Economic Valuation of Rural Wetlands in Bangladesh: *A Case Study of the Padma Beel of Pabna*

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ABSTRACT
Wetland is a valuable ecosystem for sustainable environment. These have traditionally been used for multiple purposes, and have significant roles in the livelihood of the local community. In recent years, these multiple use systems are getting converted to single use system due to economic and social pressure from dominant stakeholders. In this context, we selected a particular wetland in the district of Pabna, namely the *Padma Beel*, to estimate direct economic benefits from its multiple uses, e.g. wetland cultivation, irrigation, fisheries, jute retting, duck keeping and fodder collection. The study shows that wetlands are resourceful ecosystems that provide many benefits and services but some of these benefits and services can be difficult to recognize, quantify and value. On the other hand, direct benefits and services such as fish capture can be quantified and valued using a market price approach. Wetlands also contribute to household food security of the surrounding neighborhood locations in a number of ways.

Key Words: Common property resources, environmental valuation, market price approach, natural resource management, wetlands

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1. INTRODUCTION

1.1 Background

Wetlands are one of the most productive and resourceful areas (Dugan 1990, IWRB 1992) but are often not properly used and users also do not have proper understanding of their total economic and other non-economic values (Convention on the Biological Diversity, 2010). Yet only a few studies have yet been conducted to understand economic benefits of rural wetlands in Bangladesh (Islam, 2011; Islam, 2012). On the other hand, globally smaller and rural wetlands are often taken under valuation considering their direct economic benefits like wetland cultivation, fisheries, water for irrigation, wetlands for transportation, vegetation, jute retting and fodder collection (Mukherjee, 2008).

Economic valuation studies, taking into consideration both direct and indirect benefits of wetlands are important for informed wetland management and conservation. According to the Ramsar Convention (2007), wetlands are areas of marsh, fen, peat land or water, natural or scientific, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters (Handbook, 2010). Bangladesh is a land of water and wetlands. Wetlands constitute more than fifty percent territory of the total country and play a significant role in the social and economic livelihood of the population (Convention on the Biological Diversity, 2010). Wetlands can be of different types based on their hydrological and ecological attributes (Table 1). The wetlands in Bangladesh encompass a wide variety of ecosystems including: the main rivers (Ganges, Brahmaputra and Meghna) and their 700-plus tributaries and distributaries; some 6,300 *Beels* (permanent and seasonal shallow lakes in floodplain depressions); at least 47 major *haors* (deeply flooded depressions in the north-east), *baors* (oxbow lakes); vast areas of seasonally flooded land; the extensive mudflats and coastal chars of the estuaries of the rivers; mangrove forests; intertidal zones along the eastern coast; reservoirs; and fish ponds and tanks. They occupy about half the land area of the country in the monsoon season.

There is no recent assessment of wetland area in Bangladesh. However, National Water Resources Database (NWRD, 1997) has estimated about 172,087 hectares of permanent wetlands (excluding rivers and estuary) in the country.

Table 1: Wetlands Areas by Types

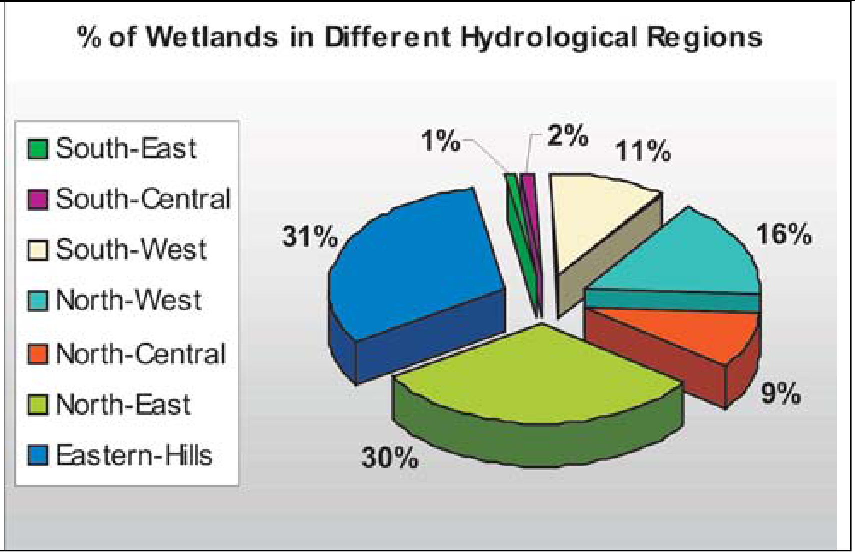
Types of Wetlands	Area in Hectares
Open Water Wetlands	
Rivers	749,700
Estuarine and Mangrove Forest	610,200
Beels and Haors	114,200
Inundable Floodplains	548,6600
Kaptai Lake	68,800
Closed Water Wetlands	
Ponds	146,900
Baors (oxbow lake)	5,500
Brackish water farms	108,000
Total	7,289,900

Source: Akonda 1989 and Khan 1994, Asian Wetland Bureau, cited in Fourth National Report, 2010.

The database also revealed that 21% of the country is deeply flooded (more than 90 cm) and 35% experiences shallow inundation during monsoon. National Water Management Plan (NWMP) has divided the country into eight hydrological zones based on their characteristics. Hydrological zone wise areas of permanent wetlands are provided in Table 2.

Table 2: Wetland Areas in Different Hydrological Regions in Bangladesh

Hydrological Regions	Area in 1997 (ha)
South -East	1,255
South -Central	2,604
South -West	18,400
North -West	27,016
North -Central	15,940
North -East	53,180
Eastern -Hills	53,692
Total	**172,087**



Source: NWRD, 1997, cited in Fourth National Report.

We purposively selected the *Padma Beel* in the district of Pabna for our case study. We interviewed a sample of households within the surrounding area (a total of three villages), and have gathered information from those households who obtained direct benefits from the *Beel*. These households were selected through a stratified random sampling framework after making three strata in terms of three villages, and yet each village was further stratified into three sub-strata in terms of socio-economic status of the surveyed households. Equal importance was assigned to lower income, middle-income and upper income residents of the villages. Direct economic valuation was measured from the survey data that we collected from the respondents. By providing a means for measuring and comparing the various benefits of wetlands, economic valuation can be a powerful tool to aid and improve wise use and management of national wetland resources. We also examined the food security aspects of benefits of wetland for the surveyed households in the surrounding areas.

The goal of this study was to estimate direct economic values of a wetland area in rural Bangladesh, taking the *Padma Beel* of Pabna as a case study, using the market price method. The following specific objectives were also set out to: (i) estimate the direct use value of the *Padma Beel*; (ii) examine various direct and indirect uses of the *Beel*; (iii) study and understand the overall ownership and management pattern of the *Beel*; and (iv)examine food security impacts of the *Beel* on neighboring resident households.

1.2 The Study Area

The study focused on economic valuation of a rural wetland as MUS (Multiple Use System) in the district of Pabna. The *Padma Beel* is identified as a wetland by the Local Government Engineering Division sub-district maps. This *Beel* is located within three villages, under two unions and two sub-districts of Pabna, namely *Ramchandapur* and *Noydapara* of Majhpapa union at *Atgoria* sub-district and *Kamalpur* of Debigram union at Chatmohar sub-district. The *Padma Beel* is connected by the *Chandabroti Khal* with the *Chandabroti River* and Kamala River. It is in the west side the *Ramchandapur* village and *Chandabroti* river north side is the *Kamalpur* village and the *Kamala* River. It is in the North side of the *Gofurabad* Railway Station and almost five kilometers away from the station. The *Beel* is in the Southside and within ten kilometers from the National Highway.

After the construction of Chandabroti *Khal,* the wetland got a fresh life. Now, most parts of the year the *Beel* gets water. It gets flooded during the rainy season and remains waterlogged for three to four months (June-July to September–October). Deposition of silt during the rainy season makes the land in the flood plain highly fertile. But in recent years, the *Beel* has been converted into a scientific fisheries location, and now there are cases of water logging problems for some months. Jute and *Aush or Amon* are the main crops cultivated during water logged periods, as it can withstand standing water or requires standing water for retting. Apart from fisheries the wetland bed itself is used for cultivation of *Boro* rice and jute. The wetland water is also used for irrigation and jute retting and farmers collect fodder from wetland. The farmers informed that they found cultivation of rice in the wetland remunerative as they could save money in terms of labor, irrigation and fertilizers costs.

3. LITERATURE REVIEW

Wetlands provide very important goods and services to the society and help in sustaining critical livelihoods of wetland communities as well as communities living far downstream. Direct economic valuation is very important tool for the wetlands goods and services, which are sometimes more important direct use values for public policies in support of wetland (Emerton, 1998 and Barbier, et al., 1997). In addition, crops, fish and aquatic food products are also important (Barbier et.al, 1997). Wetlands system has proven itself to be highly productive and ecologically sound (Rezaul et. al. 2004). Wetlands ecosystems have been recognized to provide various services (de Groot et. al., 2006). Services often provided by wetlands include storm water detention, flood protection, water quality enhancement, freshwater fisheries, food chain support, feeding grounds for juvenile marine fish, biodiversity, carbon storage and climate regulation (Hassan et. al., 2005). The needs of agriculture for flat, fertile land with a ready supply of water implies that wetlands are often a potentially valuable agricultural resource (UNEP and IWMI, 2011). Wetland agriculture can bring significant benefits in terms of food security, health and income. Therefore, wetland resources planning and management requires a clear vision of the relative importance of agricultural production and natural resource conservation (Ramsar Convention Secretariat, 2010).

Direct use values of a wetland are estimated by using market price approach. The study shows that Wetlands are complex ecosystems that provide many benefits and services but these benefits and services can be difficult to recognize, quantify and value (Kyophilavong, 2011). Taruvinga (2009) concludes that wetland cultivation in the rural setting was profitable, with statistically significant positive linear correlations with household food security such that wetland cultivators were more than twice food secure than non-wetland cultivators. Wetlands and their biodiversity have been contributing substantially to the socio-economic life of rural Bangladesh by providing opportunities of employment, food and nutrition, fuel, fodder, transportation, irrigation and so forth (Rahman, 1989). The values of wetland resources were estimated using primary and secondary data, market prices, productivity, and contingent valuation methods were used to estimate the value of wetland resources (Kakuru et.al, 2013). The valuation exercises in the literature also include calculating the values of supplying drinking water to the city, value of benefits accruing to various people whose livelihoods depended upon the wetland, value of preventive measures that people used to avoid water borne diseases and the willingness to pay of the people for enjoying better recreational facilities (Verma 2001).

4. METHODOLOGY

The study planned to have an economic valuation of marketable products and services of the *Padma Beel* using direct market price method. Based on this, the following model was designed:

$$V = \sum \left(PQ - C \right) \qquad (1)$$

where, V = Direct Use Value; P = Prices of Product; Q = Amount of Product and C = Cost of Product; A total of six major direct economic functions of the wetland were identified, these are: (1) use for cultivation; (2) use of wetland as a source of irrigation; (3) wetland fisheries; (4) use of wetland water for domestic uses; and (5) jute retting and (6) source of fodder.

The study encompassed surrounding areas of the *Padma Beel* in Pabna as the sample frame. The households residing within this area were taken as primary sampling units. We divided these households into three wetland stakeholder groups such as "A"; "B" and "C", based on income and asset levels of the households. The groups were (i) upper income group ("A"); (ii) middle income group ("B"); and (iii) the lower income group ("C").

Firstly, we listed all the households in all three survey villages, and classified these households in terms of A, B or C with the basis of discussion of field assistants with some key informants in these villages. Secondly, the field assistants conducted face-to-face questionnaire survey with households selected in terms of random sampling within the sub-categories.

A brief description of the scope and coverage of the study and possible outcomes of the study was provided before starting face to face interview. Some secondary information was also collected from the local people, particularly, the fertilizer dealers, local political leaders. Local government office records were consulted in order to prepare an accurate group classification of households.

The *Padma Beel* is surrounded by three villages; namely *Ramchandapur*, *Kamalpur* and *Nodapara*. A total of 150 families/households were selected for face-to-face questionnaire interviews. Table 3 summarizes the distribution of respondents with respect to their income level and assets status. While the total number 150 was chosen considering convenience, number of respondent households in the sub-groups was taken considering proportionality.

Table 3: Sample Size

Survey Villages	Status of Respondents			Total
	Upper (A)	Middle (B)	Lower (C)	
Ramchandapur	20	20	20	60
Kamalpur	25	25	24	74
Nodapara	5	5	6	16
Households Totals	50	50	50	Total Households n =150

Source: Poribar porikolpona, khana jorip.

The data was collected in the month of October 2014, and it took seven days to complete the face-to-face questionnaire interviews. A total of five field assistants led by one of the authors of this study completed the interviews. Data was preserved in MS Excel, SPSS and STATA. Statistical analysis was done in STATA v. 12.

5. FINDINGS AND DISCUSSION

5.1 Number of Beneficiaries According to Use of Wetland

Wetland cultivation and services were also explored with the objective of trying to estimate their potential direct economic benefit of wetland. Wetlands' direct benefits depend on the number of beneficiaries using wetlands. Our sample covers 150 sample households of a total of 888 people. A total of 44 (88%) respondents within "A" category, 47 (94%) respondents within "B" category and 33 (66%) respondents within "C" category reported to be associated with the wetlands cultivation and 13 (26%) of "A" group households, 35 (70%). According to our sample survey open access fisheries were involved with the lower class socio economic characteristics of respondent's population.

Table 4: Number of Beneficiaries According to Use of Wetland

Different Uses Of Wetland		Beneficiaries (No. of Households)		
		Upper (A)	Middle (B)	Lower (C)
No. of Surveyed Households		50	50	50
a) Wetland Cultivation (No. of HHs)		44 *(88)*	47 *(94)*	33 *(66)*
b) Wetland Fisheries (No. of HHs)	Open Access	13 (*26*)	36 (*72*)	35 (*70*)
	Scientific	36 (72)	2(*4*)	2 *(4)*
	Pond	*2(4)*	2*(4)*	5 *(10)*
c) Jute Retting (No. of HHs)		22 *(44)*	24 *(48)*	12 *(24)*
d) Duck Keeping (No. of HHs)		32 *(64)*	45 *(90)*	41 *(82)*
e) Cattle Grazing (No. of HHs)		47 *(94)*	45 *(90)*	44 *(88)*
f) Fodder Collection (No. of HHs)		2 *(4)*	5 *(10)*	10 *(20)*
g) Poultry (No. of HHs)		42 *(84)*	46 *(92)*	43 *(86)*
h) Collection of Snails (No. of HHs)		0 *(00)*	3 *(6)*	8 *(16)*
Commercial Use of Water (No. of HHs)		36 *(72)*	9 (*18*)	2(*4*)
j) Cultivation Use of Water (No. of HHs)		44 *(88)*	47 *(94)*	33 *(66)*

Source: Based on Field survey, 2014.

5.2 Total Net Benefit from Wetland Cultivation

Five categories of crops are produced in the *Padma Beel* surrounding area, such as *Amon, Boro, Robi*, jute and vegetables. During monsoon two thirds of the land of the *Padma Beel* gets water logged. This is caused by anthropogenic activities (scientific pond) that are one third of the land of the *Padma Beel,* there is no production of any crops in those areas. Another two thirds of the land of the *Padma Beel,* produce *Amon*, jute and vegetables. *Boro* rice is the major crop cultivated in the water spread area of the *Beel*. Farmers find wetland cultivation remunerative as they could save money in terms of fertilizer costs and labor costs (less time spent on irrigation), compared to upland areas. Apart from the nutrient enriched silt of the wetland, wetland water has high nutrient value--farmers generally obtain higher yield for wetland rice as compared to the case of the upland. Farmlands surrounding the *Beel* are irrigated mostly from the *Beel* and it helps the farmers to cut down their costs on fertilizers as nutrient of wetland water is higher than the fresh water from ground and/or river.

During the summer season when wetland bed dries up, wetland cultivation is a common practice carried out by the farmers having land in wetland bed or in the low-lying areas. According to our sample survey total area under wetland cultivation is 131.44 acres. *Boro, Robi*, Jute and vegetables are the major crops cultivated in the wetland bed. Total area under wetland rice cultivation is 79.67 acre, jute is 23.35 acre, wheat is 17.10 and bean is 11.32 acre.

The benefits from cultivation of rice, jute wheat, bean and others crops are provided in the Appendix Table 1. The estimated annual net benefit from wetland cultivation is Tk. 8,829,220 per year. Wetlands annual net benefit was calculated in comparison to the wetlands total benefit and upland total benefit.

5.3 Total Net Benefit from Wetland Services

Wetland services are reflected in the livelihood pattern of the surveyed residents, and this particularly benefited the lower income group. There are many services such as fisheries, Jute retting, using water, fodder, and duck keeping, caw, snail and poultry. In the Appendix Table 2, wetland net benefit is calculated by the wetland services. The table shows the average annual net benefit and total annual net benefit for the wetland services. It is evident that since the upper income group households have larger capacity to absorb benefits and services, they report higher amount of benefits as compared to the middle income group and the lower income group.

5.3.1 Benefit from Fisheries Operation

In this study, fisheries operation or benefit is one of most valuable indicators to estimate the wetland net benefit of services that it contributes to calculate the estimate of the whole wetland benefit. There are three types of fisheries operations (open access fisheries, scientific fisheries and pond fisheries) and three types of fisheries owner systems (owners operated, lease holders operated and open access fish operated). Open access fisheries are most important for livelihood of the lower income group respondents. The total area under wetland fisheries is about 142 acres. Open access fisheries involved 13, 36 and 35 of upper, middle and lower class respondent households respectively; scientific fisheries involved 36, 9 and 2 households respectively and pond fisheries involved 5, 12 and 2 with respectively.

5.3.2 Benefits from Jute Retting

Jute is the major commercial crop in the study area. During the rainy season the whole area is flooded with water from the Chandraboti River. Availability of water bodies is an added advantage, which helps farmers in jute retting. During monsoon, The *Padma Beel* is used for jute retting by large number of farmers from surrounding habitations.

The benefit of using the wetland for jute retting is estimated by taking the cost of an alternative that can perform the same function. In the table 5 shows that average annual benefits per households of Ramchandrapur Kamalpur upper class is Tk. 990 and 1196 and total annual net benefit of Ramchandrapur and Kamalpur upper class is Tk. 94050 and 143520 respectively. On the other hand, average benefits per households of Ramchandrapur and Kamalpur lower class is Tk. 170 and 276.042 that it small amount benefits than the others class. Total jute retting annual net benefit under is areas Tk. 465,177.98.

Table 5: Benefits from Jute Retting

Units	Class	Average Benefits Per HH	Total No. Of Households Within Class	Total Net Benefit
Ramchandrapur	Upper	990	95	94050
	Middle	280	114	31920
	Lower	170	171	29070
Kamalpur	Upper	1196	120	143520
	Middle	690	133	91770
	Lower	276.042	190	52447.98
Nowdapara	Upper	640	15	9600
	Middle	640	20	12800
	Lower	0	30	0
Total				465,177.98

Source: Based on Field survey, 2014.

5.3.3 Benefit from Fodder Collection

On an average 32% of our sample households collect fodder from the wetland. Farmers collect water hyacinth (Eichornia crassipes) and water borne vegetation and supplement commercial fodder to reduce the cost of feeding the cattle population. On average, for four months in a year, households collect fodder from the wetland. In our household questionnaire survey it has been revealed that on average each household of three villages can save Tk. 40861.67, 5865.64 and 12755.56 per year respectively depending on the herd size and family's dependence on wetland fodder. Since fodder collection also involves labor time, households that have their own source of fodder mostly avoid collecting from wetland. Average annual benefit per household of Ramchandrapur, Kamalpur and Nowdapara for upper class is Tk. 115202.5, 8768 and 18900 respectively. On the contrary, Average annual benefit per household of Ramchandrapur, Kamalpur and Nowdapara for lower class is Tk. 3085, 3222.917 and 466.67 respectively. Hence, the total annual net benefit from fodder collection is Tk. 15,047,299.83.

Table 6: Benefit from Fodder Collection

Units	Class	Average Benefits Per HH	Total No. Of Households Within Class	Total Net Benefit
Ramchandrapur	Upper	115202.5	95	10944237.5
	Middle	4297.5	114	489915
	Lower	3085	171	527535
Kamalpur	Upper	8768	120	1052160
	Middle	5606	133	745598
	Lower	3222.917	190	612354.23
Nowdapara	Upper	18900	15	283500
	Middle	18900	20	378000
	Lower	466.67	30	14000.1
Total				15,047,299.83

Source: Based on Field survey, 2014.

5.3.4 Benefit from Using Water

Water using system is very important for the crop cultivation and fisheries. The opportunity cost of using water is calculated to estimate the water valuation. In the appendix table 4, there are two systems of using water e.g. using water for irrigation and using water for scientific fisheries. The annual benefit from using water for irrigation is Tk. 2,496,069.46 and the benefit from using water for scientific fisheries is Tk. 7,289,261.64. Total annual using water benefit is Tk. 9,785,331.10.

5.3.5 Benefit from Others Services or Livestock (Duck Keeping, Snail, Poultry and Fodder)

Others services or Livestock play a vital role in the agricultural and rural economies of the developing world. Not only do they produce food directly, they also provide key inputs to crop agriculture. In this study area, livestock components are very important for the livelihood adjacent lower class residents of the wetland. Table 7 shows that lower income group ("C") is in a comparatively better position compared to the others groups with respect to services such as duck keeping, snail, poultry and fodder.

Table 7: Benefit from Others Services or Livestock (TK)

Surveyed Villages	Class	Average Benefits Per HH	Total No. Of Households Within Class	Total Net Benefit
Ramchandrapur	Upper	1,614	95	153,330
	Middle	3,258	114	371,412
	Lower	1,589	171	271,719
Kamalpur	Upper	429.6	120	51,552
	Middle	2,083.2	133	277,065.6
	Lower	2,555	190	485,450
Nowdapara	Upper	19,444	15	291,660
	Middle	9,444	20	188,880
	Lower	3,820	30	114,600
Total				2,205,668.60

Source: Based on Field survey, 2014.

5.4 Total Direct Benefits from the Wetland

Table 8 shows the whole benefit that can be achieved from the wetlands. Wetlands' total net benefit is calculated by the wetlands' cultivation and services. The table 8 shows the sample total net benefit, per household net benefit and total net benefit for the wetlands' cultivation and services. Total whole wetland net benefit under the area is calculated to be Tk. 7.3 crore (these are based on estimation of benefits throughout the past 12 months). Total area of the *Padma Beel* is approximately 1,500 *bighas* or 430 acres. In this connection it can also be said that one third of the land is leased out to the influential people and the current study has not included this part to estimate the direct economic valuation of the Padma *Beel*. Considering this fact into our estimation (i.e. leaving one third of the areas from this calculation), this can thus be said that the annual per acre direct values of the *Padma Beel* is Tk. 2.53 lakh (equals USD 3200, at 1 USD=BDT 79).

Table 8: Total Net Benefit from Wetland, One Year Calculations (TK)

Survey Villages	Class	Sample Total (TK.)	Sample Number	Per HH (TK.)	Total No. of Households within Class	Total Net Benefit (TK.)
Ramchandrapur	Upper	7,992,952	20	399,647.6	95	37,966,522
	Middle	854,157	20	42,707.85	114	4,868,694.9
	Lower	745,075.6	20	37,253.78	171	6,370,396.38
Kamalpur	Upper	2,285,732	25	91,429.27	120	10,971,512.4
	Middle	906,888.3	25	36,275.53	133	4,824,645.49
	Lower	460,118.9	24	19,171.62	190	3,642,607.8
Nowdapara	Upper	631,073	5	126,214.6	15	1,893,219
	Middle	526,336.5	5	105,267.3	20	2,105,346
	Lower	74,845.02	6	12,474.17	30	374,225.1
Grand Total						73,017,169.07
Area of the Wetland under consideration (Acres)						288.1
Calculated Direct Economic Benefits, per Acre of Wetland						253,443.8

Source: Based on Field survey, 2014.

5.5 Food Security Aspects

Wetlands are very useful for crop cultivation, livestock production and others services. As such wetlands are of great potential in poverty alleviation in developing countries (Mombo et.al. 2012). In the rural area, wetlands are important in sustaining much of the residents. Wetlands and food security concept is interrelated by the crop cultivation and services with the rural population especially for the *Padma Beel* stakeholders' residents. In the context of the Padma *Beel* area, food security may be affected by factors ranging from wetlands crop cultivation and services, household size, wetland net benefit, education and status etc. Therefore, access to wetlands cultivation and services affected to the rural food security. A Probit regression model has been applied to the respondents' response of the principle three meal elicitation question.

5.5.1 All Meals and Status of Household

The dependent variable "all meals" exhibits how many of the surveyed households responded "yes" to questions such as whether they afforded to take food three times in a day, all the time during the last one-year time.

Table 9: All Meals and Status of Household

All Meals			
Status	Insecure (0)	Secure (1)	Total
1	0	50	50
2	19	30	49
3	40	10	50
Total	59	90	149

Source: Based on Field survey, 2014.

The Table 9 shows that there are three socio economic characteristics in the study area but status 1 (upper income group) no one household reported "no" to the query regarding whether they were able to afford three meals in a day over the last year. Within status 2 (middle income group), 19 out of 49 were found to insecure and 30 out of 49 is secure and in status 3 (lower income group) 40 out of 50 were found to be insecure and 10 out of 50 were reported as secure.

We also asked the respondent household whether they considered their household to be "food secured". A total of 90 households reported themselves to be "food secured", whether all of them reported "yes" to question such as "all three meals?" Similarly, all 59 households which reported they to be "food insecure" also mentioned "no" to query such as "all three meals?"

5.5.2 Relationship between Food Security Scale with the Status and Months of Distress

Food security is related to status and months of distress as reported by the survey respondents. From the Table 10 it is observed that there were some food insecure people in some months whereas total food secure is 94 sample of households out of 149 and food insecure is 55 out of 149. And there were particularly two months when food insecurity was reported to be very high compared to the other months. Status 1 households are completely food secure whereas status 2 and status 3 households were not. September-October and October- November were months most often reported to be food insecure (months of distress) by the surveyed respondent households.

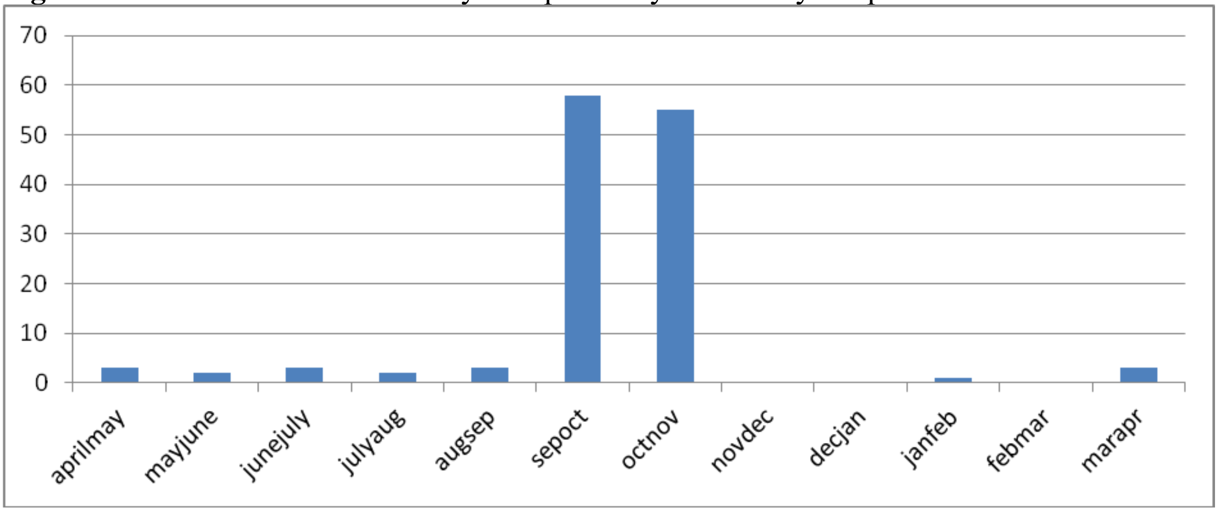
Table 10: Status and Months

Months of Distress						
Status	0	1	2	3	4	Total
1	50	0	0	0	0	50
2	30	0	18	1	0	49
3	14	1	32	2	1	50
Total	94	1	50	3	1	149

Source: Based on Field survey, 2014.

The Figure 1 shows that food security is related with the twelve months but food insecure is higher from the September- October and October- November and others months' low significantly with the food insecure. The significant social changes reflected in the diagram are that over the period (from September- October and October- November) the wetland adjacent household is food insecure as at that time wetland is made water logged situation by the anthropogenic activities.

Figure 1: Months of Food Insecurity as reported by the Survey Respondents



Source: Based on the Field Survey, 2014.

5.7.3 Relationship between Wetland and Food Security

We run a Probit regression analysis that models *food security* (household food security, value of 1 is the household is food secured, 0 if otherwise) as a function of variables such as age of the household head, education of the household head, dummy for villages, household size, brick of floor, thatch of wall, some indicator of rank or status of the household, gross total income and share of household wetland income (services and net benefits from wetland cultivation or benefit from staying close to the wetland).

The Probit model is given by:

$$P(Y_i = 1 | X) = G(\beta_0 + X\beta_1 + ... + X\beta_{10}) \quad (2)$$

where, $Y = 1$ if the household's food secured and 0 if the food insecure (all meals); X_1 = age of household head (age_head); X_2 = education of the household education (edu_head); X_3 = dummy for village of kamalpur; X_4 = dummy for village of ramchandapur; X_5 = household size (hh_size); X_6 = brick of floor (brick_fl); X_7 = thatch of wall (thatch_wl); X_8 = rank of status (status); X_9 = gross total income (lngtotal); X_{10} = share of household wetland income (shwetinc).

In equation (2), G(.) is a function taking on values strictly between zero and one: $0 < G(z) < 1$, for all real numbers z. This ensures that the estimated response probabilities are strictly between zero and one. In the case of the Probit model, G is the standard normal cumulative distribution function (CDF), which is expressed as an integral: $G(z) = \Phi(z) = \int \phi(v)dv$ where $\phi(v)$ is the standard normal density, and the integral is over minus infinity to the value of z. Since the probability P must be between 0 & 1, we have the restriction: 0 ≤ E (Yi/Xi) ≤ 1. That is the conditional expectation must be lie between 0 & 1. The standardized value of a normally distributed random variable is called a *Z* score and is calculated using the following formula.

$$Z = \frac{x - \mu}{\sigma} \quad (3)$$

where, x = the value that is being standardized; μ = the mean of the distribution; and σ = standard deviation of the distribution. Therefore, (1) equation estimates the wetland direct values, (2) equation explains the impact analysis for the qualitative that it introduces the dummy dependent variable and (3) equation explain the z – score that shows the significant level associated with standard deviation.

Table 11: Probit Regression Result of Food Security

Dependent Variable: Household reported "all meals" (1) or "not all meals" (0)				
all meals	Coefficient	Robust Std. Err.	Z	p value
age_head	.0226*	.012	1.86	0.063
edu_head	.007	.040	0.19	0.852
kamalpur	1.592***	.478	3.33	0.001
ramchan	.586	.454	1.29	0.197
hh_size	-.144	.106	-1.36	0.173
brick_fl	-.302	.401	-0.75	0.451
thatch_wl	-.366	.468	-0.78	0.434
status	-1.716***	.277	-6.20	0.000
lngtotal	.096	.222	0.43	0.668
shwetinc	-.851	.604	-1.41	0.159
constant	1.731	2.709	0.64	0.523
Number of Observations: 149				

Source: Based on Field survey, 2014.

The table shows that "all meals" is the dependent variable and it is defined in context to the food security. Food security depends on various independent variables. Nevertheless, wetland related food security is affected by household size, status, wetlands' net benefit from cultivation and wetland services. Household size, status, wetlands' net benefit, coefficient negative sign was expected as household size and status numbers are adversely related with the all meals. Wetland net benefit from cultivation are adversely related to the all meals because wetlands' net benefit from cultivation cannot properly explained for access to wetland cultivation limited to the lower class population while wetland services properly explain the food security in the wetland adjacent residents.

5.7.4 Average Marginal Effects of Food Security

In this section, we have made an attempt to understand the marginal effects of changes in independent variables. In this analysis the change in one variable resulting from the change in another, holding all else constant, is called a marginal effect (ME). In the Probit regression model this is the interpretation of the slope parameter, which can be written as $\partial\Phi / \partial x$.

For the Probit regression model, $Y_i=\beta_0+\beta_1X_i+U_{i,}$ if Yi=1, then Yi ≥ 0, the marginal effect can be written as

$$ME = \frac{\partial\Phi(\beta_0 + \beta_1 x_i)}{\partial x_i} = \varphi(\beta_0 + \beta_1 x_i)\beta_1 \qquad (4)$$

Rather than computing the marginal effect at one specific variable, we can alternatively find the marginal effect at each value of *dependable variable (food security)* and *explanatory variable* and then average this quantity across all observations. This is called an average marginal effect (AME). For the present case, the AME can be estimated as

$$AME = \frac{1}{n}\sum_{i=1}^{n} \varphi(\hat{\beta}_0 + \hat{\beta}_1 x_i)\hat{\beta}_1 \qquad (5)$$

We use this equation (5) to estimate the average marginal effect of food security of the adjacent wetland households. This average marginal effect equation interprets that a one unit change in the explanatory variable increases or decreases the probability of food security by the estimated values reported below against each variable.

Table 12: Average Marginal Effects (AMEs) of Food Security

	Delta-method			
	dy/dx	Std. Err.	Z	P>|Z
age_head	.004*	.002	1.94	0.052
edu_head	.001	.007	0.19	0.852
kamalpur	.300***	.084	6.58	0.000
ramchan	.110	.085	1.29	0.196
hh_size	-.027	.020	-1.36	0.174
brick_fl	-.057	.075	-0.76	0.449
thatch_wl	-.069	.086	-.080	0.425
Status	-.323***	.039	-8.29	0.000
Lngtotal	.018*	.042	0.43	0.669
shwetinc	-.160	.112	-1.43	0.154

Source: Based on Field survey, 2014

Average marginal effects reflect the significant change for the dummy variable, with dummy independent variables, average marginal effects measure discrete change. Average marginal effects for continuous variables measure the instantaneous rate of change. Hence, *age_head* and *lngtotal* is statistically significant at 10% level and *kalampur* and *status* variable is statistically significant at 1% level. On the other hand, share of household wetland income from the wetland cultivation is not found to be related to all meals or food security in a statistically significant way. All meals or food security related to independent variables such as *age_head*, *edu_head*, *kamalpur*, *ramchan*, *hh_size*, *brick_fl*, *thatch_wl*, *status*, *lngtotal* and *shwetinc*.

Over all 81.88% had been correctly classified in this model that explains all meals or food security phenomena. In middle class and lower class some of the households have experienced food insecurity, characterized by low harvest and households having a single meal in a day. Especially wetland adjacent lower class people utilize the wetlands' resources as an alternative source of household food. Wetlands are the basis of food security, directly providing resources for consumption, indirectly supporting crop and livestock production, materials that are sold for purchasing food in emergency situations and services that support food production. With increasing population around the wetlands, coupled with land shortage and weather variations, the poor people, especially in the study areas will continue generally to rely on wetland ecosystem services directly for subsistence and income generating activities for sustaining their livelihoods unless alternative livelihood options are provided.

6. CONCLUSION

In the study area of Pabna, wetlands which used be Multiple Use Systems (MUSs) are getting converted to Single Use Systems (SUSs) depending on economic, social & political pressure from dominant stakeholders. Economic benefits and number of beneficiaries are higher for MUSs as compared to SUSs. Economic and ecological functions of MUS change over time and space. Attempts to classify MUS according to their uses across ecological zones and economic valuation are very limited. Future research on economic valuation of MUS should focus on ecological functions- e.g., nutrient trapping and recycling; spawning and breeding ground for indigenous fish species; groundwater recharge and impacts on hydrology; runoff and soil erosion control, and flood mitigation; regulating micro-climate on the area surrounding the wetland, and biodiversity conservation. There is a need for economic valuation of wetlands in economic and ecological functions. In this study area, government and local government need to take steps (such as canal dredging) for the rural wetlands since the wetlands contribute to the livelihood and food security of the surrounding area population. Based on the principles of co-management, government and communities should work together to ensure conservation of existing protected areas (PAs), to demonstrate the development benefits of conservation of protected areas. Hence, special care must be taken to maintain wetlands with their perfect environment. Wetlands management needs to be incorporated into a system of integrated land and water use and indeed, into the socioeconomic system of the country.

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APPENDIX

Appendix Table 1: Total Net Benefit from Wetland Cultivation (in TK.)

Units	Class	Average Benefits per HH (A)	Average Benefits per HH (B)	Average Benefits per HH (C)	Average Benefits per HH (D)	Average Benefits per HH (E)	Sum Total (A+B+C+D+E)	Total No. of Households within Class	Total Net Benefit
[1]	Upper	5649.3	2683.05	556.25	30	0	8918.6	95	847267
	Middle	6611.86	604.34	535.61	847.90	166.40	8766.11	114	999336.54
	Lower	3095.31	-534.93	110.73	3454.29	0	6125.4	171	1047443.4
[2]	Upper	12267.40	3520.24	2691.72	448	3752.82	22680.18	120	2721620.6
	Middle	7523.88	2240.57	1356.74	2004.81	204	13330	133	1772890
	Lower	4747.71	533.33	356.25	0	100	5737.29	190	1090085.1
[3]	Upper	3472.80	1320	359.4	1100	0	6252.2	15	93783
	Middle	8720	1320	0	1180	0	11226	20	224520
	Lower	243.33	0	0	832.5	0	1075.83	30	32274.9
Total		**8829220.54**							

Note: A = Rice, B= Jute, C= Wheat, D= Bean, and E= Other Produces.
Legend: [1] Ramchandrapur; [2] Kamalpur; and [3] Nowdapara.

Appendix Table 2: Total Net Benefit from Wetland Services (in TK.)

Units	Class	Average Benefits per HH (A)	Average Benefits per HH (B)	Average Benefits per HH (C)	Average Benefits per HH (D)	Average Benefits perHH (E)	Sum Total (A+B+C+ D+E)	Total No. Households with. Class	Total Net Benefit
[1]	Upper	220170	990	52752.45	115202.5	1614	390729	95	37119250.25
	Middle	20705	280	5401.24	4297.5	3258	33941.74	114	3869358.36
	Lower	22925	170	3359.376	3085	1589	31128.38	171	5322952.30
[2]	Upper	41798	1196	16557.49	8768	429.6	68749.09	120	8249890.8
	Middle	9642	690	4924.332	5606	2083.2	22945.53	133	3051755.76
	Lower	5587.5	276.04	1792.875	3222.92	2555	13434.33	190	2552523.46
[3]	Upper	57000	640	23978.4	18900	19444	119962.4	15	1799436
	Middle	53000	640	12057.3	18900	9444	94041.3	20	1880826
	Lower	7100	0	11.67	466.67	3820	11398.34	30	341950.2
Total									**64187943.13**

Note: A = fisheries, B= Jute retting, C= using water, D= fodder and E= others services (duck keeping, snail and poultry). Legend: [1] Ramchandrapur; [2] Kamalpur; and [3] Nowdapara.

Appendix Table 3: Benefit from Wetlands Fisheries

Units	Class	Open Access	Scientific	Pond	Total	Sample HHs	Per HHs	Total No. of Households within Class	Total Net Benefit
[1]	Upper	3400	4250000	150000	4403400	20	220170	95	20916150
	Middle	180200	190000	43900	414100	20	20705	114	2360370
	Lower	163500	280000	15000	458500	20	22925	171	3920175
[2]	Upper	34950	810000	200000	1044950	25	41798	120	5015760
	Middle	92050	120000	29000	241050	25	9642	133	1282386
	Lower	134100	0	0	134100	24	5587.5	190	1061625
[3]	Upper	0	265000	20000	285000	5	57000	15	855000
	Middle	0	265000	0	265000	5	53000	20	1060000
	Lower	42600	0	0	42600	6	7100	30	213000
Total									**36,684,466.00**

Legend: [1] Ramchandrapur; [2] Kamalpur; and [3] Nowdapara.

Appendix Table 4: Total benefit from using water

Units	class	Using water (for irrigation)				Using water (for scientific fisheries)			
		Benefit	Per HHs	Total No. HH Within Class	Total Net Benefit	Benefit	Per HHs	Total No. Households Within Class	Total Net Benefit
[1]	Upper	64715.6	3235.78	95	307399.1	990333.5	49516.68	95	4704084.6
	Middle	51777.26	2588.863	114	295130.382	56247.5	2812.375	114	320610.75
	Lower	34973.52	1748.676	171	299023.596	32214	1610.7	171	275429.7
[2]	Upper	145383.7	5815.348	120	697841.76	268553.5	10742.14	120	1289056.8
	Middle	88642.56	3545.702	133	471578.366	34465.75	1378.63	133	183357.79
	Lower	43029	1792.875	190	340646.25	0	0	190	0
[3]	Upper	300	60	15	900	119592	23918.4	15	358776
	Middle	20800	4160	20	83200	39486.5	7897.3	20	157946
	Lower	70	11.667	30	350.01	0	0	30	0
Total					**2,496,069.46**				**7,289,261.64**
Total									**9,785,331.10**

Legend: [1] Ramchandrapur; [2] Kamalpur; and [3] Nowdapara.