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Impacts of fishing gears on the fish abundance of Hakaluki haor in Bangladesh

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Abstract
A Study was conducted to evaluate the fishing gears' impacts on fish abundance in the Hakaluki haor, between the periods of July 2013 to June 2014 under three upazilla viz. Kulaura, Fenchuganj and Baralekha (Located at Sylhet division; North-eastern part of Bangladesh). Fishers used ten types of fishing gears among them 5 were nets, 3 were traps, and 1 for both hand line and wounding gear. Among the different types of fishing gears; the highest number of species caught was for seine net (32), followed by cast net (27), gill net (25), lift net (21) and push net (17). For the traps; *Charo (square basket trap), Foria (rectangular basket trap), Bana (fish barrier)* were found to catch 11, 15 and 10 species respectively. Hand line was observed to be used to catch 11 species of carnivores group. For the observed nets the CPUE value (mean±SD) was found as 15.62±9.10, 1.04±0.33, 1.82±1.06, 2.51±1.04, 0.65±0.27 kg person^{-1} day^{-1} for *Ber jal (seine net), Veshal jal (lift net), Koi jal (gill net), Ural jal (cast net), Thela jal (push net).* In case of traps and wounding gears the CPUE value was 0.25±0.07, 0.24±0.07, 0.76±0.38, 1.10±0.44 and 0.67±0.27 kg person^{-1} day^{-1} for *Charo (square basket trap), Foria (rectangular basket trap), Bana (fish barrier), Tenta/Teora (wounding gear)* and *Hat borshi (hand lining)* respectively. Extrapolated estimation showed that the total fish production in Hakaluki haor was 322.13 kg ha^{-1} during the study period, which was more than national average production (wetland) of 257.95kg ha^{-1} in Bangladesh. This indicates that the Hakaluki haor has huge exploitation potentials sustainably.

Keywords: Fishing gears, CPUE, catch composition, fish production

1. Introduction
Bangladesh is recognized as the riverine country because of having large number of rivers distributed in and all around it [29]. It has extensive freshwater resources with huge potential for fisheries development, contributing in employment generation, income augmentation, poverty alleviation, foreign exchange earnings, and providing food and nutritional security to the millions of people. Fisheries sector already been renowned as a vital income and employment-generating sector in Bangladesh, cheap sources of healthy food for the population of the country [3,4,6,9,21]. This sector contributes 3.69% to GDP and 22.60% to agricultural GDP [12]. Fish supplements to about 60% of daily animal protein intake of Bangladesh. More than 11% of the population is dependent directly and indirectly on the fisheries for their livings. Fisheries sector was ranked 4th position in inland water productions among top ten fish producing countries in the world [12]. The Hakaluki haor (24.35´N to 24.45´N and 92.00´E to 92.08´E) is the country's largest freshwater wetland ecosystem located in the north-eastern part of Bangladesh with an area of 18,386 ha. This wetland was declared as an "Ecologically Critical Area" (ECA) since 1999 under the provisions of the Bangladesh Environment Conservation Act 1995 [11].

The principal categories of fishing gears that are traditionally used in Bangladesh can be categorized as the following: fishing nets, fishing traps, hooks and lines, wounding gears and fish aggregation device [31]. In the Hakaluki haor different types and form of gears have been operated to exploit wild fishes. The intensity of use of any form of gear in a haor is dependent on the intensity of target fish population presumed to be available in that haor [10]. Some of the gears are species selective, whereas other account for a number of species caught during operation giving multi-species nature of the fishing [18]. Among them, many of these have been responsible to catch fingerlings before they grow to legal size and many of these responsible

for sharp decline in the population of wild species from the haor of the country [2]. However, operation of all types of gear cannot be kept suspended to allow the stocked fingerlings to grow [10].

Gear catchability has been defined as a measure of the interaction between the resource abundance and the fishing effort [23]. Catchability research has developed either to give a measure of the fishing gear efficiency, or to find the relation between population size and fishing effort [14]. Whatever the adopted approach, the interpretation may be elusive unless there is a clear understanding of other associated concepts, such as selection, selectivity, accessibility, availability and vulnerability [7]. All of them are sources of catchability variation and under special situations may be equally interpreted [28]. Catchability study of different gears could be used to estimate the fish abundance and productivity status of a water body [19].

This haor is a habitat for many of commercially important species viz. carps, six species of large cat fishes, many small cat fishes and a number of other fishes. Giant freshwater prawn (*Macrobrachium rosenbergii*) and small prawns are also available in this haor which all together contribute to the fish diversity of the haor [20]. More intensive studies are required to get the more approximate ideas about the productivity of this ecologically critical wetlands [1, 18].

The carrying capacity as well as productivity of this wetland has been degrading for manmade, natural and semi-natural reasons. However, the production of this haor is still higher than others haor of Bangladesh although there is limited information on the fishing gears and present fish abundance status of this haor. Still this wetland starving a literature lacking to develop appropriate management strategy, policy and tools. Information on the above mentioned topics are essential in order to develop a sound management practice to fish sustainably from this haor. Considering the above circumstances, the present study was undertaken with the objectives (i) to identify the types of fishing gears operated in Hakaluki haor, (ii) to determine fishing gear impacts on fish abundances of the haor.

2. Materials and Methods

The study was conducted in three sub districts viz. Kulaura, Fenchuganj and Baralekha located at north-eastern part of Bangladesh (Fig. 1). The primary data were collected from fishers, fish landing centers and direct observation of catching fish at the time of operation. The detail information of the gears (mesh size, target species and operation period) were recorded during survey. Interviews were conducted through PRA method by using semi-structured open ended questions. Fishing Effort Survey (FES) and Catch Assessment Survey (CAS) were conducted by using a boat starting from 6 am to 6 pm twice in a month over 12 months. Each sampling was performed in the same sampling locations with three replicates twice a month. Anybody operating a gear was considered as a fisherman and each of the gear was considered as fishing unit (except gillnets and traps where each10 traps/nets was considered as a single fishing unit). The total amount of fish captured for each type of gear was recorded with their percentages *i.e.*, average catch composition was estimated for each gear separately through the collected catch monitoring data during sampling. Finally, an average catch composition for the study area was calculated using the recorded data.

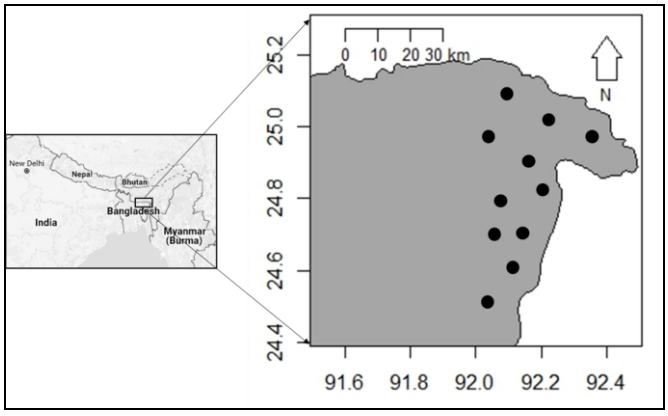

Fig 1: Study area and sampling locations

The catch per unit effort (CPUE) for the gears was taken based on the weight of fish caught during a fishing day (kg day^{-1} fishing unit^{-1}) for the different species all together. The catch efficiency of each gear employed in each fishing site was analyzed by comparing different gear based on CPUE, *i.e.*, the amount of fish caught for a certain period, for example, amount of fish caught per day. A fluctuation in the fish catch was also compared. The CPUE value was extrapolated to the mean catch gear^{-1} day^{-1}person^{-1}, mean catch crew^{-1} day^{-1} and mean catch boat^{-1} day^{-1}. The Catch per Unit Area (CPUA) for the sampling sites calculated as

$$CPUA = \frac{\text{Total catch from sampling sites for all gears}}{Sampled\ area}$$

Finally, the total production for the haor was estimated by multiplying the CPUA with the total productive area of the haor [20, 30].

Cross-check Interviews (CI) were conducted with key informants from relevant government and non-government officials. Finally collected data from three sites were analyzed by SPSS (Version 20). Simple t-test was used to observe the statistical differences among various gears and their CPUE.

3. Results

3.1 Fishing gears

The survey revealed that a comprehensive variety of fishing gears were operated throughout the year in the Hakaluki haor. Some of the gears were species selective, whereas others account for several species caught during operation giving multispecies nature of the fishing. A total of 10 types of fishing gears were observed which were further classified into four major groups viz. nets, traps, hook & line and wounding gears (Table 1). Various types of materials were used to make these fishing gears include netting, twine, plastic structural and fasteners, clips and swivels, ropes, steel wire ropes, combination wire ropes, purse rings, polyester, polyethylene, nylon, cotton, polypropylene, mixed fibers, floats and sinkers, bamboo, wood (Table 1).

Table 1: Different fishing gears used in Hakaluki haor

Category	Types of gears	Bangla Vernacular Name	Mesh size (cm)	Target species	Period	*Construction cost (BDT/net)	Material used
Fish nets	Seine net	Ber jal	0.5-2.3	All	Jun-Feb.	200000-250000	Nylon twine or double Cotton twines or tier cord
	Lift net	Dharma jal	0.5-2.0	All	Jun-Oct.	10000-14000	Nylon/ cotton twines, bamboo frame
	Cast net	Jhaki jal	0.63-1.25	All	Year round	500-1500	Cotton/Nylon
	Gill net	Koi jal	4.5-15.0	All	Jun-Oct.	15000-20000	Nylon twine or double cotton twines or tier cord
	Push net	Thela jal	0.2-1.0	All	Jun-Feb.	500-1000	Nylon/cotton twine, bamboo frame
Fish traps		Charo	-	[1]SIS	Jun-Feb.	150-250	Split of bamboo and cane
		Foria	-	[1]SIS	Jun-Feb.	200-300	Split of bamboo and cane
		Bana	-	[1]SIS	Jun-Feb.	200-500	Split of bamboo and cane
Hook and line		Hat borshi	-	Carnivore	Year round	50-100	Split-bamboo pieces with barbed iron point
Wounding Gears		Koach	-	All	Year round	150-200	Split-bamboo pieces, pointed iron barbed

*1 USD=79 BDT; [1]Small Indigenous Species

3.2 Catch Composition of Different Gears

Among the different types of nets, the highest number of species were recorded in the catches of seine net (32), followed by the catches of cast net (27), gill net (25), lift net (21), and push net (17) (Table 2). Fishing traps were mainly used to catch small fishes. Among the traps, charo, foria and bana were found to catch 11, 15 and 10 species respectively. In the haor hand lining were mainly used to catch large carnivorous fish species and this gear was capable to catch almost 11 species of fish. Catch composition of seine net-lift net and gill net-push net were found significantly different ($p<0.05$) whereas lift net, cast net, gill net, fish traps, hook& line and wounding gears were observed not differed significantly ($P>0.05$).

Table 2: The catch composition of different nets operated in Hakaluki haor

Species	Seine net	Lift net	Cast net	Gill net	Push net
Wallago attu	17.42	NF	NF	7.64	NF
Labeo calbasu	11.71	2.77	5.31	8.62	NF
Sperata aor	8.32	NF	4.61	6.41	NF
Labeo gonius	5.28	7.65	6.64	7.94	NF
Amblypharyngodon mola	5.80	2.00	4.67	NF	6.98
Anabas testudineus	4.40	4.87	3.66	3.23	6.41
Mastacembelus armatus	4.64	7.41	NF	NF	NF
Mystus vittatus	3.39	2.0	4.87	6.65	NF
Nandus nandus	3.26	6.06	2.44	4.90	6.54
Heteropneustes fossilis	3.12	NF	1.20	1.14	5.21
Labeo rohita	2.00	10.85	8.42	7.84	NF
Glossogobius giuris	2.51	7.00	4.11	5.76	NF
Puntius sophore	2.12	6.96	7.72	9.34	7.87
Channa punctatus	2.88	4.87	6.96	6.87	NF
Mystus cavasius	2.26	7.30	3.87	5.61	8.38
Chela cachius	2.14	4.98	2.29	NF	5.81
Corica soborna	2.43	5.23	3.71	NF	14.31
Pseudeutropius atherinoides	2.10	NF	1.77	1.34	NF
Botia Dario	2.00	4.66	1.87	1.50	4.88
Tetraodon cutcutia	1.95	NF	2.00	NF	5.32
Channa marulius	1.29	2.45	2.31	4.70	8.81
Gudusia chapra	2.06	NF	3.46	3.19	6.38
Ompok pabo	1.11	NF	NF	NF	NF
Cirrhinus cirrhosis	0.82	NF	7.78	3.47	NF
Xenentodon cancila	0.45	3.33	3.93	1.29	NF
Macrobrachium sp	2.34	4.67	3.47	1.06	8.92
Others	2.20	4.94	2.93	1.50	4.18

*NF=Not found

Table 3: The catch composition of traps, hooks & lines and wounding gears operated in Hakaluki haor

Species	Charo	Foria	Bana	Hat borshi	Koach
Puntius spp.	22.53	14.98	16.35	9.67	NF
Mystus spp.	18.47	5.66	14.77	16.62	NF
Amblypharyngodon mola	17.88	6.99	5.98	NF	NF
Anabus testudineus	9.62	4.76	NF	12.02	NF
Wallago attu	NF	NF	NF	3.22	2.47
Osteobrama cotio	7.31	7.98	6.90	NF	NF
Macrobrachium rosenbergii	9.52	15.04	11.09	NF	NF
Colisa fasciata	NF	10.8	NF	NF	NF
Colisa lalia	5.72	8.94	12.88	NF	NF
Mastacembalus armatus	2.48	NF	NF	4.05	6.85
Esomus danricus	NF	4.96	8.93	NF	NF
Pseudambassis baculis	NF	2.87	NF	NF	NF
Lepidocephalichthys guntea	NF	2.52	NF	NF	NF
Channa spp.	NF	NF	15.34	13.18	NF
Heteropneusres fossolis	2.0	4.04	2.90	13.19	NF
Clarius batrachus	NF	NF	NF	10.96	NF
Cyprinus caryio	NF	NF	NF	NF	16.98
Czrrhina mrigala	NF	NF	NF	NF	12.60
Labeo rohita	NF	NF	NF	7.63	15.55
Catla catla	NF	NF	NF	3.56	15.11
C. striata	NF	NF	NF	NF	28.23
Others	4.47	10.5	5.76	5.9	2.21

*NF=Not found

3.3 Family-wise catch composition

The average family-wise catch composition consisted of Channidae (10.74%), Cyprinidae (30.67%), Cobitidae (6.9%), Siluridae (3.42%), Bagridae (6%), Notopteridae (8.73%), Clupeidae (9.33%), Mastacembelidae (4.64%), Anabantidae (5.95%), Ambassidae (8.35%) and other families (5.27%) (Fig.2). It was found that, during the study cyprinidae family dominated over others family while rest of the family contributed more or less similar percentages.

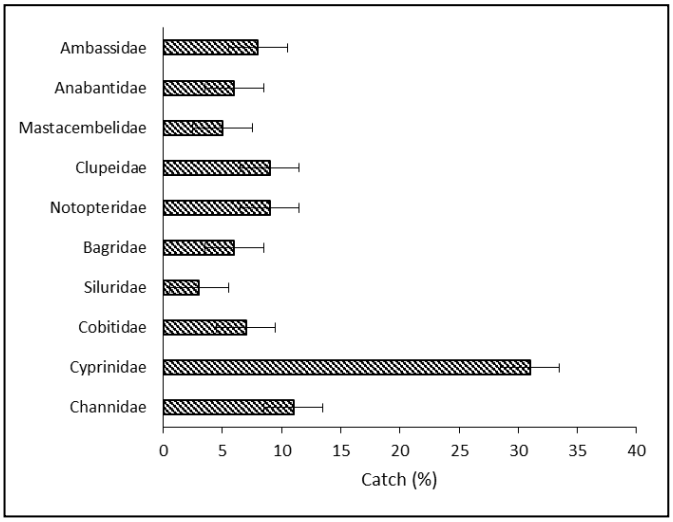

Fig 2: Contribution of different families in catch composition

3.4 The Catch per unit efforts (CPUE) of different gears

The average catch per unit efforts (CPUE) for all fishing gears in Hakaluki haor ranged between 0.24±0.07 to 15.62±9.10 kg person^{-1} day^{-1}. The mean±SD value of CPUE for *Ber jal, Veshal jal, Koi jal, Ural jal, Thela jal, Charo, Foria, Bana,* Tenta/Teora, *Hat borshi* was, 15.62±9.10, 1.04±0.33, 1.82±1.06, 2.51±1.04, 0.65±0.27, 0.25±0.07, 0.24±0.07, 0.76±0.38, 1.10±0.44 and 0.67±0.27 kg person^{-1} day^{-1} respectively (Fig.3).

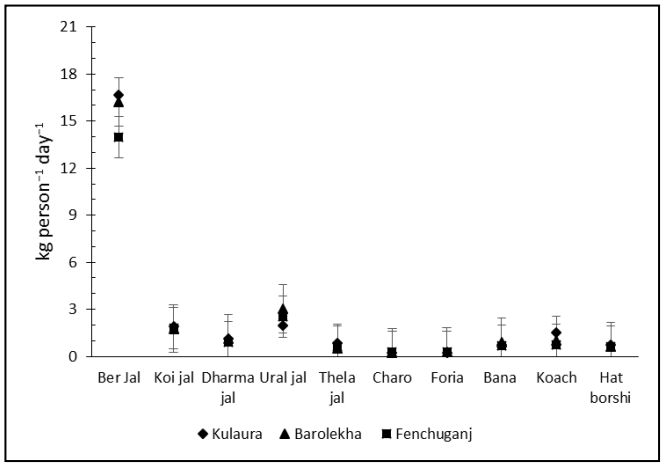

Fig 3: CPUE (kg person^{-1} day^{-1}) of different fishing gear in Hakaluki haor

3.5 Total fish production

Highest monthly catch based production was observed in Baralekha (2123.16 kg/hectare) followed by Kulaura (1765.97 kg/hectare) and Fenchiganj (1034.21 kg/hectare) for Ber jal. In case of Ural jal, the values were found as 355.08 kg/hectare, 256.8 kg/hectare, 221. 64 kg/hectare in Baralekha, Fenchuganj and Kulaura respectively. The catch composition among other gears were found non significantly different (p<0.05). However, catch composition for Ber jal was found significantly different among the three studied areas (p<0.05). For Ural jal catch was observed significantly highest in Baralekha than Kulaura and Fencuganj (Fig.4).

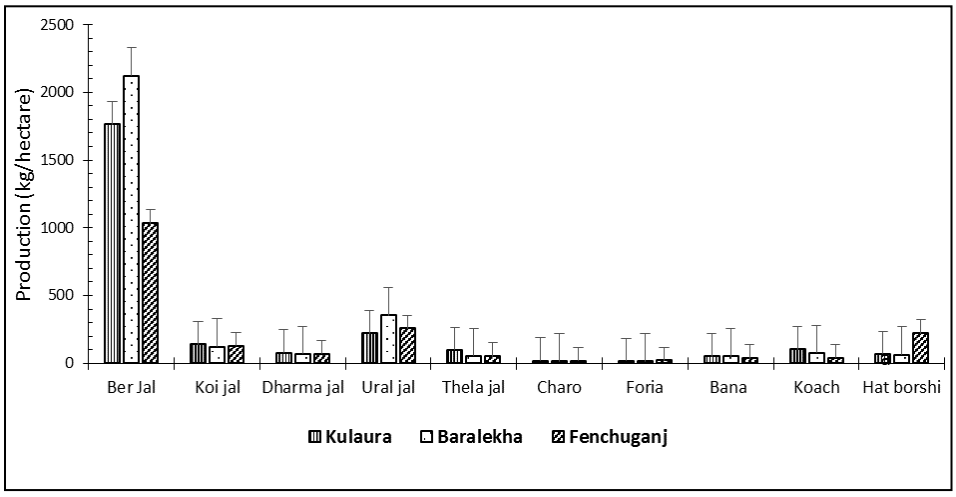

Fig 4: Monthly fish production (kg) in three sites by different gears

The average fish production in Hakaluki haor in 2013 was 322.13 kg ha-1, which was more than national production of wetland (257.95kg ha-1) in Bangladesh [13].

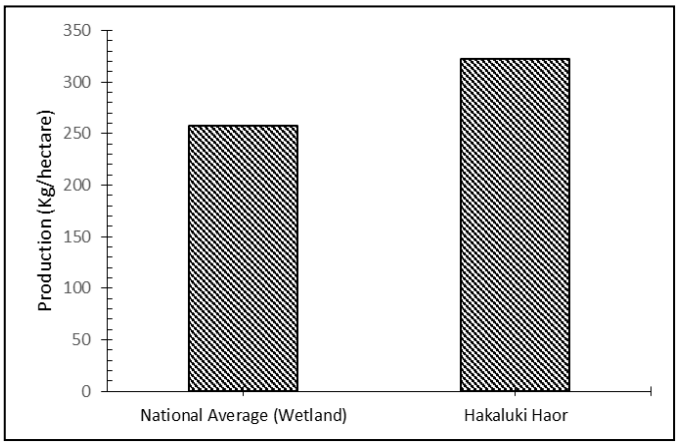

Fig 5: Fish production in Hakaluki haor in comparison to national average production (wetland)

4. Discussion

4.1 Fishing gears

Mainly one type of seine net was operated indiscriminately in the Hakaluki haor locally called ber jal. Lift net used in the haor area was not destructive and could be allowed to operate year round. Cast net was found less destructive for the same haor. Push net was found to be used widely for household consumption. Among various kinds of gillnets, mono-filament small meshed net (koijal) was found highly destructive. Although this net is banned, absence of law enforcement does not bring any fruits. The above mentioned findings are agreed with those of Ali [6] and Ray [25]. Several types of fish traps were used in the Hakaluki haor such as charo, foria and bana. The similar type of traps was observed at BSKB beel in Khulna [5]. In general, fish traps were not destructive for the water body except fishing with barrier and fence in the migration route of fish [16, 26]. The catch composition was found similar except the larger mesh sized traps. Hand lining was commonly used in the Hakaluki haor. The carnivores' fishes were mainly caught by this gear using bait. It is traditional and neither destructive nor detrimental gear as found similar with Ali [5], Sagir [26] and Ahmed[1]. However, there have some variation with Sayeed [30] from our study we found. These might be from experiment locations, times. Among different wounding gears, hand harpoon (koach) was found in Hakaluki haor during the study period. Both small and large fishes were caught by this gear [24]. Sometimes fishers operated the gears from fishing crafts. They were used to catch mostly pelagic and littoral area fishes. The wounding gears operated in the Hakaluki haor were found to be not detrimental for fishes. The finding was in agreement with Ahmed [2] and Hussain [17]. Therefore, it might be concluded that the indiscriminate operation of various destructive gears mainly small meshed net should be stopped for sustainable fish diversity and production in future.

4.2 Catch composition

The average catch composition in Hakaluki haor was dominated by *Labeo* spp. (14.67%), *Wallago attu* (11.34%), *Mystus* spp. (8.33%), *Puntius* spp. (5.84%), *Cirrhinus cirrhosus* (4.58%), *Sperata* spp. (3.77%), *Notopterus notopterus* (2.65%), small prawns- (6.61%). Our findings have got a good support by Ahmed [1], who observed *Hypophthalmichthys molitrix* (5.8%), *Wallago attu* (11.10%), *Nandus nandus* (10.20%), *Gudusia chapra* (8.40%), *Glossogobius giuris* (5.2%), *Puntius sophore* (5.1%), *P. sarana* (4.30%), *Labeo rohita* (3.5%) and small prawns (15.10%) as the dominant species in the catches of the Titas river during 2002.

The catch was extrapolated as family-wise composition where the dominant families were Cyprinidae (30.67%), Channidae (10.74%), Cobitidae (6.9%), Siluridae (3.42%), Bagridae (6%), Notopteridae (8.73%), Clupeidae (9.33%), Mastacembelidae (4.64%), Anabantidae (5.95%), Ambassidae (8.35%) and other families (5.27%). Miah, [20] reported a similar type of findings. Another study reported the similar type of findings by Sayeed [30] for another wetland adjacent to our studied water body.

4.3 The Catch per Unit Efforts (CPUE) of Different Gears

We have seen surprisingly little research on CPUE, species abundances and production of Hakaluki haor. The average CPUE for all fishing gears in Hakaluki haor varied widely because the CPUE was affected by environmental factors (water level, wind action, rainfall, water quality, productivity, lunar cycle, turbidity), fishing gears, fishing pressure and the fishers' preferences [15]. As a whole the reasons for the significant differences ($p<0.05$)) in the CPUE were the net size, number of hook, bait and the fishers experience. Fishing location was found as important influences [14]. The CPUE

value was found increasing during the month of July, passively indicates fish abundance. The May to July is the water recharging period for our study area. Oppositely, CPUE was maximum at the period of September to January. From late August, the water level of the haor starts decreasing. As a consequence, fish aggregates to more confined area than before as agreed with the studies of Miah [20]. The findings of the present study were agreed with Ahmed [2] who observed the CPUE of different gears ranged from 0.95 to 15.25 kg unit^{-1} day^{-1} in the adjacent river.

4.4 Fish production

The average production of all the gears was comparatively higher. This might be the species richness and variation of water level as well as flood intensity. Our study has a good agreement with Azher [8]; who obtained higher fish production associated with higher species richness. Moreover, the catches from different times, and locations was found significantly different supported by Minkin [22] for the seasonal variation, water depth and size of fishes [32]. Monthly fish production showed significant differences among the three studied sites. The highest fish production was observed in September followed by December. The average fish production in the Hakaluki haor at the present study was 322.13 kg ha^{-1} against the national wetland average production of 257.95 kg ha-1 [13]. Miah [20] found that the average fish production in Hakaluki haor in 2008 was 305.89 kg ha^{-1}. Saha [27] reported that the average production of fish was recorded as 242.47 kg ha^{-1}. The above findings supported the present study and the difference was due to regional variation and flood intensities, species richness and people awareness which are increased [2]. At present fishermen are trying to avoid the destructive gears responsible for decreasing production [32]. In addition to this, management authority (Government of Bangladesh) has established a temporary leasing system to group of local fishers following the principles of Community Based Fisheries Management (CBFM) strategy [11]. As a consequence, part (s) of haor (let say Beels) is leased for five years. Generally, the lease owner(s) stocks and rear the fish for first three years and after this period they start fishing. Therefore, fish get enough time to mature and fishers do avoid the capture of under size fish. The Governmental bodies monitor the overall activities to foster production, biodiversity and socio-economic outcomes. The yearly inundation connects all the water veins into Hakaluki haor system during the period of July to November. This ultimately acts as hub spot for fish.

5. Conclusion

Hakaluki haor is one of the largest wetland ecosystems in Bangladesh, has national and international importance. Hakaluki haor is being degraded causing declining trend in abundance of biodiversity. Still Hakaluki haor is a productive and potential water body. However, the fish production could be increased by improving management practices. For sustainable fish production and conservation of fishes and other aquatic animals, these water bodies must be brought under suitable and fish friendly management.

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