters (mean ± SD) recorded from the cages during the study period

Date	Temperature	Transparency (cm)	DO (ppm)	pH	Ammonia (mg/L)
01.07.2018	29.33	36.33	5.2	6.8	0.01
15.07.2018	29.75	35.62	5.1	6.7	0.01
01.08.2018	28.13	34.35	5.8	7.1	0.013
15.08.2018	29.07	35.28	5.4	6.77	0.011
01.09.2018	27.93	35.74	5.9	7.3	0.0135
15.09.2018	27.31	34.59	6.2	7.4	0.0134
Average	**28.60 ± 0.94**	**35.32 ± 0.74**	**5.6 ± 0.43**	**7.01 ± 0.30**	**0.012 ± 0.002**

Water quality parameters of the experimental nylon net cages like temperature, transparency, dissolved oxygen (DO), pH and ammonia were measured fortnightly intervals at 09-10 am in each sampling and are displayed in Table 4.6. Significant variations in water parameters were not found during the study period.

Conclusion

Considering growth, survival, FCR and production of pangus it can be surmized that the vast haor floodplain can be effectively used for culture of pangus compared to closed waterbodies. For intensified culture system, exchange of water is not needed during the culture period to maintain a congenial culture environment by reducing organic load of the culture system. In seasonal/perennial ponds, there is little scope of water exchange due to lack of source water. Open waterbodies are directly/indirectly connected with one another and water management can be suitability done in open water system. Contribution of pangus for enhancement of production in the fishery sector of Bangladesh is increasing day by day. This fish is now extensively cultured in the diverse freshwater/brackishwater systems mostly in earthen ponds. Introduction of pangus cage culture system in the haor waterbodies can enhance the national fish production to a significant level. The results of the present study reveal that the highest production, net return, cost benefit ratio were obtained in T_2 with probiotic supplementation than those of other treatments.

Expt. 5: Impacts of Technological Intervention on Livelihood Status of Fishers' Community in Haor Floodplains

Many research activities have been conducted on socioeconomic aspects of developing crops and livestock, but very little research has been devoted to such type of study on haor floodplain fisheries areas. A good socioeconomic status of the fishers' households had a serious implication for the overall development of the haor floodplain fisheries resources as well as production of the country. Thus before going to improve the haor floodplain fisheries resources by adopting suitable technology, one should have sufficient knowledge about the existing situation and their management practices and the factors which contribute to raise the socioeconomic conditions. The present study was therefore, initiated, with the following objectives:

i) To observe the socioeconomic conditions of the fishers; and
ii) To assess the socioeconomic upliftment of the fishers through adoption of technological intervention.

Methodology

The study was conducted to assess the livelihood status of fishers' community in three haor floodplain areas (Tedala Huglia beel, Chatol beel and Melan haor) during technological intervention. The study was based on personal interview of fishers, focus group discussions (FGDs) with fishers' community and cross-check interviews with key informants (KI). Semi-structured interview schedule was developed and used to collect data related to livelihood and socioeconomic variables of the 100 fishers from 3 sites of haor floodplain area.

Field survey and data collection

For collecting data on various aspects of socio-economic condition of fishers, FGD and field survey were conducted in three (03) haors floodplain area namely- i) Tedala Huglia beel floodplain in Sumanganj; ii) Chatol beel floodplain in Golapganj, and iii) Melan haor floodplain in Sylhet. An initial livelihood information (baseline

survey) was collected from the fishers before intervention of fish culture technologies. Then thefisheries technologieswere adopted in 3 sites according to the research design of the project. After successful implementation of different technologies, the changing livelihood conditions were measuredthrough socioeconomic data collection from the same community. Three different groups (community members) were involved separately in different technological packages of fish culture; like Tedala Huglia beel floodplain fishers were involved with cage culture, sanctuary establishment, SIS nursery and fingerling stocking program; Chatol beel floodplain fishers were involved with cage culture, pen culture, SIS nursery, sanctuary establishment and fingerling stocking program; Melan haor floodplain fishers were involved with sanctuary establishment, SIS nursery, pen culture and fingerling stocking program.

Data were collected by using two methods: (a) Prescribed questionnaire survey, and (b) Focus Group Discussion. All members of the community of each site were involved with data collection according to the decision of CBOs meeting. The variables of the socioeconomic survey were as follows:

- Age structure
- Religion
- Educational status
- Occupation
- Sanitation
- Medical facilities
- Annual expenditure
- Annual income.

Data analysis

The collected data was summarized and processed for analysis. These data were verified to eliminate all possible errors and inconsistencies and analyzed with IBM SPSS version 22 to understand the current status of haor floodplain fishers' livelihood of the studied area.

Result & Discussion

The livelihood and socioeconomic characteristics of the fishers in the study area are presented in the Table 28. The socio-economic condition of the fishers in three floodplain areas were very poor. Majority of people had no land of their own. The main occupation of fishers was fishing greatly influences their livelihood. A very few private and Non-government organizations (NGO) is being trying to help them occasionally. In the study area, the observed male and female fishers were 96% and 4%, respectively. Among the 100 fishers' households, it was found that most of the women were involved in domestic activities such as cooking, housekeeping, washing clothes, cow & goat rearing, taking care of children, gear making etc. However the calculating mean values of the livelihood properties of three sites are described below:

Age structure: Three categories of age group such as young age (15 to 30 years), middle age (31-50 years) and old age (51 to above years) were considered to examine the age structure. The baseline study revealed that most of the respondents (54%) belong to the young age where 34.67% was middle age and 11.33% was old age (Table 28). The age structural condition was no change after intervention of the technology because the study period was only 14 months.

Religion: Most of the respondents were Muslim (82%) of which the highest 88% observed in Chatol beel floodplain and lowest 78% in Melan haor floodplain. In the study area 18% was observed in Hindu community of which the highest 20% observed in Tedala Huglia beel floodplain and lowest 12% in Chatolbeel floodplain (Table 28). Religion can play a very important role in the socio-cultural activities of people. It was well known that only the lower caste of the Hindu community engaged in fishing activities (Halder et al., 2012) and found in their study that most of the respondents were Muslim (83.33%), which support the findings of present study.

Educational status: Education can play a vital role in efficient management and operation of farming activities. From the present study, it was found that most of the fisherman was illiterate.Educational status of the fishers has been grouped into four categories according to the level of education. In this study the highest percentage (53%) of respondents were can sign, 10% were totally illiterate, 24.67% primary level and only 12.33% had secondary level (Table 28). There were no reflections of educational status during the study period of the respective sites. Regarding educational level, it was reported that 57% fishermen can sign, 26% were primary level, 10% were secondary level and 7% were totally illiterate (Trina *et al*., 2016) in Dekhar haor Sunamganj.

Table 28. Livelihood status of fishers' community in three haor floodplain areas

Livelihood properties	**Before intervention (% values± SD)**	**After intervention (% values± SD)**	**Comments/effects**
1. Age structure			
Young structure (15 to 30 years)	54.00±1.00	54.00±1.00	No change
Middle aged (31 to 50 years)	34.67±2.52	34.67±2.52	
Old aged (51 to above years)	11.33±2.08	11.33±2.08	
2. Religion			
Muslims	82.00±5.29	82.00±5.29	No change
Hindu	18.00±5.29	18.00±5.29	
3. Educational status			
Can sign	53.00±3.61	53.00±3.61	No change
Illiterate	10.00±4.36	10.00±4.36	
Primary level	24.67±4.16	24.67±4.16	
Secondary level	12.33±2.52	12.33±2.52	
4. Occupation			
Fishing/fisheries activities	74.00±2.65	77.67±3.06	Changing in some extent (positive effect)
Agriculture	16.67±3.06	16.00±4.00	
Day labour	6.33±1.15	6.33±1.15	
Unemployed	3.00±1.00	0.00±0.00	
5. Sanitation			
Semi-pacca latrine	83.00±2.65	83.00±2.65	No change
Pacca latrine	8.00±2.00	8.00±2.00	
No latrine	9.00±1.00	9.00±1.00	
6. Medicinal facilities			

From sadar hospital	33.33±2.89	37.67±2.52	Changing in some extent (positive effect)
Kobiraj	23.33±4.16	15.00±3.00	
Homeopathic	10.00±2.00	9.33±2.31	
Village doctor	28.67±2.31	41.00±1.00	
Private doctor	4.67±0.58	35.00±4.58	
7. Annual Expenditure			
Food	81.67±2.08	81.00±1.00	Changing in some extent (positive effect)
Clothing	5.00±1.00	6.33±0.58	
Education	1.33±0.29	2.33±0.58	
Health care	10.67±0.67	9.00±1.00	
Entertained	1.33±1.00	1.33±0.58	
8. Annual income			
High income (above 100000 Tk)	11.67±1.53	15.00±1.73	Changing in some extent (positive effect)
Medium income (61000-100000 Tk)	30.67±3.79	30.67±2.52	
Lower income (40000-60000 Tk)	57.66±4.93	54.33±4.04	

Occupation: Fishing in haor waterbodies was the main job for the entire fishermen community. Some people were involved in only fishing and some were involved in seasonal agricultural activities. The people depend on different occupations on the basis of fishing season and off season. In off season some people go to other area as day labour for agricultural activities. But in fishing season, their main earning purpose was fishing and selling them into market. In the study area, they were found to be involved in catching fish; some of them were engaged in agricultural and day labour activities as their secondary occupation. From baseline information, it was found that most of the fishers (74%) to be involved only in fishing/fisheries activities for conducting their livelihood (Table 28). Some fishers (16.67%) were involved in seasonal agriculture and some people go to other areas as day labour (6.33%) for agricultural activities in off season, they were also seasonal catcher. Only 3% fishers were unemployed, actually they were not involved with main occupations of their livelihood expenditure. After successful implementation of the project activities, the frequency of occupations were little bit changed in some extent due to project support. Therefore, the unemployed persons were involved with fishing/fisheries activities. As a result the involvement of main occupation of fishing/fisheries activitieswas increased as 77.67%that was the positive impact of the project for some employment opportunities.

Sanitation facilities: There were two types of sanitation facilities available in haor basin- Service latrin and Semi-pacca latrine. From the present study, most of the facility has got from NGO's. They gave some ring-slab and people were using thisring as their sanitary latrine. Most of the households (83%) were using semi-pacca latrine. But there were 8% households who were using pacca latrine and 9% households were using open field or no latrine (Table 28). The sanitation facilities were not changed after technological intervention during the stipulated time of the project. Trina *et al*. (2016) reported that about 75% household were using semi-pacca latrine, but there were 15% households who were using pacca latrine and 5% households were using open field in haor area of Sunamganj, which supports to present study.

Medical facilities: The people of haor area were living below poverty line. Though there were government upazila hospitals in each sadar Upazila but they have to spend money on buying the medicine. The baseline result of survey was that 33.33% people get medical facilities from upazila sadar hospital, 23.33% people go to nearby kobiraj, 10% go for homeopath medicine, 28.67% people go to village doctor and rest of 4.67% people go to private doctor at town for their treatment (Table 28). After technological intervention the occupying of medical facilities were changed in some extent due to awareness built up of fishers through training program and communication networking. As a result some people were interested to take better medical facilities and going to sadar hospital, village doctor and private doctor. The changing result was 37.67% people go to sadar upazila hospital, 15% people go to kobiraj, 9.33% go for homeopathic treatment, 41% go to village doctor and 35% go to private doctor at town level clinic (Table 28).

Annual expenditure: Family expenditures are completely dependent on the household incomes.The highest expenditure of household income was food in haor floodplain areas. In baseline information recorded that they spent 81.67% of their income on the food item and 10.67% on health care. A very little money has been spent on clothing (5%), entertainment (1.33%) and education (1.33%) (Table 28). A matter of sorrow was that they do not want to spend money on study purpose. They send their children into school at nearby government primary school. But after primary level, a very few children may go to secondary school. After technological intervention the expenditure were changed in some extent due to increase of income and awareness of the fishers specially clothing (6.33%) and educational purpose (2.33%) (Table 28).

Annual Income: From the survey almost all the female were involved in household work and only male were involved in earning activities. The annual incomes of the people of selected haor area were classified into three categories. The highest annual income group was above 100,000 Tk/year. Medium income group had been categorized as 61,000-100,000 Tk/year and lower income group was between 40,000-60,000 Tk/year. According to the baseline information about 11.67% people who were highest annual income earner (above 100,000 Tk/year), 30.67% were medium income earner (61,000-100,000 Tk/year) and 57.66% were lower income earner (40,000-60,000 Tk/year) (Table 5.1). After technological intervention the annual income was changed in some extent due to increase of annual income and awareness of the fishers through involvement of project activities. Therefore, the highest annual income earner household was increased 15% instead of 11.67%. On the other hand medium income earner group was unchanged, it was observed same to the previous state (30.67%) and the number of lower income earner household was slightly decreased from 57.66% to54.33% during the study period (Table 28). The study revealed that household income was increased in certain household that's why percent (%) of higher income group was increased and lower income group was decreased. The related study by Trina *et al*. (2016) reported that 70% people's earned 40,000-60,000 Tk/year, 20% earned 61,000-99,000 Tk/year and 10% earned 100,000- above Tk/year in haor area of Sunamganj, which support to the findings of the present study.

Considering three (03) floodplain base analysis report of household annual income by the participated community people the Figures 11, 12&13 are presented below. In Figure 11 represented the annual income of fishers' family in Tedala Huglia beel floodplain area in Sunamganj. The high income group members were increased from 10% to 14%, where lower and medium income group members were decreased.

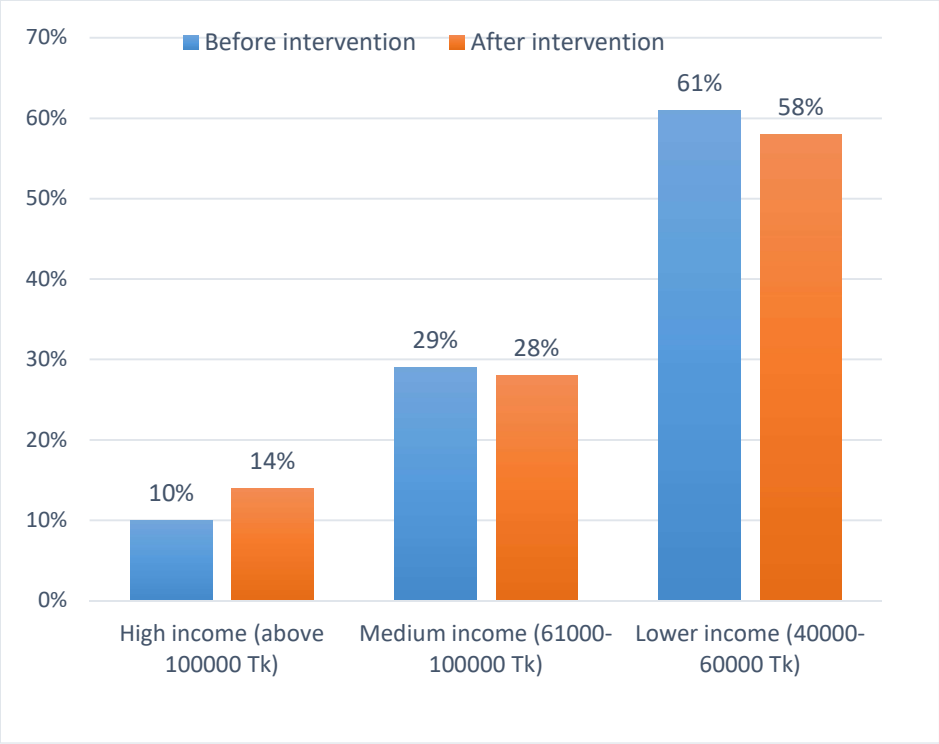


Figure 11: Annual income of fishers' family (%) in Tedala Huglia beel floodplain area

In Figure 12 represented the annual income of fishers' family in Chatol beel floodplain area in Golapganj. Here the high income group members were increased from 13% to 17%, where lower and medium income group members were decreased.

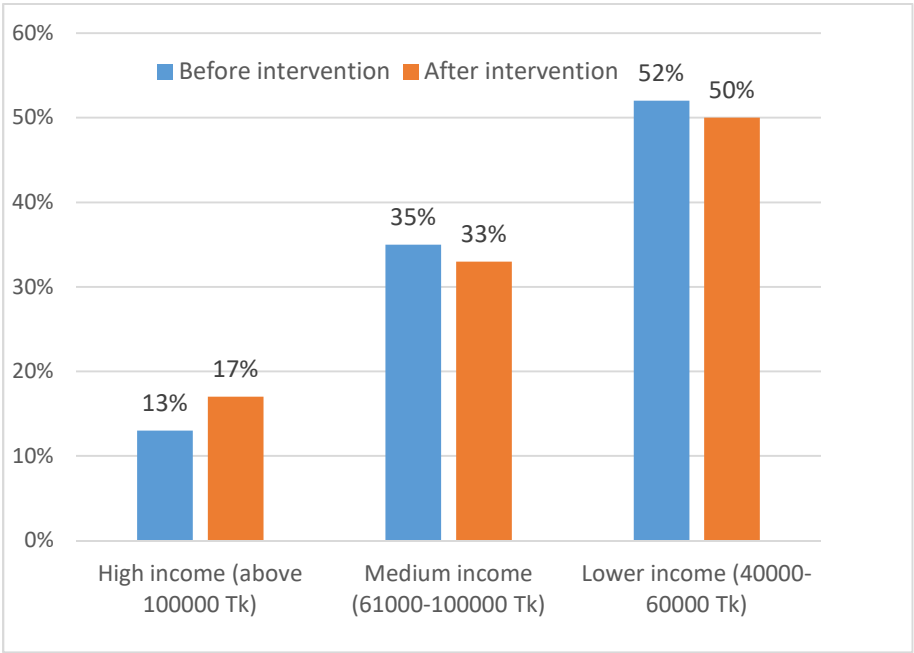


Figure 12: Annual income of fishers' family (%) in Chatol beel floodplain area

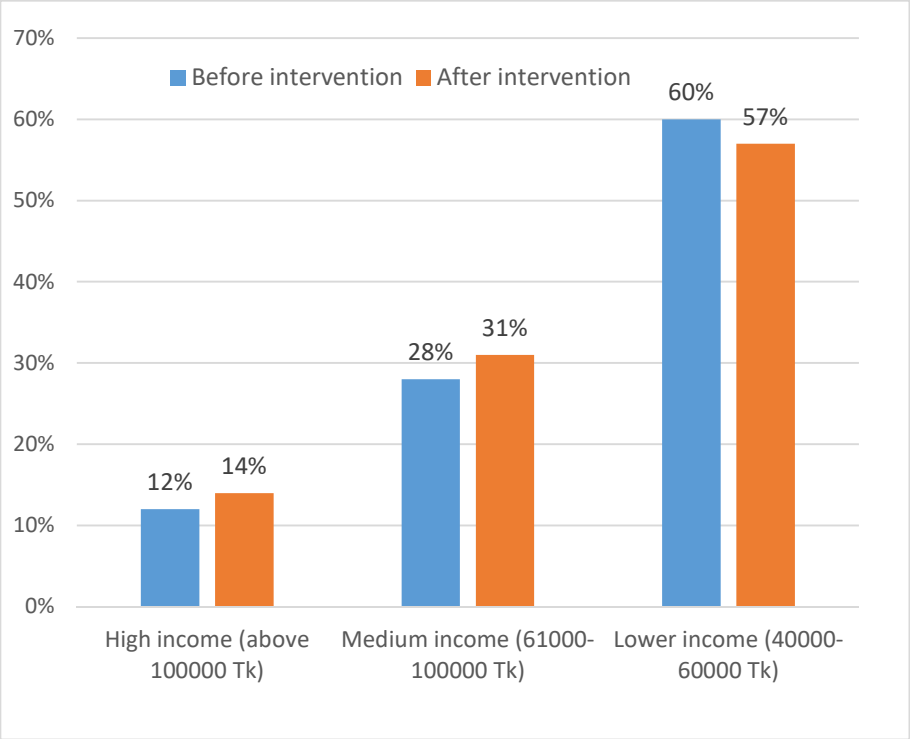


Figure 13: Annual income of fishers' family (%) in Melan haor floodplain area

In Figure 13 represented the annual income of fishers' family in Melan haor floodplain in Sylhet. The high income group households were increased from 12% to 14%, where lower and medium income group members were decreased. However it is concluded that the fisher's annual incomes of three sites were increased due to technological intervention under project supports. As because the fishers family were involved in fish culture under the financial help from the project and uphold their annual income.

Observation and comments

Livelihood situation of fisher's community in three (03) selected haor floodplain areas were not satisfactory. The fisher's communities were deprived of many aMenities. They are mostly poor, illiterate, low income earner and deprived from the actual rights to the waterbodies. They also deprived from real housing, sanitation, education and health facilities. Most of the fishers were very poor and they have limited resort to buy nets and other fishing equipment. They are neglected in all respect in the society. The fishers' family should be educated and trained to build up awareness in them to improve their socio-economic condition. Government and NGOs participation are very much important for improving the fishers' communities especially in education, health, credit facilities and scope of income generating activities.

However, after technological interventions some indicators/variables of socioeconomic conditions were remain changed in some extent specially occupation, medical facilities, annual expenditure and annual income. That could be a positive effect for upliftment of fishers' livelihood of haor floodplain areas. As because the fishers family were involved with project activities and they were benefited for the financial help, logistic support, and motivational and awareness supports from the project personnel.

11. Results and Discussion

Technological interventions had significant beneficial effect on fish production in the selected seasonal floodplains. A pronounced increase in fish production was clearly demonstrated in the selected haor floodplainconcurrent with increase in the abundance of non-stocked small indigenous fishes. Technological interventions enhanced the fish production and biodiversity fish species in terms of both quality and quantity. However, different interventions are discussed below:

Growth and production performance of Cage culture

The growth and production performance of monosex male Tilapia (*O. niloticus*) was found to be satisfactory level and was not varying among the cage due to using same commercial Mega feed. The average final length and weight of fingerling of Tilapia during harvesting was recorded in 20.70±0.46 cm, 204.28±7.96 g, respectively in Sunamganj site and 20.90 cm, 209.00±9.18 g, respectively in Golapganj site. The total fish production was recorded 160.31 and 164.50 kg/cage in Sunamganj and Golapganj site respectively during 90 days culture period.

It was also found that Panguscan be cultured in cage culture system at haor floodplain under suitable areas and production was quite satisfactory level. The highest mean final weight was recorded in 781.50±4.95 g and the lowest 754.00±2.83 g with the average highest production was 532.31 kg/cage and the lowest production was 411.67 kg/cage.

Pen enclosure in haor floodplain

The study concerned about the growth and production of fishes and availability of aquatic inhabitants in Chatol beel floodplain under pen culture technology covering an area about 2.43 ha for a period of 135 days. The gross fish production of pen was 5282.9 kg, which included 4684.9 kg from stocked fish and 598 kg from non-stocked fish. The small indigenous species of fish (SIS) was dominant in the catches of non-stocked fish. A total 9 species of phytoplankton, 5 species of zooplankton, 21 aquatic weeds and 9 taxa of benthic fauna were observed. The net profit was 2,93,156 Tk and cost-benefit ratio was 1:1.8, which delineate that composite fish culture through pen culture technology in floodplain area has immense possibilities for increasing fish production and financial gains.The present study also revealed that utilization of seasonal floodplains through pen culture technology can be considered very significant in different aspects, mainly for increasing fish production, financial profits and creating employment opportunities.Enclosure of the pen should be made and installed in such a way which can facilitate entry of other fish hatchling and larvae to ensure natural production.Culturing fish by pen technology is not so costly and can be very beneficial, rural people can practice this culture technique in unused water bodies.

Fish sanctuary enhanced biodiversity in haor floodplain

Sanctuary establishment plays a vital role for increasing fish production and biodiversity in haor floodplain fisheries. The study revealed that the fish production of stocked and non-stocked fishes and biodiversity was increased in all cases of haor floodplain. The biodiversity was increased in all cases due to establishment of fish sanctuary in haor floodplain areas. The species abundance was increased17% to 25% during study period in different floodplain sites comparing initial base level population. The total fish production of floodplain increased upto 461 kg/ha/yr and 497 kg/ha/yr compared to the baseline production was recorded 216 kg/ha/yr and 200 kg/ha/yr, respectively in different floodplain.

Socioeconomic benefits of fishers

In the study areas, the livelihood situation of fisher's community was not satisfactory. The fisher communities were deprived of many amenities. They are mostly poor, illiterate, low income earner and deprived from the actual rights to the waterbodies. After technological interventions, the socioeconomic indicators improved to some extent specially occupation, medical facilities, annual expenditure and annual income. That could be a positive effect for upliftment of fisher's livelihood of haor floodplain areas. As the fisher's families were involved in project activities and were benefited in terms of financial assistance, logistic support, motivational and awareness supports from the project personnel for upholding their annual income.

Finally, Technological intervention was found to be very conducive in enhancing the fish production and biodiversity of the wild fishes. Increased availability of the wild species of fishes in the experimental seasonal floodplains could be attributed to easy entry of larvae, hatchlings and juvenile fishes to the concerned floodplains through the spacing between the bamboo slates of the fences.Further studies should be conducted to determine the efficacy of various technological options to maximize fish production in haor floodplains in different locations.

12. Research highlight/findings:

- Cage culture, pen culture and sanctuary establishment plays a vital role for the improvement of fish production in haor floodplain fisheries under CBFM approach.
- The production performance of monosex male Tilapia (*Oreochromis niloticus*) under cage culture was found to be satisfactory in haor floodplain. The yield was recorded 160.31-164.50 kg/cage for 3 months culture period in 27 m^3 size cage.
- The growth performance of Pangus (*P. hypophthalmus*) with dietary probiotics supplementation under cage culture was found to be satisfactory. The highest fish production was recorded 532.31 kg/ cage during 3 months culture period.
- Rural people can be benefited through Pen culture technology in unused water bodies. The stocked fish production was recorded 1953.90 kg/ha/135 days where non-stocked small fish production was 246 kg/ha. The gross production of non-stocked fish was higher compared to the previous year, indicating that the pen culture enhances natural fish productivity.
- The number of non-stocked fish species increased upto 25%, over the initial baseline population under fish sanctuary establishment in haor floodplain.
- After technological intervention, the fish yield of selected haor floodplain was recorded 497 kg/ha/yr (148.5% increased) while the baseline production was 200 kg/ha/yr.
- The overall fish production increased with subsequent improvement in terms of employment of fishers, annual income and household fish consumption.

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment:					
1) File cabinet	01	20000	01	44000	100%
2) Steel Almira	01	24000	01		
(b) Lab &field equipment:					
1) Electric balance	02	50000	02		
2) Top load scale	03	60000	03	300000	100%
3) Water quality Hachkit (Digital)	01	190000	01		
(c) Computer Accessories:					
1) Laptop	01	60000	01	90000	100%
2) Printer	01	20000	01		
3) Scanner	01	10000	01		
(d) Digital Camera	01	25000	01	25000	100%

2. Establishment/renovation facilities: Not applicable

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

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

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training	50	08	58	1 day	Cage culture, Pen culture and Sanctuary management training program
(b) FGD/Group meeting	54	25	79	1 day	CBOs committee formation, Technological interventions& Project concept

C. Financial and physical progress

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	635554	635554	635554	0	100	Not applicable
B. Field research/lab expenses and supplies	2499083	2321999	2321999	0	100	
C. Operating expenses	397500	394137	394137	0	100	
D. Vehicle hire and fuel, oil & maintenance	162633	134770	134770	0	100	
E. Training/workshop/seminar etc.	179700	179700	179700	0	100	
F. Publications and printing	116530	112530	112530	0	100	
G. Miscellaneous	50000	26169	26169	0	100	
H. Capital expenses	459000	459000	459000	0	100	

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

Specific objectives of the sub-project	**Major technical activities performed in respect of the set objectives**	**Output (i.e. product obtained, visible, measurable)**	**Outcome(short term effect of the research)**
1) To improve the fish yield in haor floodplain through community based management;	a) Baseline survey of floodplain b) Cage culture program c) Pen culture program d) Arrangement of SIS beel nursery e) Stocking of fingerling program in floodplain f) Fish production data collection	a) Fish availability with incremental production from cage culture and pen culture b) Floodplain fish production increased 148.5% c) Stocked fish production was recorded 1953.90 kg/ ha/135 days where non-stocked small fish production was 246 kg/ha in Pen culture	Fish production increased in selected haor floodplain
2) To assess the biodiversity of non-stocked fish species;	g) Establishment of fish sanctuary h) Fishing banned during breeding season for conservation management	Non-stocked fish species was increased 25% over the initial baseline population under sanctuary establishment in haor floodplain.	Natural breeding occurred and re-generation of SIS
3) To uplift the livelihood of community people in haor area.	i) Baseline survey of livelihood status j) Measuring of livelihood status	a) Annual income 23% increased of fishers family b) Fish consumption rate was increased 15% c) Housekeeping 45% and sanitation 10% increased	Subsequent improvement of employment of fishers, income, and household fish consumption

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

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/ flyer etc.	-	01	**Leaflet:**grm¨Rxex‡`i Rxebgvb Dbœq‡b nvIi cøvebf~wg‡Z LuvPvq gvQ Pvl
Journal publication	03	02	**1. Title:** Observation of fish production and availability of aquatic inhabitants under pen culture in Chatol beelfloodplain. **Name of Journal:** International Journal of Fisheries and Aquatic Research, 3(3): 61-68 (2018) **2. Title:** Introduction of Cage culture technology in haor floodplain for upliftment of fishers' livelihood **Name of Journal:** Trends in Fisheries Research (Accepted) **3.** Enhancement fish production and biodiversity through establishment of fish sanctuary in haor floodplain (under process of Preparation) **4.** Dietary Probiotic Supplementation for Enhanced Growth and Survival of Striped Catfish, Pangasianodon hypophthalmus (Sauvage, 1878) at Haor Floodplain in Low-cost Cage Culture System (under processing for publication in the Asian Fisheries Science) **5.** Growth, Yield and Economic Returns of Striped Catfish (*Pangasianodon hypophthalmus*) at Different Stocking Densities under Floodplain Cage Culture System (under processing for publication in the Egyptian Journal of Aquatic Research).
Information development (Project activities broadcasting in Electronic Media)	-	02	• Broadcasting in Electronic Media (TV/ You tube) ATN Bangla, Sonali Din (Date-15.11.2017, 6.25 PM &16.11.2017, 6.30 AM); • Available in YouTube: EPS_87, Sylhet Krishi Uni_ATN. Mp4
Other publications, if any i) MS Thesis (05)	01	04	**Published MS Thesis:** 1. A study on technological intervention for the improvement of haor floodplain fisheries 2. Observation of fish Production and availability of aquatic Inhabitants through Pen culture in Chatol beel floodplain 3. Impacts of community based fisheries management approach on fish production, biodiversity and livelihoods in Chatol Beel floodplain area 4. Effect of fish Sanctuary on Fish Diversity in Melan haor Sylhet **Under preparation MS Thesis:** 1. Probiotic supplementation on growth and survival of Pangas (*Pangasius hypophthatmus*) at different stocking density under Cage culture

ii) News		01	wk‡ivbvg : grm¨Rxex‡`i Rxebgvb Dbœq‡b nvIi cøvebf~wg‡Z grm¨ Drcv`b e„w× I Dbœqb wel‡q M‡elYv Kvh©µg; cÖKvkbv : wm‡jU K…wl wek^we`¨vjq evZ©v 2017 (c„ôv-14)

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

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

Enhancement of fish production and livelihood improvement of fishers through Cage culture and Pen culture technology in haor floodplain

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

Enhancement of fish production and livelihood improvement of fishers through Pen culture technology in haor floodplain

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

Sanctuary establishment in haor floodplain for regeneration of endangered species

iv. Policy Support

An outline of conservation management of haor floodplain fishery

G. Information regarding Desk and Field Monitoring

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

Monitoring team/Officer	Date of visit	Documents studied	Comment/ Output
Dr. Salahuddin Ahmed, Consultant, PIU, BARC	03.01.18	Youtube which Broadcasting in ATN Bangla, Sonali Din (15.11.2017) and progress report	Quite satisfied with the progress of project activities & achievement analysis;
PIU-BARC, NATP-2 (Director, RMS of PIU-BARC; M & E Specialist, PMU)	07.04.18	PowerPoint presentation of project activities	Satisfied with drawn some guideline for successful completion of project
SAURES monitoring team	25.01.18	PowerPoint presentation, discussion and report handover	Progress report with drawback discussion
SAURES Team of Annual Research Review workshop	17.09.18	PowerPoint presentation on Project activities	Abstract published in SAURES Annual Report

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

Monitoring team visit (Respective members)	Date(s) of visit	No of visit	Output
Dr. Salahuddin Ahmed, Consultant, PIU, BARC	03.01.18	01	Project activities monitoring & achievement analysis
PIU-BARC, NATP-2 (Director, RMS of PIU-BARC; M&E Specialist, PMU)	06.04.18-08.04.18	01	Project activities, Sub-project activity presentation and discussion
Internal Monitoring (SAURES) (SAU Internal M & E Team)	25.01.18	01	Progress report with drawback discussion
Others Visitors (if any) (Executive Chairman, BARC)	10.01.18	01	Discussion about progress

H. Lesson Learned

The experiment is somewhat different from plain land closed water aquaculture practices. That's why high degrees of risks are associated that might lead this endeavor towards failure. Support of the nature and availability of all sorts of input and costs within its reach is considered vital factors for the successful completion of the project in addition to technical effort.

I. Challenges

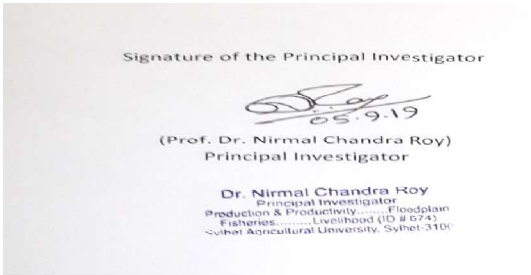
Non-establishment of fishermen's right in haor waterbodies, non-cooperation of CBO members, social conflict and early flash flood or excess surface run off are great challenges for haor fish production and productivity enhancement efforts.

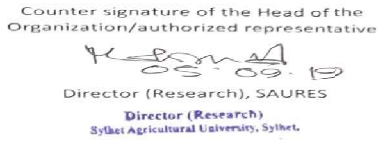
Signature of the Principal Investigator

Counter signture of the Head of the organization/ Authorized signature

Prof. Dr. Nirmal Chandra Roy
Principal Investigator

Director (Research), SAURES





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Some Pictorial Views of Project Activities

Photo 1. Cage culture in Chatol beel floodplain under Golapganj Upazila

Photo 2. Cage culture in Tedala Huglia beel floodplain inSunamganj

Photo 3. Cage culture in Tedala Huglia beel floodplain in Sunamganj

Photo 4. Fish sampling of Cage culture package

Photo 5. Fish sanctuary in Chatal beel floodplain of Golapganj

Photo 6. Fish sanctuary in Tedala Huglia beel floodplain of Sunamganj

Some Pictorial Views of Project Activities

Photo 7. Measurement of water quality parameters under Pen culture

Photo 8. Measurement of water quality parameters under Cage culture

Photo 9. Fish sampling for weight measurement

Photo 10. Tilapia harvested for selling in the market

Photo 11. Cage culture management training program for CBOs

Photo 12. Fish sanctuary management training program for CBO members in Sunamganj

Some Pictorial Views of Project Activities

Photo 13: Fish harvested from Tedala Huglia beel floodplain

Photo 14: Huge Pabda fish harvested from Tedala Huglia sanctuary

Photo 15: SIS harvested from sanctuary of Tedala Huglia floodplain

Photo 16: Fish harvested from Chatol beel floodplain

Photo 17: Fish harvested from Chatol beel floodplain

Photo 18: Fish harvested from Chatol beel floodplain

Some Pictorial Views of Project Activities

Photo 19: Pangus fish sampling for length measuring in cage culture

Photo 20: Melan haor fish sanctuary establishment

Photo 21: Presentation and discussion meeting at SAU, Sylhet with presence of Director, PIU and Monitoring & Evaluation Team, PMU, BARC

Photo 22: Director, PIU, BARC discussed the various issues of project implementation