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IMPACT ASSESSMENT OF LAND USE CHANGE ON ECO-SYSTEM SERVICES OF TANGUER HAOR OF BANGLADESH

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Abstract

A study was conducted at the Tangua Haor wet land ecosystem under Tahirpur upazila of Sunamganj District in Bangladesh with a view to holistic assessment of the changes in land use and other resources and impacts of those changes on ecosystem services. The study was accomplished through intensive household level survey, focal group discussion, field observations and satellite images analysis. Once this wetland ecosystem provided diversified resources which have been considerable depleted over time. The Haor ecosystem was probably the best place for the fish biodiversity, but some of those are now about to be extinct. Frequently found tree species except Koroch (*Pongamia pinnata*) and Hijal (*Barringtonia acutangula*) have been decreased noticeably, whereas, swamp forest increased because of strengthening social forestation programs. The diversity index of birds reduced from 2.13 to 1.98 indicating a great loss of bird diversity presumably due to various anthropogenic pressures including shrinking of fish reserves in the Haor. The satellite image analysis showed a great change in land use pattern during 1989-2010. The most important was the transformation of water bodies into mudflat and cropland, and to some extent to swamp forest. The occurrence of flashf lood increased causing huge damage of crops, communication network and houses. As a result, most of the ecosystem services like fish, food, fuel wood, fiber, drinking water have already been decreased in varying degrees over time. Recognizing these worst situations, the Government of Bangladesh has restricted the free access of the people for harvesting resources and undertaken various programs like promoting swamp forest and creating awareness among the people. These might have positive sign to maintain and obtain better ecosystem services from the Haor in future.

Keywords: Wetland ecosystem, land use change, biodiversity and ecosystem service.

Introduction

Tanguar Haor is the largest wetland in Bangladesh comprising of 10000 ha of land area. It is located at the foot of the Khasi Hills under northeastern district Sunamgonj. This wetland has

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been recognized as wetland of global importance under the Ramsar Agreement since 2000. The ecological system surrounding the Tanguar Haor provides enormous opportunities of income and employment to some 77,000 population spread over 88 villages (Anonymous, 2007). Rice farming and fishing are the major economic activities along with other subsidiary earning sources for the people around the Haor. Once it was very rich in fish biodiversity and many threatened species were abundant in this ecosystem indicating a high importance of the Haor in conserving fish biodiversity. This Haor ecosystem is also known for its mother fishery where parent fishes take refuge in the winter, and in early monsoon, the grassland and rice field surrounding the Haor becomes their spawning ground. Moreover, the Haor also protects the low lying crop fields from early monsoon flood by taking in water, and hence delays the flooding of the low lying area. This delay of flooding is blessing for people to safe harvest of their rice crop. The swamp forest is another unique ecological feature of the Haor ecology. The Haor is one of the largest revenue sources of the government of Bangladesh and fishery sector is the major provider of this earning (IUCN 2010).

The Tanguar Haor is a resting place of many water fowls in the winter months. Its rich fish stocks attract the birds migrating from the Siberian region to avoid extreme cold environment during winter months. Every year more than one lakh birds used to come in Haor area. However, the government of Bangladesh declared this Tanguar Haor as an Ecologically Critical Area (ECA) in 1999 due to tremendous pressure on its resources and damaging of its ecosystems. The majority of the pressures are increasing population at the vicinity of Haor and subsequent over exploitation of fisheries, forests and other resources. For this the government halted its age old system of leasing for revenue collection and enlisted it as a 'Ramsar Site' under the Ramsar Agreement. Under this agreement the policy of commercial exploitation of the Haor is expected to be replaced by a policy of 'wise use' which allows local people to harvest resources but not for a pure commercial point of view.

The new management rules are thought challenge for all the parties involved in the Haor ecosystem. Regarding this Swiss Development Cooperation (SDC) came forward with a package of financial grant to ensure sustainable management of the Haor resources and continual growth of

income for the welfare of the Haor people. Although the Haor is considered as a treasure house of resources, the inventorizing and changing trends of those resources was not yet adequately done. Particularly the information about land use and land cover changes are still lacking. Such changes and its impacts on the ecosystem services are necessary for formulating conserving strategies of Haor resources and their sustainable development. It is also important to know how the Haor communities are adopting with the changing environment and what would be the best option to cope up with those situations.The above information would be useful to develop policies and programs under the changing scenarios for environmentally compatible and economically viable production and livelihood systems. Taking these into consideration, a typical site of the Tanguar Haor was selected for this study with a view to holistic assessment of land use changes and other resources, and impacts of those changes on ecosystem services.

Materials and Method

Household survey

The study was conducted at the south-eastern part of the Tanguar Haor. A household level survey was carried out in three villages at the vicinity of Tanguar Haor viz. Hukumpur, Silon Tahirpur and Golabari under Tahirpur upazila of Sunamganj district. The villages were very close vicinity to the Haor and having good communication. Out of the total 185 households, 50 respondents keeping atleast 15 from each village were randomly selected and extensively studied through pre-tested interview schedules by face to face interview during June to September, 2012. Several Focal Group Discussions (FDGs) were made with the respondents and non-respondents of the villages to verify the collected information and their responses on other relevant issues. The major parameters included in the study were socio-economic and livelihood pattern, trends of changing resource availability, land use changes and the impacts these changes on the ecosystem services. The changing pattern of resources and perception of the respondents on land use change were compared.

Climate data analysis

The long-term meteorological data (1961-2010) were collected from the nearby meteorological station. These data were analyzed to identify the climate variability and extreme events, and to verify the climate variability and events with the farmer experiences and perceptions. The Standardized Precipitation Index (SPI) of the location

was calculated using following formula (Edwards and McKee, 1997):

$$SPI = \frac{Xi, \bar{X}}{\sigma}$$

Where, SPI is Standardized Precipitation Index; Xi, $\bar{X}$ and are ith year precipitation, long-term mean of precipitation and standard deviation of mean, respectively.

Land use change

The land use changes during 1989-2010 were analyzed using Lands at imagery of 30n resolution downloaded with free of cost from the sites http://earthexplorer.usgs.gov/. The image classification was done using ERDAS Imagine 11 and Arc GIS 10. With the help of Landsat imagery 2010, a future scenario of land use change in 2020 has been predicted. The spatial and temporal changes of land use and other resources in the study area were analyzed. Beside the study focused the subsequent impacts of these changes on plant and bird diversity as well as household dependence in Haor ecosystem.

Species of plant and bird diversity

Homestead plant species were identified through field visits and Household Level Questionnaires (HQL) survey. Swarm forest was documented through same processes and also from secondary sources. To indicate the importance and species richness of different plant species Relative Prevalence (RP) of species was calculated through population of the species per homestead multiplying by percent homesteads with the species. Bird species were documented based on opinions of the respondents, local experience persons and documentation of IUCN. The Shannon-Wiener Index (SWI) was used to evaluate the species richness and abundance of trees and birds in all three locations (Margurran, 1988). The proportion of species (i) relative to the total number of species (pi) was calculated and then multiplied by the natural logarithm of the same proportion (lnpi). The resulting product is summed across species, and multiplied by 1.

$$SWI = p_i\,[ln(p_i)]$$

Results and Discussion

Demographic and socio-economic profiles of the respondents

The highest proportion of the respondents belonged under the old age group i.e. more than 50 years and closely followed by the young aged group. This indicated that majority of the respondents were well experienced. In case of education, majority of the respondents had some level of education though most of them passed the primary level. The higher rate of

literacy in the study might have good values for decision making pertaining to any stress conditions. The average family size of the respondent was 6.28, while about half of the respondents had medium sized family. It revealed that the family size was relatively bigger in the study area than that of the national average family size of 4.50 (BBS, 2011). This might be due to joint family system in the studied community. Regarding farm size, marginal farm size group was dominating followed by small and landless groups. The average farm size was 0.33 ha per family which is almost half of the national average of 0.67 ha (Krishi Dairy, 2012). This information clearly stated that respondent community was the resource poor and mainly depended on common natural resources of Haor.

The income level of the respondents revealed that majority of the respondents were extreme poor to poor. The poor income of the respondents was possibly due to shrinkage of livelihood opportunities like resource collection from the Haor.In view of occupation types/economic activities, majority of the respondents (90%) were dependent on fishing, closely followed by farming and day laborer. The other minor occupations were small business, duck rearing, sand and coal collection, bird hunting and trading, boatman etc.

Change of climate of the study site

Temperature during 1961-2010 showed a steady increasing trend of both maximum and minimum temperatures over time (Figure 1 and 2). The increment rate of maximum and minimum temperatures were 0.025 and 0.019°C per year, respectively indicating that increase in maximum temperature was more pronounced than that of minimum temperature. It was observed that the minimum temperature during winter season (December-January) had been slightly decreasing, while it exhibited increasing trend in rest of the months. This indicated a gradually warming of the area regardless of seasons. These changes might have impact on the incidence of pests and diseases as well as productivity of the cropsand forest vegetation.

The long-term changes in rainfall was not significant over seasons. The annual drought and wet frequency corresponding to standardized precipitation index (SPI) in the study area has been shown in Figure 3. The result revealed that drought frequency was dominant in the recent years and the SPI values crossed the normal level (-0.5 to +0.5) in most of the years. Subash and Mohan (2011) reported a wide year-to-year variability in the monthly distribution of rainfall in Indo-Gangetic region.

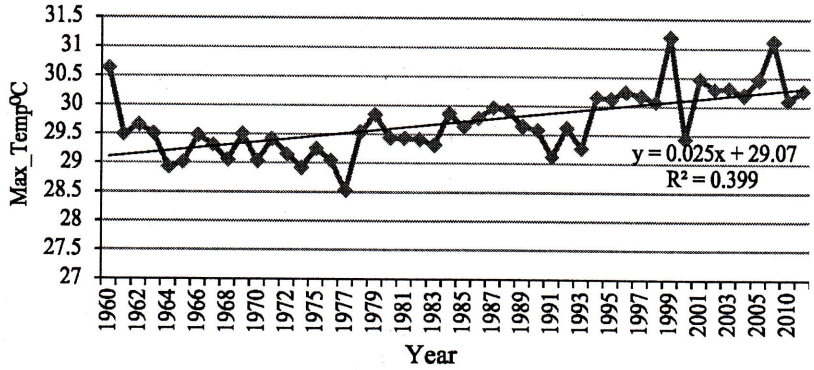

Figure 1. Long-term (1961-2010) trend of maximum temperature in the study area.

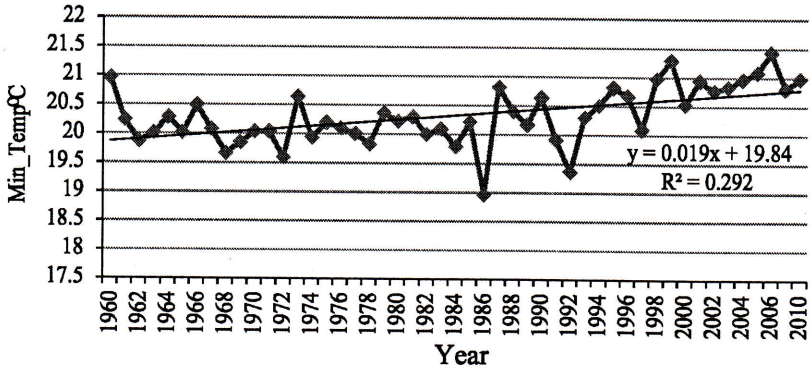

Figure 2. Long-term (1961-2010) trend of minimum temperature in the study area.

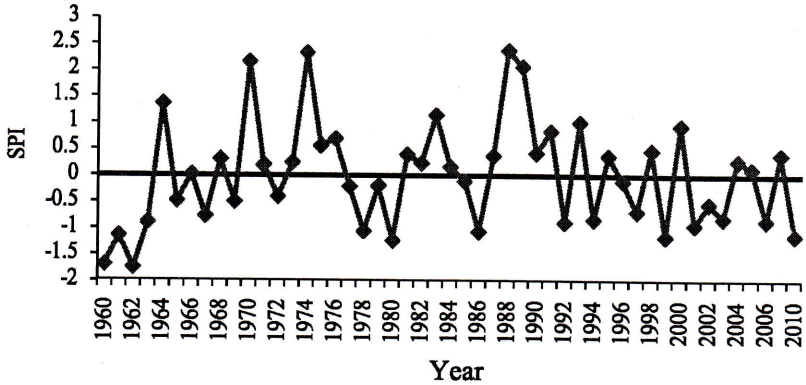

Figure 3. Long-term (1960-2009) annual Standardized Precipitation Index (SPI) in the study area indicating frequency of dry and wet conditions.

Changes in land use pattern

The Tanguar Haor had have diversified land used and land cover (LULC) from a long time. The major land use pattern was waterbodies (beel and river) (46.2%) followed by single and double cropland (20.5%) in 1989. The other important LULC were mudflat, settlement and swamp forest (Figure 4 & Table 1). During 1989-2010, waterbodies decreased 14.4% of the total studied area, but area under other land classes increased except some area under double cropped that decreased probably due to seasonal variation in land use. The area under waterbodies have been transformed to mudflat as well as single cropland. During the study period swamp forest also increased 1.1% of based on total area. These findings justified with the perception of local community. The findings also illustrated that the shrinking of waterbodies will be continued and predicted 18.9% of the total area in 2020, and will be transform into new mudflat and single cropland.

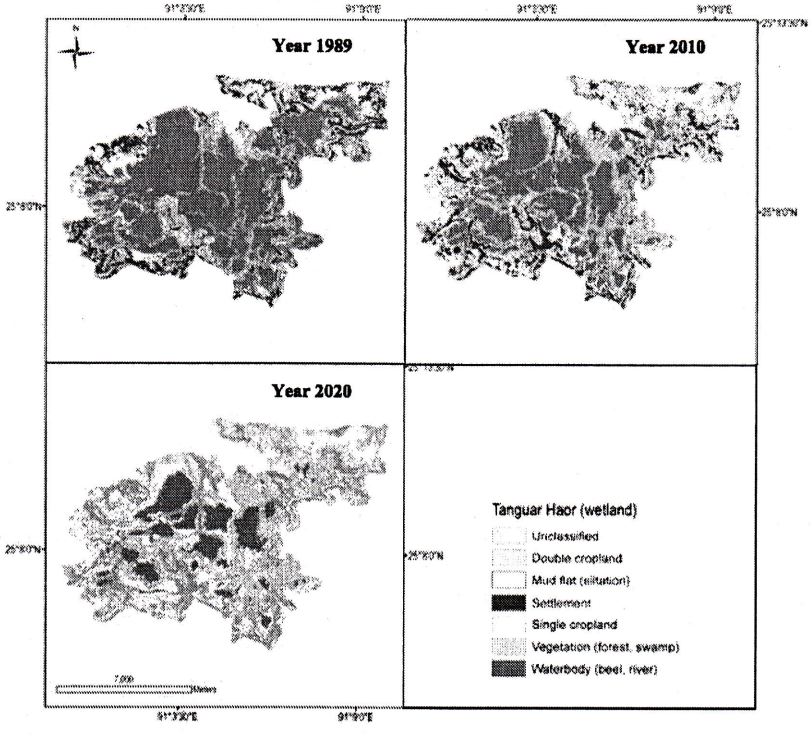

Figure 4. Land use land cover map in the study area.

Table 1. Land use change during 1989-2010 and prediction of siltation in 2020 in Tanguar Haor

Land use and land cover types (LULC)	1989		2010		2020*		Area Change	% Area Change
	Area (ha)	%	Area (ha)	%	Area (ha)	%	1989-2010	1989-2010
Settlement	1157	10.2	1454	12.8	1454	12.8	297	2.6
Double cropland	328	2.9	314	2.8	314	2.8	-14	-0.1
Single cropland	2003	17.6	2889	25.4	2753	24.2	886	7.8
Vegetation (swamp forest)	1084	9.5	1209	10.6	1209	10.6	125	1.1
Mudflat (siltation)	1561	13.7	2168	19.0	1863	16.4	606	5.3
Waterbodies (beel, river)	5261	46.2	3359	29.5	1646	14.4	-1902	-16.7
Mudflat (predicted siltation)	-	-	-	-	2154	18.9	-	-

*only area under siltation has been predicted

Changes of rice varieties over time

The major farming in the Haor area is only the boro rice (winter season) cultivation because of long-termland inundation during the rainy season. About 0.68 million ha area (80%) is occupied by boro rice, while others are under transplanted aman (Huda, 2004). High yielding boro rice cultivation is generally restricted due to early flood, hailstorm and drought. However, development of rice variety suitable for the area significantly increased HYV rice cultivation replacing local rice varieties in the area. The most remarkable adoption of HYV rice varieties includes BRRI Dhan 28 and BRRI Dhan 29. For the last 10 years, these two rice varieties have became almost double (Table 2) In contrast, except two fine rice cultivars i.e. Shail and Gochi all the local cultivars decreased to a great extent.

Table 2. Respondent's opinion on changes of rice varieties over time in the study area

Rice variety	Respondent's opinion on changes of rice varieties over time (%)		Change(%)
	10 years before	Year 2010	
High Yielding Rice (HYV)			
BR28	17.60	34.80	+97.73
BR29	12.75	24.45	+91.76
BR19 18.40		21.20	+15.22
BR45 7.40		9.80	+32.4
Hira	8.20	6.20	-24.40
Local Rice (LR)			
Shail	10.60	11.16	+5.28
Gochi	13.85	14.45	+4.33
Tepi	8.48	5.78	-31.84
BaygunBachi	9.55	6.84	-28.38
Agni 9.90		6.48	-34.55
Agam	9.14	4.46	-51.80
Lakai	8.13	3.71	-54.37
Rata 7.42		3.14	-50.00
Basful	7.42	2.35	-68.33

Changes in homestead forest/tree species

Changes in dominance of tree species over time in the homestead are expressed as relative prevalence (RP) (Table 3). About 21 woody and fruit species have been identified in the study area. This indicates a very good tree biodiversity in the homestead area. Based on RP values, the dominant woody species were. Koroch (*Pongamia pinnata*), Hijal (*Barringtonia acutangula*), Raintree (*Samanea saman*) and Mehogony (*Swietenia macrophylla*) and that of fruit species Mango (*Mangifera indica*), Jackfruit (*Artocarpus heterophyllus*), Guava (*Psidium guajava*), Blackberry (*Syzygium cumini*) and Betel nut (*Areca catechu*) in the study area.In 2012, the RPof Koroch (*Pongamia pinnata*), Hijal (*Barringtonia acutangula*) and Acacia (*Acacia auriculiformis*) increased and others are decreased. All the fruit species showed decreased RP in 2012 indicating gradual extinction of all fruit species in the study area. The increase of RP for Koroch (*Pongamia pinnata*), Hijal (*Barringtonia acutangula*) were 80.6 and 42.89% respectively during 2000-2012. This indicates their ability to withstand standing water for a long

time possibly because of their genetic makeup and adaption to the site.There were very lowRP values in some species like Bilimbi (*Averrhoa bilimbi*) Neem (*Azadirachta indica*), Sofeda (*Manilkara achras*), Olive (*Olea europa*), Coconut (*Cocos nucifera*) indicated they were about to extinct. The Shannon-Wiener Diversity Index (H) that indicates the species abundance and richness showed that diversity of tree species decreased from 2.60 in 2012 to 1.96 in 2000in the study area (Figure 5). This indicates that the species abundance and richness became poor and needs restoration measures.

Table 3. Changing scenario on the relative prevalence of tree species in homestead area during 2000-2010

Name of tree species	Relative prevalence of tree species over time		% Change
	2000	2012	
Forest/woodyspecies			
Acacia (*Acacia auriculiformis*)	0.50	0.60	+20.00
Hijal (*Barringtonia acutangula*)	4.36	6.23	+42.89
Khair (*Acacia catechu*)	0.32	0.28	-12.50
Koroch (*Pongamia pinnata*)	5.27	9.52	+80.65
Koroi (*Albizia sp*)	0.95	0.44	-53.68
Mehogony (*Swietenia macrophylla*)	1.29	0.36	-72.09
Neem (*Azadirachta indica*)	0.83	0.04	-95.18
Raintree (*Samanea saman*)	1.98	1.44	-27.27
Shimul (*Bombax ceiba*)	0.78	0.28	-64.10
		Fruit species	
Betel nut (*Areca catechu*)	1.28	0.48	-62.50
Bilimbi (*Averrhoa bilimbi*)	0.92	0.04	-95.65
Blackberry (*Syzygium cumini*)	0.87	0.72	-17.24
Coconut (*Cocos nucifera*)	1.02	0.16	-84.31
Custard apple (*Annonas quamosa*)	0.36	0.3	-16.67
Guava (*Psidium guajava*)	1.01	0.72	-28.71
Jackfruit (*Artocarpus heterophyllus*)	1.46	0.76	-47.95
Jujube (*Zizyphus jujube*)	1.11	0.24	-78.38
Lemon (*Citrus limon*)	0.58	0.36	-37.93
Mango (*Mangifera indica*)	3.56	2.28	-35.96
Olive (*Olea europa*)	1.45	0.16	-88.97
Sofeda (*Manilkara achras*)	0.46	0.04	-91.30

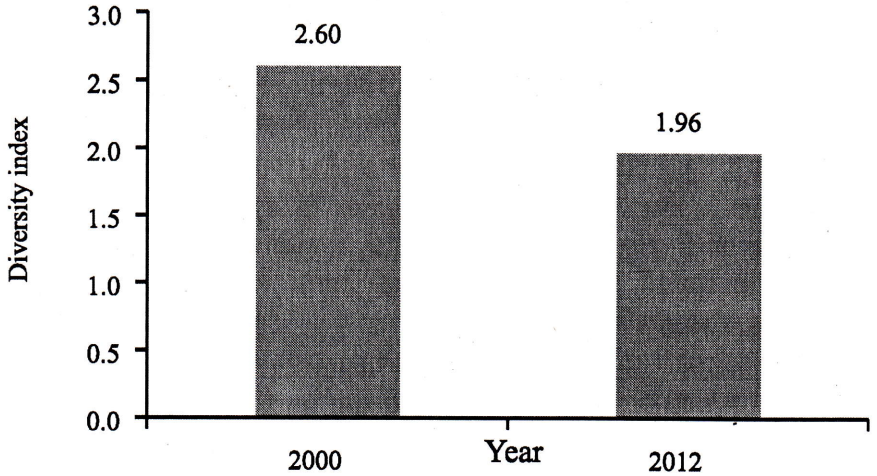

Figure 5. Diversity Index of tree species in the study area. Index note: 0?2 = poor and need restoration measure; 2?3 = abundant and need protection work; and >3 = rich and naturally survived.

Changes in swamp forest

Swamp forestsare inundated with freshwater either permanently or seasonally. It is normally occurred along the lower reaches of rivers and around freshwater lakes.The forest goes under 7-10 meters water during rainy season. Rest of the year, the water level is about 3 meters deep. This forest is the good shelters of the fishes during rainy season.Itis the habitat of different snakes, monkeys, lizards, insects and birds. The changes of swamp forest both in area and species richness over time in Tanguar Haor are illustrated in Table 4. The major swamp forests species recorded in the different locations are *Pongamia pinnata, Barringtonia acutangula, Crataeva nurvala, Sonneratia caseolaris, Erythrina variegata, Phragmites karka, Saccharum spontaneum, Ipomoea alba, Trewia polycarpa, Girardinia heterophylla, Typha elephantine, Hibiscus tiliaceus.* It is interestingly observed thatthe swamp forest increased in most of the locations, while almost all other resources have been found to decrease remarkably. Various promotion activities primarily the social forestry program implemented by the government and non-government organizations accelerated this increase of swamp forests which reflect the development of plant biodiversity.

Table 4. Change of swamp forest both in area and species richness over time in Tanguar Haor

Location of observation	Area (ha) Year 2000	% Year 2012	Species richness Change	Year 2000	Year 2012	% Change
Alamdaor	12.36	8.77	-41.04	4.66	1.2	-74.25
Bagmara Kanda	8.24	6.48	-27.31	3.13	2.88	-7.99
Binnabon	8.15	6.27	-30.00	5.00	4.83	-3.40
Kailary Kanda	8.34	5.16	-61.73	2.00	1.25	-37.50
Kaillatur	6.62	9.93	+50.00	1.86	2.90	+55.91
NainderHaor	7.76	11.13	+43.45	1.17	2.00	+71.38
Osakanda	7.62	11.52	+51.06	2.80	5.00	+78.57
Patichula	8.22	10.87	+32.30	3.21	3.87	+20.56
PoillaBeel	13.41	17.20	+28.28	3.00	3.50	+16.67
PuranGaon	13.15	9.78	-34.46	3.00	2.00	-33.33
Rajar Dai	6.27	4.86	-29.17	2.67	1.91	-28.46
Razdaigang	11.38	14.42	+26.66	1.75	3.00	+71.43
Ulush Nagar Kanda	5.75	9.89	+71.87	2.13	2.53	+18.78
Mean	9.02	9.71	+7.65	2.80	2.84	+1.43

Changes in fish resources

Fish resources in Tanguar Haor declined remarkably during the last decade. In 2000, this wetland ecosystem was the home of 128 varieties of fish which is about half of the freshwater fish varieties in Bangladesh, but recently many of them have been found to extinct. Fish species in the study site was categorized into seven groups according to abundance or availability (Table 5). Thehigh availability of fish species expressed as very common, common and fairly common groups decreased remarkably showing 42.86, 20.00 and 11 54%, reduction, respectively. While less abundance or threatened species in terms of few, very few, occasional and very rare groups were increased manifolds (Table 8). Therefore it is urgent need of undertaking conservation measures for sustainability of very common fish species. Respondent opinion on the availability of fish resources when compared for present status to 10 years before showed a strongly supportof changing fish species over time. More than 50% respondents opined that Darkina (*Rasbora rasbora*), Moha shol (*Tor tor*), Chitol (*Chitala chitala*), Boro boal (*Wallago attu*), Boro Rui (*Labeo*

rohita), Kali Baush (*Labeo calbasu*), Ayer (*Sperata aor*), Katla (*Catla catla*), Mrigel (*Cirrhinus cirrhosus*), Chanda (*Chanda nama*), Meni (*Labeo ariza*), Baim (*Mastacembelus armatus*), Koi (*Anabas testudineus*) were the abundant fish species in Tanguor Haor in 10 years before, but those abundant species were reached to either less abundant or endangered stages.

Table 5. Changes of fish species over time in the study area

Species availability	Changes of fish species (type of species)		
	Year 2000	Year 2010	Change (%)
Very common	28	16	-42.86
Common	35	28	-20.00
Fairly common	26	23	-11.54
Few	15	22	+46.67
Very few	19	23	+21.05
Occasional	4	9	+125.00
Very rare	1	3	+200.00

Note: very common=very high abundance, common=high abundance, fairly common=moderately abundance etc.

Changes in bird resources

About 30 migratory and residential bird species was recorded from five beels of Tanguar Haor of which 11 species were presented in Table 6 based on number of birds available in the area. Alam and Hasibur (2011) recorded a total 167 species (65010 in number), among them 83 species are resident and the rest 84 are migratory. In this study the common and most prevalent bird species were *Gadwall* (1905), *Eurasian Coot* (930), *Purple Swamphen* (810), *Tufted Duck* (320), *Eurasian Wigeon* (305) and *Pheasant-tailed Jacana* (300) in 2000. The number of birds of all species decreased in varying degree ranging from 21.3-75.0%. Among them, Grey headed Lapwing, Tufted Duck and Eurasian Coot showed more than 50% reduction. The reasons for decreasing trend of the number of birds regardless of species were the increasing trend of hunting and other anthropogenic activities particularly, habitat destruction, persecution in cage and perhaps accidental poisoning (CNRS, 2007). The Shannon-Wiener diversity index (H) showed that the diversity index of bird species decreased from 2.13 to 1.98 over the last 10 years (Figure 6).

Table 6. Changing scenario of different bird species in the study area over time (in surrounding 5 beels out of 120 beels)

Name of birds	Number of birds		% Change
	Year 2000	Year 2010	
Gadwall	1905	1500	-21.3
Eurasian Coot	930	411	-55.8
Purple Swamphen	810	530	-34.6
Tufted Duck	320	111	-65.3
Eurasian Wigeon	305	210	-31.2
Pheasant-tailed Jacana	300	140	-53.3
Little Cormorant	225	120	-46.7
Gergeny	220	125	-43.2
Common Moorehen	100	53	-47.0
Cotton Pygmy-goose	52	34	-34.6
Grey headed Lapwing	40	10	-75.0

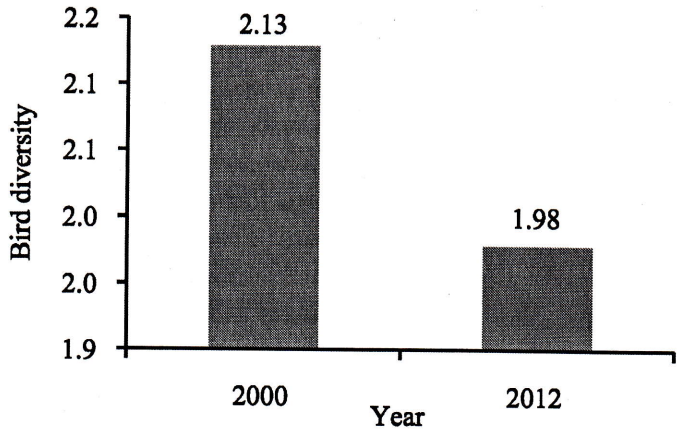

Figure 6. Diversity Index of bird species over time in the study area.Index note: 0?2 = poor and need restoration measure; 2?3 = abundant and need protection work; and >3 = rich and naturally survived.

Impact of land use change onthe ecosystem services

Once Tanguar Haor ecosystem provided all major household requirements and the economic activities of the local people but these have been remarkably decreased during the last 10 years (Table 7). In 2000, all most all basic

needs like fish and food were fulfilled from Haor resources, but now their supplies reduced up to 40%. Out of 80% fuelwood/cooking materials those generally came from reeds, leaves, branches of swamp forest, 56.3% has been reduced from 2000 to 2010. Once the Haor was considered as the best safe home of local and migratory birds, but now this safe place have been reduced 64.3%. About half of the drinking water requirement was met up from Haor's waterbodies in 2000. Now this source of drinking water reduced 50% because of impurity caused by various anthropogenic activities. However, Haor is using as a major source of irrigation water, although water has been polluted heavily. Conversely, increasing siltation in lakes assumed 30.7% during 2000-2010 which causes frequent overflow of water and flood during rainy season. Use of swamp forest as a source of raw materials for house making reduced drastically for the last 10 years possibly because of alternative raw materials like galvanized steel/metalsare available which is affordable for improving economical conditions of the people.In spite of enormous opportunities of the site for recreation and development of tourism, various facilities including communication have not yet developed in the area. Although it a place of recreation for local people, its use as recreation site is reduced due to lack of securities and communication tools.

Table 7. Impact of changes of land use and resources of Tanguar Haor on ecosystem services over time based on respondents' opinion

Ecosystem service	Changes of ecosystem		Change (%)
	Year 2000	Year 2010	
Fish	100	80	-20.0
Food	100	60	-40.0
Fuel wood/cooking material	80	35	-56.3
Fiber 45		33	-26.7
Bird's habitat	70	25	-64.3
Source of drinking water	50	25	-50.0
Source of irrigation water	100	100	0.0
Siltation/sedimentation and rising up of land	62	81	+30.7
Natural hazards control/regulation (mainly flood)	40	20	-50.0
Source of house making materials	100	15	-85.0
Recreation 30		25	-16.7

Actions suggested for livelihood development

A number of actions have been listed for maintaining better livelihoods through appropriate resources management in Tanguar Haor. Among these, the highest priority is given for conserving the natural resources followed by developing infrastructure such as building roads, embankments and protection walls. Priority is also given for ensuring early rice cultivation which is often damage by flooding for which strengthening agricultural extension and training activities need to be strengthened. To reduced flood damage dredging of adjacent rivers is necessary. Moreover, tree plantation program planning and execution is most urgent for a friendly ecosystem. Awareness building program for the conservation of fish, bird, swamp forest is also needed. Other necessary actions include protection of water from pollution, building mounds (killa) for livestock shelter during disasters, and creating alternate income generating opportunities and providing facilities of health services both human and animal.

Conclusion

The findings of the study revealed that socio-economic status of local community was poor and their lives and livelihoods were centered on the resources of Tanguar Haor wetland ecosystem from generation to generation. Currently the dependency on this Haor has been decreasing remarkably because of depletion of resources. Over exploitation of resources, other anthropogenic activities and climate change were the main driving forces of this depletion. The main visible change was the change of landuse pattern where water bodies were transformed to crop land, settlement and unproductive swamp forest. Because of the good water bodies, this ecosystem was considered as the treasure house of diversified resources especially fishes and bird habitat as well as income of the local people that are being depleted over time. The analysis of satellite image of the study site supported the field records on the changes of land use pattern. As a result, most of the ecosystem services such as fish, food, fuel wood, fiber, drinking water etc have already been decreased in varying degrees over time. Considering the worst situation of this important ecosystem, the government has restricted the free access of the people for harvesting resources and promoted social forestry activity for improvement of swamp forest. The community people well accepted the social forestry program and government's other

initiatives and they are co-operating for its well execution. These might have positive sign to conserve wetland ecosystem and create better ecosystem services for the Haor communities.

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