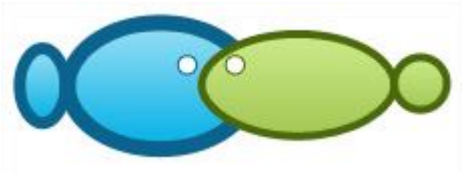

Impact of agrochemicals on fish production in two important beels of Bangladesh

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Abstract. Water bodies often receive agrochemicals indiscriminately, but we know little about the effects of agrochemicals on the flora and fauna of the water bodies. In this study we assess the direct effects of pesticides and fertilizer on the fish production and biodiversity of two important beels; Hilna beel and Kumari beel of Rajshahi district, Bangladesh from July 2007 to June 2009. The result shows that in Hilna beel 2.92 kg ha^{-1} and Kumari beel 2.95 kg ha^{-1} pesticide was used. The amount was found to be increased 1.41 times for Hilna beel and 1.44 times for Kumari beel from 2005 to 2009. The results documented that fish production in both beels was decreased with the increment of pesticides used. The results obtained from this study will improve the understanding of the influence of agrochemicals on the important small indigenous fishes.

Key Words: agrochemical, fertilizer, beel, biodiversity, fish.

Introduction. Beels are parts of a riverine complex, being generally formed due to changes in the course of a river or strengthening of river embankments for flood control (Saha et al 1990), these potentially rich inland fishery resources are known as “floodplain wetland” (Das 2002). Locally, these floodplain wetlands are known as beels in Bangladesh and India especially in the states of Assam, West Bengal, Arunachal Pradesh, Manipur, Meghalaya and Tripura (Sugunan & Sinha 2001; Bandyopadhyaay & Hassan 2002). These aquatic bodies are usually rain fed and may possess a completely separate ecosystem than pond or river and other wetlands. These open water habitats are naturally rich in various species of fishes and provide considerable fish production of the country.

The beels generally poses high potential for its high production. The vast open water bodies provide natural habitats for various aquatic resources including wild fishes and prawns (Das et el 1990). The open water fisheries resources are declining day by day due to lack of proper management policy, over fishing, unplanned establishment of flood controlled drainage (FCD) and flood control drainage and irrigation dams (FCDI). Every year about 8000 mt. of pesticides are used in agriculture fields of Bangladesh (BFRI 2005). As a result about 54 indigenous species among 260 fresh water species is about to extinct which are born in floodplains and beels and these are main nutrition source of poor people (Haque et al 2010). Among many beels of Rajshahi district, Hilna beel and Kumari beel are two of the most important beels contributing to the adjacent people’s livelihood. In recent years fish production from these sources has alarmingly declined (Haque et al 2010; Sultana et al 2003). Although the culture fisheries sector has

always got to the key attention for the enhancement of fish production, the sector failed to meet the per capita fish requirement for the nation. This could not keep pace with the increasing demand of the people due to a static as even declining trends of its more resourceful inland open water and marine counterparts (Haque et al 2010).

Pest control is an integral part of modern agriculture to protect crops, but unfortunately it has fatal impact on the environment. Until 1940's, the naturally occurring pesticides were in common use. Inorganic fertilizers have been introduced into this country during early 1950's as a supplemental source of plant nutrients. Until 1980, three primary major plant nutrients, Nitrogen (N), Phosphorus (P) and Potassium (K) along with one secondary, Calcium (Ca) were used in soil nourishments. Since then, the use of fertilizer was progressively increased over the years, especially in intensive cultivation of high yielding crop varieties. Due to such a development, the productivity of soils is likely to be seriously affected (BARC 2005). Meanwhile, pesticide use in Bangladesh started from mid 1950s and gained momentum in late 1960s with the introduction of green revolution through the use of high yield variety (HYV) rice in the country (Rahman 2004). Farmers have been receiving extension services and considerable subsidies from the government over the years (Rasul & Thapa 2003). As a result of this expansive policy and to minimize the increasing demand of staple food, pesticide use has been increased tremendously.

HYV Boro cultivation is common in the catchment area of the beel. Due to indiscriminate use of fertilizer and pesticides, the environment of the beel is undergoing gradual changes. Farmers mainly use urea, triple super phosphate (TSP), muriate of potash (MP) and zinc fertilizers in the crop fields as well as pesticides like Basudin, Diazinon, Furadan in the rice fields around the beel that are toxic to aquatic animals (CPP 1992). The run-off water coming from the farmers' fields always carries a proportion of the applied fertilizers and pesticides and thereby pollutes the beel water (Ahmed 1985). Severe depletion of fisheries resources of the beel is reported due to water pollution (Alam et al 2007).

Pesticide affects the aquatic ecosystem by interrupting the aquatic food chain of open water ecosystem and finally results in the loss of fish abundance of natural species (Parveen & Faisal 2002). Besides fish mortality, there are also chronic effects of pesticides including changes in reproductive system, metabolism, growth patterns, food availability and population size and number. However, the indiscriminate use of insecticides and pesticides in the crop fields by the farmers is one of the main causes of disappearance of fish from the natural waters in Bangladesh.

In an attempt to reduce pesticide use, important changes have taken in strategic approaches to plant protection. Integrated Pest Management (IPM) methods have brought ecological principles and social scientific perspectives into traditional crop management (Huan et al 1999). The objective of this study was to assess the direct effects of pesticides and fertilizer on the fish production of two important beels; Hilna beel and Kumari beel of Rajshahi district, Bangladesh.

Material and Method

Study area. The study was conducted two year period from July 2007 to June 2009 on Hilna beel and Kumari beel the two important water bodies of Rajshahi, Bangladesh. The beels are basically floodplains and the areas of Hilna beel and Kumari beel covers about 1500 and 996 ha in rainy season and 160 and 156 ha in dry season respectively. The geographical position of Hilna beel and Kumari beel are from 88°38' to 88°39' and from 88°33' to 88°34' longitude and from 24°37' to 24°38' and from 24°35' to 24°36' latitude, respectively (Figure 1).

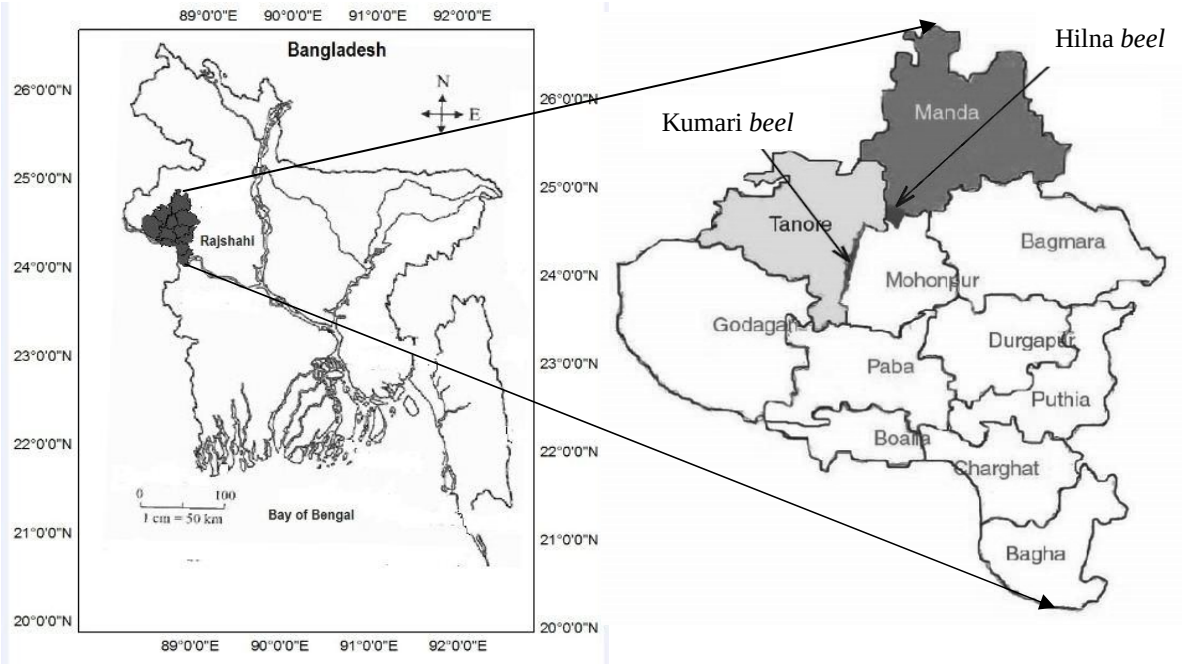

Figure 1. Maps indicating study areas. Dense marked and arrow denotes sampling site (Alam et al 2015).

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.

Table 1

Number of key informants interviewed in two beels

Key informants	*Activities*	*Number*	
		Hilna beel	*Kumari beel*
Pesticides dealers	Interviewed	3	2
Pesticides retailers	Interviewed	6	4
Crop farmers	Interviewed	30	15
Fishermen	Interviewed	30	15
Upazila Agriculture Officers (UAO)	Interviewed	3	1
Upazila Fisheries Officers (UFO)	Interviewed	3	1
Total		75	38

Besides, nine focus group discussions (FGD) were conducted (three for Kumari beel and six for Hilna beel) 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. The questions were asked systematically in a very simple lay-man manner with explanations wherever necessary. Local customs and manner was always followed for collecting information. New information and respondents' attitudes were recorded. The recorded data was crosschecked subsequently.

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 2003 computer program (Zar 1984).

Results

Physical characteristics. The details of physical characteristics of Hilna and Kumari beel area are given in Table 2. The studied Hilna beel covers three upazila, which is a geographical region in Bangladesh used for administrative or other purposes (Tanore, Mohonpur and Manda) whereas Kumari beel covers two upazila (Tanore and Mohonpur). The number of village and pesticide dealers involved with Hilna beel almost 3 times to that of Kumari beel. Also the no. of pesticide retailers and area of land pesticide used (ha) were 1.5 times higher in Hilna beel than Kumari beel. But cropping area and pesticide retailer ratio and pesticide usage in rice field (kg ha^{-1}) were similar in both beels. In Hilna beel around 75% people used deep tube well water for irrigation and 80% in Kumari beel. The rest were used beel water as a source of irrigation.

Table 2

Physical characteristics in the studied beels

Characteristies	*Hilna beel (ha)*	*Kumari beel (ha)*
No of district	02	01
No of upazila covered by the beel	03	01
No of village mostly involve with the beel	11	4
No of pesticide dealers	8	3
No of pesticide retailers	12	8
Area of land pesticide used (ha)	1340	840
Cropping area and pesticide retailer ratio (ha)	111.67	105
Pesticide usage in rice field (kg ha^{-1})	2.92	2.95
Water usage for irrigation (%)		
Beel water	26	21
Deep tube well	74	79

Use of chemical fertilizers. Details of various types of chemical fertilizers usage in Hilna and Kumari beels area are shown in Table 3. Yearly over 1000 and 600 metric ton (mt) fertilizers used in Hilna beel and Kumari beel respectively which ultimately drained out to the beel waters causing serious problem. A total of 1092.7 and 1187.52 mt. chemical fertilizers of different types in Hilna beel and 611.51 and 615.39 mt. in Kumari beel were used in 2007-2008 and 2008-2009 respectively (Table 3). Farmers are using more fertilizer except NPKS and Zinc. They are using Boron without recommendation of Upazilla Agriculture Office due to insistence of fertilizer dealer. Some elite farmers are interested to use overdose fertilizer.

Table 3

Details of various chemical fertilizers usage in Hilna and Kumari beel areas in 2008 and 2009

Fertilizer	*Hilna beel (mt)*		*Kumari beel (mt)*	
	2007-2008	*2008-2009*	*2007-2008*	*2008-2009*
Urea	610.25	593.52	346.13	348.73
TSP	151.52	155.29	92.76	90.14
SSP	48.42	184.07	10.71	28.04
DAP	42.37	76.65	27.68	41.31
MOP	132.21	85.44	72.57	57.21
Gypsum	75.57	50.81	41.28	19.90
NPKS	21.35	30.41	10.67	21.71
Zinc	9.29	9.52	8.64	7.26
Boron	1.72	1.81	1.07	1.09
Total	1092.7	1187.52	611.51	615.39

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

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 (17%). About 51% respondents opined that pesticides usages had many harmful effects. Among the harmful effects, 17% respondents thought that pesticides killed useful insects and animals, whereas 11% believed that pesticides had adverse effect on fish biodiversity. Around 6% farmers thought that number of migratory birds is decreasing because of using pesticides and around 5 and 7% farmers perceived that it also have negative impact on human health and agro-bio diversity respectively whereas only 5% perceived adverse impact on soil fertility (Table 4).

Table 4

Farmers' perception on the adverse effect of pesticide

Farmer's perception	*Response (%)*
Pesticide have harmful effect	51.1
Kill beneficial insects and microorganism	17.4
Reduce fish biodiversity	11
On birds	6.4
On human health	6.7
On agro-bio diversity	5.3
On soil fertility	4.2
Pesticide do not have harmful effect	37.6
Do not know	11.3

Trends of pesticide usage in Hilna and Kumari beel. 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 25,466 mt to 30,777 mt in 2009 (Table 5 and Figure 2). In Hilna beel area, pesticide usage have been increased 1.41 times from 2005 (2.78 mt.) to 2009 (3.91 mt.). But in Kumari beel area, the increment was 1.44 times (usage was 1.72 mt in 2005 and 2.48 mt. in 2009) (Figure 2).

Table 5

Group wise pesticide consumption in Bangladesh for the year 2000-2009

Name of pesticides		*Amount of pesticides (in mt) used in agriculture*									
		2009	*2008*	*2007*	*2006*	*2005*	*2004*	*2003*	*2002*	*2001*	*2000*
Insecticides	Granular	16971	16147	15023	14282	14061	12,113	11781	12,335	10788	10113
	Liquid	2698	2583	2543	2523	2511	2,008	1830	1,497	1426	1150
	Powder	387	327	292	279	268	192	155	115	86	76
Miticide		102	85	71	62	56	37	0	27	0	21
Fungicide		6826	6359	6113	5881	5772	4297	2941	5772	2190	3278
Herbicide		3747	3211	2841	2791	2775	3,463	1354	1,354	838	876
Rodenticide		46	39	28	25	23	23	19	19	70	27
Total		30777	28751	26911	25843	25466	22,133	18,080	21,119	15,398	15,541

Source: BBS (2008).

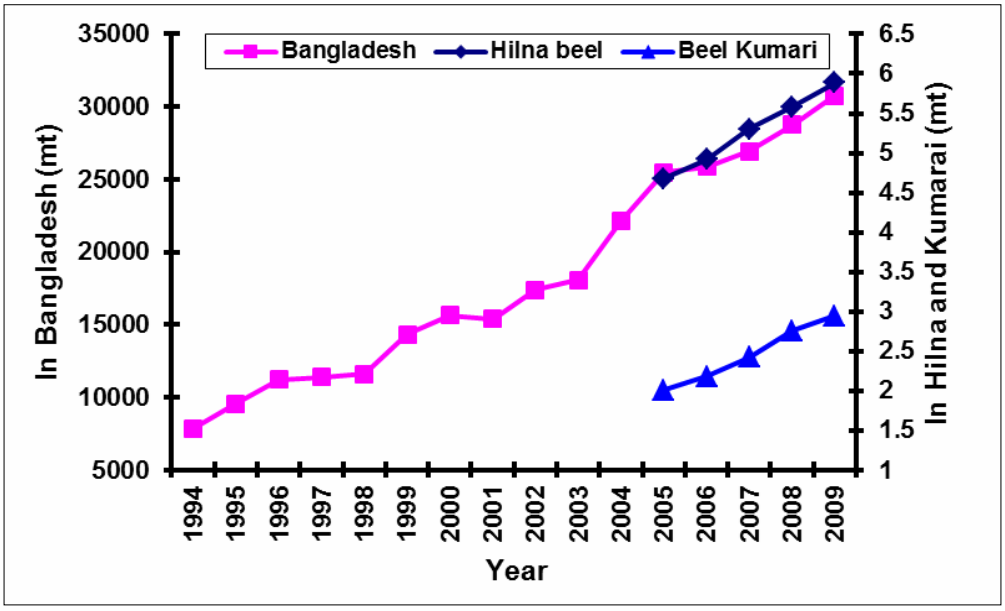

Figure 2. Pesticide consumption in Bangladesh and the studied beels (BBS 2008).

It was observed that about 25 different kinds of pesticides were used in Hilna and Kumari beels area. The dominant pesticides usages in studied beels with their prescribed and used doses are presented in Table 6. The average pesticide usage in crop land inside the beels 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 using more or less below the recommended level.

Table 6

The common pesticides usages by the crop and fish farmers in Hilna and Kumari 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}	-

Impacts on fish production. 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 using high amount of detrimental pesticide in the crop field but at the same time fish biodiversity decreased overtime. The frequent incidences of fish mass mortality have been reported by the Upazila Fisheries Officers in the Hilna and Kumari beel areas (Table 7). In Hilna beel, 118.8 and 129.0 kg fish was died during the month of pesticide application and flash flood in 2007-2008 and 2008-2009 respectively. But in Kumari beel only in 2008-2009, 94.8 kg fish was died (Table 7).

Every year incidence of different types of fish mass mortality were recorded by the fishery officers where the estimated damage was not so much 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 areas. Therefore, farmers are more interested in culturing rice crops ignoring the importance of fisheries in and around the beels. 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 7

List the amount of fish mortality due to use of different pesticides in the studied beels during study period

Month	*Mortality of fish (kg)*			
	Hilna beel		*Kumari beel*	
	2007-2008	*2008-2009*	*2007-2008*	*2008-2009*
July	-	-	0	0
August	-	-	0	0
September	-	-	0	0
October	-	-	0	0
November	-	-	0	0
December	-	-	0	0
January	-	-	0	0
February	-	11.0	0	0
March	13.0	6.0	0	7.0
April	19.5	19.8	0	9.8
May	74.3	78.2	0	66.0
June	12.0	14.0	0	12.0
Total	118.8	129.0	0	94.8

It was observed that the decreasing rate of fish production followed the similar pattern with the increasing rate of pesticide used from 2004 to 2008 (Figures 3a and 3b). But the production trend was being increased in Kumari beel after 2008 whereas in Hilna beel the production trend was further decreased with increasing the rate of pesticide usages. Figure 3 showed that the fish production in Kumari beel was increased after 2008 onward. A fish sanctuary was established in the Kumari beel during 2007-2008 and fish production increased from about 322 t in 2007-2008 to about 326t in 2008-2009.

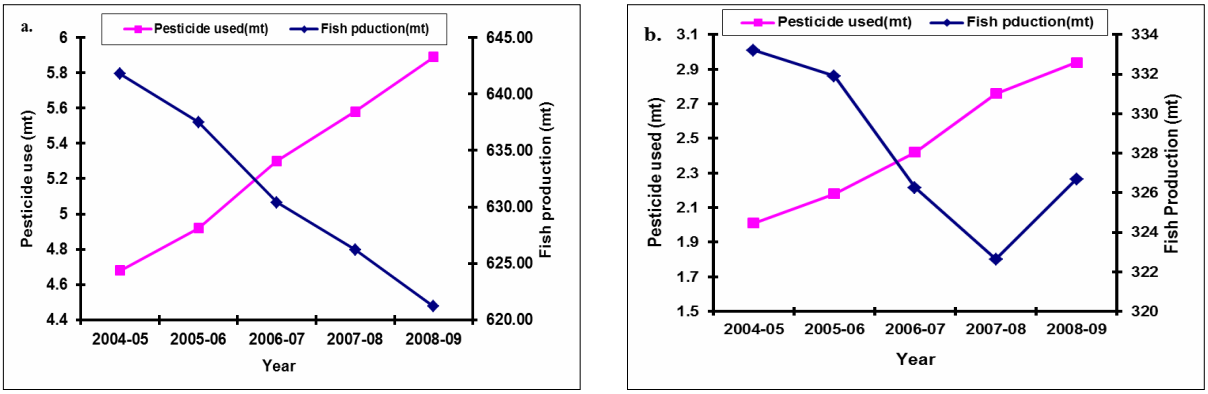

Figure 3. Fish production trend in relation to pesticide use in: a. Hilana beel, and b. Kumari beel.

Discussion

Physical characteristics, land ownership and chemicals used status. The average pesticide use in each hectare crop land was 2.92 kg in Hilna beel and 2.95 kg in Kumari beel. Ahmed (2004) reported that farmers on an average apply 0.2 liter pesticide per hectare in rice fields. It was lower than the studied sites. It may differ depending upon types of pesticide, types of pest and also attitude of farmer. There were 8 and 3 pesticide

dealers and 12 and 4 pesticide retailers in Hilna beel and Kumari beel area respectively. The unutilized portion of pesticides and chemicals finally find its destination to the water of the beel and causes effects negatively to aquatic production and biodiversity. Mazid & Haldar (2005) reported that 25% of the pesticide applied in the agricultural field washed out to the nearby waterbody resulting aquatic biodiversity under threat.

Use of chemical fertilizers. More fertilizers were found to be used in 2008-2009 than that of 2007-2008 which might be due the increasing agricultural activities in the studied 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 high yield variety (HYV) rice in the country (Rahman 2004). 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 (Hossain & Halder 1996; Rasul & Thapa 2003). As a result, pesticide usage had been increased abnormally in the Hilna and Kumari beels 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 (Sayeed et al 2015). 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 (Parveen & Faisal 2002). Rohr & Crumrine (2005) 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.

To address food security, the farmers in the Hilna and Kumari beels, mostly the medium and marginal farmers are engaged in the farming activities. Boro was the most dominant rice 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 three upazilas and the occurrences were increasing year after year. Knight et al (2005) 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 Hilna and Kumari beels now do not breed (Knight et al 2005).

Farmers' knowledge on pesticide usage. Among the respondents who opined pesticides uses have harmful effects, 17.5% respondents thought that pesticides kill useful insects and animals, whereas 11% responded to have an adverse effect on fish biodiversity. Rahman & Hossain (2003) reported that 33% respondents considered there was no harmful effect of pesticide use, 9% did not give any opinion and 58% were naive about the harmful effects of pesticides which are closely related with the present study. The result indicates that lack of proper knowledge of the farmer and also attitude is responsible to use such pesticide in their cropland. Ramaswamy (1992) reported that lack of proper knowledge of the pesticide users has led to administer widespread and excessive quantity of pesticides.

Trends of pesticide use in Hilna and Kumari beels. In Hilna and Kumari beels occupies a major source of fish protein but importance is given on cereal food production ignoring the poor peoples' access to fisheries as easy protein sources. The development initiatives of the beels 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 are being used (Thompson et al 2004; Sayeed et al 2015). 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.

According to DAE (2008) around 18% of total crop may be lost due to only insect. To avoid this loss, farmers have to apply pesticides in their agricultural land. Twenty five pesticides of different company have been found to be used in the beels area during the study period. In some cases, rich farmers use more pesticide than the recommended dose to avoid risk. Authority has cancelled 109 pesticides. Unfortunately, many banned or restricted pesticides even 12 particularly controversial pesticides known by activists campaigning worldwide as the "dirty dozen" are available and sold in the country (SOS-arsenic.net 2004). The scenario is more or less same in the studied beels. As a consequence, water ecosystem is being damaged through using banned pesticide. Knight et al (2005) reported that application of herbicides may cause cross-ecosystem cascades and ecosystems are also affected by it. Zooplanktons have found large reductions of its abundance due to pesticide (Van Wijngaarden et al 2005).

Impacts on fish production. Bangladesh is rich in fish and aquatic resources and other biodiversity and ranked 3rd in the world. The residues of huge amount of pesticide used in the Hilna and Kumari beel area eventually washed out into the surrounding river and beel systems. The result indicates that fish production of both the beels has been decreased with the increase of pesticide use. Almost all respondents concluded that the indiscriminate use of pesticide and change in cropping practice were responsible for fish biodiversity degradation of the two studied beels. Hossain & Halder (1996) reported that 70% farmers agreed that the main cause of disappearance of the fish from the water body 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 (Mahmud 2006) killed fish as well as other aquatic organisms (Parveen & Faisal 2002).

In Hilna beel, 118.8 and 129.0 kg fish mortality were recorded during the month of pesticide application and flash flood in 2007-2008 and 2008-2009 respectively. But in Kumari beel during the year of 2008-2009, 94.8 kg fish mortality was recorded due to sharp rising of pesticide usage. Similar trend of results were also reporded in California in the mid 50's (Rudd & Genelly 1956). Mahmud (2006) also reported that lethal dose and even at sub lethal dosage of chemical residues of pesticides largely attributed to cropland runoff contaminants killed fish. Not only fish but also other beneficial animals are killed by pesticides and it also affect 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 (Parveen & Faisal 2002). Many valuable indigenous fish species, however, are under threat, depleted or fully disappeared from the studied fishes of Bangladesh. However, after establishing a fish sanctuary in the Kumari beel during 2007-2008, there was an increasing production trend and the rate of mortality was being lowered. Most of the respondent commented that many fishes that were previously available in the beel are no longer captured now days. Important negative impact of insecticide in aquatic ecosystem are: causing death of planktons and breakdown of food chain, direct fish killing, physiological change of fish and other aquatic organisms, alteration of feeding and breeding grounds and sporadic increase of fish diseases epidemic (Mazid & Haldar 2005).

Conclusions. The Hilna beel and Kumari beel are moderate productive water body with decreasing fish species diversity. The government of Bangladesh has formulated some laws, policies to conserve and protect the wetland environment. But, many pesticides found using in aquatic systems that are not registered or legal for application. Different government and non-government agencies in Bangladesh have been campaigning against use 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. Lack of awareness, severe poverty, inadequate knows how and poor integrity among authorized officials prevents the implementation of existing policies and laws. There is crying need to adjust the existing laws and legislation on integrated

resource management to save these fisheries resources and to implement them. This could be done in a combined effort by the relevant Government agencies, NGOs as well as the people benefiting from common natural resources.

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References

Ahmed M. F., 1985 Modern agriculture and its impact on environmental degradation. In: BMOE, Protection of Environment from Degradation, Proceedings of South Asian Association for Regional Cooperation Seminar, pp. 42-49.

Ahmed R., 2004 Goodbye pesticides. Available at: www.thedailystar.net/2004/06/16/d4061601033. Accessed: June, 2014.

Alam A., Mustafa M. G., Azad M. A. K., 2007 Water and sediment quality and plankton diversity of Posna beel, Tangail. Bangladesh Journal of Fisheries (Special Issue) 30:177-188.

Alam M. T., Hussain M. A., Sultana S., Hasan M. T., Haque M. Z., Das S. K., Mazumder S. K., 2015 Water quality parameters and their correlation matrix: a case study in two important wetland beels of Bangladesh. Ciência e Técnica Vitivinícol 30(3):463-489.

Bandyopadhyaay M. K., Hassan M. A., 2002 Floodplain wetlands (beels) - an important aquatic resource for enhancement. In: Culture-based fisheries for inland fisheries development. Sugunan V. V., Jha B. C., Das M. K. (eds), CIFRI, Barrackpore, India, pp. 102-107.

BARC (Bangladesh Agricultural Research Council), 2005 Fertilizer recommendation guide-2005. Miah M. M. U., Farid M. T. M., Miah M. A. M., Jahiruddin M., Rahman S. M. K., Quayyum M. M. A., Sattar A., Motalib M. M. A., Islam M. F., & Razia M.S. (eds), Peoples Press and Publications, Purana Paltan, Dhaka, Bangladesh, 260 pp.

BBS (Bangladesh Bureau of Statistics), 2008 Statistical Yearbook of Bangladesh 2007. Planning division, Ministry of Planning, Government of the Peoples Republic of Bangladesh, Bangladesh, 580 pp.

BFRI (Bangladesh Fisheries Research Institute), 2005 Conservation technique of small indigenous fish species. 38 pp.

CPP (Compartmentalization Pilot Project), 1992 Environmental Impact Assessment Case Study on Compartmentalization Pilot Project, Tangail, FAP–16, Ministry of Irrigation, Water Development and Flood Control, The People's Republic of Bangladesh 5:16-17.

DAE (Department of Agricultural Extension), 2008 List of registered agricultural and public health pesticides in Bangladesh. Plant Protection Wing, Department of Agricultural Extension, Khamarbari, Dhaka-1215, 76 pp.

Das A. K., 2002 Nutrients dynamics in the floodplain wetlands of west Bengal. In: National Symposium on Fisheries Enhancements in Inland Waters-Challenges Ahead. Sugunan V. V., Das M. K., Vinci G. K. (eds). Abstract. IFSI and Central Inland Capture Fisheries Research Institute, Barrackpore, India, 20 pp.

Das D. N., Roy B., Mukhopadhay P. K., 1990 Fish culture with DW rice in West Bengal. In: Deepwater and Tidal Wet Land Rice Bulletin, No. 17, November 1990, International Rice Research Institute, Philippines.

Haque M. E., Karim M. A., Ali M. H., Barman A. C., Zoardar M. A. R., 2010 Present status of fishes and their harvesting in Beel Kumari under Rajshahi district. Journal of Agroforestry and Environment 3(2):107-110.

Hossain Z., Halder G. C. 1996 Impact of pesticide on environment and fisheries. In: Fisheries fortnight publication: technologies and management for fisheries development. Mazid M. A. (ed), Fisheries Research Institute, Mymensingh, Bangladesh, 160 pp.

Huan N. H., Mai V., Escalada M. M., Heong K. L., 1999 Changes in rice farmer's pest management in the Mekong Delta, Vietnam. Crop Protection 18:557-563.
Knight T. M., McCoy M. W., Chase J. M., McCoy K. A., Holt R. D., 2005 Trophic cascades across ecosystems. Nature 437:880-883.
Mahmud A., 2006 Shidhulai Swarnivar Sangstha: bringing information technology to rural Bangladesh by boat. Council on Library and Information Resources, Washington DC, 26 pp.
Mazid M. A., Haldar G. C., 2005 Harmful effects of pesticides used in rice fields on fish and aquatic animals. Extension Manual No. 26, Bangladesh Fisheries Research Institute, Mymensingh, 16 pp.
Parveen S., Faisal I. M., 2002 Open water fisheries in Bangladesh: a critical review. Environmental Studies, North South University, Dhaka, Bangladesh, 20 pp.
Rahman M. M., 2004 Uses of persistent organic pollutants (POPs) in Bangladesh. Paper presented at the Inception Workshop of the Project Bangladesh: Preparation of POPs National Implementation Plan under Stockholm Convention (POP NIP), Department of Environment, held at Hotel Sonargaon, Bangladesh.
Rahman S., Hossain M. Z., 2003 Pesticide demand in hybrid seed production technology. Food, Agriculture and Environment 1(3-4):174-179.
Ramaswamy S., 1992 Pest control and environment. Notes for discussion at a seminar on environment and agriculture. Agriculturalist Association of Bangladesh, Dhaka, 19 pp.
Rasul G., Thapa G. B., 2003 Sustainability analysis of ecological and conventional agricultural systems in Bangladesh. World Development 31(10):1721-1741.
Rohr J. R., Crumrine P. W., 2005 Effects of an herbicide and an insecticide on pond community structure and processes. Ecological Applications 15:1135-1147.
Rudd R. L., Genelly R. E., 1956 Pesticides: their use and toxicity in relation to wildlife. Calif Fish Game Bull 7, 209 pp.
Saha S. B., Bhagat M. J., Pathak V., 1990 Ecological changes and its impact on yield of Kulia beel in Ganga Basin. Journal of the Inland Fisheries Society of India 22(1-2):7-11.
Sayeed M. A., Hossain M. A. R., Wahab M. A., Hasan M. T., Ghaffar M. A., Das S. K., Mazumder S. K., 2015 Chemical and pesticides uses status in the Chalan beel, Bangladesh and present status of fish biodiversity. American Journal of Experimental Agriculture 6(5):267-289.
SOS-Arsenic.net, 2004 Agrochemicals: imported pollutants in Bangladesh. Available at: http://www.sos-arsenic.net/index.html. Accessed: December, 2015.
Sugunan V. V., Sinha M., 2001 Sustainable capture and culture-based fisheries in freshwater of India. Sustainable Indian Fisheries, pp. 43-70.
Sultana P., Alam S. S., Thompson P., 2003 Understanding livelihoods dependent on inland fisheries in Bangladesh and Southeast Asia. DFID/FMSP Project R8118, Bangladesh PRA Report, WorldFish Center, 82 pp.
Thompson D. G., Wojtaszek B. F., Staznik B., Chardrand D. T., Stephenson G. R., 2004 Chemical and biomonitoring to assess to potential acute effects of vision herbicide on native amphibian larvae in forest wetlands. Environmental Toxicology and Chemistry 23:843-849.
Van Wijngaarden R. P., Brock T. C., Douglas M. T., 2005 Effect of chloropyrifos in freshwater model ecosystem: the influence of experimental conditions on ecotoxicological thresholds. Pest Management Science 61:923-935.
Zar J. H., 1984 Biostatistical analysis. New Jersey, Prentice-Hall International. Annex. 718 pp.

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