INTEGRATED PROTECTED AREA CO-MANAGEMENT (IPAC)

FISH CATCH MONITORING REPORT – PART 2

April 15, 2013

COVER PHOTO:

Bangladesh's wetlands provide livelihoods, thereby contributing nutritional diet for rural poor. But wetland degradation, land encroachment and land conversion threaten both livelihoods and food security. USAID's IPAC project works with the Government of Bangladesh and wetland-dependent communities to conserve and sustainably manage the country's wetlands to ensure healthy ecosystem and aquatic production today and into the future.

INTEGRATED PROTECTED AREA CO-MANAGEMENT (IPAC)

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EXECUTIVE SUMMARY

The importance of Bangladesh's freshwater fisheries, especially wetllands fisheries as a source of nutrition, employment and income for the rural poor can hardly be emphasized. In the past, the management of wetlands fisheries has often excluded marginalized fishers and encouraged elite's to effectively 'mine' resources at non-sustainable levels of exploitation. To address these concerns, USAID supported the Government of Bangladesh to establish co-management and restoration of three major wetlands (Hail haor, Kangsho-Malijhee and Turag-Bangshi) through the MACH project. Integrated Protected Area Co-management Project (IPAC) continued and strengthened co-management of wetlands including the Sundarbans. IPAC continued detailed fish catch monitoring to determine the relationship between wetlands management practices and impacts on biological significance and fish catches in wetlands.

Fisheries production was measured by monitoring a sample of individual catches from defined areas which was used to estimate the total catch in each wetland. The total fish catch in the study year (2011-12) was estimated to be about 102 tons in Hail Haor, 65 tons in Kangsha-Malijhee wetland, and 10 tons in Turag-Bangshi system. A total of 85, 62 and 52 species of fish and prawn were recorded during the study period in Hail haor, Kangsho Malijhee and Turag-Bangshi respectively.

In **Hail Haor** the common species caught by all types of gears were Grass carp (*Ctenopharyngodon idella*), Rui (*Labeo rohita*), Jatputi (*Puntius sophore*), Foli (*Notopterus notopterus*), and Taki (*Channa punctata*), contributing 7.93%, 7.58%, 6.77%, 5.77% and 5.27% respectively. Analysis of catch monitoring data reveals that 20 main species contributed 77% of the catch by weight in 2011-12. The annual contribution of the other 65 species recorded was 23%. High catches of two exotic species - Common carp and Grass carp – are notable, and it appears that Common carp has natrualised in the Gopla River. But as Grass carp is not known to reproduce in the wild in Bangladesh these fish presumably escape from the rapidly expanding aquaculture enterprises, encroaching around the fringes of Hail Haor. These exotic species did not dominate the MACH data, but floodplain aquaculture areas have expanded rapidly since the start of MACH and co-management has been unable to influence this trend.

In **Kangsha-Malijhee** system the common species caught by all types of gears were Baila (*Glossogobius giuris*), Boal (*Wallago attu*), Taki (*Channa punctata*), Kakila (*Xenentodon cancila*) and Kholisha (*Colisa fasciatus*), and contributing 13.76%, 11.63%, 9.99%, 7.88% and 6.57% respectively. The 20 main species contributed to 89.96% of the catch by weight in 2011-12. The contribution of the other 42 species was 10.04% of the catch by weight.

In **Turag-Bangshi** system the common species caught by all types of gears were Jatputi (*Puntius sophore*), Guchi baim (*Mastacembelus pancalus*), Titputi (*Puntius ticto*), Ranga chanda (*Chanda ranga*), and Chola puti (*Puntius chola*) contributing 14.99%, 11.75%, 9.39%, 8.15% and 7.56% respectively. The 20 main species contributed to 95.56% of the catch in 2011-12. The contribution of the other 32 species was 4.44% of the catch.

The data gererated during the study period provided an opportunity to explore the continued impact of management by RMOs by comparision with the period when MACH was in operation, in terms of fisheries management performance indicators i.e., production (kg/ha), Catch Per Unit Effort (CPUE) and biodiversity. The results suggested that the Hail Haor and Kangsha-Malijhee sites showed considerably improved biological diversity (number of species) in 2011-12 when compared with the baseline and impact period under MACH. However, biodiversity was found lower in Turag-Bangshi when compared to MACH.

Simultaneously, production (kg/ha) reached 377 kg/ha in Hail Haor (compared with 322 kg/ha in the last two years of MACH) and was 556 kg/ha in Kangsha-Malijhee (compared with 307 kg/ha in the last two years of MACH). The results also suggested that occurrence of exotic cultured species may be a new challenge in Hail Haor since the present study suggested that in the river within Hail Haor exotic cultured species (Grass carp, Common carp, Mirror carp, Bighead carp and Silver carp) contributed a considerable part in the open catch. In Turag-Bangshi system fish catches fell to 139 kg/ha in 2010-11 and 88 kg/ha in 2011-12 compared with 278 kg/ha in the last two years of MACH. Pollution from industrial development has adversely impacted the fishery in Turag-Bangshi. Here water quality problems that arose with the growth of textile related industries during the MACH period have continued to adversely impact wetland biodiversity and fish catches and work to negotiate cleaner production systems and adoption of the mandatory effluent treatment plants are yet to bear fruit.

Main recomemndations of this astudy are : i) community based co-management should continue .in the long term through the existing system of RMOs, ii) well managed capture fisheries in freshwater wetlands are diverse and inherently resilient to environmental variability and drifts including climate change, and iii) the practices of floodplain aquaculture and encroachment of the haor land will impact the overall natural fishery, and these need to be regulated, but the existing co-management bodies lack the authority to do this.

1. INTRODUCTION

Bangladesh lowland rivers and floodplains are most productive for wild-capture inland fisheries in the world. The combined deltaic floodplains covers nearly all of Bangladesh's 147,570 km2 areas and are formed by a network of the major rivers – the Padma, the Meghna, the Namuna and the Brahmaputra. These rivers have rich and diverse fish faunas. Fish is an essential staple food for the people of Bangladesh and the fisheries sector plays a vital role in the economy through employment generation, nutrition supply and poverty alleviation (Alam 2005 and Nasir Uddin *et al.*, 2003). This sector provides employment to nearly 1.2 million full time fishers and 11 million part time/artisanal fishers, fish/shrimp farmers, fish traders and processors, labourers and input suppliers (DoF-FRSS 2005-06). However, almost two-thirds of the rural households get involved in fishing during the monsoon season. Nearly 5.2 million people or 9% of the labour force were involved in fisheries full time (FSRFDS 2003a). Several studies, including FAP-17 (1994) and a study conducted by Thompson and Hossain (1998) indicate that about 80% of rural households traditionally catch fish for food or for sale. Studies have shown that, many "miscellaneous" small fish species caught from the floodplains and lakes by people, which have always been neglected in official statistics and policies, provide relatively more essential nutrients than the large fish favoured by fish culture programs (Minkin, 1989).

Floodplains contribute to 31% of the total fish production, followed by rivers, estuaries and *beels*, and the total inland open water fisheries contributes to 41% of the country's total fish production. The inland openwater fisheries of Bangladesh are common property and share two characteristics; it is expensive to exclude potential users from gaining access to the resource and each person's use of the resource subtracts from the potential welfare of others. In inland fisheries, more than half of the fishermen exclusively produce fish for their own households; only a small number of fishermen deliver more than half of their catch to the market.

1.1. Integrated Protected Area Co-management Project (IPAC)

Bangladesh is rich in natural resources, especially in water and soil. The productivity of valuable wetlands has come under increasing pressure as human population has spiraled and drainage for agricultural development and the construction of flood embankments in tandem with over-exploitation and pollution have degraded fish stocks and other aquatic species harvested by the poor. The consequences have been devastating and also alarming for the future food security. Funded by USAID and the GoB, IPAC is being implemented over a five year period (June 2008 – June 2013) by the GoB involving the two ministries i.e. MoEF and MoFL, through the three line agencies i.e. FD, DoF and DoE. International Resource Group (IRG) is the main contractor while WorldFish Center is a subcontractor with principal responsibility to deal with matters relating to wetlands and fisheries. IPAC supports the co-management of a range of protected and ecologically critical areas (ECAs) in both terrestrial and aquatic ecosystems. The project is principally located in five clusters scattered throughout Bangladesh (Figure 1). Main role of WorldFish is as below:

- Contribute to policy reviews for developing a coherent national strategy for protected area co-management and drafting a strategic framework of integrated and landscape based management of aquatic ecosystems and biodiversity.

- Undertake monitoring and evaluation of past management needs and develops models of best practices for co-managing wetland resources and biodiversity.
- Undertake participatory monitoring and action research and provides guidelines for site-specific interventions aimed at fostering sustainable development and conservation of wetland resources and livelihoods.

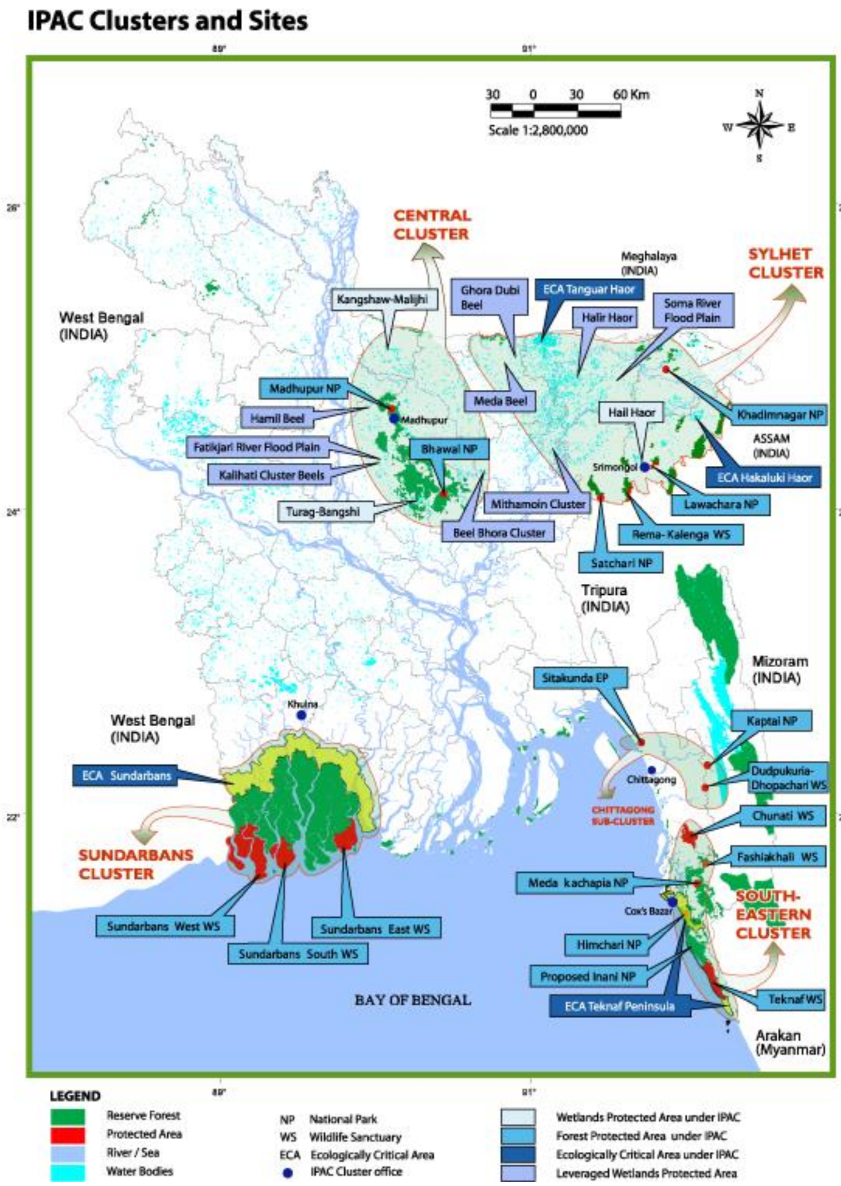


Figure 1. Working sites of IPAC project

2. METHODOLOGY

2.1. Site Selection and Waterbody Sampling

The IPAC wetlands are located in the Sylhet cluster, Cenral cluster and Sundarbans cluster. Wetlands in Sylhet and Central clusters are the intensely flooded areas of the Srimongal Upazila of Hobiganj district and Zinaigati Upazila of Sherpur district and Kaliakur Upazila of Tangail district. All adjacent waterbodies are connected during monsoon and is in fact treated as a single cluster. The IPAC project targeted to work in 6 selected waterbodies in Hail haor (Srimongal), 4 water bodies in Kangsha-Malijhee (Zanaigati) and 3 water bodies in Turagh-Bangshi (Kaliakur) sites and these water bodies have been earlier MACH catch monitoring sites. However, IPAC replaced two new water bodies (directly related with earlier MACH site) in Hail haor. Fish catch monitoring sites are presented in Table 1.

Name of Cluster	Name of wetland	Name of River/Beel	Habitat	Monitoring Area (ha)
Sylhet Cluster	Hail haor	Gopla River	River section	41.23
		Cheruadubi Beel	Open Beel	30.4
		62 Beels Hunamua	Open Beel	8
		Almiberi	Open Beel	30
		Balla Beel	Open Beel	159.09
		Lata River	River	7.5
Central Cluster	Kangsha-Malijhee	Kewta Beel	Open Beel	33.04
		Takimari Beel	Open Beel	34.75
		Malijhee River	Open Beel	5
		Doli Beel	Open Beel	44.1
	Turag-Bangshi	Mokash Beel	Open Beel	100
		Mokesh Khal	Cannel	2
		Turag River	River section	14

Table 1. Distribution of waterbodies by location, habitat and monitoring area.

2.2. Assignment of Monitoring Sites to PMA Research Associates

In order to design a representative sample size, the project targeted to work in 13 sample water bodies (6 in Hail Haor, 4 in Kangsha-Malijhee and 3 in Turag-Bangshi) under two IPAC clusters (Sylhet cluster and Center cluster). The respective PMA Research Associates supervised the monitoring activities. The main task of the PMA Research Associate was to collect PMP data of daily activities.

The specific responsibilities of the PMA Research Associates have been described below:

- to oversee the method of collection and ensure data accuracy for all information collected from project participants by the respective Community Enumerators;

- to facilitate and conduct relevant training for all Community Enumerators including frequent coaching and mentoring support
- to coordinate with RMOs (Resource Management Organizations) and FRUGs (Federations of Resource User Groups) to get information on fisheries management related activities in the sample water bodies;
- to disburse monthly salary and field expenses to respective Community Enumerators;
- to verify data sheet, data encoded and data checking;

Respective Research Associates were instructed to liaise with IPAC Cluster Director (CD), Data collector, IPAC staff, RMOs and FRUGs for ensuring proper monitoring of the water bodies.

A list of the community enumerators assigned to different water bodies is given in Table 2

Name of Cluster	Name of wetland	Name of River/Beel	Name of Community Enumerator
Sylhet Cluster	Hail haor	Gopla River	Sajal Sarker
		Cheruadubi Beel	Sajal sarker
		62 Beels Hunamua	Md. Abdullah
		Lata River	Md. Abdullah
		Almiberi beel	Aurun
		Balla Beel	Aurun
Central Cluster	Kangsha-Malijhee	Kewta Beel	Md. Abdul Khaleque
		Takimari Beel	Md. Amiruzzaman
		Malijhee River	Md. Amiruzzaman
		Doli Beel	Abu Bakar
	Turag-Bangshi	Mokash Beel	Md. Delwar Hossain
		Mokesh Khal	Md. Delwar Hossain
		Turag River	Md. Amir Hossain

Table 2. List of community enumerators assigned in different wetlands.

2.3. Monitoring Framework

Main principals underlying the monitoring activities are:

- Assessment of fish production at 3 sites of IPAC (Hail Haor, Kangsha-Malijhee and Turag-Bangshi);
- Population dynamics for important fish species at project wetlands;

2.3.1. Catch Monitoring and Biodiversity

An individual catch monitoring study incorporated data from Feb'11 to Jan'12 in Hail Haor, May'11 to April'12 in Kangsha-Malijhee, and Mar'11 to Feb'12 in Turag-Bangshi sites. Catch and effort were monitored to estimate the annual total catch and fishing effort through a catch assessment and a frame survey. The daily catch of every individual fisherman and his gear (CPUE) were monitored for 4 days a month. The numbers and weight of all fish species in the catch were recorded. Furthermore, the gear-type, mesh size, owner status and the number of units used per fisherman were recorded 4 days a month through a standardized counting of the number of gears to estimate gear wise fishing efforts (f).

2.3.2. Data Analysis

Survey sampling covered gear census and catch monitoring. Catch monitoring is an observational process on fishing effort that was done for four days a month per site. It recorded species wise catch statistics of each gear type. Gear survey involves a regular spot survey for a sample of gears in operation and their total catch. In this case, gear census covered all the gears (types and numbers) operating in the study sites.

The total monthly catch for each water body was calculated with;

$$Monthly\ \ Catch\ \ per\ \ site = N * \sum_{i,j=1}^{n} \overline{f}_{i,j} * \overline{cpue}_{i,j}$$

Where:

N: Number of days per month when fishing was monitored

f: Average number of gears used per day (for each gear type)

cpue: average daily catch per gear type (calculated yield/no of gears).

Average number of gear per day was used to estimate total number of gear-wise fishing effort for that month as well as for the whole year. Simultaneously, mean gear-wise catch rate was used to estimate total catch for that month, as well as for the whole year. Overall species distributions by gear were calculated using annual catch statistics data. Year wise as well as overall species distribution were calculated using catch statistics data. Overall production was estimated by summing all estimated production of different gear types in each year.

2.3.3. Shannon-Wiener Bio-Diversity Index

The Shannon-Wiener Index (H') is one of several diversity indices used to measure biodiversity. In this study, species wise production rates were used to estimate the Shannon-Wiener diversity index (H'). The function was originally devised to determine the amount of information in a code or signal, and is defined as:

$$H \ = \ -\sum_{i=1}^{S_{obs}} pi\ loge\ p$$

Where,

H: Information content of sample (Index of diversity or Degree of uncertainty),

s: Number of species

pi: The proportion of individuals in the i^{th} species.

(Species Diversity & Richness calculates the index using the natural logarithm).

2.3.4. Fish Catch Monitoring

Individual fish catch monitoring is an important task of the present study. IPAC has started fish catch monitoring at randomly selected sample waterbodies to observe fish biodiversity, fishing intensity, fishing activities, gear diversification, species composition, and estimated total catch. One Community Enumerator was responsible for one or two water bodies for fish catch monitoring data collection. In addition to catch monitoring, the Community Enumerators also collected information on the gear types used by each fishermen during fishing and landing from fishing. They kept records on types of gears, numbers of gears and length of gears used, etc. PMA Research Associates, who were assigned to each waterbody, provided the Community Enumerators with logistical and technical support and field orientation. Fish catch monitoring data collection started from February' 10 in Hail Haor, Mar' 10 in Turag-Bangshi and May' 10 in Kangsha-Malijhee sites. However, in Takimari beel, Kangsha Malijhee site fish catch monitoring starts in July'10.

2.3.5. Monitoring Fishing Activities

According to the activity plan, fish catch monitoring data has been collected from 13 related MACH earlier water bodies by Community Enumerators. The catch monitoring records reflect quantity of fish catches (Kg), species diversity, fishing activities and consumption during harvesting. In MACH project sufficient fund was allocated to conduct large scale fish catch monitoring. In contrast, IPAC did not have resources or even mandate to do more general fish catch monitoring like MACH. IAPC used sub-set of MACH monitoring sites and similar methodology as MACH. However, instead of 3 days sampling per month by the MACH, the IPAC conducted 4 days sampling per month following minimum detectable difference at 95% confidence limit (Zar, 1984).

2.4. Gear Characteristics

Various types of fishing gear are used in the inland open water bodies of Bangladesh. Their specification differs according to target species, type of water body, labour intensity, fabrication, cost, materials available and profit. There are more than 100 types of fishing gear used by professional fishermen communities. List of most common gears by type is shown in Table 3.

Name of gears	Local Bengali name used in different district of Bangladesh
Gill net	Pata Jal, Fash Jal, Poa Jal, Current Jal, Dacon Jal
Seine net	Ber jal, Jagat ber jal, Moia jal, Katha ber jal, Gamcha jal
Set bag net	Bada jal
Lift net	Bheshal jal, Dharma jal
Cast net	Utar jal, Khepla jal, Toira jal, Jhaki jal
Push net	Thela jal, Hanga jal
Trap	Kholsun, Anta, Polo, Charai, Ghuni, Fala, Bair
Long-line	Chara Barshi, Taja Barshi
Hook and Line	Barshi, Dati Barshi, Shola borshi
Spear	Achra, Aro, Jutya, Koch, Teta
Others	Bana, Katha, Kua, by Hand

Table 3. List of common gears used in *haor* areas.

Cast nets, spears, lift nets and gill nets are operated both day and night. The trap units, long-lines and hooks and lines are operated only at night time while the push net and seine net are operated only during the daytime. Operation of spears and lift nets are occasional and seasonal.

3. RESULTS AND DISCUSSION

3.1. Fisheries Production

The fish production at each cluster site was obtained from fish catch monitoring. Total fish catch from monitored sites was found to be 104 tons in Hail haor, 65 tons in Kangsha-Malijhee and 10 tons in Turag-Bangshi sites. From this, Gopla river, Cheruadubi beel and Almiberi beel comprises of 26%, 25% and 24% respectively in Hail haor while Doli beel, Kewta beel and Takimari beel comprises of 32%, 26% and 24% respectively in Kangsha-Malijhee, and the Mokash beel compreses of 75% in Turagh-Bangshi sites. A short statement regarding monitoring periods and estimated production is given in table 4. However, this is a one year study. Further study is required to know how it may affect total production.

Name of Cluster	Name of wetlands	Monitoring periods	Est. total catch (Kg)
Hail Haor	62 Beels Hunamua	Feb'11 to Jan'12	2,806
	Almiberi beel	Feb'11 to Jan'12	25,401
	Balla beel	Feb'11 to Jan'12	17,082
	Cheruadubi beel	Feb'11 to Jan'12	26,507
	Gopla River	Feb'11 to Jan'12	26,689
	Lata River	Feb'11 to Jan'12	3,622
Kangsho-Malijee	Malijhee River	May'11 to April'12	14,929
	Doli beel	May'11 to April'12	11,851
	Kewta beel	May'11 to April'12	20,750
	Takimari beel	May'11 to April'12	17,510
Turagh-Bangshi	Mokash beel	Mar'11 to Feb'12	7,446
	Mokash khal	Mar'11 to Feb'12	1,658
	Turagh River	Mar'11 to Feb'12	1,115

Table 4. Total harvests from fish catch and monitoring in all monitored sites.

Fish Production (Kg/ha)

There was substantial variation in production (Kg/ha) at most sampling sites and production varied from 74 to 2986 Kg/ha with overall production of 377 Kg/ha, 556 Kg/ha and 88 Kg/ha in Hail haor, Kangsho-Malijhee and Turagh-Bangshi sites, respectively. Lowest production (Kg/ha) was found in Mokash beel (74 Kg/ha), Turagh river (80 Kg/ha), and Balla beel (107 Kg/ha). Two water bodies (Malijee beel and Mokesh Khal) stand away from this general production value and have the highest production (2986 and 829 Kg/ha respectively). Water body wise comparison of fish production (Kg/ha) are shown in Figure 2. The present study is directly related to tracking the impact from improved management practices being applied by IPAC Co-management and also compare with MACH result on fish production (Kg/ha). A comparision of fish production (Kg/ha) between MACH and IPAC for Hail haor, Kangsha-Malijhee and Turag-Bangshi sites are shown in Figure 3. Production (Kg/ha) has increased by 69%, 106% in Hail Haor and Kangsha-Malijhee. However, production (Kg/ha) decreased by 7% in Turag-Bangshi sites when compared to MACH average impact year 3 (production, Kg/ha). Fish catch trends in Hail Haor are presented in Figure 4. However, there are variations of sampled water bodies of MACH and IPAC. In MACH, numbers of sampled water bodies were 7, 8 and 8 in Hail Haor, Kangsha-Malijhee and Turag-Bangshi, respectively.

In contrast, the numbers of sampled water bodies in IPAC are 6, 4, and 3 in Hail Haor, Kangsha-Malijhee and Turag-Bangshi respectively. MACH project covered a total area of 1174.26 ha, 267.7 ha and 382.7 ha in Hail-Haor, Kangsha-Malijhee and Turag-Bangshi, respectively. On the contrary, present fish catch monitoring areas are 276.22 ha, 116.89 ha and 116 ha in Hail-Haor, Kangsha-Malijhee and Turag-Bangshi, respectively.

The main effective factors that influence better production performance (> 400 kg/ha) at seven waterbodies (62 Beels Hunamua, Almiberi beel, Cheruadubi beel, Gopla River, Lata River, Kalijhee beel and Mokashkhal) are habitat type (e.g., beels, river, catchment khal), water extension during monsoon, tenure effectiveness of restriction in fishing, fish sanctuary, higher species diversity, presence of professional fishers around water bodies, fisher's density, good link with other water bodies or big *haors*, no restriction during monsoon & near by *beel* areas and interruption of organized harvest at some sites, etc. Simultaneously, the effective factors that may cause a lower production at three water bodies (Balla beel, Mokash beel and Turagh river) may be the RMOs restricting fishing in and around beels, a lower fisher density, restricted fishing with destructive fishing nets and huge pollution in Mokash beel and Turagh river. Mokash beels pollution is industrial in nature and for the last two decades enormous and uncontrolled industrial development contributing to significantly decline fisheries production. Afrin (2010) reported that local residents of the Mokash beel strongly believe that the main reason hehind the pollution problem is increasing Industrial development. Ferdousi (2013) also reported that due to ongoing pollution, there has been a steady reduction in fish production, aquatic biodiversity, biomass, and migratory and aquatic bird population.

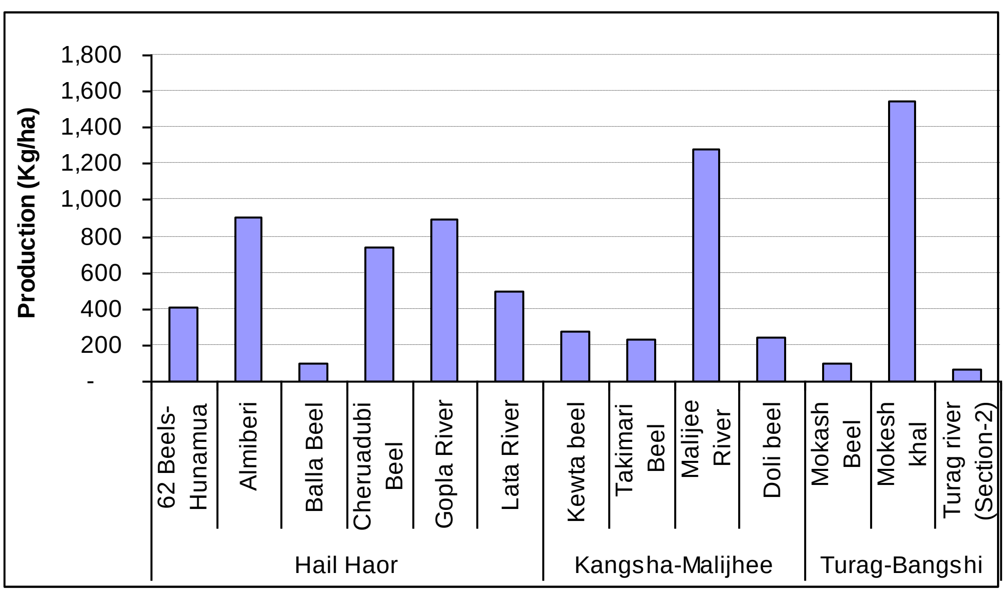


Figure 2. Estimated production (Kg/ha) based on catch monitoring (annual for Hail haor and Turag Bangshi, 10 months for Kangsha-Malijhee) in all studied sites.

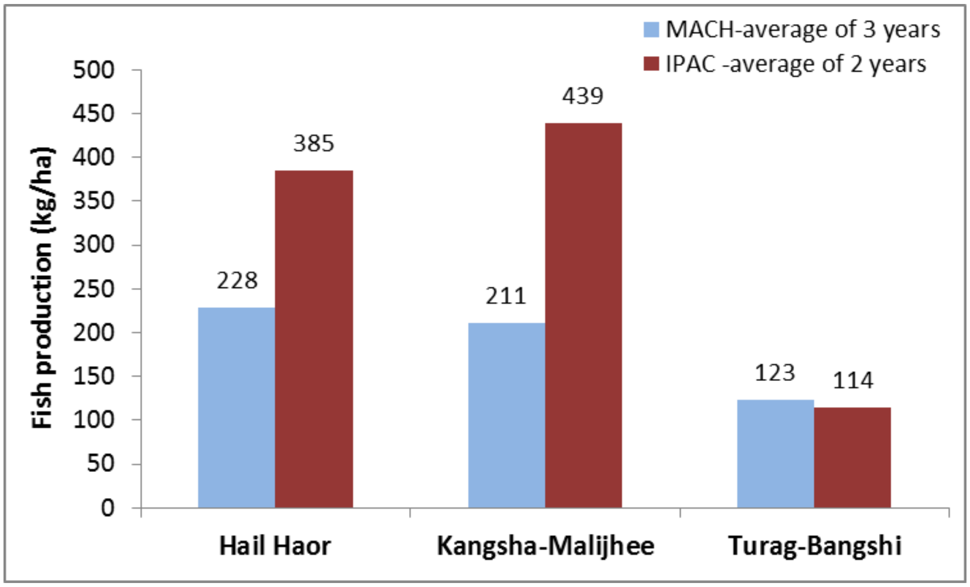


Figure 3. Comparision of fish production between MACH (average of 3 years impact) and IPAC in Hail haor, Kangsha-Malijhee and Turag-Bangshi sites.

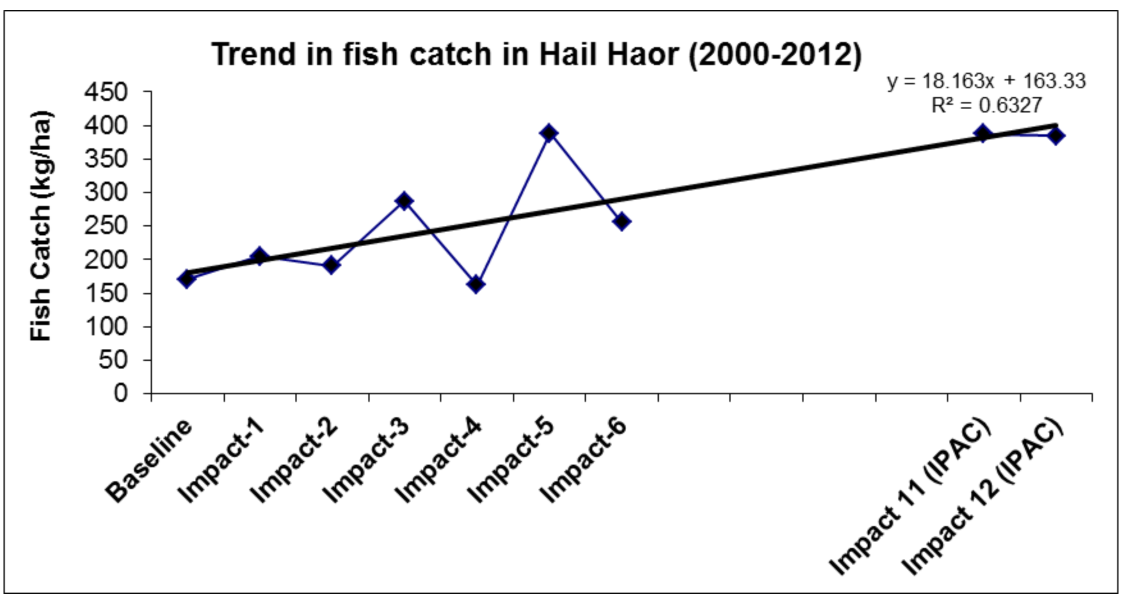


Figure 4. Fish catch trands in Hail Haor.

Using the fish catch monitoring data, the study presents a graphical distribution of fish production (Kg/ha) and total number of species in the monitored sites of Hail haor, Kangsha-Malijhee and Turag-Bangshi sites. Simultaneously, using species data, the study also presents a pictorial distribution of key fish species in the monitored sites. Figure 5 shows pictorial distribution of key species at monitored sites, fish production (Kg/ha) and total number of species in Hail haor. Figure 6 presents pictorial distribution of key fishes, fish production (kg/ha) and total number of species in Kangsha-Malijhee. Figure 7 presents pictorial distribution of key species, fish production (Kg/ha) and number of species in Turag-Bangshi site.

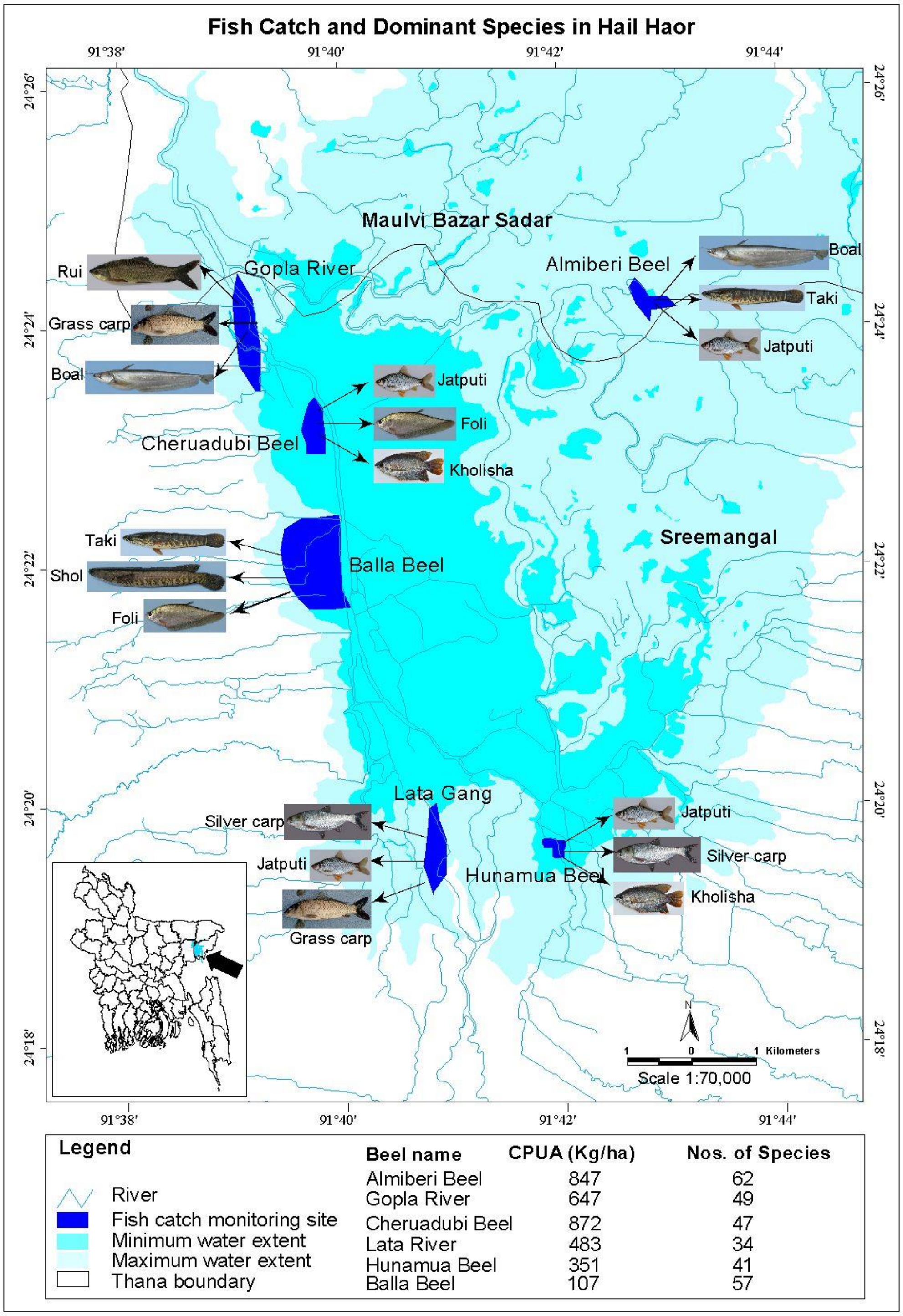


Figure 5. Dominent fishes, production (Kg/ha) and total number of species at six monitored sites in Hail Haor.

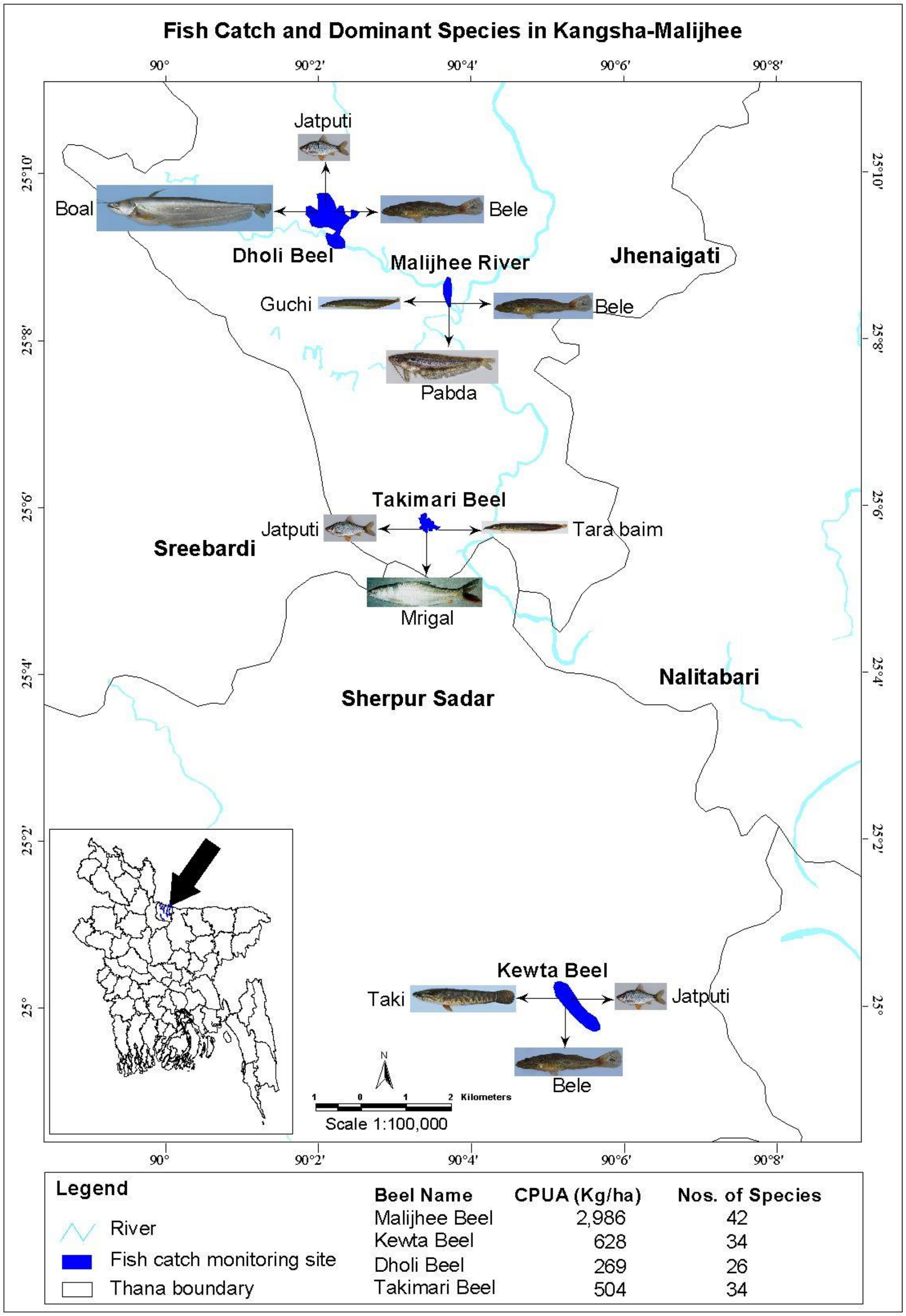
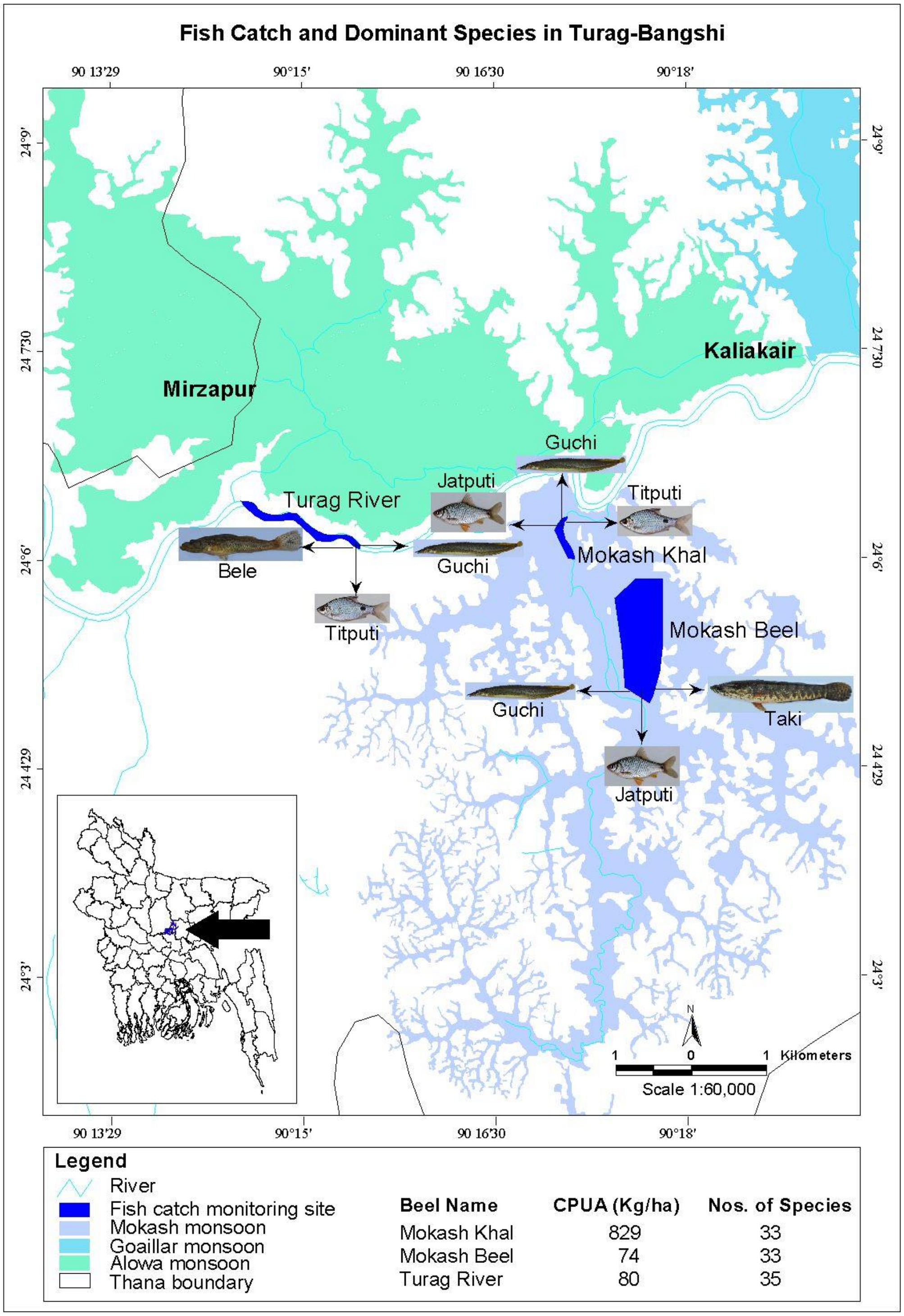


Figure 6. Dominent fishes, production (Kg/ha) and total number of species at four monitored sites in Kangsha-Malijhee..

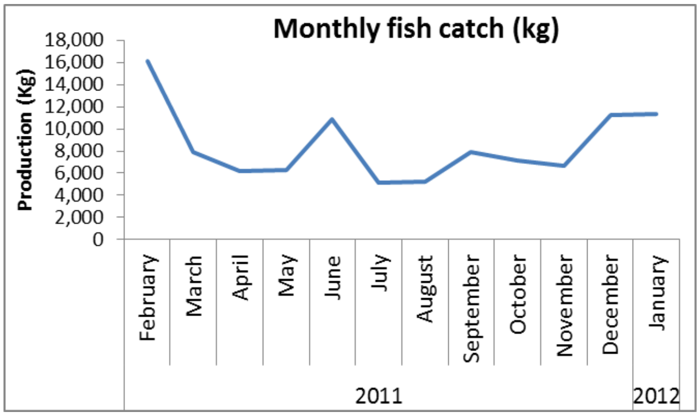


Beel Name	CPUA (Kg/ha)	Nos. of Species
Mokash Khal	829	33
Mokash Beel	74	33
Turag River	80	35

Figure 7. Dominent fishes, production (Kg/ha) and total number of species at three monitored sites in Turag-Bangshi.

3.2. Seasonal Variations of Fish Production

The seasonal variation of fish production is very high in the Haor habitat and is mainly affected by inundation regimes, gear use, fishing patterns, fishing intensity and availability of fishes. In Hail haor sites, 24 % of the annual catch was caught in the post monsoon season (Oct-Dec), 35% in the dry season (Jan-Mar), 18% in the full monsoon (Jul-Sept) and 23% in the pre monsoon (Apr-Jun) season (Figure 8). The pre-monsoon is a very critical period of the year in the Hail Haor site as the area of water coverage becomes reduces during dry season.



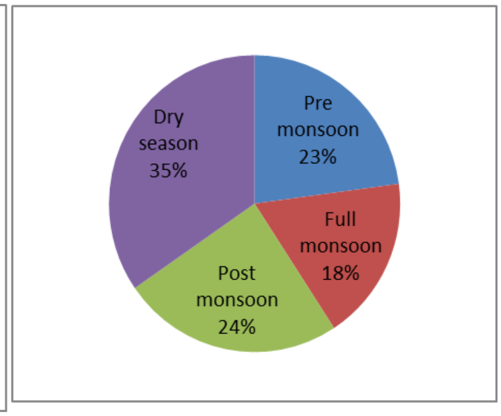
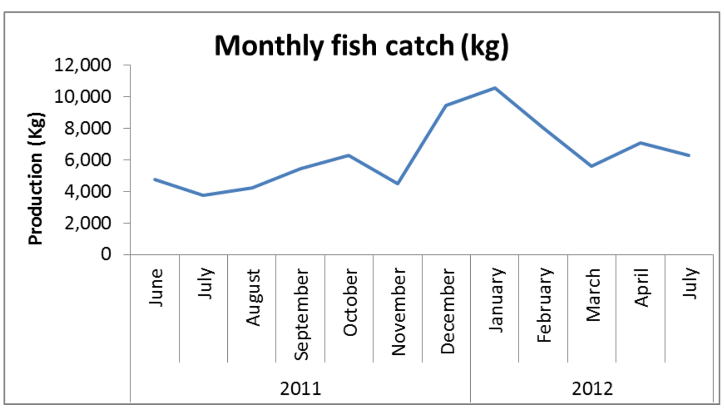


Figure 8: Monthly & seasonal variation of total estimated production (kg) in **Hail Haor** sites.

In the Kangsha-Malijhee sites, 18 % of the annual catch was caught in the monsoon season (July-Sept) 26% in the post monsoon (Oct-Dec), 32 % in the dry season (Jan-Mar) and 24% in the pre monsoon (Apr-Jun) (Figure 9). The pre-monsoon is also a very critical period of the year in Kangsha-Malijhee site as the area of water coverage is reduced.



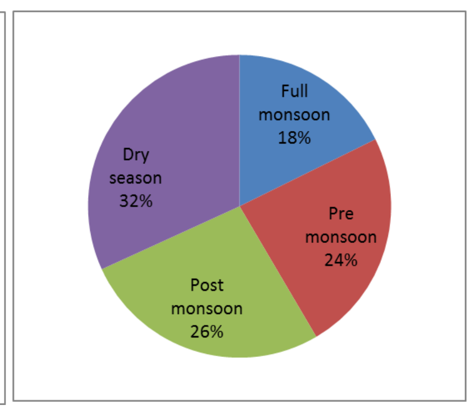


Figure 9: Monthly and seasonal variation of fish production (kg) in **Kangsha-Malijhee** sites.

In the Turag-Bangshi sites, 43 % of the annual catch was caught in the post monsoon season (Oct-Dec), 36% in the full monsoon (Jul-Sept), 11% in the pre monsoon (Apr-Jun) and only 10% in the dry season (Jan-Mar), (Figure 10). The dry season is a very critical phase of the year in Turag-Bangshi site as the area of water coverage is reduced.

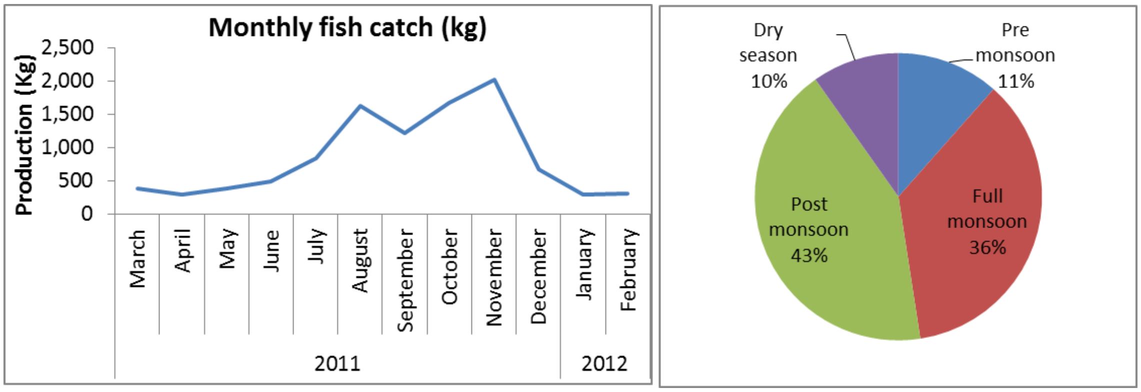


Figure 10: Monthly and seasonal variation of fish production (kg) in **Turag-Bangshi** sites.

3.3. Catch Composition Based on Catch Monitoring Data

The top 20 species are ranked according to their contribtion in the annual catch. In Hail Haor the common species caught by all types of gear were Grass carp (*Ctenopharyngodon idella*), Rui (*Labeo rohita*), Jatputi (*Puntius sophore*), Foli (*Notopterus notopterus*) and Taki (*Channa punctata*) contributing to 7.93%, 7.58%, 6.77%, 5.77% and 5.27% of overall catches respectively. Analysis reveals that 20 main species contributed to 76.95% of the annual catch by weight. The annual contribution of the other 61 species was 23.05% of the catch by weight. The percentage compositions of the 20 main species in annual production are given in Figure 11. Grass carp is the species making the highest contribution in Hail haor. This reveals the increasing trend towards stocking of exotic species around the Hail haor.

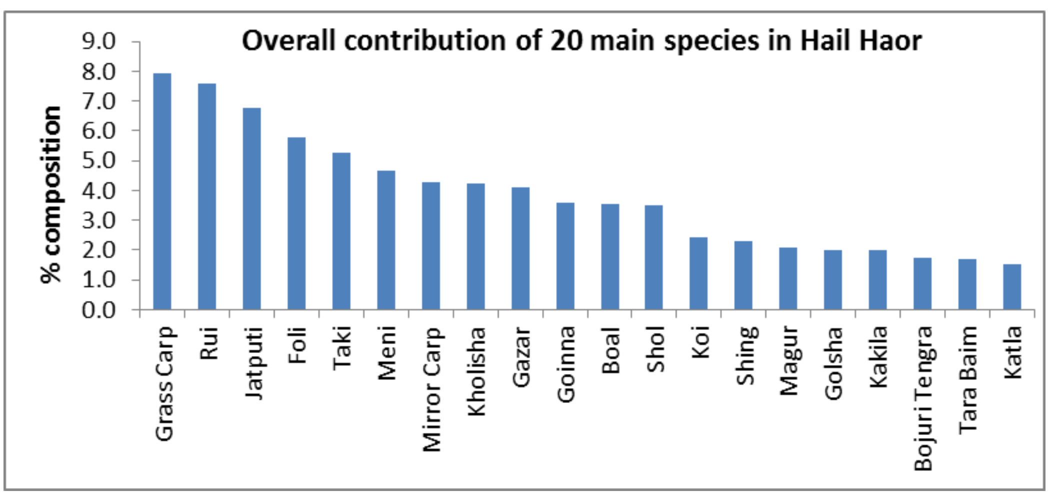


Figure 11. Species composition by weight (20 main species) in Hail haor site.

In the Kangsha-Malijhi sites, the common species caught by all types of gear were Baila (*Glossogobius giuris*), Boal (*Wallago attu*), Taki (*Channa punctata*), Kakila (*Xenentodon cancila*) and Kholisha (*Colisa fasciatus*) contributing to 13.76%, 11.63%, 9.99%, 7.88% and 6.57% of overall catches respectively. The 20 main species contributed to 86.96% of the catch by weight in 2011-12. The contribution of other 42 species was 13.04% of the catch by weight. The percentage compositions of 20 main species are presented in figure 12. Baila is making the highest contribution in Kangsho-Malijhee site.

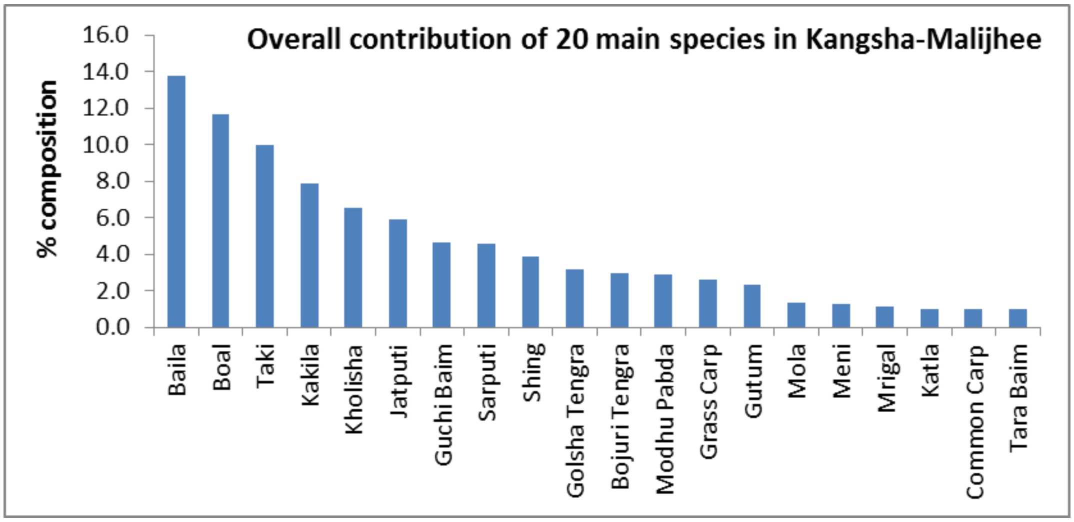


Figure 12. Species composition by weight (20 main species) in Kangsha-Malijhee site.

In Turagh-Bangshi site the common species caught by all types of gear were Jatputi (*Puntius sophore*), Guchi baim (*Macrognathus pancalus*), Titputi (*Puntius ticto*), Ranga chanda (*Chanda ranga*) and Chola puti (*Puntius chola*) contributing to 14.99%, 11.75%, 9.39%, 8.15% and 7.56% respectively. The 20 main species contributed to 95.56% of the catch by weight in 2011-12. The contribution of other 32 species was 4.44% of the catch by weight. The percentage compositions of 20 main species are presented in Figure 13. Jatputi is the main specie making the highest contribution in Turagh-Bangshi site.

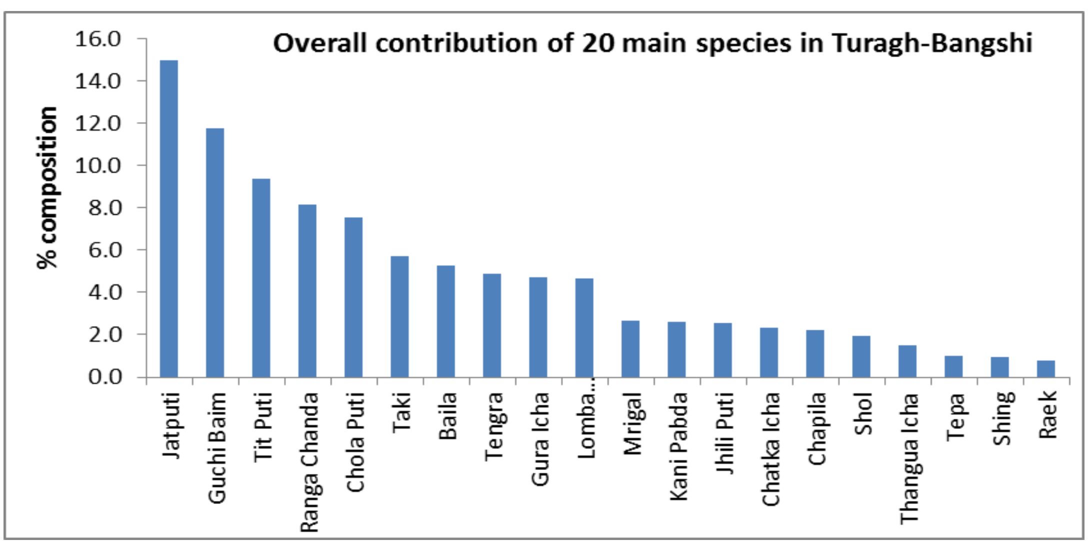


Figure 13. Species composition by weight (20 main species) in Turag-Bangshi site.

3.4. Gear Efficiency and Production

The main fishing gears operated in the IPAC wetlands sites harvested most of the available species in the *haor* habitat. Some species are caught selectively with different gears and some gears themselves are selective such as gill nets, traps, hook and lines and long lines. After assessing the gear efficiency (fisher's day by gear) and fish production (catch by gear), it was observed that in Hail haor, the highest catch occurred through gill nets (41%) and Trap units (27%), and in Kangsha-Malijhee, the highest catch occurred with gill nets (75%), cast net (16%) and Trap units (5%). Similarly the highest catch was observed by the seine nets (51%), gill nets (18%) and cast net (13%) in Turag-bangshi. Variation of gear efficiency and fish production were calculated for Hail haor, Kangsha-Malijhee and Turag-bangshi using data from all monitored sites (Figures 14, 15 & 16).

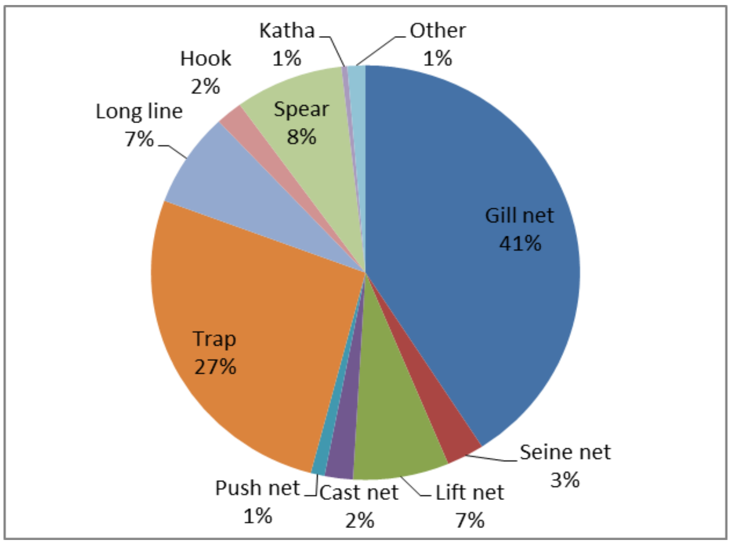


Figure 14. Gear wise production from *Hail haor* site during study period.

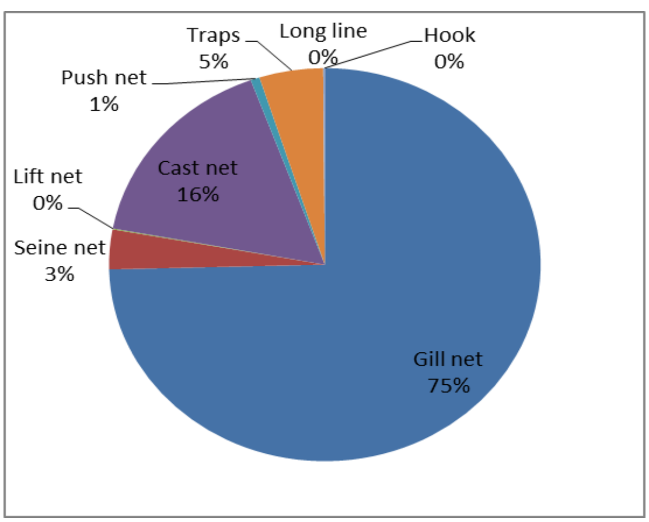


Figure 15. Gear wise production from Kangsha-Malijhee site during study period.

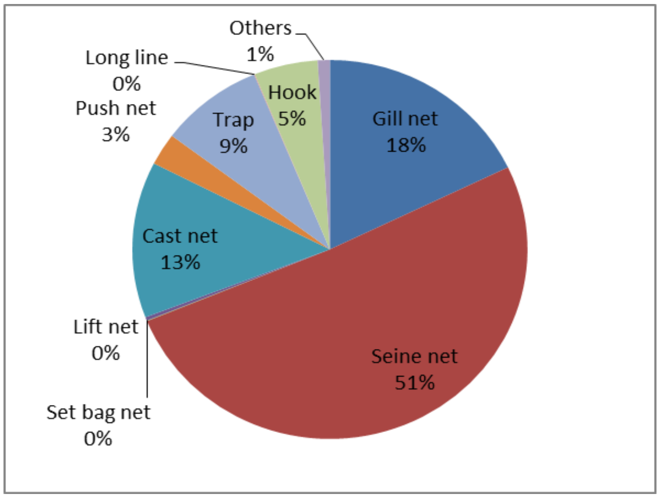


Figure 16. Gear wise production from Turag-Bangshi site during study period.

Catch Per Unit Effort (CPUE)

Catch Per Unit Effort (CPUE) is the average daily catch per gear type (calculated yield/no of gears). Fish production derived from fishing activities is influenced by several factors, such as the catch rates of different gear, gear intensity, effiency of gears and number of active fishing days. It was observed CPUE varies for different gears in haor areas. However, in Hail haor and Turagh-Bangshi the Seine net showed significantly higher CPUE. Whilst in Kangsha-Malijhee Seine net, Gill nets, Cast nets and Push nets showed higher CPUE. Gear wise catch per unit effort in Hail haor, Kangsha-Malijhee and Turagh-Bangshi sites are presented in Figures 17, 18 and 19 respectively.

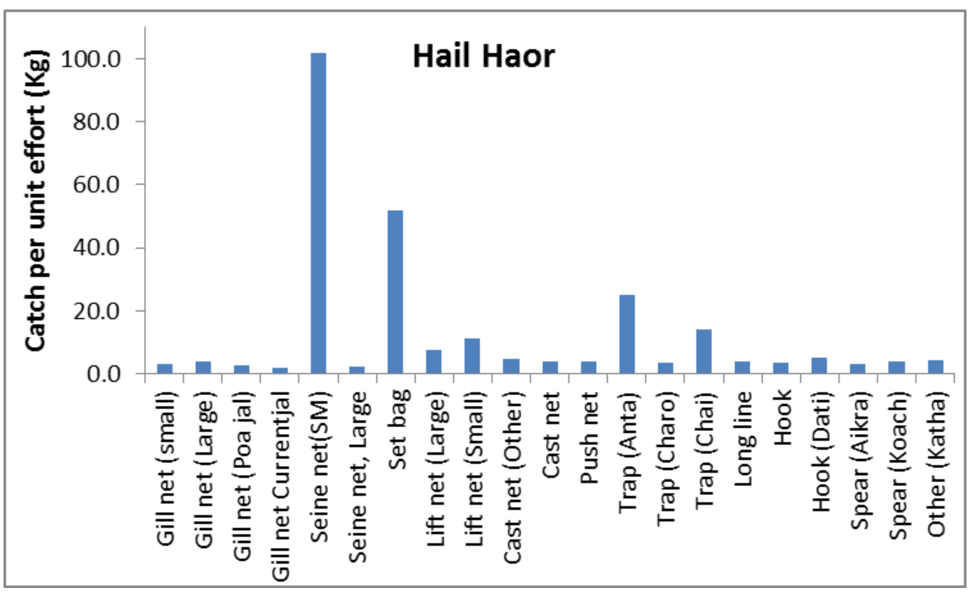


Figure 17. Annual Catch Per Unit Effort (CPUE) by different gears in Hail haor site.

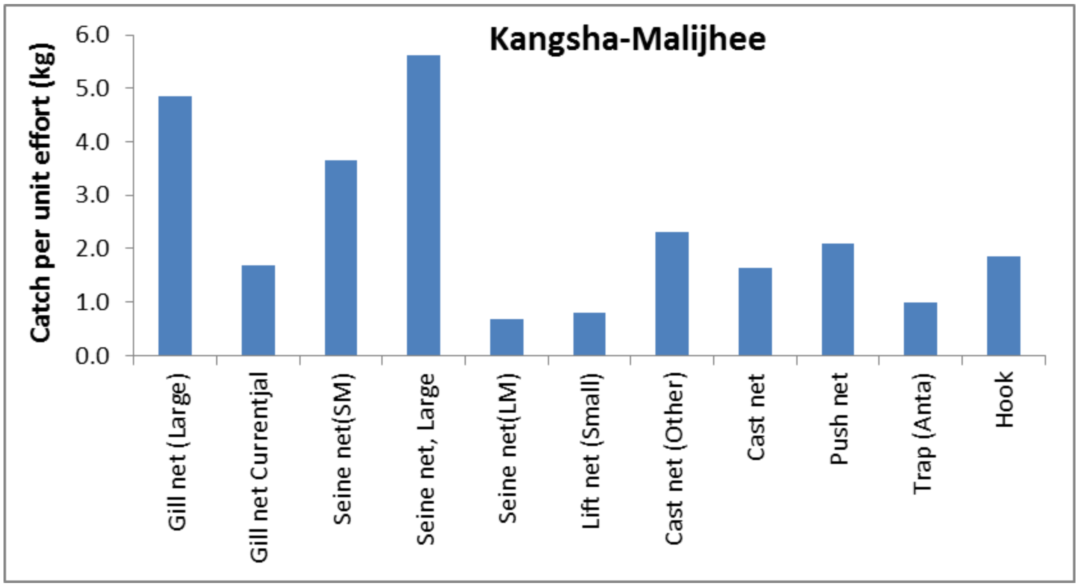


Figure 18. Annual Catch Per Unit Effort (CPUE) by different gears in Kangsha-Malijhee site.

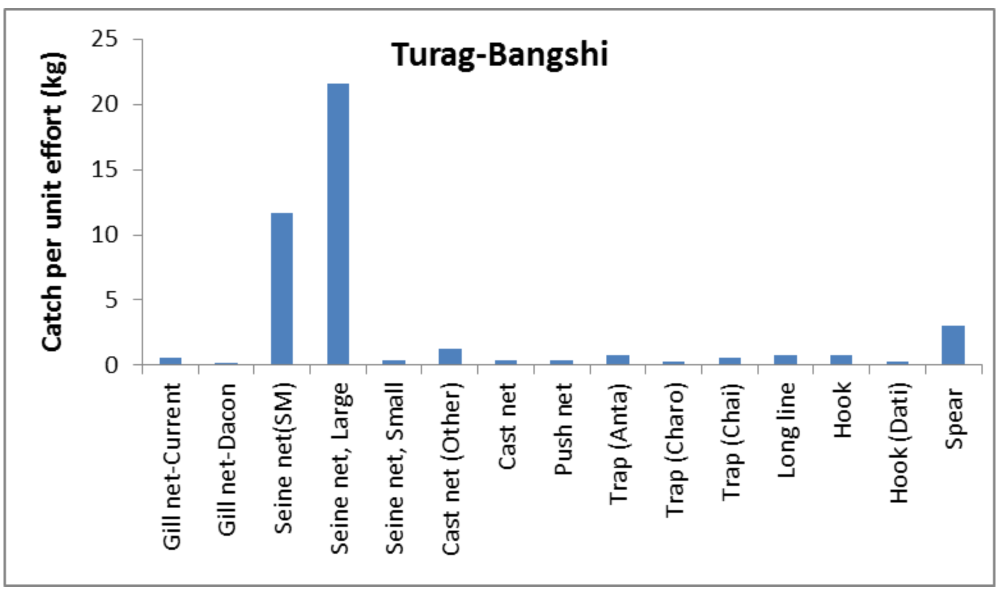


Figure 19. Annual Catch Per Unit Effort (CPUE) by different gears in Turag-Bangshi site (Seine net: Small mesh and Large mesh).

Catch per person per day *(kg person^{-1} day^{-1})*

Income derived from fishing activities are influenced by several factors, such as the catch rates of different species, ownership of gears and family participation in the work process, the number of active fishing days and fish prices. Annual variations of average catches (kg) gear^{-1} day^{-1}, number of person days and catch person^{-1} day^{-1} in the three study sites – Hail haor, Kangsha-Malijhee and Turagh-Bangshi are presented in figures 20, 21 and 22 respectively. This data can be an indicator of abundance and shows a significantly higher annual average daily catch with Set bag net and Seine net (Small mesh) in Hail haor sites; Gill nets and Cast nets in Kangsha-Malijhee sites, and Seine nets (both small and large mesh) and Spear in Turagh-Bangshi sites.

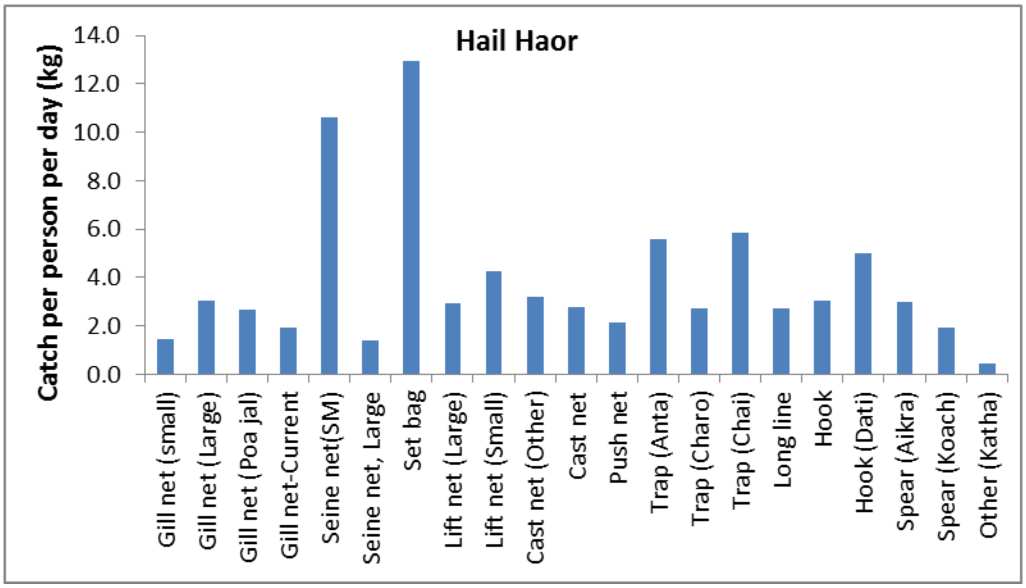


Figure 20. Catch per person per day (*kg person^{-1} day^{-1}*) by different gears in Hail haor site.

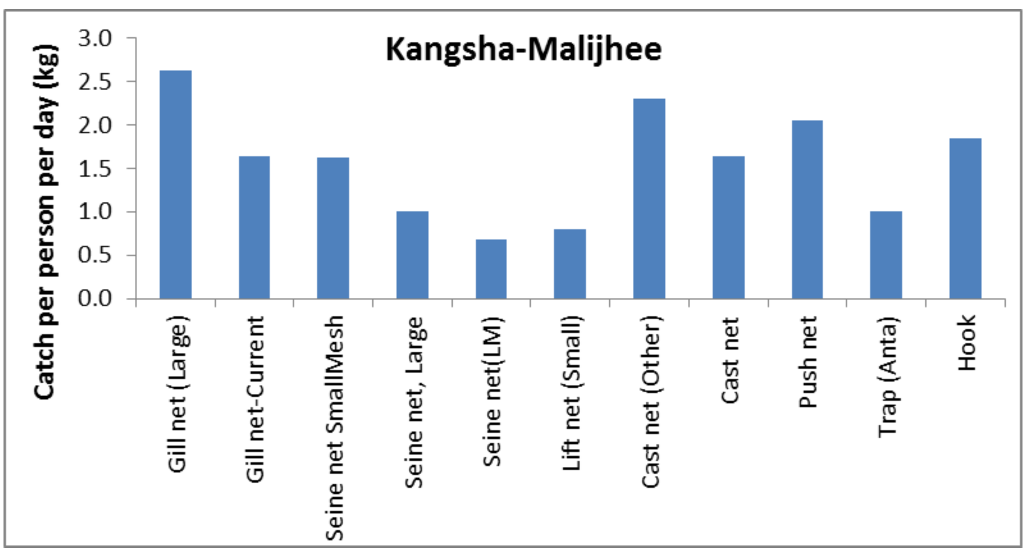


Figure 21. Catch per person per day (*kg person^{-1} day^{-1}*) by different gears in Kangsha-Malijhee site.

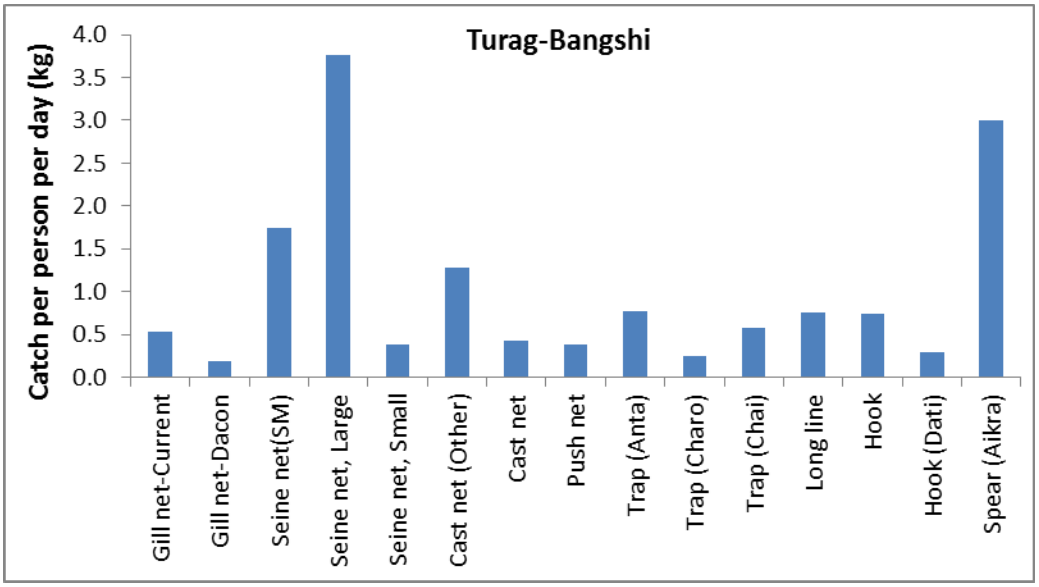


Figure 22. Catch per person per day ($kg\ person^{-1}\ day^{-1}$) by different gears in Turag-Bangshi site.

3.5. Biodiversity Based on Catch Monitoring Data

A total of 85, 62 and 52 species of fish and prawn were recorded during the study period in Hail haor, Kangsho Malijhee and Turag-Bangshi respectively. In Hail haor, the number of species caught in the monitored sites, revealed that the maximum number of species (62) was found in the Almiberi beel, Balla beel (57), Cheruadubi beel (47), Gopla river (49), Hunamua beel (41) and Lata river (34). In Kangsho-Malijhee, the number of species caught in the monitored sites revealed that the maximum number of species (42) was found in the Malijhee River, followed by Kewta beel (34), Takimari beel (34) and Doli beel (26). Total number of species varied from 34 to 62 in Hail haor, 26 to 42 in Kangsho-Malijhee and 33 to 35 in Turagh-Bangshi. Total number of species in each sampled wetland is shown in Figure 23. There was a substantial variation in species in each cluster and among wetlands. Number of species was found to be higher in Hail haor, when compared with MACH impact year 5. However, number of species was found to be lower in Kangsha-Malijhee and Turag-Bangshi when compared with MACH, which might be the difference of number and area of sampling water bodies.

In MACH project, number of sampling water bodies were 7, 8 and 8 in Hail Haor, Kangsha-Malijhee and Turag-Bangshi respectively. In contrast, in IPAC, number sampling sites are 7, 4 and 3 in Hail Haor, Kangsha-Malijhee and Turag-Bangshi respectively. The MACH project covered a total area of 1174.26, 267.7 and 382.72 ha in Hail-Haor, Kangsha-Malijhee and Turag-Bangshi respectively. In contrast, fish catch monitorig sampling areas are 276.22, 116.89 and 116 ha in Hail-Haor, Kangsha-Malijhee and Turag-Bangshi respectively. The present study is directly related to tracking the impact of biological significance from improved management practices being applied by IPAC and also compare with MACH results on number of species. Trend in number of species in Hail Haor during MACH and IPAC are presented in Figure 24. Present study reveals that fisheries co-management play a significant role in sustainability of fish species that might ensure resource sustainability at water body level. Scale up of fisheries co-management program will reduce climate change threats and stability in nutritional security of the poor people.

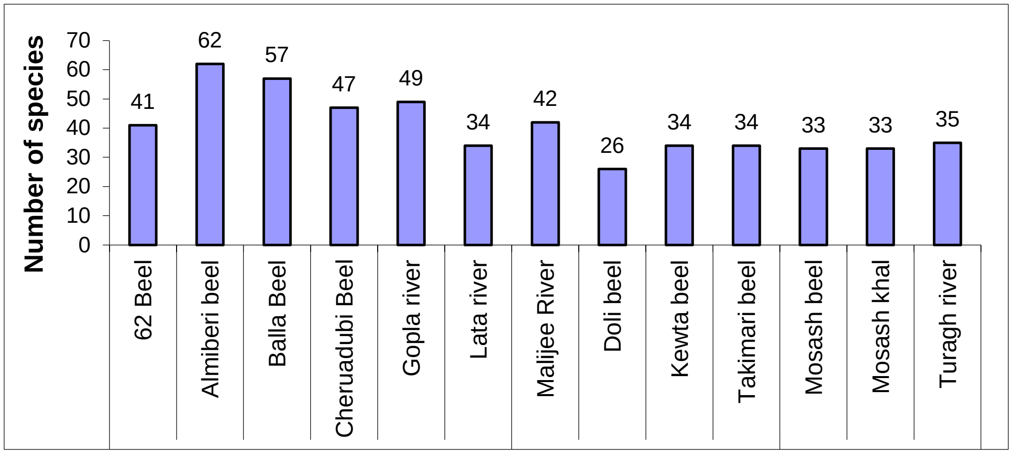


Figure 23. Total numbers of species recorded from catch monitoring at all studied sites.

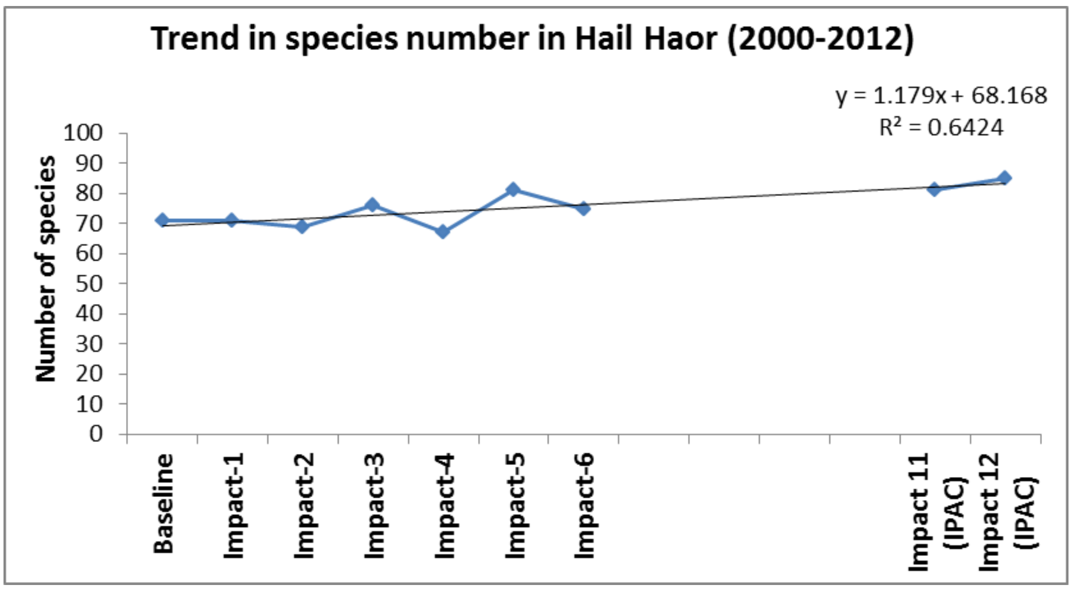


Figure 24: Trend in species number in Hail Haor (Baseline: 1999-00, Impact-1: 2000-01; Impact-2: 2001-02; Impact-3: 2002-03; Impact-4: 2003-04; Impact-5: 2004-05; Impact-6: 2005-06 during MACH and, Impact-11: 2010-11; Impact-12: 2011-12 during IPAC).

Biodiversity of all fish species using the Shannon-Weiner index (H') in the study sites, ranged from 1.588 to 3.314 in 2011-12. The biodiversity monitoring research has demonstrated optimum level of biodiversity at seven water bodies. However, the project management needs to focus very clearly on increasing biodiversity at some water bodies (H'>2.5), since *haor* and *beels* generally depend on what is happening in other surrounding water bodies. The comparison of biodiversity index (H') for 13 sites, based on all species is shown in Figure 25. Fish biodiversity has decreased in the Turagh-Bangshi site when compared with IPAC impact year in 2010. Afrin (2010) reported that in focus group discussion participants and key informants also reported that in rivers and other bodies of water affected by pollution the species diversity and numbers of fish have dramatically dropped.

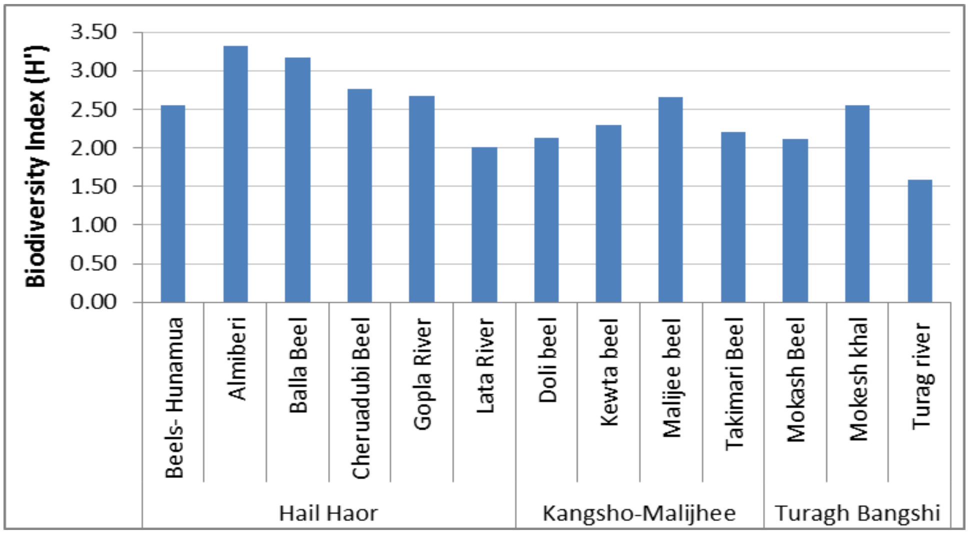


Figure 25. Biological significance (biodiversity index - H') of fish catches monitoring sites.

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