Effectiveness of community-enterprise approach in promoting crop-fish culture practice in some tidal floodplain areas of Bangladesh

A thesis submitted to the University of Dhaka, in the fulfillment of requirements for the degree of Doctor of Philosophy

Submitted by

Rowsan Ara Begum

Registration Number: 5/2015-2016
Session: 2015-2016
Re-registration number: 91/2020-2021
Session: 2020-2021

Department of Zoology
University of Dhaka
Bangladesh

September, 2022

CERTIFICATION

The dissertation entitled **"Effectiveness of community-enterprise approach in promoting crop-fish culture practice in some tidal floodplain areas of Bangladesh"** submitted to the Department of Zoology, Faculty of Biological Sciences, University of Dhaka, Bangladesh in partial fulfillment of the requirements for the degree of Doctor of Philosophy. I certified that the candidate, **Rowsan Ara Begum** (Registration No. **5/2015-2016, Re reg. No. 91/2020-2021**) has been completed her research under my supervision and suggestions. I have read this dissertation and that, in my opinion, it is fully adequate in scope and quality as a dissertation for the degree of Doctor of Philosophy. The work has not been and will not be presented for any other degree. It is further certified that to the best of our knowledge the thesis contains original research.

Supervisor

Dr. Md. Sagir Ahmed
Professor
Department of Zoology
University of Dhaka

Co-Supervisor

Dr. Md. Abdur Rob Mollah
Professor
Department of Zoology
University of Dhaka

DECLARATION

I do hereby declare that the research work entitled "**Effectiveness of community-enterprise approach in promoting crop-fish culture practice in some tidal floodplain areas of Bangladesh"** submitted to the Department of Zoology, Faculty of Biological Sciences, University of Dhaka, Dhaka, Bangladesh, for the degree of Doctor of Philosophy is the results of my own observations and analysis. The thesis or part of it has not been presented before for any other degree.

Rowsan Ara Begum
Ph.D. Student
Registration No. 5/2015-2016
Re reg. No. 91/2020-2021
Department of Zoology
University of Dhaka
Dhaka

Abstract

Bangladesh has 2.8 million ha floodplain water bodies and these floodplains are essential for the livelihoods of most of the rural people of the country. A study was conducted to assess the impacts of community enterprise approach floodplain aquaculture practices on the local environment, its biota and local production systems in three selected tidal floodplains, namely Jhanjhania Floodplain (FP) in Pirojpur District, and Bisnudia and Uttampurpur Floodplains in Jhalakathi District, located in the southern Bangladesh. In particular, the impacts were assessed in terms of water quality, zooplankton, fish and other aquatic biodiversity, soil fertility and rice production, cropping pattern, abundance of aquatic vegetation, access rights to the floodplain resources by the local people. Field data was collected for the period of three years (2016-2019) with provision for seasonality. Initially, the study focused on the documenting the prevailing environmental quality of the floodplain under the culture practice. Later, concomitantly, data were also collected from three selected control sites, corresponding to each intervention site, with a view to compare the data collected from intervention and control sites in order to able to assess impacts.

A total of 12 physico-chemical parameters, namely water pH, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), salinity, alkalinity, total hardness, total phosphate, total ammonia-N, nitrate-N, ammonia-N, nitrite-N and temperature was monitored quarterly. The values of observed water parameters, particularly that in wet season, represent the typical values for floodplain ecosystem in Bangladesh. There were strong seasonal fluctuations in most measured water parameters. Except pH, salinity and DO levels, in most cases, the intervention sites had higher values for measured water parameters compared to that of control sites.

The zooplanktonic community of the project sites was represented by 45 species, belonging to six major groups, *viz.*, Cladocera (9 sppecies), Copepoda (5 species), Ostracoda (3 species), Rotifera (20 species), Ostracoda (3 species). Protozoa (3 species) and others (2 species). Rotifers, copepods appeared most dominant groups, followed by cladocerans and naupli. Seasonal variations were observed in the abundance of zooplankton in all study sites.

A total of 60 species of fish belonging to 26 families have been recorded from all the three study sites, of which 51 species occur naturally in the wild and 9 species are cultured in the floodplains. Of the stocked fishes, 5 species were exotic. In the studied floodplains showed a declining trend in fish abundances, which is reflective of regional decline in fish abundance. In general, the study sites were comparatively poor in molluscan fauna. In total, six species of molluscs were recorded from the study sites. Three species of crabs and five species prawn were recorded from

the three study sites and all the species were common to fairly common within each site. There is no evidence on the disappearance of any fish species or the other animal species due to project intervention. As per local accounts production of indigenous species in the stocked floodplain has increased which simply reflect the absence of fishing, complete harvest of fish at the outlets, with having any fish escapes.

Soil quality analysis was done only for dry season; both for intervention and control sites, and parameters investigated were organic matter, total nitrogen, phosphorous, sulphur, potassium, pH and electrical conductivity. The results indicated that soil fertility of the study sites was medium to high. The measured soil parameters were comparatively higher in intervention sites compared to control sites and probably resulted from fertilizer and feed inputs and less uptake of soil nutrients by the reduced abundance of aquatic vegetation. As revealed by Focus Group Discussion (FGD) and interview of farmers, the production of crop in Jhnjhania intervention site increased by about 25%, compared to pre-intervention period. Concomitantly, the production cost for HYV boro cultivation decreased at least by Tk. 1500-2000 per bigha as because less labour cost for removal of weeds from land and less use of pesticides in crop field, compared to pre-intervention period. There had been little changes in the cropping pattern in the study sites, except the Bishnudia site, which has been modified to perennial water body dedicated for only fish culture.

While the project has many positive impacts in increasing the fish production and generating income streams for local people, however, future promotion of the initiative should address the constraints identified. The promotion of floodplain fish culture practices must not be done on a large scale in an area in order to avoid the negative consequences on river fisheries and local biodiversity. Since the floodplains are stocked with over wintered or large fingerlings, the inlets to the floodplains could be blocked with large mesh size nets, allowing the lateral migrations of small fish, juveniles even during the grow out period. In any case the inlets (connectivity with the rivers) must not be blocked /closed before the end of Ashar to facilitate lateral migration of fish, fry, etc. The provision for water inlets/outlets should be kept more and as far as possible no inlets should be permanently closed. An alternate livelihood options should be generated to the affected fishers with provision for easy and interest free access to micro-credits and facilitate their access to different welfare service providers. In each stocking floodplain an auto stocked fish pit should be preserved (unfished) to maintain a self-sustaining indigenous fish population. The modification of floodplains to a complete impoundment in the form of a closed water body (as done in Bishnudia) over a large area with complete regulated hydrology only for fish culture purpose must not been done.

Dhaka University Institutional Repository

ACKNOWLEDGEMENT

First of all, I would like to thank and express my gratitude to my supervisor, Dr. Md. Sagir Ahmed, Professor, Department of Zoology, University of Dhaka, for his valuable suggestion, necessary counsel, constructive criticism, cooperation, and continuous improvement inspiration throughout the research work. The door to Dr. Md. Sagir Ahmed was always open, whenever I ran into a trouble or had a question about my research work or writing this thesis.

I would also like to thank my co-supervisor professor Dr. Md. Abdur Rob Mollah, Department of Zoology, University of Dhaka, for his cooperation and continuous inspiration made me possible to finish this research work.

I register my heartfelt thanks to our honorable Professor Dr. Niamul Naser, Chairman, Department of Zoology, University of Dhaka for allowing me to undertake the research and use all facilities required for carrying out this research in the department.

I also want to thanks Mr. Firoj-Al Amin, Mrs. Shahida Afroz, Sujan Kumar Datta, Deparment of Zoology, University of Dhaka for their sincere cooperation throughout the study.

I take the opportunity to impart my best regards to all respected teachers and staff of the Department of Zoology and the university authority for providing opportunity to perform this research work.

This study was supported by Krishi Gobeshana Foundation (KGF) and I am very grateful to them. SHISHUK, a development NGO, extended their support to my field work and helped me a lot during my field sampling.

Finally, I must express my very profound gratitude to my family members for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of research and writing this thesis. This accomplishment would not have been possible without their support.

September, 2022

The Author

Table of Contents

List of Tables

List of Figures

Chapter 1

Introduction

1. Introduction

Fisheries, second only to agriculture in the overall economy of Bangladesh, contribute nearly 3.52% to the Gross Domestic Product (GDP), 26.37% of gross agriculture products and 1.39% to the total export earnings (DoF 2020). Fisheries production of the Bangladesh was 4503370 MT in the fiscal year 2019-20, while it rose from 4384221 MT in 2018-19, meaning the fish production increased by 119149 MT.

During the last decade the community based fisheries management concept has gained increasing acceptance as a potential way forward to improve fisheries management performance. It has, however, at the same time become increasingly evident that the community based fisheries management concept is not clearly defined and means very different things to different people. Its attempt to document experience available from a recent study on fisheries co-management that has researched case studies of various implementations of co-management arrangements in coastal floodplain fisheries in Southern part of Bangladesh to present a more comprehensive understanding of community based fisheries management and to summarize the experiences with both the positive outcomes and the problems in actual implementation.

1.1 Floodplains and floodplain fisheries in Bangladesh

Floodplains are flat lands that are alternately exposed and inundated depending on the monsoon wet and dry seasons. It is a very important type of landscape in the country in the context of agriculture and fish habitat. In Bangladesh, most of the floodplains are cultivated lands. Floodplains in Bangladesh cover about an estimated area of 5,486,609 ha and are considered as the second most important inland fisheries resource, contributing to country's total fish production. Floodplains become alternately exposed and inundated depending on the hydrological regimes (Brammer, 2004).

These are abundant with aquatic vegetation and support a wide variety of fish species, mostly the smaller ones. Floodplain wetlands are mainly rain fed, shallow and low laying areas existing along the riverine system characterized by poor drainage and prolonged water logging, with immense production potentials and support millions of people through wide ranges of resources and services (Ali and Ahmed,1993). During early monsoon the connection between the rivers and the

Table 1. Different aquatic habitats of Bangladesh by types and by areas

Description	Area (km^2)	% of total area
Rivers, canals, streams	8,300	5.76
Estuaries, brackish-waterbodies	1,828	1.27
Floodplains	112,010	77.76
Wetlands	2,930	2.03
Freshwater ponds and lakes	794	0.55
Artificial lakes	906	0.63
Hill areas	17,286	12.00
Total	144,054	100

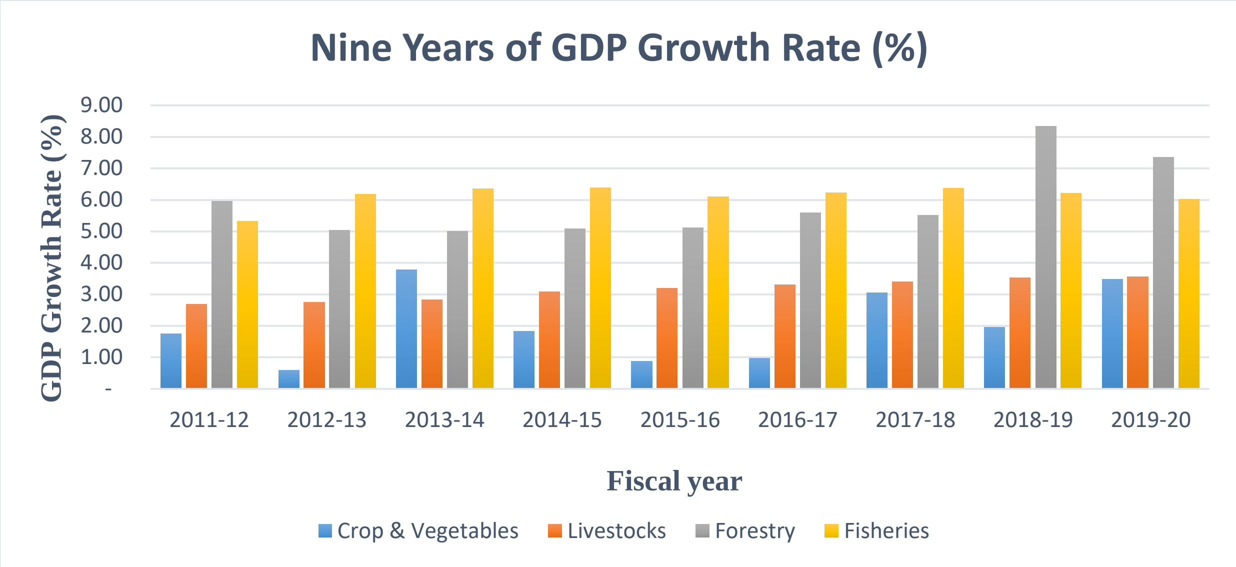
Source: DoF (2019)

floodplains occur due to overspills and back up waters from rivers and local rainfalls allowing the lateral migration of spawns of riverine and migratory species from rivers to floodplains and utilizes this habitat as feeding ground. Floodplains retain waters for up to 5-7 months at varying flood depths. Initial flooding takes place in late May or early June, depending on local topography, peak flooding occurs in August and water starts to recede between early October to middle October.

Table. 2 Extent of different type of water areas

Types of water areas	Area (ha)
a) Inland open waters	
1. Rivers (during dry season)	
The Ganges	27,165
The Padma	42,325
The Jamuna	73,666
The Meghna (upper)	33,592
The Meghna (lower)	40,407
Other rivers and canals	262,580
2. Estuarine area	551,828
3. Beels and haors	114,161
4. Kaptai lake	68,800
5. Inundated floodplains (seasonal)	5,486,609
Total	6,701,133
b) Coastal waters	
1. Ponds and ditches	146,890
2. Baors (oxbow lakes)	5,488
3. Brackish water farms	108,000
Total	260,378

Source: FRSS (2018)



Source: Bangladesh Economic Review 2021

Figure 1. Contribution of Fisheries in GDP

These water bodies are not only rich in fish biodiversity, but also support a wide variety of other aquatic resources. The livelihoods of people living around these floodplains are historically dependent on these resources. Growth, survival and reproduction of fish and other aquatic biota of floodplains depend on the prevailing environmental conditions, and is finely tuned to the hydrological regimes (Bayley, 1988). Therefore, the water quality of any ecosystem should be regularly monitored. The characterization of physic-chemical parameters is also required for understanding the floodplain production dynamics.

The unique hydrological events in floodplain allow a specialized group of fish to breed, grow and adapt to the floodplain conditions. In fact, growth, survival and reproduction of floodplain fish species are finely tuned to the hydrological dynamics of floodplains (Bayley, 1988).

The shallow water zones of the floodplains and the abundant aquatic vegetation provide an excellent feeding area for fish. On the onset of monsoon the floodplain resident species begin to breed and the shallow edges of the floodplains serve as nursery grounds. Many migratory species also perform lateral migrations to floodplain areas during this period for breeding in the floodplains. Similarly, juveniles of many reverine species also perform lateral migration to avail plenty of food in floodplains. During dry season many floodplain resident species find their refuge in the perennial water bodies, including rivers. Therefore, connection between the river and floodplain play the important role in floodplain fisheries. During the monsoon the Bangladesh floodplain becomes integrated into a single biological productive system. As the wet season advances the feeding area of fishes in floodplain expands.

A wide range of species have been successfully established in floodplain water and production dynamics. These fishes are called floodplain resident species. Besides, a number of migratory species, particularly the juveniles perform lateral migration for feeding and breeding during wet season. Among the recorded 260 species, about 36 migratory (travelling rivers and floodplains) and about 113 are floodplain resident species (FAP 17 1994). In addition, a large number of molluscs, prawns and crabs also occur in floodplain ecosystem.

The inland open water fishery resources have been playing a significant role in the economy, culture and tradition and food habit of the people of Bangladesh. Fishing continues throughout flood period; however, peak harvesting coincides with the recession of waters. Subsistence fisheries dominates the floodplain fisheries and a huge part-time and full-time fishers become engaged in floodplain fishing. Thus, it provides a good source of nutrition to rural people.

Unfortunately, production from inland open water capture fisheries is declining due to over-exploitation and habitat degradation. Presently, formulation and implementation of strategies and policies for conservation and sustainable management of degraded aquatic habitats have been immensely effective along with the generation and wider application/dissemination of suitable aquaculture and management technologies, which are expected to ensure the conservation of aquatic genetic resources.

The yield in the floodplain may vary from 50 to 400 kg ha^{-1} per year and the majority of the fishes is eaten as fresh. For full-time fishers, conflict over water resources can be intense during the dry season when water is required for irrigation. Flood control, drainage and irrigation schemes obstruct the lateral migrations of some whitefish species and the passive drift of larvae from the main channel to the modified floodplains. Existing modifications to the hydrological regimes also cause reductions in catch per unit area and fish biodiversity. The open access policy, which has led to severe competition for the resources, has reduced the effectiveness of co-management. The future aim is to shift the benefits to the fishers and to ensure the long-term sustainability of the resources. Both habitat restoration and fish enhancement are important in sustaining the floodplain fisheries. Over and unplanned fish harvesting also major the causes for the decline in fisheries production. Another, major cause include the fragmentation of floodplains due to construction of road networks in the rural areas.

The floodplain has been subjected to aquatic pollution due to use of agro-chemicals in the process of rice cultivation in the floodplain areas. In the backdrop of this situation, floodplain fish culture practice has been expanded to the floodplain areas. This practice involves a variety of interventions likely to impact the quality of waters. Therefore, there is a need to document the changes caused by the fish culture practices.

1.2 Floodplain characteristics

A floodplain is that area adjacent to a stream that is composed of alluvium and over which the stream presently flows at times of flooding. Floodplain features are landforms produced by stream erosion, sediment transport, and deposition, such as point bars, oxbow lakes, and terraces. Haors (large deeply flooded depressions), baors (oxbow lakes) and beels (lakes) are the permanent and semi-permanent standing water bodies in the floodplain, which become inundated during the flooding season and support rich fisheries (Craig *et al*., 2004). During the rainy season the inundated areas are regarded as seasonal floodplains. Floodplains also contain beels. Beels are part of a riverine complex and are generally formed due to changes in the course of a river, or strengthening of river embankments for flood control (Saha *et al*., 1990; Saha and Hossain 2002). In simple word, beels are usually deeper depressions in the floodplain (Thompson, 2004).

1.3 Fish production from floodplain fisheries

Fisheries, second only to agriculture in the overall economy of Bangladesh, contribute nearly 5.0% to the Gross Domestic Product (GDP), 23% of gross agriculture products and 5.71% to the total export earnings (DoF 2008). It accounts for about 60% of animal protein intake in the diet of the people of Bangladesh (DoF 2020). The fisheries sector provides full-time employment to an estimated 1.2 million fishermen and an estimated 10 million households or about 64% of all households are partly dependent on fishing, e.g. part time fishing for family subsistence in flooded areas. Another 10% poor and middle class people are engaged in part-time fishing, aquaculture, fish seed production and collection of shrimp and prawn seed, fish handling, processing and marketing, net making, input supply etc.

The total fish production including inland and marine resources is estimated at 2.7 mt in Bangladesh (DOF, 2010). About 81% of the fish production (2.19 mt) comes from the inland fresh water resources and the remaining from marine resources (0.5 mt). According to the Fisheries Resource Survey System (FRSS) of Department of Fisheries (DoF), Bangladesh, the contribution of open water fisheries and closed water resources to fish production is over

1.12 mt (41%) and 1.06 mt (39%), respectively (DOF, 2010). Floodplains offer immense opportunity to the rural people for fishing for food as well as income (Das, 2002; Pathak *et al*., 1989). In 1998-99 floodplain fish production was 0.41 mt which reached to 0.82 mt in 2009-2010 accounting for 77% of fish production from inland open waters (DOF, 2010). Considering the natural productivity of the floodplain water bodies, it is obvious that fish production could be increased substantially through extensive aquaculture, adopting a co-management approach

1.4 Floodplain culture fisheries and associated risks

1.4.1 Natural fish

There are 266 species of inland fishes (in freshwaters and brackish waters) belong to 61 families and 14 orders. Among the inland fishes, the family Cyprinidae (order Cypriniformes) includes the largest number of species: 61 species under 25 genera; these include carps (Rui, Catla, Mrigal, Kalibaus, etc); barbs (Punti); minnows (Darkina, Chela, Mola, etc). About 55 species of catfishes (Tengra, Air, Shingi, Magur, etc), are found in the freshwaters of Bangladesh. Loaches (Rani, Gutum, Puiya, etc) are the least explored fish species (about 12 species) (Rahman et al., 2008)

1.4.2 Introduction of floodplain fish culture

Floodplains in Bangladesh have different types of resources involving different types of stakeholders (professional and subsistence fisher, rice producer, leaseholder, farm laborers, irrigation pump owners, etc.) (Islam and Dickson, 2007). There are over 12000 public water bodies (Ahmed and Dickson, 2007) including 6034 floodplains. Of these floodplains, 3400 are perennial and 2634 are seasonal (Rahman, 2005; Bernaesek *et al*., 1992). There are innumerable numbers of private seasonal floodplains including beels in Bangladesh which are highly potential water bodies for practicing culture-based fisheries for many reasons. These floodplains are very rich in nutrients and natural fish food organisms to allow the stocked fishes to grow faster. Again the seasonal floodplains support higher stocking densities by virtue of their higher natural productivity. Moreover the connection with canals and spillways permits entry of natural fish stocks.

1.5 Problems in floodplain fish culture

The inundated floodplains of Bangladesh during monsoon are the seasonal habitat of the many indigenous fish. The residual effects of pesticides applied to these floodplains for agricultural purpose before monsoon lead to the fish mass mortality. Besides fish killing, there are also many other chronic effects of pesticides on fish including changes in their reproductive system, metabolism, growth patterns, food availability and population size and numbers (Rohar and Crumrine 2005). Lower abundance of phytoplankton and, consequently, lower abundance of zooplankton are observed as a result of pesticide use in the water bodies. The application of a pesticide might kill all individuals and it can be substantial perturbation to the ecosystem.

Floodplains under private ownership provide a common pool resource during the flood season and are now under extreme pressure from exploitation due to indiscriminate fishing by different users. Many floodplains under public ownership are leased to fisher groups to establish their fishing rights although there is hardly any initiative to protect or enhance the fish stock. Floodplains in Bangladesh are considered common property resource. Water and land use in such areas are subject to conflict between multiple resources users (Payne, 1997). Convincing evidence sow exist that rice-fish farming contributes to the food security and poverty alleviation in rural areas (Purba, 1998; Halwart, 1998; Gupta et al, 2002; Frei and Becker, 2005; Ahmed et al., 2007). It is an efficient way of using the same land resource to produce both carbohydrate and animal protein. Fish also add to the rice fields fertility and can reduce fertilizer requirements. Integrating aquaculture with agriculture results in an efficient nutrient use through product recycling since many of the agricultural by-products can serve as fertilizer and feed inputs to aquaculture or vice-versa (Gupta et al., 2002).

SHISUK successfully implemented rice-fish culture practices involving local community and developed a community enterprise model, tested and replicated locally in a number floodplains in Daudkadi area. SHISUK's success in floodplain aquaculture encouraged them further to take the technology to costal floodplain areas through a process of piloting with a view to tailoring the technology to suit local conditions.

However, arguments still surround the potential impacts of the floodplain aquaculture on local biodiversity, water quality and fishers' livelihoods, although information to substantiate this is still poor.In the process of preparation of the site for fish culture, some physical modifications are required, resulting in the compartmentalization of the floodplain. The inlets and outlets feeding and draining the floodplain are blocked with mesh screen and hydrology is sometimes partially regulated. This is likely to hamper the lateral migration of fish affecting the river-canal-floodplain fish production system. The floodplain is stocked with many exotic species having potential environmental/ ecological risks, which may compete with local species. Sometimes, weeds are cleared to facilitate fish harvesting. All these are expected to affect the local aquatic biodiversity.Stocked fishes are often fed with supplementary feed and fertilization is sometimes done, which might affect the environmental quality. Fishing ban is established over entire year with provision for trade off. All these have been a concern while promoting rice-fish culture practice in floodplain ecosystem. Therefore, need for a study investigating the impacts, both positive and negative, of the promotion of rice-culture practice which are being introduced in the floodplains. Krishi Gobeshana Foundation (KGF) also emphasized on the issue and suggested to keep a provision for impact study of the floodplain fish culture practice. The Department of Zoology, University of Dhaka, is a partner of the project to conduct the impact study.

The study component of the project focuses on the issues mentioned above through field data collection, while SHISUK implements the project inthe field. SHISUK has been implementing the project in 3 floodplain sites with different management and environmental scenarios.Our study was also carried out in the same floodplains. However, later 3 more floodplains, adjacent and comparable to the intervention floodplains, were selected as control sites for comparison.

1.6 Objectives of the study

Overall objective of the study is contribute to the understanding of the impacts of floodplain fish culture practices on the local aquatic biodiversity. However, the immediate and specific objectives of the study were –

- To assess the impact of the rice-fish practice on the fish production performance under different culture scenarios;
- To assess the effect of the culture practice on the floodplain biodiversity;
- To document the impact of the introduced culture practice on the socio-economics of the local people and beneficiaries and
- To assess the overall suitability of the culture practices in different culture scenarios and recommend on the improvement in the introduced rice-fish culture practices.

Chapter 2

Review of Literature

2. Review of literature

Al though this is a unique work in contest of Bangladesh working with a pilot project with a sacred vision and misson. A large number of works has been done worldwide in floodplain water bodies especially on the water quality of various water bodies, including lakes, reservoirs, rivers, canals, floodplains, ponds etc. The purpose of this section is to review these particular literatures with a view to make and in-depth understanding of the study.

Ehsan *et al*., (2014) carried out an investigation to assess water and soil quality of Roktodaha beel, a floodplain of northwest Bangladesh over period of a flood cycle. They studied physical parameters including temperature, depth and transparency and chemical parameters including pH, dissolved oxygen, ammonia nitrogen, hardness and alkalinity and showed interrelationship among the parameters. Most of the water and soil qualities were found in suitable ranges that support flora and fauna productivity.

Hossain *et al*., (2014) worked on the water productivity for living aquatic resources in floodplains of Northwestern Bangladesh. They found the water quality data within the normal range and suggested that proper management of water quality would improve the water productivity.

Perera *et al*., (2014) assessed the seasonal fluctuation of nitrate, phosphate, chloride, dissolved oxygen (DO) and turbidity of river water in different locations of Malwathu Oya, Srilanka. They reported that, the mean nitrate, phosphate, chloride and DO concentrations ranged from 1.05 to 5.28, 0.004 to 0.043, 2.63 to 8.72, 3.11 to 8.50 mg/L, respectively, and the mean turbidity level ranged from 81.75 to 256.10 NTU. The nitrate, phosphate and chloride concentrations were significantly higher ($p<0.05$) in all the segments and channel units during the first inter-monsoon season (March - April) in the Paddy growing area. The highest mean DO and turbidity values were observed in the north- east monsoon season. Significant difference was not observed ($p>0.05$) in DO and turbidity in paddy and non-paddy areas.

Razzak *et al*.,, (2013) studied the water quality of Ramna and Gulshan lakes and reported that concentrations of the studied pollutants were highest during summer. But during the winter the values were in general low and fell within various standard levels as water level increased.

DPHE (2013) analyzed the water quality parameters of Gulshan lake, Dhaka and reported the following water quality data: pH-7.2, turbidity- 29 NTU, TDS-266 (mg/l), TSS-12 (mg/l), phosphate-1.1 (mg/l), ammonia-N-12.5 mg/l), nitrate -0.25 mg/l, dissolved oxygen-5.9 mg/l.

Rahman *et al*., (2013) studied the physico-chemical parameters of Passur river in the

Sundarbans, the world's largest mangrove forest. The study was conducted over four sampling points: Mongla, Dangmari, Koromjol, and Koromjol Creek of the Passur river during the year of 2008- 2009 at rainy, winter, and summer seasons. They showed that, the water quality parameters of the river were acceptable during rainy season; however, moderate to high values of these parameters were appeared for winter and summer seasons. The concentration of TSS (10.8 -19.7 g/L) during summer and TDS (3.5-53.3 g/L) in all the season exceeds the recommended concentration for Bangladesh. The highest DO concentration (6.0-7.33 mg/L) was observed in winter; nonetheless, the highest BOD (20.2-28.0 mg/L) was obtained in summer season. The alkalinity and hardness of river water was gradually increased in winter and summer seasons than that of the rainy season.

Iqbal *et al*., (2013) studied the seasonal variation of water quality of Bhairab river, Khulna, The physicochemical 16 parameter in water were assessed from 10 location during Summer and Rainy 2013. They reported that the physicochemical parameters such as chloride, pH, dissolved oxygen, hardness, sulphate, chromium, copper, zinc, TKN and lead were in compliance with Bangladesh (ECR 1997) and WHO (2004) standards, but turbidity was above the standards. They stated that, alkalinity, hardness, ammonia, phosphate, TDS values were higher in summer and low in monsoon which might be due to effect*S* of runoff water and discharge from agricultural fields.

Khatoon *et al*., (2013) studied the seasonal variation in the water quality among different ghats of river Ganga and recorded minimum DO and EC value in monsoon and highest value in summer.

Alam *et al*., (2012) studied on spatiotemporal assessment of water quality of the Sitalakhya river, Bangladesh and observed higher concentration of water quality parameters like BOD, COD, ammonia, phosphate during dry season and low concentration in wet season.

Rahman *et al*., (2012) studied the seasonal variations of water quality parameters in Turag river and showed that the recorded pH ranged from 6.6 to 7.98 and Electrical Conductivity (EC) from 160 to 1107 µs/cm, dissolve oxygen (DO) varied from 0.11 to 6.8 mg/L.

Haque *et al*., (2012) conducted different laboratory tests on specific physico-chemical parameters (color, odor, temperature, salinity, EC, TDS, TSS, turbidity, hardness, DO, BOD and COD) of small water bodies (pond, dighi, doba, khal, beel) in Ghiduary Mouza and indicated that the water quality condition was moderately polluted.

Saha *et al*., (2012) conducted a study on water quality of river Ganga at Kolkata region and concluded that the water quality revealed an enhancement during the post Monsoon or winter period and degrade during summer period.

Ahmed *et al*., (2011) carried out an extensive study to elucidate the distribution and occurrence of different physicochemical parameters of water quality of the greater Noakhali region- Noakhali, Lakshmipur and Feni districts, water resources, Bangladesh. Temperature, transparency, pH, EC, TDS, TSS, DO, BOD, COD, acidity, total alkalinity, total hardness, nitrite- N, nitrate-N, o-phosphate-P, sulphate-S, chloride, iron, manganese, zinc, copper, lead, cadmium, cobalt, nickel, arsenic and chromium were measured in surface and groundwater samples collected from different rivers and tube wells of this region. Average value of pH of the surface waters was found in the alkaline region. EC and TDS values were found higher for some surface water samples.

Kumar *et al*., (2011) conducted a study to assess the spatio-temporal variation in water of Sabarmati River and Kharikat canal at Ahmedabad. Various physico-chemical characteristics of water such as pH, temperature, DO, Hardness, Phosphate, Sulphate, Nitrate, and COD was assessed and statistical analysis among various physico-chemical parameters was also carried out. They observed Spatial and temporal variation in river with increasing value of various parameters from upstream to downstream and relatively high pollution load at two sites of Kharicut canal.

Ahmed *et al*., (2010) conducted a study to assess the surface and ground water quality of greater Chittagong region of Bangladesh and showed that the water quality slightly differs in pre-monsoon and post-monsoon than monsoon season. They also reported that, the maximum water quality parameters of Kaptai Lake and other Rivers of Chittagong region were existed within the permissible limits of WHO guideline.

Begum and Ahmed (2010) measured different water quality parameters at Hazaribagh and Chadnighat of Buriganga river, at tongi of Turag river, at Demra and Moinertek of Balu river, at Demra ferryghat of Shitalakhya river and found that the BOD, COD, DO and TDS were far beyond the standard limits set by the Department of Environment (DoE).

Mondal et al. (2009) conducted a study in two floodplain lakes to assess the seasonal variations in quality parameters and suggested that the impact of environmental change (e.g. depth ,conductivity ,salinity of water etc.) on diversity indices was significant and should be taken into consideration when designing policies to increase the long term sustainability of fishing activities in the lakes.

Verma (2009), studied the seasonal variation of water quality in Betwa river at Bundelkhand Region, India. Total 15 physico-chemical parameters were analyzed and result showed that the water was slightly alkaline in nature, the range varies from 7.5 to 8.7 and 7.4 to 8.9 during winter and summer season respectively. Ammonia and phosphate were mostly found in equel concentrations in the river.

An investigation was conducted by Moniruzzaman et al. (2009) on temporal variation of physico-chemical parameters of Buriganga River through employing GIS (Geographical Information System) Technology and suggested that Dissolved Oxygen (DO) concentration was very low particularly in dry season (2-3 mg/l); ammonium ($NH4^+$) and Nitrate (NO_3^-) concentration near Hazaribagh, Sadarghat, Zinzira, Lalbagh, Kotouali and Shutrapur area were very high, which crossed the maximum permissible limit and in dry season the level of pollution was much higher than that of in wet season.

Hasan *et. al*. (2009) studied and compared water of Buriganga River of Dhaka and a rural river Panguchi for determining various water quality parameters for one year and showed that the river Buriganga is subjected to severe pollution whereas Panguchi is considered a less polluted river. The pH ranges were 6.69 to 8.14 for the river Buriganga and 6.90 to 8.80 for the river Panguchi. The organic pollution in river Buriganga was much more severe as indicated by DO (4.22 to 6.84) and BOD (0.97 to 3.12) than that of river Panguchi were in the range of 7.16 to 8.66 and 5.43 to 5.73 mg/l, respectively.

Smitha *et al.*, (2007) studied on physico-chemical characteristics of water samples of Bantwal Taluk, south-western Karnataka, India and collected water from different sources like open wells, bore wells, streams, rivers and farm ponds of 20 villages of Bantwal taluk of Dakshina Kannada district, SW Karnataka had been carried out. The physical and chemical characteristics of this water showed that it was suitable for agricultural and irrigational purposes.

Alam and Elahi (2006) worked on the water quality assessment of river Sitalakhya, stating that the physico-chemical parameters namely temperature, transparency, total dissolved solids, suspended solids, electrical conductivity, hardness, pH, dissolved oxygen, biological oxygen demand, chemical oxygen demand, nitrate, ammonia, phosphate showed significant (at < 0.05 level by DMRT) spatial and temporal variations and suggested that measures needs to be taken for the safe aquatic lives as well as human health.

Rahman and Hadiuzzaman (2005) studied different water quality parameters of the Shitalakhya and Balu rivers and found that the highest BOD value was recorded to be 16 mg/l for Lakhya River at station L1 nearTanbazar (Narayanganj) and that for Balu was recorded at downstream of outfall of Norai Khal as 54 mg/l. The highest TDS value for Lakhya River recorded at upstream of the intake of Saidabad water treatment plant and was found to be 352 mg/l and that for Balu River at location upstream of outfall of Norai Khal is 456 mg/l, respectively. The highest value of Ammonia recorded for Balu River was 24.75 mg/l at downstream of outfall of Norai Khal.

Graaf (2003), studied the dynamics of floodplain fisheries in Bangladesh and stated that the fish catch exhibited a strong seasonal variation, with the highest catch in October, when the floodwater recedes towards the river, and the lowest catch during the dry season in April/May. The annual catch varied with the extent of flooding, with high catches in wet years and low catches in dry years.

Hosain *et al*., (1997) studied the physico-chemical parameters of the Basukhali-Salimpur Kolabarnal Beel, a completely closed system floodplain. The turbidity values of the floodplain was almost translucent, conductivity values were found higher in comparison to some other aquatic ecosystems and dissolved oxygen maintained and inverse relationship with temperature.

Bhuiyan and Nessa (1996) made a study on the physico-chemical parameters of a fish pond in Rajshahi. They observed that the co-efficient of correlation between water temperature and turbidity was found to be of limited degree of relationship (r = 0.21). Similar result was also observed in case of water temperature and pH (r = 0.09), while inverse relationship was found with free carbon dioxide (r = -0.66) and alkalinity (r = -0.87).

Begum *et al*., (1994) reported the fluctuations in the physico-chemical parameters of a semi intensively managed fish pond. They compared the degree of variability of each physical or chemical parameter with the variability of other parameters. The pH value of the pond was found to have the lowest variability, while carbonate had the highest variability.

Azim (1992) reported results of two sampling programs. It is seen that during monsoon the DO values are all 6 mg/l or above, which indicates that there is no septic problem. During dry seasons, except two stations, the DO values are all above 11 mg/l.

Khan *et al*., (1990) reported that the productivity of water bodies is related to pH. High seasonal pH condition in the water may pose some health hazards. Hardness of water is directly related with biological productivity. Hardness above 500 mg/l is unsuitable for domestic use, 170 mg/l is termed as good quality water.

Khan *et al*., (1990) observed the seasonal variation in physico-chemical characteristics of water in Dhanmondi lake. They observed an inverse correlation between temperature and dissolved oxygen throughout the period.

Begum et al., (1989) studied the limnology of a mini pond and discussed seasonal variation and interrelationship between physico-chemical parameters and plankton.

Ali *et al*., (1989) recorded the seasonal variations of physico-chemical and biological condition in a pond. They observed considerable variation in water qualities in different seasons.

Latif et al., (1986) made a comparative study of the physico-chemical characteristics of a well-managed fish pond and a derelict pond. They studied the physico-chemical factors such as air temperature, water temperature, water depth, transparency and rainfall and the chemical factor of water like dissolved oxygen, free carbon dioxide, pH, total hardness, nitrogen and phosphate.

Ali *et al*., (1985) worked on the physico-chemical parameters of Maheshkhali channel, Bay of Bengal and observed that the seasonal variation of some physico-chemical parameters of water was interrelated.

Rahman *et al*., (1982) conducted a limnological study of four ponds. They suggested the primary productivity of different water bodies is essentially dependent on their physico-chemical conditions.

Mollah *et al*., (1979) found a more or less direct relationship between pH and dissolved oxygen content and an inverse relationship between carbon dioxide and pH.

Shafi *et al*., (1978) studied the limnology of river Meghna at Daudkandi and Chandpur. The water was slightly alkaline and hard. They observed high values of nutrient in summer and in early monsoon and low values in winter, which might possibly due to climatological and physical factors.

Miller and Lisky (1976) reported that the hardness of water body is directly related with biological productivity. In water bodies calcium acts as nutrient and then complexing with oxidents to form insoluble precipitates.

Dewan (1973) in a study on the ecology of lake from Mymensingh established an inverse relationship of carbon dioxide and direct relationship with pH and total alkalinity. He observed the lowest vlue of water level and transparency during summer and the highest values during monsoon.

Nelson and harp (1972) recorded the highest concentrations of oxygen in winter when the temperature was the lowest; following the principle that colder water has a greater capacity for holding dissolved gases.

Alkunhi (1957) confirmed that in Madras States, India water of pH 6.5 to 7.5 gave high average yield than that of pH 7.5 to 8.5 in carp pond.

Hutchinson (1957) stated that temperature influences the solubility of different gases, especially that of oxygen n carbon dioxide in water

Villadolid *et al*., (1954) reported that water with pH from 7.3 to 8.4 provided optimum condition for the growth of plankton. They stated that the lower pH values were known to adversely affect the plankton production and subsequent growth of fish.

Chapter 3

Materials and Methods

3. Materials and Methods

3.1 Description of the Study Area

The present study was conducted in three selected tidal floodplains, namely Jhanjhania floodplain in Pirojpur District, and the Bishnudia and Uttampur floodplains under Jhalakathi District. Initail data collection was limited to these 3 project intervention sites, while later 3 more additional sites adjacent and comparabale to the intrerventions were also selected for study as control sites. The research work was carried out during the period July 2016 to June 2019. The geographic locations of the selected floodplains are shown in Map 1, while information on the administrative locations of the selected floodplains is given below:

Table 3. Information on the administrative locations of the selected floodplains

Name of floodplain	Union	Upazila	District	Area	Uses
Jhanjania FP	Malikkali	Nazirpur	Pirojpur	75 acres	Remain fallow in wet season and cultivated to HYV rice in dry season, Was almost a semi-closed floodplain. Some rabi-crops.
Bishnudia FP	Binoykathi	Jhalakathi Sadar	Jhalakathi	35 acres initially (12 acres later)	A semi-closed floodplain, remains fallow, no crop cultivation since 7 years back.m modified to closed water body.
Uttampur FP	Uttampur	Rajapur	Jhalakathi	30 acres	Cultivated for aman crop; grow HYV boro in small area, was almost open, compartmentalized for fish culture.

Table 4. GPS coordinates of the study sites

Area Name	Longitude	latitude	Longitude	latitude
Janjaria FP	89°58'50.70"	22°50'22.21"	89.97417	22.8395
Uttampur	90° 9'15.46"	22°33'30.22"	90.1575	22.55839
Bishnudia	90°15'5.04"	22°43'24.84"	90.2575	22.72357

Brief descriptions on the individual floodplains are provided below:

3.1.1 Jhanjhania Floodplain

This floodplain is located on the eastern bank of the River Modhumoti. One end of the floodplain is connected to a canal leading to the river. The entire floodplain dries out completely during dry season and most of the land areas are used for rice cultivation during that time. Usually, it is flooded in the range of 6-7 ft, however, the flooding may reach up to 10 ft during peak flooding period. Inundation of the floodplain initially takes place by local rainfall and later by back up water from the adjacent river. Water starts receding during middle October. It is bounded by roads on all sides with breaches and culverts. In the past, both aman and boro rice were used to be cultivated. Presently, only high yielding variety is grown in dry season. At present, the floodplain is stocked under a floodplain aquaculture programs as rice-cum paddy culture practice. The floodplain has luxuriant growth of aquatic vegetation. Village groves encircle the floodplain from all sides and it receives storm water from the adjoining households. Wild stocks of fishes are abundant in this floodplain.

Figure 2. A partial view of the Jhanjhania Floodplain

3.1.2 Bishnudia Floodplain

This floodplain is comparatively shallower and smaller than the two other floodplains study sites and represents a part of a large floodplain system. It is also bounded on all sides by earthen roads and village groves and is fragmented and compartmentalized from the rest of the floodplain area. The floodplain is also connected to a local large canal through a narrow water channel. The floodplain has two ponds located within it. The floodplain is also fed by local rainfall and back water from nearby river. It is flooded in the range 4-5 ft, initial flooding takes place in July, and reaches peak in September, and water starts receding in October and completely dries out by late October. However, presently some water is retained throughout the year for undertaking aquaculture. Earlier, it was used to be extensively used for rice cultivation, but now-a-days it remains fallow. The floodplain has overgrowth of vegetation.

Presently, a part of earlier floodplain intervention site has been further modified deepening and raising the dykes and converted to a perennial water body with only 3 openings. Hydrology is entirely control and has provision for water supply during very lean period. Fish culture is done almost around the year.

Figure 3. A partial view of the Bishnudia Floodplain

3.1.3 Uttampur Floodplain

Uttampur Floodplain is situated in Rajapur Upazilla under Jhalkati District. It is a moderately flooded floodplain. The floodplain is extensively used for aman rice production. It is connected to a river tributary through a narrow water channel. It is flooded in the range of 4-6 ft. early flooding takes place in June, initially by local rainfall, later by back up river water, and draw down starts in early October and most part of the floodplain dry out by late October, although some perennial water remains in a deeper part of the floodplain. There are 10 excavated fish pits located in the deeper part of the site. This floodplain is also bounded by roads and canal bank on all sides and has few openings for water movement. This floodplain is connected by a canal with Gabkhan River.

Figure 4. A partial view of the Uttampur Floodplain

3.2 Data Collection Methodology

3.2.1 Monitoring of Water Quality

In the initial of the study (2016) water samples were collected from the intervention sites only in 4 seasons with an intent to characterize the floodplain water quality under fish culture practices. However, in the subsequent year water samples were taken from both intervention and control (a comparable floodplain adjacent to the intervention floodplain). In order to capture the influence of season on the water quality, samples were collected during wet season (June-August), post monsoon (September-November), dry season (December-February) and pre-monsoon (March-May) in the year 2016 and in the year 2019 water samples were collected for wet season (monsoon), post monsoon, and dry season only. A brief description on the sampling and analytical procedures is provided below.

3.2.2 Selection of sampling stations

To ensure representative sampling, water samples for quality analysis were taken from three marked stations of both intervention and control floodplain sites. The selection of sampling stations was based on the spatial physiography of each floodplain, availability of water in dry season, flood depth, and ease of sample collection. Water samples were collected from 3 selected sampling sites, which are as follows:

Station-1: It is situated in the peripheral region of each of the floodplains.

Station-2: It is situated in the sub-middle region of each of the floodplains.

Station-3: It is situated in the middle region of each of the floodplains.

3.2.3 Water quality parameters investigated and sampling procedures

A total of 12 water quality parameters, pertinent to pollution and aquaculture were measured. The measured parameters are pH, Dissolved Oxygen (DO), Conductivity, Total Dissolved Solids (TDS), Salinity, Water Temperature, Hardness, Alkalinity, Ammonia-Nitrogen (NH3-N), Nitrite-nitrogen (NO2-N), Nitrate and Phosphate (PO4).

3.2.4 Sampling frequency

Sampling of water was done in August, October, January and May, representing 4 seasons of the year, viz. Monsoon, post monsoon, winter and pre-monsoon, respectively. Samples were collected in duplicate from each selected stations approx 6 cm below the water surface.

Figure 5. Photo of Sampling

3.2.5 Analytical Procedures

3.2.5.1 Onsite analysis

A few water parameters, like pH, DO, conductivity, TDS, temperature and salinity were measured onsite immediate after sample collection using HACH Water Quality Multimeter (Model: HQ 40d, U.S.A).

3.2.5.2 Laboratory analysis

The samples were transported to the laboratory at the Department of Zoology, University of Dhaka, in cool box for the analysis for the analysis of the rest of the parameters. Most the parameters (phosphate, hardness, alkalinity, ammonia-N, nitrite-N) were analyzed within six hours of sample collection, while nitrate were analyzed next day and the samples were preserved overnight in a refrigerator at 8℃

Table 5. The analytical methods for each of the parameters

WQ parameters	Analytical methods used
Ammonia-N:	Ammonia- Nitrogen was measured employing Salicylate Method using spectrophotometer (Model: DR/1900,Hach,USA)
Nitrite-N:	Nitrite-N was measured Diazotization method using spectrophotometer (Model: DR/1900, HACH, USA**).**
Total Phosphate:	Total phosphate was measured by Molybdovanadate method using spectrophotometer (Model: DR/1900, HACH, USA)
Nitrate-N	Nitrate-N was measured by using spectrophotometer (Model: DR/1900, HACH, USA)
Total Hardness:	Total hardness (as calcium carbonate) was measured by Man Ver* method using Hach Kit: FF-2, USA.
Alkalinity:	Alkalinity was measure by phenolphthalein method using Hach Kit:FF-2, USA.
Salinity	HACH Water Quality Multimeter (Model: HQ 40d, U.S.A).

3.3 Collection and Analysis of Soil

3.3.1 Method of Soil sampling

The bulk soil samples representing 0 – 15 cm depth from the soil surface was collected by composite sampling method as suggested by the Soil Survey Staff of the USDA (1951). The samples were scrapped from top to bottom with the help of a plastic spade. Approximately equal amounts of soil for a particular depth were taken from each sampling site at the defined intervals along the traverse and then were mixed thoroughly. Samples were put into polythene bags, closed with rubber band and tagged with paper tags for subsequent identification**.**

3.3.2 Sample preparation

The collected soil samples were dried in the air for 4 to 5 days - by spreading in a thin layer on a clean piece of plastic sheet. Visible roots and debris were removed from the samples and discarded. Thereafter the samples were further dried in a oven until a constant weight was reached. A portion of the larger and massive aggregates were broken by crushing them gently. Grounded samples were screened to pass through a 2 mm stainless steel sieve. Then the sieved samples were mixed thoroughly for making a composite sample and preserved in labelled plastic containers with required information. These samples were used for various physical analyses and for the determination of pH and organic carbon content. A portion of the samples (2 mm sieved) were further grounded and screened to pass through a 0.5 mm sieve. The sieved sample was mixed thoroughly for making a composite sample for a location and preserved in the same way as above. Theses samples were used for chemical and physico-chemical analyses.

For total nitrogen, the soil samples were digested with conc. sulfuric acid, and for total phosphorus, total potassium and all other metals, samples were digested with aqua regia. Nitrogen, potassium and phosphorus in the digestants were extracted by adding KCI (1;10), Bray and Kurtz 1 (1:7) and ammonium acetate, respectively

The total organic carbon of the samples was determined by Walkley and Black's wet oxidation method (Huq and Alam, 2005). Total nitrogen in the extractant was determined by Kjeldahl's method following concentrated Sulfuric acid (H2SO4) digestion as suggested by Huq and Alam (2005). The distillation of digested samples was done with 40% NaOH and the distillate was collected on a 2% Boric acid mixed indicator solution. The distillate was titrated against 0.01N Sulfuric acid (H2SO4) (Huq and Alam, 2005). Total phosphorus contents in the extracted samples were determined by vanadomolybdate method in a spectrophotometer (HACH DR 5000) at a wave length of 490 nm. Total potassium contents in extracts was determined by flame photometer (Jackson, 1962).

The soil analysis was done only for the dry season and samples were taken from both intervention and control sites. Samples were analyzed in the soil laboratory at Department of Soil, Water and Environment, University of Dhaka.

3.4 Zooplankton Analysis

3.4.1 Sampling procedure and preservation of zooplankton

Water samples for zooplankton analysis were also collected from 3 stations selected for water quality analysis. As with water quality monitoring zooplankton samples were also monitored in 4 seasons. A 50 liters of water was passed through a plankton net of 64 µm mesh size. About 50 ml water was retained in the bottom collector and was then transferred to the sample container. A 5% buffered formalin solution was added in the sample to avoid any damage of the plankton for long-term preservation. The sample containers were then placed in the carrying box for transportation to laboratory at the Department of Zoology, university of Dhaka.

3.4.2 Observation and enumeration of zooplankton

Observation on zooplankton was made under a high resolution compound microscope (Potoplate…) and enumeration of zooplankton was done by a S-R counting cell. The S-R cell is the device most commonly used for counting. The S-R cell is approximately 50 mm long by 20 mm wide by 1mm deep. The total area of the bottom was approximately 1000 square mm and the total volume was approximately 1000 cubic mm or 1ml.The length, width and depth of the cell were checked carefully with a micrometer and a slide calipers.

Before filling the S-R cell with sample the cover glass was placed diagonally across the cell. The sample was transferred with a dropper. Placing the cover in this manner helped to prevent formation of air bubbles in the corners of the cell. The cover glass was rotated slowly to cover the inner portion of the S-R cell during filling.

Overfill of the cell was avoided, since it could yield a depth of greater than 1mm and an invalid count would be resulted. To prevent air spaces by evaporation during a length examination small drop of distilled water were placed at the edge of the cover glass.

Before proceeding of the count, the S-R cell was allowed to stand at least for 15 minutes to permit the setting of the planktons. In a counting cell about 1 ml sample was taken and spreaded over evenly. The cell contains 1000 squares and it was placed under a microscope for counting. 10x and 40x magnifications were used in the microscope to count planktons carefully in each square. It took longer or shorter time to count depending on the density of the plankton number.

Figure 6. Compound microscope (Olympus, Model-CH30RF200, Japan) is for viewing zooplankton

3.4.3 Identification and estimation of Zooplankton

The specimens were identified upto genera or species level. Identification was made following Ward & Whipple (1959), Edmondson (1959), Tonapi (1960), Mellanby (1975), Bhouyain & Asmat (1992) and Ali & Chakrabarty (1992). Quantitative analysis of zooplankton was followed by the total count method of Welch (1948). The number of zooplankton estimated per ml was calculated by adopting the following formula:

$$N = \frac{AxC}{L}$$

where,

N=Number of zooplankton/L of original water

A=Volume of the concentrated sample (in ml)

C=Number of zooplankton counted in 1ml sample

L=Total volume of water (in litre) passed through plankton net (50L)

3.5 Biodiversity Study

Fish and some aquatic invertebrate groups, like molluscs, crabs and prawns were considered for the study. Information on the species composition and their relative abundances of the selected aniaml communities were collected. The following tools were used:

3.5.1 Direct field observation

During each field visit intended observations were made on the fish catches, and all visible fauna within each study floodplains. Observations were recorded by using a predesigned proforma.

3.5.2 Key formant interview

Local knowledgeable persons, including fishers and others were interviewed to know the occurrences of fish, crabs, mollusks and prawns. Pictorial guidebooks were used to help identification of the species.

3.5.3 Group discussion

In order to get idea about the relative abundances, in addition to field observation, discussions were organized at suitable place involving a number of local people. The participants were given the idea how to decide on the relative abundances of different species.

Figure 7. Photo of Group discussion

The collected information on different fauna groups were used to prepare inventories with a number of matrices.

3.6 Information Collection on Aquatic Weeds

An intended effort was put to collect different types of aquatic weeds from JHanjhania floodplain and its local name was ascertained by the local people. A dedicated FGD was conducted participated by local people, particularly the farmers and fishers, to harvest information on the abundance of individual weed type/ species prior and after the project implementation. Taxonomic identification of weeds were done by a competent Botanist.

3.7 Information Collection on Crop Production

Information on crop production and its related expenditure were collected through organizing FGD and interview of individual farmers. Altogether 2 FGDs, one in Jhanjhania and one in Uttampur, were conducted and a total of 6 farmers were interviewed. Information was collected on production rate in unit land and itemized expenditures for crop production. Local perceptions were also captured on the causes for changes in the production and production cost. A filled in sample proforma for crop production data collection is provided in Annex.

3.8 Documentation of Cropping Patter

The purpose of this exercise was to demonstrate any changes in the type, extent and timing in crop production. During the FGD organized for collecting information on crop production, information on the cropping pattern. The participants actively took part in preparing yearly calendar on crop production with its timing and extent of different crops. The tabulated information was then converted to a map. The information on cropping pattern were further validated during subsequent field visits.

3.9 Study of Access Rights /Benefit Sharing

The access rights of the local people, particularly the fishers were investigated by holding FGD and also by individual interview in a confidential manner. Information were also collected on impacts of the project on their livelihood. Recommendations on how the constraints and their hardship could be improved were also sought.

3.10 Data Processing and Presentation

The numeric data were processed and analyzed by using EXCEL software. The data are presented as mean+ SD. Paired t-test were performed to compare the data from the intervene and corresponding control site.

Chapter 4

Results and Observations

4. Results and Observations

4.1 Present aquaculture practices in the study sites

4.1.1 Aquaculture Practices in Jhanjhania Floodplain

Floodplain stocking in Jhanjhania FP takes place in late Ashar or early shrabon with a variety of over wintered fish species. The floodplain is stocked with both indigenous and exotic fish species. The indigenous species include rui, catla, mrigel and the exotic species include silver crap, carfu, grass carp, mirror carp (minar carp), tilapia, thai sarputi. The fish fingerlings are overwintered locally nearby the floodplain.

Earlier, the floodplain was almost fragmented from the adjoining floodplains by local road networks with opening/ breaches at places. In the process of fish culture, the floodplain has been further enclosed by constructing and repairing of beribandh. There are now 3 inlets/outlets across berribandh/road. Until the end of Ashar the outlets remain completely open which corresponds with the breeding season of local fishes. According to local people, fish fry and eggs or even the gravid fish from the river can enter the floodplain during this period and permits the lateral migration of fish. As stocking starts these water channels are barricaded by using 2 types of mesh devices: large meshed rod screen and bamboo made banna (pata), which at best might allow the movements of fish eggs, larvae and fry, but not the juveniles or the adult fish. There are 10 auto-stocked fish pits within the floodplain, which are used by fish as refuge when the floodplain water recedes and the fish remain there until harvesting. Fishing starts in November and continues until the end of December. During November, most large fish find their refuge in the fish pits which are then fished out.

In the initial years of the project, the fish was used to be fed with locally prepared supplementary feed made from oilcakes, rice barn, cowdung, etc., however, now this practice has been discontinued. Last year the floodplain was fertilized with 21 bags of urea (each bag contains 50 kg) to facilitate the growth of vegetation to be consumed by the fish. Last year a substantial number of aquatic weeds (locally called Sheyalla) was supplied to the floodplain after collecting from adjacent floodplain. As per local accounts, the left part of the rice plant (locally called nara) become decomposed and consumed by carfu and mirror carp. The floodplain is not cultivated for any crop during the culture period. As a strategy for maintaining natural fish production in the floodplain, the auto stocked ponds within the floodplains are not completely fished out, a good number of residual fish remain within these ponds and contribute to production of natural stock of fish. Some under sized stocked fish are restocked in nearby ponds for its stocking in the subsequent year. It is to be mentioned that all sorts of fishing are banned during the culture period and local people don't have access to fishing and all fishes, stocked and non-stocked, are harvested by the project, of course by employing local poor people.

4.1.2 Fish culture Practice in Uttampur Floodplain

This site represents a part of the Uttampur Floodplain. In the process of the preparation of the floodplain for fish culture, the canal dykes and an existing road that partially divided the floodplain have been repaired. A new small cross road has been constructed to completely separate the site from the remaining part of the floodplain. The floodplain is fed by a canal end and 2 more inlets. The Although, Uttampur floodplain is flooded in late Baishakh, stocking of fish could only be done in mid-Bhadra, as because local people prepare their land for aman rice cultivation until the mid-Bhadra, which necessitate ploughing and leveling of land. These processes may cause mortality to fish. Therefore, fish is stocked only after aman rice is planted. Therefore, fish experiences a limited period of growth. Traditionally, local people manipulate the natural hydrology by constructing a temporary cross dam on the canal connecting the floodplain with the adjacent river. This dam is breached in Baishakh and allows the fish movement (including eggs, fry, juvenile, gravid fish, etc.). During fish culture period the connecting canal and some open areas of the floodplain is bearricaded by bana and small mesh nets and it is done only during the period mid-Bhadra to Kartik.

The stocking materials are similar to that are used in Jhanjhnaia floodplain, except the grass carp. Since, aman rice is cultivated during the culture period, therefore grass carp is not stocked. This floodplain has also 10 fish ponds. As drawdown starts in October fish finds their refuge in these fish ponds. Fish are fed with pelleted feed in the pond and locally prepared feed, made of oil cakes, rice barn and cow dung and fed until the ponds are fished out. Under sized fishes are retained in the pond for release in the subsequent year. Fish are slowly harvested and continues up to the month of February.

4.1.3 Aquaculture Practice in Bishnudia Floodplain

Although initially, fish culture started in the Bishnudia floodplain area, however , later a part of the floodplain (about 35 bigha) has been modified into shallow perennial water body with high dykes, allowing fish culture round the year and no longer it has the floodplain characteristic. There are three water inlet/outlets and hydrology is completely regulated. Water depth is maintained at 4-7 ft. During very lean period, water is supplied to the water body from the adjoining canal by using motor pump. The fish is fed with locally fermented feed, made with locally available ingredients, like oil cake, rice bran, cow dung and urea. Pelleted feed (3 types) is also fed to the stocked fish. Prior to cultivation the water body is almost dried, liming and fertilization are done. Urea, potash and phosphate fertilizers are used to increase the pond fertility. Fingerlings are raised in nearby ponds and overwintered for about a year and released in the water body. Unlike the other 2 floodplains, stocking Bishnudia is done during April-May and fishing starts from October and continues up to January. Like other two floodplains both indigenous and exotic fishes are stocked and include rui, catla, mrigel, tilapia, carfu, mirror carp, grass carp, silver carp, thai sarputi, etc . In addition, some other native species of fish, like shol, shing, pabda, foli, chitol area also released in the water body. Fish culture is done here at a commercial scale and shareholders are limited.

4.2 Water Quality

A total of 12 physico-chemical parameters, namely water pH, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), salinity, alkalinity, total hardness, total phosphate, total ammonia-N, nitrate-N, ammonia-N, nitrite-N and temperature was monitored for 3 intervention (namely, Jhanjhnaia, Bishnudia and Uttampur floodplains) and 3 control floodplain sites in 3 three different seasons (monsoon, post monsoon and dry season) during the period 2016-2019. The data obtained on measured water quality parameters from the project intervention sites were compared with that of the respective control sites to assess the impacts of floodplain aquaculture on water quality. It may be mentioned that water samples were collected from both control and intervention sites. The results obtained are graphically shown in Figure -8 and numeric data are presented in Annex-1 For convenience, a brief season wise description of data are made below:

4.2.1 Wet season

The values of water pH in the intervention sites in wet season ranged from 6.84 to to 6.99 in intervention sites and 6.97 to 7.42 in control sites, EC from 218.80 uS/cm to 241.20 uS/cm in intervention sites and 142.7 uS/cm to 184.0 uS/cm in control sites, TDS from 146.53 mg/l to 200.50 mg/l in intervention sites and 68.7 mg/l to 85.5 mg/l in control sites, salinity from 0.10% to 0.11% in intervention sites and 0.08% to 0.09% in control sites, DO from 5.82 mg/l to 6.64 mg/l in intervention sites and from 6.90 mg/l to 7.70 mg/l in control sites site, alkalinity from 117.93 mg/l to 130.95 mg/l in intervention sites and from 72.4 mg/l to 81.02

mg/l in control sites, hardness from 123.95 mg/l to 148.90 mg/l intervention sites and 59.3 mg/l to to 61.1 mg/l in control sites, phosphate from 1.01 mg/l to 1.58 mg/l in intervention sites and from 0.77 mg/l to 1.30 mg/l in control sites, ammonia from 0.02 mg/l to 0.05 mg/l in intervention sites to 0.14 mg/l in control sites, nitrate from 1.94 mg/l to 2.77 mg/l in intervention sites and from 1.56 mg/l to 2.29 mg/l in control sites, nitrite from 3.65 mg/l to 4.94 mg/l in intervention sites and from 0.80 mg/l to 1.80 mg/l in control sites, while temperatures varied from 30.44℃ to 30.73℃ intervention sites and from 30.20℃ to 31.50℃ in control sites.

Except the nitrate and nitrite levels, the values of all other parameters represent the typical floodplain water quality in Bangladesh floodplains. There were not appreciable differences in the observed values between the intervention and control sites, except that for nitrite and nitrate. In case of Bishnudia, both nitrite and nitrate levels were significantly higher in intervention site than the corresponding control site and in case of Jhnajhnai such difference was noted only for nitrite level.

4.2.2 Post Monsoon

The pH values measured in post monsoon ranged from 7.02 to 7.46 in intervention sites and 6.56 to 7.11 in control sites, EC from 279.18 uS/cm to 298.63 uS/cm in intervention sites and 155.30 uS/cm to 285.33 uS/cm in control sites, TDS from 244.70 mg/l to 252.18 mg/l in intervention sites and 83.52 mg/l to 146.57 in control sites, salinity from 0.09% to 0.20 in intervention sites and from 0.08% to 0.16% in control sites, DO from 5.70 mg/l to 7.24 mg/l in intervention sites and from 4.18 mg/l to 5.82 mg/l in control sites, alkalinity from 113.10 mg/l to 119.60 mg/l in intervention sites and from 81.0 mg/l to 108.67 mg/l in control sites, hardness from 124.23 mg/l to 150.68 mg/l in intervention sites and 68.66 mg/l to 111.0 mg/l in control sites, phosphate from 0.61 mg/l to 1.10 mg/l in intervention sites and 1.12 mg/l to 2.16 mg/l in control sites, ammonia from 0.02 mg/l to 0.03 mg/l in intervention sites and 0.22 mg/l to 0.25 mg/l in control sites, nitrate from 2.18 mg/1 to 2.67 mg/l in intervention sites and 0.70 mg/l to 2.16 mg/l in control sites and nitrite from 3.01 mg/l to 4.91 mg/l in intervention sites and 1.03 mg/l to 2.66 mg/l in control sites, water temperatures fluctuated between 29.56℃ to 32.24℃ in intervention sites and 26.03℃ to 29.15℃ in control sites.

In almost all cases, all the measured water parameters in intervention sites showed elevated values than their corresponding control sites, particularly in case of Bishnudia intervention site, the levels of pH, TDS and nitrate were exceptionally higher compared to corresponding control site and these differences were statistically significant. In case of nitrite and TDS, significant difference was also observed in Jhanjhania intervention site compared to its control site. Although, Uttampur intervention site had high level of nitrite, however, due to large fluctuations among the sampling stations this difference was found statistically in significant. In case of phosphate and ammonia, all intervention sites had lower level.

4.2.3 Dry season

The values of water pH in the intservention sites in dry season varied from 7.42 to to 7.66 in intervention sites and 7.22 to 7.42 in control sites, EC from 391.70 uS/cm 635.90 uS/cm in intervention sites and 176.0 uS/cm to 236.0 uS/cm in control sites, TDS from 272.10 mg/l in to 403.40 mg/l in intervention sites and 94.0 mg/l to 12.0 mg/l in control sites, salinity from 0.13% to 0.30% in intervention sites and 0.10% to 0.15% in control sites, DO from 7.40 mg/l to 8.80 mg/l in intervention sites and from 5.50 mg/l to 7.20 mg/l in control sites, alkalinity from 119.25 mg/l to 147.00 mg/l in intervention sites and from 120 mg/l to 174.0 mg/l in control sites, hardness from 132.50 mg/l to 185.50 mg/l intervention sites and 112.67 mg/l to 152.0 mg/l in control sites, phosphate from 8.57 mg/l to 10.00 mg/l in intervention sites and from 1.60 mg/l to 5.80 mg/l in control sites, ammonia from 0.11 mg/l to 0.16 mg/l in intervention sites and from 0.02 mg/l to 0.12 mg/l in control sites, nitrate from 4.47 mg/l to 11.63 mg/l in intervention sites and from 3.0 mg/l to 4.33 mg/l in control sites, nitrite from 1.45 mg/l to 3.81 mg/l in intervention sites and from 0.41 mg/l to 4.60 mg/l in control sites, while temperatures ranged from 17.79℃ to 18.83℃ in intervention sites and from 18.90℃ to 22.50℃ in control sites.

In general, the values of measured parameters were bit higher in intervention sites than the control sites and no trend was evident from the results of pH, EC, DO, salinity, alkalinity and hardness data. However, phosphate, nitrite and nitrate levels were comparatively much higher than the normal ranges reported for Bangladesh floodplains. Similarly, values measured for these parameters in intervention sites were comparatively higher than the control sites.

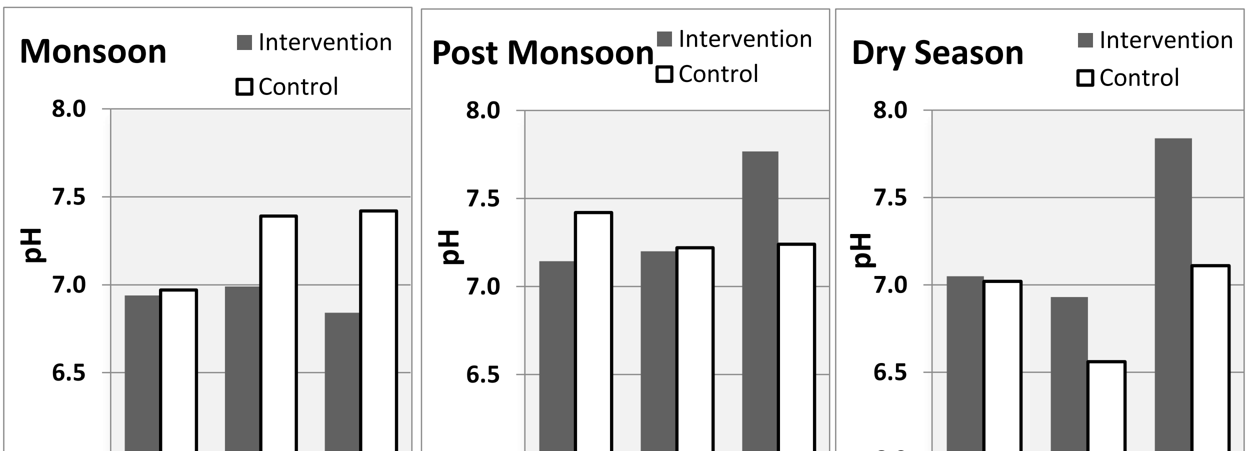


Figure 8a. Measured pH in waters of intervention and control sites in different seasons

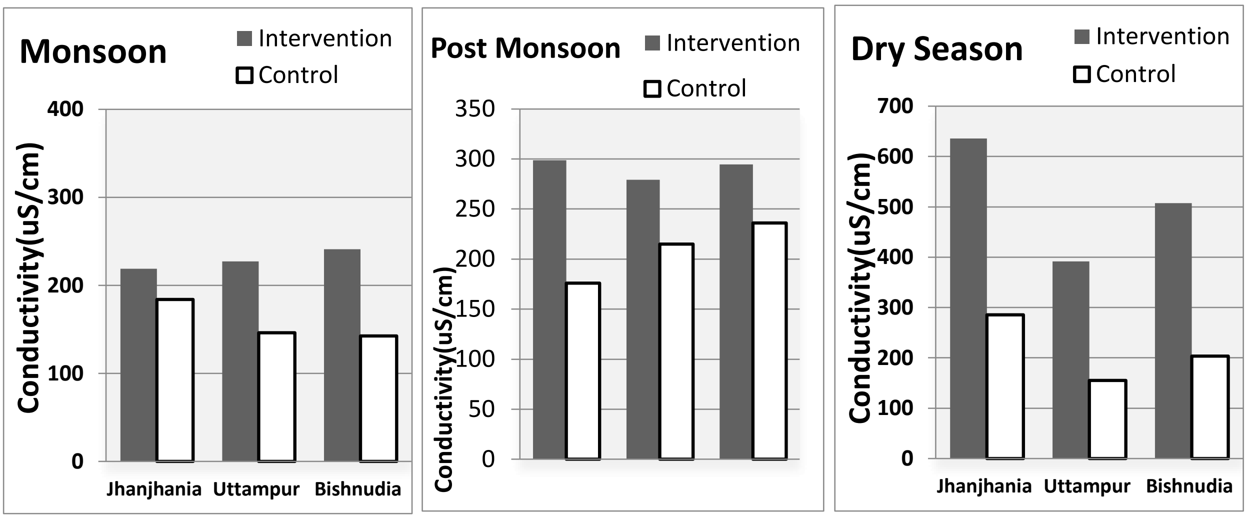


Figure 8b. Measured Conductivity(uS/cm) in waters of intervention and control sites in different seasons

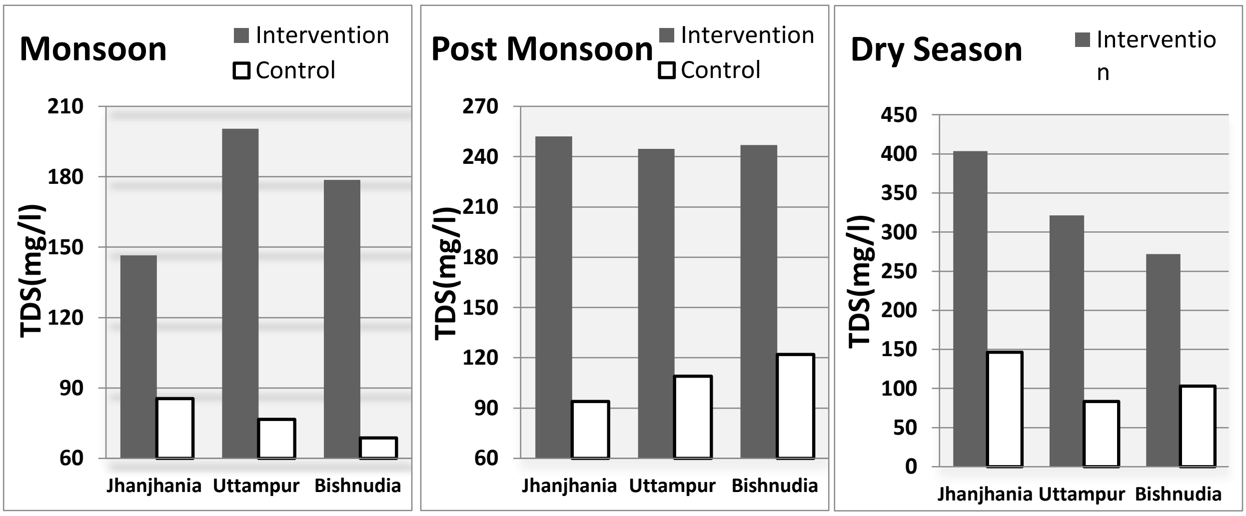


Figure 8c. Measured TDS levels (mg/l) in waters of intervention and control sites in different seasons

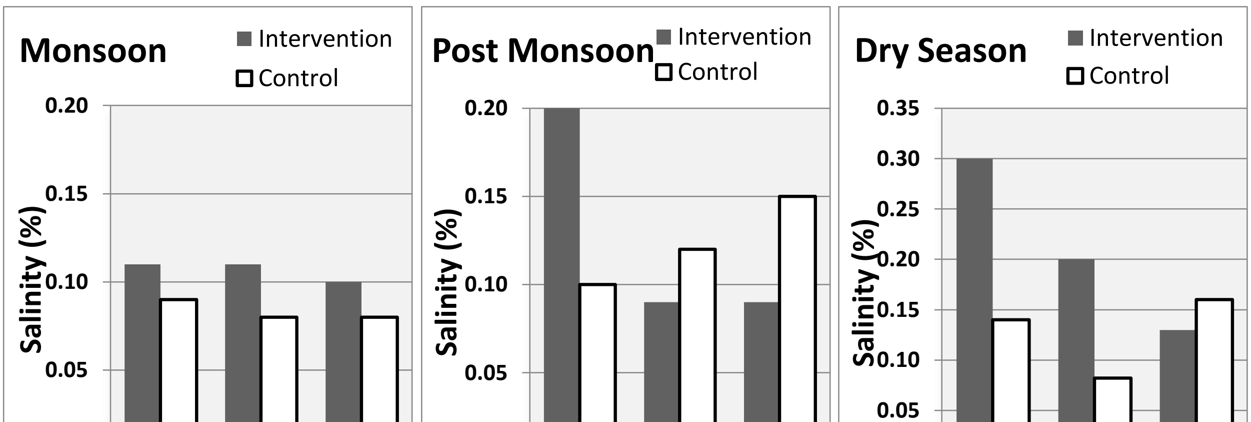


Figure 8d. Measured Salinity levels (%) in waters of intervention and control sites in different seasons

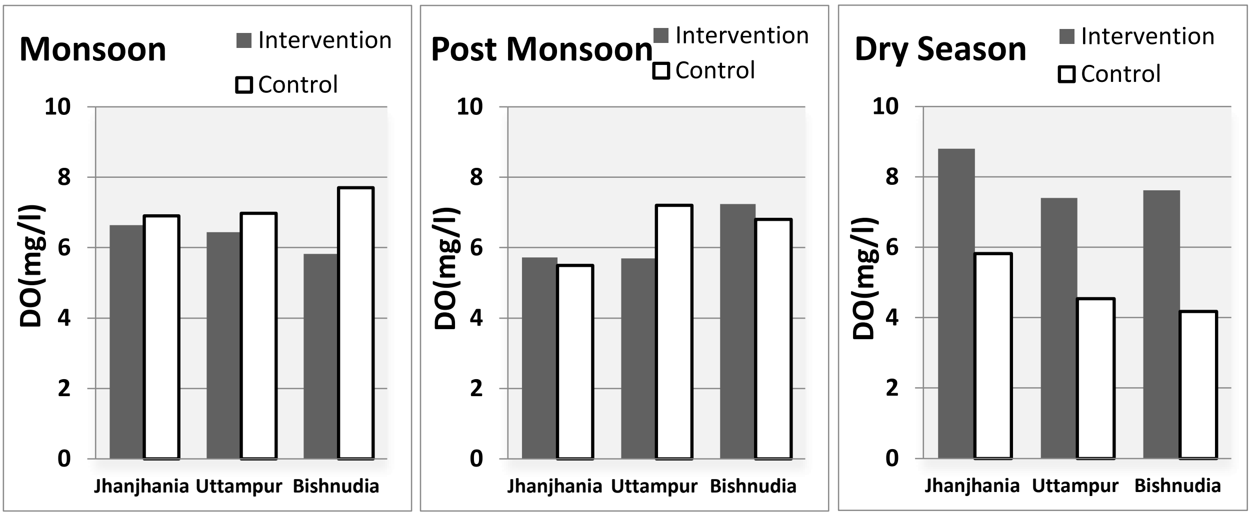


Figure 8e. Measured DO(mg/l) levels in waters of intervention and control sites in different seasons

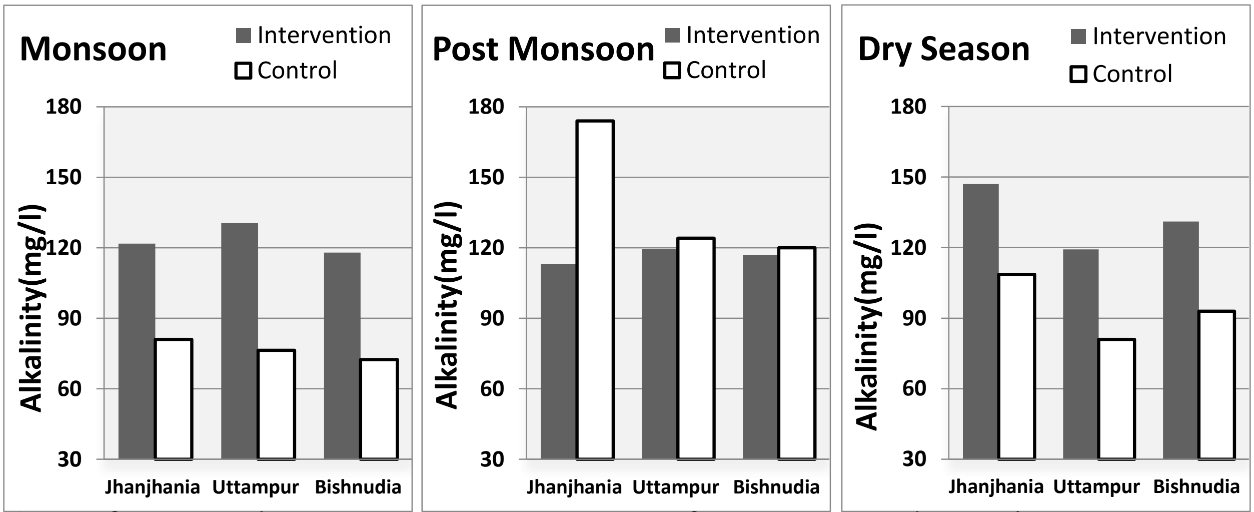


Figure 8f. Measured Alkalinity levels (mg/l) in waters of intervention and control sites in different seasons

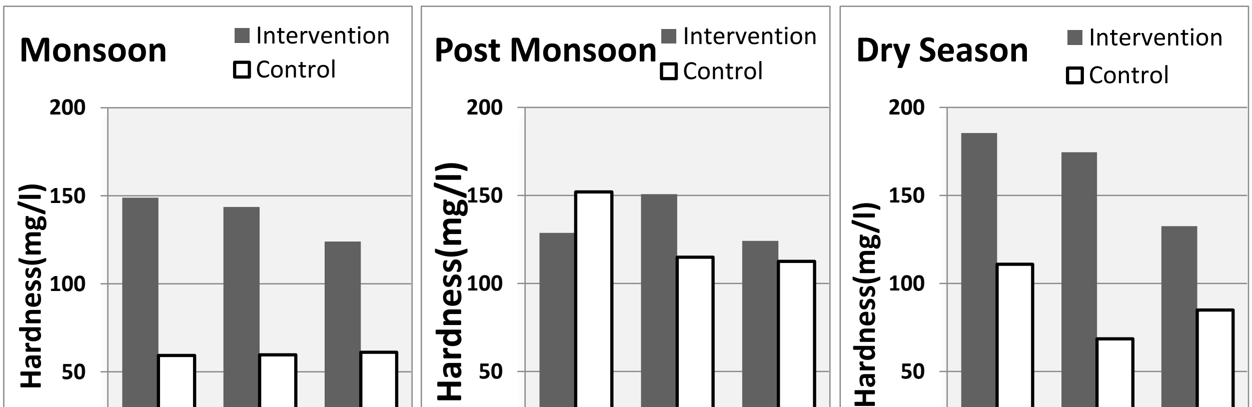


Figure 8g. Measured hardness levels (mg/l) in waters of intervention and control sites in different seasons

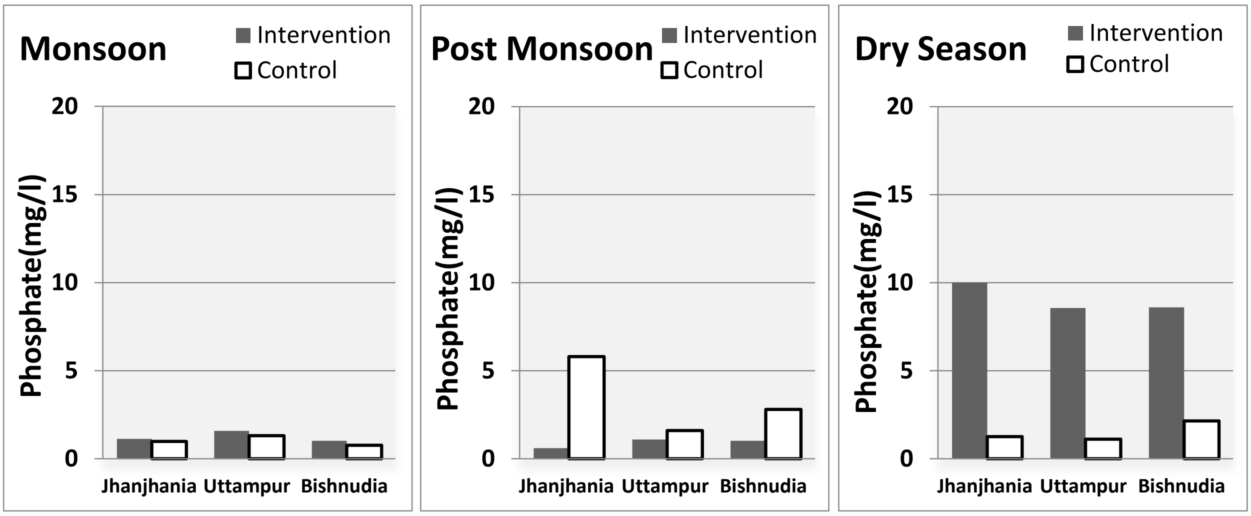


Figure 8h. Measured Phosphate concentrations (mg/l) in waters of intervention and control sites in different seasons

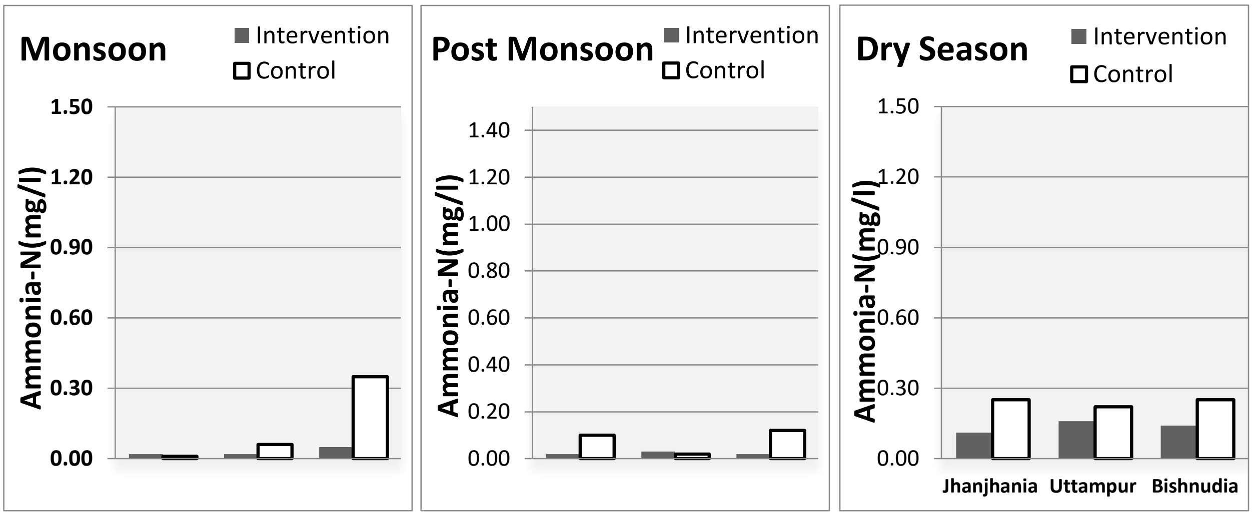


Figure 8i. Measured Ammonia-N(mg/l) in waters of intervention and control sites in different seasons

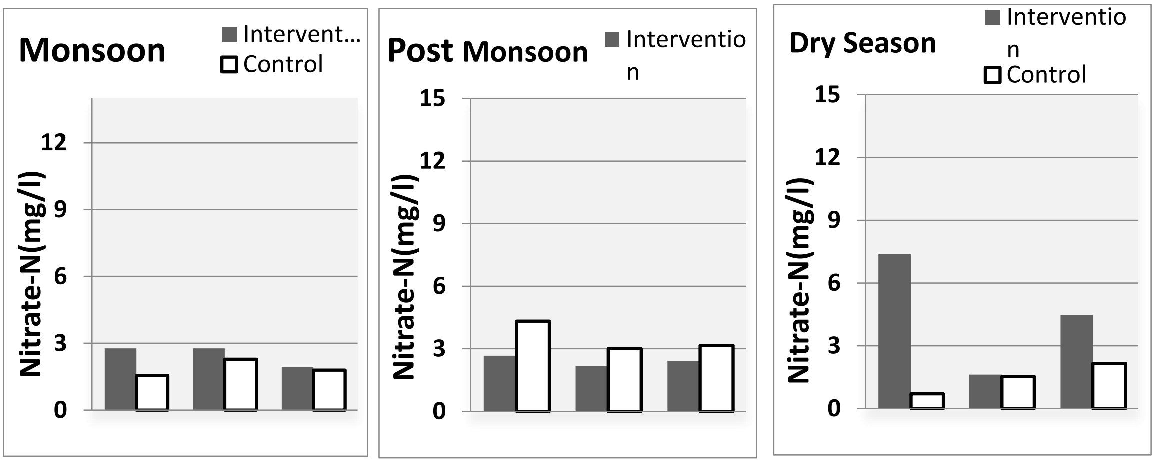


Figure 8j. Measured Nitrate-N(mg/l) in waters of intervention and control sites in different seasons

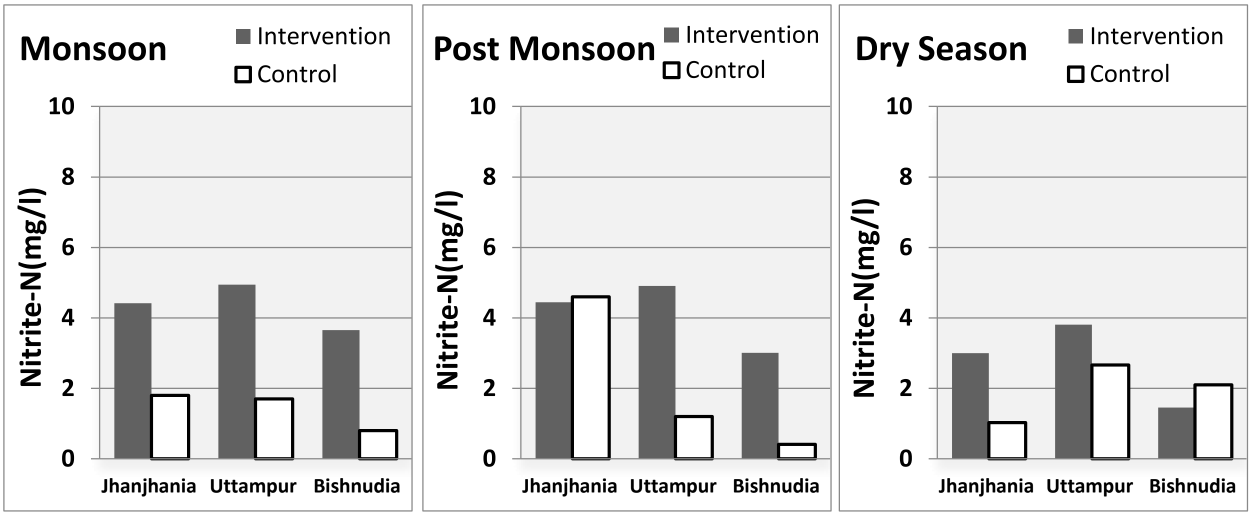


Figure 8k.Measured Nitrite-N conc. (mg/l) in waters of intervention and control sites in different seasons

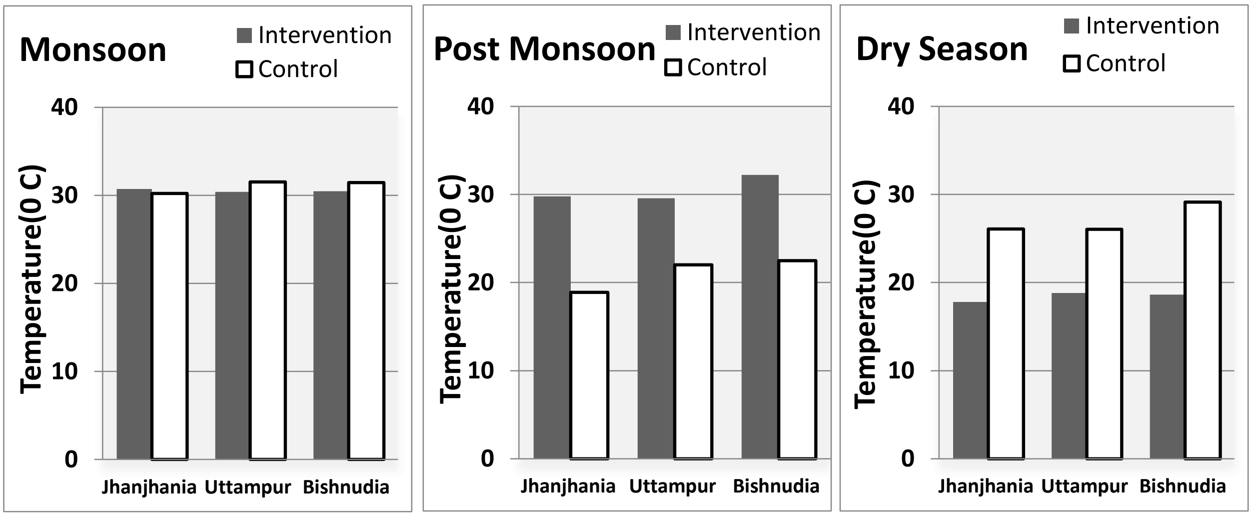


Figure 8l. Measured water temperature (˚C) in waters of intervention and control sites in different seasons

4.3 Water quality parameters of the study area

4.3.1 Water pH

The results of pH measurements are graphically shown in Figure 7 and further detail data are provided in Table 6. In Jhanjhania FP, the water pH varied from 6.88 to 7.77 with an average of 7.10. Seasonal variations in water pH were noted little. The highest pH level in this site was noted in winter season (7.77). Similarly, the pH levels fluctuated from 6.77 to 7.89 with an average of 7.31 in Bishnudia FP, the highest being recorded in pre-monsoon and lowest in monsoon. In Uttampur FP, the pH values ranged from 6.80 to 7.78 with an average of 7.26, the highest value was recorded in pre-monsoon and the lowest value was noted in monsoon. A

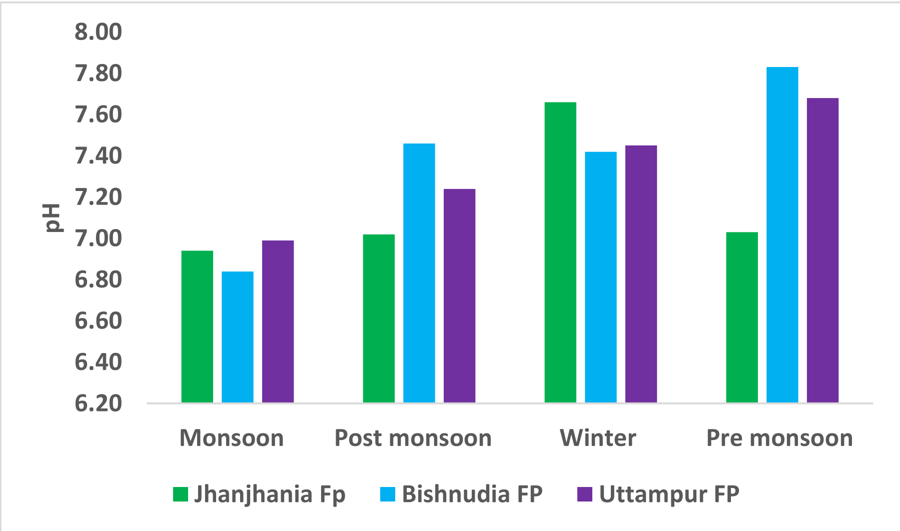


Figure 9. Seasonal variations in water pH from July 2016 to June 2019

higher value was recorded in Bishnudia at one station (pond). This pond was limed a day before sampling. This probably contributed to this elevated pH level. According to Boyd (1982), liming increases the water pH by adding carbonate and bicarbonate.

Table 6. Seasonal variations in water pH from July 2016 to June 2019

Season	Jhanjhania FP				Bishnudia FP				Uttampur FP			
	2016	**2017**	**2018**	**2019**	**2016**	**2017**	**2018**	**2019**	**2016**	**2017**	**2018**	**2019**
Monsoon	6.97	7.00	6.88	6.90	6.86	6.77	6.86	6.88	7.15	7.00	6.80	7.00
Post monsoon	7.02	7.10	6.97	7.00	7.67	7.50	7.65	7.00	7.18	7.20	7.44	7.15
winter	-	7.77	7.55	-	-	7.39	7.44	-	-	7.39	7.50	-
Pre monsoon	-	7.06	6.99	-	-	7.89	7.77	-	-	7.58	7.78	-
Total	13.99	28.93	28.39	13.90	14.53	29.55	29.72	13.88	14.33	29.17	29.52	14.15
Yearly average	7.00	7.23	7.10	6.95	7.27	7.39	7.43	6.94	7.17	7.29	7.38	7.08
Floodplain average	7.10				7.31				7.26			

4.3.2 Conductivity

The results of conductivity measurement are provided in Table 7 and graphically shown in Figure 8. In Jhanjhania FP, the conductivity of water varied from 205.5 µS/cm^2 to 769.0 µS/cm^2 with an average of 348.0 µS/cm^2. The highest conductivity was observed in winter and the lowest in monsoon. Similarly, the conductivity ranged from 191.8 µS/cm^2 to 765.0 µS/cm^2 with an average of 313.5 µS/cm^2 in Bishnudia FP, the highest being recorded in winter and lowest in monsoon. In Uttampur FP, conductivity levels ranged from 173.0 to 532.8 µS/cm^2, with an average of 251.1 µS/cm^2, the highest value was noted in winter period and the lowest in monsoon An exceptionally high level of conductivity was measured only in one station in Jhanjhania during in winter. This probably occurred due to use of certain type of fertilizer.

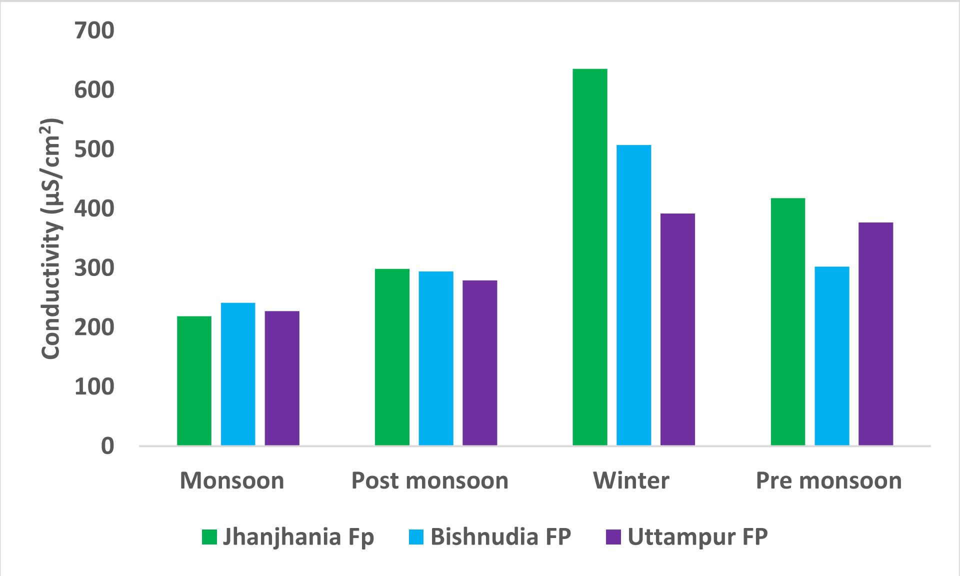


Figure 10. Seasonal variations in water conductivity (µS/cm^2) from July 2016 to June 2019

Table 7. Seasonal variations in water conductivity (µS/cm^2) from July 2016 to June 2019

Season	Jhanjhania FP				Bishnudia FP				Uttampur FP			
	2016	2017	2018	2019	2016	2017	2018	2019	2016	2017	2018	2019
Monsoon	219.1	220.5	230.1	205.5	191.8	215.0	308.0	250.0	173.0	310.2	210.1	215.5
Post monsoon	293.7	300.0	298.8	302.0	202.9	301.7	402.7	270.5	215.9	300.0	288.8	312.0
winter	-	769.0	502.8	-	-	250.0	765.0	-	-	250.6	532.8	-
Pre monsoon	-	402.7	432.5	-	-	305.5	298.8	-	-	341.3	412.5	-
Yearly average	256.4	423.1	366.1	253.8	197.4	268.1	443.6	260.3	194.5	163.0	361.1	263.8
Floodplain average	348.0				313.5				251.1			

4.3.3 Total Dissolved Solids (TDS)

Figure 9 and Table 8 show the results of TDS measurements in the study sites in 4 different seasons. The levels ranged from 104.3 to 404.0 mg/l with an average of 234.1 mg/l in Jhanjhania FP, the highest was measured in winter, while that of Bishnudia FP varied from 96.6 ton 404.0 mg/l with an average of 224.9 mg/l, the highest being recorded in winter. Similarly, in Uttampur FP, TDS levels ranged from 82.2 to 502.8 mg/l with an average value of 250.0 mg/l, the highest value was noted in winter period and the lowest in monsoon.

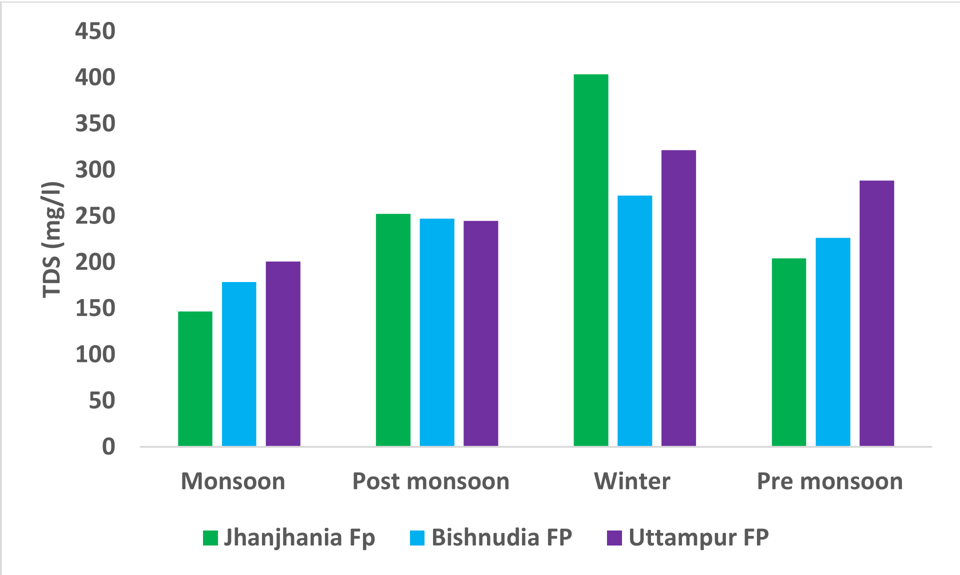


Figure 11. Seasonal variations in TDS (mg/l) of water in three floodplains during the period July 2016-June 2019

Table 8. Seasonal variations in TDS (mg/l) of water from July 2016 to June 2019

Season	Jhanjhania FP				Bishnudia FP				Uttampur FP			
	2016	**2017**	**2018**	**2019**	**2016**	**2017**	**2018**	**2019**	**2016**	**2017**	**2018**	**2019**
Monsoon	104.3	109.0	167.3	205.5	108.5	119.0	237.0	250.0	82.2	304.2	210.1	205.5
Post monsoon	220.7	250.5	235.5	302.0	96.6	270.5	350.5	270.5	103.0	300.0	256.8	319.0
winter	-	404.0	402.8	-	-	140.2	404.0	-	-	140.0	502.8	-
Pre monsoon	-	206.0	202.5	-	-	146.6	306.0	-	-	163.9	412.5	-
Yearly average	162.5	242.3	252.0	253.7	102.5	169.0	324.3	260.2	92.6	227.0	345.5	262.2
Floodplain average	234.1				224.9				250.0			

4.3.4 Salinity

The results of salinity measurements are provided in Table 9 and graphically shown in Figure 10. In Jhanjhania FP, the salinity of water fluctuated from 0.09% to 0.40% with an average of 0.20%. The highest salinity was observed in winter and the lowest in monsoon. Similarly, the salinity in Bishnudia FP ranged from 0.05 to 0.15% with an average of 0.11%, the highest being recorded in pre-monsoon and lowest in post monsoon. In Uttampur FP, salinity levels ranged from 0.05 to 0.25%, with an average of 0.13%, the highest value was noted in winter period and the lowest in monsoon. These arranges I salinity for coastal areas is quite normal and not unsuitable for the fresh water fishes.

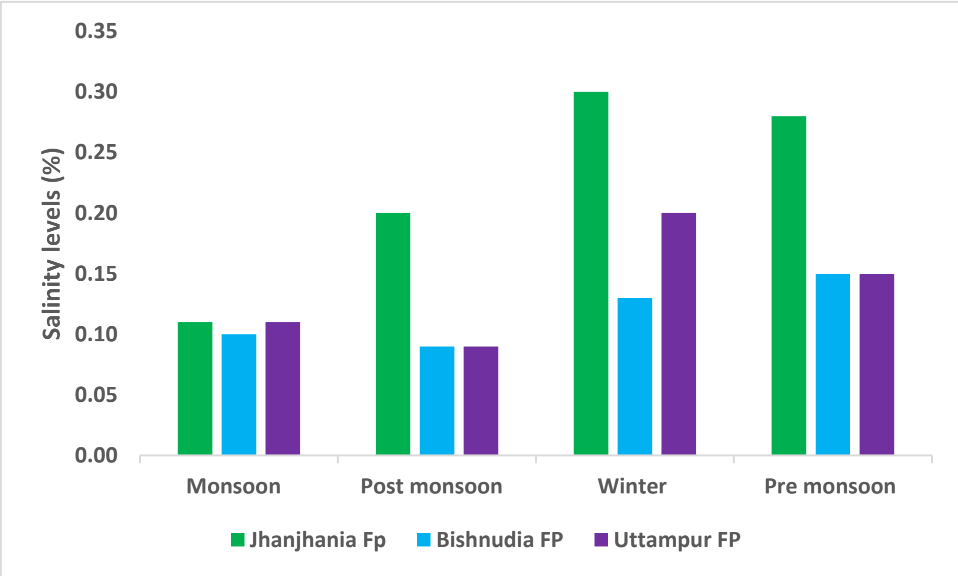


Figure 12. Seasonal variations in salinity levels (%) of water in three study sites during the period July 2016-June 2019

Table 9. Seasonal variations in salinity levels (%) of water in three study sites during the period July 2016-June 2019

Season	Jhanjhania FP				Bishnudia FP				Uttampur FP			
	2016	2017	2018	2019	2016	2017	2018	2019	2016	2017	2018	2019
Monsoon	0.10	0.09	0.11	0.15	0.11	0.09	0.08	0.11	0.08	0.15	0.05	0.17
Post monsoon	0.20	0.15	0.25	0.20	0.09	0.12	0.10	0.05	0.10	0.07	0.09	0.11
winter	-	0.40	0.20	-	-	0.14	0.11	-	-	0.14	0.25	-
Pre monsoon	-	0.35	0.20	-	-	0.15	0.14	-	-	0.16	0.14	-
Yearly average	0.15	0.25	0.19	0.18	0.10	0.13	0.11	0.08	0.09	0.13	0.13	0.14
Floodplain average	0.20				0.11				0.13			

4.4.5 Dissolved Oxygen (DO)

Figure 11 and Table 10 present results of DO measurements in the study sites in 4 different seasons. In Jhajhania FP, the DO levels ranged from 4.87 to 9.10 mg/l with an average of 6.60 mg/l, the highest was noted in winter, while the lowest was recorded in pre-monsoon and the highest level was observed in winter. In Bishnudia FP, the DO levels varied from 5.12

to 9.50 mg/l with an average of 7.10 mg/l, the highest being recorded in pre-monsoon and the lowest in monsoon. Similarly, in Uttampur FP, DO fluctuate from 5.16 to 7.72 mg/l with an average value of 6.60 mg/l, the highest value was noted in pre-monsoon period and the lowest in post monsoon.

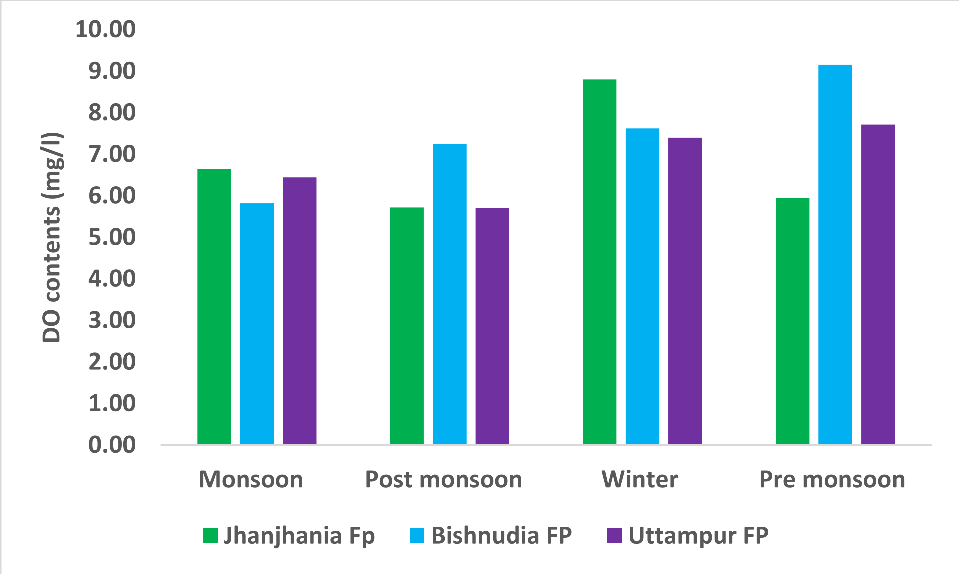


Figure 13. Seasonal variations in DO contents (mg/l) of water in three floodplains during the period July 2016-June 2019

Table 10. Seasonal variations in DO contents (mg/l) of water in three floodplains during the period July 2016-June 2019

Season	Jhanjhania FP				Bishnudia FP				Uttampur FP			
	2016	2017	2018	2019	2016	2017	2018	2019	2016	2017	2018	2019
Monsoon	6.64	6.70	6.55	6.67	5.12	6.55	5.50	6.10	6.49	6.25	6.33	6.70
Post monsoon	5.40	5.50	6.00	5.97	8.06	7.50	5.40	8.00	5.16	5.90	6.22	5.50
winter	-	9.10	8.50	-	-	7.24	8.00	-	-	7.24	7.55	-
Pre monsoon	-	4.87	7.00	-	-	9.50	8.80	-	-	7.72	7.70	-
Yearly average	6.00	6.50	7.00	6.30	6.60	7.70	6.90	7.10	5.80	6.80	7.00	6.10
Floodplain average	6.60				7.10				6.60			

4.4.6 Alkalinity

Figure 12 and Table 11 provides data on alkalinity measurements in the study sites in 4 different seasons. The levels ranged from 102.3 to 182.0 mg/l with an average of 121.5 mg/l mg/l in case of Jhanjhania FP. The highest alkalinity was measured in winter and the lowest in pre-monsoon while that of Bishnudia FP varied from 109.0 to 132.0 mg/l with an average of 120.6 mg/l, the highest being recorded in winter. Similarly, in Uttampur FP, alkalinity levels ranged from 110.0 to 139.0 mg/l with an average value of 124.7 mg/l, the highest value was noted in monsoon period and the lowest in post monsoon.

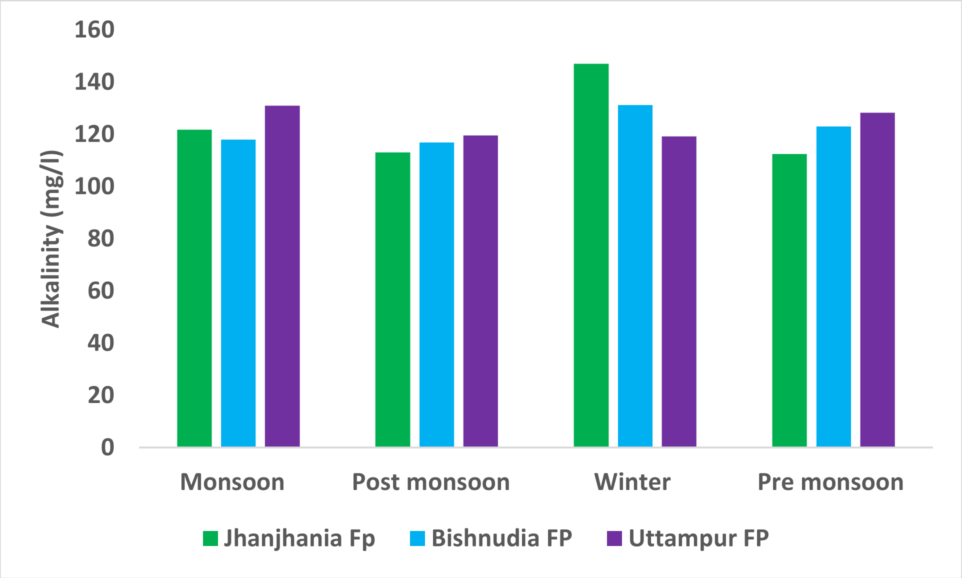


Figure 14. Seasonal variations in alkalinity (mg/l) of water in three study sites during the period July 2016-June 2019

Table 11. Seasonal variations in alkalinity (mg/l) of water in three study sites during the period July 2016-June 2019

Season	Jhanjhania FP				Bishnudia FP				Uttampur FP			
	2016	2017	2018	2019	2016	2017	2018	2019	2016	2017	2018	2019
Monsoon	127.0	129.0	119.5	111.5	122.0	130.3	109.0	110.4	139.0	120.5	130.5	133.8
Post monsoon	113.0	115.0	105.0	119.4	111.0	129.8	115.0	111.6	110.3	110.0	129.0	129.1
winter	-	182.0	112.0	-	-	130.3	132.0	-	-	121.3	117.2	-
Pre monsoon	-	102.3	122.6	-	-	123.6	122.3	-	-	124.6	132.0	-
Yearly average	120.0	132.1	114.8	115.5	116.5	128.5	119.6	111.0	124.7	119.1	127.2	131.5
Floodplain average	121.5				120.6				124.7			

4.4.7 Hardness

The hardness of water measured as $CaCO_3$ in water. The hardness levels also varied depending on the season and sampling sites and stations. The data on hardness measurements are provided in Table 12 and the same are graphically shown in Figure 13. The hardness concentrations in Jhanjhania FP ranged from 106.6 to 201.0 mg/l, with an average 143.3 mg/l, the highest level was recorded in winter and the lowest in pre-monsoon. The levels fluctuated from 105.6 to 148.0 mg/l in Bishnudia FP, with an average concentration of 124.5 mg/l. In this site, the highest level was noted in monsoon and winter and the lowest level in pre-monsoon. Similarly, In Uttampur FP, the levels varied from 106.6 mg/l to 200.2 mg/l, with an average of 146.8 mg/l. In this case, the highest hardness level was noted in in monsoon and the lowest in pre-monsoon. The hardness levels measured compare well with data from other studies for floodplains.

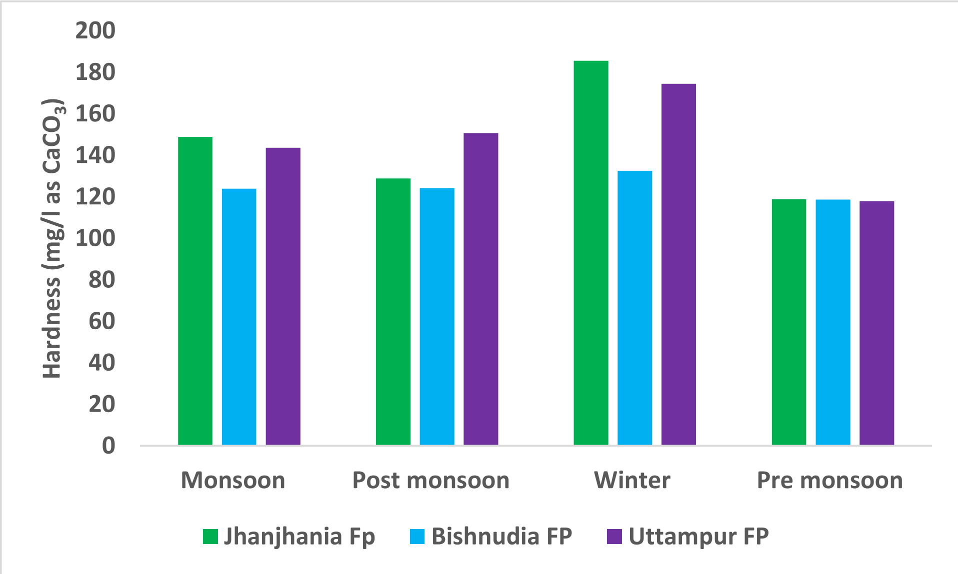


Figure 15. Seasonal variations in hardness (mg/l as $CaCO_3$) of water

Table 12. Seasonal variations in hardness (mg/l as $CaCO_3$) of water from July 2016-June 2019

Season	Jhanjhania FP				Bishnudia FP				Uttampur FP			
	2016	**2017**	**2018**	**2019**	**2016**	**2017**	**2018**	**2019**	**2016**	**2017**	**2018**	**2019**
Monsoon	133.0	130.1	201.0	131.5	114.0	130.3	131.0	120.5	123.3	200.2	130.1	120.8
Post monsoon	131.0	125.0	130.0	129.4	112.6	129.7	133.0	121.6	108.6	160.0	125.0	209.1
winter	-	201.0	170.0	-	-	148.0	117.0	-	-	148.0	201.0	-
Pre monsoon	-	106.6	131.0	-	-	105.6	131.7	-	-	129.3	106.6	-
Yearly average	132.0	140.7	158.0	130.5	113.3	128.4	128.2	121.1	116.0	159.4	140.7	165.0
Floodplain average	143.3				124.5				146.8			

4.4.8 Total Phosphate

The phosphate concentration in water varied greatly depending on the seasons as well as depending on sampling stations. The results on phosphate measurements are provided in Figure 14 and Table 13. In Jhanjhania FP, the measured phosphate levels ranged from 0.33 to 12.10 mg/l with an average of 2.70 mg/l., the highest was measured in winter and the lowest in post monsoon. Similarly, the levels varied from 0.40 to 8.70 mg/l in Bishnudia, with an average of 3.27 mg/l, the highest being measured in winter and lowest in post monsoon. Similarly, in Uttampur, the phosphate concentrations in water fluctuated from 0.45 to 8.70

mg/l, with an average concentration of 3.26 mg/l, the highest was observed in winter and the lowest was recorded in post monsoon. The extreme fluctuations were only observed in particular station In each sampling station in particular season. This coincided with application of phosphate containing fertilizer I rice fields during the winter season.

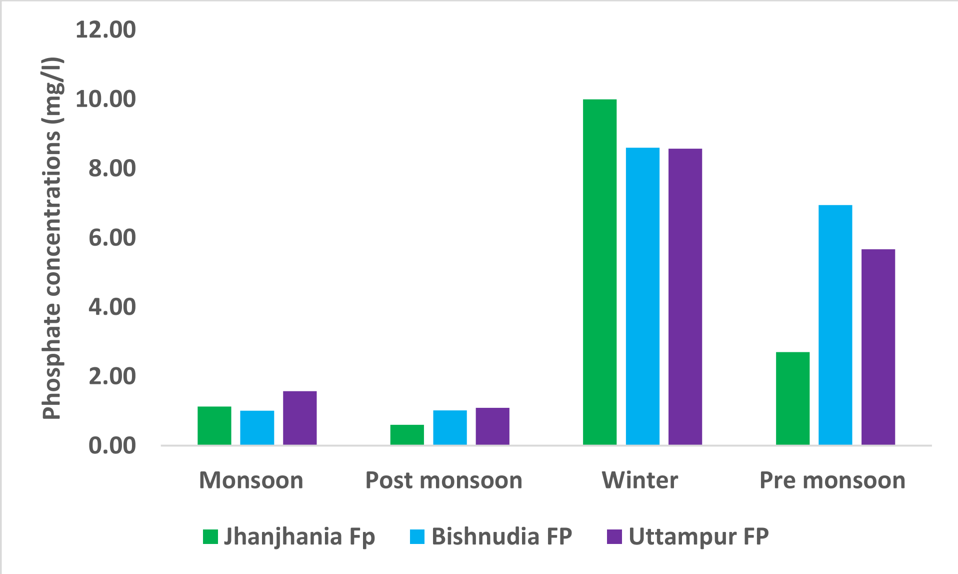


Figure 16. Seasonal variations in the total phosphate concentrations (mg/l) of water in three study sites during the period July 2016-June 2019

Table 13. Seasonal variations in the total phosphate concentrations (mg/l) of water in three study sites during the period July 2016-June 2019

Season	Jhanjhania FP				Bishnudia FP				Uttampur FP			
	2016	2017	2018	2019	2016	2017	2018	2019	2016	2017	2018	2019
Monsoon	0.83	1.00	1.20	1.50	0.96	1.33	1.11	0.65	2.43	1.35	1.65	0.87
Post monsoon	0.33	0.67	1.02	0.40	1.83	1.23	0.60	0.40	0.45	0.85	1.80	1.29
winter	-	12.10	7.89	-	-	8.70	8.50	-	-	8.70	8.44	-
Pre monsoon	-	2.80	2.60	-	-	8.35	5.55	-	-	4.64	6.70	-
Yearly average	0.58	4.14	3.18	0.95	1.40	4.90	3.94	0.53	1.44	3.89	4.65	1.08
Floodplain average	2.70				3.27				3.26			

4.4.9 Total Ammonia-N

The ammonia concentrations also varied extremely, particularly during winter season. The data on ammonia measurements are provided in Table 14 and the same is graphically presented in Figure 15. In Jhanjhania FP, ammonia concentrations fluctuated from 0.013 to 0.113 mg/l with an average of 0.038 mg/l. The highest level was recorded in winter and the lowest level in monsoon. In case of Bishnudia FP, the levels ranged from 0.013 to 0.160 mg/l with an average of 0.060 mg/l, the highest level being noted in winter and the lowest in monsoon. In Uttampur FP, the ammonia concentrations varied from 0.011 to 0.160 mg/l, with an average of 0.047 mg/l. The highest level was recorded in winter and lowest level in monsoon. The extreme variation was noted only in a very few cases and that probably occurred due to use of ammonia containing fertilizer.

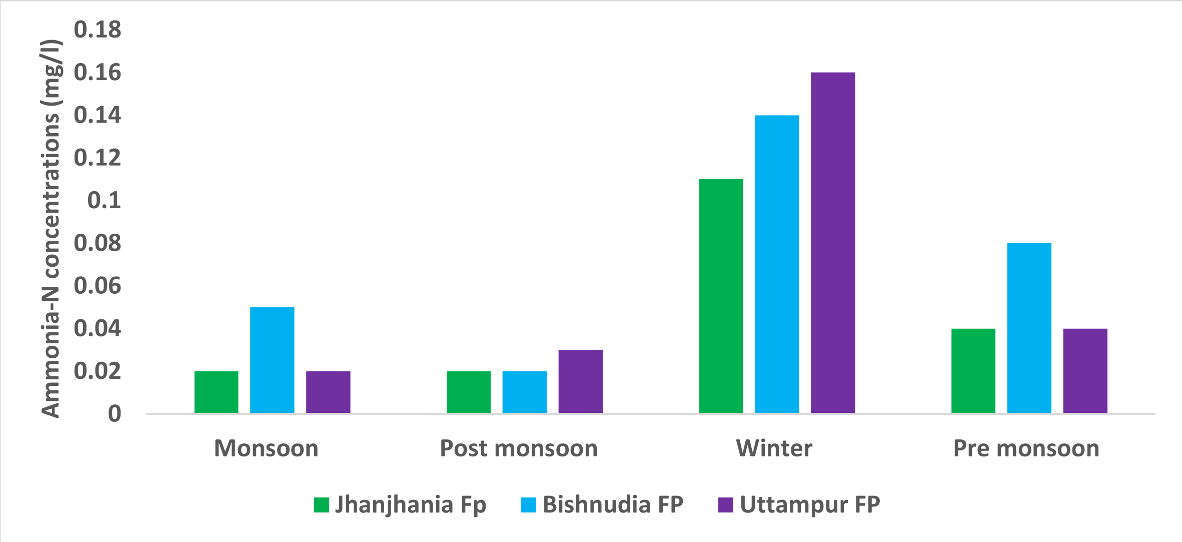


Figure 17. Seasonal variations in the total ammonia-N concentrations (mg/l) of water in three study sites during the period July 2016-June 2019

Table 14. Seasonal variations in the total ammonia-N concentrations (mg/l) of water in three study sites during the period July 2016-June 2019

Season	Jhanjhania FP				Bishnudia FP				Uttampur FP			
	2016	**2017**	**2018**	**2019**	**2016**	**2017**	**2018**	**2019**	**2016**	**2017**	**2018**	**2019**
Monsoon	0.013	0.026	0.016	0.030	0.023	0.140	0.013	0.020	0.023	0.017	0.011	0.012
Post monsoon	0.023	0.011	0.021	0.013	0.020	0.016	0.032	0.020	0.036	0.017	0.024	0.029
winter	-	0.103	0.113	-	-	0.160	0.117	-	-	0.160	0.155	-
Pre monsoon	-	0.047	0.037	-	-	0.130	0.023	-	-	0.046	0.034	-
Yearly average	0.018	0.047	0.047	0.022	0.022	0.112	0.046	0.020	0.030	0.060	0.056	0.021
Floodplain average	0.038				0.060				0.047			

4.4.10 Total Nitrate-N

Results of nitrate-N measurements are graphically presented in Figure . 16 and the data for the same are given in Table 15. Exceptionally high fluctuations in data are evident. In case of Jhanjhania FP, the concentrations ranged from 2.30 to 9.00 mg/l with an average of 3.85 mg/l, the highest being recorded in winter and the lowest in post monsoon. Similarly, nitrate concentrations in Bishnudia FP, varied from 1.30 to 11.46 mg/l with an average of 3.47 mg/l.

The highest level was observed in pre monsoon and the lowest level was noted in monsoon. In case of Uttampur FP, the levels fluctuated between 1.25 and 14.63 mg/l with an average of 4.36 mg/l, the highest level was recorded in winter and the lowest in monsoon.

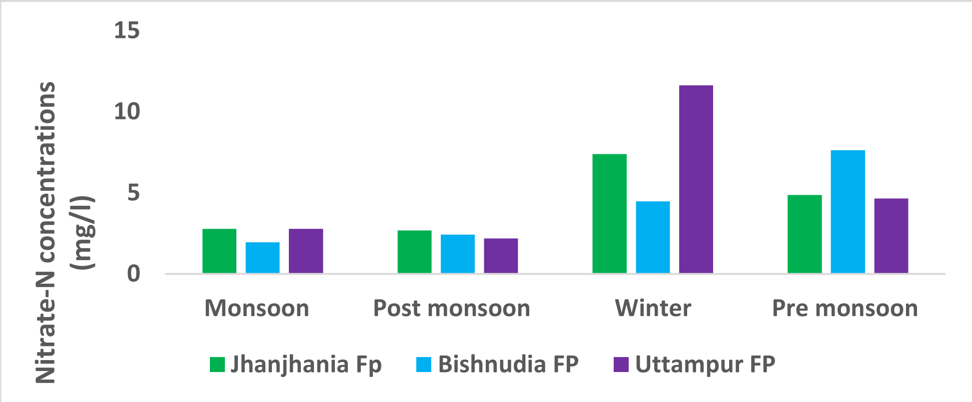


Figure 18. Seasonal variations in the total nitrate-N concentrations (mg/l) of water in three study sites during the period July 2016-June 2019

Table 15. Seasonal variations in the total nitrate-N concentrations (mg/l) of water in three study sites during the period July 2016-June 2019

Season	Jhanjhania FP				Bishnudia FP				Uttampur FP			
	2016	2017	2018	2019	2016	2017	2018	2019	2016	2017	2018	2019
Monsoon	2.63	2.54	3.30	2.60	1.30	2.10	2.50	1.84	2.50	1.25	5.45	1.87
Post monsoon	2.30	3.00	2.97	2.40	2.16	2.87	3.00	1.65	1.80	2.00	2.80	2.10
winter	-	9.00	5.76	-	-	4.63	4.30	-	-	14.63	8.62	-
Pre monsoon	-	4.53	5.20	-	-	11.46	3.78	-	-	4.77	4.50	-
Yearly average	2.47	4.77	4.31	2.50	1.73	5.27	3.40	1.75	2.15	5.66	5.34	1.99
Floodplain average	3.85				3.47				4.36			

4.4.11 Total Nitrite-N

Figure 17 provides information on the nitrite-N measurements, while same numerical data are provided in Table 16. As with nitrate concentrations, nitrite concentrations also varied greatly and found elevated than the normal ranges for floodplains. The nitrite levels in Jhanjhania FP ranged from 2.03 to 6.00 mg/l with an average of 4.19 mg/l. The highest level was noted in post monsoon and the lowest level was measured in winter. In case of Bishnudia FP, the levels varied from 1.30 to 4.67 with an average of 3.17 mg/l, the highest level was found in pre monsoon and the lowest level in winter. Similarly, the level fluctuated from 3.10 to 8.36 mg/l in Uttampur FP, with an average nitrite concentration of 5.20 mg/l, the highest level was observed in pre monsoon and the lowest level in post monsoon. The elevated nitrate

level was probably caused due to breakdown process of bitrate containing fertilizer. Nitrite is highly toxic to fish. The higher levels were found in shallow water devoid of fish and planted rice
crops.

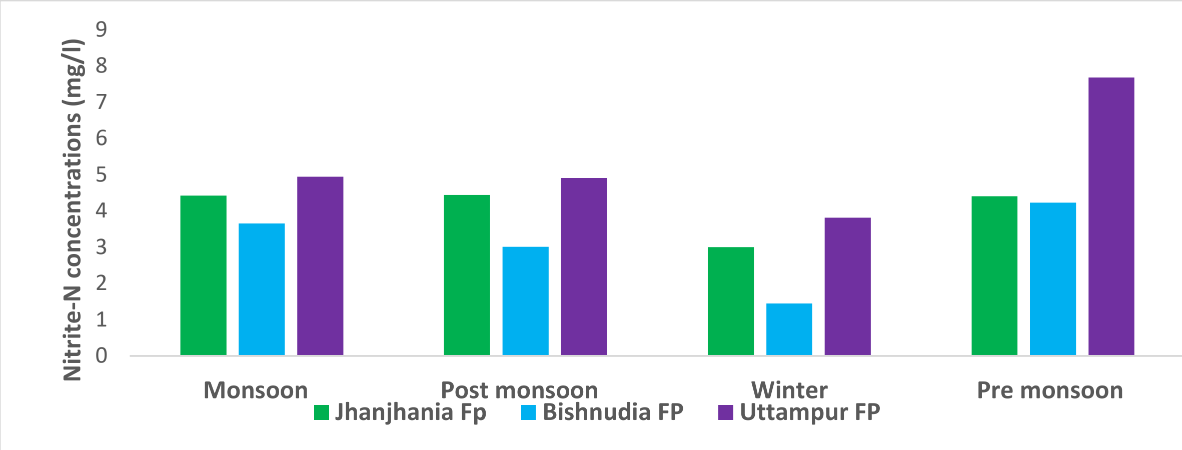


Figure 19. Seasonal variations in the total nitrite-N concentrations (mg/l) of water in three study sites during the period July 2016-June 2019

Table 16. Seasonal variations in the total nitrite-N concentrations (mg/l) of water in three study sites during the period July 2016-June 2019

Season	Jhanjhania FP				Bishnudia FP				Uttampur FP			
	2016	**2017**	**2018**	**2019**	**2016**	**2017**	**2018**	**2019**	**2016**	**2017**	**2018**	**2019**
Monsoon	4.67	4.50	4.00	4.50	3.83	3.33	4.00	3.45	7.00	5.25	3.65	3.87
Post monsoon	4.37	5.00	6.00	2.40	2.53	2.87	3.00	3.65	6.33	5.40	4.80	3.10
winter	-	2.03	3.97	-	-	1.60	1.30	-	-	4.00	3.62	-
Pre-monsoon	-	5.60	3.20	-	-	4.67	3.78	-	-	8.36	7.00	-
Yearly average	4.52	4.28	4.29	3.45	3.18	3.12	3.02	3.55	6.67	5.75	4.77	3.49
Floodplain average	4.19				3.17				5.20			

4.4.12 Water Temperature

Only water temperature was monitored. As evident from Figure 18, as expected, temperature varied depending on the seasons. It is also evident from the Table 17 that within the same season temperature levels varied between the study sites. This probably reflects the time of sampling during different times of the day in different study sites.

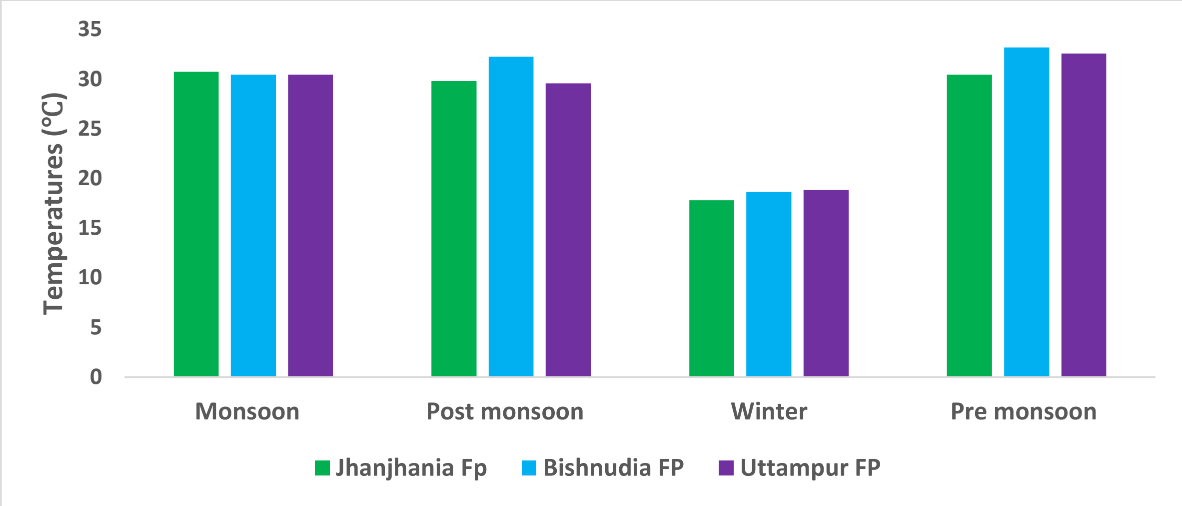


Figure 20. Seasonal variations in the water temperatures (°C) of water in three study sites during the period July 2016-June 2019

Table 17. Seasonal variations in the water temperatures (°C) of water in three study sites during the period July 2016-June 2019

Season	Jhanjhania FP				Bishnudia FP				Uttampur FP			
	2016	2017	2018	2019	2016	2017	2018	2019	2016	2017	2018	2019
Monsoon	30.33	30.10	31.00	31.50	30.03	30.33	31.00	30.45	30.00	30.25	30.65	30.87
Post monsoon	29.80	30.00	29.97	29.40	34.43	29.87	33.00	31.65	29.33	30.00	29.80	29.1
winter	-	18.57	17.00	-	-	19.96	17.30	-	-	20.03	17.62	-
Pre monsoon	-	29.67	31.20	-	-	34.55	31.78	-	-	33.16	32.00	-
Total	60.13	108.34	109.17	60.90	64.46	114.71	113.08	62.10	59.33	113.44	110.07	59.97
Yearly average	30.07	27.09	27.29	30.45	32.23	28.68	28.27	31.05	29.67	28.36	27.52	29.99
Floodplain average	28.21				29.53				28.57			

4.5 Composition and Abundance of Zooplankton

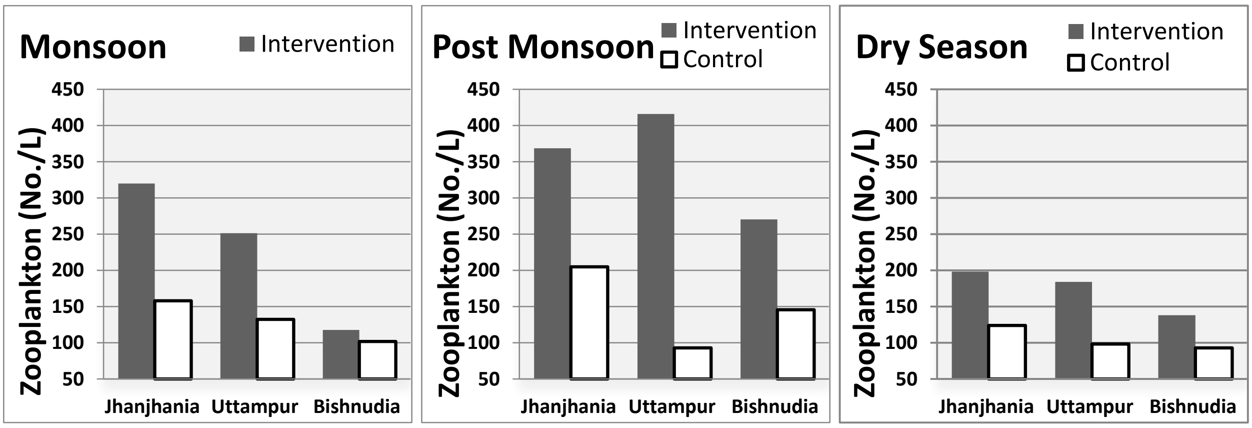
The zooplanktonic community of the project sites is represented by 45 species belonging to 6 major groups, viz. Cladocera (9 sppecies) , Copepoda (5 species), Ostracoda (3 species), Rotifera (20 species), Ostracoda (3 species). Protozoa(3 species) and others (2 species). Summary information on the abundances of zooplankton by zooplankton groups are provided in Table 4 and graphically shown in Figure 3, while lists of the recorded zooplankton species by individual intervention and control sites with its abundances are given in Annex 2.

The composition and abundances of zooplankton showed both spatial and temporal variations. In general, all intervention sites had higher number of zooplankters compared to its corresponding control sites. Similarly, there were also strong seasonal variations.

Variations were also found among different floodplains. A season wise description and discussion on the compostion and abundances of zooplankton is made below:

4.5.1 Wet season (Figure . 21a)

The abundance of zooplankton in wet season in intervention sites ranged from 117.62 /l (Uttampur) to 320.11/l (Jhanjhania, while that of control sites varied from 101.75 (Uttampur) to 157.87/l (Jhnjhania) (Figure . 19 and Annex 2.). As evident from the data in wet season all the intervention sites had higher abundances of zooplankton compared to control sites. However, compared to control, such difference in zooplankton abundance was not statistically different. In total, the number of zooplankton species recorded from the intervention site in wet season varied from 23 species (Bishnudia) to 28 species (Jhanjhania) and control sites had 22-26 species (Figure . 19 Table 18). The rotifers, copeponds, followed by c;adocera appeared as dominatant groups of zooplankton in wet season. Detail information on the species and its abundances are provided in Annex 3.



a b c

Figure 21. Zooplankton abundance (No./L) in intervention and control study sites in different

Table 18. Abundance (No./L)of zooplankton by groups in intervention and control study sites in wet season

Plankton groups	Jhanjhania Intervention	Jhanjhania Control	Bishnu dia Intervention	Bishnudia Control	Uttampur Intervention	Uttampur Control
Protozoa	10.19	2.4	0.4	2	2	0
Rotifera	19.87	37.6	57.01	23.8	15.86	28.8
Nauplii	70.2	26.4	36.93	16	21.67	16.4
Copepoda	69.44	12.4	27.95	30.4	26.88	7.6
Cladocera	28.33	15.2	34.31	7.6	6.77	7.4
Ostracoda	2	4.66	0.67	2.06	0.4	3.2
Total	**200.03**	**98.66**	**157.27**	**81.86**	**73.58**	**63.4**

4.5.2 Post monsoon (Figure . 21b)

In post monsoon, the zooplankton abundance varied from 270.4/l (Uttampur) to 416.0/l (Bishnudia) in intervention sites and from 93.12/l (Bishnudia) to 204.80/l (Jhanjhania) in control sites. All the intervention sites in post monsoon had higher number of zooplankton compared to the corresponding control sites, however, significant difference was noted only in case of Bishnudia. The species diversity varied from 22-29 in tervention sites and from 14 (Bishnudia)-22 control sites. Rotifers emerged as the modt dominant group, followed by nauplii and copeoda. Detail information on the species composition and its abundances are provided in Annex 3B.

It is apparent from the results that both species diversity and its abundances were higher in intervention sits than their corresponding control sites.

Table 19. Abundance (No./L)of zooplankton by groups in intervention and control study sites in post monsoon

Plankton groups	Jhanjhania Intervention	Jhanjhania control	Bishnu dia intervention	Bishnudia control	Uttampur intervention	Uttampur control
Protozoa	0.8	0.4	2	1.2	6.33	0
Rotifera	59.6	49.6	120.4	11.5	52.66	18.4
Nauplii	74.6	21.6	55.73	11.5	42.26	28
Copepoda	54.4	40.4	33.6	20.7	42.8	21.6
Cladocera	40.8	18.8	30.8	8	19.73	22
Ostracoda	0	3.2	18.4	5.6	4.8	1.06
Total	**230.2**	**134**	**260.93**	**58.5**	**168.58**	**91.06**

4.5.3 Dry season (Figure. 21c)

Overall, in dry season the composition and abundance of zooplankton were much lower than the wet season and post monsoon. 138.08/ to 189.44/ intervention sites, while the abundance ranged from 93.17/l to 124.16/l in control sites. Although, the intervention sites had higher abundances compared to the control sites, but the observed differences were not statistically significant. In dry season the differences in abundances from station to station were highly varied. The occurrence of species number ranged from 17 to 30 inintervention sites, while that of control sites fluctuated from 12 to 22 species. Comparatively, the bishnudia sites had lower species abundances. The dominant groups of zooplankton were in the order of rotifers>copepods>cladocerans.

Table 20. Abundance (No./L)of zooplankton in intervention and control study sites in wet season

Plankton groups	Jhanjhania Intervention	Jhanjhania Control	Bishnu dia intervention	Bishnudia Control	Uttampur intervention	Uttampur Cnontrol
Protozoa	7.8	0.8	2.8	0.8	1.2	2.4
Rotifera	25.46	27.6	32.06	19.2	24	3.6
Nauplii	23.8	13.8	20.93	10	16.8	12
Copepoda	19.4	18	47.4	14	30.3	25.5
Cladocera	36.46	14.4	9.6	14.7	6.6	14.8
Ostracoda	6	3.2	2.8	2.73	6.6	0
Total	**118.92**	**77.8**	**115.59**	**61.43**	**85.5**	**58.3**

Table 21. Species abundance (number/individual/site) of zooplankton in intervention and control study sites

Wet Season

Name of Group	Uttampur		Jhanjhania		Bishnudia	
	Intervention	**Control**	**Intervention**	**Control**	**Intervention**	**Control**
Protozoa	2	0	3	1	1	2
Rotifera	15	11	12	12	11	10
Nauplii	2	2	2	2	2	2
Copepoda	4	3	4	5	3	4
Cladocera	2	4	6	4	5	3
Ostracoda	1	2	1	2	1	2
Total	**26**	**22**	**28**	**26**	**23**	**23**

Post Monsoon

Name of Group	Uttampur		Jhanjhania		Bishnudia	
	Intervention	Control	Intervention	Control	Intervention	Control
Protozoa	2	0	1	1	2	1
Rotifera	8	5	10	9	12	4
Nauplii	2	2	2	2	2	2
Copepoda	3	3	4	4	4	3
Cladocera	5	3	5	2	6	2
Ostracoda	3	2	0	3	3	2
Total	**23**	**15**	**22**	**21**	**29**	**14**

Dry Season

Name of Group	Uttampur		Jhanjhania		Bishnudia	
	Intervention	Control	Intervention	Control	Intervention	Control
Protozoa	1	1	3	1	2	1
Rotifera	7	4	10	8	5	3
Nauplii	2	2	2	2	2	2
Copepoda	4	3	4	4	4	3
Cladocera	3	3	8	5	2	3
Ostracoda	2	2	3	2	2	0
Total	**19**	**15**	**30**	**22**	**17**	**12**

The species recorded in the present study represent the typical pond and floodplain species (Ehsan et al., 1997; Kabir et al., 1996; Kabir et al., 1997; Mozumder, 2011). Anonymous (2016) also recorded similar species from the same study sites. However, the present study recorded higher number of species than the earlier study in same floodplains. However, such differences could be expected as oscillation in year to year in zooplankton abundances as noted by various authors.

In general, the intervention sites showed comparatively higher population abundances of zooplankton, in spite of grazing by the stocked fish. Zooplankton productions are enhanced following fertilization and manuring (Boyd, 1992). The intervention sites, particularly the Bisgnudia site, were fertilized and also used supplementary feed consisting of oil cakes, rice barn and cow dung and probably contributed to enhanced production of zooplankton. The abundances of zooplankton in dry season were recorded much lower than the other two seasons. Most studies reports higher abundances of zooplankton in dry season in pond conditions. In fact, in dry season most part of the floodplain dried out or hold very little waters or had had irrigated waters and were not suitable for plankton growth. In Bishnudia intervention FP, the water body was made almost empty for facilitate last fishing and was sampled at that stage and probably that was the probable cause for reduced zooplankton abundance in Bishnudia intervention site.

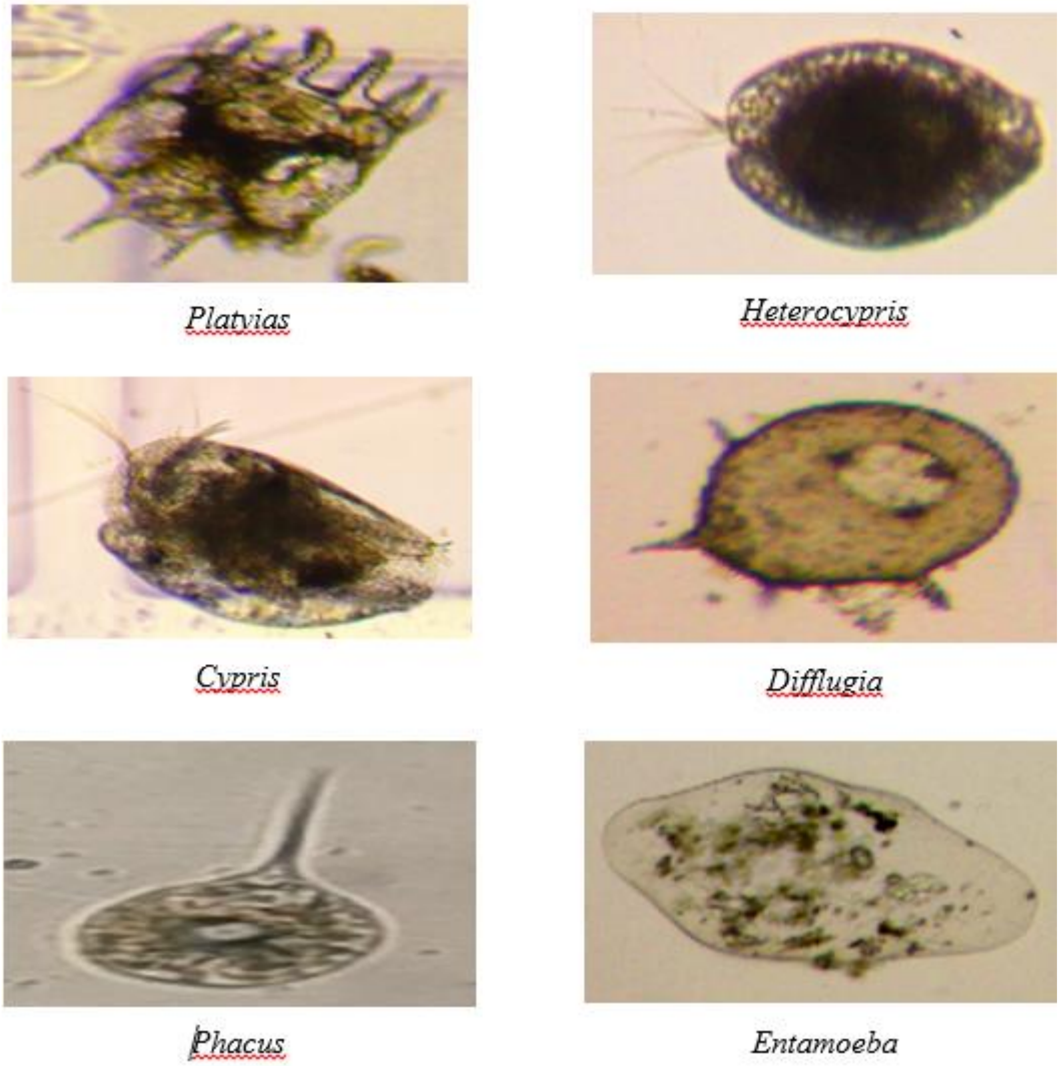
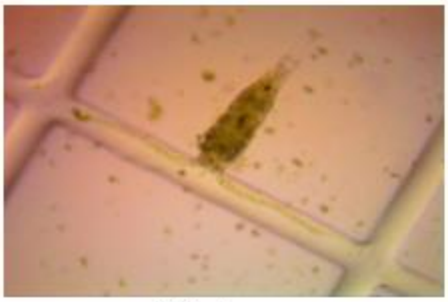


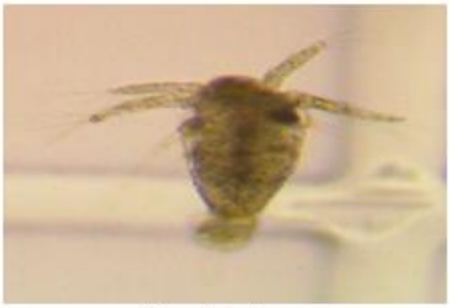
Figure 22. Plate of identified zooplankton

Cyclops



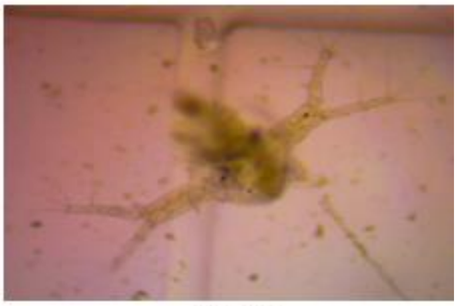
Diaptomus

Metanauplius larva



Nauplius larva

Canthocamptus



Moina

Figure 23. Plate of identified zooplankton

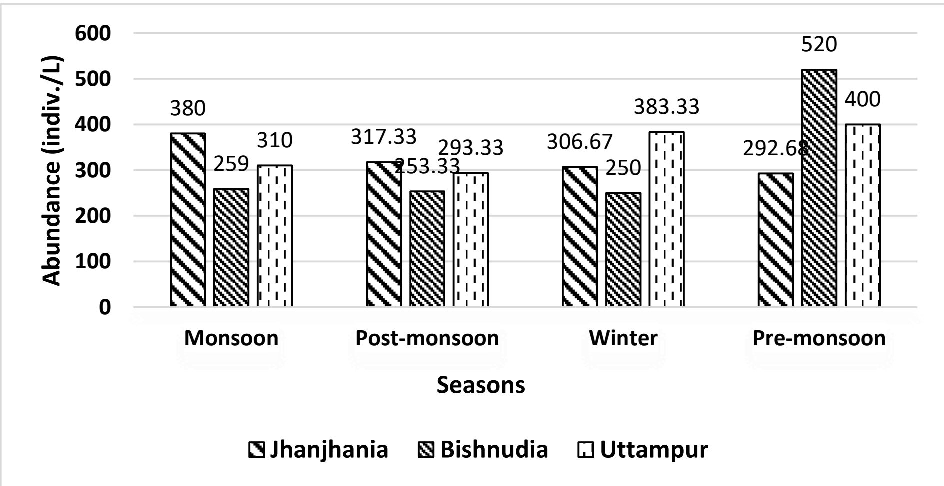


Figure 24a. Abundance (indiv./L) of zooplankton recorded from 3 floodplains in different seasons

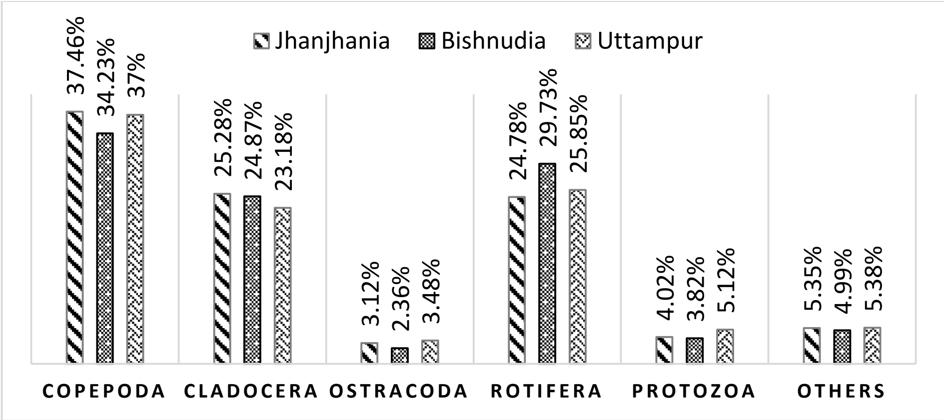


Figure 24(b). Percent occurrences of zooplankton by groups recorded from 3 floodplains .

4.6 Impact on Fisheries and Aquatic Biodiversity

4.6.1 Fish Diversity in the research sites

Fish species survey was carried out only in the three intervention floodplains. Local perception was captured to assess the changes in the species abundance through holding FGD.

A total of 60 species of fish belonging to 26 families have been recorded from all the three study sites, of which 51 species occur naturally in the wild and 9 species are cultured/stocked in the floodplains. Of the stocked fishes, 5 species are exotic. An inventory of the recorded fish species is provided in Table 22. A site wise account of the recorded fish species is given below.

Jhanjhania Site

In total, 50 species of wild fish species were recorded from the Jhanjonia Intervnetion Site. In addition, 5 exotic and 4 local species which usually do not occur in the site are stocked in the floodplain. Of the recorded species, 6 species are very common, 7 species common, 9 species fairly common, 20 species less common and another 8 species are rare within the Jhanjhania floodplain study site.

Bishnudia Site

The Bishnudia FP site has comparatively fewer number of fish species. Only 31 species have been recorded from the site, of which five are exotic stocked species. Of the native species, 3 species very are common, 4 species are common, 6 species fairly common, 13 species less common and another 5 species are rare within the Bishnudia floodpalin study site.

Uttampur Site

A total of 44 species of native wild fish species are known from the Uttampur FP Site, while another 9 species are also stocked including 5 exotic species. According to relative abundances of the recorded species, 6 species could be considered very common, 8 species common, 11 species fairly common, 12 species less common and another 7 species are rare within the site.

Table 22. List of observed native fish species

	No. of native species	Relative abundance				
		VC	C	FC	LC	R
Jhanjhania FP	50	6	7	9	20	8
Bishnudia FP	31	3	4	6	13	5
Uttampur FP	45	6	8	12	12	7

VC= Very common; C=Common; FC=Fairly common; LC=Less common ; R=Rare

Changes in the fish abundances

As per local accounts, apparently, in Jhanjhania floodplain, 9 fish species showed an increased abundance, 21 species registered a decreased abundance, while the abundance of 20 fish species remained unchanged, relative to the fish abundances in 2015. Similarly, in Uttampur site 8 species showed increased abundance, 15 species showed decreased abundance and another 22 species showed no changes in relative abundances, compared to the abundances in the year 2015. In Bishnudia study site, abundance of 8 fish species increased, 8 species remained unchanged, while another 15 sepcies showed a decline in abundance, compared to the pre-intervention period. The relative changes in fish abundance in the study sites shown in Table 23.

Table 23. The relative changes in fish abundance in the study sites

Name of FP	No. of species	Increased	decreased	Unchanged
Jhanjhania FP	50	9	21	20
Bishnudia FP	31	8	15	8
Uttampur FP	45	8	22	15

4.7 Diversity of Mollusc , crabs and Prawns

4.7.1 Molluscan diversity

The inventory of the recorded molluscan species is provided in Table 25. In general, the study sites are comparatively poor in molluscan fauna. In total, six species of molluscs were recorded from the study sites. Six species of molluscs inhabit Jhanjhania FP, 5 species Uttampur FP and four species of molluscs inhabit the Bishnudia FP study site. Information on the relative abundances of the recorded species are provided in Table 24.

Table 24. Information on the relative abundances of the recorded species

Relative Abundance					
Site name	**VC**	**C**	**FC**	**LC**	**R**
Jhanjhania FP	3		1	1	1
Uttampur FP	2	1	2		
Bishnudia FP		1	1	1	1

In Jhonjonia Site three species of molluscs are very common, while the rest two are less common within the site. In contrast, in Bishnudia site, two species are common, one species fairly common, one species less common and another species is rare within the site.

4.7.2 Prawn diversity

An inventory of recorded prawn species provided in in Table 13. The prawn species of the study sites are represented by five species. Both Jhnjhania and Uttampur sites have five species of prawns each, while the Bishnudia site has three species of pawns. Of the recorded species in Jhanjhania Site, one species is very common, two species fairly common and another two species are less common within the site, while in Uttampur Site, of the recorded species, one species is very common, two species are less common and two species are rare. Similarly, in Bishnudia Floodplain, one species of prawn is very common, one species fairly common, one species less common within the floodplain site. Information on the relative abundances of prawns recorded from the study sites are given in Table 25.

Table 25. Information on the relative abundances of prawns recorded from the study sites

	Relative abundances of prawn species

Site name	VC	C	FC	LC	R
Jhanjhania FP	1		2	2	-
Uttampur FP	1		2		2
Bishnudia FP	1		1	1	

4.7.3 Crab diversity

Two species of crabs were recorded from the three study sites and both the species are available in each side. Both the species are common to fairly common within each site. Apparently, no fish species has disappeared from the studied FPs, except for the Bishnudia FP, which recorded a decline in species number. Anonymous (2016b) recorded 46 species of fish from Jhanjhania FP, 34 species from Bishnudia FP and 44 species from Uttampur FP. This observed discrepancies with the number of species recorded in the present study probably occurred from overlooking of some rare species. We have revisited the last year data and arrived at conclusion that some very uncommon and rare species were missed during the last year survey. In general, there is a decline in fish abundance in the area, as elsewhere in the country. In spite of this fact, as per local accounts, some fish species showed increased abundance. It probably reflects that no fish is harvested until at the end of culture period and no fish can escape from harvesting, thus apparently there is a increase in fish abundance. Since, the floodplains are fertilized and manured, this might also contribute to increased fish production and abundance, particularly the smaller species. Usually, no carnivore species is cultured which could predate on the smaller species and therefore smaller fishes are not depleted due predation. It is probable that native species might have become more abundant due to these facts.

4.8 Predicted/Potential Impacts on Fish and Fisheries

In the process of water body development for culture purpose repair of local roads have done, some breaches in the road have been mended and few water channels leading from the river/canals to the floodplains were closed. Now, limited number of water channels exist in each of the stocking floodplains. This has further added to the already existing fragmentation of the floodplain by local road networks and thus likely to negatively impact the local biodiversity.

However, so far there has been no evidence that any fish species has disappeared from the Jhanjhania and Uttampur FPs during the last three years. However, there are some fish species that occur occasionally in the floodplains, meaning that a fish may be found in a year and may not found in the next year and again could be found to occur in the year after next year. Some riverine species that were reported for the pre-intervention period were also noted in the post intervention period indicating that lateral migration of fish was not hindered due to project interventions.

Spawning of most native species extends from May to July (in few cases August). This period is critical as lateral migration of fish for breeding (for example boal) and also lateral migration of eggs, fry and fingerlings between floodplains and rivers take place during this period. In both Jhanjhania and Uttampur FPs, the water channels feeding the floodplains remain open during this period without having any barricade or mesh screen. However, it is probable that reduction in migratory pathways caused by repairing of some breaches and some channels may have contributed to reduced lateral migration of fish fries and juveniles.

A large amount of indigenous non-stocked natural fish was harvested from the intervention floodplains along with the stocked fish. Apparently, it is seen by the local people as the increased production of fish from the floodplain and is interpreted as a positive aspect of the floodplain culture practice. In fact, no fish is caught during the culture period since there was no access by anyone what so ever. Again, during the draw down period the water outlets were closed with fine mesh screen (bana,) allowing no fish to escape in to the nearby connected river/ canals. Therefore, all the fish produced in the floodplains are harvested, having a negative impact on the river fish production. In fact, much of the river fish production is dependent on the fish migrating from the floodplain areas (FAP-17, 1992). Many large riverine fish species feed on the fish coming from the catchment floodplains; therefore blockade of fish migrating passage is likely to affect the river fisheries. If a large scale promotion of floodplain aquaculture is done this is likely to disrupt the ecological integrity of the river-canal-floodplain fish production system, affecting the local fisheries. This remains as a crucial issue in promoting floodplain aquaculture, particularly on a large scale.

Another risk associated with the escape of exotic fish in to the natural environment, which may cause a wide range of ecological problems, negatively affecting the local fish stocks and its production ,and also the other aquatic biodiversity. The fish species cultured in the floodplain has been brought into the country and are being cultured over a long period of time. So, far these species have not been able to establish in the wild, in spite of its accidental releases very often and nor it was able to establish a self-producing population/stock. Still, this is also an important issue to consider and requires stringent controlled culture of the exotic species.

4.9 Impact on Aquatic Weeds

In total, 22 species of aquatic weeds were recorded from the Jhanjhania floodplain. (Table 26). According to local accounts, during the pre-intervention period, there had been a luxuriant growth of aquatic vegetation in the absence of aman rice production, covering an almost all the floodplain areas. The vegetation was so abundant that it was difficult for one to move through the floodplain areas in the wet season. Removal of these aquatic weeds in the process of boro rice cultivation was too expensive and labour intensive. After the introduction of the project and stocking of the floodplain with grass carp, the abundance of the aquatic vegetation in the floodplain has greatly reduced. Physical inspection of the adjacent floodplain showed highly abundant, dense and extensive weed coverage almost covering the entire floodplain, while that of the intervention floodplain (Jhanjhania FP). All these species were noted in the first year (2016) of the project have also been noted in the last year of the study (2019).

Information on the abundance of aquatic weeds during and after the project intervention periods were collected through holding FGD and outcomes of the FGD to assess the trends in its abundances and are summarized. Our visual filed observation and FGD indicated that many of the weed, particularly, those are consumed by grass carps are highly reduced in terms of its coverage and density. In fact, grass carps are effective in reducing the aquatic weed abundance (Sutton and Vandiver, 2006) of its preferred plant species.

However, it was also noted that the coverage of kata shaola has increased compared to earlier. In fact, once an aquatic plant is consumed, a niche becomes available for other plants. What species, if any, will replace the species removed by the grass carp depends mostly on grazing pressure or regrowth of a preferred can occur following grass carp stocking. Grass carp feeding, if selective for the indigenous plants, might also further support spreading of alien species (Papilova, 2006; for review). It is reported that large grass carp (over 15 pounds) consume up to 30% of their body weight daily, whereas smaller fish less than 10 pounds) can consume as much as 150% of their body weight a day (Collie, 2012).

Hogla, an emergent aquatic plant, which earlier occupied a small area of the Jhanjhani FP has been removed to facilitate the harvesting of fish, which is now absent in the floodplain. It was learnt that this particular species was maintained by a farmer for household use.

Expert opinion suggests that continued stocking of grass carp over long period of time may cause disappearance of some sensitive aquatic plant species. Grass carps graze on the preferred aquatic plants which keep on growing and don't have scope for maturing. In addition to vegetative growth, some of these plant species regenerate through seeds. In the absence of mature plants reproduction through seeds production might be hampered leading to reduction in population abundance. However, aquatic vegetation has high regeneration rates and successful reappearance.

Table 26. Information on aquatic weeds recorded from Jhanjhania study

Name of weeds	**Before intervention**			**After intervention**			**Comments (whether eaten or not eaten by fish**
	Density	**Land coverage (%)**	**Abundances (More or less in **)**	**Density**	**Land coverage (%)**	**Abundances (More or less in **)**	
Katasheola	Less	4-5%	***	Less	1-2%	**	Favourite food for grass carp
Kolmi lota	Less	3-4%	***	Less	0-1%	*	Highly preferred
Maloncholota	More	20-25%	****	Medium	5-8%	***	Less preferred
Shapla	More	60-70%	*****	Less	10-15%	**	Highly preferred
Topasheola	More	80-90%	*****	More	20-25%	**	Not eaten
Kochuripana	More	15-20%	***	Less	3-5%	**	Not eaten
Puisha	Medium	10-15%	***	Less	2-3%	*	Highly preferred
Hogla	Medium	5-10%	***	Very few	0-1%		Not used as food
Murmuria	Less	4-5%	***	Less	3-4%	**	Not eaten
Kolma	Very few	20-25%	**	Very few	1-2%	*	
Chechor	Less	5-10%	**	Very few	0-1%	*	Not eaten
Dorisheola	More	40-50%	****	More	30-40%	****	Eat less
Shipshalu	More	50-60%	****	More	40-50%	***	Eat less
Aralighas	Less						Eat less
Ghechu	Very les						Not eaten
Boroptata	Medium						Eat less
Durbagas	Medium						Highly preferred
Helenccha	Less						Not eaten
Botol	Less						Not eaten
Khudepana	Less						Highly preferred
Teluaghas	Less						Highly preferred
Secheshak	Less						Not eaten

4.10 Impacts on Agricultural Production

Impacts of floodplain aquaculture practices on agricultural production and practices were evaluated in terms of rice production, production cost, changes in cropping pattern and soil quality. It may be mentioned that information on crop production was collected by holding FGD with farmers and also by interviewing some randomly selected farmers following a structured questionnaire. The findings are as follows:

4.10.1 Impacts on rice production and production cost

Two FGDs were conducted, one in Jhanjhania FP and one in Uttampur FP, only in intervention sites. No FGD was held in Bishnudia as there had been no agricultural activities. FGD revealed that there has been an increase in rice production by about 25% compared to pre-intervention rice production. On the other hand, labour cost and cost for pesticides have decreased by 50% and 40%, respectively. Overall, the cost for rice production has decreased by Tk 1500-2000/bigha. The results of interview are shown in Table 27 Arbitrary cross checks with local people during movement across the site also revealed similar trend in rice production.

Table 27. Information on crop yield and related expenses as revealed by FGD in Jhanjhania FP

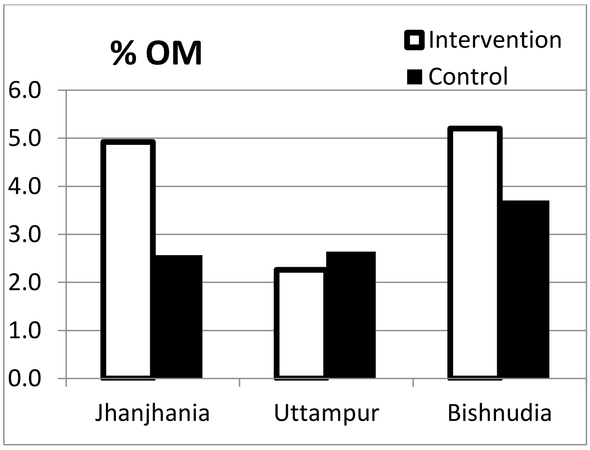
Parameter	Pre-intervention period	Present	Comments
Rice production/decimal (mond=40 kg)/decimal	0.65	0.94	
Total cost for production (Tk/decimal)	206.0	147.0	
Labour cost (TK/decimal)	96.0	57.0	
Cost for pesticides (TK/decimal)	11.50	5.10	

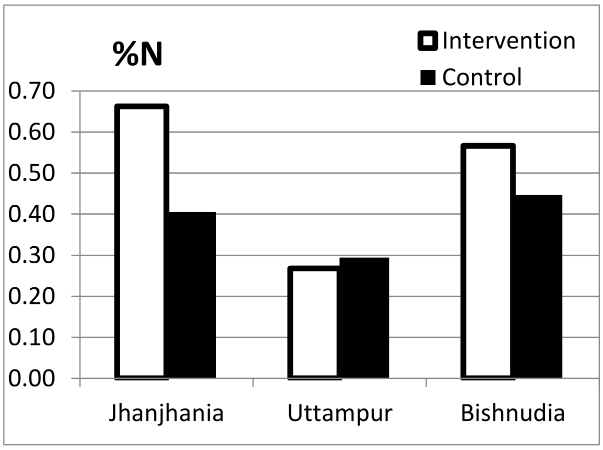
Causes for the changes in production were also investigated during the FGD sessions. The perceived causes for the changes are summarized below.

4.10.2 Impacts on soil quality / fertility

Some parameters of soil, such as organic matter, soil pH nitrogen, soil electrical conductivity and levels of phosphate, potassium and sulphate, indicative of soil fertility, were measured for both intervention and control sites. The data on the soil quality measurements are provided in Annex 4 . and graphically shown in Figure

Overall, the soil quality parameters showed high level of variability among the sites as well between the intervention and control sites. Soil organic matter varied from 2.26 % to 5.2% in intervention sites, while that of control sites ranged from 2.57% to 3.70%. Except Uttampur, the other two intervention sites showed higher levels of organic matter compared to control sites. However, the significant difference was noted in case of Jhanjhania intervention sites. Soil nitrogen levels also fluctuated from 0.27% to 0 0.66% in intervention sites and 0.29% to 0.45% in control sites. Although, both Jhanjhania and Bishnudia intervention sites had elevated levels of nitrogen than the control sites, however, the differences were not statistically significant. The sulphur contents were noted very high (260-511 ppm) in all cases, however, due to high fluctuations in replicate values these differences in sulphur contents were not statistically significant. Phosphorous levels were also high in all cases and the values varied from 18.29 ug/g to 33.62 ug/g in intervention sites and fluctuated from 17.29 to 27.55 ug/g in control sites. However, differences in phosphorus contents between intervention and control sites were insignificant statistically. The pH values showed no trend and ranged from 6.57 to 6.75 in intervention sites, while the values fluctuated between 6.18 and 6.80 in control sites. All the intervention sites showed higher conductivity values ranging from 188.0 to 428 uS/cm compared to control sites (128.23-325.75 uS/cm). However, the differences were insignificant. All the sites had high levels of potassium, ranging from 118.29 to 326 ug/g in intervention sites and 136.15 to 241.74 ug/g in control sites. Although, Jhanjhania and Bishnudia intervention sites had elevated levels of potassium compared to the corresponding control sites, however, the differences were not statistically significant.





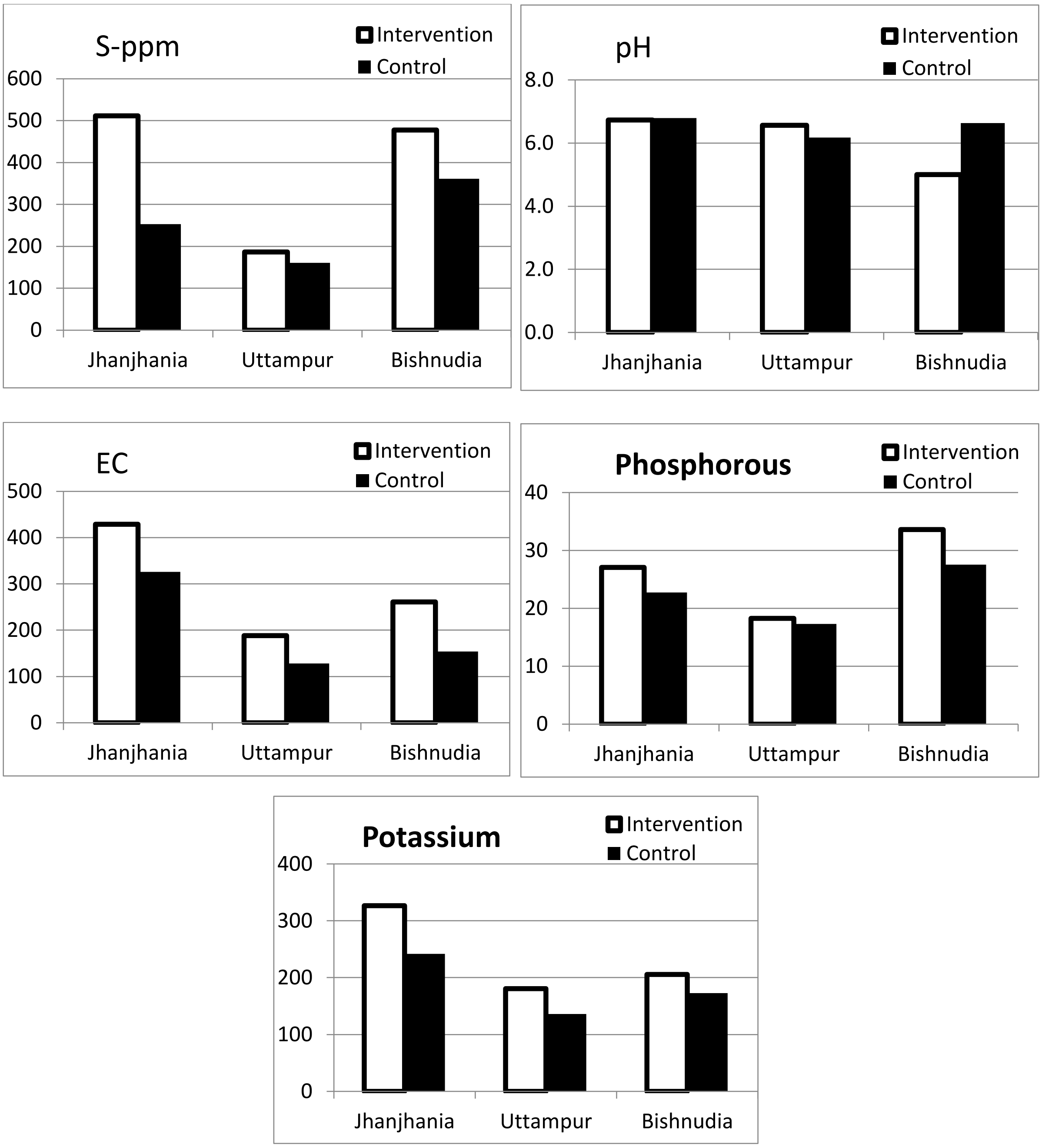


Figure 25. Measured soil quality of intervention and control study sites in different season

4.10.3 Impacts on cropping pattern

Table 28-31. depict the cropping pattern in Jhanjhania and Uttampur floodplains during pre-and post intervention periods.

4.10.3.1 Cropping Pattern in Jhanjhania Floodplain

Total area of the floodplain is about 75 acre (225 bigha)

Pre-intervention period: (Table 28) Aman was used to be grown in about 20-30 bigha land, comparatively on higher land, which is not deep flooded during the monsoon, during the period Ashar to poush. During Poush to Falgun/Chitra in most of this higher land is used for robi crop production, including mustard, wheat, kalai (lentil) and after that some of the land used to be utilized for jute cultivation during the months of Chitra- to Ashar. Jute was used to be grown after harvesting of robi crops. Rest of the areas were used to be remained fallow from Shrabon to Poush. Except the higher land (about 25-30 bgha), all lands of the floodpalins were used to be used for cultivating high yielding Boro rice during the period Poush/Magh to mid-Jhaistha.

Post intervention period: (Table 29) After the introduction of floodplain fish culture practice, there has been a little change in cropping pattern. Only change occurred in the coverage of aman cultivation. Earlier aman was used to be cultivated in about 20-30 bigha, particularly at the shallower part of the floodplain. However, now aman is cultivated in only 10-15 bigh only, because rice plant is grazed by the cultured fish (by grass carp). However, there is no conflict over this issue, as all land holders get a subsidy at the rate of Tk 200/- per bigha of land.

4.10.3.2 Cropping Pattern in Uttampur Floodplain

Pre-intervention period: (Table 30) Uttampur Floodplain under fish culture practice covers an area of about 40-45 acres of land. Before 10-12 years, the floodplain was used to grow broadcasting aman rice along with aus seeds and two stage harvesting was done; aus in Shraban and aman in Poush months. This broadcasting cultivation practice has been discontinued by the local famers. Four-five years back (pre-intervention period) only transplant aman paddy was used to be cultivated during the period Ashar to Poush months in all areas under the project. The traditional aman variety had been replaced with HY variety of rice, the Lan variety. There was no practice of boro cultivation.

Post-intervention period: (Table 31) During the aman season the same rice variety is grown in all areas under the project, except a couple acres in the deeper part of the floodplain. The only change is now has occurred after project introduction that a part of the floodplain (about 15 bigha of land, is used for boro cultivation with high yielding variety. The production of both aman and boro are good.

It may be mentioned that in Bishnudia FP no agricultural activities was carried out during pre- (particularly during the recent past), nor it is done in the post intervention period. It remained fallow with luxuriant growth of emergent vegetation. In the first year of the project, the floodplain remained in its original state with only low height berribandh constructed by the project. However, about two years back, part of the floodplain (around 12 acres) has been compartmentalized by making berriband and modified it in the form of a shallow perennial water body with provision for regulation of water depth. Therefore, no attempt was taken to investigate the aspects of crop production and cropping pattern.

Table 28. Cropping pattern in Jhnjhania Floodplain during pre-intervention period

<table>
<tr><th>Baishakh</th><th>Jaistha</th><th>Ashar</th><th>Shraboan</th><th>Bhadra</th><th>Aswin</th><th>Kartik</th><th>Agrahayan</th><th>Poush</th><th>Magh</th><th>Falgun</th><th>Chaitra</th></tr>
<tr><td colspan="3">Jute</td><td colspan="5">Aman (20-30 bigha)</td><td colspan="3">Mustard, kalai, wheat, potato</td><td>Jute</td></tr>
<tr><td>Boro (HY)</td><td colspan="7">Fallow</td><td colspan="4">Boro (high yielding)</td></tr>
</table>

Table 29. Cropping pattern in Jhanjhania FP during post- intervention

<table>
<tr><th>Baishakh</th><th>Jaistha</th><th>Ashar</th><th>Shraboan</th><th>Bhadra</th><th>Aswin</th><th>Kartik</th><th>Agrahayan</th><th>Poush</th><th>Magh</th><th>Falgun</th><th>Chaitra</th></tr>
<tr><td colspan="3" rowspan="2">Jute</td><td colspan="5">Aman (10-15)</td><td colspan="3" rowspan="2">Mustard. Kalai, wheat</td><td rowspan="2">JUTE</td></tr>
<tr><td colspan="5" rowspan="2">Fallow</td></tr>
<tr><td>Boro (HY)</td><td colspan="2">Fallow</td><td colspan="4">Boro (HY)</td></tr>
</table>

Table 30. Cropping pattern in Uttampur Floodplain during pre-intervention period

<table>
<tr><th>Baishakh</th><th>Jaistha</th><th>Ashar</th><th>Shraboan</th><th>Bhadra</th><th>Aswin</th><th>Kartik</th><th>Agrahayan</th><th>Poush</th><th>Magh</th><th>Falgun</th><th>Chaitra</th></tr>
<tr><td colspan="2">Fallow</td><td colspan="7">Aman rice (40-45 bigha)
High yielding variety (LAN variety)</td><td colspan="3">Fallow</td></tr>
</table>

Table 31. Cropping pattern in Uttampur Floodplain during post-intervention period

<table>
<tr><th>Baishakh</th><th>Jaistha</th><th>Ashar</th><th>Shraboan</th><th>Bhadra</th><th>Aswin</th><th>Kartik</th><th>Agrahayan</th><th>Poush</th><th>Magh</th><th>Falgun</th><th>Chaitra</th></tr>
<tr><td colspan="2">Fallow</td><td colspan="7" rowspan="2">Aman rice (40-45 bigha)
High yielding variety (LAN variety)</td><td colspan="3">Fallow</td></tr>
<tr><td>Boro (HY)</td><td>Fallow</td><td colspan="3">Boro (HY) (10-12 bigha)</td></tr>
</table>

4.10.4 Impacts on access Rights and livelihoods of Fishermen

In addition to household socio-economic survey, few case studies were conducted on full-time and part-time fishers' households having fishing as the main livelihood occupation in order to get insight into the impacts caused by the project implementation. The findings of the case studies are summarized in Table 32

Table 32. The findings of the case studies

Issues/Items	Past and Present scenarios
Habitat exploited	• All fishers interviewed were used to fish in the project intervention floodplains, adjacent floodplains and in the adjacent river • Due to fishing ban in the study floodplains, now fishers can fish only in the river, while some have moved to adjacent floodplains for fishing. However, there is a conflict with local people.
Dependence on fishing	• Full-time fishers entirely or mostly rely on fishing for their livelihoods. • Part-time fishers also supplement their household incomes, mainly during the wet season and post-monsoon by fishing
Access right to the floodplain for fishing	• Earlier, fishers could fish freely in the concerned floodplains during the entire fishing period. • Presently, in all cases, no access at all in the concerned floodpalins for fishing in any season • Villagers (shareholders) on a consensus basis implement fishing ban in all seasons in all study floodplains, in spite of resistance from some fishers, particularly
Household income	• Income from fishing has reduced due to imposition of fishing ban in the concerned floodplains. Daily income during peak fishing season decreased by about Tk. 100 to Tk. 200. Some fishers think that fishing ban has jeopardized their livelihood and compelled them to borrow money from NGOs • However, some said that overall there is no change in income as they could move to other floodplains and also as a result of benefit from the project. They also think that there is a trend in reduced fish catches from open waters and many fishers are abandoning the occupation.

Issues/Items	Past and Present scenarios
Impact on nutrition	• It clearly appears from the case studies that fishing ban has caused reduced fish intake (therefore protein intake) particularly during the fishing season. The fishers, both full-time and part-time, consume less amount of fish. According to them, not only the fishers, but also others consume less fish compared to earlier as amny of them were used to undertake some sorts of fishing in the floodplains.
Benefit from project	• Some fishers strongly said they are not benefitted from the project, nor they get any share from the project. However, many fishers, particularly, those who have lands in the floodplains ate benefitted, although they also face some hardship during the ban period. • Some of the fishers are employed by the project, while some others are become involved fish harvesting. However, many are left out of the opportunity to be employed by the project. • Overall, it appears from the project that both full-time and part-time fishers are negatively affected by the project implementation. • While contacted the project management over the issue of shares for fishers, the management said that all HHs having no lands in the floodplain have been provided with a each a shre/HH. However, the landless have not got any benefit this year as the cost of share (TK 1000/-/share) is beig adjusted from their benefit accrued from their share.
Suggestions made by the fishers	One full-time fisher suggested for the discontinuation of the project, while others (5 fishers) continuation of the project. However, the made the following suggestions in case the project is continued. • There should be some sorts of compensation scheme for the fishers • All affected fishers should be employed by the project or there should be a scheme for making compensation to the really affected fishers

Issues/Items	Past and Present scenarios
	• Promotion of alternate livelihood development scheme for the affected people. • Providing adequate (meaningful) number of shares to the really affected fishers and provide shares to those left out fishers.

4.11 Socio-economic condition of the fishermen of Jhanjhania, Uttampur and Bishnudia areas

A survey on socio-economic condition of the fishermen of Jhanjhania, Uttampur and Bishnudia areas were conducted among the fishers and non-fishers before and after the study.

Gender

In Jhanjhania, about 52.5% of male and the rest 47.5% were female. The percentage male and female was 50.5 and 49.5 in Uttampur and 47.2 and 52.8 in Bishnidia respectively (Fig. 26). Generally, most women were involved in household works and so they could not afford to go out for fishing in a large scale but male were free from those barriers and engaged themselves in fishing.

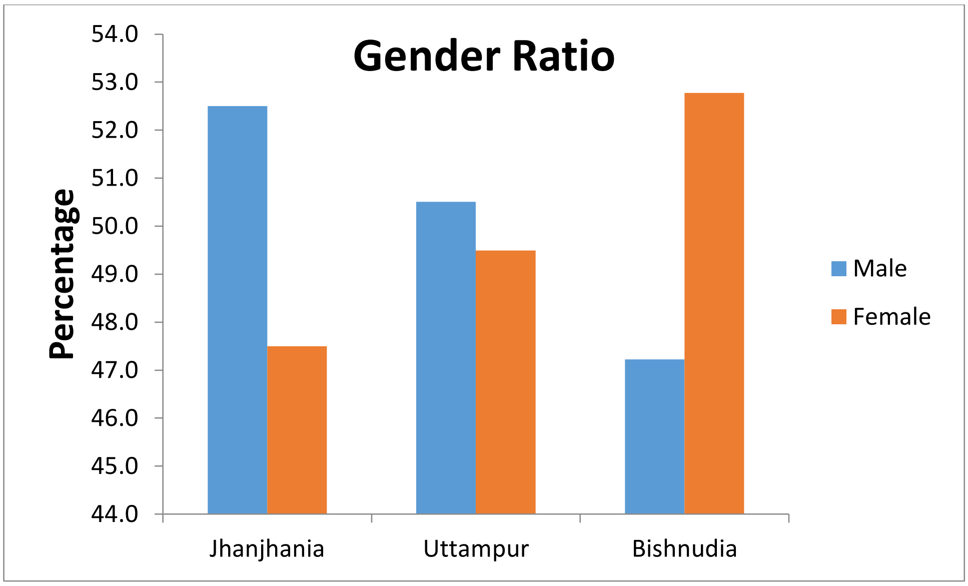


Figure 26. Gender ratio in the three study area

Age group

In this study, the age group was classified in four categories ranging 0-5 years, 6-20 years, 21-40 years and above 40 years. In Jhanjhania, 14.4%, 30.0%, 40.6% , 15.0% of family members were belonged to the age group 0-5, 6-20, 21-40 and above 40 years, respectively (Fig. 27). In Uttampur the percentage was 4.1, 30.5, 35.0 and 30.5 respectively where in Bishnudia the percentage was 8.3, 22.2, 47.2 and 22.2 respectively (Fig. 27). Mainly the people of age group 21-40 and above 40 years were engaged in fishing. Among them, the highest number of fishermen was in between 21-40 age group indicating middle age group was the dominant in fishing.

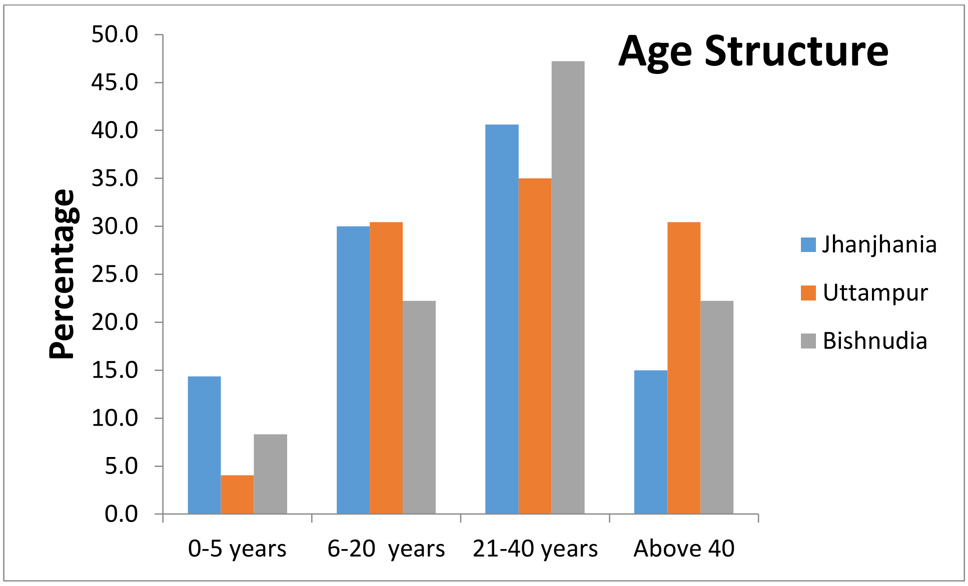


Figure 27. Age structure of the family member of fishermen of the three study area

Income and Expenditure

Both the income and expenditure were increased after implementing the project. The annual income and expenditure for both fishermen and Non-fishers of three study area were shown in table 33a & 33b and figure 28, 29 & 30. The annual income of both fishermen and Non-fishers were increased for the project. The economic condition was improved and the living style was changed.

Table 33a. Annual income and expenditure of the fishers and non-fishers

	Jhanjhania				**Uttampur**			
	Fishermen		**Non-fishers**		**Fishermen**		**Non-fishers**	
	Before	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**
Income (BDT)	86833	132587	157933	186577	102567	123569	129556	163442
Expenditure (BDT)	81437	93522	88000	105600	67563	72496	75761	122563

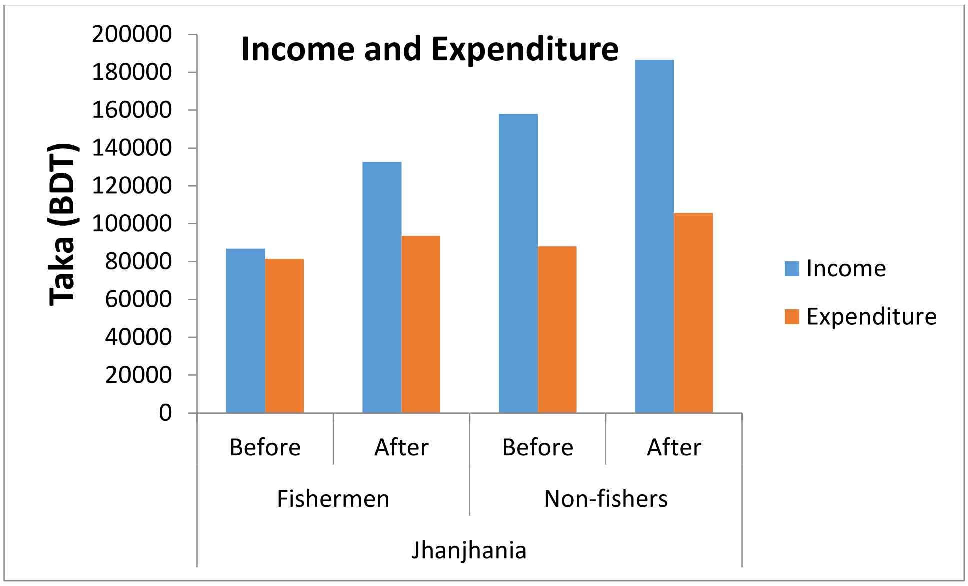


Figure 28. Annual income and expenditure of the fishers and non-fishers

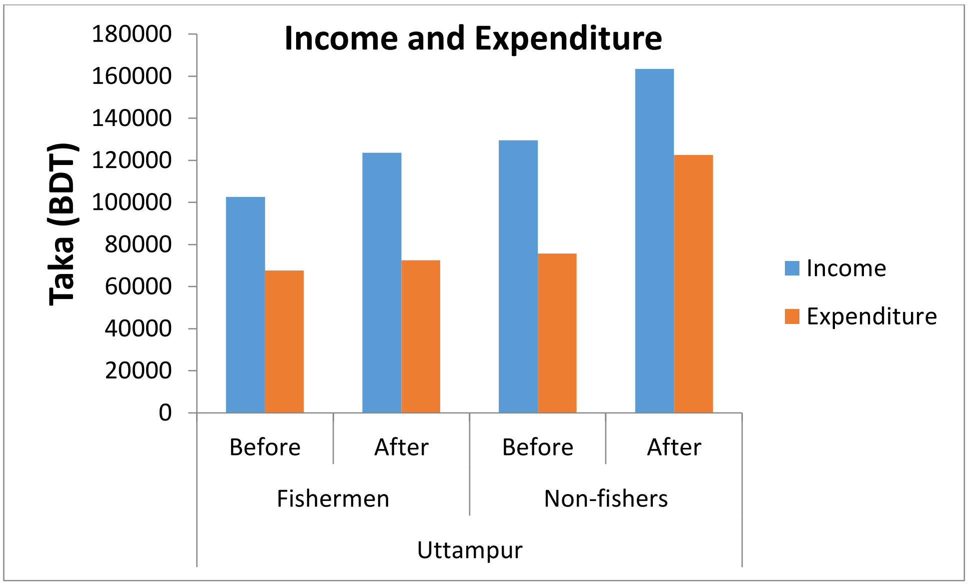


Figure 29. Annual income and expenditure of the fishers and non-fishers of Uttampur

Table 33b. Annual income and expenditure of the fishers and non-fishers

	Bishnudia			
	Fishermen		**Non-fishers**	
	Before	**After**	**Before**	**After**
Income (BDT)	100000	126498	176550	198757
Expenditure (BDT)	55060	54659	88500	97456

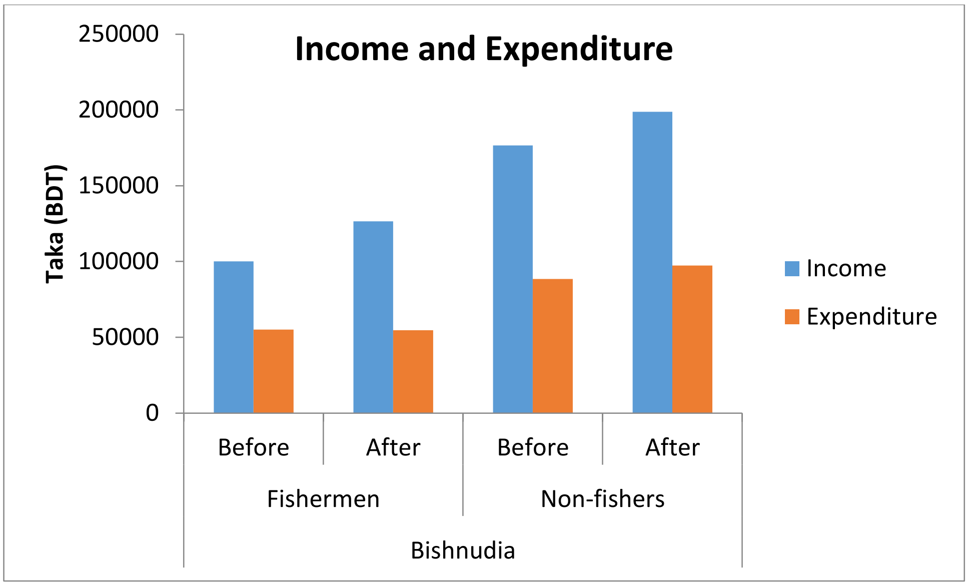


Figure 30. Annual income and expenditure of the fishers and non-fishers of Bishnudia

Chapter 5

Discussion

5. Discussion

The study was carried out on the water quality and zooplankton of the three selected floodplains of Jhanjhania, Uttampur and Bishnudia under Jhalakathi and Pirojpur Districts during the study period.The water quality parameters investigated were water temperature, pH, conductivity, TDS, DO, salinity, ammonia_N, nitrite-N, total sulphate andphosphate, and chemical oxygen demand (COD). Water sample were taken from three stations of each floodplain in the different months (August, November and March) representing three different seasons (wet, post monsoon and dry seasons, respectively). Different groups of zooplankton were observed during this investigation, viz. Protozoa, Rotifer, Copepod, Cladocera, Ostracod. Many researchers have found the presence of above groups of zooplankton in freshwater habitats (Chakrabarty *et al.*, 1959; Habib *et al.*, 1984; Naz and Nazia, 2008; Mozumder *et al.,* 2010; Hossain *et al.*, 2015; Biswas and Panigrahi, 2015).

5.1 Water Quality

A total of 12 physico-chemical parameters, namely water pH, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), salinity, alkalinity, total hardness, total phosphate, total ammonia-N, nitrate-N, ammonia-N, nitrite-N and temperature was monitored quarterly.

The values of observed water parameters, particularly that in wet season, represent the typical values for floodplain ecosystem in Bangladesh. There were strong seasonal fluctuations in most measured water parameters. Except pH, salinity and DO levels, in most cases, the intervention sites had higher values for measured water parameters compared to that of control sites. However, major fluctuations were observed in case of phosphate, ammonia-N, nitrite-N and nitrate-N concentrations, particularly in post monsoon and dry seasons. The phosphate concentrations ranged from 1.02 -16.30 mg/l in intervention sites and from 0.77 to 5.80 mg/l in control sites. The ammonia levels varied from 0.01-1.48 mg/l in intervention sites, while that in control sites ranged from0.0 to 0.35 mg /l. Similarly, nitrate and nitrite concentrations varied from 1.13-12.93 mg/l and 2.60-9.50 mg/l in intervention sites, respectively, and that of control sites fluctuated from 0.70 to 4.33 mg/l and 0.41-4.60 mg/l. Higher concentrations of these parameters were observed in post monsoon and dry seasons and in intervention sites, particularly in Bishnudia site. The observed higher levels of ammonia, phosphate and nitrite are toxic to biota and are considered unacceptable. However, elevated nitrate and phosphate levels are indicative of fertility.It has been inferred that these increased levels probably produced from feeding of fish, use of fertilizers in ponds and crop fields, and decaying of aquatic weeds. Again, the exceptional levels were measured at some stations only. As per literature, these observed levels are highly toxic to fish. However, such levels are common in fertilized crop fields and fertilized ponds and its toxicity is probably due to presence of high levels of organic ligands The measured values for different parameters in different study sites, particularly in the monsoon period, represent the typical values for the waters of floodplains in Bangladesh (Ehsan et al., 1997). The higher values recorded for the post monsoon and dry seasons probably resulted from concentration of water due to evaporation of water. The higher values in most water parameters in intervention sites may have resulted from the feed and fertilizer. Both formulated feed from market and locally prepared compost made by using oil cake, rice bran, urea, cow dung, etc. The formulated feed uses fish meal as one of the components. Oilcakes contain lot of phosphates and sulphates (RFG, 2012). Besides, in Bishnudia the intervention water body is fertilized with fertilizer containing phosphate and potash and which probably also contributed to the elevated levels of phosphate, nitrate and nitrites in water. Decomposition of urea and organic matters produces the intermediaries, ammonia and nitrite and finally is converted to nitrate (Boyd, 1982). The observed higher levels of phosphate, nitrite and nitrate during the dry season (January) probably resulted from the use of fertilizers in the boro rice fields both in intervention and control sites, particularly both in Jhanjhania intervention and control sites.

Extremely high levels of phosphorous, nitrite and nitrate were measured, particularly during the winter season and in certain sampling stations. Ammonia (unionized forms) and nitrite is considered highly toxic to life forms and it results from breakdown products of ammonia, the later is an intermediary product of nitrogenous compound breakdown process and is converted to nitrate which is non-toxic nutrient utilized by plants (Boyd, 1982). However, such elevated levels are not expected from the floodplains.

In fact, in the present case, the elevated levels nitrite and nitrate probably resulted due to application of nitrogenous and phosphate fertilizers in rice fields in winter season and also from the decaying vegetation and also probably from intense feeding of fish. Rice is cultivated in 2 study sites and large amounts of fertilizers are used. Similarly, high levels of phosphate were also noted, particularly during the winter and post-monsoon period, which again probably resulted from the application of phosphate containing fertilizer in the rice field and intense feding, particularly in Bishnudia intervention site.

i. The very high levels of phosphate, nitrate, ammonia, nitrite in Bishnudia intervention site probably resulted in post monsoon and dry season from the use of feed, fertilizer and liming in the water body.

ii. The high level of phosphate, nitrite and nitrate in both intervention and control sites probably resulted from the use of fertilizer in the boro rice fields in

Extremely high levels of phosphate, nitrate and nitrite were measured from the Bishnudia intervention sites, particularly during the post monsoon and dry season.In general, the values of measured parameters were bit higher in intervention sites than the control sites and no trend was evident from the results of pH, DO, salinity alkalinity and hardness data. However, phosphate, nitrite and nitrate levels were comparatively much higher than the normal ranges reported for Bangladesh floodplains,. Similarly, values measured for these parameters in intervention sites were comparatively higher than the control sites. In case of phosphate, nitrate and nitrite significant differences between control and intervention sites were, however, noted in case of Bishnudia and Uttampur floodplains only.

5.2 Zooplakton

The zooplanktonic community of the project sites is represented by 45 species, belonging to6major groups, viz. Cladocera (9 sppecies) ,Copepoda (5 species), Ostracoda (3 species),Rotifera (20 species), Ostracoda (3 species). Protozoa(3 species) and others(2 species).The abundance of zooplankton in wet season in intervention sites ranged from 117.62 /l (Uttampur) to 320.11/l (Jhanjhania), while that of control sites varied from 101.75 (Uttampur) to 157.87/l (Jhnjhania). In post monsoon, the zooplankton abundance varied from 270.4/l (Uttampur) to 416.0/l (Bishnudia) in intervention sites and from 93.12/l (Bishnudia) to 204.80/l (Jhanjhania) in control sites. All the intervention sites in post monsoon had higher number of zooplankton compared to the corresponding control sites. Overall, in dry season the composition and abundance of zooplankton were much lower than the wet season and post monsoon, ranging from 138.08/l to 189.44/l in intervention sites, while the abundance ranged from 93.17/l to 124.16/lin control sites. Rotifers, copepods appeared most dominant groups, followed by cladocerans and naupli. The Jhnjahnia intervention site had the highest number of species, followed by Uttampur and Bishnudia sites. It is concluded that observed higher (not significant)abundance of zooplankton probably resulted from the use of feed and fertilizers in the floodplains.

The species recorded in the present study represent the typical pond and floodplain species (Ehsan et al., 1997; Kabir et al., 1997, Mozumder, 2011). Anonymous (2016) also recorded similar species from the same study sites. However, the present study recorded higher number of species than the earlier study in same floodplains. However, such differences could be expected as oscillation in year to year in zooplankton abundances as noted by various authors.

In general, the intervention sites showed comparatively higher population abundances of zooplankton, in spite of grazing by the stocked fish.Zooplankton productions are enhanced following fertilization and manuring (Boyd, 1992). The intervention sites, particularly the Bisgnudia site, were fertilized and also used supplementary feed consisting of oil cakes, rice barn and cow dung and probably contributed to enhanced production of zooplankton.

The abundances of zooplankton in dry season were recorded much lower than the other two seasons. Most studies reports higher abundances of zooplankton in dry season in pond conditions. In fact, in dry season most part of the floodplain dried out or hold very little waters or had had irrigated waters and were not suitable for plankton growth. In Bishnudia intervention FP, the water body was made almost empty for facilitate last fishing and was sampled at that stage and probably that was the probable cause for reduced zooplankton abundance in Bishnudia intervention site.

5.3 Fish and invertebrate diversity

A total of 60 species of fish belonging to 26 families have been recorded from all the three study sites, of which 51 species occur naturally in the wild and 9 species are cultured/stocked in the floodplains.Of the stocked fishes, 5 species are exotic.In total, 50 species of wild fish species were recorded from the Jhanjonia Intervnetion Site. In addition, 5 exotic and 4 local species, which usually do not occur in the site, are stocked in the floodplain. Of the recorded species, 6 species are very common, 7 species common, 9 species fairly common, 20 species less common and another 8species are rare within the Jhanjhania floodplain study site.The Bishnudia FP site has comparatively fewer number of fish species. Only 31 species have been recorded from the site, of which five are exotic stocked species. Of the native species,3species veryare common,4 species are common, 6 speciesfairly common, 13 species less common and another 5 species are rare within the Bishnudia floodpalin study site.A total of 44 species of native wild fish species occured from the Uttampur FP Site, while another 9 species are also stocked including 5 exotic species. According to relative abundances of the recorded species, 6 species could be considered very common, 8 species common, 11 species fairly common, 12 species less common and another 7 species are rare within the site. In the study floodpalins show a declining trend in fish abundances, which is reflective of regional decline in fish abundance. However, as per local accounts, a number of species showed increasing abundance. There is no evidence on the disappearance of any fish species or the other animal species due to project intervention.

In general, the study sites are comparatively poor in molluscan fauna. In total, six species of molluscs were recorded from the study sites. Six species of molluscs inhabit Jhanjhania FP, 5 species Uttampur FP and four species of molluscs inhabit the Bishnudia FP study site.The prawn species of the study sites are represented by five species. Both Jhnjhania and Uttampur sites have five species of prawns each, while the Bishnudiasite has three species of pawns. Three species of crabs were recorded from the three study sites and all the species are available in each side. All thespecies are common to fairly common within each site.

5.4 Impacts on fish and fisheries

Apparently, no fish species has disappeared from the studied FPs, except for the Bishnudia FP, which recorded a decline in species number. Anonymous (2016b) recorded 46 species of fish from Jhanjhani FP, 34 species from Bishnudia FP and 44 species from Uttampur FP. This observed discrepancies with the number of species recorded in the present study probably occurred from overlooking of some rare species. In general, there is a decline in fish abundance in the area, as elsewhere in the country. In spite of this fact, as per local accounts, some fish species showed increased abundance. It probably reflects that no fish is harvested until at the end of culture period and no fish can escape from harvesting, thus apparently there is a increase in fish abundance. Since, the floodplains are fertilized and manured, this might also contribute to increased fish production and abundance, particularly the smaller species. Usually, no carnivore species is cultured which could predate on the smaller species and therefore smaller fishes are not depleted due predation.It is probable that native species might have become more abundant due to these facts.

- In the process of developing the site for fish culture, breaches in roads and some passages, connecting the adjacent river, canals or floodplains, are closed which restrict the movement across water bodies and its production systems.
- However, the limited inlets to the floodplain are kept open until at least the end of Ashar or early shraban which corresponds with the breeding period of indigenous species allowing the lateral migration of eggs, larvae, fry, fingerlings and adults of fish and other animals between the river and floodplains.
- The inlets (also serves as outlets) are closed after stocking and maintained throughout the grow out and harvesting periods, allowing on fish to migrate to the adjacent canal and river, affecting river fish production as well as the riverine fish species predating on migrating fish, prawns, crabs from floodplains.
- There is no evidence in support of disappearance of any fish or other aquatic animal species or its serious reduction that may pose threat to its extinction.
- Floodplain stocking with exotic species, like silver carp, grass carp, common carp, mirror carp are likely to pose environmental risks. However, these species are being cultured in

Bangladesh for long period of time with frequent escapes into open waters without having any known or reported impacts.

- As per local accounts production of indigenous species in the stocked floodplain has increased which simply reflect the absence of fishing, complete harvest of fish at the outlets, with having any fish escapes.

5.5 Soil quality

The levels of soil parameters measured for the soils of the study floodplains are more or less similar to the observed ranges reported in other studies, except sulphur contents (Hasan *et al*., 2012; Sheel *et al.,* 2015; Ahmed *et al*., 2017). According to FRG (2012), the observed values for phosphorous and total nitrogen were high to very high and optimum to very high, respectively. Organic matter was also very high in the soil. Organic matter has a close relation with the nutrient availability of soil. At least 2% organic matter content is suitable for better crop production (Sheel *et al.,*. 2015) and in the present study all the intervention and control sites had organic matter higher than 2%.

Nitrogen, phosphorous and potassium levels are indicative of soil fertility. In the present study, the levels of these nutrients were medium to very high and thus signify the high fertile lands (FRG, 2012). In general, the intervention sites had comparatively considerable higher nutrient levels than the corresponding control sites, although the level were not statistically signiifacnt, thus signifying higher soil fertility in intervention sites. This increased nutrient levels, vis-à-vis increased soil fertility probably caused due to use of fish feed and fertilizers for increased fish production. In fact, fish were fed with locally prepared feed with oil cake, rice bran, cow dung and other ingredients. Oil cakes contain high level of are high levels of sulphur and phosphorous (FRG, 2012). Further, inorganic fertilizers (NPK) were also in fish ponds, particularly in Bishnudia intervention sites. This also probably contributed to increased levels of nutrients. In addition urea and NPK fertilizers were also used in the floodplains for cultivation of boro crop.

As per local accounts, higher soil fertility may have also resulted from the decaying of left straw from the boro crop. It was also argued by the local people that grazing on weeds by cultured fish reduced the abundance of weeds. Weeds take up considerable amount of soil nutrients depleting its levels in the soil and do not become available for cultivated rice crop. In the intervention sites, stocked fish removed most aquatic weeds decreasing their abundance with reduced uptake of nutrients by weeds.

5.6 Crop production and cropping pattern

As revealed by FGD and interview of farmers, the production of crop in Jhnjhania intervention site increased by about 25%, compared to pre-intervention period. Concomitantly, the production cost for HYV boro cultivation decreased at least by Tk. 1500-2000 per bigha as because less labour cost for removal of weeds from land and less use of pesticides in crop field, compared to pre-intervention period. There had been little changes in the cropping pattern in the study sites, except the Bishnudia site, which has been modified to perennial water body dedicated for only fish culture. In Jhanjhania, compared to pre-intervention period, about 10-15 bigha of land now remain fallow, which were earlier used for aman rice cultivation, as the rice plant is grazed by crass carp. In contrast, in Uttampur about 10-15 bigha land now has been brought under HYV rice cultivation in the dry season. However, this was not caused a result of project intervention, but for promotional activities.

Major production cost involves with the removal of aquatic weeds which grow luxuriantly in the absence of aman crop. As the stocked fish feeds on most types of weed and now the land remains much more clearer and thus cultivation process does not require weeding, which in fact reduces cost. It was not much clearer to the local people, but they invariably say that there is now much less pest attacks than earlier. They think that the weeds host the pests which are then available for the next cultivated crop plants. In the absence of the weeds the pests probably are not able to colonize well and therefore less pest attack to the crop plants occur. Therefore, less pesticides are required. As per local accounts, the wastes produced from supplied feed in the floodplains may have some impacts on the soil fertility. They also think that the growing weeds probably take up the soil nutrients and contribute to the reduction in soil fertility. The reduced aquatic vegetation in the cultured floodplains takes up less nutrients, which become available for rice plants. It is also perceived that grass carps eat huge amount of grasses and produce lot of excreta which may increase soil fertility resulting in increased rice production.

5.7 Access rights and livelihoods

Ban on fishing by fishers and local people during the culture and harvesting period is strictly implemented in the stocked floodplain through a consensus building among local people. Case study, however, revealed that the fishers are affected by the fishing ban, although they could exploit adjacent water bodies. Income from fishing has decreased and fishers consume less fish during the wet period. As a strategy, the project provides a compensatory package by giving shares to the affected poor people and through employing them in project work. While most fishers are not unhappy with the project, while some fishers have reservation, if they are not properly compensated.

Chapter 6

Conclusions and Recommendations

6. Conclusions and Recommendations

6.1 Conclusions

The purpose of this Section is to discuss the major findings and related issues concerning the impacts of floodplain aquaculture practices in order to draw final conclusions and put forward recommendations to address the issues and constraints for environmental safety.

i. In Bangladesh floodplain areas, in most cases, are fragmented due to local road network development, FCD/I interventions and other development activities. Jhanjhani and Bishnudia floodplains were fragmented by road construction in the past. In the process of the present project development, like repairing of roads, mending of road breaches, construction of new berribandh and closure of few water inlets, have added to the already existing fragmentation. Fragmentation of floodplain areas are considered to affect the local biodiversity as it restrict the lateral migration of animals.

ii. The water quality, particularly the phosphate, nitrate, nitrate and ammonia concentrations were highly elevated in the intervention sites, particularly during post monsoon and dry season, although the levels were found elevated at certain sites. The levels were also found elevated in Jhnjhania control sites. The levels found are highly toxic to fish. However, it seems that the fish were not affected at this level of exposures. The elevated levels in Bishnudia and Uttampur sites probably resulted from intense feeding and fertilization. In Jhanjhania intervention and control sites these substances probably formed due to use of fertilizers and decaying of organic matters.

iii. Although, observed levels of nitrite and ammonia are highly toxic to fish, however, these levels did not cause fish mortality or affected growth of fish. Because of the probable presence of organic ligands (organic molecules mainly) probably reduced the toxicity. It may be mentioned that we measured the total ammonia and total nitrite. Not all species of nitrite and ammonia are toxic. We have not measured different species of nitrite and ammonia.

iv. Composition and abundance of zooplankton did not differ much between intervention and control sites in rainy season. However, varied highly during post monsoon and dry seasons. The high abundance of zooplankton noted in Bishnudia was due to use of feed in Bishnudia.

v. Soil quality and fertiliy

vi. As revealed by FGD, aquaculture practices in the study floodplains contributed to increased rice production and that probably caused due to less nutrient used by reduced abundance of weeds, excreta from fish, mainly the grass carps and also due to use of organic feed. The reduced abundance of aquatic weeds in the stocked floodplain uptook less nutrients from soil and was available for rice production.

vii. The cost for cultivation of boro rice had decreased due to less labour cost, use of less fertilizers and less costs for pesticides. The major cost involved with cultivation of boro rice was due to cost involved with the removal of aquatic weeds. Grazing by stocked fish on aquatic weeds higly reduced the abundance of weeds which required less labour for weed removal. Further, due to less abundance of aquatic vegetation in the floodplain the occurrence and incidences of pests were less and cost less than earlier.

viii. The introduced aquaculture practice had little impacts on changes in the local cropping pattern. Earlier, in Jhanjhnia FP, aman rice was used to be grown in a small shallow land area. After introduction of the aquaculture, now a part of it is left fallow. The reason is that grass carp graze on this and the land owner gets compensation. In Uttampur FP, after the introduction of fish culture practice, a small area of land (about 10 bigha) has been brought under HYV boro cultivation. This change was not caused due to fish culture, but due to promotional activity of the project.

ix. There was a small conflict between fish culture and rice cultivation in Uttampur FP. In Uttampur aman rice cultivation continues until end of Bhadra. Fish could only be stocked in floodplain once the cultivation is completed, i.e. after the end of Bhadra, allowing the fish culture onlyfor a short period of time. Otherwise, there was no other conflict at all.

x. There is no evidence of disappearance or loss of any fish or other aquatic animal species as a result of introduction of fish culture practice in the floodplain. Similarly, decline in fish abundance is not conclusive. As revealed by FGD, several species have declining trend, while some other species showed increasing tendency. The decline in fish abundance is not probably as a result of consequence of fish culture, rather it reflects the overall declining trend in the area.

xi. The inlets of the floodplain remain open until late shraban in Jhanjhania and end of Badra in Uttampur FP and this coincides with the fish breeding period and seems that these adequately allow the lateral migration of fish, fish eggs, larvae and juveniles between floodplain and rivers, particularly the eggs, larvae, fry and fingerlings.

xii. Fish migration from floodplain to rivers are greatly hampered as a two stage sieve is used which does not allow fish to move from floodplain to the rivers. This is very likely to reduce the river fisheries production and also the abundance of fish species dependant on migrating fishes from the floodplain. This may disrupt the river-floodplain-river fish production system.

xiii. The floodplains are stocked with a number of exotic species. There is always a risk associated with the introduction of exotic fish species. Altgough, most exotic species in Bangladesh were not able to establish in open waters, still there may be a wide range of risks.

xiv. Stocking of grass carp in the floodplain has greatly reduced the abundance of major species of aquatic weeds in Jhanjhania FP and is apparently seen as a positive impact of floodplain aquaculture. However, if long-run continued stocking is done with grass carp may lead to the disappearance of some aquatic species locally.

xv. The major concern associated with the floodplain fish culture relates to the denial of access right by the project to the local fishers and others. Fishing ban is the major tools of floodplain aquaculture. As fishing is altogether banned under the project, therefore both professional and subsistence fishing do not take place. This is likely to jeopardize the livelihood of fishers dependent on the fisheries, unless otherwise they are compensated or alternate livelihood is provided to them.

xvi. The Bishnudia FP is modified to an impoundment with regulated hydrology and used only for fish culture. Such closure and modification of large floodplain is likely to affect local environment and its biota.

6.2 Recommendations

The following recommendations are put forward for the improved environmental and social performances of the promoted aquaculture:/ address the constraints and impacts

i. The promotion of the piloted aquaculture practices must not be on a large scale in an area in order to avoid the negative consequences on river fisheries and local biodiversity.

ii. Since the floodplains are stocked with over wintered or large fingerlings, the inlets to the floodplains could be blocked with large mesh size nets, allowing the lateral migrations of small fish, juveniles during the growing period.

iii. In any way the inlets (connectivity with the rivers) must not be blocked /closed before end of Ashar

iv. Stocking of floodplains with sterile exotic fishes is more preferable and stringent control measure should be taken against accidental escapes of exotic fishes into the open waters

v. The fishers affected by the project should be identified, be compensated or employed by the project, particularly in fishing activites.

vi. Efforts should be taken to provide alternate livelihood options to affected fishers with provision for easy and interest free access to micro-credits and facilitate their access to different welfare service providers.

vii. In each stocking floodplain auto stocked fish pit should be preserved (unfished) to maintain a self-sustaining indigenous fish populations/ stocks.

viii. The modification of floodplains to a complete impoundments in the form of a closed waterer body (as done in Bishnudia) over a large area with complete regulated hydrology with only intent for fish culture must not been done.

Chapter 7

References

7. References

Ahmed, A.A.S, Hassan, M. Ahmed, S.U. and Rahman, M.K.. 2017. Fertility Status on Some Tista Floodplain Soils Of Bangladesh . International Journal of Scientific & Engineering Research Volume 8, Issue 6, 579-582. pp.

Ahmed, N., Wahab, MA and Thilsted, SH. 2007 Integrated aquaculture-agriculture systems in Bangladesh: potential for sustainable livelihoods and nutritional security of the rural poor *Aquaculture Asia.*

Ali, S. and Charabarty, T. 1992. *Bangladesher Mitha Panir Amerudandi Prai (A Book of Freshwater Invetebrates of of Bangladesh)*. Bangla Academy, Dhaka. 176 pp.

Ali, S.andCharabarty, T. 1992. BangladesherMithaPanirAmerudandiPrai (A Book of

Ali, M.H., Miah, M.N.I. and Ahmed, N.U. 1993. Experiences in deepwater ricefish culture. Bangladesh Rice Research Institute. 107. Gazipur, Bangladesh.

Alkunhi, K. H. 1957. Fish Culture in India. Farm Bull No.20, Indian Coun. Agr. Res. New Delhi. 144pp

Anonymous. 2016a. Assessment of water qualities of some tidal floodplain areas under rice-fish culture practice. MS Thesis (unpublished), Department of Zoology, University of Dhaka, Dhaka. 87 pp.

Anonymous2016b. Zoopalnkton composition and aquatic biodiversity in some selected floodplains under rice-fish culture practice. . MS Thesis (unpublished), Department of Zoology, University of Dhaka, Dhaka. 77 pp.

Bayley, P.B. 1988. Factors affecting growth rates of young tropical floodplain fishes: seasonality and density-dependence. Environmental Biology of Fishes. 21: 127–142.

Bhouyan, A.M. and ASmat, S.M. 1992. Freshwater Zoolplankton from Bangladesh. 137 pp.

Biswas, B. C., & Panigrahi, A. K. (2015). Ecology and zooplankton diversity of a wetland at Jhenidah district Bangladesh. *International Journal for Innovative Research in Science and Technology*, *1*(9), 246-249.

Boyd, C.E. .1982.. Water quality criteria for warm water fishes. Elsiveir, London, NY. 338 pp/

BRAMMER, H. 2004. Can Bangladesh be Protected from Floods? Dhaka, The University Press Ltd. 262 pp.

Chakrabarty, R. D., Roy, P. and Singh, S. B. 1959. A quantitative study of the plankton and the physic-chemical conditions of the river Jamuna at Allahabad in 1954 - 55. Indian J. Fish., 6(1): 186-201.

Das, A. K., 2002. Chemical Indicators of Productivity in Small Water Bodies. In: *Cultured Based- Fisheries for Inland Fisheries Development*, (Ed., Sugunan, V. V., Jha, B. C. and Das, M. K.) Central Inland Fisheries Research Institute, Barrackpore, West Bengal, India. 38-45.

De Graaf, G. 2003. Dynamics of floodplain fisheries in Bangladesh, results of 8 years fisheries monitoring in the Compartmentalization Pilot Project. Fisheries Management and Ecology. 10(3): 191–199.

DoF. 2017. Yearbook of Fisheries Statistics of Bangladesh 2016-17. Fisheries Resources Survey System (FRSS), Department of Fisheries. Bangladesh : Director General, DoF, 2017. Volume 34 : p. 129.

DoF. 2018. Yearbook of Fisheries Statistics of Bangladesh, 2017-18. Fisheries Resources Survey System (FRSS), Department of Fisheries. Bangladesh : Ministry of Fisheries, 2018. Volume 35 : p. 129.

DoF. 2020. Yearbook of Fisheries Statistics of Bangladesh, 2019-20. Fisheries Resources Survey System (FRSS), Department of Fisheries. Bangladesh: Ministry of Fisheries and Livestock, 2020. Volume 37: 141p.

DPHE (Department of Public Health Engineering). 2013. Water Quality Assessment Report on Gulshan Lake. DPHE Central Laboratory, Mohakhali, Dhaka

Edmonson, W.T. 1959. *Freshwater biology*, 2nd Edition. John Wiley and Sons, New York, NY.1248 pp.

Ehshan, M. A., Hossain, M. S., Mazid, M. A., Mollah, M. F. A., Rahman, S., & Razzaque, A. (1997). Limnology of Chanda beel.

Ehshan, Md & Bhuiyan, As & Golder, Mi & Chowdhury, Muhammad. (2014). Water and soil quality of Roktodoha beel, a floodplain of northwest Bangladesh.

FAP (Flood Action Plan) 17. 1994. Final report, Main volume. UK: Overseas Development Administration, UK. 131 pp.

Frei, M. and Becker, K. 2005. Integrated rice-fish culture: coupled production saves resources.

FRG (2012). Fertlizer Recommendation Guidelines. Bangladesh Agricultural Research Council (BARC), Farmgate, Dhaka. 274 p.

FRSS, 2016. Fisheries Statistical Report of Bangladesh. Fisheries Resources Survey System (FRSS), Department of Fisheries, Bangladesh. Volume 32: 57 p.

Gupta, M.V., Sollows, J.D. Mazid, M.A., Rahman, A., Hussain, M.G. and Dey, M.M.(2002). Economics and adoption patterns of integrated rice-fish farming in Bangladesh. In: Edwards, P., Little, D.C. and Demaine, H. (eds), Rural Aquaculture. CABI International, Oxford, UK. pp. 41–54.

Habib, M. A. B., Islam, M. A., Mohsinuzzaman, M., & Rahman, M. S. (1984). Effect of some physico-chemical factors of water on the abundance and fluctuation of zooplankton of two selected ponds. *Univ. j. zool. Rajshahi Univ*, *3*, 27-34.

Halwart, M. and Gupta, M.V. (2004). Culture of Fish in Rice Fields. Food and Agriculture Organisation (FAO) of the United Nations and the WorldFish Center, 83 pp. FAO, Rome, Italy. Natural Resources Forum, 29, 135–143 pp.

Hasan, M.K. ,Mohiuddin, A.S.M and Uddin, M.J.. 2012. Characterization of some representative soils from the Ganges floodplain of. Dhaka Univ. J. Biol. Sci. 21(2): 201-205, 2012 (July). P. 201-205.

Hossain, Istiaque & Alam, Md. Mahmudul & Chamhuri, Siwar & Dey, Madan & Mokhtar, Mazlin & Jaafar, Abdul & Hossain, Md. Yeamin. (2014). Water productivity for living aquatic resources in floodplains of Northwestern Bangladesh. Journal of Coastal Life Medicine. 2. 324-331. 10.12980/JCLM.2.2014J50.\

Hossain, S., Rahman, M. M., Akter, M., & Bhowmik, S. (2015). Species composition and abundance of zooplankton population in freshwater pond of Noakhali district, Bangladesh. *World Journal of Fish and Marine Sciences*, *7*(5), 387-393.

Huq, S. I., & Alam, M. D. (2005). A handbook on analyses of soil, plant and water. *BACER-DU, University of Dhaka, Bangladesh*, *246*.

Islam, G. M. N. and Dickson, M. 2007. Turning social capital into natural capital: Changing livelihoods of fishers through CBFM. Proceedings of the CBFM-2 International Conference on Community Based Approaches to Fisheries Management, Dhaka, Bangladesh, March 6-7, 2007, The WorldFish Center. 1-21.

Jackson, M. L. 1962. *In: Soil chemical analysis*, London: Prentice Hall Inc.

Kabir, A. K. M. N., Ali, S. and Khondoker, M. 1997. Study on the zooplankton from Noakhali north floodplain. *Dhaka Univ. J. Biol. Sci.***6**(1): 31-37pp.

Khan, S.M.M.H., Aziz, K.M.S., Morshed, M.G. and Shafi, M. 1990. Seasonal variations in physico-chemical conditions of Dhanmondi Lake water. Bangl. J. Zool. 18(1): 61-66

Khatoon, N., Rehman, M., & Husain, K. A. 2013. Study of Seasonal Variation in the Water Quality Among Different Ghats of River Ganga , Kanpur , India. Journal of Applied Chemistry (IOSR-JAC). 5(3): 80-90.

Mellanby, H. 1975. Animal Life in Freshwater. 6th ed. Trowbridge and Esher, Fedowood, Burn Ltd. pp. 308

Mozumder, P. K., Naser, M. N., Alam, M. and Huq, A. 2011. Abundance and seasonal diversity of zooplankton in coastal aquatic environments of Mathbaria, Bangladesh. *Dhaka Univ. J. Biol. Sci.* **20**(2): 163-171pp.

Mozumder, P. K., Naser, M. N., Ali, M. S., Alam, M., Huq, A., Sack, R. B. and Collwell, R. R. 2010. Qualitative and quantitative analysis of zooplankton of some coastal waterbodies of Bakerganj, Bangladesh. *Bangladesh J. Zool.* **38**(1): 127-132pp.

Pathak, V., Bhagat, M. J. and Mitra, K. 1989. Fisheries Potential and Management of Oxbow Lakes of Ganga and Brahmaputra Basins. In: *Conservation and Management of Inland Capture Fisheries Resources of India*. (Ed., Jhingran, A. V. and Sugunan, V. V.) IFSI, Barrackpore, India. 143- 147.

Payne, I. 1997. Tropical Floodplain Fisheries. In: *Open-Water Fisheries of Bangladesh,* (Ed., Tsai, C. and Ali, M. Y.) The University Press, Dhaka, Bangladesh. 1-26.

Perera, PACT & Sundarabarathy, T. & Sivananthawerl, Thavananthan & Edirisinghe, Udeni. (2015). Seasonal variation of water quality parameters in different geomorphic Channels of the upper Malwathu Oya in Anuradhapura, Sri Lanka. Tropical Agricultural Research. 25. 158. 10.4038/tar.v25i2.8138.

Pipalova.I. 2006. A Review of Grass Carp Use for Aquatic Weed Control and its Impact on Water Bodies. J. Aquat. Plant Manage.44: 1-12.

Purba, S. 1998. The Economics of Rice-fish Production System in North Sumatra, Indonesia: An Empirical and Model Analysis. Farming Systems and Resource Economics in the Tropics, Vol.31. Wissenschafverlag, Vauk, Kiel, KG.

Rahman, A. K. A., 2005. *Freshwater fishes of Bangladesh.* 2nd Edn., Zoological Society of Bangladesh, Dhaka, Bangladesh. 394 pp.

Rahman, A. K. M. L., Islam, M., Hossain, M. Z., & Ahsan, M. A. 2012. Study of the seasonal variations in Turag river water quality parameters. African Journal of Pure and Applied Chemistry. 6(10): 144–148.

Rahman, H.S., Chowdhury, M.Y. and Haq, M.S.1982. Limnological studies of four ponds. Bangladesh J. Fish. 2-5(1-2): 25-35

Rahman, M. A., Rahman, M. M., Ahmed, A. T. A., Mollah, A. R. and Hossain, M. A. 2008. A survey on the diversity of freshwater crabs in some wetland ecosystems of Bangladesh. *Int. J. Sustain. Crop Prod.* **3**(3): 10-17.

Razzak, N. R. B., Siddik, A. Z., & Ahmeduzzaman, M. (2013). Evaluation of water quality of Ramna and Gulshan lakes. *International Journal of Environmental Monitoring and Analysis*, *1*(6), 273-278.

Rohar, J. R. and Crumrine, P. W. 2005. Effects of an herbicide and an insecticide on pond community structure and processes. *Ecological Applications*, **15**(4): 1135-1147.

Saha, P. D., Sengupta, R., Saha, J. & Banerjee, P. K. 2012 Assessment on the water quality characteristics of River Ganga at Kolkata Region,India using Water Quality Index and ANN simulation method. Environmental Science 6,34–41.wws

Sheel, P. R., Chowdhury, M. A. H, Ali, M. [1] and. Mahamu, M. A. (2015). Physico-chemical characterization of some selected soil series of Mymensingh and Jamalpur districts of Bangladesh. J. Bangladesh Agril. Univ. 13(2): 197–206

Sutton D.L. and Vandiver, V.V. Jr. 2006. Grass carp: A fish for biologic al management of hydrilla and other aquatic eeds in Florida. Bulletin 867. Florida Cooperative Extension Service of the University of Florida. http:// edis.ifas.ufl. edu/FA043

Tonapi, G.T. 1960. *Freshwater Animal in India (an Ecological Approach)*. Oxford and IBH Publissing C., New Delhi. 341 pp.

Villadolid, D. V., Panganiban, P., and Megia, T. G. 1954. The role of pH in pond fertilization. Indo-Pacific Fish Council Proc., 5(11): 109-111.

Ward, H., and C. Whipple. 1959. *Freshwater biology*, 2nd Edition. John Wiley and Sons, New York, NY.1248 pp.

Welch, P. S. 1948. Limnological Methods. McGrow-Hill Book Company, New York, 381 p.

Annexure

Annex 1

Measured water quality parameters in different intervention and control study sites

Annex 1A: Wet season:

Parameters	Jhanjhania		Uttampur		Bishnudia	
	Intervention	Control	Intervention	Control	Intervention	Control
PH	6.94	6.97	6.99	7.39	6.84	7.42
Conductivity(uS/cm)	218.80	184.00	227.20	146.10	241.20	142.70
TDS(mg/l)	146.53	85.50	200.50	76.60	178.63	68.70
Salinity (%)	0.11	0.09	0.11	0.08	0.10	0.08
DO(mg/l)	6.64	6.90	6.44	6.98	5.82	7.70
Alkalinity(mg/l)	121.75	81.02	130.45	76.30	117.93	72.40
Hardness(mg/l)	148.90	59.30	143.60	59.70	123.95	61.10
Phosphate(mg/l)	1.13	0.98	1.58	1.30	1.01	0.77
Ammonia-N(mg/l)	0.02	0.01	0.02	0.06	0.05	0.35
Nitrate-N(mg/l)	2.77	1.56	2.77	2.29	1.94	1.80
Nitrite-N(mg/l)	4.42	1.80	4.94	1.70	3.65	0.80
Temperature(0 C)	30.73	30.20	30.40	31.50	30.45	31.43

Annex 1B: Post monsoon

Parameters	Jhanjhania		Uttampur		Bishnudia	
	Intervention	Control	Intervention	Control	Intervention	Control
PH	7.02	7.02	7.24	6.56	7.46	7.11
Conductivity(uS/cm)	298.63	285.33	279.18	155.30	294.45	203.53
TDS(mg/l)	252.18	146.57	244.70	83.52	247.03	103.10
Salinity (%)	0.20	0.14	0.09	0.08	0.09	0.16
DO(mg/l)	5.72	5.82	5.70	4.54	7.24	4.18
Alkalinity(mg/l)	113.10	108.67	119.60	81.00	116.85	93.00
Hardness(mg/l)	128.85	111.00	150.68	68.66	124.30	85.00
Phosphate(mg/l)	0.61	1.26	1.10	1.12	1.02	2.16
Ammonia-N(mg/l)	0.02	0.25	0.03	0.22	0.02	0.25
Nitrate-N(mg/l)	2.67	0.70	2.18	1.53	2.42	2.16
Nitrite-N(mg/l)	4.44	1.03	4.91	2.66	3.01	2.10
Temperature(0 C)	29.79	26.10	29.56	26.03	32.24	29.15

Annex 1C: Dry season

Parameters	Jhanjhania		Uttampur		Bishnudia	
	Intervention	Control	Intervention	Control	Intervention	Control
PH	7.66	7.42	7.45	7.22	7.42	7.24
Conductivity(uS/cm)	635.90	176.00	391.70	215.00	507.50	236.00
TDS(mg/l)	403.40	94.00	321.40	109.00	272.10	122.00
Salinity (%)	0.30	0.10	0.20	0.12	0.13	0.15
DO(mg/l)	8.80	5.50	7.40	7.20	7.62	6.80
Alkalinity(mg/l)	147.00	174.00	119.25	124.00	131.15	120.00
Hardness(mg/l)	185.50	152.00	174.50	115.00	132.50	112.67
Phosphate(mg/l)	10.00	5.80	8.57	1.60	8.60	2.80
Ammonia-N(mg/l)	0.11	0.10	0.16	0.02	0.14	0.12
Nitrate-N(mg/l)	7.38	4.33	1.63	3.00	4.47	3.17
Nitrite-N(mg/l)	3.00	4.60	3.81	1.20	1.45	0.41
Temperature(0 C)	17.79	18.90	18.83	22.00	18.63	22.50

Annex 2

Station wise zooplankton abundance in different intervention and control sites

Annex 2A: Wet season (August 2017)

Station	Jhanjhania		Bishnudia		Uttampur	
	Intervention	Control	Intervention	Control	Intervention	Control
St-1	259.84	109.44	195.2	176.64	203.2	140.16
St-2	214.08	117.12	40.32	94.08	83.2	49.92
St-3	486.4	247.04	518.4	127.04	66.448	115.2
Average	**320.11**	**157.87**	**251.31**	**132.59**	**117.62**	**101.76**
SD	**145.82**	**77.32**	**243.93**	**41.56**	**74.59**	**46.60**

Annex 2B: Post monsoon

Station	Jhanjhania		Bishnudia		Uttampur	
	Intervention	Control	Intervention	Control	Intervention	Control
St-1	392	257.6	601.6	96	368	90.24
St-2	371.2	166.4	284.8	42.24	228.8	128
St-3	342.4	190.4	361.6	141.12	214.4	219.2
Average	**368.53**	**204.80**	**416.00**	**93.12**	**270.40**	**145.81**
SD	**24.91**	**47.27**	**165.26**	**49.50**	**84.83**	**66.30**

Annex 2 C: Dry (January 2018) season

Station	Jhanjhania		Bishnudia		Uttampur	
	Intervention	Control	Intervention	Control	Intervention	Control
St-1	395.2	157.44	94.08	132.16	179.2	134.08
St-2	74.88	84.48	228.8	63.36	96.96	53.76
St-3	98.24	130.56	232	99.52	0	91.68
Average	**189.44**	**124.16**	**184.96**	**98.35**	**138.08**	**93.17**
SD	**178.58**	**36.90**	**78.72**	**34.42**	**89.70**	**40.18**

Annex 3

Abundances (No./L) of zooplankton species in different intervention and control sites during
3A: Wet season

Group Name	Species Name	Jhanjhania		Bishnudia		Uttampur	
		Intervention	Control	Intervention	Control	Intervention	Control
Protozoa							
	Centropyxis sp.	11.73	-	0.64	-	2.05	-
	Phacus sp.	0.64	-	-	0.64	-	-
	Difflugia sp.	3.84	3.84	-	2.56	1.62	-
	Sub-total	**16.21**	**3.84**	**0.64**	**3.20**	**3.67**	**-**
Rotifera							
	Anuraeopsis sp.	0.64	2.56	-	-	0.16	2.56
	Asplanchna sp.	5.12	10.24	1.99	2.56	0.26	7.04
	Brachionus angularis	-	-	1.99	-	-	0.64
	Brachionus diversicornis	-	6.40	28.73	1.92	-	4.48
	Brachionus caudatus	0.64	1.92	-	-	-	-
	Brachionus quadridentata	-	10.88	0.71	-	3.34	-
	Brachionus falcatus	-	-	7.40	-	2.31	-
	Brachionus forficula	5.76	0.64	1.99	7.36	0.40	10.24
	Brachionus urceolaris	-	-	32.28	-	9.76	-
	Diplois sp.	-	-	1.99	-	0.51	0.64
	Filinia longiseta	1.28	1.28	-	7.68	-	0.64
	Hexarthra sp.	1.71	4.48	-	1.28	6.63	5.12
	Lecane sp.	-	-	-	3.20	0.08	0.64
	Monostyla sp.	1.71	-	-	-	0.26	-
	Polyarthra valgaris	-	3.20	-	-	0.08	-
	Platyias patulus	10.45	-	-	0.64	1.11	-
	Platyias quadricornis	2.35	5.76	1.07	-	-	7.04
	Rotaria sp.	0.43	6.40	-	5.76	0.26	-
	Trichocerca similis	0.64	-	5.76	3.84	0.08	7.04
	Unidentified	1.07	6.40	7.40	3.84	1.03	-
	Sub-total	**31.79**	**60.16**	**91.31**	**38.08**	**26.23**	**46.08**
Nauplii							
	Nauplius	54.61	21.76	39.04	10.88	24.99	9.60
	Metanauplius	57.71	20.48	20.05	14.72	20.35	16.64
	Sub-total	**112.32**	**42.24**	**59.09**	**25.60**	**45.33**	**26.24**
Copepoda							
	Cyclops sp.	-	5.12	-	3.20	29.02	7.68
	Cyclops nanus	56.49	3.84	21.55	-	7.82	-
	Diaptomus sp.	38.83	3.84	7.40	2.56	6.78	2.56
	Mesocyclops sp.	13.87	1.92	15.79	4.48	0.51	-
	Unidentified	1.92	5.12	-	1.92	-	1.92
	Sub-total	**111.10**	**19.84**	**44.73**	**12.16**	**44.13**	**12.16**
Cladocera							
	Bosmina sp.	7.04	1.28	-	2.56	-	6.40
	Daphnia sp.	0.85	-	-	-	-	0.64

Group Name	Species Name	Jhanjhania		Bishnudia		Uttampur	
		Interven tion	Control	Interven tion	Control	Interven tion	Control
	Diaphanosoma sp.	19.09	7.68	44.73	5.76	9.32	-
	Kurzia sp.	5.33	6.40	1.99	-	3.50	3.84
	Leydigia sp	-	-	4.98	-	-	-
	Macrothrix sp.	12.59	-	-	-	-	-
	Moina sp	-	8.96	2.13	3.84	-	1.28
	Chydorus sp.	0.43	-	-	-	-	-
	Oxyurella sp	-	-	1.07	-	-	-
	Sub-total	**45.33**	**24.32**	**54.90**	**48.64**	**12.82**	**12.16**
Ostracoda							
	Cypris sp.	-	1.92	-	0.75	-	2.56
	Heterocypris sp.	-	-	-	-	-	-
	Stenocypris sp.	3.20	5.55	1.07	2.56	0.92	2.56
	Sub-total	**3.20**	**7.47**	**1.07**	**3.31**	**0.92**	**5.12**
	TOTAL (Plankton/L)	**319.96**	**157.87**	**251.73**	**130.99**	**133.11**	**101.76**
	Number of species	28	26	23	23	26	22

3B: Post monsoon

Group Name	Species Name	Jhanjhania		Bishnudia		Uttampur	
		Interven tion	Contr ol	Interven tion	Control	Interven tion	Control
Protozoa							
	Centropyxis sp.	-	0.64	1.92	-	5.12	-
	Difflugia sp.	1.28	-	-	1.92	5.97	-
	Phacus sp.	-	-	1.28	-	-	-
	Sub-total	**1.28**	**0.64**	**3.20**	**1.92**	**11.09**	**-**
Rotifera							
	Asplanchna sp.	1.92	21.65	1.92	-	3.84	-
	Anuraaeopsis sp.	16.64	-	48.64	-	-	-
	Brachionus diversicornis	21.76	5.12	0.64	2.56	-	2.56
	Brachionus forciculata	-	-	-	-	-	-
	Brachionus falcatus	-	-	-	-	13.44	15.36
	Brachionus calyciflorus	-	-	-	-	-	5.76
	Branchionuscaudata	-	-	-	-	-	-
	Brachionus angularis	-	-	3.20	-	-	-
	Brachionus quadridentata	3.84	2.56	1.28	-	-	-
	Brachionus urceolaris	-	10.24	1.28	7.04	-	-
	Beauchamlpiell Sp.	-	-	6.40	-	6.61	-
	Filinia longiseta	19.84	2.56	-	-	-	-
	Hexathra sp.	-	-	-	-	10.88	-
	Lecane sp.	1.92	-	24.32	5.76	-	3.20
	Lecane luna	-	2.56	-	-	0.85	-
	Polyarthra valgaris	-	2.56	-	-	-	-
	Platyias patulus	10.88	19.84	1.92	-	17.07	2.56
	Platyias quadricornis	0.64	2.56	0.64	-	-	-

Group Name	Species Name	Jhanjhania		Bishnudia		Uttampur	
		Intervention	Control	Intervention	Control	Intervention	Control
	Rotaria neptunia	17.28	-	28.80	3.09	-	-
	Trichocerca braziliensis	0.64	-	-	-	0.85	-
	Trichoceros similis	-	-	-	-	-	-
	Unidentified	-	-	73.60	-	30.72	-
	Sub-total	**95.36**	**69.65**	**192.64**	**18.45**	**84.27**	**29.44**
Nauplii							
	Nauplius	85.76	12.80	62.93	10.77	36.05	24.96
	Metanauplius	33.60	21.76	26.24	7.68	31.57	19.84
	Sub-total	**119.36**	**34.56**	**89.17**	**18.45**	**67.63**	**44.80**
Copepoda							
	Cyclops sp.	44.16	30.72	30.08	22.29	42.67	21.76
	Diaptomus sp.	28.16	1.28	7.68	2.56	20.69	-
	Mesocyclops sp.	13.44	17.92	14.72	7.68	5.12	10.24
	Unidentified	1.28	14.72	1.28	-	-	2.56
	Sub-total	**87.04**	**64.64**	**53.76**	**32.53**	**68.48**	**34.56**
Cladocera							
	Bosmina sp.	9.60	-	13.44	6.40	-	-
	Cyclops nanus	-	-	7.68	-	-	12.16
	Daphnia sp.	14.72	-	-	-	2.56	-
	Diaphanosoma sp.	8.32	24.96	4.48	6.40	11.95	14.08
	Kurzia sp.	20.48	5.12	7.68	-	0.85	-
	Macrothrix sp.	-	-	-	-	-	8.96
	Moina leygidia	-	-	13.44	-	7.68	-
	Oxyurella sp.	-	-	-	-	-	-
	Chydorus sp.	12.16	-	2.56	-	8.53	-
	Sub-total	**65.28**	**30.08**	**49.28**	**12.80**	**31.57**	**35.20**
Ostracoda							
	Cypris sp.	-	1.92	-	8.96	4.48	-
	Heterocypris	-	-	7.68	-	-	-
	Stenocypris sp.	-	0.64	21.76	-	3.20	1.71
	Sub-total	-	2.56	29.44	8.96	7.68	1.71
	Sub-TOTAL	**-**	**5.12**	**58.88**	**17.92**	**15.36**	**3.41**
	TOTAL (Plankton/L)	**368.32**	**204.69**	**446.93**	**102.08**	**278.40**	**147.41**
	No. of Species	**22**	**21**	**29**	14	**23**	**15**

Annex 3C Dry season

Group Name	Species Name	Jhanjhania		Bishnudia		Uttampur	
		Intervention	Control	Intervention	Control	Intervention	Control
Protozoa							
	Centropyxis sp.	1.92	-	2.56	-	1.92	-
	Difflugia sp.	6.40	-	1.92	3.84	-	1.28
	Phacus sp.	3.84	1.28	-	-	-	-
	Sub-total	**12.16**	**1.28**	**4.48**	**3.84**	**1.92**	**1.28**

Group Name	Species Name	Jhanjhania		Bishnudia		Uttampur	
		Intervention	Control	Intervention	Control	Intervention	Control
Rotifera							
	Anuraaeopsis sp.	0.64	-	7.68	-	-	9.60
	Asplanchna sp.	3.20	1.28	-	-	-	-
	Branchionus angularis	0.64	-	-	-	-	-
	Branchionus caudata	-	-	-	-	-	-
	Brachionus diversicornis	1.92	-	12.16	-	-	3.84
	Branchionus falcatus	-	-	-	-	-	-
	Branchionus forcipulata	-	13.44	-	-	-	-
	Brachionus calyciflorus	-	-	-	-	6.72	-
	Brachionus quadridentata	5.76	-	10.24	1.92	-	7.04
	Brachionus urceolaris	-	-	-	-	2.88	-
	Beauchamlpiell Sp.	-	-	-	-	-	-
	Filinia longiseta	9.39	5.12	-	-	2.88	-
	Hexanthra	-	-	-	-	-	-
	Lecane sp.	1.28	-	-	1.28	-	-
	Lecane luna	-	8.32	-	-	-	-
	Polyarthra valgaris	3.84	-	-	-	-	-
	Platyias patulus	-	1.92	9.07	-	7.68	-
	Platyias quadricornis	-	-	-	-	-	-
	Rotaria neptunia	10.24	3.20	-	-	0.96	-
	Trichocerca braziliensis	-	-	-	2.56	15.36	-
	Trichoceros similis	-	4.48	-	-	-	-
	Unidentified	3.84	6.40	12.16	-	1.92	10.24
	Sub-total	**40.75**	**44.16**	**51.31**	**5.76**	**38.40**	**30.72**
Nauplii							
	Nauplius	28.80	9.60	15.36	13.44	11.52	5.76
	Metanauplius	8.96	12.16	18.13	5.76	15.36	10.24
	Sub-total	**37.76**	**21.76**	**33.49**	**19.20**	**26.88**	**16.00**
Copepoda							
	Cyclops nanus	1.92	1.92	-	-	-	-
	Cyclops sp.	11.84	17.92	10.88	19.09	2.40	-
	Diaptomus sp.	9.28	-	24.00	16.00	11.52	9.60
	Mesocyclops sp.	8.00	7.68	39.68	5.76	32.64	10.88
	Unidentified	-	1.28	1.28	-	2.88	1.92
	Sub-total	**31.04**	**28.80**	**75.84**	**40.85**	**49.44**	**22.40**
Cladocera							
	Bosmina sp.	3.20	5.76	-	1.28	1.92	10.77
	Daphnia sp.	5.76	0.64	-	19.84	-	3.20
	Diaphanosoma sp.	24.32	5.76	11.52	-	6.72	-
	Kurzia sp.	8.96	-	-	2.56	-	-
	Macrothrix sp.	6.83	-	-	-	1.92	-
	Moina sp.	7.68	10.24	-	-	-	9.60
	Oxyurella sp.	0.32	-	-	-	-	-
	Chydorus sp.	1.28	0.64	3.84	-	-	-

Group Name	Species Name	Jhanjhania		Bishnudia		Uttampur	
		Intervention	Control	Intervention	Control	Intervention	Control
	Sub-total	**58.35**	**23.04**	**15.36**	**23.68**	**10.56**	**23.57**
Ostracoda							
	Cypris sp.	2.56	4.48	2.56	-	1.92	1.28
	Heterocypris	1.28	-	-	-	-	-
	Stenocypris sp.	5.76	0.64	1.92	-	8.64	3.09
	***Sub-*Total**	**9.60**	**5.12**	**4.48**	**-**	**10.56**	**4.37**
	TOTAL (Plankton/L)	**189.65**	**124.16**	**184.96**	**93.33**	**137.76**	**98.35**
	No. of Species	**30**	**22**	**17**	**12**	**19**	**15**

Annex 4

Data on selected soil quality parameters measured in intervention and control sites in three floodplain ecosystems measured in January 2018

Parameters	Jhanjhania Intervention		Jhanjhania Control		Uttampur Intervention		Uttampur Control		Bishnudia Intervention		Bishnudia Control	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Orgaic matter (%)	4.92	0.94	2.57	0.88	2.26	1.00	2.64	0.99	5.20	0.57	3.70	0.74
Nitrogen (%)	0.66	0.16	0.41	0.26	0.27	0.03	0.29	0.23	0.57	0.04	0.45	0.05
Sulphate (ppm)	511.11	230.08	252.71	153.08	186.72	265.22	160.86	96.33	477.43	287.66	361.27	145.96
pH	6.74	0.15	6.80	0.10	6.57	0.44	6.18	0.90	6.75	0.17	6.63	0.33
Electrical conductivity (uS/cm)	428.92	255.59	325.73	27.03	188.23	81.03	128.23	89.43	261.00	5.20	153.75	82.65
Phosphorous (ug/g)	27.08	11.27	22.74	6.74	18.29	1.25	17.29	3.32	33.62	5.17	27.55	6.29
Potassium (ug/g)	326.41	61.93	241.74	53.34	180.65	4.89	136.15	10.64	205.57	12.74	173.02	27.85

Annex-5

List of fishes recorded from the study sites in the year 2016-2019

Sl. No	Scientific name	English name	Locale name	Family name	Relative abundance(2018)			Changes relative to 2015			Habitat preference	IUCN threat categor	Comments
					JHA	BIS	UTA						
1	*Amblypharymgodon mola*	Mola carplet	Mola	Cyprinidae	VC	VC	VC	++	Same	+	R, FP,D		
2	*Anabas testudinius*	The Climbing Perch	Koi	Anabantidae	FC	LC	FC	_	_	same	FP,D		
3	*Aplocheilus panchax*	Blue panchax	Kanpona, Choukkani	Aplocheilidae	FC	C	C	Same	+	same	FP,D		
4	*Apocryptes*sp.	Goby	Chewa Bele, Chiring	Gobidae	LC		LC	-		_	R		
	Badis badis	*Dwarf chameleon fish*	Koi bandhi/ Napte koi	Pristolepidae	R		R	same		_	FP,D		
5	*Barbonymus gonionotus*	*Java barb*	Thai sarputi	Cyprinidae									Exotic-stocked
	Botia Dario		Bourani	Cobitidae	R		R	-		-	R	EN	
6	*Brachyogobius nunus*		Nuna baila	Gobidae	LC		LC			---	ES, R		
7	*Catla catla*	Catla	Katal, Catla	Cyprinidae							R		Stocked
8	*Chaca chaca*	Squarehead Catfish	Chaka, Chaka Veka.	Chacidae	R			-			FP	EN	
9	*Chanda baculis*	Indian glassy fish	Kata chanda	Ambassidae	VC	FC	C	Same	+	Same	R, FP, D		
10	*Chanda nama*	Elongate Glass-perchlet	Nama Chanda	Ambassidae	LC		LC	-		- _	R, FP,D	VU	
11	*Channa marulius*	Giant Snakehead	Gajar, Gajal	Channidae	R			same			R, FP	EN	
12	*Channa orientalis*	Walking Snakehead	Gachua, Raga, Cheng	Channidae	LC	LC	LC	Same	-		FP,D	VU	
13	*Channa punctatus*	Spotted Snakehead	Taki	Channidae	C	LC	VC	-	Same	+	R, FP,D		Stocked in BS

14	*Channa striatus*	Snakehead Murrel	Shol	Channidae	FC	LC	C	Same	+	same	R, FP,D		Released in BS
15	*Chela sp.*		Chela	Cyprinidae	FC	LC	FC	+	--	-	Fp, D,R		
16	*Cirhinus reba*	Reba	Bhagna, Raik, Tatkini, Bata.	Cyprinidae	LC	R		+	_	Same	R	VU	
17	*Cirrhinus cirrhosus*	Mrigal Carp	Mi1rka, Mrigal	Cyprinidae							R		Stocked
18	*Clarias batrachus*	Walking catfish	Magur, Jagur	Claridae	LC	R	R	-		-	R, FP,D		Stocked in BS
19	*Colisa fasciata*	Giant Gourami	Khails20ha, Khoila	Osphronemidae	C	LC	FC	Same	-	same	FP,D		
20	*Colisa lalia*	Red Gourami	Lal Khailsha, Baicha	Osphronemidae	VC	C	C	++	+	same	FP,D		
21	*Ctenopharyngodon idella*	Grass Carp	Grass Carp	Cyprinidae									Exotic-stocked
22	*Cyprinus carpio*	Common Carp	Carpu, Carphu	Cyprinidae									Exotic-stocked
23	*Danio dangila*	Dangila danio	Nipati	Cyprinidae	LC			same			FP,D		
24	*Eleotris fusca*	Brown sleeper	Kuli, Kalthu	Eleotridae	LC	LC	FC	-	-	-	R , FP		
25	*Esomus danricus*	Flying barb	Darkina	Cyprinidae	C	FC	VC	++	+	same	FP,D		
26	*Glassogobius giuris*	Bar-eyed Goby	Bele, Bailla.	Gobidae	C	LC	FC	Same	--	Same	R, FP		
27	*Heteropneustes fossilis*	Stinging catfish	Shing	Heteropneustidae	FC		FC	--	--	Same	R,FP,D		Released in BS
28	*Hypophthalmichthys molitrix*	Silver Carp	Silver Carp	Cyprinidae									Exotic-stocked
29	*Hyporhamphaus limbatus*	Congaturi halfbeak	Ek Thota	Hemirhamphidae	C	FC	FC	Same	same	same	R,FP		
30	*Labeo calbasu*	Black Rohu	Kalibaus	Cyprinidae							R	EN	Stocked
31	*Labeo rohita*	Rohu Carp	Rui, Rohit.	Cyprinidae							R, FP		Stocked
32	*Lepidocephalichthys guntea*	Guntea Loach	Gutum, Puiya.	Cobitidae	LC	LC	LC	-	-	same	R, FP,D		
33	*Macrognathus aculeatus*	Spotted spiny Eel	Tara Baim	Mastacembelidae	LC	LC	LC	-	-	+	R, FP,D	VU	
34	*Macrognathus pancalus*	Striped spiny Eel	Guchi Baim	Mastacembelidae	C	FC	C	-	--	Same	R, FP,D		

35	*Mastacembelus armatus*	Tire-track spiny Eel	Baim	Mastacembelidae	R		R	-		+	R, FP,D	EN	
36	*Mirror carp-hybrid*		Minar	Cyprinidae									Exotic-stocked
37	*Monopterus cuchia*	Freshwater mud Eel	Kuicha	Synbranchidae	LC	FC	LC	+	+	+	R, FP,D	VU	
38	*Mystus cavasius*	Gangetic Mystus	Gulsha tengra	Bagridae	LC		LC			--	R, FP	VU	
39	*Mystus tengara*	Stripped Dwarf Catfish	Bajari Tengra, Guitta Tengra	Bagridae	VC	C	VC	Same	+	++	R, FP,D		
40	*Mystus vittatus*	Stripped River Catfish	Tengra	Bagridae	FC	LC	FC	Same	-	-	R, FP,D		
41	*Nandus nandus*	Mud Perch	Meni, Bheda	Nandidae	LC		LC	-		+	FP,D	VU	
42	*Notopterus notopterus*	GreyFeatherback	Foli	Notopteridae	FC		FC	Same		same	R, FP,D	VU	Released in BS
43	*Ompok bimaculatus*	Two spot glass catfish	Kani pabda	Siluridae	LC		R	same		-	R, FP,D	EN	
44	Ompok pabda		Madhu pabda	Siluridae	R			Same			R,FP	EN	
45	*Oreochromis niloticus*	Nile Tilapia	Nilotica	Cichlidae									Exotic-stocked
46	Oryzas melastigma	Estuarine ricefish	Kanpona	Cyprinodontidae	C	VC	VC	same	same	same	R,FP,D		
47	*Osteobrama cotio*	Cotio	Dhela	Cyprinidae	R		R	--		---	R, FP,D	EN	
48	*Pangasius hypophthalmus*	Pungas	Thai Pangas	Pangasiidae									Exotic-stocked
49	*Pethia ticto*	Two-spot Barb	Tit Punti	Cyprinidae	LC	R	C	Same	-	-	R, FP,D	VU	
50	*Pseudambassis ranga*	Indian Glassy Fish	Ranga chanda, Chanda	Ambassidae	VC	FC	C	+	+	+	R, FP,D	VU	
51	*Puntius chola*	Chala Barb	Chalapunti	Cyprinidae			LC			-	R, FP,D		
52	*Puntius conchonius*	Red barb	Kanchan punti	Cyprinidae	LC	LC	VC	+	same	same	R, FP,D		
53	*Puntius sarana*	Olive barb	Sar Punti	Cyprinidae	R		R	Same		-	R, FP	CR	Relaesed in BS
54	*Puntius sophore*	Spotfin Swamp	Jat Punti	Cyprinidae	VC	C	C	+	-	same	R, FP,D		

55	*Rhinomugil corsula*	Corsula Mullet	Khalla, Bata.	Mugilidae	LC	R	LC	-	--	-	R		
56	*Salmostoma bacaila*	Large Razorbelly Minnow	Narkalichela	Cyprinidae	LC	LC	FC R	same	-	-	R,FP,D		
57	*Notopterus chitala*	Giant featherhead	Chitol	Notopteriade	R			--			R		Releasedin BS
58	*Tetradon cutcutia*	Common Pufferfish	Tepa, Potka.	Tetradontidae	LC	R	FC	-	--	-	R, FP,D		
59	*Wallago attu*	Freshwater Shark	Boal	Siluridae	LC		LC	-		+	R, FP,D	VU	
60	*Xenentodon cancila*	Needle fish	Kaikya, Kakila	Belonidae	FC	R	FC	same	--	same	R, FP,D		

Relative abundance
VC=Very common; C=Common; FC = fairly common; LC=Less common; R=Rare
Habitat preference
R=River; FP=Floodplain; D- Ditch and ponds

Sl.N0	Name of species	Common English name	Local name	Family	Jhanjhania	Bishnudia	Uttampur	Habitat	Changes relative to 2015
4.a. MOLLUSCAN SPECIES									
1	*Pila globosa*	Common Apple-Snail	Bara Shamuk	Pilidae	VC	FC	VC	R,FP,D	Decreased slightly
2	*Bellamya bengalensis*	Banded Pond/River Snail	Guli Shamuk	Viviparidae	FC	LC	FC	R,FP,D	Decreased
4	*Indoplanorbis exustus*	Ram's Horn Snail	Chapta Shamuk	Planorbidae	VC	C	VC	R,FP,D	DEcreased
5	*Gyraulus convexiusculus*	Horn Snail	Choto Pachano Shamuk	Planorbidae	VC	C	VC	R,D	Decreased
6	*Lamellidens marginalis*	Freshwater mussels	Jhinuk	Unionidae	LC	R	FC	R, D	Decreased (found mainly in ponds)
4.b. CRUSTACEA- PRAWNS/ SHRIMP									
1	*Macrobrachium rosenbergii*	Freshwater Prawn	Gholda Chingri	Palaeminidae	LC		R	R	Increased slightly
2	*Macrobrachium malcolmsonii*	Moonsoon River Prawn		Palaeminidae	FC	R	R	R	Decreased slightly
3	*Macrobrachium villosimanus*	Dimua River Prawn	Dimoala Icha, Dimua Icha	Palaeminidae	LC	LC	LC	R	Decreased
4	*Linder stylifera*				FC	FC	LC	FP, R	
5	*Caridina gracilirostris*	Needle nose Caridin	Gusa chingri	Atyidae	VC	VC	VC	R,FP,D	Increased highly
4.c CRUSTACEA- CRABS									
1	*Sartorina spinigera*	Sartorina Crab	Chimta Kakra	Potamidae	C	FC	C	R,FP.D	
2	*Labothelphusa wood-masoni*	Freshwater Crab	Kata kakra	Potamidae	C	C	C	R,FP,D	

Annex-6

4.18 Individual Case Study: Impact of Project Intervention on Livelihood of Local Fishermen.

Name of the Fisherman: Md. Siraj Mollah

Father name: Abdul Ali

Address: Village: Jhanjhania(Uttar), Upazila: Najirpur, District: Pirojpur.

Siraj Mollah is a full-time fisherman and inherited the occupation from his father and is involved in fishing since his childhood and undertook fishing for 50 yeaars. They were used to fish in the Jhanjhania and adjacent floodplains as well as in the nearby river. He does not possess any agricultural land. His family consists of 9 members, his wife, two daughters and five sons. Three of his sons help him in fishing and also undertake agricultural productions in some leased lands. However, still fishing is the main and major source of income for his family. Loss of fishing grounds and less availability of open water fishes have been jeopardizing their livelihood and pushing them out of their occupation. In order to maintain their livelihood Siraj Mollah borrowed about One Lakh taka from NOGs and Mohajons as the incomes from fishing reduced.

According to him, the present project has added miseries to their livelihood as they cannot fish in the Jhanjhania floodplain where they were used to fish for the last 50 years. He strongly thinks that they are highly affected by the project implementation. He also said that in spite his strong resistance the villagers together implemented fishing ban in the Jhanjhnia floodplain. Now, he fish in the river and also needs to move to distant floodplains for fishing and sometimes it creates unpleasant environment in fishing in the distant floodplains. He has no share nor has got any benefit as compensation from the project. (However, according to project management all affected fishers have been employed by the project and has been given a share worth TK. 1000/- each). According Siraj Mollah, his daily income has reduced by TK. 300/ day during peak fishing season due to project implementation. Peak fishing season coincide with August-October. In addition to reduced income he thinks they consume less fish compared to earlier and thus they area also nutrionally affected.

Siraj Mollah has strong reservation about the implementation of the project in the floodplain and made an appeal for its discontinuation. However, he indicated that if there are sufficient compensation scheme or any work they should not have any objection. His suggestions are as follows in case the project continues: (a) provide them with sufficient number of shares (b) provide financial help as compensation (c) employ all fishers in the project work