Economic valuation of inland open water fisheries resources

Pradeep K. Katiha
A. P. Sharma
Anjana Ekka
Arun Pandit
B. K. Bhattacharjya
D. K. Biswas

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Central Inland Fisheries Research Institute
Indian Council of Agricultural Research
Barrackpore, Kolkata-700 120, West Bengal

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Director
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ABBREVIATIONS

Abbreviation	Expanded form
av., avg.	Average
CIFRI	Central Inland Fisheries Research Institute
cm	Centimeter
CPUE	Catch Per Unit Effort
DAHD&F	Department of Animal Husbandry, Dairying and Fisheries
DARE	Department of Agricultural Research and Education
DDG (Fy)	Deputy Director General (Fisheries)
DG	Director General
DVC	Damodar Valley Corporation
FAO	Food and Agriculture organization
Fig.	Figure
FRL	Full Reservoir Level
GIS	Geographical Information System
ha	Hectare
ICAR	Indian Council of Agricultural Research
IMC	Indian Major Carps
kg	Kilogram
m	metre
NAIP	National Agriculture Innovation Project
NGO	Non Governmental Organization
SD	Stocking Density
SHG	Self Help group
sq.ft.	Square feet
sq. km.	Square meter
t	Ton
yr	Year

Introduction

The increasing pressure on common pool resources made their sustainable use a global imperative. One of the scarcest natural resources is inland open waters. The mounting demand for these waters for domestic, industrial and agricultural uses, deteriorate and decline in quantity and degradation of these resources made them scarce. This trend is expected to deteriorate in future. Rivers, the most important natural freshwater aquatic resources are glaring example of common pool resources following above-mentioned trend. Now global focus is on increasing the water productivity, water use efficiency on sustainable basis. Over the years, these are dammed under various river valley projects for the purpose of irrigation, hydro-power generation, flood control, eco-tourism, potable water, domestic uses, *etc*. Besides these uses, fishery development has got impetus as their fish productivity has increased from 30 kg/ ha to 110 kg/ka during XI Five Year Plan (Sharma *et al*., 2012). Much emphasis has also been laid on these activities during XII Plan (Anon., 2011). Considering the multiple use and multi-stakeholders nature of inland open waters and broad demand supply gap for freshwater, it is pertinent to document various tangible/non-tangible goods/services provided by these waters to estimate the value of these outputs. Traditional cost benefit analysis fails to adequately capture many environmental benefits and services that do not enter the market or cannot for other reasons are adequately valued in economic terms. As a result, the decisions taken are not only economically inefficient, but also socially unacceptable and lack suitability. Therefore, economic valuation is very important to provide information on the economic value of goods and services of these ecosystems to researchers, policy makers and project implementation authorities (Munasinghe, 1992; Mitsch, and Gosselink, 1993; Farber, *et al*., 2002; Katiha and Marothia, 2006).

Central theme of aquatic ecosystems valuation is the need to place proper values on environmental goods and services, which are crucial for its utilisation and sustainable development. In the most fundamental way, valuation should begin from eco-system functions of natural resources in general and fisheries resources in particular in the context of river basin approach. Ecosystems are noticeable, observable and to some extent measurable. Eco-systems have three peculiar attributes in the context of valuation, namely, existence, intrinsic and option values (Kadekodi *et al*., 2001). The goods and services provided by ecosystems are mostly available to consumers at a zero price, so, they do not affect market, and cannot be valuated as easily as marketed goods. This is a serious issue because, typically, environmental goods and services have private value and many individuals and citizens are willing to pay to ensure their continued availability (Pearce and Markandya, 1989). As mentioned earlier, traditional cost benefit analysis fails to adequately capture these environmental goods and services and in turn their value in economic terms. Information on the economic value of goods and services of ecosystems is, therefore, important for researchers, policy makers, project implementation authorities, who make decisions (or engage in conducting the ecosystem projects) that affect the ecosystems, if optimal choice are to be made. Comparison between options cannot be made fairly, unless the full range of costs and benefits of the projects, including their impact on the environment are full accounted for.

Greater attempts are now being made to rationalize the decision making process with respect to the use of common water bodies. The water needs to be managed sustainably (*i.e*. the production of fisheries and goods and services needs to be balanced

with the conservation of the resource base), if the returns from common water bodies (*e.g.* reservoirs, ponds and lakes) are to be optimised over the long term. In order to make sustainable water management decisions, more reliable information on the environmental, social, and economic value of common water bodies in their own right and relative to other land are the prerequisite. As stated earlier, the problem in this context has been the traditional project evaluation procedures, which do not incorporate the full range of environmental and social costs associated with multiple water use options. Due to this omission, decision on common water bodies in general use have been biased in favour of development options, some of which have been shown to be economically unjustifiable once the relevant environmental costs are accounted for. One reason for this shortcoming has been lack of understanding of and, expertise in, monetary evaluation of environmental impacts such that they can be included in the appraisal process. In response to the need to value environmental goods and services, economists have developed a range of new valuation techniques. Meaningful assignment of monetary values to environmental goods and services is therefore possible. This facilitates their use in the economic appraisal framework and thereby refines (improves) traditional measurement. A key objective of economic valuation of the environment is, therefore the integration of environmental concerns into the conventional economic decision making process in order to furnish policy analysts and decision makers with better information upon which to better decisions could be made.

Economic valuation can be defined as the attempt to assign quantitative values to goods and services provided by the resources. This principle is applicable to aquatic resources/ecosystems also. The economic value of any good or service is generally measured in term of what we are willing to pay for the commodity, less what it costs to supply it. Any aquatic resource, if simply exists and provides us products and services at no cost, it is our willingness to pay alone which describes the value of the resource in providing such commodities, irrespective of the fact whether we make any payment for it. Many aquatic resources are complex and multifunctional, and it is not obvious how the myriad goods and services provided by these resources affect human welfare. Economic valuation provides us the tools to assist these difficult decisions. Loss of environmental resources is an economic problem because values are lost, some perhaps irreversibly, when these resources are degraded or lost. The decisions as to what use(s) at which rate to pursue for a given environmental resource to be sustainable. It is a dynamic process and continuously change over the period. Considering the importance and scarcity of natural inland aquatic ecosystems, continuous valuation of these resources over time is very crucial to know about their exploitation, loss and sustainability. These very crucial questions are addressed under the process of economic valuation.

The present bulletin is an attempt to i) present an overview of inland open waters in the country with special emphasis on sustainability of their fisheries; ii) status of research on valuation of natural aquatic ecosystems; iii) indicators of benefits, functions and services of aquatic eco-system; iv) Major direct, indirect and non use values of typical inland open water ecosystem; v) the assessment framework for economic valuation including the process, types of value and their estimation techniques/ methods and the constraints; vi) CIFRI experiences in valuation of inland open waters including three floodplain wetlands, one each of reservoir, river stretch and estuarine zone; vii) sources of inefficiencies in aquatic eco-systems use: market and policy failures; vii) future scope of work; and viii) literature cited.

2. Inland open waters

The inland fisheries resources of India include rivers and canals (1.95 lakh km), reservoirs (3.15 m ha), floodplain wetlands (0.35 m ha), estuaries (0.26 m ha), *etc*. These have greater potential for enhancing fish production and productivity and providing livelihoods to millions of people. Multiple use nature of majority of these waters with multiple stakeholders is the major constraint to harness their production potential. The fisheries practices followed in these waters are capture fisheries, culture-based fisheries and other forms of fisheries enhancement. Coldwater fisheries and aquaculture waters in India include rivers (8253 km), natural lakes (21900 ha) and reservoirs (29700 ha). Although, they form smaller component of inland fisheries sector, but have greater scope for development.

2.1 The Rivers

The river systems of India may be classified into two major groups, namely, Himalayan or extra-peninsular rivers and peninsular rivers. The general profile of these groups is mentioned below.

2.1.1 The Himalayan or extra-peninsular rivers

Originating from the Himalayas to transverse great alluvial Indo-Gangatic plains, these snow and rainfed rivers are characterised by complicated flood regimes and seasonal variations in volume of flow. Descending on the plains, they become sluggish and inundate vast land area. These rivers may be categorised into three systems, the Ganga the Brahmaputra and the Indus. The Ganga river system has combined length of 12500 km and a catchment area of 97.6 million ha. The Ganga, Ghagra, Gomti, Ramganga, Kosi, Gandak, Yamuna, Chambal, Sone and Tons are the major rivers of this system. These rivers are spread over most of the north Indian states (except the hilly states) to extend upto West Bengal through Bihar. In upland river system, commercial fisheries is virtually absent, due to inaccessible terrain and other exploitation problems. The stretch of river Ganga from Haridwar to Lalgola is recognised as one of the richest source of capture fisheries in India, comprising highly priced major carps, hilsa and catfishes. Mid September to June are peak months for fishing. During lean period of monsoon months the fishing activities generally confined to river banks.

The combined length of the Brahmaputra river system is 4023 km with catchment area of 51 million ha. Originating from Tibet the river flows through northern slopes of Himalayas to enter India at north-east corner of Arunachal Pradesh. It has 918 km stretch in India, including 730 km only in Assam. Its northern tributaries Subansiri, Kameng and Manas are large with steep, shallow-braided channels, whereas those on the southern bank, Buri Dihing, Dhansiri and Kopilli are deeper with meandering channels and low gradient. The Brahmaputra valley is marked for its abandoned river beds (beels) supporting rich fishery. Catfishes, major and minor carps dominate the commercial catches of upper middle and lower stretches, while the commercial catch in lower-middle stretch primarily composed of catfish and miscellaneous catch.

In case of the Indus river system, main Indus and its tributaries in upper and Beas and Sutlej in the lower reaches are important from Indian fisheries viewpoint. Its headwaters in the states of Kashmir, Himachal Pradesh and Punjab mainly harbour mahseer, snow trout, some cyprinids and exotic trout. The rivers Beas and Sutlej contain indigenous carps and catfishes, which are commercially exploited.

2.1.2 The Peninsular Rivers

The torrential and rain fed, peninsular rivers have well defined stable course. These include two river systems, the East Coast and the West Coast. The East Coast river system has vast expanse of water in the states of Odisha, Madhya Pradesh, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu. This river system mainly has four constituent rivers, the Mahanadi, the Godavari, the Krishna and the Cauvery have a combined length of 6437 km and catchment area of 121 million ha. This system drains entire peninsular India and east of Western Ghats in the west and south parts of central India. Besides its own fish fauna of several carps, catfishes, murrels, and prawn, the system is repeatedly enriched by transplantation of Gangatic carps.

The combined length of rivers of West Coast river system and catchment area are 3380 km and 69.16 million ha, respectively. The Narmada and the Tapti are the longest rivers of system along with 600 small rivers. Its rivers are distributed in the states of Gujarat, Maharashtra and Madhya Pradesh. The fish fauna of the system consists of carps, catfishes, mahseers, prawns, *etc*.

The riverine resources had major share in inland capture fisheries. But, during past few decades riverine ecosystem witnessed marked alterations due to mammoth human interventions in the form of water abstraction, dam construction, sedimentation, and irrational fishing. These have discerningly disturbing effect on natural riverine fish production, which showed continuous declining trends. The studies of Central Inland Fisheries Research Institute, Barrackpore revealed that the average yield of major carps from Ganga river system has declined from 26.62 kg/ha/year during1958-61 to 2.55 kg/ha/year during 1989-95. The fisheries of anadromous hilsa have declined by 96% above Farakka after construction of Farakka barrage in 1974. These examples of Ganga river system may be extended to depict the status of fish production in all the rivers of India. The restoration of riverine fisheries would entail an integrated approach encompassing the requirements of fisheries alongwith other uses of land and water.

2.2 The reservoirs

The reservoirs are common landscape of most of the Indian states. They can significantly contribute to the inland fish production basket of our country and provide livelihoods to a large number of fishers ousted from riverine stretches due to different water diversion projects. Classified as large, medium and small, the reservoirs have immense potential for fish yield enhancements (Table 1 & 2). Manifold increase in fish yields has already been documented through case studies of CIFRI and NFDB Reservoir Fisheries development (RFD) Programmes.

Table 1 Potential for fish yield enhancements in reservoirs

Category	Area (lakh ha)	Yield (kg/ha) (1994-95)	Yield (kg/ha) (2010)*	Targeted yield (kg/ha) (2017)	Yield gap (kg/ha)
Small	14.9	50	174	250	76
Medium	5.3	12	94	125	31
Large	11.4	11	33	50	17
Total	31.5	30	110	166	56

*Fish yield of reservoirs adopted under RFD programme of NFDB

Table 2 Projected enhancements of fish production in reservoirs

Category	Area (lakh ha)	Production (1994-95) (lakh t)	Production (2010) (lakh t)	Targeted production (lakh t) (2017)	Expected increase (lakh t)
Small	14.9	0.74	2.59	3.73	1.14
Medium	5.3	0.07	0.50	0.66	0.16
Large	11.4	0.13	0.38	0.86	0.48
Total	31.5	0.94	3.47	5.25	1.78

This production potential can be harnessed by providing enabling policy and technology supports. To address these issues, major interventions proposed during XII Plan are: bringing more and more reservoirs under scientific fisheries management practices; ownership and leasing of reservoirs on long term basis, stocking them with fingerlings of carps and other relevant species (requirement being 3.6 billion fingerlings), adequate rearing space (on/off site) for *ex-situ* fingerling production, *in-situ* seed production in cage and pen, efficient fish harvesting gear & crafts, support for efficient fish marketing and HRD for reservoir fisheries managers and fishers.

2.3 The floodplain wetlands

The rivers Ganga and Brahmaputra have major floodplains wetlands of our country. Most of these waters are located in states of Assam, Bihar, West Bengal and Uttar Pradesh. These waters are considered as storehouse of significant fish biodiversity of both indigenous and exotic fish species and provide sustaining livelihoods and nutritional security to large local populace. They are also abode for number of potential ornamental fish species. These ecosystems also offer opportunities for developing eco-tourism. These also provide other indirect benefits to the community, *e.g.* water recharging of aquifers, ensuring water for crops, *etc*. These natural aquatic systems also have significant potential to raise fish productivity and production (Table 3 & 4).

These water bodies are ecologically sensitive and some of them are declared as Ramsar sites, but can be harnessed as sustainable fish production systems without altering their ecological functions. Specific approaches for integrated fishery development, conservation for the native high value species and eco-tourism promotion are suggested to bring significant direct and indirect benefit to all stakeholders. The issues for sustainable fish production in

Table 3 Potential for fish yield enhancements in floodplain wetlands

Category	Area (lakh ha)	Yield (kg/ha) (2000-01)	Targeted yield (kg/ha) (2017)	Yield gap (kg/ha)
West Bengal	0.425	225	2000	975
Bihar	0.4	120	500	880
Assam`	1.00	150	1200	1050
Uttar Pradesh	1.52	175	900	725
N.E. States	0.192	75	500	425
Total	3.537	162	1010	848

Table 4 Potential for enhancements of production in floodplain wetlands

Category	Area (lakh ha)	Production (1994-95) (lakh t)	Targeted production (2017) (lakh t)	Targeted increase (folds)
West Bengal	0.425	0.1	0.51	4.1
Bihar	0.4	0.05	0.4	7.0
Assam	1.00	0.15	1.2	7.0
Uttar Pradesh	1.52	0.27	1.368	4.1
N.E. States	0.192	0.01	0.096	8.6
Total	3.537	0.57	3.57237	5.27

These wetlands are: appropriate stocking material (requirement being 1.0 billion fingerlings), adequate rearing space (on/off site) for good size seed, restoration through desilting, dyke construction & removal of aquatic weeds, integrating fisheries with agriculture and animal husbandry, and pen and cage culture. The congenial institutional environment and community-based fisheries management are the necessary conditions for better results.

2.4 Estuaries

The estuarine capture fishery forms an important component of inland fisheries. The open estuarine system includes Hoogly-Matlah and Mahanadi estuarine systems (Table 5). Godavari estuary is the main estuary of peninsular India, with Adyar Mankanam and Mandovi as other estuaries and Chilka, Pulicat and Vembanad as important brackish water lagoons. These estuaries and lagoons are recognised as excellent sources of naturally occurring fish and prawn seed. The fisheries of the estuaries are considered as above the subsistence level. The average yield varies between 45-75 kg/ha.

Table 5 Important estuarine fishery resources of India

S. No.	Estuarine system	Estimated area (ha)	Production (t)
1	Hoogly-Matlah	234 000	20 000 to 26 000
2	Godavari estuary	18 000	c.5 000
3	Mahanadi estuary	3000	c.550
4	Narmada estuary	30 000	c.4 000
5	Peninsular esturine system	----	c. 2 000
6	Chilka lagoon	103 600	c.4 000
7	Pulicate lake	36 900	760-1370
8	Vembanad lake and Kerala Backwaters	50 000	14000-17000
9	Wetlands of West Bengal		
	a) Freshwater Bheries	9 600	10-14
	b) Saline Bheries	33 000	c. 25 500
10	Mangroves	356 500	NA

(Sinha, 1997)

3. Status of research in valuation of natural aquatic ecosystem

The research and case studies in valuation of inland aquatic ecosystem are of comparatively recent origin during early seventies. But, in India it picked up only in early nineties. Some of the researches under Indian and abroad conditions are: Rao, 1979; Pearce and turner, 1990; Aylward and Barbier, 1992; Marothia, 1992, 1993, 1995, 1997, 1997a 2001, 2003; Marothia and Sammaraweera, 2002; Munasinghe, 1992; Pearce, 1992; Dugan, 1994; IIED, 1994; Murthy and Menkhaus, 1994; sugunan, 1995; Barbier *et al*., 1997; Chopra, *et al*. 1990 ,1997; Chopra and Kadekodi 1997; Costanza, *et al*. 1997; Bann, 1998; James and Murthy, 1998; Whittington, 1998 and 2002; Kadekodi and Gulati, 1999; Chattopadhyay, 2000; Das *et al*., 2000; Verma, 2000; Babu, *et al*., 2001; Bhatta, 2001, 2003; Dasgupta, 2001; Katiha and Seth, 2001; Parikh, 2001; Chopra, 2002; Reddy, 2002; Sinha and Katiha, 2002; Katiha and Marothia, 2003, 2006; Neiland and Bene, 2008; *etc*.). Some of the publications from present study included Katiha *et al*., 2011, 2012; Ekka and Pandit, 2012. Many researchers have used different methods to valuate inland fisheries resources depending upon the goods and services provided by them. The methodology adopted by them varied accordingly. Most of them were partial valuation to put monetary tag on particular good and service, but complete valuation is very rare. It is because of the process and dynamic nature of resources. Complete valuation needs intensive information on different components, attributes and function performed by the ecosystem.

4. Indicators of benefits, functions and services of aquatic eco-system

Aquatic resources are generally highly productive ecosystems, providing many important benefits. These benefits sometimes described as 'goods and services', may be ecosystem functions (*e.g*. ground water recharge, flood control), uses of ecosystems or its products (*e.g*. site for wood collection or research site) or attributes of the ecosystems (aesthetic component of the landscape, religious significance). In order to utilize these benefits successfully, it is important to identify, enlist and assess the benefits that a particular ecosystem provides. To valuate these goods and services, this list may be made use of. These may be enlisted as resources, attributes and functions. These are the pre-requisite for the valuation process.

Table 6: Potential benefits from aquatic ecosystem and their existence indicators

Benefit	Existence Indicators
The resources	
Forestry, agriculture and forage	• Plant species • Plant primary productivity • Evidence of use
Wild life or fish	• Habitat suitable for wild life and fish species • Variety of water conditions and vegetation structures • Large population of fish birds and animals
Aquaculture	• Relatively stable water table • Relatively stable water quality • High plant productivity • Nutrient rich waters • Evidence of use

Water supply	• Permanent or during seasonal floods • Acceptable quality for human or agriculture or industrial use
Energy production	• Resources for hydro-power generation • Large through flow and a constricted outlet
Transport	• Permanent channels
Recreation/ tourism	• High landscape or species diversity • Habitats to rare species
Research or education site	• High species diversity • Range of vegetation structure • High sediment organic content
The attributes	
Biological diversity	• High species diversity • Diversity of water conditions and vegetation structure • Relatively undamaged/ undisturbed • Contain rare, threatened or endangered species • Support genetically viable populations of significant species • Significant topographic, edaphic and hydrological variation
Cultural or historic value	• Local oral or written cultural materials • Significant cultural or historical features
Aesthetic value	• Significant natural features • Range of landscape types • Range of habitats • Large number of attractive species
Wilderness value	• Remote area • Areas relatively uninfluenced by human activities • Not subject to significant levels of visitation
The functions	
Nutrient retention/ cycling	• High capacity for sediment retention • Constricted flow • Out flow less than its inflow • Low flow velocity • Relatively long duration and large extent of seasonal flooding • High ratio of seasonally flooded area to permanently flooded area • Effect of slowing the velocity of through flowing water • Intercepts over land run-off • Regular flooding by a river • Shallow and vegetative • Permanently flooded or saturated, or tidally flooded
Nutrient export	• High rate of primary productivity • Permanent outlet • Potentially eutrophic • Significant area of erect or submerged vegetation that dies seasonally

Ground water recharge	• Constricted outflow • Outflow less than its inflow • Water table which slopes away from it • Permanent inlet but no permanent outlet • Permeable substrate • Located at or below the crest of a major mountain or range • Water balance in which infiltration rate plus inflow exceeds evapo-transpiration rate plus outflow
Ground water discharge	• Constricted inflow • Outflow less than its inflow • Neither an outlet nor an inlet • No permanent standing water • Permeable substrate • Slope less than that of nearby water courses
Flood and erosion control	• High capacity of flood mitigation • Densely vegetated • High capacity for sediment retention
Salinity control	• Seasonally flooded • Plant communities that are able to remove salts
Water treatment (Toxicant removal)	• High capacity for sediment retention • Constricted outflow • Low flow velocity • Relatively long duration and large extent of seasonal flooding • High ratio of seasonally flooded area to permanently flooded area • Intercepts over land run-off
Climate Stabilization	• High evapo-transpiration potential • Large vegetated area that provide shadow and reduce velocity of air movements • Condense accumulated peat
Role in the life cycle of species	• has a high plant species diversity • has a range of different vegetation structures • has a diversity of water conditions • is relatively rich in habitats, water and feed when conditions are unfavourable to fish, bird and mammal species elsewhere • is relatively undisturbed
Maintenance of the stability of the ecosystem	• has a high capacity for nutrient retention • has a high rate of primary productivity • has a relatively undisturbed trophic change • is rather stable in terms of plants and wildlife populations
Maintenance of the integrity of other ecosystems	• regulates flows and mitigates floods • regulates water salinity • removes toxicants • regulates sediments exports • exports nutrients • provides seasonally/temporary habitats to migratory species • shows evidence of continuing ecologically, geomorphological and geological processes

Source: Roggeri (1995 modified)

5. Major direct, indirect and non use values of typical inland open water ecosystem

The features of eco-system may be grouped into components, functions and attributes (Barbier *et al.*, 1997). The components of the system are the biotic and non-biotic features which include the soil, water, plants and animals. The components include fish, forest products, wildlife, agriculture, water supply and water transport. The interactions between the components express themselves as functions, including flood control, storm protection, groundwater recharge, sediment/pollution retention, nutrient cycling, evaporation and preservation. The eco-systems also have attributes, such as bio-diversity, and cultural heritage.

Based on the components, functions and attributes these waters provide large number of goods and services having direct, indirect and non-use benefits and economic values (Table 7).

Table 7: Major direct, indirect and non use values of typical inland open water ecosystem

Ecosystem	Direct use values	Indirect use values	Non use values
River	Fisheries; Agriculture; Habitat for aquatic biomass; Recreation and tourism; Boating; Swimming; Water sports; Waterways; Domestic needs; Bathing; Washing clothes; Tending cattle; Dumping of domestic and industrial waste; Sand and silt mining	Ecological functions Nutrient cycling Air pollution reduction Micro climatic functions Natural habitat biological/ecosystem support Groundwater recharge	Option value Biological conservation, habitats expending uses Bequest values Habitats for aquatic biomass, irreversible change Existence value Natural habitats, endangered ecosystem, aesthetics and cultural heritage
Reservoir	Fisheries; Agriculture; Habitat for aquatic biomass; Hydro-power generation, Recreation and tourism; Boating; Swimming; Water sports; Domestic needs; Bathing; Washing clothes; Tending cattle; Dumping of domestic and sometimes industrial waste	Ecological functions Flood control, Watershed protection, Nutrient cycling, Natural habitat biological/ecosystem support, Groundwater recharge	-do-
Floodplain wetland	Fisheries; irrigation for agriculture, Habitat for aquatic biomass; Fuel wood, Fodder, Recreation and tourism; Domestic needs; Bathing; Washing clothes; Tending cattle; Dumping of domestic and sometimes industrial waste	Ecological functions Nutrient cycling Micro climatic functions Natural habitat biological/ecosystem support Groundwater recharge	-do-

Estuaries	Fisheries; Habitat for aquatic biomass; Recreation and tourism; Water sports; Waterways; Domestic needs; Bathing; Washing clothes; Tending cattle; Dumping of domestic and industrial waste	Ecological functions Nutrient cycling Micro climatic functions Natural habitat biological/ecosystem support Groundwater recharge	-do-

Modified from Katiha and Marothia, 2006, Marothia, 2001, 2003, Munasinghe 1992

6. The assessment framework for economic valuation

To develop a general framework for assessing the economic benefits of alternative uses of inland fisheries waters, following three stage process was followed (Fig 1).

The first stage is to define the overall objective or problem and choose type of economic assessment approach. The approach chosen will depend directly on the problem confronting the analyst. Three broad categories of approaches, namely, *impact analysis, partial valuation and total valuation* are of most relevance to the economic analysis. Corresponding to each of these three evaluation objectives, a specific economic assessment approach is to be followed. Considering the objectives of the project for valuation of resources with special reference to fisheries, partial valuation approach is to be adopted. In this case, those benefits which affect fisheries are to be assessed.

After identification of appropriate economic assessment approach, the next stage is to define scope and limits of the analysis and information needs required to conduct the assessment. The first step is to identify the resource area under consideration, the time scale of the analysis and the geographic and analytical boundaries of the eco-system. Once the system and analytical boundaries are defined, further analysis is needed to determine the basic characteristics of the waters being assessed. The next step is to determine the type of value associated with components, functions and attributes of selected water bodies. It was helpful to distinguish between *direct, indirect and non use* values. Once the major characteristics and values have been identified, they need to be *ranked*.

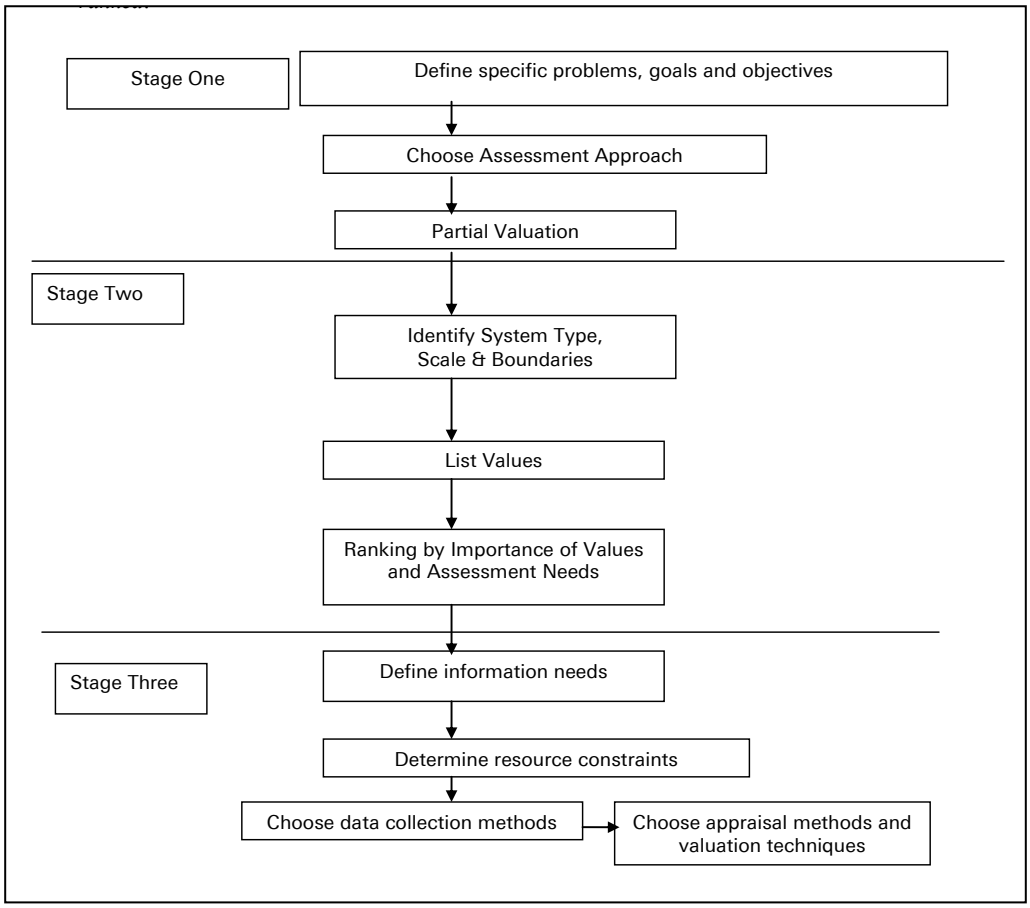


Fig 1: Assessment framework for economic valuation
Adopted from IIED (1994)

The final stage involves carrying out the actual assessment itself. Priority should obviously be given to assessing those resources, functions and attributes with the highest ranking. However, resource constraints, e.g., time, finances and skills, will also affect which characteristics can be valued and with what degree of accuracy. A resource, function or characteristic may initially be given a high ranking, but resource constraints may in fact prevent its valuation. Resource constraints will also determine which data collection methods are appropriate and how they are implemented. Resource constraints and data collection options will influence the choice of *valuation techniques* to be selected.

An aquatic ecosystem and its resource use largely depend on the *property rights* regime governing wetland access and use. The goods and services of the ecosystem may be undervalued and thus misallocated under different regimes. Therefore, the property and management regimes and the institutional arrangements of these waters were studied.

The questionnaires and schedules were prepared and finalized for investigations on valuation and socio-institutional activities. The role of environmental economists to collect, analysis and make available the total information to the policy makers so

that costs and benefits associated with a project are meaningfully weighted before a decision is undertaken. In order to establish a valid decisionmaking framework within which socio-economic – cultural – institutional constraints could be determined.

6.1 The framework for estimation of economic values

The framework for economic valuation of aquatic eco-system can be understood using concepts of total economic value. Conceptually, the total economic value (TEV) of a eco-system comprises of use values and non use values. Use values may be broken down further into the direct use value (DUV), the indirect use value (IUV), and the option value (OV, potential use value). One needs to be careful not to double-count both the value of indirect supporting functions and the value of the resulting direct use (for a discussion and example please see Aylward and Barbier, 1992). The categories of non use value are existence value (EV) and bequest value (BV). Therefore, we may write:

TEV = UV +NUV or

TEV = (DUV + IUV + OV) + (EV + BV)

Figure 2 shows this disaggregation of TEV in schematic form. Below each valuation concept, a short description of its meaning and a few typical examples of the environmental resources underlying the perceived value are provided.

Use values: Use values involve some human interaction with the resource as is evident from the name itself. These may be of two types again - direct use values and indirect use values. The former is as the name suggests tangible in nature while the latter may be indirect in the form of an intangible benefit. The value obtained from the microclimatic stabilization effects of a aquatic ecosystem, for example, for which the people do not pay anything, is an indirect use value. Since the indirect use values are actually unmarketed they become difficult to quantify and till now have been generally ignored in spite of being so important.

Option values: An aquatic resource has option value if the future benefits it might yield are uncertain and depletion of the resource is effectively irreversible- which is the case with most natural resources. In this case one may be willing to preserve the option, in the chance that it might prove valuable in the future. In this context quasi option value is defined as the expected value of the information derived from delaying exploitation and conversion of the resource today.

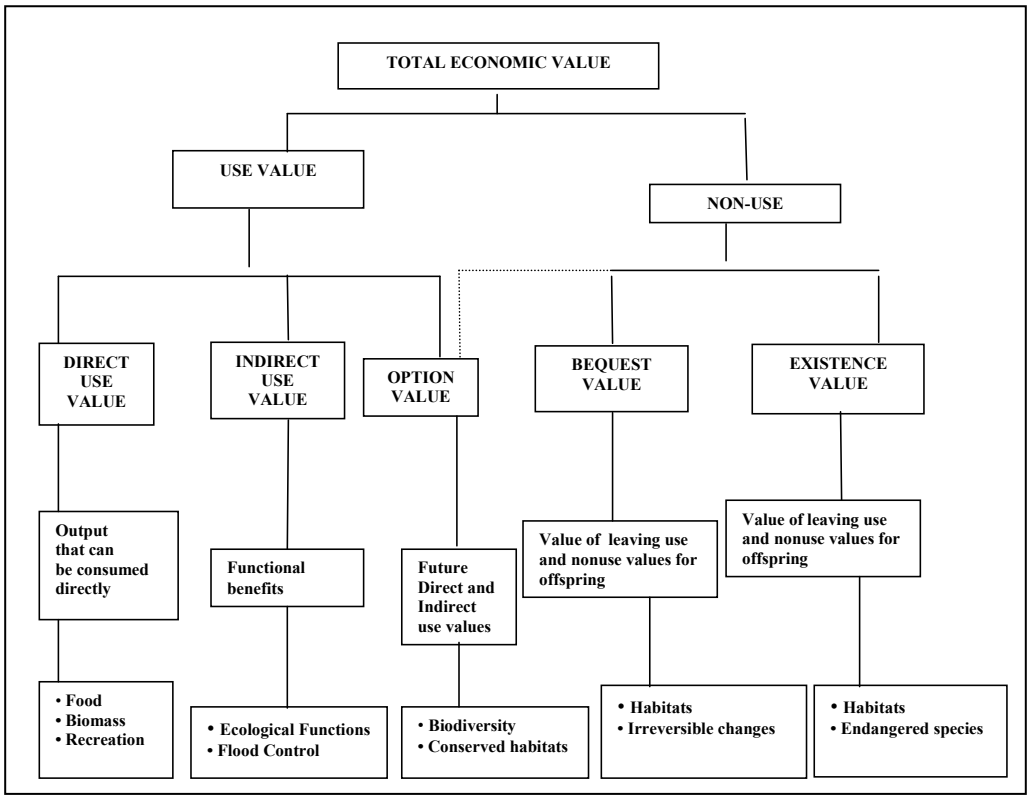


Figure 2 Conceptual Framework of Economic Values
Source: Munasinghe, 1992 Modified

Existence values: Sometimes a resource may be having an intrinsic value known as existence value. It is a form of non-use value where the individual's moral concerns about environmental degradation, empathy for other species and the satisfaction that he /she derives from the mere existence of a certain resource which the person is not in direct contact with. Bequest value is a type of existence value where one would desire to leave an unspoiled planet for one's descendants.

An example of the concept of TEV is being shown through the Fig 2, which takes into account all values emerging from an environmental resource, say a forest. But again all natural resource economists have not accepted the pure additive form of the total economic value. Some writers regard intrinsic value as part of existence value rather than as its equivalent. On the other hand, others regard intrinsic value as being inclusive of option value. These variations in definitions most probably arise from what exactly is meant by 'use'. The concept of existence value and bequest value need further investigation since in some cases double accounting may easily take place in case the equation mentioned above is taken as it is. Therefore the uses have to be carefully defined in order to avoid problems that may arise in trying to separate various values.

7. Valuation Techniques

A variety of economic techniques and models have been developed for assigning

monetary values to gains or losses associated with changes in the availability (quantity) or character (quality) of environmental amenities. The aim of these techniques is to obtain an estimate of the value of an environmental amenity that would be revealed if there were a competitive market for the amenity or stated in a survey. The values could be obtained either through direct valuation or through indirect valuation and thus could be expressed in monetary terms. But in some cases it is difficult to ascertain their monetary values as only qualitative information like preferences, ordering, priorities or their presence or absence are available. In such cases non-monetary valuation techniques are used to capture the value of the resource. Valuation methods have been classified mainly into two categories (Box - 1).

Box 1 Categories of Valuation Techniques

PRICE BASED:

Price based approaches use the market price of forest goods and services(corrected for market imperfections and policy failures that may distort prices).

Related goods approach: The related goods approach uses information on the relationship between a marketed and non-marketed good or service in order to estimate the value of the non-marketed good (e.g., barter exchange approach, direct substitute approach, indirect substitute approach).

INDIRECT APPROACHES

Indirect approaches are those techniques that seek to elicit preferences from actual, observed market based information. These techniques are indirect because they do not rely on people's direct answers to questions about how much they would be WTP. The indirect group of techniques can be divided into two categories.

Surrogate Markets Approach (Revealed Preference Approach): Which use information about a marketed commodity to infer the value of a related, non-marketed commodity (e.g. travel cost method (TCM), hedonic pricing).

Conventional Markets Approach (Market Valuation of Physical Effects): which use market prices to value environmental services in situations where environmental damage or improvement shows up in changes in the quantity or price of marketed inputs or put (e.g. the value of changes in productivity approach: the production function approach; does-response functions)

DIRECT APPROACHES

Constructed Market Approaches: such as contingent valuation method (CVM) – are used to elicit directly, through survey methods, consumer's willingness to pay for non-marketed environmental values.

COST-BASED METHODS

Cost based methods use some estimate of the costs of providing or replacing a good or service as an approximate estimate of its benefit (e.g. opportunity cost, indirect opportunity cost, restoration cost, replacement cost, relocation cost, preventive expenditure). Cost-based methods are second best techniques and must be used with caution.

Source: Othman (1999 Modified)

A basic requirement of any aquatic eco-system management strategy is a better understanding of value of these resources both in use and non-use value terms. Range economic techniques have been used by several researchers to place monetary values on the aquatic eco-systems goods, services and functions. In the above mentioned box a summary of valuation techniques is presented which were used frequently by the researchers to place value to the eco-systems in general and wet-lands in particular.

8. Constraints in estimating the economic value

It may not always be possible to convert all environmental benefits and costs into monetary terms, due to lack of information about the complexity of a particular ecosystems. Assigning a value under such circumstances will lead to a loss of information and to trivialize the importance of the environmental resources. Economic valuation has several limitations particularly if one takes in to controversial ethical aspects. The valuation in many cases governs by current income distribution, prefaces indicated largely by present generation and individuals. These may not reflect values of unborn generation and society at larger. The research on valuation is still in the process of development and meaningful conceptualization of available models with careful section of variables reflecting the non-use values may provide guidelines to the policy makers for understanding values of aquatic eco-systems.

8.1 Sources of inefficiencies in aquatic eco-systems use: market and policy failures

Aquatic eco-system accounts for significant proportion of global land area and are considered by many environmentalists to be among the most threatened of all environmental resources. In India in the recent past aquatic eco-systems have been destroyed or altered as growing human population sought to exploit the benefits provided by these natural systems beyond their carrying capacity. Extensive aquatic resources have already been lost or are under growing increasing changes in the major river basins in India. These losses are occurring either as a direct result of conversion to intensive agriculture, aquaculture or industrial waste disposal, or through slow degradation process associated with hydrological parameters, biotic and abiotic pressures, *etc*.

Aquatic ecosystems are valuable environmental assets with high preservation and conservation values. Despite this, a large number of the aquatic eco-system within an outside the river basin network are not being managed optimally in economic, social and institutional context. Aquatic eco-system users have inadequate understanding about the social cost associated with utilization of these resources. The misutilization of aquatic eco-systems has largely been the result of market and policy failures. Social inefficiency in aquatic eco-system use is related to the fact that these resources are multifunctional and that some of the multiple use conflict with each other. In particular because of spatial location of the majority of aquatic systems (along rivers, coast and terrain) multiple use pressure is inevitable and can be treated as natural use conflict. However, conflicting social objectives and inefficient government policies can result in created use conflict and as a result most of the time these eco-systems operate at sub-optimal levels.

Conservation and preservation values of the aquatic eco-systems generally do not have any readily available market expression, unlike a number of possible eco-system development values. For example value of agriculture output, residential and industrial

complex values etc. Economically inefficient habitat modification of eco-systems has been encouraged as natural and semi-natural eco-systems have been completely or partially converted to other land users and as a result social benefits have been sacrificed for smaller monetary benefits in many parts of India (Marothia, 1995).For example complete infilling of urban water bodies in some parts of India for housing and commercial complexes may represent irreversible policy decisions. (Marothia, 1997, 2003).

Aquatic ecosystem, generally, provide tangible benefits in form of plants, animals, fish, soil and water function services in terms of life supporting services, pollution assimilative capacity, cycling of nutrients and maintenance of the balance of gases in the atmosphere .The potential benefits provided by aquatic eco-system are given in table 7. Many ecosystems often extend beyond the boundaries of ecosystem itself in the broad framework of river basin. Benefits of the aquatic eco-system should be, in principle, based on a full appreciation of total economic value.

9. Economic valuation of inland open water fisheries resources: CIFRI case Studies

The complete valuation of any natural resource including aquatic eco-systems is very difficult. It requires complete enlisting of all the goods and services provided by the ecosystem. As indicated earlier, to document services in general and non tangible services in particular indirect methods of valuation are used. These ecosystem also provide many indirect services, which are even difficult to document, so, valuation becomes very cumbersome exercise.

It is for the first time, Central Inland Fisheries Research Institute, Barrackpore has made a novel attempt to valuate inland open waters. Considering the nature of the resources and their use, results are based on partial valuation exercises. It covered three floodplain wetlands, one reservoir, one riverine stretch and an estuarine region. The observations of these investigations are summarised in following pages.

9.1 Floodplain wetlands/*beel*

9.1.1 Chandania *beel*

9.1.1.1 Location, area boundary and infrastructural facilities

The lake Chandania was located at Shergarh village in block Gaighata, Tehsil Ghoja and district 24 Parganas (North). The area of lake was 49.5 ha. The water area at DSL was 47 ha.

The lake was perennial and open. The parent river Icchmati was connected to the lake through its tributary Yamuna. The lake also had a connection with Kamaria canal. Total area surrounding the beel is 84 km^2 of which 50 km^2 are agriculture land. The total number of tube wells in the vicinity of the reservoirs is 250 out of which arsenic free tube well were only 14. Major crops grown in the area are paddy, potatoes, jute, mustard, muskmelon, vegetables.The fisher villages,

namely, Shergarh, Chandigarh, Narikala, Ghoja, Rampur Matikunda, Tegra and Belgani were located in the vicinity of the lake. The infrastructural facilities at the lake included metalled road, protection dykes, landing shed and one outlet gate.

9.1.1.2 The socio-economic features of fishers

As per 2001 census as a whole there are 4156 number of households with total population at 16, 627 around Chandania beel. In fisher community over 90% fishers were scheduled caste and remaining belonged to scheduled tribe. The average family size was 4.2 with sex ratio at one and adult minor ratio at 3:2. Nearly two third of the fishers were illiterate and remaining were mostly literate upto 10th standard. Major occupation of the fishers was fisheries with agriculture and daily labour as the secondary sources of income. Over 80% families had the kaccha houses with on average about two rooms. About 38% fisher families kept animals like cattle and goats, etc. Only 25% of fishers had their own non-mechanised wooden boat. Most of the fisher had one or other type of gears (gill net, cast net, traps, hook and line, vessel etc.)

9.1.1.3 Institutional arrangements

The ownership and control of beel is with Department of Revenue and welfare, Government of West Bengal, while for fisheries management the beel is leased out and managed by department of Fisheries, Government of West Bengal. It was leased out annually to Jaleswar Matsyajivi Samanbay Samiti Limited, Shergarh with annual lease amount of Rs 9398/-. The working and fisheries management of the beel by the lessee co-operative is mentioned below.

The society has 374 members. The organizing body of the society comprises of Chairman, Secretary, Vice chairman, Board of Directors (BoD) and members. Executive members are elected through voting (ballot box) held once in three years. BoD had 12 meeting, while one General Body meeting was held during last year. Members of BoD can be removed in case of any irregularity. The society has 32 women members.

9.1.1.3.1 Condition needed for society membership

Membership was open only for the local fishers of any of the seven villages cited above who attained minimum 18 years of age. Applicant should have good character. At most 7 persons of a single household could be member. Membership is transferable under the condition that all the criteria of membership should be fulfilled. A life time membership fee for society members is Rs 300/-.

9.1.1.3.2 Monitoring of functioning of society

BoD and manager of the society regularly monitor the functioning of society. The financial records and other records are also maintained by the manager. A representative of Department of Fishery (Chief Executive Officer) visits society office twice a week for monitoring the functioning of society. Monitoring and surveillance is done by society with two motor and four non-mechanised boats.

9.1.1.3.3 Decision making and rights

Decision regarding stocking, fishing days, fishing duration are solely taken by the BoD. Other members have to follow the decisions taken by them. Fishers have voting right, access to the beel and fishing right.

9.1.1.3.4 Conservation measures

The conservation measures were displayed at the office of the co-operative society. These are mesh size regulation and minimum size of fish caught (*Catlacatla*> 500(g), *Labeorohita*> 300 (g), Cirrhinusmrigala>300(g) and exotics> 1000 (g)

9.1.1.3.5 Fishing and remuneration

Fishers are primarily dependent on fishing either for stocked fish or other small fishes. Fishermen have their own fisheries asset such as small indigenous boats and gears, namely, gill net, hook and line, scoop net, vessel (lift net) and traps. These are used by them only to fish non-stocked/minnows. The fishers do this type of fishing round the year (320 days/year).

Commercial fishing for stocked fishes is done by members in groups using society drag nets during May-June and November-February. Fishing group comprises of 30 fishers, which do fishing alternately. Number of commercial fishing days per fisher varied from 30 to 65.

9.1.1.4 Fish disposal and remuneration

Catch are assembled by the fishers in the landing centre. Landing time varies according to season. In the winter season fish landing time is 10:00 am to 1:00 pm whereas in the summer it is 1:00 am to 4:00 am. Almost 90% catch are disposed off to the cooperatives who in turn dispose it off to the local dealers through auction. Nearly 20 society member fishers also took part in auction and do fish marketing. Transactions either with the fishers or with the local dealers are mainly done in cash. Fishes are packed in plastic container as well as in bamboo basket (Jhuri). Remaining 10% which are not disposed to the local dealers are sold in the nearby markets in Gaighata, Bongaon and Barasat.

The share of fisher and society for remuneration of fish catch is 50%. The society used this money for fisheries management of the beel e.g. fish seed stocking, lease amount and other expenses for fish catch and maintenance of the beel.

The fish marketing channel observed was Fisher - Co-operative- Local Dealer/ Wholesaler - Retailer – Consumer

9.1.1.4.2 Fish price

The price received by the co-operative varied according to size and species of the fish from Rs. 45-50 for IMC. The rate of weed fishes/minnows varied from Rs. 35-350/kg with an average of Rs. 120/kg.

9.1.1.5 Livelihoods and community interaction in resources

As per 2001 census there are 4156 number of households with total population at 16, 627 around Chandania beel. The population composition indicated 70% farmers, 24%

fishers, and remaining in service or business. Total area around the beel is about 84 km^2, out of which Agriculture land is 50 km^2 and others including forests, pastures, domestic lands is 34 km^2. These form the major resources for the livelihood and the resources for community interaction/utilization besides the beel itself. The information collected on these issues revealed that about 40% families living in the adjoining areas of the lake use lake directly for domestic purposes for bathing; washing clothes; tending cattle; dumping of domestic waste, fuel wood, fodder, etc. Direct uses also included use of natural resources in terms of fuel wood from forests, grazing of animals at pasture lands, use of bamboos and soil for house construction, etc. Tourism may also be considered as one direct use of the lake, particularly during winter months of December and January, when some tourists from Kolkata and nearby areas come on holidays. Remaining 60% of the families were either indirect or non users. Indirect uses included the ground water recharge used by the farmers on the periphery/otherwise around the beel. They use water either directly or through tube wells for irrigation.

9.1.1.6 Various uses, goods and services and secondary data

The information was gathered both from the primary and secondary sources regarding uses, goods and services provided by the selected water bodies. The primary sources were the fishers, members of co-operatives, farmers, tourists, residents living in the vicinity of the lake, etc. The secondary sources were co-operative society, Gram panchayat, fish market intermediaries. Based on this information and analysis of the components functions and attributes of Chandania wetland revealed following uses.

Direct uses: Fisheries; Agriculture, Habitat for aquatic biomass; Recreation and tourism; Domestic uses; Bathing; Washing clothes; Tending cattle; Dumping of domestic waste, Fuel wood, Fodder,

Indirect uses: Nutrient cycling, Pollution reduction, Natural habitat, Biological/ ecosystem support, Groundwater recharge, etc.

Non use: Biological conservation, habitats expending uses for aquatic biomass, aesthetics and cultural heritage

9.1.1.7 Information compilation and analysis

The information collected on the formats developed was verified and compiled in MS excel. Analysis of the complied information was done using market prices, indirect costs, travel cost and contingent valuation. The direct used values were computed from market prices or indirect and travel costs and indirect and non-use values were computed using contingent valuation method and willingness to pay technique.

The tangible goods of the beel comprised of fish, irrigation water, fuel wood and other natural goods. The value for fish was directly calculated through the price it received in the market, the value for the irrigation water and natural resources was estimated through indirect cost and hedonic prices.

The factors affecting the willingness to pay are worked out for direct users (fishers), indirect users (Farmers) and non-users. Linear and semi log models were estimated to identify the factors responsible for willingness to pay. The results for Chandania beel indicated that the factors included explained about 72 to 87% variation in willingness to pay. In case of direct users, most important factors influencing willingness to pay were

family size, House hold education and income. Total number of livestock, household education and income, and time to reach the resources was identified as the significant factors for willingness to pay. For non-users also total number of livestock, House hold income, distance to water body from home and time taken to reach the resource were the significant factors.

To valuate tourism in the beel, data collected from the tourists on travel cost and expenditure at the site. Based on this data a demand function was estimated to work out the value of tourism services.

9.1.1.8 Values for goods and services

The total value estimates are summarized in following tables. Table 8 gives the summary of value and quantity of fish catch for stocked and other fish species.

Table 8: Economic value for the fish produced

Item	2007-08		2008-09	
	Quantity (t)	Value (Rs lakh)	Quantity (t)	Value (Rs lakh)
Stocked fish	48.02	21.91	64.75	26.02
Minnows	20	24	32.73	39.27
Total	68.02	45.91	97.48	65.40
Fish Yield	**kg/ha**	**Rs./ha**	**kg/ha**	**Rs./ha**
Stocked fish	970.1	44263	1308.07	52570.00
Minnows	404.04	48485	661.12	79332.75
Total	1374.14	92748	1969.19	131902.75

The value of fish catch was estimated at Rs 97.48 lakh with the share of stocked fishes at about 65% and other minnows at 35%. It was estimated taking the market prices of the fishes.

The total value of goods and services (Table 9) provided by Chandania beel was estimated at Rs 105.58 lakh with highest share for fish (62%) followed by natural resource use (29%)

Table 9: Total value of goods and services provided by Chandania beel

Good/Service	Value (Rs lakh)	% share
Fish	65.40	61.94
Irrigation	4.9	4.64
Recreation and tourism	1.12	1.06
Natural resource use	30.4	28.79
Conservation of habitat for aquatic biomass, aesthetics, etc.	3.76	3.56
Total	105.58	100.00

9.1.2 Charan *beel*

9.1.2.1 Location, area boundary and infrastructural facilities

The Charan floodplain wetland (*beel*) is located at Morigaon district of Assam. Surrounded by the mighty Brahmaputra on North, Karbi Anglong district on South, Nagaon District on East and Kamrup District on West, the district has an area of 1450 km^2.

The greater part of the district is an alluvial plain, criss-crossed with numerous rivers and water ways and dotted with many *beels* and marshes. Killing, Kollong and Kapili rivers flow through the southern part of the district. The district has 183beels covering an area of 11658 ha. Located at about 80 Km from Guwahati, the *beel* got the publicity as boating and yachting events under 33rd National Games were held in the *beel*. A perennial stream originating from Kollongriver runs through the *beel* and joins the main river during monsoon. The *beel* is perennial with FSL area at 80 ha and DSL at 50 ha. The average area of the *beel* is 60 ha. The fisher villages, namely, Aujhari, Salanpar, Baghora, TaraniKalbari and Simibari are located in the vicinity of the lake. The infrastructural facilities at the lake

included metalled road, protection dykes and landing shed. Assam Fisheries Development Corporation (AFDC) has also one office at the *beel* to monitor fisheries activities. Major crops grown in the area are paddy, potatoes, vegetables and cucurbits.

9.1.2.2 The socio-economic features of fishers

As mentioned above, the beel is surrounded by five villages with about 800 families. The family composition indicated 70% farmers (Tiwa tribe), 20% fisher and 10% others. The fishers belonged either to scheduled caste or to scheduled tribe. The analysis of demographic pattern revealed average family size at 6.71 with male-female ratio at 1:0.95 for adults, 1:0.75 for children and overall 1:0.85. The adult minor ratio was estimated at 1:0.9. The literacy rate information indicated about 45% illiterate, 28% primary, 22% middle and remaining above middle school. Most of the fisher families had Kacha houses (70%) and remaining had semi pucca houses. The houses on an average had 2 small rooms. The earner dependent ratio was 1:3.89. Major occupation of fishers was fisheries with agriculture and daily labour as the secondary sources of income. About 50% families kept animals like cattle and goats, *etc*.

9.1.2.3 Institutional policy and governance

The ownership of *beels* in Assam is of State Revenue Department. But, AFDC has been leasing out *beels* since 1977 for fisheries purposes. The Charan *beel* was adopted for fisheries long back, but adopted by co-operative since 1976. Initially the number of co-operative members were 31, which increased to 91 in 1990 and to 101 in the year 2000. The number of members of lessee fisher society, namely, Morigaon Matsya Vyavsayi Samanvya Samiti Ltd is 101 with 56 active fishers. The non-member fishers fishing in Charan were 74. The fisheries leasing policy of the *beel* indicated that the lease period was only one year initially, which increased to 3, 5 and now seven years, since 2004, primarily due to CIFRI interventions. The total lease amount for seven years was Rs16.2 lakh. The annual lease amount was estimated at Rs 4250/ha. The annual lease amount is paid in three installments. The functioning of co-operative and fisheries management of the *beel* by the lessee co-operative is mentioned below

9.1.2.3.1 Condition needed for society membership

Membership was open only to the actual fishers of any of the five villages cited above. Most of the fisher families living in these villages had one co-operative member. Membership is transferable under the condition that these criteria of membership should be fulfilled. The non-member fishers had to pay fishing charges to the lessee society for fishing.

9.1.2.3.2 Functioning of society

The society has Management Committee (MC) with elected President, Vice President, secretary, etc. The fisheries management of the *beel* is generally done by the Secretary in consultation MC members. The local official of AFDC and DoF also monitor the management operations. The financial and other records are maintained by the secretary. Decision regarding stocking, fishing days, fishing duration are solely taken by the MC. Other members have to follow the decisions taken by them. Fishers have voting right, access to the *beel* and fishing right.

9.1.2.3.3 Fisheries Management

The beel has 6 small ponds in its periphery. The society stocks spawn in these ponds in March @ 25000 spawn/tank to raise fingerlings. They give supplementary feeding of MOC and rice bran (in ratio of 1:1) @ each constituent 200 kg/15 days. The fingerlings were harvested in June-July to stock in the *beel*. On an average 60-70 thousand fingerlings were harvested to stock in the *beel* after the floods. Society kept two to four persons for fish seed production and watch and ward. It sometimes varied depending upon the need.

9.1.2.3.4 Conservation measures

The members of co-operative society were aware of conservation measures of mesh size regulation and minimum size of fish caught (*Catlacatla*> 500 (g) *Labeorohita*> 300 (g) *Cirrhinusmrigala*> 300(g) and exotics> 1000 (g), but their adoption was moderate. The closed season is observed during April 1 to June 30.

9.1.2.3.5 Fishing

Only half of the fishers had their own non-mechanised wooden boat. Most of the fisher had one or other type of gears (gill net, cast net, traps, hook and line, *etc*.). The average fishing effort per fisher was 170 days/year. The composition of the operating fishers in the *bee l* revealed that 57% of them were Co-operative member and remaining were non-members. The fishing practices primarily included gill and drag net fishing during October to mid January (Bihu) and March to June. The Katal fishing was very prominent and conducted whole the year. On an average 8-10 katals were operative all




the times. Considering extremely high demand for fish during Bihu period, the peak period of fishing in the *beel* was first fortnight of January, *i. e*. before Bihu festival.

The fish price increases many times during this period. In some of the *beels* over 50% of fish was harvested during this period.

Commercial fishing for stocked fishes is done by members in groups using society drag nets during May-June and November-February. Fishing group comprises of 30 fishers, which do fishing alternately. Number of commercial fishing days per fisher varied from 30 to 65.

9.1.2.4 Fish disposal and remuneration

The fish catch at the *beel* is disposed off at the landing centre in front of the lessee, local dealers/wholesalers and representative of AFDC/DoF. The fish marketing channel and physical flow of the catch observed were

Fisher–Co-operative–Local Dealer/Wholesaler-Retailer-Consumer (70-80%)
Fisher-Wholesaler (5-20%)
Fisher-Consumer (10-15%)

The fish production and sale values were recorded from the AFDC office for last five years. It was the maximum for 2007-08 at 52.9 t and Rs 32.8 lakh. The fish catch during 2008-09 was very less at 26.3 t with sale value of Rs. 17.88 lakh. The fishers received 50% share in wholesale price. Remaining 50 % was retained by the society to pay the lease amount and meet other expenses. About 30% of the lease amount was given to AFDC. It was mandated to spend half of the lease value on fisheries development of the *beel*, but the developmental activities were rarely observed.

9.1.2.4.1 Fish price

The price received by the co-operative varied according to size and species of the fish and season from Rs 60-100/kg for IMC, Rs 60-70/kg for catfish and Rs 20-40/kg for others. The rate of weed fishes/minnows was quiet high.

9.1.2.5 Livelihoods and community interaction in resources

As per primary information collected from the stakeholders, about 800 of households with total population at 5368 reside around Charan beel. The population composition indicated 70% farmers, 20% fishers, and remaining in service or business.

Total area around the *beel* is about 105 km^2, out of which Agriculture land is 68 km^2 and others including forests, pastures, domestic lands, Arc nut trees, *etc*. These form

the major resources for the livelihood and the resources for community interaction/utilization besides the *beel* itself. The information collected on these issues revealed that about 50% families living in the adjoining areas of *beel* use lake directly for domestic purposes for bathing; washing clothes; tending cattle; dumping of domestic waste, fuel wood, fodder, *etc*. Direct uses also included use of natural resources in terms of fuel wood from forests, grazing of animals at pasture lands, use of bamboos and soil for house construction, *etc*. Tourism may also be considered as one direct use. The *beel* could not got momentum for tourism, but some Yachters and swimmers do practice there. Remaining 50% of the families were either indirect or non users. Indirect uses included use of groundwater by the farmers on the periphery/otherwise around the *beel*. They use water either directly or through tube wells for irrigation.

9.1.2.6 Various uses, goods and services and secondary data

The information was gathered both from the primary and secondary sources regarding uses, goods and services provided by Charan *beel*. The primary sources were the fishers, members of co-operatives, farmers, water sports, tourists, residents living in the vicinity of the lake, *etc*. The secondary sources were co-operative society, Gram panchayat, AFDC, DoF, fish market intermediaries and North–eastern Regional Centre of CIFRI at Guwahati. This information and analysis of the components functions and attributes of Charan *beel* revealed observations almost similar to those at Chandania *beel* in West Bengal. The uses of the *beel* are:

Direct uses: Fisheries; Agriculture, Habitat for aquatic biomass; Recreation and tourism; Domestic uses; Bathing; Washing clothes; Tending cattle; Dumping of domestic waste, fuel wood, fodder, Arecanut cultivation, *etc*.

Indirect uses: Nutrient cycling, Pollution reduction, Natural habitat, biological/ ecosystem support, Groundwater recharge, *etc*.

Non use: Biological conservation, habitats expending uses for aquatic biomass, aesthetics and cultural heritage

9.1.2.7 Compilation and analysis

The information collected on the formats developed was verified and compiled in MS excel. Analysis of the complied information was done using market prices, indirect costs, travel cost and contingent valuation. The direct used values were computed using market prices or indirect/surrogate market and. Indirect and non-use values were computed using contingent valuation method and willingness to pay technique. The tangible goods of the *beel* comprised of fish, irrigation water, fuel wood, Arecanut and other natural goods. The value for fish was directly calculated through the price it received in the market, the value for the irrigation water and natural resources was estimated through indirect cost and indirect/surrogate market. Value of tourism was calculated through travel costs method. For non-uses, revised choice based contingent valuation method was used.

9.1.2.8 Values of goods and services

The total value and quantity of fish catch are given Table 10. The estimates for 2007-08 were the highest during past five years due to better rains. Therefore, total average fish catch for past five years was estimated at 44.25 t. The average value of fish catch was estimated at Rs 22.45 lakh.

Table 10: Economic value for the fish produced

Year	Production (t)	Sale value (Rs Lakh)
2004-05	46.1	20.75
2005-06	48.0	24.00
2006-07	30.0	16.80
2007-08	52.9	32.80
2008-09	26.3	17.88
Average	44.25	22.45

The total value of goods and services (Table 11) provided by Charan beel was estimated at Rs 50.24 lakh with highest share for fish (45%) followed by natural resource use (34%).

Table 11: Total value of goods and services provided by Charan beel

Good/Service	Value (Rs lakh)	% share
Fish	22.45	44.69
Irrigation	6.37	12.68
Recreation and tourism	1.25	2.49
Natural resource use	17.28	34.39
Conservation of habitat for aquatic biomass, aesthetics, etc.	2.89	5.75
Total	50.24	100.00

9.1.3 Janaki Chak: Seasonally flooded wetland

9.1.3.1 Location, area boundary and infrastructural facilities

Janki chak mauza is located in Moyna block of East Midnapur district in West Bengal. It is in Damodar-Kangsabati basin having approximately 77.2 thousand ha of floodplains. The major water feeding rivers in the area are Kangsabati, Chandi and Keleghai. The rivers are at higher altitude than the block. Therefore, river water flows down in the block from May end and remain till January. In wet season, the deepwater fields get inundated from nearby water sources of the locality. The flood water level varies from 3-6 ft with minimum in June and January and maximum in September. These can be utilised for fish based farming system through deepwater rice-fish (DWR) cultivation. The Block Moyna comprised of 84 villages, which are ideal for DWR farming as it is a continuous water sheets of low lands or saucer shaped depressions.

Climate condition of the area is tropical, characterized by hot summer, medium monsoon and mild winter season. Summer season starts from mid February and extends till May. The period from June to September is the monsoon period followed by winter season, which starts from November and continues up to February. The Chak has a water spread of 33 ha with average water level of 1.3 m during 2010-11.

9.1.3.2 Institutions policy and governance

The information on institutional and governance arrangements and policy issues were collected adopting stakeholder participatory approach. All the stakeholders actively participated in the discussions. The information gathered was on the society, necessary conditions for getting membership, tenure and functioning of Board of Directors, its number of meetings per month and participation; the water area with society members, their role in fish and fish seed production and marketing; fisheries assets of the society and functioning. The farmers/fishers organised themselves into a co-operative society, namely, Moyna Vivekananda Fishermen Co-operative Society Ltd, Janaki chak, PO Gourangochak, Moyna. Gram Samiti annually leased out the water through open auction. The Gram Samiti is an informal local governance institution. It was responsible for water level maintenance over the months according to the requirements for aqua and paddy culture. The society has taken lease of Janaki Chak for one year for fish culture during May-April at a lease amount of Rs.15 lakh. The owners of the land were compensated for not growing the paddy by higher lease amount. No conflict was found among the fishers and the owners of the leased water area. The area also had sluice gates for intake and outflow of the water. During the year 2010-11, it was leased only for fish culture. Fish caught from both the waters were disposed off in different fish markets, namely, Annapurna market (18 fish shops), Moyna block (70-75 fish shops), Moyna market (8 fish shops). Market commission rate for auctioneer was 2%.The institutional and governance environment were favourable for the fish based production system.

9.1.3.3 Information on stakeholders

The information on stakeholders were collected on the pre-tested questionnaires through personal interview. It primarily included socio-economic parameters. During yesteryears, the water body was used for paddy cum fish culture. Two paddy crops (Aus/ Aman and boro) were taken beside fish culture during May to December. But, due to very high profitability in fish culture the water body is used only for fish culture for last two years. Therefore, the major stakeholders were the fisher cum farmers. The community using these resources included 79% farmers, 12% fishers and 9% others.

Janaki chak mauza has 450 households, while in the nearby Charandaschak their number is 565. The caste structure indicated 75% general, 17% scheduled caste and 8% scheduled tribes. Most of the families were nuclear (62%) with 5-7 members. Average age of farmers was 48 years. The literacy rate was 65%. Most of the family members had qualification upto secondary level. The fishers have both agricultural and aquacultural lands. They were dependent upon both on agriculture and fisheries in seasonally flooded waters. The fishers also either had ponds or lease them for fish seed and fish production. The main occupation was agriculture (55%) followed by aquaculture (35%) and business. Average income of most of the farmers varied between Rs. 50-60 thousand/year with over 60% contribution from fisheries.

9.1.3.4 Livelihoods and community interaction in resources

As mentioned above, the water body was used for paddy cum fish culture till 2008-09. Two paddy crops (Aus/Aman and boro) were taken beside fish culture during May to December. But, due to very high profitability in fish culture the water body is used only for aquaculture activity. Therefore, the livelihood of the community directly depended on fish culture. Only 29 families of the lessee co-operative members conducted the fish culture activities. The water body was used for domestic day to day activities till 2008, but, due to intensive fish culture, these activities are ceased, primarily because of the poor water quality. The water of the beel was also used for irrigating the agricultural crops. During high water level period water was drained to nearby common water channel and used for irrigation. The indirect uses included ground water recharge. The difference between the maximum and minimum level of water is on an average 0.75 m (35% for evaporation, 65% ground water recharge). The volume of water is estimated at 26.3 ha m.

9.1.3.5 Various uses, goods and services and secondary data

The information was gathered both from the primary and secondary sources regarding uses, goods and services provided Janaki chak *beel*. The primary sources were the fishers, members of co-operatives, farmers, residents living in the vicinity of the *beel*, *etc*. The secondary sources were co-operative society, Gram Panchayat, Department of Agriculture (DoA), DoF, Gram Samiti, fish market intermediaries, *etc*. Based on this information and analysis of the components, functions and attributes the uses of the *beel* are:

Direct uses: Fisheries; agriculture, Habitat for aquatic biomass; domestic uses; dumping of domestic waste, fuel wood, fodder, *etc*.

Indirect uses: Nutrient cycling, biological/ecosystem support, Groundwater recharge, *etc*.

9.1.3.6 Compilation and analysis

The information collected on the formats developed were verified and compiled in MS excel. The valuation of the goods and services was done using market prices, indirect costs and contingent valuation. The direct used values were computed using market prices or indirect/surrogate market. Indirect and non-use values were computed using contingent valuation method and willingness to pay technique. The tangible goods of the *beel* comprised of fish, irrigation water and other natural goods. The value for fish was directly calculated through the price it received in the market, the value for the irrigation water and natural resources was estimated through indirect cost and indirect/surrogate market. For non-uses, revised choice based contingent valuation method was used.

9.1.3.7 Values for goods and services

The total quantity of fish catch at Janaki Chak *beel* is given in Table 12.

Table 12: The fish catch at Janki Chak beel

Fish	Total production (kg)			Production (kg/ha)		
	2010-11	2009-10	2008-09	2010-11	2009-10	2008-09
C. catla	27876	56549	34155	844	1714	1035
L. rohita	45957	22864	17820	1394	693	540
C. mrigala	27454	15405	12623	832	467	383
Total IMC	101287	94818	64598	3070	2873	1958
Other	23149	16661	19214	701	504	582
Total	124436	111479	83811	3771	3377	2540

The estimates for 2010-11 were the highest during past three years due to better cultural practices adopted by the society. Therefore, total average fish catch for the year was estimated at 124.44 t with fish yield at 3771 kg/ha.

The total value of goods and services provided by Janki Chak *beel* for both fish culture and paddy cum fish production systems are summarized in Tables 13 and 14. In fish culture system the value was estimated at Rs. 167.85 lakh with highest share for fish (74%) followed by irrigation (20%)

Table 13: Total value of goods and services provided by Janki Chak beel under fish culture production system

Good/Service	Value (Rs. lakh)	% share
Fish	123.63	73.7
Irrigation	33.64	20.0
Conservation of habitat for aquatic biomass, aesthetics, etc.	10.58	6.3
Total	167.85	100.0

The total value for goods and services provided under paddy cum fish culture production system was estimated at Rs. 125.79 lakh with 47% share of fish followed by paddy (28.5%), irrigation and groundwater recharge at 13.8%.

Table 14: Total value of goods and services provided by Janaki Chak beel under paddy cum fish culture production system

Goods/Services	Value (Rs. lakh)	% share
Fish	59.02	46.9
Paddy	35.89	28.5
Irrigation	17.31	13.8
Conservation of habitat for aquatic biomass, aesthetics, etc.	13.58	10.8
Total	125.79	100.0

9.2 Reservoir

9.2.1 Kangsabati

9.2.1.1 Location and morphology

The Kangsabati reservoir located in Bankura and Purulia districts of West Bengal was selected for the study. The reservoir is one of the largest reservoirs in eastern India. It is used for different uses and provides various services. Constructed in 1956, it is the second biggest earth dam of India with length of 11.3 km, average area of 3626 ha. It is fed by rivers Kangsabati, Kumari and Tarak. The reservoir water flows through two main canals (800 km) and their tributaries about 2200 km. Water is released whole the year through small gate for agricultural purpose.

9.2.1.2 The data, sample and tools for data collection

Both primary and secondary data were used in the study. The primary data were collected from different users and secondary data were collected on institutional and governance arrangements and macro-level use of waters and production.

Checklist was prepared for uses based on the livelihood and community interaction with the reservoir. These uses were prioritized based on information available. The Sample size was according to probability proportional to size of population for different users (Direct, Indirect and non-use). In case of reservoir, sample included maximum number of tourists (100) and farmers (100) followed by local riparian households (75) and fishers (50).

The schedules and questionnaires were prepared and pretested for fishers, farmers, tourists and nonusers to collect general information and data related to willingness to pay. Schedule was also

developed for collection of data on community interaction with these waters, institutional framework and governance.

9.2.1.3 The methods

A partial valuation exercise was conducted to value different prioritized goods and services of the reservoir and river stretch. The direct use values primarily involved aquatic resources harvested. Market prices were considered as measures of these values. However, complications arose in many values, which were not directly reflected in market prices. In some cases, techniques such as the travel cost method (tourism), contingent valuation (existence and bequest value) and surrogate market and hedonic pricing and indirect cost (Irrigation and forest products) were adopted. Following Table 15 describes the valuation techniques used to estimate various goods and services provided by the reservoir.

Table 15: The goods and services of reservoir with valuation techniques

Good/Service	Valuation technique used
Fish	Market price
Irrigation	Surrogate market, Hedonic pricing, Indirect cost
Domestic water supply	Surrogate market
Recreation and tourism	Travel cost
Forest products	Surrogate market, Hedonic pricing, Indirect cost
Conservation of habitat for aquatic biomass, aesthetics and cultural heritage	Contingent valuation method

9.2.1.3.1 Travel cost method

The reservoir is also a tourist spot having many site seeing points. It provided the recreation and tourism services. The travel cost method is used to value these services. The consumer surplus was calculated through regressing total no of days of visit for a tourist on total cost of visit. The cost at which number of days of visit by the tourist to Kangsabati becomes zero was estimated. The total no of days of visit of the visitor and added costs were plotted to have a smooth curve. The bottom part of the curve gave the consumer surplus of visitor to visit Kangsabati reservoir. It is used as the travel cost.

9.2.1.3.2 Non-use/Option value

Option value (OV) refers to an individual's Willingness to Pay (WTP) to preserve the *option* of using a good in the future. Contingent valuation method was used to valuate this indirect and non-use values. To determine the factors affecting the willingness to pay linear and log-linear production functions were tried for different stakeholders.

9.2.1.4 The stakeholders and community

The reservoir has about 127 riparian villages with 55 on river Kumari and 72 on river Kangsabati. These included number of tribal and fishermen villages. The number of families per village varied from 40-45. The tribal population constituted 55-65% of the

population around the reservoir. The overall composition of population in command area of reservoir included 31% other backward caste (OBC), 28% scheduled tribe (ST), 23% scheduled caste (SC) and 18% of general category. The villages around the reservoir fall under five gram panchayats, five blocks and two districts. The average family size was between 5-10 with about 45% male and 55% females. The population in these villages consisted of both fisher and agriculturists. The other stakeholders were Department of Irrigation, Department of Fisheries (DoF); Department of Health and Water Supply, eleven fishermen co-operatives, National Fisheries Development Board, *etc*.

9.2.1.5 Institutional framework

The reservoir is primarily under control of Department of Irrigation but the fisheries is managed by Department of Fisheries (DoF); Government of West Bengal. For fisheries purpose, the department provided the fishing rights to the eleven fishermen co-operatives in the vicinity of the reservoir. DoF does not charge any rent from the fishers for fishing. Earlier the fisher co-operatives managed the reservoir under supervision of DoF. This year DoF stocked the reservoir with NFDB funding.

Out of eleven fisher co-operatives seven are engaged in fishing in the reservoir. Two societies are from district Purulia and the rest are from Bankura.

Four other fishermen cooperative societies in Mukutmanipur live far away from the reservoir and are not fishing in the reservoir. All the primary cooperative societies formed a central cooperative society to look after their functioning. This central cooperative society issue license every year to transfer the fishing right to the individual fishers. Fishers of primary cooperative societies get fishing right for one year with payment of Rs 250/- to the central co-operative society. The number of fishers at Kangsabati was 2010 in 1999 which is increased to 2840 in 2010.

In Kangsabati reservoir, moneylender extends loan which are both productive as well as non productive and enjoy the key position in fish disposal and marketing. It adversely affected the equity issues and remunerations for the fishers.

9.2.1.6 The Livelihood and uses

The catchment and command area of the reservoir is used for agriculture, fishing, tourism, natural resources and day to day domestic purposes. The reservoir provided irrigation to 3.4 lakh ha agricultural land in Bankura, Purulia, West Medinipur and Hoogly districts of West Bengal. The main purpose of the reservoir is to store water for irrigation to agricultural purpose and flood control. The reservoir irrigates kharif and rabi crops in 11 blocks of Bankura District, 13 blocks under Midnapur District and one block each of Purulia and Hooghly District.

Few hills are also located in the vicinity of reservoir exhibiting very good natural scenery. Bangopalpur Reserve Forest, a home of many species of flora and fauna is about two km from the reservoir. One deer park is also located inside the reservoir. It makes the reservoir one of the favourite tourist sites. There are 9-10 hotels around reservoir. In peak and medium season time on an average 2000 visitors visit Mukutmanipur per day. They come from different states like Orissa, Bihar, Jharkhand, Uttar Pradesh and most of the districts of West Bengal. In lean season average daily visitors were 150-200. During peak season boat charges are Rs 20/- per head, while in lean boat is to be reserved for Rs 350/-.

Boat owners have to pay Rs 300/year to the Gram Panchayat. Absence of Sulabh complex and lack of garbage disposal cause the value degradation of the tourist spot.

9.2.1.6.1 Fisheries

As indicated earlier the number of fishers fishing in the reservoir was 2840 during 2010. They belonged to seven co-operative societies. The fishing practices included indigenous wooden craft, gill nets and hook and line throughout the year and cast nets in rainy season. Auto stocking took place through breeding in monsoons. Seedlings of 49 fish species were observed. Lack of fisheries management in the reservoir is reflected in the amount of catch and its composition. Co-operative society charged a commission of Rs1/kg for IMC and catfishes and Rs 0.50/Kg for small and miscellaneous fishes. It is the source of revenue for the cooperatives.

9.2.1.7 Valuation of goods and services

9.2.1.7.1 Fisheries

The fish production, prices and value of fish from the reservoir are mentioned in Tables 17-18. The catch of all the categories of fish fluctuated and declined for most of them except the other miscellaneous species. The total catch fluctuated between 118 to 167 t. The prices of all the fish species followed an increasing trend. Maximum fish prices were for prawn (Rs 200/kg) followed by IMC (Rs 65/kg). The highest price rise was also for prawn. The increase in fish prices has compensated the decrease in fish catch to some extent. The total value has decreased from Rs 131 to 95 lakh. The marketing channel for the reservoir fish was Fisher – Co-operative – Wholesaler – Retailer – Consumer.

Table 16: Fish catch from Kangsabati reservoir (in t)

Year	IMC	Minor carps	Catfish	Prawn	Other	Total
2007	29.30	26.86	34.19	51.28	25.64	167.28
2008	30.64	40.85	37.44	74.89	56.58	240.40
2009	20.35	27.75	14.80	35.15	91.95	190.00
2010	8.29	14.21	8.29	27.28	60.38	118.45

Table 17: Fish prices at Kangsabati reservoir (Rs/kg)

Year	IMC	Minor carps	Catfish	Prawn	Other
2004	52	35	42	165	28
2005	55	39	47	170	30
2006	60	42	50	180	35
2007	65	45	55	200	40

9.2.1.7.2 Irrigation

As mentioned above reservoir provided irrigation to 3.4 lakh ha agricultural land in Bankura, Purulia, West Medinipur and Hoogly districts. The irrigation was valued

through indirect cost method, by asking the cost of irrigation/ha from the sampled farmers.

Table 18: Value of fish catch from Kangsabati reservoir(Rs lakh)

Year	IMC	Minor carps	Catfish	Prawn	Other	Total
2007	15.24	9.40	14.36	84.62	7.18	130.79
2008	16.85	15.93	17.60	127.31	16.98	194.66
2009	12.21	11.66	7.40	63.27	32.18	126.72
2010	5.39	6.39	4.56	54.56	24.15	95.06

The total value of irrigation was estimated at 16.28 crore.

9.2.1.7.3 Domestic water supply

The reservoir is also supplying potable water in the catchment area, particularly in the local blocks. The water is supplied by local municipality to local residents. The municipality is charging water tax from the users. The value of total water tax collected by Municipality is mentioned as the value for domestic water. It was only Rs 1.23 lakh

9.2.1.7.4 Recreation and tourism

The value of this service was calculated through travel cost method by estimating the consumer surplus. The information collected from sampled tourists was analysed to compute this value. It was estimated at Rs 28.18 lakh.

9.2.1.7.5 Natural Forest products

The local populace collected natural forest products. These included the fuel wood, wood for furniture and house construction, fodder/leaves for the livestock, etc. The information collected from the local residents was analysed to estimate this value. It was estimated at Rs 48.54 lakh.

9.2.1.7.6 Option/ Non-use value

As mentioned earlier, continent valuation method was used to estimate the non-use value. Linear and semi log models were estimated to identify the factors responsible for willingness to pay for direct users (fishers), indirect users (Farmers) and non-users. The results for Kangsabati reservoir indicated that the factors included explained about 62 to 89% variation in willingness to pay. In case of direct users, most important factors influencing willingness to pay were household education and income and total number of livestock. For non-users also household income and age of respondent were the significant factors. Since the resident stakeholders are not able to quantify the non-uses properly, the estimate for this was only Rs 10.15 lakh.

9.2.1.7.7 Total value

The total value of goods and services (Table 19) provided by Kangsabati reservoir was estimated at Rs 1810.94 lakh with highest share for irrigation (90%) followed by fish (5%) natural resource use (3%) and tourism about at 2%.

Table 19: Valuation of goods and services at Kangsabati reservoir

Good/Service	Value (Rs lakh)	% share
Fish	95.06	5.25
Irrigation	1627.78	89.89
Domestic water supply	1.23	0.07
Recreation and tourism	28.18	1.56
Natural resource use Forest products	48.54	2.68
Conservation of habitat for aquatic biomass, aesthetics, etc.	10.15	0.56
Total	1810.94	100.00

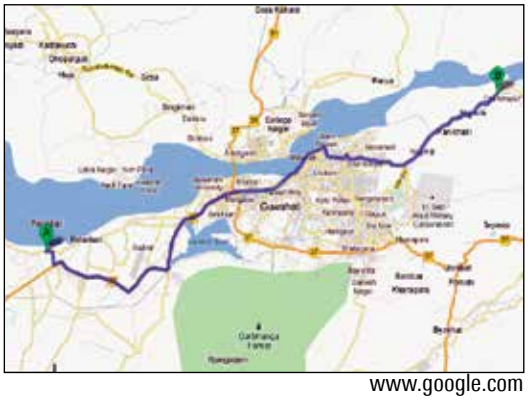
9.3 River

9.3.1 Brahmaputra River

9.3.1.1 Location

Palasbari (26.13° N and 91.5° E) to Chandrapur (26.23° N and 91.92° E) stretch located in Kamrup Metropolitan District was selected for the study. The river stretch has length of about 22 km, while road the two points have distance of 55 km. The geographical area of the District is 127.84 sq. km.

The Kamrup Metropolitan district is comprised of only one sub-division namely, Guwahati Sadar. From developmental angle, the rural area of the district is divided into 4 Development Blocks namely Bezera, Chandrapur, Dimoria and Rani. Below the block level set-up, there are 22 *Gaon Panchayats*, each comprising of a number of villages and governed by local-self bodies. The stretch is around the capital of Assam, Guwahati. The stretch has access by pucca road.



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9.3.3.2 Institutions policy and governance

The river is the rich source of natural resources. For fisheries the fishing rights were leased out to the private parties. There were five leasees in the selected stretch for fishing of Bramhaputra. The leasees allows fishermen to catch the fish, in return they give 40% of the catch to the leasees. Directorate of Agriculture, Irrigation Department, Chief Engineer- Agricultural Irrigation is all concerned with the utilization of surface and ground water for agricultural irrigation. Panchayat departments are also facilitating for providing the small irrigation projects. Directorate of Inland Water Transport issues the ferry service rights to private players through auctions. There were 11 ferry service routes in the selected stretch. Some of the private companies also arrange river cruise on

payment basis. Government Tourism department also operate the cruise service. Water resources department mainly concerned with the maintaining the record of water flow and taking flood controlling measures.

Recognizing the magnitude and complexity of the problem of floods and its disastrous consequences in the North Eastern Region, the Brahmaputra Board, a statutory body was set up by the Govt. of India under the Ministry of Water Resources. The primary job of this board is to carry out surveys and investigations in the Brahmaputra Valley and prepare the Master Plan for control of floods, bank erosion and improvement of drainage in the Valley and to prepare the Master Plan on development and utilization of water resources of the Brahmaputra Valley for irrigation, hydropower, navigation and other beneficial purposes.

With a view to promoting uninterrupted, hygienic, piped drinking water and hygienic environment in the Guwahati Metropolitan Area (GMA), Government of Assam notified the Guwahati Metropolitan Drinking Water and Sewerage Board (*Guwahati Jal Board*) Act through the Government order GDD 80/145 dated 21st December 2011, in accordance with the Guwahati Metropolitan Drinking Water and Sewerage Board Act, 2009.

Among the NGOs Aranyak and NEDF are the prominent players. Aranyak works to foster conservation of biodiversity in Northeast India through research, environmental education, capacity building and advocacy for legal and policy reform to usher a new era of ecological security. North East Development Foundation (NEDF) is a not-for-profit development-focused consulting and participating organization contributing to aspects of sustainable development like livelihoods, natural resource management (NRM), and rural technology. Since 2006, NEDF has implemented key socio-economic projects with a bottom up approach. Among the R&D organization which works for the development and sustainability of the river basin including fisheries are CIFRI, IIT Guwahati, Guwahati University and Assam Agricultural University. Other stakeholders who are directly associated with the river are Guwahati Municipality, Sand miners, brick klin owners, visitors of parks, temples, picnic spots situated on the river bank.

9.3.3.3 Information on stakeholders

A number of stakeholders are involved in the selected stretch of Bramhaputra River. Government, private agencies and NGOs are directly associated with the river. Among the state government departments, Directorate of Fisheries, Directorate of Agriculture, Water Resources department, Directorate of Inland Water Transport, Directorate of Irrigation, Chief Engineer- Agricultural Irrigation are the major. Some central government establishments are also associated with the river. Among them Bramhaputra Board (Ministry of water resources), Central Ground water Board are major.

9.3.3.4 Livelihoods and community interaction in resources

Brahmaputra basin encompassing North East Region of India is one among the water rich basins in the world. Annual available surface water potential of the region (Brahmaputra-Barak basin) is 585.60 km^3, which is 31.33% of the national potential. Surface water potential of Brahmaputra basin is highest of all the river basins in the country (11.54% more than that of Ganga basin). With geographical area of 7.3% of the total area of India, the basin houses 4.2% population with diverse ethnic groups. Annual

available water resource of the basin is 31.33% of national potential. Per capita water availability in the Brahmaputra basin is 16589 cum per year, in comparison to national per capita availability is 2208 cum per year (Kaman, 2011). The basin is highly undulating and also experiences heavy annual rainfall of about 5100mm to 6400 mm in Arunachal Hills and 2500 mm to 5400 mm in Brahmaputra plains. The basin also dotted with dense forest and natural parks and sanctuaries. Tens of thousands of fishermen get their livelihood from this river.

9.3.3.5 Various uses, goods and services

The studied river stretch like any other natural ecosystem provides a number of tangible and intangible goods and services. Among the prominent goods and services *the* provision goods are production of fish and other aquatic animals/plants, water for domestic, industrial, and agricultural use, production of logs, fuelwood, peat, fodder, ornamental species, biodiversity are major. It has got profound regulating activities in the form of controlling greenhouse gases, temperature, precipitation, and other climatic processes; groundwater recharge; retention, recovery, and removal of excess nutrients and pollutants, nursery and breeding grounds for fish, flood control, storm protection. It has also got spiritual, inspirational, recreational and aesthetic values. It also helps in carbon sequestration and nutrient cycling.

Among the goods and services discussed above the following six of them viz. fisheries, navigation, Municipality supplied water, surface irrigation water, tourism and sand mining were considered for the valuation exercise.

9.3.3.6 Collection of data

The required data were collected from the following sources:

- Directorate of Fisheries, Agriculture, Water Resources, Inland Water Transport and Irrigation, Govt. of Assam, Guwahati
- The Bramhaputra Board, Ministry of Water Resources, Govt. of India
- Office of the Chief Engineer, Agricultural Irrigation, Govt. of Assam, Guwahati
- District Agricultural Office, Kamrup District
- Visitors of temples, parks, river cruise, picnic spots located along the river stretch
- Sand miners
- Lesees of ferry operations, fisheries, etc.

The information collected on the formats developed was verified and compiled in MS excel. Analysis of the complied information was done using market prices, indirect costs and contingent valuation. The direct used values were computed using market prices or indirect/surrogate market and. The tangible goods of the river comprised of fish, irrigation water, sand and other natural goods. The value for fish was directly calculated through the price it received in the market, the value for the irrigation water and natural resources was estimated through indirect cost and indirect/surrogate market. For non-uses, travel cost method was used.

9.3.3.7 Values for goods and services

In the above stretch there were five leases for fishing of Bramhaputra. Fishing is a highly important activity in the study area. The majority of fishers use nets, although traditional traps and hooks are also still commonly used. The average fish catch per day was estimated to be 84.4 kg. The fisheries value comes at Rs. 46.21 lakh per year. There are 11 ferry service points in the selected stretch which government gives to the private agencies for the ferry services. During 2011-12 the government earned Rs. 21.35 lakhs and the total revenue generated by the private agencies was around Rs. 32 lakh. In addition to this, government provides some boats for short term hiring. It was estimated that around Rs. 24 lakh was earned from this source.

As per the census 2011 the total number of households in Guwahati was 1,87,000. Assuming that all are getting drinking and other purpose water from the municipality supply and Rs. 75 water tariffs per households, the total value comes at Rs.16.83 crores. The crops grown using Bramhaputra surface water are very minimum in the given stretch. The area irrigated out of this water was approximated to be 50 ha for paddy and 10 ha for vegetables. Since no crops would have been possible to grow without Bramhaputra water the total value of the crop was taken for the valuation purpose and Rs.23.71 lakh was the estimated value.

For valuation of tourism potential, two temples, three parks and one river cruise were visited and data were taken from the 50 respondents. The consumer surplus generated was estimated to be Rs. 4046 per trip. Therefore the total tourism potential was worked out to be Rs. 28.32 crores based on an estimated 70,000 trips tourists have made during the past one year. Sand mining is the other important industry which use the Bramhaputra river. This industry is in operation for 7 months in a year. There are about 10 sand mining sites in the selected stretch. It was found that on an average about 500 mini trucks loaded sands are mined daily. The total value of this industry came to about Rs. 8.10 crores. Therefore, the total value of these 6 goods and services of 22km stretch of Bramhaputra was estimated to be about Rs. 55 crores annually.

Table 20: Value of goods and services provided by 22 km stretch of Bramhaputra river

Goods and services	Rs. (lakhs)	% share
Fisheries	46.21	0.85
Navigation	56.03	1.03
Municipality supplied water	1683.00	30.89
Surface irrigation	21.21	0.39
Tourism & pilgrims	2832.20	51.98
Sand mining	810.00	14.87
Total	5448.64	100.00

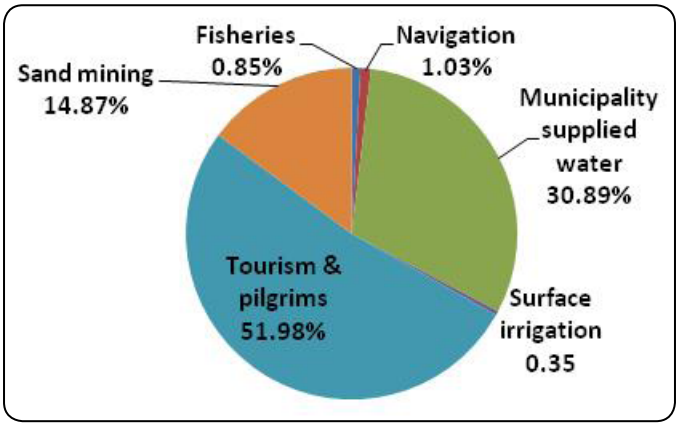

Fig 3 : Share of different components in total value

9.4 Estuary

9.4.1 Case study of Sundarbans

The Sundarbans in India is the largest river delta and also the largest estuarine mangrove forest in the world. The Indian Sundarbans has a forest area of 4263 sq. Km (Anon 2009) It became a UNESCO world heritage site in 1987 (UNESCO,WHC 2012). Being situated in the intertidal zone, inundated by tides twice a day, the mangroves possess a range of features which makes them uniquely adaptable to their stressful environment. The mangrove swamp provides an ambience of food and shelter to a wide range of both land & aquatic organisms. It acts as nutrient stock for both esturine and marine ecosystems supporting local and commercial yields (Camilee, 1998).The mangroves forest acts as a nursery for many fish species all along the Eastern coast of India (Anon, 2009). Apart from that, Mangroves acts as natural buffer against cyclones and storms. Mangroves protect vulnerable embankment from tidal surges and act as bio shield against storms (Sathirathi and Barbier 2001).

Most of the people depend on Sundarban Ecosystem for their livelihood and sustenance through fishing, collection of honey and fuelwood/timber (Anon 2009). It is an example of a community living in a balance with a surrounding mangrove forest, upon which it depends for subsistence and livelihoods. These people are poor and have fewer years of education, employment & income, therefore their dependence on mangrove is higher (Hussain and Badola 2010). Irrespective of many benefits, mangroves are under intense pressure from competing resource uses, increased commercial activities and urban development demands. Every year mangroves are being destroyed during prawn seed collection by the villagers or eaten up by their domesticated animals. Such activities can, therefore, have a drastic negative effect on the wellbeing of mangrove dependent

community including the whole ecosystem. The balance will become fragile, because excessive exploitation can undermine the resource availability (Chowdhury, 2010). Therefore, investment in the conservation and management of mangroves is increasingly being seen as a key element of sustainable livelihood, risk reduction and disaster management (Mangrove for future 2012). The value of goods and services provided by mangrove ecosystem is given below:

9.4.1.1 Direct use

Non Timber Forest Products (NTFP's)

Honey and Bee Wax are the minor forest produce which are collected during the months of April and May. Golapata (Nypa sp) and Hental (Phoenix sp) which discontinued in 1978 and 1991 respectively.The wild honey collected from the Gosaba region including the adjoining Sundarban Wild life Sanctuary (SWLS) was around 13800 kg in 2009-10 which fetch an annual price of Rs.77,8734. Also the honey collected from the apiary box was around 406000 kg from 16240 apiary box established in SWLS which fetched market price of Rs. 3.45 crores.

Fisheries:

The value of fisheries was calculated by the average income of a household gained purely by fisheries activities which includes inshore & off shore fisheries, prawn seed collection etc. The estimated value from the primary survey of the household shows that the average annual income and the overall value was calculated to be Rs.16022/- and Rs. 15.04 crore respectively.

Agriculture

Nearly 62% of total cultivable land of this region is low lying and suffers from elevated salinity during dry season, from intrusion of saline water, capillary action, and increasingly acid sulphate build up. Soil drainage is generally inadequate and deep water stagnation occurs in monsoon season. At present nearing 20% of the agricultural land in this region is multi cropped. In this region 9% of the farmers are classified as small farmers and 35% as marginal farmers. The total area of the Gosaba block is 29672.52 ha. In this region 9% of the farmers are classified as small farmers and 35% as marginal farmers.

9.4.1.2 Indirect use

Eco Tourism:

The tourist has to pay an entry fees for entering in those area which is mainly restricted to buffer zone. The total revenue earned from the eco tourism in the year 2009-10 from Gosaba Range and Sajnekhali range was Rs. 22.79 lakh

Secondly, the travel cost method is used to estimate economic use values associated with ecosystems that are used for recreation to the site. The relationship between number of visits and travel costs was regressed using individual data. The regression equation (-0.003x +45.58) gives us the demand function for the visitor to the site. The average consumer surplus of the site was calculated as Rs. 6250/- and the overall consumer surplus of the site based on the no. of people visited the site in the year 2009-10 was estimated based on people visited in Gosaba range (8600 visitors) & SWLS Range (44,000 visitors) was Rs. 3287.5 lakh.

Dike protection value of mangroves

The rises in relative sea level in Sundarban are due to land subsidence, resulting from auto-compaction, tectonic activity and anthropogenic processes including water abstraction from tube wells. More problematic is the impact of surge events on the embankments. The impact of this increase in sea level on the embankment crest levels has been progressively offset by regular maintenance, carried out by local labour using in situ estuarine clay-silts: an arduous but cost-ineffective process. Every year crores of Rupees are being spent on maintenance and repairing of these embankments. It is an established fact that Mangrove ecosystems are highly valuable for protection against natural coastal disasters, and their conservation and restoration are needed to maintain national and global natural capital. The present study tries to value the indirect use of mangrove protecting by estimating the reduction in maintenance cost annually.

The dike protection functions of mangroves is based on so many ecological factors like wavelength of tides, width of the tree stand, stand density (trees/ sq.m), diameter of canopy, and Diameter of stem. The role of mangroves protecting sea dikes is estimated from expenditures on sea dike maintenance and repair.

The planting of mangroves in front of sea dike system provides a benefit in terms of avoided maintenance costs of the sea dike. The data were collected from 5 zones of Gosaba region and based on annual maintenance cost, it has been estimated that planting mangroves along the embankments can reduce the cost by 94 percent. The annual reduction in cost for study region was estimated to be 18.63 crore annually.

Carbon storing value of mangroves

Due to climate change carbon sequestration by forests continues to gain in value. Due to their high biomass density and productivity mangroves play a significant role in carbon sequestration. Since many of the ecosystem services have, in the long run, economic consequences, valuation is necessary. The present study is an attempt to give monetary value to carbon sequestration of mangroves of Sunderbans. The economic valuation of carbon sequestration is completely based on published literature, amount of carbon stored, area of mangroves in Sunderbans and existing carbon market. The Gosaba region is dominated mainly by *Avicennia sp, Sonneratia sp, Excocaria sp*. of mangroves The level of carbon stored in these species varied from 19.93 to 106.35 t /ha.

Table 21: Level of carbon stored in mangroves of Sunderbans

Mangroves Genera	Total No. of species	Av. of height (m)	Total % of plants	Total land area covered (ha)	Carbon stored (t/ha)	Total carbon stored (t)
Avicennia L.	4 species	10	40	92000	36.98	3402160
Sonneratia L.	4 species	10	5	11500	106.35	1223025
Excoecaria L.	2 species	10	10	23000	19.93	458390

Source: Mitra *et al*. (2011)

The economic value of carbon depends on law of supply & demand. And it is valued based on carbon credit. It is a generic term for any tradable certificate or permit representing the right to emit one tonne of carbon dioxide or the mass of another green

house gas with a carbon dioxide equivalent (tCO_2e) equivalent to one tonne of carbon dioxide. Carbon prices change depending on the location of the market, the type of market (e.g. Voluntary market) & supply and demand. The present study assumes the carbon credit price as 16 pound per ton as on April 2013 price. The price of carbon is likely to increase 30 pound per ton therefore both upper and lower value was calculated based on market prices. The per ha value of carbon was calculated Rs. 53772.57

Table 22 : Economic value of carbon based on different prices

Mangrove species	Total Land area covered (th ha)	Total carbon stored (lakh t)	Lower (existing) (Rs lakh)	Upper by 2030 (Rs lakh)
Avicennia L.	92	34.02	45523.62	85356.79
Sonneratia L.	11.5	12.23	16365.05	30684.47
Excoecaria L.	23	4.58	6133.62	11500.54
Total	126.5	50.84	68022.30	127541.81
Per ha			0.537	1.008

9.4.1.3 Option-use value

This study employs the contingent valuation (CV) method, which involves finding an individual's Willingness to Pay (WTP) for the goods by constructing a hypothetical market (2000). CV is a method of recovering information about preferences or willingness to pay from direct questions. The purpose of contingent valuation is to estimate individual's willingness to pay for changes in the quality or quantity of goods and services as well as effect of covariates on willingness to pay (*Haab*, 2002). Typically the survey asked how much money people would be willing to pay to maintain the existence of (or be compensated for the loss of) an environmental feature, such as biodiversity, ecosystem health etc. (Nijkamp *et. al.*, 2008). WTP indicates the strength of one's preference for environmental quality, and it is influenced typically by several factors, including an individual's income, gender, cultural preferences, education, or age (Nguyen and Vietnam, 2007).The estimation of value of natural system as consideration of option and existence value, which is usually defined in terms of the preservation of species, groups of species or ecosystems (Randall 1991, Bishop, 1978). Randall (1991) concluded that we should approach the potential loss of any species, habitats with the presumption that its expected value to humans is positive.

The description of the variables taken under study is given in Table 23. The willingness to pay (WTP) was the dependent variable and the explanatory variables includes those variable which directly or indirectly affect the willingness to pay of the stakeholders. The explanatory variables were divided into 3 types viz; quantitative variables, binary variable and categorical variable. The quantitative variables include age, household income, distance to the water body, and time spent on collection of resources. Since the residents of Sundarbans have direct interaction with the nature in their day-to-day life and were dependent on these resources for livelihood, therefore, it is important to note how much time they spent on various activities like firewood collection, prawn seed & crab collection, fishing, honey collection etc.

Table 23: Description of variables under study

Variables name	Description
Dependent Variables (Binary)	
WTP	Stated willingness to pay in Rs; 1 for positive response & non-response recorded to zero
Quantitative Variables	
AGE	Age of the respondent (in yrs)
HH INC	Household income in Rs per year
DIST	Time taken to reach water body (km)
TM SPENT	Time spend in collection of resources (in hours)
BID	Bid value. The value in Rs. the respondent's willingness to pay
Binary & Categorical Variables	
GDR	Gender , Binary variable: 1= female; 0= male
EDU	Education, Binary variable: 1= literate; 0= illiterate
MGR DEG	Respondent's perception regarding mangrove resource degradation: 1 for positive response; 0 otherwise
MODE	1 for response option 1 & 2; 0 otherwise
WPAY	Whom you want to pay 1 for response option 2 & 3 ; 0 otherwise
OCUP	Occupation Categorical variable: Agriculturist-1, Fisherman -2, Traders -3, others - 4

The variable bid value represents the amount in rupees the respondent's are willing to pay. The binary variables included gender, education, respondent's perception regarding resource degradation, mode of payment. One categorical variable namely occupation were also included as explanatory variable having 4 levels (See table 23) to see the response of stated WTP across various occupational strata. The dominant livelihood option for Sundarbans dwellers was agriculture followed by fisheries. Some traders who were having permanent shops in the survey area are also included in the list of respondents. The last composite group of workers were denoted by word "others" which includes diverse occupational strata, who were mainly daily labour, rickshaw puller, vendors, etc. Due to frequent crop failure and low income from fishing, most of the people have diverted towards other occupation.

The analysis was centred around the probability of person's willingness to pay (WTP) for the future. The proportion of cases where the respondents are willing to pay (WTP) was given value of 1 and those who do not want to pay were assigned o values. Step-wise logistic regression was used to determine which independent variable were predictor

of people's willingness pay for the subsistence of this estuarine region. Mathematically speaking logistic regression is based on probabilities, odds and the logarithms of the odds (SJSU, 2001). By applying the concept of odds to work out logistic regression of classification as willingness to pay is defined as:

$$\text{Odds}_{WTP} = \frac{P\ (WTP)}{1 - P\ (WTP)} \qquad \textit{(Equation. 1)}$$

Where

WTP = f (AGE, HH INC, DIST, TM SPENT, BID, GDR, EDU, MGR DEG, MODE, WPAY, OCUP)

In present analysis the probability of having one outcome or another based on non linear model resulting from the best linear combination of explanatory variables can be written as

$$\gamma_i = \frac{e^u}{1+e^u} \qquad \textit{(Equation. 2)}$$

Where γ_i is the estimated probability of the i^{th} case of the dependent variable and e is a constant equal to 2.718, raised to the power u, where u is the usual regression equation

$$u = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_kX_k \qquad \textit{(Equation. 3)}$$

The linear regression equation (u) is then the natural log of the probability of being in one group divided by the probability of being in the other group (Tabachnick and Fidell, *1996)*. The linear regression equation creates the logit or log of the odds:

$$In\left[\frac{\gamma}{1-\gamma}\right] = Bo + B1X1 + B2X2 + B3X3 + BkXk \qquad \textit{(Equation. 4)}$$

The Individual's willingness to pay was given given in Table 24. It depicts that around 64.71 percent of respondents agreed to pay for conservation and restoration of mangroves at different bid levels. And 35.29 percent of respondent's did not agree to pay at specified bid level. The maximum bid value which the respondents were willing to pay was Rs.10 (40.07 percent) followed by Rs. 20 (20.27 percent) & Rs.30 (18.86 percent). As the bid value is increasing the willingness to pay is decreasing. The respondents valued the conservation of the mangroves at the same time their low income and poor standard of living forbids them from paying more for the conservation and restoration of mangroves. It becomes impossible for them to pay higher amount for its restoration in spite of being knowing the importance of mangroves. In this study Mean and median were estimated as central tendency measured of WTP which is Rs. 25.90 and Rs. 20 respectively.

Table 24: Individual's willingness to pay for hypothetical market scenario

WTP Bid value (in Rs)	Accepted (WTP=1)	Rejected (WTP=0)	Total
10	119(40.07)	27(16.67)	146
20	81(27.27)	29(17.90)	110
30	56(18.86)	27(16.67)	83
50	16(5.39)	19(11.73)	35
70	6(2.02)	9(5.56)	15
100	5(1.68)	11(8.02)	16
120	6(2.02)	7(3.09)	12
150	4(1.35)	10(6.17)	15
200	2(0.67)	7(4.32)	9
250	1(0.34)	6(3.70)	7
300	1(0.34)	5(3.09)	6
500	0 (0.00)	5(3.09)	5
>500	0 (0.00)	0(0.00)	0
Total	297 (64.71)	162 (35.29)	459 (100.00)
Mean WTP-25.90±1.697			
Median WTP- 20			

Note: Figure in parenthesis indicate percentage to their respective total

Test of theoretical validity: The bid value curves for mangroves conservation

Following Cameron and Huppert (1989), maximum likelihood estimation using logistic regression approach was used. The model was fitted using the SAS software package in Enterprise guide 4.2 (2006-2008 by SAS Institute Inc., Cary, NC, USA.) The models clearly classify 92.4 percent among all cases at 0.5 percent of probability level.

Table 25: The variables influencing the WTP responses for conservation of mangroves

Dependent variable: WTP for conservation & restoration of mangroves	
Model: binary logit	$X^2 = 246.07$
Probability modelled ; WTP= '1'	$R^2 = 0.67$
Optimization Technique: Fisher's scoring	P=0.05
No. of observations : 459	D.F.= 13
Log. Likelihood of the model: 190.825	
Log. Likelihood (only intercept): 436.89	

Analysis of Maximum Likelihood Estimates					
Parameter	Estimate	Standard Error	Wald Chi-Square	p	Sig.[c]
Intercept	-1.6470	0.9273	3.1550	0.0757	*
AGE	-0.00025	0.0136	0.0003	0.9855	n.s.
HH INC	-0.00002	0.000027	0.6122	0.4339	n.s.
DIST	0.4632	0.3134	2.1846	0.1394	n.s.
TIME SPENT	0.1369	0.0892	2.3551	0.1249	n.s.
BID	-0.0443	0.0199	4.9910	0.0255	*
GENDER(0)	-0.3627	0.2581	1.9747	0.1600	n.s.
EDU	0.2490	0.2139	1.3551	0.2444	n.s.
MGR DEG	-0.7215	0.2113	11.6566	0.0006	***
MODE	-1.6953	0.3644	21.6397	<.0001	***
W PAY	-0.4500	0.3423	1.7288	0.1886	n.s.
OCUP (Agriculturist)	-0.6847	0.5702	1.4420	0.2298	n.s.
OCUP (Fisherman)	0.5839	0.3713	2.4733	0.1158	n.s.
OCUP (Traders)	-0.5695	0.6107	0.8696	0.3511	n.s.

[c] p< 0.01(***); p < .05(**); p < 0.1 (*); n.s : non- significant

A test of the full model against a constant only model was statistically significant indicating that the predictors as a set reliability distinguished between WTP & non-WTP (Chi-square 246.07; <.000 df-13). Also the R^2 value of 0.67 indicates a moderately strong relation of 67 percent between the predictors and prediction of WTP. The Wald criteria of maximum likelihood estimates that only 3 variables *viz* bid value, mode of payment & perception of mangrove degradation made significant contribution to the predictors. Other variables like age, education, income, distance, occupation status were not significant predictor of willingness to pay for restoration of mangroves. The odds ratio estimates (see table 26) value indicates that when there is increase in 1 person for negative response perception towards degradation, the probability of WTP will decrease by 76.4 percent. Likewise for payment to NGOs or autonomous body, will also decrease the WTP by 3.4 percent. For the predictor bid value the 1 rupee increase in tax will decrease the WTP by 4.5 percent. Also, the occupational strata do not significantly contribute in willingness to pay.

Table 26: The probability for WTP for restoration of mangroves

Odds Ratio Estimates		
Effect	Odds	Log-odds
AGE	1.0	0
HH INC	1.0	0
DIST	1.589	0.589
TIME SPENT	1.147	0.147
BID	1.045	-0.045
GENDER (0 vs 1)	0.484	-0.516
EDU (0 vs 1)	1.645	0.645
MGR DEG (0 vs 1)	0.236	-0.764
MODE (0 vs 1)	0.034	-0.966
W PAY (0 vs 1)	0.407	-0.593
OCCUP (Agriculturist vs others)	0.258	-0.742
OCCUP (Fisherman vs others)	0.917	-0.083
OCCUP (Traders vs others)	0.289	-0.711

The concept of economic value has its foundations in welfare economics. Therefore, valuation in an economic sense is always the result of an interaction between the subject and an object. Moreover, economist does not pursue total value assessment of an environment system but rather change (Nijkamp *et. al.*, 2008). The mangroves of Sundarban are of great importance. The residents were directly dependent on these mangroves as a last alternative for their livelihood. But its utility has been ignored by the inhabitants due to lack of awareness, lower household income & poor livelihood condition. The study may be an eye opener which shows that for conservation of natural resources the involvement of local people is necessary and they will pay more for it if more income generation options would be made available to them. Also, awareness regarding conservation of mangroves will also increase its value. This study would be useful to the policy makers and decision-making would become easier with more information concerning the economic values of different ecosystem services (both marketed and non-marketed) which in turn leads to optimal allocation of funding towards sustainable development.

10. Valuation: A tool for sustainable management of inland open water fisheries resources

A major reason for excessive depletion and conversion of inland fisheries resources is often the failure to account adequately for their non-market environmental values in development decisions. Economic valuation can be a powerful tool for sns tainable management of these resources. The open water resources are under immense threat and are being used for multiple purposes and have significant role in the livelihoods of the local people. Over the years, in many cases they are getting converted into single use systems due to economic and social pressure from dominant stakeholders. The MUS are often not fully appreciated. The valuation tool will be of immense help to delineate the various gods and services and the associated economic importance. It provides the objective evidence of monetary and non nonmonetary benefits of the natural ecosystems to managers and public to obtain their support for conservation.

Loss of environmental resources is also an economic problem in addition to the ecological problem because important values are lost, some perhaps irreversibly. Each choice or option for the environmental resource – to leave it in its natural state, allow it to degrade or convert it to another use – has implications in terms of values gained and lost. The decision as to what use to pursue for a given environmental resource, can only be made if these gains and losses are properly analysed and evaluated. This requires that all the values gained and lost under each resource use option are carefully considered. If the resource is converted then all the direct, indirect goods and services are sacrificed, and these foregone values are additional costs associated with the conversion option. Therefore, governments and donors should consider the *total costs* – the direct costs plus the foregone benefits when choosing to 'develop' the inland fisheries resources. The failure to account the total economic costs of conversion or degradation of environmental resources is a major factor behind the design of inappropriate development policies (Barbier *et al.*, 1997). The result is too much conversion and over-exploitation of environmental resources. This failure occurs both in private and public projetcs concerning the use of environmental resources – particularly wetland resources. Hence it is necessary to assess the total net economic benefits arising from different wetland uses. Thus, valuation is an important tool for environmental managers and decision makers to justify public spending on conservation activities and natural resources management.

11. Future plan of work

The importance of sustainable use of environmental goods and services has already been established. With passage of time it is bound to increase due to their diminishing nature and increasing anthropogenic pressures. The scope of environmental economics is immense and valuation exercise will become compulsion for planners and policy makers if they want judicious use of natural resources. Therefore, further emphasis needs to be given on economic valuation research in future in more intensive manner addressing more of the non-tangible environmental goods and services provided by the natural aquatic ecosystems.

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