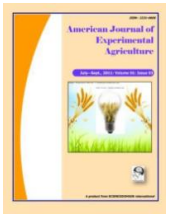

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Chemical and Pesticides uses Status in the Chalan *beel*, Bangladesh and Present Status of Fish Biodiversity

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Authors' contributions

This work was carried out in collaboration between all authors. Authors MAS, MARH and MTH designed, wrote the protocol and executed the study. Authors MAS, MTH and MAG participated in data collection. Authors MTH, MAG and SKD managed the analysis of the study. Authors MAS and SKM wrote the first draft. All authors read and approved the final manuscript.

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ABSTRACT

Aims: A study was conducted to investigate the status of agrochemicals used and its impact on aquatic biodiversity in the Chalan beel, the largest beel of Bangladesh.

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Duration of Study: A period of six months from January to June 2009.
Methodology: The study was based on questionnaire survey. A semi structured and structured questionnaires were developed, pretested and adapted prior to the survey proper.
Results: The abundance of several fish species showed decreasing trend from 1982 to 2009. The average total annual fish production of the *beel* was 12017.57 MT having average fish production of 281.86 kg ha^{-1} during the study period. Crop farmers applied 2.76 kg pesticide ha^{-1} $crop^{-1}$ and average annual chemical fertilizers practiced was more than 125000 MT. A total of 108 and 143 large to minor scale fish mass mortality incidences were recorded with estimated fish damage of 2117 and 2980 kg respectively during the study period.
Conclusion: It is the obligation of concerned GOs, NGOs and the people of Bangladesh to control the gear efficiency in the Chalan *beel*, stop the illegal usage of harmful pesticides 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: Aman; fertilizer; total dissolve solids; residual effect; organic matter; inland fishery.

1. INTRODUCTION

Inland water bodies have been supporting rich and diversified fisheries and thus these are critically important to Bangladeshi people for their food security and livelihood [1]. However, due to sharp decline in fish intake over the last years, we have reached a situation of protein deficiency. At present, fish consumption per capita per day is only 47.19g, whereas the actual requirement is about 49.3 g [2]. For centuries, a delicate cycle of flooding, fish migration between rivers and floodplains, spawning and growing has been maintained in the wetlands of the country. Large areas of permanent, semi-permanent or seasonal wetlands are found in floodplains of lowland rivers with unperturbed hydrology. There are great differences in the area flooded from year to year, and this greatly influences the population dynamics of many fish species [3].

The *beel* is a Bengali term used for relatively large surface, static water body that accumulates surface run-off water through an internal drainage channel [4]. This type of shallow, seasonal water body is common in low-lying flood plain areas throughout Bangladesh [5]. *Beels* are one of the important sources of fish supplies in Bangladesh. Natural depressions (*beels*) comprise about 2.49% (114161 hectares) of total aquatic resources which supplied 75137 MT (3.08% of total fish production and 7.46%of open water fisheries) in 2006-07 [6].

Chalan *beel* is the largest 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 km^2 and looks like a cluster of *beels* of different sizes [5,7]. The Chalan *beel* is a confluence for numerous smaller water ways and, in turn, is drained by channels that flow south, finally discharging into the Padma and Brahmaputra Rivers [8]. The *beel* serves about 5 million people by providing fish and aquatic products, agricultural crops, and pasture lands for the livestock. But now nearly deserted due to different Flood Control Drainage and Irrigation (FCDI) facilities and siltation. A large number of fish and aquatic organisms have been diminished from this water body. About 100,000 fishermen living in and around the *beel* have been severely threatened to the loss of livelihood [5].

Gradual habitat degradation and overexploitation are key drivers of biodiversity degradation and declining aquatic production in Chalan beel [5]. Habitat degradation results from increased siltation rates, construction of flood control embankments and roads, uncontrolled usage of pesticides, insecticides and chemical fertilizers on croplands, excessive removal of surface water and extraction of groundwater for irrigation, diversion of water courses, unregulated discharge of untreated industrial and aquafarms effluents, fish harvesting by dewatering, etc. These factors, which also contribute to already significant reductions in the areal extent of Chalan *beel*, are pushing many indigenous species to the verge of extinction [7].

A rich diversity of a species is critical to the ecology and sustainable productivity of the

floodplains. While tremendous genetic diversity is embodied from 260 to over 500 fish species which inhabit in Bangladesh's inland, estuarine and coastal waters ever little substantive data on the ecology of these species is available to say something significantly [9,10]. Paul [11] stated that 143 indigenous species and eight exotic species of fish inhabiting in the northeast region of which carps and catfishes are dominant groups. Fish biodiversity has been degraded due to many reasons for anthropological and agricultural encroachment thus the availability of indigenous freshwater fish species have declined to a great extent over the years and many of them are either rare or at the verge of extinction. Among the 260 freshwater fish species belonging to 52 families many of them are threatened in Bangladesh.

The inland aquatic habitats of Bangladesh are rich in faunal diversity containing at least 260 species of finfish, 60 species of prawn and shrimp, several species of turtles, tortoises, freshwater mussels and other living aquatic organisms [12]. The importance of fisheries in Bangladesh is clearly very large, and given its strategic importance for food security and national development, the fisheries sector has received considerable attention.

Pesticide affects the aquatic ecosystem by interrupting the aquatic food chain of open water fish species and finally results in the loss of abundance of natural species [13]. The inundated floodplains during monsoon are the seasonal habitat of the fish and the residual effects of pesticides applied to these floodplains for agricultural purpose before monsoon lead to the large scale fish killing. Besides fish killing, there are also chronic effects of pesticides including changes in reproductive system, metabolism, growth patterns, food availability and population size and numbers.

Presently Chalan *beel* like many other *beels* are at the risk of partial or total degradation due to manifold reasons like agricultural encroachment including pesticide usage, siltation along with other anthropogenic activities. However, it is very difficult to say about the exact rate of degradation occurred and how the problems would be solved. Therefore, a comprehensive study on the Chalan *beel* seems to be of timely value and immense necessity. The study was conducted to investigate the present status of pesticide usages and its effects on fish biodiversity of Chalan *beel.*

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The Chalan *beel* is situated between 24.35º and 24.70º North latitude and between 89.10º and 89.35º East longitudes (Fig. 1). Historically the *beel* spreads over the upazilas (Sub-distrcts) of the districts of Rajshahi (Paba, Bagmara and Mohonpur), Pabna (Chatmohor, Bhangura and Faridpur), Sirajgong (Tarash, Ullapara, Raigonj and Shahjadpur), Natore (Sadar, Singra, Gurudaspur and Baraigram), Naogoan (Manda, Raninagar and Atrai) and Bogra (Nandigram). In present day, the *beel* has been squeezed only in the districts of Pabna, Sirajgonj and Natore due to crisscross roads, embankments and other infrastructural development. 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 under the district of Natore, Chatmohar, Bhangura and Faridpur under Pabna and Shahjadpur, Ullapara, Tarash and Raygong under Sirajgong were included (Fig. 1).

2.2 Methodology

The study was based on questionnaire survey where primary data were collected both from the fishermen, crop farmers, pesticide dealers and retailers and other local stakeholders living in and around the *beel*. A reasonable size of sample to achieve the objectives of the study was considered keeping in view limitation of time and resources. A stratified random sampling procedure covering all selections among the people with an age of 25 years or more was followed to collect information on a participatory stakeholder approach. The study was based on the data collection from different stakeholders related to pesticides usage and detailed of them in Table 1.

Besides, ten Focus Group Discussions (FGD) were conducted in ten upazilas including all section of resource users and covering all aspects of pesticides. Secondary information from published reports (*e.g.*, Bangladesh Crop Protection Association (BCPA), scientific articles, web sites etc. was also reviewed.

Initially a draft questionnaire was prepared following other relevant questionnaire and information. Then it was pre-tested among 10

respondents from the *beel* area (Appendix 1A-1H). New information and respondent's attitude was recorded.

2.3 Data Processing and Analysis

The data were generated and subjected to descriptive analyses to characterize the sample pesticide sellers and farmers' crop management practices. The collected data were tabulated and analyzed in accordance with the objective of the study. The data were compiled and processed by using calculator, MS word and MS Excel computer program [14].

3. RESULTS AND DISCUSSION

3.1 Physical Characteristics and Chemicals usage Status

The details of physical characteristics of Chalan *beel* area are given in Table 2.

Details of various types of chemical fertilizers usage in Chalan *beel* area are shown in Table 3. Yearly, over 1.25 lac. MT. of various chemical fertilizers were being used which ultimately drained out to the Chalan *beel* causing serious problem. More fertilizers were found to be used in 2008 than that of 2009 which might be due the impact of integrated pest management (IPM) activities and motivation programs through different GOs and NGOs in the Chalan *beel* areas.

Pesticide usage in Bangladesh got started from mid 1950s and gained momentum in late 1960s with the introduction of green revolution through the use of HYV rice in the country [15]. Pesticides have been promoted and increased in Bangladesh mainly due to expansion of agricultural land area and increase in crop production. Farmers have been receiving extension services and considerable subsidies from the government over the years [16,17]. As a result, pesticide usage had been increased abnormally in the Chalan *beel* and the demand of pesticide is increasing day by day. Many farmers practiced banned and inferior quality pesticides which came through illegal channel from neighboring countries as the price of such type banned or illegal pesticides was relatively lower. As a consequence, water ecosystem is being damaged through using banned pesticide. The indiscriminate use of insecticides and pesticides in the crop fields by the farmers was one of the causes of disappearance of fish from the natural waters in Bangladesh. Not only fish but also other beneficial animals were killed by pesticides and pesticide affected the aquatic ecosystem by interrupting the aquatic food chain of open water fish species and finally resulted in the loss of abundance of natural species [13]. Rohar and Crumrine [18] also reported that the application of the herbicide atrazine to a lentic system resulted in lower periphyton abundance and, as a result, reduced herbivore biomass.

Table 1. Number of key informants interviewed in different upazilas

Sl. No.	Key informants	Activities	Number	Remarks
1.	Pesticides dealer	Interview	1×10 = 10	10 indicate upazila in and around Chalan *beel.*
2.	Pesticides retailers		2×10 = 20	
3.	Upazila Agriculture Officers (UAO)		1×10 = 10	
4.	Upazila Fisheries Officers (UFO)		1×10 = 10	
5.	Crop farmers		4×10 = 40	
6.	Fish farmers		3×10 = 30	
Total			120	

Table 2. Farm physical characteristics in the Chalan *beel*

Characteristics	Natore	Pabna	Sirajgonj
Average annual rainfall (mm)	1620	1529	1376
Average landholding (ha.family^{-1})	1.06	0.72	1.19
Cropping intensity (%)	180	164	173
Food grain production (ton.ha^{-1})	3.4	3.1	3.6
Village with pesticide retailer ratio	0.23	0.34	0.27
Pesticide usage (kg ha^{-1})	2.87	2.41	3.01

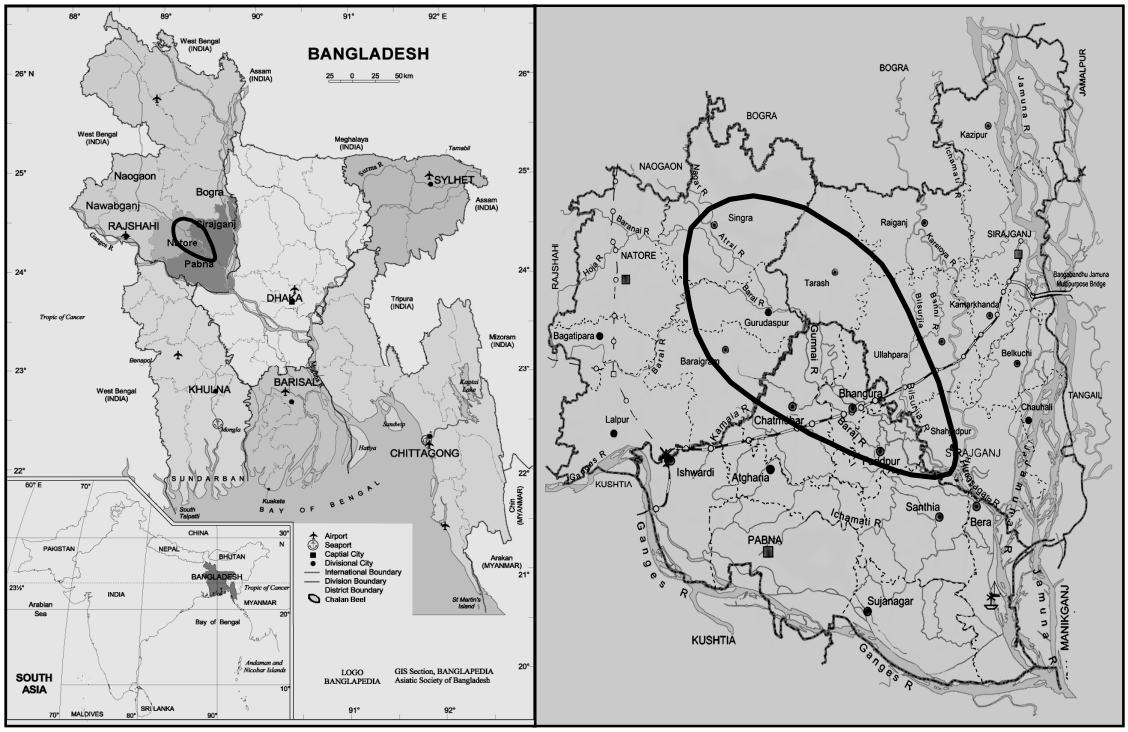

Fig. 1. The study site "Chalan *beel*" showing in the map of Bangladesh

To address food security, the farmers in the Chalan *beel,* mostly the medium and marginal farmers are engaged in the farming activities in 0.19 million ha of land. *Boro* was the most dominant crop varieties using pesticide and fertilizers and causing loss of fish biodiversity. A number of major to minor fish mass mortality were recorded by the fishery officers during 2008 and 2009 in ten upazilas where the estimated damage was more than three lakh in BDT and the occurrences were increasing year after year. Knight et al. [19] reported that applications of herbicides may cause cross-ecosystem cascades and ecosystems were also impacted by it. Local migrant fish used to breed in mass scale in Chalan *beel* now do not breed [19].

3.2 Dynamics of Cropping Practice

The most important source of people's livelihood in the Chalan *beel* area is agriculture. In Chalan *beel,* there were 8, 10, 30, 35 and 18% of large, medium, small, marginal and landless farmers, respectively engaged in the farming activities in 0.19 million ha of land (Table 4).

High yielding varieties of *boro* and *aman* rice were the most dominant crops occupying about 73% and 25% land area, respectively, whereas only 2% area was occupied by traditional rice varieties. Flood and drainage problems affect annually two thirds of cultivable area of Chalan *beel*. Prior to implementation of the FCDI, the cropping area used to suffer from combined effect of river bank spilling of Little Jamuna and Atrai River and runoff during May-October almost every year. The floods adversely affected the late growth and harvest of *Aus, Boro* and the early *Aman* crop.

3.3 Scenario of Pesticide usage in Chalan *beel*

There are a total of 44 dealers and 791 retailers have been engaged in pesticide trading in the Chalan *beel* area with an average annual turnover of BDT 52 million. In Bangladesh there are more than three hundred commercial pesticides. Among them 102 commercial pesticides have been either banned or cancelled by the authority. In Bangladesh, pesticide usage has been almost double since 2000, rising from 15,410 MT. to 29,364 MT. in 2009 (Table 5 and Fig. 2).

Table 3. Details of various chemical fertilizers usage in the Chalan *beel* areas in 2008 and 2009

Upazilla	Fertilizers (MT)																	
	Urea		TSP*		SSP*		DAP*		MOP*		NPKS*		GYPSUM*		ZINC		BORON	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Singra	15700	14999	7978	3077	388	3077	809	68	5467	607	160	2326	4788	48	574	177	300	96
Gurudaspur	5506	5651	635	598	-	-	359	380	437	-	-	2	197	273	31	33	-	91
Boraigram	7315	8826	1595	2250	145	301	708	946	1225	1700	56	537	313	672	36	95	6	59
Chatmohar	6658	7050	488	1962	13	3455	690	3115	235	1559	341	725	286	575	44	130	-	133
Bhangura	3412	3600	685	960	1579	1686	1422	1502	497	508	31	36	247	255	37	50	44	73
Faridpur	2530	4300	180	839	39	1825	269	1309	90	494	136	36	105	250	16	40	-	-
Shahjadpur	7900	8008	2601	2889	-	-	-	210	2901	2953	206	7	1204	1372	145	95	6	5
Ullapara	8775	11920	3015	2850	-	-	25	50	2512	2405	230	350	1350	350	148	150	6.5	7
Tarash	5546	1653	2086	360	168	160	700	100	2640	300	800	54	1400	180	110	2	-	-
Raigang	9000	2500	90	250	250	50	420	100	1050	250	50	15	520	150	110	30	10	3
Total	72342	68507	19353	16035	2582	10554	5402	7780	17054	10776	2010	4088	10410	4125	1251	802	372.5	467

**TSP-Triple super phosphate, SSP-single super phosphate, DAP-diammoniaum, phosphate, MOP-murate of Potash and NPKS-nitrogen, phosphorus, potassium and sulpher*

Table 4. Crop land area and number of farmers in Chalan *beel* area

District	Area of crop land (ha)	Number of farmers					
		Large	Medium	Small	Marginal	Landless	Total
Natore	74,956	6261	14,995	16,129	16,723	16,696	70,804
Pabna	46,093	5667	636	17,985	34,540	5520	64,348
Sirajgonj	67,330	3476	3008	22,944	15,189	12,039	56,656
Total	188,329	15,404	18,640	57,058	66,452	34,255	191,809

**Large farmer: >3.0 ha, medium farmer: 1.0-3.0 ha, small farmer: 0.60-1.0 ha, marginal farmer: 0.20-0.60 ha, landless farmer: below 0.2 ha*

Table 5. Group wise pesticide consumption for the year 2000-2009

Name of pesticides		Figures in MT (KL – Kiloliter for the liquid)									
		2009	2008	2007	2006	2005	2004	2003	2002	2001	2000
Insecticides	Granular	16971	16147	15023	14282	14061	12113	11781	12335	10138	10113
	Liquid	2698	2583	2543	2523	2511	2008	1831	1497	1286	1150
	Powder	387	327	292	279	268	192	123	115	87	76
Miticide		102	85	71	62	56	37	32	27	25	21
Fungicide		6826	6359	6113	5881	5772	4297	5772	4279	3308	3278
Herbicide		3747	3211	2841	2791	2775	3463	1354	964	901	876
Rodenticide		46	39	28	25	23	23	19	36	31	27
TOTAL		30777	28751	26911	25843	25466	22115	18080	17357	15776	15541

Source: Bangladesh crop protection association (BCPA)

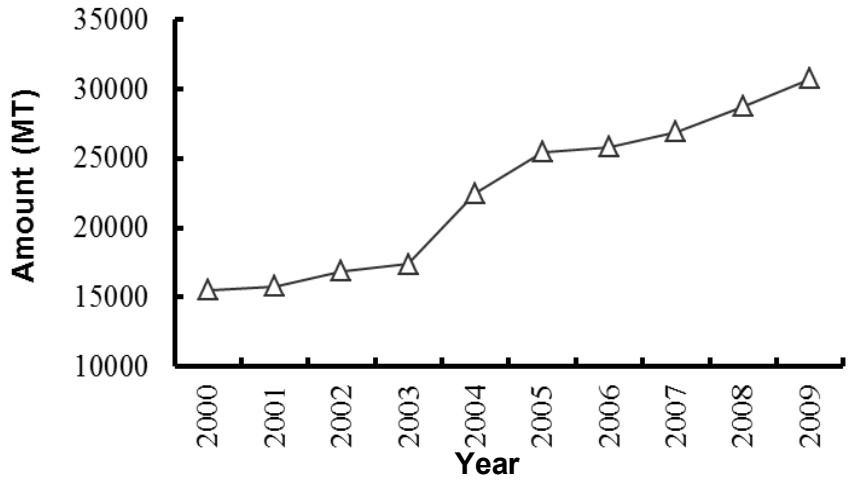

Fig. 2. Pesticide usage in Bangladesh

It was observed that about 117 different kinds of pesticides were used in the Chalan *beel* area. The dominant pesticides usages in Chalan beel with their prescribed and used doses are presented in Table 6. The average pesticide usage in crop land inside Chalan *beel* was 2.76 kg ha^{-1} $crop^{-1}$. The fish farmers also being used several pesticides, eg. Sumithion 50EC, Nogos100EC and Dipterex 80SP during the pond preparation more or less below the recommended level.

Chalan *beel* occupies around 18% share of the country's total *beel* area but importance is given always on cereal food production ignoring the poor people's access to fisheries as easy protein sources. The development initiatives of the Chalan *beel* only focused on agriculture crop rather than biological management of this rich floodplain system for fish production. The government of Bangladesh has formulated some laws, policies to conserve and protect the environment.

Interestingly, many pesticides found in aquatic systems were not intended or legally registered for application to aquatic systems, but they still [20]. Various government and non-government agencies in Bangladesh have been campaigning against using of pesticides. They have been motivating and suggesting farmer to apply IPM (Integrated Pest Management) and ICM (Integrated Crop Management) for controlling the harmful insects.

3.4 Farmers' Knowledge on Pesticide usage

Lack of proper knowledge of the pesticide users has led to administer widespread and excessive quantity of pesticides. Majority of the respondents (68%) in the survey conducted during the study period agreed that they lacked proper knowledge regarding the residual effects of pesticide usage. The information they received on pesticide usage came from pesticide seller (57%), neighboring farmers (26%) and different extension services (18%). About 51% respondents opined that pesticides usages had many harmful effects. Among the harmful effects, 13% respondents thought that pesticides killed useful insects and animals, whereas 11% believed that pesticides had adverse effect on fish biodiversity. Around 8% farmers thought that number of migratory birds are decreasing because of using pesticides and around 7% farmers perceived that it also have negative impact on human health and agro-bio diversity whereas only 5% perceived adverse impact on soil fertility (Table 7).

3.5 Impacts on Fish Biodiversity

The provision of drainage and flood control under FCDI offered large opportunities to increase the cropping intensities during the monsoon. As a result, rice production increased but at the same time fish biodiversity decreased overtime due to severe lack of water in the Chalan *beel* and use of high amount of detrimental pesticide in the crop field. The frequent incidences of fish mass mortality have been reported by the Upazila Fisheries Officers in the Chalan *beel* area (Table 8).

Every year incidence of different types of fish mass mortality were recorded by the fishery officer during 2007 and 2008 in ten upazilas where the estimated damage was not so more in monetary value, but the tendency of incidences are increasing day by day. The fish breeding grounds were also destroyed. A large number of deep tube-well, shallow tube-well and low lift pump were used for irrigation purposes in entire *beel* area. Therefore, farmers are more interested in culturing rice crops ignoring the importance of fisheries in and around the Chalan *beel*. In the late monsoon, landowners install the brush park demarking their area with the objective of capturing fish by pumping out the remaining water during winter.

Table 6. The common pesticides usages by the crop and fish farmers in the Chalan *beel* area

Trade name	Active ingredient	Recommended dose	Company name
Brifur5G	Carbofuran	10 kg ha^{-1}	ACI BD. Ltd.
Bisterin 5G	Carbofuran	10 kg ha^{-1}	Alfa-Agro BD. Ltd
Alfafuran 5G	Carbofuran	10 kg ha^{-1}	Alfa-Agro BD. Ltd
Chloropyrifos 20EC	Chloropyrifos	740 ml ha^{-1}	Alfa-Agro BD. Ltd
Basudin10G	Dizinon	15 kg ha^{-1}	Syngenta BD.Ltd
Karate 2.5EC	Lambdcyhalothrin	740 ml ha^{-1}	Syngenta BD.Ltd
Furadan 5G	Carbofuran	10 kg ha^{-1}	Padma Oil Company Ltd
Diazinon 60EC	Diazinon	740 ml ha^{-1}	Mcdonal BD.Pvt. Ltd
Agrifuran 5G	Carbofuran	10 kg ha^{-1}	3-Star Ltd
Forwafuran 5G	Carbofuran	10 kg ha^{-1}	Corbel Co. BD. Ltd
Sumithion 50EC	Fenitrothion	3 mg l^{-1}	-
Nogos100EC	Dichlorvos	3 mg l^{-1}	-
Dipterex 80SP	Trichlorphon	3 mg l^{-1}	-

Table 7. Farmers' perception on the adverse effect of pesticide usage

Farmer's perception	Response (%)
Pesticide have harmful effect	51.1
Kill beneficial insects and microorganism	12.7
Affect fish biodiversity	10.6
On birds	8.4
On human health	7.3
On agro-bio diversity	6.9
On soil fertility	5.2
Pesticide do not have harmful effect	37.6
Non response	11.3

It was observed that the fish production in Chalan *beel* reduced by 31%, 52% and 56% in 1992, 2002 and 2009, respectively when compared with the production of 1982 [5]. The trend of pesticide usage and fish production is presented in Fig. 3. Initially, the pesticide usage was increasing in a slow rate whereas the fish production was decreasing faster. However, in the twenty first century its usage increased more and the trend of fish production decrease was slower that might be due to the activities of different fisheries development activities in the Chalan *beel* area.

Table 8. List of fish mass mortality incidences reported due to over usage of different pesticides in the Chalan *beel* during the study period

Upazilla	2007			2008		
	Number of incidence	Amount of dead fish (kg)	Value of dead fish (USD)	Number of incidence	Amount of dead fish(kg)	Value of dead fish (USD)
Major incidences						
Singra	2	125	188	1	75	125
Gurudaspur	3	175	281	2	225	344
Boraigram	1	25	39	0	0	0
Chatmohar	4	525	938	4	650	1319
Bhangura	2	155	250	3	175	288
Faridpur	1	65	100	0	0	0
Shahjadpur	0	0	0	2	180	338
Ullapara	2	250	400	3	450	938
Tarash	3	310	563	4	560	1375
Raigang	1	55	94	1	85	169
Total	19	1,685	2851	20	2,400	4894
Moderate incidences						
Singra	2	25	38	4	75	100
Gurudaspur	4	75	106	7	75	106
Boraigram	1	12	19	2	34	52
Chatmohar	6	55	94	4	45	69
Bhangura	3	15	31	4	45	81
Faridpur	2	25	44	5	40	69
Shahjadpur	3	35	53	7	55	90
Ullapara	5	60	100	8	60	100
Tarash	6	70	106	6	80	113
Raigang	2	25	40	4	35	65
Total	34	397	630	51	544	844
Minor incidences						
Singra	5	5	9	6	10	15
Gurudaspur	7	0	0	9	0	0
Boraigram	3	0	0	4	0	0
Chatmohar	6	5	9	5	12	19
Bhangura	4	0	0	8	10	20
Faridpur	3	5	9	5	2	3
Shahjadpur	4	0	0	7	5	8
Ullapara	8	5	8	10	0	0
Tarash	12	10	16	11	15	26
Raigang	3	5	9	7	10	16
Total	55	35	59	72	64	107
Grand total	108	2,120	3540	143	3,008	5845

Natural recruitment of the fish has been declined and a large number of non-migratory, resident fish spawners have mostly lost their breeding grounds [5]. Many valuable indigenous fish species are now under threat, depleted or fully disappeared from the important fish habitats of Bangladesh – the Chalan *beel* (Table 9).

In our study, about eight species viz., *Setipinna phasa, Chitala chitala, Ompok bimaculatus, Pangasius pangasius, Eutropiichthys vacha, Mystus aor*, *Gangata youssoufi* and *Labeo boga* were identified as disappeared from the *beel*. Another 11 species viz., *Rhinomugil corsula, Tenualosa ilisha, Puntius sarana, Rita rita, Ompok pabda, Lepidocephalichthys berdmorei, Labeo calbasu, Labeo gonius, Puntius chola, Chelonodon patoca, Tetraodon cutcutia* were found to be at the verge of extinction. Therefore, pesticides usage in the paddy field had drastically decreased the variety of fishes while many have become extinct for using the pesticides in the paddy fields in the course of time.

The residues of huge amount of pesticide used in the Chalan *beel* area eventually washed out into the surrounding river and *beel* systems. Almost all respondents concluded that the indiscriminate use of pesticide and change in cropping practice were responsible for fish biodiversity degradation of the Chalan *beel*. Hossain and Halder [16] reported that 70% farmers agreed that the main cause of disappearance of the fish from the waterbody was the usage of excessive and banned pesticide. Lethal dose and even at sub lethal dosage of chemical residues of pesticides largely attributed to cropland runoff contaminants [21] killed fish as well as other aquatic organisms [13].

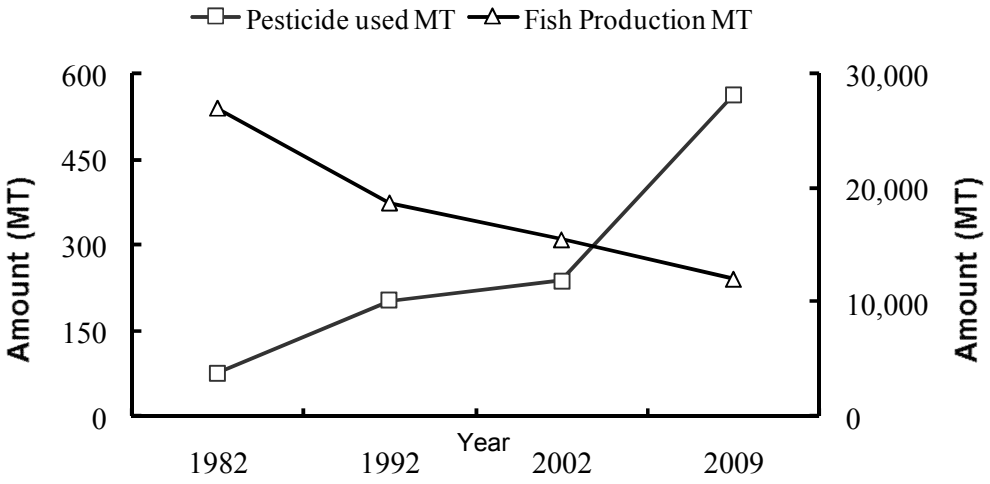

Fig. 3. Trends of fish production and pesticide usage in Chalan *beel*

Table 9. Threatened fish species in Chalan *beel*

Order	Family	Species	Order	Family	Species
Cypriniformes	*Cyprinidae*	*Labeo calbasu*	*Siluriformes*	*Siluridae*	*Ompok bimaculatus*
		Labeo gonius			*Ompok pabda*
		Labeo boga			*Gangata youssoufi*
		Puntius sarana		*Bagridae*	*Mystus aor*
		Puntius chola			*Rita rita*
	Cobitidae	*Lepidocephalichthys berdmorei*		*Schilbeidae*	*Eutropiichthys vacha*
	Clupeidae	*Tenualosa ilisha*		*Pangasidae*	*Pangasius pangasius*
	Engraulidae	*Setipinna phasa*	*Tetraodontiformes*	*Tetraodontidae*	*Chelonodon patoca*
Osteoglossiformes	*Notopteridae*	*Chitala chitala*			*Tetraodon cutcutia*
Mugiliformes	*Mugilidae*	*Rhinomugil corsula*			

4. CONCLUSION

Chalan *beel* is a moderate productive water body with decreasing fish species diversity. It is the duty of concerned GOs, NGOs and the people of the country to control the gear efficiency, stop the illegal usage of harmful pesticides and provide alternative livelihood options to the resource-poor fishers along with other measures. Thus care must be taken to protect ecosystem and the ecological balance by developing mills and other agricultural development in a planned way in this area. Moreover, 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 remaining, highly marginal fishermen in the largest *beel* of Bangladesh - the Chalan *beel*. Finally, more in depth research is needed to ensure the chemical and pesticide contamination and its impact on Chalan *beel* and its resources (namely; fisheries). The findings obtain from this study can be used for analysing the correlations between fish responses and chemical contamination not only in Chalan *beel* but also the other inland water bodies of Bangladesh.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX-1A

Questionnaire for Fishermen

1. General Information

1.1 Name:
1.2 Father's/ Husband Name:
1.3. Address:
1.4 Category of fisher person
1=Full time, 2=part time, 3=occasional

2. Socio Economic Information

Age	Family size	Gender	Marital status	Education	Alternate Occupation	Annual Income (Tk)
		Male- 1 Female-2	Married-1 unmarried-2 widow-3 divorsy-4	Can sign and count - 1 1-5 years school-2 6-10 years of school - 3 SSC & above-4	1-Agriculture 2-Businness 3-Daily labor 4-Others (specify)	

3. Crafts & Gears

3.1 Water transports and uses

Sl No	Type of transport	Size (m)	Use[1]	Duration of use (month[2])	Number of personnel engaged

[1]Type of use: 1=fishing, 2=carrying passengers as business, 3=carrying goods as business, 4= own goods and family members carrying 2Please mention the name of months

3.2 What types of gear used for fishing in Chalan *beel*?
3.3 Which fish generally caught in those types of gears?

Sl No	Gear type	Material used	Dimension & using techniques	Fish species

4. Fishing

4.1 Which fishing points covered?
4.2 How many times you engaged in fishing per 24 hours?
4.3 Fishing season (Please mention the months)

Pick season	Less pick season	Off season

4.4 What is your work during off season (when no water existed everywhere)?
1= farming agriculture, 2=business, 3=nothing did, 4=day labor 5=others (specify)
4.5 Which amount fish you caught per day?
4.6 How many days you engaged in fishing in a season?
4.7 Which month's water existed everywhere?
4.8 Which months were most favorable for fishing?
4.9 Which fishes are mostly available now in this area?
4.10 Which fishes are mostly rare now in this area?
4.11 What type of change in quantity of your catching fish have you observed during the last 5 years?
1=same, 2=decreasing, 3=increasing
If quantity is decreased please mention the reason you think.
4.12 In your opinion, how can the quantities of fish be increase in Chalan *beel* area?
4.13 What are the problems you face in marketing of fish?
4.14 What types of problems do you face in catching fish from the *beel*?
4.15 Which fish species are not found considerably now-days in your area? (Mention 5 species)

Signature

Appendix-1B

Questionnaire for fish farmer

1. General information
1.1 Name: 1.2 Father's/ Husband Name: 1.3. Address:

2. Pond ownership type

Ownership code: Single -1, Multiple -2, Leased -3
Lease period (years) : Lease cost (Tk/year):

3. Pond type Perrenial-1, Seasonal-2

4. Pond characteristics

4.1 Area of the Pond (decimal) Water area: Dyke area:
4.2 Average Depth of the Pond (ft) 4.3 Age of the Pond (years):
4.4 Soil Type Loamy -1, Clay -2, Red-3, Sandy-4, and Sandy-loam-5

5. Fish culture

5.1 Experience of fish culture (Year):
5.2 Source of fry
1=wild fish stock, 2=fingerling stock from external sources, 3=wild & fingerling both.
5.3 Please mention the Fish culture period (days and name of months)
5.4 Did you fish culture in the previous year (2007) Yes-1, No-2

If yes, what were the species cultured (Please use tick and mention the numbers)

Catla……	Bighead carp…….	Silver carp……	Telapia……
Rui……	Grass carp…….	Raj puti……	Thai pangus……
Mrigal……..	Kalibaus…….	Carpio…….	Others……

5.5 What was the source of fingerlings? 1=hatchery, 2=river, 3=beel
24.6 Did you use supplementary feed (oil cake, rice bran etc.)?
1=always used, 2=sometimes used, 3= never used
5.7 Did you use all the fish culture inputs (Lime, urea, TSP, cow dung, poultry droppings etc.)?
1=always used, 2=sometimes used, 3= never used
5.8 Please mention the amount of fish prod. in 2007. ……. .Kg
5.9 Please mention the fish culture cost 2007. Tk …….
5.10 Please mention the income from fish culture Tk ……..
5.11. Have you received any training about fish culture? Yes-1, No-2
5.11. Are you happy with present production? 1= Very 2= moderately
3= Unhappy

6. What is your alternative occupation?

Signature of Data Enumerator
Date

APPENDIX-1C

Questionnaire for key informant

Name of UFO: **Upazilla:**

1	**No of Union:**	
	Inside CB:	Outside CB:
2	Area	
	Inside CB:	Outside CB:
3	Population:	
	Inside CB:	Outside CB:
4	No of Village:	
	Inside CB:	Outside CB:
5	Literacy rate (%):	
6	No of River(s):	Name of the river(s):
7	No of Beel(s):	Name of Beel(s):
8	Fish Culture in Chalan *Beel*:	Area of Pond (dec):
	Total No of Pond:	Area of Boropit (dec)
	Total No of Boropit:	Monoculture-
	Types of Culture, Polycuture-	

- Name the species used for fish culture-
- What is the major source of fingerling with (%) for fish culture?

River- *Beel*- Hatchery-

- Which technologies are popular for fish culture in Chalan *beel* area (list chronologically)?
- Which inputs are used for fish culture?
- Mention the chemicals and pesticides with doses used in fish culture-

Trade name	Chemical name	Mode of use	Price	Rec. dose	Used dose	Source	Season	Import channel

- Purpose of pesticides/chemicals use-
- Have you heard/faced any incidents due to use of pesticides and chemicals (if any, please mention number and loss kg and Tk.)
- Severe- No. Loss (kg)- Loss (Tk)-
- Moderate- No. Loss (kg)- Loss (Tk)-
- Minor No. Loss (kg)- Loss (Tk)-
- Generally, which people are involved in fish culture?

Local elites- youths- professional fish culturist- others-

- Culture –wise production per decimal

Polyculture- Monoculture- rice fish- cage culture-

9. Total fish production from different waterbodies:

Total aquaculture production (kg):	Total Open water production (kg):
Total beel production (kg):	Total river production (kg):
Total floodplain production (kg):	

9. Please mention the name of destructive gears (no.) used in the chalan *beel*?

10. Please mention the number and name of the NGO concerned with fisheries activities

11. Number of fisheries cooperative society with member:

12. Please mention the name and number of different institutions-

13. Effect of infrastructure on the fishery:

APPENDIX-1D

Questionnaire for crop farmer

1. General Information

1.1 Name: 1.2 Father's/ Husband Name: 1.3. Address:

3. Land Owned by the Household

Crop Land (decimal) – Homestead (decimal) –
Leased land (decimal) - Pond area (decimal)-

4. Farming

4.1 Farming experience (Year) 4.2 cropping pattern: (1/2/3crop in a year)
4.3 Variety used (rice, wheat & other major crops): 4.4 Aquaculture

5. Which methods do you use to control pests? Pesticide/IPM/Resist.Varieties/No ans.

5.1 Do you use Pesticide/chemicals/Fertilizers in your lands? If, yes

5.1.1 Particulars of usages of pesticides/chemicals/Fertilizers for crop farming and aquaculture?

Sl. No.	Name of pesticides/chemicals/Fertilizer	Dose	Season	Days after planting	Name of Crop	Freq/ Yr
1	2	3	4	5	6	7

5.2Where did you learn how to use the pesticide? From DAE/farmers/pesticide shop or dealer/retailer/No. answers

5.3 How often do you see extension workers (times/yr)?

5.4 Any problems related to important pesticides? Cost of pesticides/Health effects/Environment effects/No. answers

5.4.1 Pesticides have harmful effect and kill beneficial insects and microorganism/ Reduce fish biodiversity/ birds/agro-bio diversity/soil fertility.

5.4.2 Pesticides have harmful effect

5.4.3 Pesticides do not have harmful effect

5.4.1 Have pesticides been a problem for your health? Yes/No/Don't know/No. ans.

5.4.2 What Kind of health problem from pesticides spraying? Get tired/Feel hot and itchy/Feel dizzy/Get headache/No. answers.

5.4.3 Which pesticides are problems for your health? Inse. /herb./ fung./No. ans. 5.4.4 Do you use any protection when spraying?

6. Can pesticides have a negative effect on the yield? Yes/No/Do not know/ No. answers
7. If, yes, Why? Pesticides are toxic to fish/Natural feed for the fish decrease/Fish growth decrease/No. answers

8. Do you apply IPM? If, yes, give example) No insecticides the first forty days/ Adjust pesticide use to pest infestation/ Limit pesticide use/ No. answers

9. Would you like to start with IPM? Yes/No// No. answers

10. Reasons for applying start with IPM? Lower cost/ Protect health/ protect the environment/No. answers

Enumerator
Date

APPENDIX-1E

Questionnaire for pesticide dealer

1. General Information

1.1 Name: 1.2 Father's/ Husband Name:
1.3. Address:

2. Socio Economic Information

Age	Family size	Gender	Marital status	Education	Annual Income (Tk)
		Male- 1 Female-2	Married-1 unmarried-2 widow-3 divorsy-4	Can sign and count -1 1-5 years school-2 6-10 years of school -3 SSC & above-4	

3. Business Experience (Year)

4. Pesticide

4.1 Number of pesticide sold in the previous year (2007):

4.2 Important pesticides (10):

Trade name	Chemical name	Mode of use	Price	Rec. dose	Used dose	Source	Season	Import channel

4.3 Amount and monitory value of pesticide:

2006		2007		2008	
Amount (kg)	Cost (Tk)	Amount (kg)	Cost (Tk)	Amount (kg)	Cost (Tk)

4.4 Pesticide selling:

Most selling months	Less selling months

Signature of Data Enumerator

Date

APPENDIX-1F

Questionnaire for key informant

Name of UAO: **Upazila:**

1. Please mention important pesticides:

Trade name	Chemical name	Mode of use	Price	Rec. dose	Used dose	Source	Season	Import channel

2. Mention the name and amount of various chemical fertilizers used in the year 2007 and 2008:

3. Amount and monitory value of pesticide:

2004		2005		2006		2007		2008	
Amount (kg)	Cost (Tk)	Amount (kg)	Cost (Tk)	Amount (kg)	Cost (Tk)	Amount (kg)	Cost (Tk)	Amount (kg)	Cost (Tk)

4. What are the harmful effects of pesticide (Please few words)?

On Fish	On Bird
On Agriculture	On Human
On environment	

5. Area of crop land (ha):
6. Cropping pattern:
7. Number of farmers: Small farmers-
   Marginal farmers- Large farmers-
8. Important rice variety:
9. Important agriculture product:

Cereal crop	Pulse	Spice	Vegetables	Others

Enumerator:
Date:

APPENDIX-1G

Catch assessment survey sheet

Ref No.	Site No.	Location	Date	Recorder

1. Name and address of the Fisherman:
2. Amount of catch:
3. Amount of sample:
4. Duration of Fishing:
5. No. of fishing days in a week in this site:
6. Species-wise weight of fishes:

Common name	Code	No. of fish	Weight(g)	Comments

Fishing effort survey sheet

Ref No.	Site No.	Location	Date	Recorder

Gear type	Recorded numbers during sampling times						Remarks
Name	6-8 am	8-10 am	10-12 am	12-14 pm	14-16 pm	16-8pm	

Questionnaire for gear survey

1. Name: 2. Address:

3. Description of the gear:

Name of the gear	L×W×H & materials used	Making cost/Piece	Fish species and amt. per day	Used month	Remarks

Species check list

Code	Species	Code	Species
201	*Anguilla bengalensis bengalensis*	217	*Amblypharyngodon mola*
202	*Congresox talabon*	218	*Aspidoparia jaya*
203	*Pisodonophis boro*	219	*Aspidoparia morar*
204	*Chitala chitala*	220	*Chagunius chagunio*
205	*Notopterus notopterus*	221	*Chela cachius*
206	*Gonialosa manmina*	222	*Chela laubuca*
207	*Gudusia chapra*	223	*Rasbora daniconius*
208	*Tenualosa ilisha*	224	*Megarasbora elanga*
209	*Setipinna phasa*	225	*Catla catla*
210	*Setipina taty*	226	*Cirrhinus cirrhosus*
211	*Acanthocobitis botia*	227	*Labeo ariza*
212	*Botia dario*	228	*Labeo bata*
213	*Botia dayi*	229	*Labeo boga*
214	*Botia lohachata*	230	*Labeo calbasu*
215	*Botia rostrata*	231	*Labeo gonius*
216	*Lepidocephalichthys guntea*	232	*Labeo rohita*
233	*Somileptus gongota*	274	*Batasio batasio*
234	*Salmostoma acinaces*	275	*Batasio tengana*
235	*Salmostoma bacaila*	276	*Hemibagrus menoda*

Code	Species	Code	Species
236	*Salmostoma phulo*	277	*Mystus armatus*
237	*Securicula gora*	278	*Mystus bleekeri*
238	*Danio rerio*	279	*Mystus cavasius*
239	*Esomus danricus*	280	*Mystus tengara*
240	*Mystus vittatus*	281	*Puntius conchonius*
241	*Rama chandramara*	282	*Puntius gelius*
242	*Rita rita*	283	*Puntius phutunio*
243	*Sperata aor*	284	*Puntius sarana*
244	*Sperata seenghala*	285	*Puntius sophore*
245	*Chaca chaca*	286	*Puntius ticto*
246	*Clarias batrachus*	287	*Poropuntius clavatus*
247	*Heteropneustes fossilis*	288	*Raiamas bola*
248	*Pangasius pangasius*	289	*Psilorhynchus sucatio*
249	*Ailia coila*	290	*Conta conta*
250	*Ailichthys punctata*	291	*Erethistes hara*
251	*Clupisoma garua*	292	*Erethistes jerdoni*
252	*Eutropiichthys vacha*	293	*Erethistoides infuscatus*
253	*Neotropius atherinoides*	294	*Pseudolaguvia shawi*
254	*Silonia silondia*	295	*Pseudolaguvia inornata*
255	*Ompok bimaculatus*	296	*Pseudolaguvia murikata*
256	*Ompok pabda*	297	*Pseudambassis baculis*
257	*Ompok pabo*	298	*Anabas testudineus*
258	*Wallago attu*	299	*Badis badis*
259	*Bagarius bagarius*	300	*Channa gachua*
260	*Gagata cenia*	301	*Channa marulius*
261	*Gagata gagata*	302	*Channa punctata*
262	*Gagata youssoufi*	303	*Channa striata*
263	*Gogangra viridescens*	304	*Glossogobius giuris*
264	*Parachiloglanis hodgarti*	305	*Rhinomugil corsula*
265	*Aplocheilus panchax panchax*	306	*Sicamugil cascasia*
266	*Monopterus cuchia*	307	*Nandus nandus*
267	*Mastacembelus armatus*	308	*Colisa lalia*
268	*Macrognathus aculeatus*	309	*Polyacanthus fasciatus*
269	*Macrognathus pancalus*	310	*Trichogaster chuna*
270	*Chanda nama*	311	*Xenentodon cancila*
271	*Parambassis ranga*	312	*Hyporhamphus limbatus*
272	*Osteobrama cotio cotio*	313	*Chelonodon patoca*
273	*Puntius chola*	314	*Tetraodon cutcutia*

APPENDIX-1H

Water and sediment quality parameters sampling sheet

For the month of **Date:**

Water quality parameters

Sl no.	Parameters	S_1	S_2	S_3	Remarks
1.	Water depth (cm)				
2.	Temperature (ºC)				
3.	Transparency (cm)				
4.	P^H				
5.	Alkalinity				
6.	Conductivity(COND)				
7.	Total suspended solids(TDS)				
8.	Nitrate (NO_3)				Monthly
9.	Ammonia (NH_3)				
10.	Phosphate (PO_4)				

Sediment quality parameters

Sl no.	Name of elements	S_1	S_2	S_3	Remarks
1.	Soil pH (SPH)				
2.	Organic matter (%)				
3.	Potassium (Ex-K)				Quarterly
4.	Total Nitrogen-TN (%)				
5.	Available phosphorus				

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