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EFFICIENCY OF FISHING GEARS AND THEIR EFFECTS ON FISH BIODIVERSITY AND PRODUCTION IN THE CHALAN *BEEL* OF BANGLADESH

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Abstract

A study was conducted to provide an overview on the aquatic resources and fisheries status of the Chalan *beel* and to identify the opportunities for improvement of the existing fisheries management strategies, focusing on fish biodiversity conservation. The Chalan *beel* is the largest and important watershed in the Northern Bangladesh which covers an area of about 400 km^2 during the wet season. Sampling for Catch Assessment Surevey (CAS), Fishing Effort Survey (FES) and water-sediment was carried out at the Gumani, the Katagang and the Baral sites. Interview and Focus Group Discussions (FGDs) were conducted in ten upazilas in and around Chalan *beel*. The most abundant fish species were *punti* (*Puntius sophore* and *Puntius ticto*) followed by chanda (*Chanda nama* and *Parambassis ranga*), tengra (*Mystus vittatus*) and chapila (*Gudusia chapra*). The abundance of several species showed decreasing trend from 2007 to 2008. The number of professional fishers has declined by 58% between 1982 and 2008 and the fishers left the profession due to much decreased fish availability in the *beel* as a result of very low fish catch and falling income. A total of 34 different types of fishing gears including nets

(11), traps (11), hook and lines (4), wounding gears (4), Fish Aggregating Devices (FADs) (3) and hand-fishing (1) were observed. Seine nets were the dominant gear followed by gill nets and set bag nets. The mean Catch Per Unit Effort (CPUE) of different fishing gears varied widely ranging from 2.04 to 48.99 kg unit^{-1} day^{-1}. The average total annual fish production of the *beel* was 12,566.57 MT having average fish production of 281.86 kg ha^{-1} during the study period. If present trend of fish catching of Chalan *beel* legally and illegally continues without proper management and control measures, then one of the most valuable aquatic resources of Bangladesh – the Chalan *beel* would soon be empty of all kinds of fishes. It is the obligation of concerned GOs, NGOs and the people of the country to control the gear efficiency in the Chalan *beel* and provide alternative livelihood options to the resource-poor fishers of the *beel* along with other measures for sustainability of the Chalan *beel* - a major fish reservoir of the country.

Keywords: Fishing Gear, Biodiversity, Catch Assessment Survey, Fishing Effort Survey

Introduction

Fisheries sector plays a vital role in the agro-based economy of Bangladesh through its contributions to employment and income generation, foreign exchange earnings, and providing food and nutritional security to the people. The fisheries and aquaculture sector contribute 4.39 and 2.46 % to Gross Domestic Product (GDP) and in export earning, respectively (DoF, 2013).

Inland waterbodies have been supporting rich and diversified fisheries and thus are critically important to the people of Bangladesh for their food security and livelihood (Hasan, 2004). However, due to sharp decline the natural fish production and consumption over the last years and created protein deficiency.

The *beel* ecosystem is extra-ordinarily complex with wide temporal and spatial variations of many key parameters. Among the various factors that influence the wetland ecosystem are depth, nature of catchments area or river basin and precipitation and duration of connection to river (Sugunan *et al*., 2000). The living part of the ecosystem or the biotic communities (autotrophs and heterotrophs) is governed by the variation of physical and chemical features of the water body and trophic interactions associated with it.

The Chalan *beel* is the largest natural depression covering 18% of the total *beel* area and most important watershed in the North Central Bangladesh. It comprises a series of depressions interconnected by various channels to form one continuous sheet of water in the rainy season (July-

November) when it covers an area of about 400 km^2. During the dry winter and summer, the water area decreases down to 52-78 km2 and looks like a cluster of *beel*s of different sizes (Shahnaz, 2005) and offers an excellent alluvial crop land in the post monsoon season.

Indiscriminant, unplanned and destructive gears are being used by the fishers of Chalan *beel*. The harmful modern gears and technological advancement have negative impact over the situation. For this reason fish biodiversity are being declining day by day. Many researchers in Bangladesh have studied gear selectivity and their impact on water body. However, there is no real data about the present status of different gears used and their efficiencies to evaluate the prevailing situation of the *beel*. Therefore, a comprehensive study on the Chalan *beel* seems to be of timely value and immense necessity. The present study is aimed to provide an overview on present status of fishing practices, gear used, catch assessment and production of the Chalan *beel*. In view point of that, the present study is very much significant to make aware the development planners and policy makers to undertake initiatives to save the important natural resources through proper recommendations and suggestions.

Materials and methods

Description of the study area

The Chalan *beel* is situated between 24.35^o and 24.70^o North latitude and 89.10^o and 89.35^o East longitudes. Historically Chalan *beel* was spread over the districts of Rajshahi, Pabna, Sirajgang, Natore, Naogoan and Bogra (Figure 1). At present, the *beel* has been compressed in the districts of Pabna, Sirajgonj and Natore due to crisscross roads, embankments and other infrastructural expansion. Therefore, the research was conducted in three representative cluster sites under the above districts. For data collection, ten upazilas such as Singra, Gurudaspur and Boraigram of Natore district, Chatmohar, Bhangura and Faridpur of Pabna and Shahjadpur, Ullapara, Tarash and Raygonj of Sirajganj district were selected.

Experimental site

In experimental site, three cluster sites covering a river, a canal and a *beel* were selected for this study. The cluster sites were the Gumani and its adjacent floodplains (CS1 - the Gumani) under Natore, the Katagang and its adjacent floodplains (CS2 - the Katagang) under Sirajgong and the Baral and its adjacents floodplains (CS3 - the Baral) under Pabna district where the sampling for CAS and FES were performed (Fig. 2).

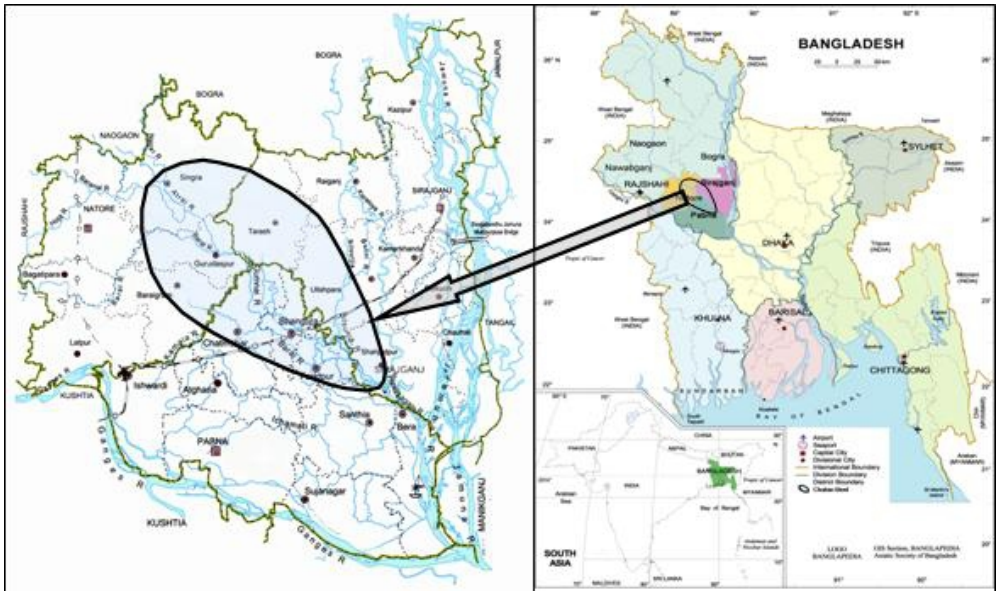

Fig.1: The study site "Chalan *beel*" showing in the map of Bangladesh

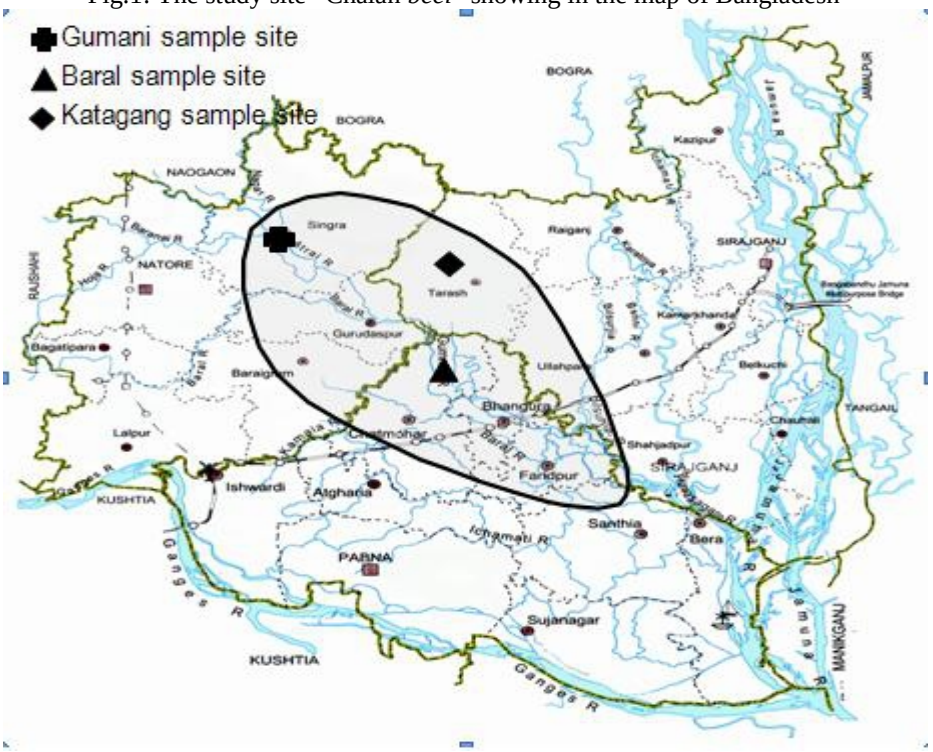

Fig. 2 The map of Chalan *beel* area showing the sample sites

Data collection

The study was conducted based on the data collected through direct CAS and FES sampling from the CS1, CS2 and CS3; also direct interviews

and Focus Group Discussions (FGDs) with different stakeholders with sufficient replicates from in and around the upazilas. The FGDs were conducted with a pre-structured and pre-tested questionnaire involving people from all sections.

Catch assessment and gear survey

Fishing Effort Survey (FES) and Catch Assessment Survey (CAS) were conducted using a boat starting from 6 am to 6 pm twice in a month over 12 months in two years during fishing seasons. Each sampling was performed in the same sampling locations with three replicates twice a month during July to December in 2007 and 2008.

Catch effort calculation

The catch per unit effort (CPUE) for the gears were taken based on the weight of fish caught during a fishing day (kg day−1 fishing unit−1) for the different species combined. The catch efficiency of each gear employed in each fishing site was analyzed by comparing different gear on the basis of CPUE, i.e., the amount of fish caught for a certain period, for example amount of fish caught per day. Fluctuations in the fish catch were also compared. The CPUE value was extrapolated to the mean catch gear−1 day−1person-1, mean catch crew−1 day−1 (MCCD) and mean catch boat−1 day−1.

Calculation of total catch per unit area (CPUA) for the sampling sites

The Catch per Unit Area (CPUA) for the sampling sites calculated as

- CPUA = (Total catch from sampling sites for all gears + Total catch from brush parks)/sampled area.

Finally, the total annual catch for the *beel* was estimated by multiplying the CPUA with the total productive water area of the *beel*. The production of ponds and boro pits was estimated multiplying the average production per hectare with total area.

Cross-checking of data

The Upazila Fisheries Officers (UFOs) and other stakeholders including fishers were interviewed about the use, pattern and intensity of different gears in the water body to know the real situation as well as cross checking the collected data. Finally, all the data were analyzed statistically. Also it was reviewed with the secondary data sources mainly reports of the Department of Fisheries (DoF), research reports, case studies, NGO reports, scientific journal articles and other published materials including internet resources.

Statistical analysis

Various types of models were used in this study. The coefficient of variation (CV) analysis assessed the variability in the CPUE by gear types. The differences in CPUE of the catch and production between months and fishing sites were analyzed employing analysis of variance (ANOVA) techniques. A similar ANOVA technique was employed to test the difference in the CPUE of katha fishing in the catchments site, year, months and also their interaction.

Results

Fishing crafts

In the Chalan *beel*, the fishing operations were mainly carried out using two types of crafts - the small dingi (buddi) and the medium and large size boats (Table1). The dingi was use to operate gill nets, hook and line, traps and sometimes for jhakijal where normally one or two persons were engaged. Fishers used gill net and hook and lines for capturing pelagic and demersal fishes, respectively. Boats were used for seine and set bag nets operation. Fishers normally operated moderately higher mesh sized gillnets at night and the smaller mesh sized gillnets during day time, whereas seine and set bag nets were operated during both day and night. The hook and line fishing was mainly operated using baits at night.

Table 1: Characteristics of fishing crafts in Chalan beel during study

Characteristics	Craft type	
	Boat	Dingi
Length (m)	4.5 – 10	2.5-4.5
Number of personnel engaged	7-8	1-2
Operation period (days/year)	120-130	60-105
Fishing duration (hour/day)	7-18	7-10
Area covered (km2)	0.5-3	1-2.5
Duration of use (month/year)	6	4
Peak season	June-Sep., Oct.-Nov.	May- Dec.
Manufacturing cost (US$*)	75-285	100-250

*US$=70 BDT

There was significant difference ($P<0.05$) in the catches among fishing crafts. Fishing efficiency of boat was found much higher than that of the dingis. There was also a significant difference of fish catches over the fishing months by different crafts and gears. The interaction of months and fishing crafts were also significantly ($P<0.05$) different in Chalan *beel*. The mean CPUE of fishing crafts was 12.17±3.87 kg.

Fishing Gears

The capture fishery in Chalan *beel* is decreasing day by day. One of the major causes is the indiscriminate killing of small fishes in the early

stage by various illegal fishing gears. Thirty four different gears under six categories were observed in Chalan *beel* during the study (Table 2).

Table 2: Different of fishing gears with period of operation in Chalan *beel*

Category	Types of gear	Name of gears	Main habitat type	Mesh size(mm)	Target species	Period
Fish nets	Seine net	*Ber/Badai/ mosharijal*	FBR	3-10	All	May-Oct.
		Kochaljal	FBR	10-15	All	May-Oct.
	Lift net	*Veshaljal* (*Khora*)	FBR	≥5	All	June-Nov.
		Dharmajal	FBR	5-12	All	June-Oct
	Cast net	*Jhaki/kheplajal*	R	≥10	All	Year round
	Drag net	*Moijal*	RF	4-6	Itcha	June-Sep.
	Push net	*Thelajal*	RB	5-15	All	June-Dec.
	Gill net	*Puntijal*	BF	25-50	Puti	May-Nov.
		Koijal	BRF	32-45	Koi	May-Nov.
		Fashjal	FBR	45-150	All	May-Nov.
	Fixed net	*Sutijal* (*Behundijal*)	BR	5-45	All	Sep.-Nov.
Fish traps		*Baga*	RB	5-15	SIS	May-Dec.
		Khadum	RF	15-25	SIS	May-Dec.
		Britti/Dhudi/Khalsane	BF	5-10	SIS	May-Dec.
		Bhair	BF	25-35	SIS	May-Dec.
		Dohair	BF	5 -10	SIS	May-Dec
		Cheng	BF	2-5	SIS	May-Dec.
		Ucha	RB	-	SIS	May-Dec.
		Polo	B	-	Big Fish.	Dec.-Jan.
		Charo	FB	1-3	SIS	May-Dec
		Hogra	RF	-	SIS	May-Dec
		Bana	FB	-	SIS	May-Dec
Hook and Line		*Chip borshi*	FB	-	Carnivore	July-Dec.
		Nol borshi	FB	-	Carnivore	July-Dec.
		Boallah borshi	RB	-	Carnivore	July-Dec.
		Daun	RBF	-	Carnivore	July-Dec.
Wounding Gears		*Juti*	RB	-	All	July-Dec.
		Koach	FB	-	All	June-Feb.
		Teta	FB	-	All	June-Feb.
		Achra	RBF	-	Mud dweller	Oct-April
FADS		*Chong*	BR	-	Carnivore	Oct-April.
		Katha	RB	-	All	Nov.-Jan.
		Kua	B	-	All	Dec.-Apr.
Others		Hand fishing	BR	-	SIS	Nov –Apr

R = River, B = *Beel* and F = Floodplain; FAD= Fish aggregating device

The Catch per unit efforts (CPUE) of different gears

The average CPUE for all fishing gears in Chalan *beel* varied widely ranging between 2.04 and 48.99 kg unit−1 day−1. Fig. 3 represents the average CPUE for all fishing gears used in three study areas of the *beel*. The CPUE values ranged between 2.05 and 224.54 kg unit−1 day−1 for fishing nets, and between 2.85 and 3.37 kg unit−1 day−1 for hooks and line fishing. The mean CPUE from Gillnet, Jhakijal, Seine net, Thela jal, lift net, Traps, Wounding gears, Moijal, Hook and line and Sutijal was 2.83 ± 0.92, 2.05 ± 0.81, 48.99 ±12.34, 2.60 ± 1.56, 2.66 ± 1.46, 4.69 ± 2.11, 1.83 ± 1.07, 3.03 ± 1.76, 3.11 ± 1.76 and 224.54 ± 126.89 kg unit−1 day−1, respectively.

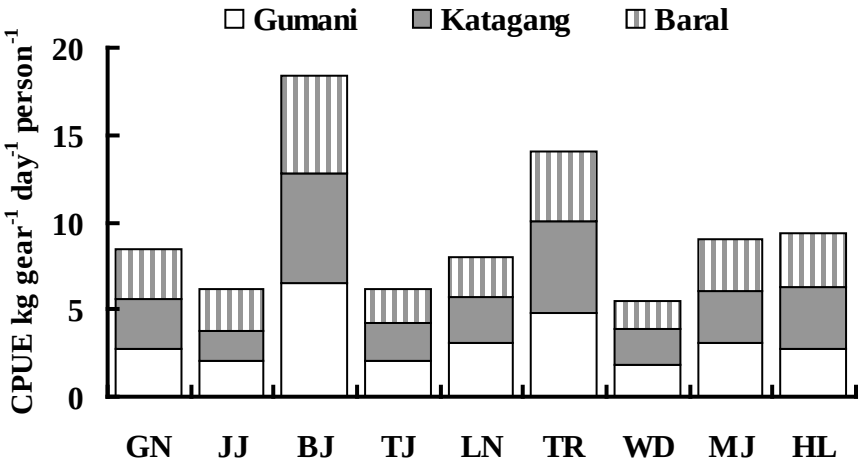

Fig. 3: Catch per unit effort (CPUE) of different fishing gear employed in Chalan *beel*

Variations in catch rate in different study sites

The mean, standard deviation (SD) and CV of the CPUE for each fishing gear with respect to three sites are presented in Table 3. The analysis of variation between the sites and types of fishing gear showed no significant difference, except for gill net and sutijal which exhibited significant variation ($F = 20.846$ and 41.667, $P < 0.05$) Table 3). CV of CPUE for fishing nets did not vary > 64% (moijal; Katagang site), whereas the highest CV of 68% was recorded at the Gumani site for hook and lines among the hooks and line fishery.

Table 3. Statistical presentation of catch unit effort−1 (CPUE) characteristics of different catchments areas in Chalan *beel*

Gear	Gumani			Katagang			Baral		
	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV
Gillnet	2.72	0.90	33	2.87	0.85	30	2.88	1.05	36
Jhakijal	2.10	0.74	35	1.66	0.77	47	2.38	0.81	34
Berjal	51.69	11.84	23	50.29	10.52	21	44.99	14.18	32
Thelajal	2.07	0.71	34	2.11	1.26	60	1.98	0.92	46
Lift net	3.08	1.49	48	2.60	1.56	60	2.30	1.31	57
Moijal	3.09	1.79	58	3.00	1.92	64	2.99	1.69	56
Traps	4.80	1.64	34	5.24	2.45	47	4.02	2.10	52
Wounding	1.81	1.03	57	2.07	1.37	66	1.60	0.75	47
Hook & line	2.70	1.85	68	3.55	2.08	58	3.08	1.28	41

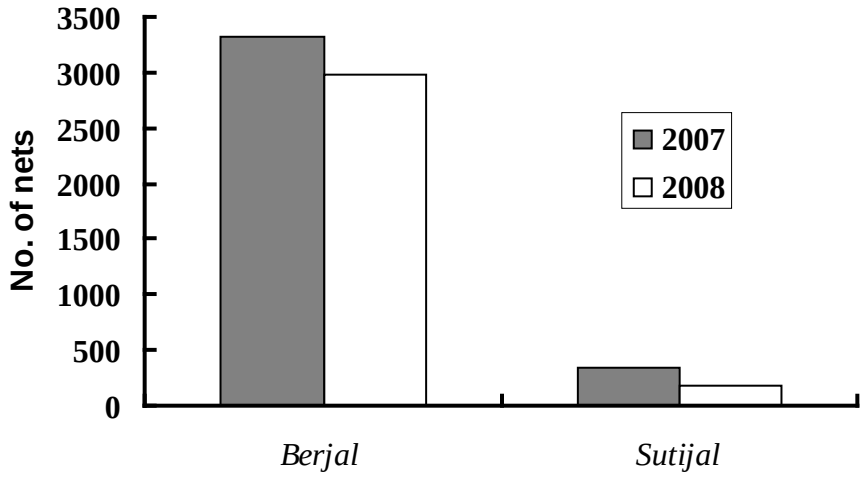

Fig. 4: Number of destructive gears used in Chalan *beel* during study period

Fish harvest in kua and katha

The fish harvest from Kua fishing per decimal in the Chalan *beel* is presented in Fig 5. There was no significant difference ($P>0.05$) in production between 2007 and 2008, although it was numerically higher in 2007. The fish production was significantly ($P<0.05$) higher at the Baral site followed by the Gumani and the Katagang site in both years.

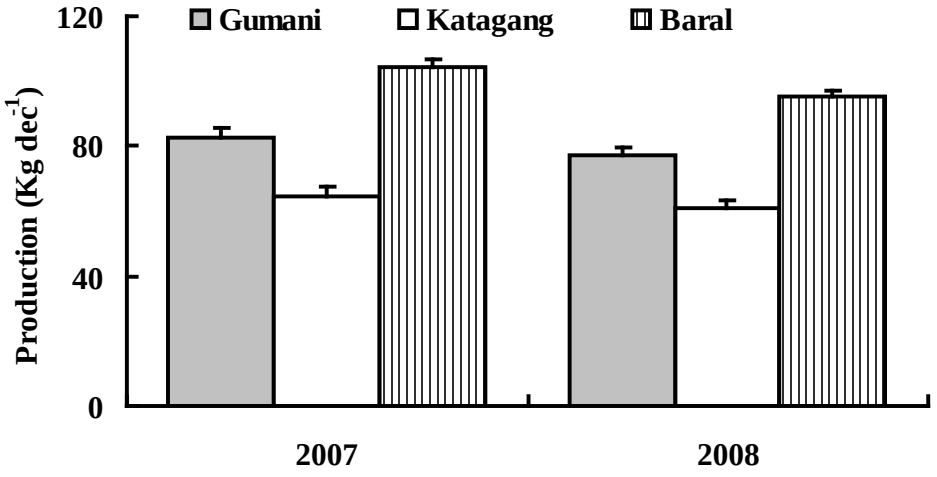

Fig. 5: Production of Kua per decimal in three catchment areas under

Chalan *beel*

Monthly fish production during study period is given in Table 4 and Fig. 6. The fish production showed significant ($P<0.05$) difference among the months, however, not among the sites. The higher fish production was observed in the month of December followed by October and September. The monthly production differed significantly ($P<0.05$) in different months.

Table 4: Mean ± SD of fish capture (MT) in different sites and months during study period

Month	The Gumani	The Katagang	The Baral
July	6.08 ± 0.12	3.32 ± 0.19	6.33 ± 0.01
August	6.73 ± 0.70	8.37 ± 0.35	5.51 ± 0.05
September	8.77 ± 0.25	9.40 ± 0.03	10.39 ± 0.15
October	8.94 ± 0.17	10.93 ± 0.12	13.34 ± 0.03
November	7.45 ± 0.08	10.50 ± 0.16	8.12 ± 0.07
December	15.8 ± 0.15	14.62 ± 0.09	14.44 ± 0.05

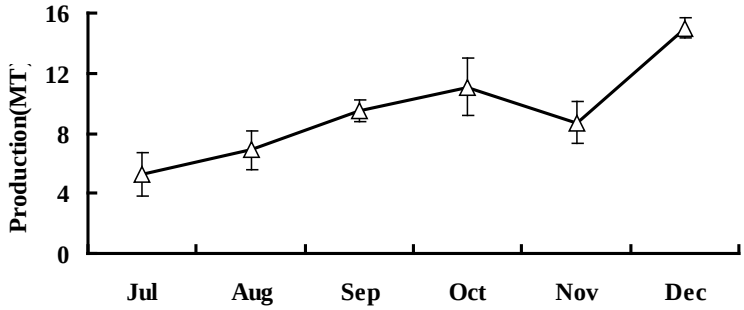

Fig. 6: Fish production trends in different months in the Chalan *beel* during study

Average national and Chalan *beel* fish production is shown in Fig.7. Average fish production from the *beel* was higher than the national average from the open waterbodies.

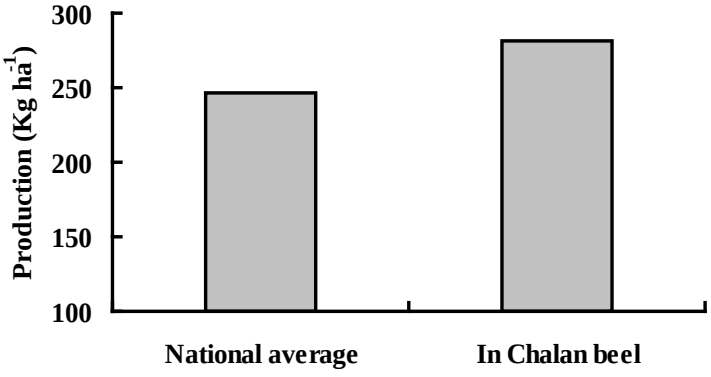

Fig. 7: Comparison of fish production from the Chalan *beel* with national average

The fish production from *beel*s was 2,582.97 MT, from other sources (2,748.53 MT) and from rivers 930.14 MT and total fish production was 12,566.97 MT during study period. (Fig 8)

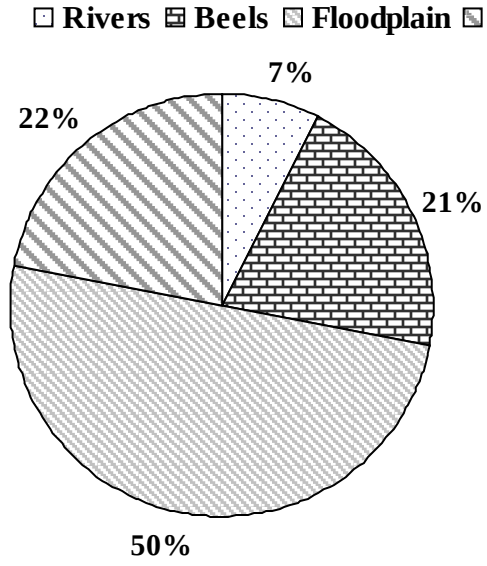

Fig. 8: Fish production from different types of waterbodies in Chalan *beel* during study

The fish production from *beel*s was 2,582.97 MT, from other sources (2,748.53 MT) and from rivers 930.14 MT and total fish production was 12,566.97 MT during study period.

Discussion

Fishing crafts

In Chalan *beel*, the fishing operations were mainly carried out using two types of boats; the smaller Dingi (Buddi) and the moderate boats. Significant difference ($P<0.05$) in the catches by different crafts i.e. fishing efficiency of boat was much higher than that of the dingis and significant ($P<0.05$) difference of fish catches over the fishing months were observed. The result was in agreement with the findings of Ahmed *et al.* (2003), Mursheduzzaman, (2006), Dutta (1983) except fewer variations which might be due to size, area and location of the waterbody and also difference in the availability of fish species. The characteristics of the fishing crafts observed in the Chalan *beel* were similar as described by Tsehaye (2007).

Nets

Two types of Seine net namely Ber jal and Kochal jal were operated in the *beel* which also used in ponds. There were several types of lift nets used in the *beel* area such as triangular Veshal jal, rectangular Dharma jal

and conical Chabi jal. They are not destructive and could be allowed to operate round the year. Jhaki jal was less destructive to the fisheries. Moia jal and thela jal were found to be used widely for household consumption. Among various kinds of gillnets, monofilament small meshed one was very destructive and should be banned. The findings were supported by (Rahman *et al*., 1999; Dutta, 1983) Amarasinghe and De Silva (1999) cited that in Srilanka, the annual fish production declined dramatically after 1990.

Traps

In general, fish traps were not destructive for the waterbody except fishing with setting up of barrier on the path/migratory route of fish movement. The catch composition was more or less similar except the larger mesh sized traps. There were observed several types of fish traps used in the Chalan *beel* such as Baga, Khadum, Britti/Dhudi/Khulsane, Bhair, Dohair, Cheng, Ucha, Polo, Charo Hogra, Bana and Khaloi. The more or less similar type of traps was observed by Rahman *et al*. (1999) at BSKB *beel* in Khulna. Among all traps, koi dughair and ramani were recorded as deleterious for carps especially for stocked fingerlings. For relatively small sized wild fishes ghitni traps were identified as detrimental gear.

Hook and line

Chipborshi, Nolborshi, Boallah borshi, and Daun under the hook and lines were used in the the Chalan *beel*. The carnivores' fishes were mainly caught by these ype of gear using baits. It is traditional, but the long lines are used commercially in big rivers. They are neither destructive nor detrimental gear. The present finding agreed with Rahman *et al.* (1999); Ahmed *et al.* (2003); Hussain (1999) except slight variations might be due to season, area, location and other environmental factors affecting them.

Wounding gears

Among different wounding gears, juti, koach, teta, and ek-kata were found in Chalan *beel* during the study. Both small and large fishes were caught by these gears. The wounding gears operated in the Chalan *beel*. The findind was in agreement with Ahmed (2008) and Hussain (1999).

Finally, a total of thirty four types of fishing gears including 11 fishing nets, 11 fish traps, 4 types of hook and lines, 4 wounding gears, 3 fish aggregating devices and hand fishing were employed to catch fishes of different groups, ages and sizes in the *beel*. The findings are more or less similar with the findings of Saha (2007) who found 40 types of gears in Boro *beel* adjacent to the Chalan *beel*. Ahmed (2008) cited that more than 100 types of fishing gears are used all over the country for fishing. Dewan and

Mazid (1994) stated that, a total of 90 gears are found to be used by the fishermen in different types of waterbodies in the country.

The Catch per Unit Efforts (CPUE) of Different Gears

The average CPUE for all fishing gears in Chalan *beel* varied widely because the CPUE was affected not only by environmental factors (e.g. water level, wind action, water quality, productivity, lunar cycle, turbidity), but also by fishing gears, fishing pressure and the fishers' preferences. The reasons for the significant differences in the CPUE were the size of the nets, the total number of hooks used, the fish lure ingredients and bait and the experience of the fishers. Another reason for the difference in the fish catches was the fishing places. The environmental factors such as waves, turbidity, wind direction, rainfall and weather during monsoons sometimes seemed to affect catches throughout the study period. The CPUE showed increasing and decreasing trends over the study period because the month of July was the water entering period, therefore, fishes entered with flood water in the Chalan *beel* and resulted fish abundance. On the other hand, the entered fishes were brought up and the water level reached to minimal in the month of October onward. Then the availability of fishes increased from October to onward. The findings of the present study were agreed with Ahmed (2008) who observed the CPUE of different gears ranged from 0.95 to 15.25 kg unit−1 day−1 in Titas river. The CPUE for all gear except seine net was moderately higher due to species richness and open access of water of the big river Jamuna. Statistical analyses of the catch rates of the dominant gear utilized in the Chalan *beel*, revealed no significant differences between the sites (FAP-17, 1995).

The fishery of Chalan *beel* had changed from a rich fishery to a small-sized and less important fishery. The under-size fish constituted more than 90% of the catch. The water level manipulation for the crop irrigation in the *beel* was not only related to the fluctuation of the CPUE or fish yield, but also the reproduction, abundance, distribution and migration of the fishes. In 2008, extreme fluctuations in water level were observed with an increased threat for the future reproduction of fish in the water body.

Fish production

The mean production of all the gears was comparatively higher might be due to the species richness and closeness and connection with the mighty Jamuna which coincided with the findings of (Azher *et* al., 2007) who obtained higher fish production associated with higher species richness. The production per haul in katha fishing in different catchments in the Chalan *beel*, year and months had significant differences due to seasonal variation, water depth and biological condition of fishes which is supported by Mankin

(1989). Monthly fish production showed significant differences. The highest fish production was observed in December followed by October and September which was in compliment with the findings of FAP-17 (1995). The average production from inland open water in the present study was 281.86 kg ha-1 against the national average of 246.32 kg ha-1 (FRSS, 2008). Saha and Hossain (2002) reported that the average production of fish was recorded as 242.47 kg ha-1 in Saldu *beel* of Tangail. The findings of the studies supported the present finding and the slight difference was due to regional variation and flood pulse type of the waterbodies and species richness. The abundance and production of fish species were tightly bound to the flooding pattern during the monsoon season (Ahmed, 1991). The yearly inundation connects all the aquatic areas into one large production system for up to four to five months (June to July). Fishes enter to the Chalan *beel* by up-stream migration from the Jamuna River through the Baral and Gumani river when inundation commences in the pre-monsoon period. The Chalan *beel* then serves as an excellent feeding and nursing ground for many important indigenous fish species. Overfishing of brood fish within the river, however, restricts up-stream migration to the Chalan *beel* area during the key months of April to July. In addition, during the late monsoon (September to October) when the flood waters recede, fishermen indiscriminately harvest fish of all sizes using non-selective sutijal, thereby reducing returns to the Jamuna river. Other anthropological effects, including construction of roads, dams, embankments and human settlements, also obstruct migratory routes, causing adverse affects on the aquatic ecosystems.

Conclusion

Chalan *beel* is a moderate productive waterbody with decreasing fish species diversity. Species selectivity of different gears differed considerably. Nets were found more harmful than those of other gears. At the onset of monsoon, each year, the large number of spawners and spawns enter in the Chalan *beel* and caught by mono-filament gill nets and mosquito seine nets set in the migratory route. These types of illegal fishing practices were widespread and resource-poor fishers continued these for their livelihood as they could not find other alternative works during the period.

If fish catches in Chalan *beel* legally and illegally continued to increase without control, then a valuable resource like Chalan *beel* would be empty of fish in near future. It is the duty of concerned GOs, NGOs and the people of the country to control the gear efficiency, stop the destructive gears and provide alternative livelihood options to the resource-poor fishers along with other measures.

Finally, it is imperative that efforts should be undertaken to develop ecosystem-based management strategies with inputs from scientists, resource

managers, policy makers, government and non-government organizations and other stakeholders, with the objectives of enhancing production, maintaining biodiversity in a sustainable manner and improving the livelihoods of the marginal fishermen in the largest *beel* of Bangladesh – the Chalan *beel*.

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