Wetland Natural Resources Economic Evaluation and Impacts of Different Management Options [1]

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The wetland (*haor*) system provides a wide range of economic and non-economic benefits to the local people as well as to the people of Bangladesh and the world at large. These include benefits in terms of fish production, rice production, cattle and buffalo rearing, duck rearing, collection of reeds and grasses, and collection of aquatic and other plants. The haor system also protects the lower floodplains from flash floods occurring in the months of April-May, recharges the water tables, maintains the supply of fish in other lower riparian water bodies, provides habitat for migratory and local waterfowl, and generates important carbon sequestration services. At the same time, the unique haor system is a natural beauty both during the monsoon months and the dry season. In monsoon, its unique physical characteristics make it a huge natural bowl of water and in the dry season it is natural grassland with pockets of beels serving as the resting place for migratory birds. Such a unique natural system, if appropriately marketed, could be a major attraction for tourists. However, as of today, there is little evidence of this.

Calculating the economic value of wetlands is a means and not an end in itself. It was evident during the discussions and various reports that a bio-economic model highlighting the interlinkages between the man and nature in the haor basin would be very useful to develop a proper management strategy. Consequently a schematic bio-economic model was developed as a means of providing information which can be used to make better and more informed choices about how resources are managed, used and allocated. Such a model would help the decision-making processes as it can be used to trace the economic implications of changes in the stock of wetland resources, flows of wetland services, or attributes of wetland systems that result from following a particular course of action, and factor them into measures of its economic desirability.

It incorporates the four management options for developing a management strategy that are articulated in the bio-economic model described in the preceding chapter (silt control, establishment of a sanctuary, construction of embankments, and afforestation). Each of these management options has different implications for wetland costs and benefits — for example those associated with changes in the area or stocks available for different resource uses, and with changes in the quality or quantity of ecosystem services generated by the wetland.

Result of the bio-economic model is analyzed using four management perspectives. First, benefit for the fishing folks – accrued to the people who are directly or indirectly linked with fishing or related activities in the haor area. Second benefit for the farmers – accrued to the people involved in rice farming. Third, benefit to the poor – for the people involved in duckkeeping, cattle-rearing, collection of fuelwood, medicinal herbs, and other construction materials for houses. Fourth, benefit to the environment – in terms of watershed benefits, biodiversity benefits, aesthetic benefits and flood control benefits. Management options are, therefore, weighted in terms of these four benefits to understand the pros and cons for the management of Hakaluki *haor*.

This study is not expected to provide a value for its resources. It simply provides a glimpse in terms of changes that would take place if the resources are not conserved properly. Consequently, the NPV estimates are also indicative of the amount of maximum feasible investment for conservation of haor in the next 30 years time.

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1. INTRODUCTION

1.1. The issues

Wetlands in Bangladesh have long been facing serious degradation and loss, due to many natural and anthropogenic factors. Besides natural causes, factors like overuse of resources, lack of property rights, human encroachment, conversion to other uses and also absence of effective enforcement of laws are some of the most important factors for the decline in wetland biodiversity of the country (Islam, Irfanullah 2005).

Hakaluki haor is one of the major wetlands of Bangladesh. With a land area of 18,386 hectares, it supports a rich biodiversity and provides direct and indirect livelihood benefits to nearly 190,000 people. Because of the critical conditions of the haor ecology, the government of Bangladesh declared Hakaluki as an Ecologically Critical Area (ECA) in April 1999. There are 8 ECAs in the country which are considered to be under severe threat. The government has designated these as ECAs to bring them under a management strategy which will ensure their conservation and sustainable use.

1.2. Aims of the evaluation

This evaluation aims to provide information on the values of conserving Hakaluki haor in terms of its economic, ecological and social benefits for local communities and for the nation at large. It has the following objectives:

- To understand the inter-linkages between economic and ecological functions of the haor system and to understand the pros and cons with respect to changes in the quality of the environment.
- To find a 'value' for measuring change in the quality of the environment.
- To develop a bio-economic model describing and illustrating the interactions between the people, resources and economic activities.
- To contribute towards developing a strategic policy for management of the haor so that it is used as a decision-support tool for wetland management.
- To determine a feasible set of economic and financial instruments to ensure wise use of the resources of the Haor basin.

2. DESCRIPTION OF THE SITE

2.1. Agricultural production

There are three major rice crops in Bangladesh: *Aus*, *Aman* and *Boro*. Of them, *Boro* is the main form of production in the haor area, while *Aus* and transplanted *Aman* are almost universally found on highland and medium highland floodplain ridge soils. *Aus* are widely transplanted in this wet region; elsewhere, sprouted seeds are sown on wet puddle soils. Most such land remains fallow in the dry season. With irrigation, HYV *Boro* is followed by rain fed transplanted *Aman*.

On lower land, mixed *Aus* and *Aman* or deepwater Aman are the traditional practices on basin margins, with local *Boro* paddy or grass land (used for dry season cattle grazing) in basin sites. With LLP irrigation, the area under *Boro* paddy — mainly early maturing local varieties — has greatly expanded in the past 30 years, thus considerably reducing the area formerly under grassland and reed swamp. Rabi crops such as vegetable, spices, sweet potato, potato, pulses and mustard are mainly grown on loamy-bank soils.

2.2. Natural resources

Fisheries: Haors and Floodplains in Bangladesh are important sources of fisheries resources for the country. *Kalibaus*, *Boal*, *Rui*, *Ghagot*, *Pabda* and *Chapila* are the main fish species of the Haor. From the Kushiyara there are frequent upstream movements of fish towards the *beel*s and tributaries of Hakaluki. *Beel*s in Hakaluki haor are important for fisheries. They provide the winter shelter for the mother fisheries, and in early monsoon these mother fisheries produce millions of fries for the entire downstream fishing communities. Consequently, protection of these fisheries not only benefits local people, but also all the people in the lower floodplains. Floodplains are also an important source of fisheries resources within the ECA.

At the same time it important to note that each of these *beel*s also provide a natural habitat for different species of fishes. However, many of the *beel*s have lost their capacity to provide shelter as mother fisheries, and hence are subjected to severe degradation due to a) sand deposits from upstream rivers and canals, b) using complete dewatering technique for fishing activities and c) absence of aquatic plants to provide feed and shelter for parent fish. Chatla *Beel* has come under threat of sedimentation from the Juri River. To counteract this threat, an embankment was constructed to deflect river sediments away from the *beel*.

Most of these *beel*s are leased out by the Government of Bangladesh for fishing activities for at least a period of three years, with provision for renewals. Each *beel* has a surrounding land area known as *kanda* where reeds and swamp forests used to exist in the past. Over time, human pressure, encroachment and also land allocations by the government to the landless has reduced the reed and the swamp forest area which provided shelter and feed for fish during the monsoon.

There are claims that under the current practice of land leasing, Hakaluki haor is in danger of losing nearly 32 fish species out of 107 because of over fishing by the lessee. This is a serious threat to fish stocks in the haor.

Waterfowl: Hakaluki haor is a very important resting place for migratory waterfowls flying in from the north. The most interesting species is the Barheaded Goose, which is now very rare in fresh water wetlands. Other important species include Adjutant Stork, Bear's Pochard, Falcated Teal, Broadbill Sandpiper, Spotted Redshank, Nordmann's Greenshank, Temmiinck's Stint, Steppe Eagle and Osprey. In a survey conducted under FAP 6 in 1994, 64,000 waterfowl were counted in Haorkhal and 15,000 waterfowl were counted in Chatla *beel*. Illegal poaching has been a threat to the waterfowl population.

Vegetation: Ecological characteristics, particularly vegetation patterns, differ sharply between the permanent and seasonal water bodies in Hakaluki haor. Within the permanent water bodies, vegetation is less dense in the monsoon than in winter, since the vegetation becomes submerged and does not thrive without light. However, the aquatic vegetation that exists begins germinating with the onslaught of the monsoon floods. Aquatic vegetation occurs mainly in the shallower parts of the Haor. Other than the shorelines (*kanda)*, most of the open water areas are weed-free.

Livestock: Hakaluki haor is known as good grazing land. People from villages around the haor and also from distant areas send their herds for grazing in winter. During this time, herders make permanent shelters near the *beel*s and graze their animals for a period of 4-5 months. During monsoon, many keep their herds in-house or send them to nearby hills for grazing.

Forests: Hakaluki haor contained a very dense swamp forest in the past, but deforestation and the lack of conservation practices have virtually destroyed this unique forest in the last two decades. Two small patches of swamp forest remain in the Hakaluki haor. One is in Chatla *beel* another is near the village of Kalikrishnapur. The plants which are common in this type of forest are also found in homestead groves. With the exception of these two swamp forest patches, the vegetation surrounding Hakaluki haor is unique since it includes both swamp forest as well as mixed evergreen rain forest.

Thatching material is the most useful natural wetland product of the area. The people in the vicinity use this material in various ways: for example as roofing, wall or wall panel material for their houses and for making mats. The utilization of wetland products is now less intensive, because in recent years the vegetation has decreased considerably. Another important use of the resources from this wetland is for fuel wood. Due to the scarcity of fuel wood around homesteads, the people are becoming increasingly dependent on this source of fuel. Swamp forest trees, except for ***hijol***, are the most popular fuel wood in these areas. However, all woody shrubs including grasses are also used for this purpose. The naturally regenerating saplings in the swamp forests are being harvested at a non-sustainable rate because of the scarcity of fuel. Wetlands products are also used as bio-fertilizer or green manure. All the small herbs and grasses grown in the Haor are used as green manure. Farmers living around the Haor use these materials instead of chemical fertilizer. The soft aquatic plants are gathered immediately after the monsoon and placed in piles in the fields, to allow them to decompose. There are many aquatic plants which are grown in the Haor area, and are used as food, medicinal plants, duck feed, or for fuel. These common property resources are of considerable importance to the poor.

2.3. Wetland goods, services and economic values

The haor system provides a wide range of economic and non-economic benefits to the local people as well as to the people of Bangladesh and the world at large. These include benefits in terms of fish production, rice production, cattle and buffalo rearing, duck rearing, collection of reeds and grasses, and collection of aquatic and other plants. The haor system also protects the lower floodplains from flash floods occurring in the months of April-May, recharges the water tables, maintains the supply of fish in other lower riparian water bodies, provides habitat for migratory and local waterfowl, and generates important carbon sequestration services. At the same time, the unique haor system is a natural beauty both during the monsoon months and the dry season. In monsoon, its unique physical characteristics make it a huge natural bowl of water and in the dry season it becomes natural grassland with pockets of ***beel***s serving as the resting place for migratory birds. Such a unique natural system, if appropriately marketed, could be a major attraction for tourists. However, as of today, there is little evidence of this.

The property rights regime of the haor is complex. Most of the agricultural lands in the haor basin are private land. While the majority of the water bodies are owned by the government and are generally leased out for fishing activities, smaller water bodies are sometimes owned by local villages or by a few families. The banks of the water bodies, which were once tracts of swamp forests, are public land.

The cycle of economic activities in the haor region also varies significantly with changes in the seasons. During the monsoon months, most of the land is under water and so fishing is the major economic activity. However, during this time leaseholders have no control over fish, because they are spread over a large area and people are able to catch them freely.

During the dry season, a large number of activities take place.. Agricultural land under private ownership is often put under ***Boro*** rice production. The banks of the wetland provide grazing grounds, and herds of cattle and buffaloes are brought in. Water bodies are more organized and defined, and leaseholders take full control of their fish harvests. Local people collect building materials such as reeds for fences, various plants and fuel wood for personal and commercial use, and sometimes are engaged in hunting and poaching of migratory birds.

3. METHODOLOGY

3.1. Steps in undertaking the study

The valuation exercise involved several steps and stages, as outlined in the table below.

Step	Involves	Results
Identifying wetland goods, services and values	Identifying and listing different wetland goods and services, their economic benefits, and determining the methods to be used to value benefits	List of wetland goods, services, benefits and valuation methods
Conducting a household survey	Administering a questionnaire to local community members	Information on the local use of wetland resources, and their value
Constructing a wetland bio-economic model	Establishing a model which describes the inter-linkages between biophysical and socio-economic aspects of wetland status and management	Information on wetland ecologicaleconomic relationships
Estimating the economic value of wetland goods and services	Quantification of the monetary value of wetland goods and services	Estimate of the value of the wetland
Assessing the economic impacts of wetland management options	Simulating the economic impacts of different wetland management options in terms of their effects on key goods and services	Estimates of the economic impacts of planned wetland management strategies

Each component of the study also provides information which feeds into other aspects. As illustrated in the Figure below, household surveys on the value of wetland goods and benefit transfer analysis of the value of wetland services provide the basic information which is fed into the bioeconomic model which describes the links between wetland ecology and economic processes. Using these data and this model, it is then possible to simulate the economic effects of alternative wetland management options for Hakaluki haor.

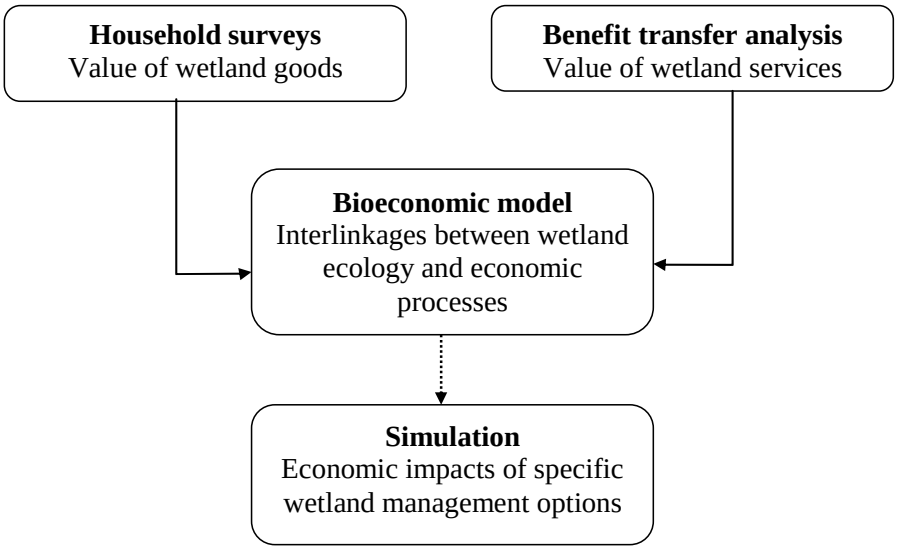

Figure 01: How different aspects of the study link together

3.2. Identifying wetland goods, services and values

To value the haor resources one needs to have an in-depth assessment of all environmental goods and services produced. Field trips and key informant interviews using unstructured questionnaires were used to assess and identify the resources of the haor. This provided actual information on the beneficiaries, property rights, conflicts for resource management, marginalization and institutional success/failures. Once the environmental goods and services associated with Hakaluki haor had been identified, it was necessary to assess how these benefits had economic value. A total economic value (TEV) framework was used to do this. TEV is composed of both use and non-use values, and use values can come in the form of direct and indirect uses

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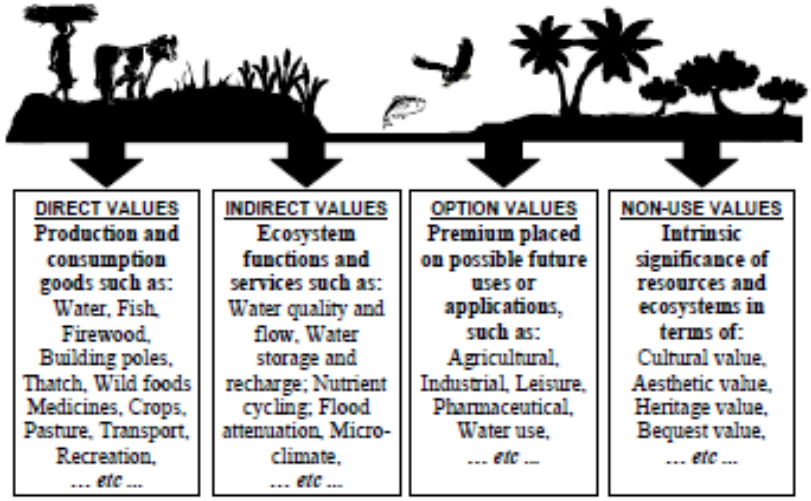

Figure 02: Total economic value of wetlands

Having identified the key economic benefits associated with Hakaluki haor, different methods were identified which could be used to value these wetland goods and services. These were:

- Conducting a household survey
- Estimating the economic value of wetland goods and services
- Constructing a wetland bio-economic model
- Assessing the economic impacts of wetland management options

Table 18: Summary of wetland goods, services and economic values

	Benefits	Valuation method used
Direct values	Fish harvest	Market values (through household survey)
	Fish hatchling supplies	
	Fish trading	
	Rice production	
	Non Fish Non Rice Products	
	Duck rearing	
	Cattle and buffalo rearing	
	Other benefits	
Indirect values	Watershed benefits	Benefit transfer
	Flood control benefits	
	Biodiversity benefits	
	Carbon sink	Not valued
Existence values	Aesthetic benefits	Benefit transfer

3.3. Conducting a household survey

To determine the nature of dependence of the people on the haor resources and to estimate the use value of haor resources, household level survey of 837 randomly chosen households were conducted between Jan-April 2006. A modular questionnaire was developed to elicit information from these households. To value the productivity value of the Hakaluki haor, a structured questionnaire was used with the following modules:

Module 1 on General Information- This included general information about the households such as total number of family members, number of earning members, education, religion, occupation, food habit, sanitation, drinking water, energy source, involvement with micro-credit system etc. This part was designed to find out their socio-economic condition.

Module 2A: Agricultural Activities- This part includes questions on agriculture, land ownership, expenditure and income from agricultural production, types of crops grown in the haor area, irrigation etc. It was designed to investigate agricultural production functions and income generation from agro-products in the haor area.

Module 2B: Fisheries- This part was designed to collect data on fish diversity of the study area, existing fish catch system, fishing expenditure, production cost and earnings from fishing.

Module 3: **Access and Rights to Collect Haor Resources-** The questions of this section concerned rights of the inhabitants to haor resources, obstacles and hindrance they face during resource collection, labour market, partnership and economic activities based on haor resources.

Module 4: Livelihood, Haor Resources and Other Non-use Value- This segment of the questionnaire consisted of questions on livelihood aspects such as full time/part time fishing, fish cultivation, livestock, collection of wetland plants and other resources

3.4. Estimating the economic value of wetland goods and services

This brings together the information gained from the household survey about the economic value of wetland resource use with an analysis of the economic value of wetland services. The benefit transfer method was used to value wetland services such as watershed, flood control,. biodiversity, carbon sink and aesthetic benefits. This involved extrapolating the results of a valuation exercise carried out in a similar wetland elsewhere in Bangladesh, which had established values for wetland services. The resulting values are expressed per hectare.

3.5. Constructing a wetland bio-economic model

Calculating the economic value of wetlands is a means and not an end in itself. It was evident during the discussions and various reports that a bio-economic model highlighting the interlinkages between the man and nature in the haor basin would be very useful to develop a proper management strategy. Consequently a schematic bio-economic model was developed as a means of providing information which can be used to make better and more informed choices about how resources are managed, used and allocated. Such a model would help the decision-making processes as it can be used to trace the economic implications of changes in the stock of wetland resources, flows of wetland services, or attributes of wetland systems that result from following a particular course of action, and factor them into measures of its economic desirability.

In the context of this study (as a first phase), it is particularly important to be able to trace the likely and actual impacts of development activities on wetland economic value, and to relate changes in environmental status to economic indicators. This type of model involved a number of iterative steps − establishing an economic baseline from which to measure wetland changes, linking physical changes in wetland status and integrity to changes in these economic values, and expressing the results as indicators or measures that can be integrated into broader economic appraisal or analysis processes.

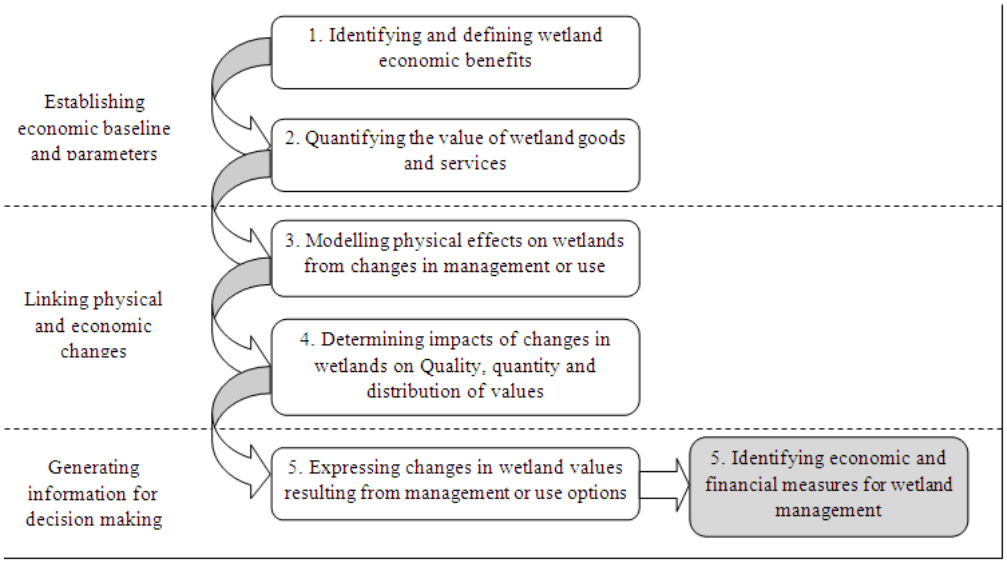

Figure 03: Steps in generating a wetland bio-economic model

3.6. Assessing the economic impacts of wetland management options

This models their economic impact in terms of changes in the supply of key wetland goods and services, using the bioeconomic model developed. It compares the present value of future flows of wetland goods and services under these different management options.

4. SOCIO-ECONOMIC PROFILE & WETLAND RESOURCE USE

4.1. Profile of households living around Hakaluki

Occupation and social identity: the primary occupation of households living around Hakaluki haor is agriculture, closely followed by fishing. Just under half of the population is engaged in other activities, many of them wetland-based, including manual labourers, boatmen, small traders and remittances from abroad. In terms of the social identity of the people in the area, the occupation of head of the households was used for this survey. There is variation in average monthly income between households. Approximately half of the population earns between 1,500 and 5,000 BDT, and half above 5,000 BDT a month. (1 US$ ≈ 70 BDT)

4.2. Average Income of the Households

However, it was also clear during our reconnaissance survey that the majority of the people living in the haor basin are absentee landlords, and that most of the land are used only for one crop. This means that land is not tilled as intensively as in other regions, a positive sign for the environment. Consequently, the questionnaire included questions regarding the source of income.

A large majority of local residents receive their income from crops (reflecting a dependency on haor land for rice cultivation), the next important source is remittance received from abroad (people in this region have a high migration rate to Europe and the US), the third important source of income is river or waterbodies. Average income from crop selling (agriculture) was BDT 20,793 and 45.28% of the respondents earned this amount. The second main source of income is share cropping and annual income was BDT 13,419. Remittance from the expatriate Bangladeshis is the third source of income for 27.72%. (1 US$ ≈ 70 BDT)

4.3. Quality of life

Quality of life is an important element of decision – making in conservation efforts. Types of toilet used, source of electricity and source of fuel are considered good proxy variables for quality of life.

In terms of toilet facilities 54% of the households use ring slab, 26% uses sanitary latrine. In terms of source of lighting, only 32% uses electricity (or had access to electricity) and the large majority uses kerosene. In terms of source of water, people use multiple sources: 95% uses tube-wells and another 70% uses ponds and rivers. Overall these indicators are above the national average for most of these variables. For the source of fuel for cooking, data shows that timber residue and cow-dung are the two major sources of fuel for cooking purposes. Over a quarter of respondent state that they collect these fuel sources from the haor.

4.4. Ownership of Properties

Nearly all respondents own their houses in the Hakaluki haor area. This reinforces the observations above that people in the Hakaluki haor basin are comparatively well-off in terms of property ownership, compared to other parts of Bangladesh.

Dependence on the Haor Resources

The property rights regime in the haor has several dimensions. First, agricultural land is privately owned and operated; second, the leased out beels are also private property for the period of lease while government regulates operations through its district administration; and third, the kanda land is government land with no private claims on it. These lands are the rural commons where grazing activities, collection of reeds, duck rearing activities take place. Various departments of the Government of Bangladesh including the Ministry of Environment and Forests have claims on this land or on part of this land. To implement a management strategy for the haor resources, it is important to understand the connectivity of people with this land.

4.5. Who collects haor resources from the commons and the private lands

About two thirds of the households living in the region regularly visit the haor in order to collect wetland resources. However, they face the threats from private operators. Survey reveals that 46% of them face such obstructions during collection of resources. 90.8% of them said that the barriers come while fishing in the beels (whereas big beels are leased out there are many small beels inside the haors which are part of the rural commons but the leaseholders often encroach into their rights as common people do not have legal papers to defend their access to these commons); 29.48% have reported resistance during bird hunting (which shows that government campaigns to protect birds in the haors have found its footage); 19.3% faced hindrance during fuel wood collection and 13.9% faced difficulties while grazing herds in the commons. In terms of whom the players are in creating such obstacles, Table above shows that nearly 75% of the people found the obstacles coming from the lease-holders, government officials were next in the line and then the land owners. Local influential people, interestingly, do not violate the rights of the common people on the beels/haor resources.

Only 25% of beel lease holders and cooperatives have legal fishing rights. Nearly 50% of the beels are 'open access' resources, 22% are under private ownership, in 1.2% of beels villagers have common rights, and in some beels rights are not well defined (0.5%). This provides a picture of the potential for conflicts if there is an initiative to unify or to redefine their rights without appropriate consultation or participation and without amending legal regimes in the haor area.

4.6. Economic Activities in the Haor

Other than fishing and rice cultivation, there are various economic activities from which people benefit. Table below shows that fishing and fish related activities is the major source of livelihood for the people. Nearly 83% of people are involved in activities related to fish production from the haor. Cattle grazing and duck rearing is also very common in the haor and nearly 97 and 87 percent of the people are involved in it respectively. Fuel wood collection is also an important economic activity while poaching of birds is also crucial for nearly 16% of the people. About 9% people are involved in sand extraction while about 6% are engaged in reed collection. Only 9.8% of the jobs

are initiated by the Lessee of the beels. Similarly, local Member of the Parliament, or members of the elected local government institutions are responsible for nearly 5% of the economic activities.

4.7. Income Generated from Economic Activities

Table below shows that average income from capture fisheries is over 16,000 BDT per household, and that nearly half of households are engaged in this. However, culture fishing is also a growing industry in the area, providing an average income of 14,440 Taka for participating households. Just under half of the population is engaged in collecting other wetland products for their residential use, and about 6% in direct income-generation from haor resources.

Table 01: Annual Income of Households from Haor related Economic Activities

	Percent	Annual Income
Aquatic resources		
Involved in Capture fisheries, including:	**48.39**	**16,307.27**
Full time fishing	6.09	36,911.76
Part time fishing	18.64	25,066.67
Fishing for self consumption	23.89	2,807.73
Fish drying	0.36	666.67
Net weaving	24.97	-
Other gadgets for fishing	24.97	-
Others	0.84	35,428.57
Involved in Culture Fisheries, including:	**2.99**	**14,440.00**
Release/transport fries	0.24	2,250.00
Provide food and fertilizer in fish cultivation pond	0.12	5,000.00
Selling of cultivated fish	2.63	15,977.27
Fish trading	**8.96**	**31,826.67**
Poultry farming (snail/Jhinuk)	**0.48**	**1,400.00**
All Aquatic resources (fisheries+fish trading+poultry)	**52.09**	**21,463.41**
Other productive goods		
Involved in other productive goods from haor, including:	**42.05**	**3,755.96**
Food for human	1.08	3,480.00
Feed for cattle	31.54	3,430.78
Roofing materials	0.84	1,085.71
Fencing materials	2.99	888.00
Medicinal plants	4.66	3,551.28
Fuel	9.44	2,620.89
Others	0.48	2,425.00
Animal husbandry		
Involved in Animal Husbandry, including:	**63.08**	
Earning reported in Animal Husbandry	**19.83**	**8,513.43**
Cattle rearing	39.31	
Goat rearing	6.09	
Sheep rearing	1.19	
Buffalo rearing	3.58	
Duck keeping	22.10	
Chicken keeping	37.51	

	Percent	Annual Income
Small business	1.19	26,300.00
Other income-generating activities		
Involved in other income-generating activities, including:	**6.33**	**14,318.87**
Handicrafts	0.36	7,600.00
cane made materials	0.36	5,833.33
vegetable cultivation	2.75	2,613.04
Fish cultivation	1.55	16,423.08
others	0.36	60,666.67
Rice production		
Rice Production	**66.31**	**7,050.00 /hectare**

Table below summarises information on participation in wetland activities, and income arising from this, in order to express earnings per hectare of wetland. It shows that a high proportion of households are engaged in wetland activities, generating substantial income. Fishing, rice production and cattle rearing cater high incomes in terms of income generated per hectare.

Table 02: Income per hectare from Hakaluki haor

IG Activities	Income in BDT per hectare	Percent of household	Area in ha in Hakaluki haor
Fish harvest	13,586.43	48%	13,595
Fish hatchlings supplies	761.69	3%	13,595
Fish trading	5,010.90	9%	13,595
Rice cultivation	7,050.00	66%	13,418
Other productive goods	5,330.37	42%	7,116
Duck rearing	11.89	0.5%	13,595
Cattle rearing	5,466.82	19%	7,116
Other productive services	3,063.27	6%	7,116

4.8. Local support for wetland conservation

In addition to collecting information on the economic value of wetland resource use, the study also investigated local perceptions of and participation in wetland conservation. As illustrated in Table 16, 687 out of 837 or 82% of households are engaged in economic activities in the haor area. Among them, 83% of them are 'friends' of the ECA and are likely to strengthen the efforts of the DoE. The other 17% are still not 'the friends' of the ECA. They can either be persuaded with a strong 'campaign' to become friends of the ECA or else kept disengaged from the ECA management related activities so that they cannot be the 'power brokers' at the ECA groups. Finally the other 18% of the people are currently not engaged in any type of economic activities inside the haor (despite the fact that they live in the villages surrounding the haor). However, it was also observed that 81% of these 'disengaged' households are 'friends' of the haor. Consequently, they are likely to derive 'existence value from the haor'. We have not valued them in this study.

5. THE ECONOMIC VALUE OF WETLAND GOODS AND SERVICES

It is evident from the preceding discussion that the Hakaluki haor ecosystem generates a set of economically valuable goods and services. These serve over 80% of the people living in the haor basin. These economic values arise from: a) fisheries production, b) rice production and c) NFNRPs.

Besides these direct use values, the wetland ecosystem also provides several other streams of indirect values. These include the economic benefit of a) watershed services - maintaining the waterflow and supplies by recharging, storing and regulating water flows, b) flood control services - through storing waters during flash floods, so the downstream people in the river basins are protected from flash floods and crop damages, c) biodiversity benefits – by conserving rich and diverse wetland biodiversity, d) carbon sink services - wetland ecosystems also serve as carbon sinks and therefore benefit the global community and e) recreational and knowledge benefits for tourists, academics and researchers.

Although direct uses can be valued through the information collected via the household questionnaire, this survey instrument did not provide data which would enable indirect values to be calculated. In order to express these values in monetary terms, the benefit transfer method was used. This relies on detailed recent work carried out by the MACH project in Hail haor, located in Mouvibazar. As many of the conditions and services provided by Hail haor and Hakaluki haor are extremely similar, the results of valuation carried out for Hail haor were considered suitable for extrapolation to the Hakaluki haor case. It should however be noted that three significant wetland services have been omitted from valuation: water quality improvements, aquifer recharge and carbon sequestration. This underlines the fact that the values specified for Hakaluki haor are very conservative, and represent a minimum estimate.

Collating the information on wetland goods (direct values) and services (indirect values), it is evident that Hakaluki Haor is worth an average of Tk 48 thousand per hectare, or almost Tk 585.75 million in total. Of this total, wetland goods comprise the major amount (84%), and fisheries and rice production are of particular importance.

Table 03: Value of wetland goods and services in Hakaluki haor

	Land Area in Hectar	BDT per Hectare	Total value (Tk mill) per year	% total
Wetland goods				
Fish harvest	13,595.10	13,586.43+	184.71	28%
Fish hatchlings supplies	13,595.10	761.69+	10.36	2%
Fish trading	13,595.10	5,010.90+	68.12	10%
Rice Production	16,102.19	7,050.00+	113.52	15%
Non Fish and Non Rice Products	7,115.87	5,330.37+	37.93	11%
Duck rearing	13,595.10	11.89+	0.16	0%
Cattle and buffalo rearing	7,115.87	5,466.82+	38.90	11%
Other benefits	7,115.87	3,063.27+	21.80	6%
Wetland services				
Watershed benefits	13,595.10	1,020.93*	13.88	2%
Flood control benefits	13,595.10	2,242.04*	30.48	5%
Biodiversity benefits	13,595.10	4,174.63*	56.75	9%
Aesthetic benefits	13,595.00	671.91*	9.13	1%
Total		**48,390.89**	**585.75**	**100%**

Source:+IUCN Study 2006; * MACH Project Study, USAID 2002, values adjusted for 2006 using CPI.

6. ECOLOGICAL-ECONOMIC LINKAGES

Biological process models designed to depict agro-ecological processes can be used to simulate the impact of changes in biological and anthropogenic processes on an ecosystem. These models are quite useful to understand the process of inter-linkages and determine impacts of policy changes as well as rationalize policy decisions.

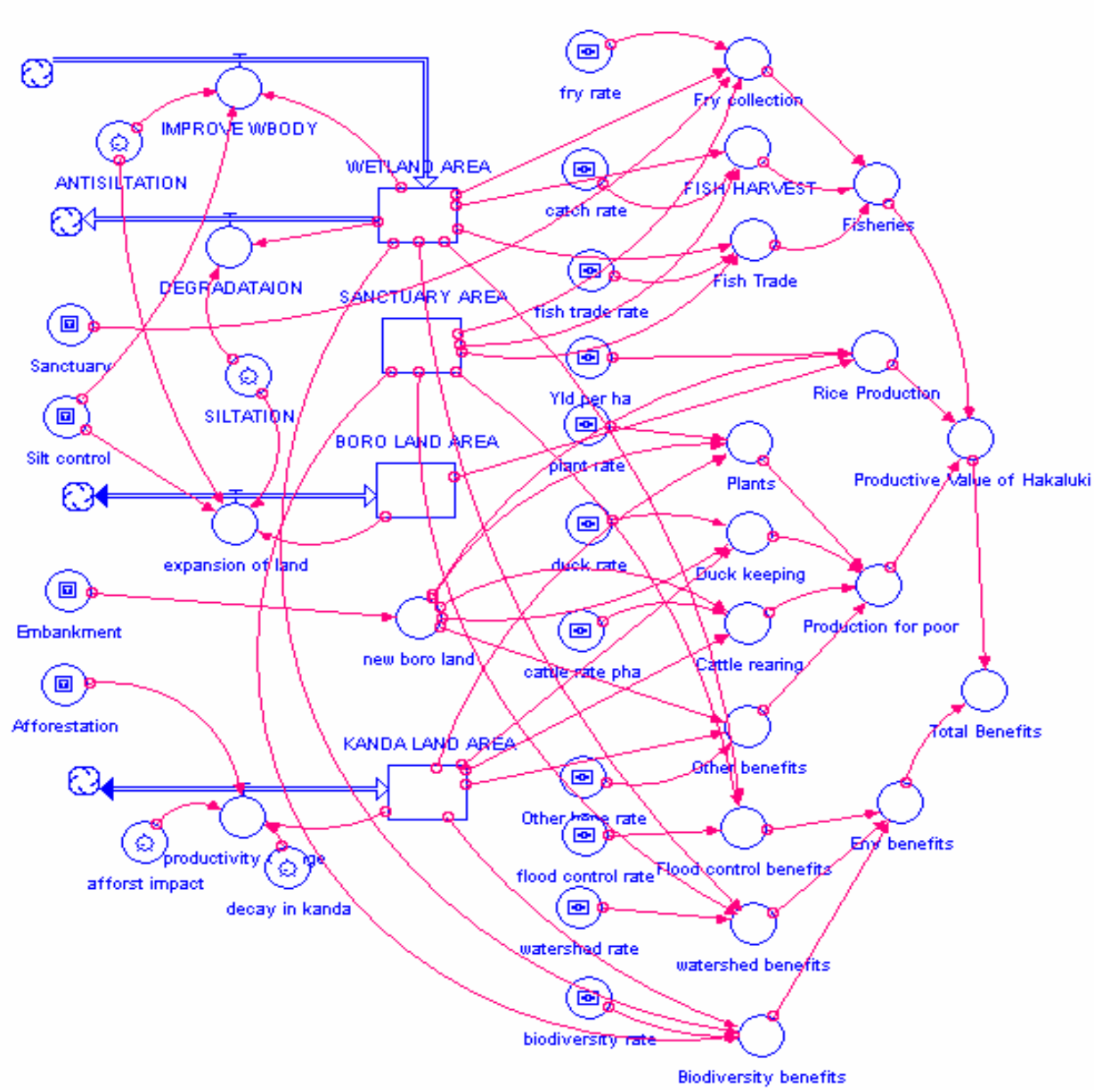

Figure 04: Bio-economic Model for Haor Resources (adopted from Haque, 2006)

Most of the bioeconomic models uses 'mechanistic' or 'theory driven' relationships to model the 'biological processes' and determines the impacts of changes in the nature. Very few of these models (Pulina, et al. 1999; King et al 1993; Coughenour et al, 2000; Shepherd and Soule, 1998; Maxell et al, 1999, Milne et al, 1999; Milne and Sibbald, 1998; Van Noordwijk, 1999 and 2000; Kaufman, 2000 and Metherell et al, 1996) include human components explicitly in the model specification beyond the part played in specifying the management regime for the scenario under simulation. However, these models use a set of accounting equations to determine benefits and costs (economic and biological) associated with various strategies or scenarios. These models do

not explicitly optimize any variables but they do provide an analysis from which it is possible to take decisions which are welfare maximizing.

In Bangladesh, no bio-economic models were ever been developed that links the economy and the bio-physical world of haor area to understand the impact of changes. From the discussion above, it is clear that there is a strong economic tie between people living in the area and the changes in the quality of the ecosystem that prevails in the Hakaluki haor.

Based on the survey data, and discussions with various individuals and stakeholders we developed the schematic bio-economic model for understanding the choices that lies ahead in developing a management strategy for Hakaluki haor. The model has three distinct components. Component 1 shows the biological processes and exchanges between the nature and human actions, component 2, shows the economic activities based on the natural resources in the haor basin, and component 3 shows the policy options for developing a management strategy for the the Hakaluki haor.

Component 1: Biological Processes

Water Resources: It has been assumed in the model that Hakaluki haor area consists of the ECA as demarcated by the Department of Environment. Biologically, the ecosystem is under threat from sand deposits flowing into the beels through some of the rivers and canals during monsoon months. It reduces the productivity of the beels. Total area of floodplains, beels, rivers and canals in the ECA is 13,395 hectare (GIS information from CNRS). Fish catch, fry production and also fish trading are the major economic activities based on this resource.

Paddy Land: Most of the land used for agriculture in the Hakaluki haor are Boro crop land and our survey has shown that nearly 90% of the Boro land of the for 66% of the people living in the haor area are located inside the haor. Compared to this only 6-10% people have aus and aman crop land inside the haor area and that too is less than 50 percent. In our model we are ignoring the ausaman crops from the analysis. Paddy land is also threatened by sand deposits from the rivers.

Kanda Land or Banks of the Beels: Banks of the beels are the commons which serve a multiple purposes. During the dry season, these are the grass lands used for cattle grazing, whereas during monsoon, the reeds provide shelter to young fish, providing them with feed. It helps growth of fisheries output. Area of Kanda land is used to produce goods and services other than fish and rice in the haor area. They are usually encroached by farmers who use these lands if better irrigation facilities are made available and if embankments can be erected for expanding Boro cultivation.

Component 2: Economic Activities

Fisheries activities: From Table 25, we have seen that there are three major activities based on water resources in the haor. These are fish catch from the beels, fish trading, and fish fry supplies and related trades. Returns on these activities depend on a) the quality of water resources (both land area and water quality), b) type of fishing gears used by the people, c) road networks that exists in the region and d) efforts given by the people involved in various economic activities

Rice Production: Table 25 also shows the productivity of Boro rice in the region. A total of 13,418 ha of land is currently under Boro cultivation. Boro production depends on a) irrigation facilities, b) labor supply, c) soil quality and d) the possibility of flash floods during early monsoon months.

Other goods and services production: Table 25 further shows that the kanda land area is used as the launching ground for a) cattle grazing, b) duck keeping, c) collection of fuelwood, food plants, other plants, and d) other goods and services using the haor resources. This production is a function of a) the area of kanda land, b) the quality of water bodies and c) time used to collect resources (effort). Major threats in this production are a) expansion of Boro crop land b) decay in the quality of vegetation.

Component 3: Management Options

Option 1: Sedimentation control - During the field trips to the area it was evident from discussions with local people, DoE officials and local elected representatives that sedimentation control is a major issue both for fisheries group and rice producers. As a result, any effort to bring local people in the fold of management of Hakaluki haor would require a well designed policy adoption to control silt deposits on the beels and the paddy land. The general demand is to construct barrages (temporary) to avoid sedimentation.

Option 2: Sanctuary - Fishing is the life-blood of the people of the haor area. Most of the fishermen are quite aware of the consequences of over fishing, but due to leasing of major beels, there is a growing pressure on the stock of fish. In the recent months, the pressure is more intense because some leaseholders use dewatering techniques in beels to catch fish. As a result the entire fish stock is depleting. It was also clear during field trips, focus group discussions and interviews that there exists a popular demand for establishment of sanctuaries in various parts of the haor basin. The local elected officials expressed their strong desire to establish at least one sanctuary per union.

Option 3: Submergible Embankments - Boro crops are often threatened by early monsoon flash floods. Consequently, the probability of crop damage is very high in the haor basin. In fact, it is the major problem in the area. This has resulted in another popular demand for construction of submergible embankments so that rice can be salvaged from the onslaught of early monsoon floods. Although popular, this proposition runs in conflict with environmental interests for two reasons a) such construction will lead to expansion of Boro land and so a reduction of kanda land will occur and b) it might prohibit fish migration during crucial periods of fish movement and will therefore reduce fish stock.

Option 4: Afforestation - Hakaluki haor like other haors in Bangladesh provides fuelwood, medicinal plants, reeds and grass for the people. The swamp forests in the haor basin are unique forests that survive deep flooding during monsoon months. However, due to human pressure these forests are virtually non-existent. As a result, the poor groups of people suffer the most. The ecology also suffers as fish stocks decline and erosion occurs. Considering these, there has been also popular demand for continuing with afforestation programs. This is also the most pro - poor effort because much of the benefit from such programs (if designed properly) would directly benefit the poor people in the haor area who would collect fuelwood, construction materials and also medicinal herbs from these new plantations.

Using the above three components, it is possible to develop an elaborate bio-economic model where all the relationships are well developed and the policy options are weighed in terms of maximum returns.

7. ECONOMIC IMPACTS OF WETLAND MANAGEMENT OPTIONS

7.1. Economic simulation

The following simulation of the economic impacts of different wetland management options is based on the goals of the in Hakaluki haor development, as well as on the information gathered during the course of field surveys conducted as part of this study. The study presents below a summary of benefits to be derived from Hakaluki haor if various management options are introduced in order to improve the condition of the wetland. In other words it looks at different conservation and sustainable use scenarios, not at scenarios which involve further degradation of the wetland. For the purpose of this study a 30 year lifetime of the project is assumed.

It incorporates the four management options for developing a management strategy that are articulated in the bio-economic model described in the preceding chapter (silt control, establishment of a sanctuary, construction of embankments, and afforestation). Each of these

management options has different implications for wetland costs and benefits — for example those associated with changes in the area or stocks available for different resource uses, and with changes in the quality or quantity of ecosystem services generated by the wetland.

Result of the bio-economic model is analyzed using four management perspectives. First, benefit for the fishing folks – accrued to the people who are directly or indirectly linked with fishing or related activities in the haor area. Second benefit for the farmers – accrued to the people involved in rice farming. Third, benefit to the poor – for the people involved in duckkeeping, cattle-rearing, collection of fuelwood, medicinal herbs, and other construction materials for houses. Fourth, benefit to the environment – in terms of watershed benefits, biodiversity benefits, aesthetic benefits and flood control benefits. Management options are, therefore, weighted in terms of these four benefits to understand the pros and cons for the management of Hakaluki haor.

Using the results of the valuation exercise, and the relationships specified in the bio-economic model, the simulation looks at the economic impacts of these different management options, both individually and as aggregates. The results are presented below.

The results of the simulation exercise were judged using the following criteria: a) the business as usual scenario presents what would happen if nothing is done in terms of conservation efforts in the haor; b) different management options were simulated using the dynamic bioeconomic model and simulation results in terms of total economic value and compared with business as usual scenario; c) the NPV of benefits were calculated from the stream of predicted benefits and the higher differences between the values, greater is the net gain in welfare; d) the flow of TEV is also examined to determine if the effort is sustainable implying that future flow of benefits cannot go down in case of sustainable conservation effort. In all the figures below we present a) Total Benefits – implying TEV over time, b) Fisheries benefits – implying benefits accrue due to fishing and fishing related activities, c) rice benefits – meaning benefits related to rice and rice production related benefits, d) environmental benefits – implying environmental benefits in terms of flood control, biodiversity, recreational and watershed benefits, and e) production for poor – implying portion of benefits accrue directly to poor due to their use of kanda land.

7.2. Economic impacts of management options

Table 04: Present Value of Benefits and its Distribution from Various Management Policies

	PV of Productive Goods and Services from Hakaluki haor in BDT millions (for 30 year life time with a 5% rate of discount)			
	Total Benefits	**Economic Benefits**	**Envi Benefits**	**Poors' Benefit**
Business As Usual	7,019.25	6,381.71	637.54	1,379.60
Silt control	7,671.15	6,959.91	711.24	1,379.60
Sanctuary	7,874.20	7,209.56	664.65	1,379.60
Afforestation	7,367.02	6,729.47	637.54	1,727.36
Embankment	6,788.78	6,151.24	637.54	910.91
sedimentation + Sanc	8,342.55	7,631.32	711.24	1,379.60
Sedimentation control + Sanc + afforest	8,690.32	7,979.08	711.24	1,727.36
Sedimentation control + Sanc + afforest + embankment	8,459.85	7,748.61	711.24	1,258.67

Construction of an embankment will not bring in net additional benefits, as illustrated in Figure below. Although there are gains in rice production, loss in kanda land would outweigh the gains. Overall the total benefits are declining and so the option is unsustainable.

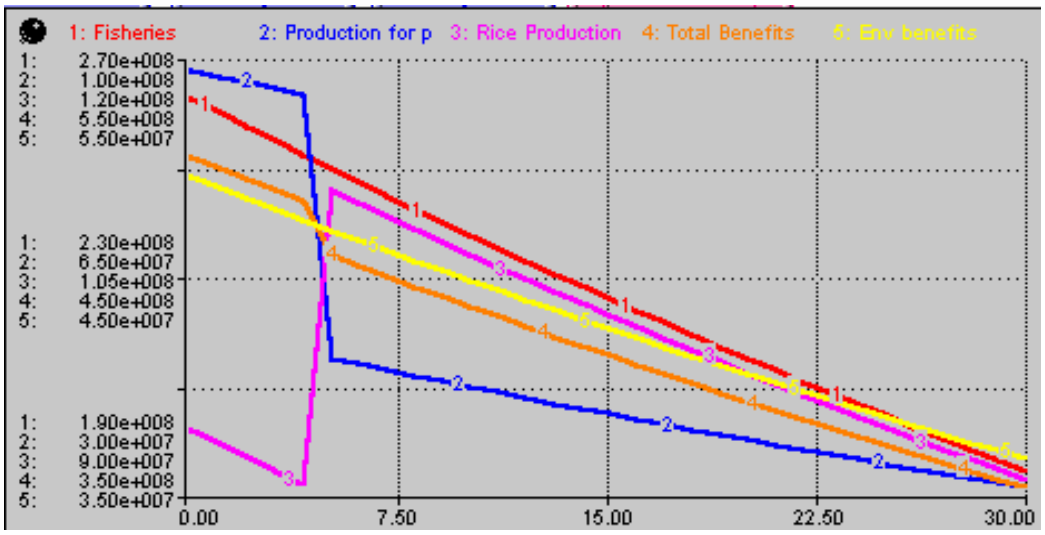

Figure 05: Effect of Embankment (adopted from Haque, 2006)

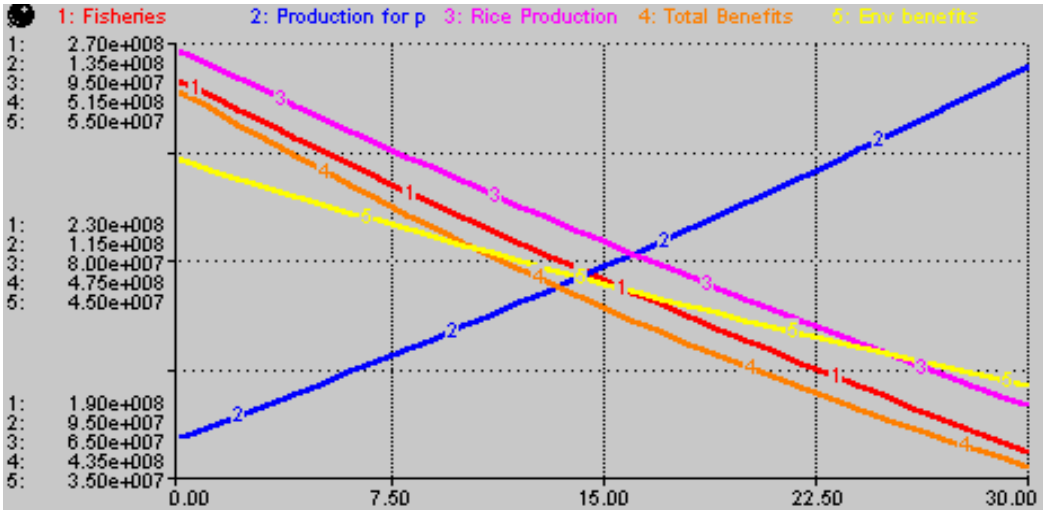

Figure 06: Impact of Afforestation Program (adopted from Haque, 2006)

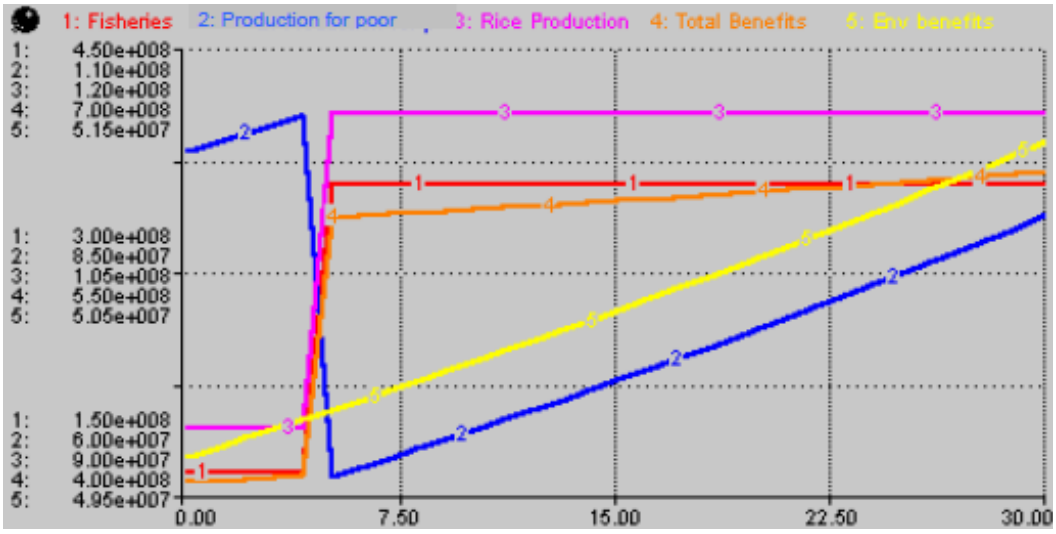

Figure 07: Effect of sedimentation control, sanctuary creation, embankment and afforestation (adopted from Haque, 2006)

Similarly, simulation exercises using option 1 (sedimentation control), option 2 (establishment of sanctuary), option 3 (afforestation) and option 4 (embankment) are all unsustainable if adopted as a standalone activity of the development interventions. As long as the total productive value of the haor declined, we assumed that the management regime is unsustainable.

Consequently, the simulation exercise using a combination of policies were used to determine the sustainability of the Hakaluki haor ecosystem. Figure below illustrates the result of a simulation exercise with effective silt control, sanctuary creation on 5000 ha of land, embankment construction and also afforestation and this also shows the total productive value is still declining and hence such an intervention is also unsustainable.

Summary of wetland benefits under different management options have differing economic implications. However, both the sustainability and present value of productive goods and services from Hakaluki haor is highest under a management regime which combines sedimentation control, establishment of a sanctuary and afforestation.

Table 05: Comparative Analysis of Benefits from Hakaluki haor Management Policies and its impact

	Changes in the PV of Benefits from Hakaluki haor in BDT millions (for 30 year life time with a 5% rate of discount)			
	Total Benefits	**Economic Benefits**	**Envi Benefits**	**Poors' Benefit**
Sediment control	651.90	578.20	73.69	-
Sanctuary	854.95	827.85	27.10	-
Afforestation	362.09	347.76	14.32	347.76
Embankment	(230.47)	(230.47)	-	(468.69)
Sediment Control + Sanctuary	1,323.30	1,249.61	73.69	-
Sed con. + Sanct. + afforestation	1,685.39	1,597.37	88.02	347.76
Sed. Con. + Sanct. + Affor. + Embankment	1,454.92	1,366.90	88.02	(120.93)

Note: - means no change, numbers in parenthesis means negative effect.

Three types of benefits are included in above Table. In terms of total benefits the highest benefit is accrued when the management policy includes sedimentation control, establishment of sanctuary, including dry season beel area which is the refuse for parent fish and continuation of afforestation activities in the haor area. In terms of distribution of benefits, poor receive most of the benefit from the afforestation activities provided that the afforestation activities take care of the following aspects during its implementation: a) involvement of the poor during plantation and its protection, b) selection of plants, herbs and trees that would provide fuelwood supplies, herbs and materials for home constructions, c) ensuring the rights of the poor to collect these materials from the haor, d) guaranteeing their rights for using kanda for cattle-buffalo rearing and duck keeping during winter months. Sedimentation control provides the maximum benefit for fishers and farmers. However, there are some environmental benefits too.

7.3. Management intervention 1: Sedimentation Control

In terms of impacts, the simulation result shows that this option would generate nearly 651 million taka in terms of additional benefits in 30 years time (at 5% rate of discount). Of these, 88.7% will be economic benefits and 11.3% will be environmental services benefits. All the economic benefits will accrue to people related to fishing and the farming. In the simulation exercise we assumed that the level of sedimentation control will not exceed the rate of sedimentation in the beels of the haor. As such we assumed that the area of wetland will remain same over time.

7.4. Management Intervention 2: Establishment of Sanctuary

Establishment of sanctuary is seen as a crucial element to conserve the freshwater fishes. Our model shows that nearly 854 million taka would be received in terms of additional benefits if this policy is pursued for 30 years time. 96% of these benefits will be in terms of increased fishing output and the rest in terms of biodiversity benefits. During the simulation exercise we assumed that about 2000 ha of land (less than 50% of the beel area) will come under sanctuary. Sanctuaries will have a 5 year delay in increasing the fish production and it would eventually come under production after the fifth year. However, there will be a rotation to ensure that 50% of the total water body remains as temporary sanctuary. This implies that after every fifth year the particular sanctuary can be harvested while a new area will become sanctuary for the next 5 years. Such conservation effort is expected to double the fish production from the beels in the five years time.

7.5. Management Intervention 3: Afforestation

Afforestation activities is an ongoing activity of the current management regime. Pursuing this activity would generate an additional income for the poor if they have access to such forest products and services. It was assumed that Kanda land will continue to be used by local poor people under a prescribed guidelines so that they continue to enjoy the services of nature in terms of a) cattle rearing, duck rearing, buffalo rearing, b) collection of fuelwood, medicinal herbs, and c) collection of housing materials for roof and wall. It was also assumed that such efforts by the development official will consider these aspects while planting saplings in the kanda land.

7.6. Limitation of the bio-economic model

The bio-economic model developed above represents a stylized fact and it is designed to elicit the outcome of conservation effort in terms of economic values. Results of the simulation exercises could be improved using an interdisciplinary team to improve the parameters and assumptions used in this model. At the same time, it would be fair to conclude that the results of this model are indicative in terms of the benefits from conservation effort. They are never assumed to be the actual values but the true value will follow the trend presented by this model. The model helps us determine the impact of conservation using tables and diagrams and it provides an authentic estimate of the gesture that we often use to argue for conservation.

Hakaluki haor is an important biological resource in Bangladesh. This study is not expected to provide a value for its resources. It simply provides a glimpse in terms of changes that would take place if the resources are not conserved properly. Consequently, the NPV estimates are also indicative of the amount of maximum feasible investment for conservation of haor in the next 30 years time.

8. CONCLUSIONS

The fact that Hakaluki haor has been designated as an Ecologically Critical Area signifies its importance as a reservoir of disappearing natural resources. This study underscores the reality that that Hakaluki also constitutes an important source of natural capital, which yields high economic and livelihood values to surrounding populations and the country as a whole.

Survey findings show that more than 80% of local households depend on wetland resources, and that the bulk of income-earning and livelihood opportunities in the area are wetland-based. The wetland also generates a series of economically important ecosystem services, which function to underpin, support and safeguard essential production and consumption processes. In total, it has been estimated that Hakaluki haor is worth at least BDT 585 million, or an average of BDT 48,000/hectare. The study describes the complex inter-linkages between wetland ecology and economic processes. In addition to confirming the economic value attached to wetland conservation, it highlights the costs associated with the loss or degradation of wetland goods and services in terms of losses to livelihoods and the economy.

By modelling and simulating the economic effects of alternative management options for the wetland, the study points to important conclusions with regards to the costs and benefits of conservation. Although achieving conservation goals remains a priority for Hakaluki haor, there is an additional need to factor in consideration of the economic implications of different conservation actions and alternatives. Study findings confirm that the most economically sustainable policies for sustainable management of the Hakaluki haor are:

- Silt control to ensure that no new beels are damaged by it
- Sanctuary creation in 2000 ha of wetlands in all unions and the effect of such conservation activities are felt after at least 5 years and
- Afforestation activities continued as has been started by the haor development project. The objective of such afforestation activities shall be to improve the livelihood of the people.

The NPV of benefits from the new activities indicates the maximum sustainable investment for conservation of this haor for the next 30 years time period with a 5% rate of discount.

One of the major objectives of this study was to recommend best practices in applying economic and financial instruments for management of Hakaluki haor which are mentioned above. Using the bioeconomic model developed in this study it has been shown that to ensure sustainable management of the haor. The results show that construction of submergible emabankments will act against sustainable use of the haor system.

It also shows that sanctuary development is a major step to be adopted by the haor development projects which will ensure sustainable use of haor resources. Furthermore, result also concludes that sediment control in the haor is the most important step which must be adopted to ensure sustainable use of haor resources. In fact, the model concludes that without sediment control the total resource base in the Hakaluki haor will become unsustainable. At the same time, it reveals that afforestation activities must be planned to ensure that the poor can appropriate the benefits. This is the most poor-friendly component of haor development. However, it is also important that afforestation activities guarantee access to and also participation of the poor. Finally, cattle rearing are also poor friendly and to manage the haor resources sustainably, and should concentrate on these aspects of the haor management.

REFERENCES

Carolyn Fischer, Edwin Muchapondwa, and Thomas Sterner, 2005 Bioeconomic Model of Community Incentives for Wildlife Management Before and After CAMPFIRE, Resource for the Future, March.

Carolyn Fischer, Edwin Muchapondwa, and Thomas Sterner, 2005 Bioeconomic Model of Community Incentives for Wildlife Management Before and After CAMPFIRE, Resource for the Future, March.

CNRS, 2003. Biophysical and Socioeconomic Characterization of Hakaluki Haor: Step towards Building Community Consensus on Sustainable Wetland Resources Management

Colavito, L., 2002, 'Wetland Economic Valuation Using a Bioeconomic Model: the case of Hail haor, Bangladesh', paper presented at Workshop on Conservation and Sustainable Use of Wetlands:

Learning from the World, IUCN − The World Conservation Union, Kathmandu

CWBMP, 2005. Hakaluki Haor Management Plan (Draft)

Douglas R. Brown, 2000, A Review of Bio-Economic Models, Paper prepared for the Cornell African

Food Security and Natural Resource Management (CAFSNRM) Program. Cornell University.

Douglas R. Brown, 2000, A Review of Bio-Economic Models, Paper prepared for the Cornell African

Food Security and Natural Resource Management (CAFSNRM) Program. Cornell University.

Flood Action Plan, Northeast Regional Water Management Project (FAP 6). 1994. NEMREP: Northeast

Region Environment Management, Research and Education Project. Pre-feasibility Study Final Report.

Flood Action Plan, Northeast Regional Water Management Project (FAP 6). 1994. Summary

Flood Action Plan. Northeast Regional Water Management Project (FAP 6). "Wetland Resources

IUCN 2006. Inception Report: Economic Evaluation of Hakaluki Haor

Specialist study (final draft), Canadian International Development Agency (CIDA), April 1993.