



## Economic valuation of natural ecosystems - an empirical study in a stretch of Bramhaputra River in Assam, North-east India

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### ABSTRACT

Aquatic resources, like any other natural resources are complex, multi-functional, and provide many ecosystem services. However, their values are often underestimated as most of the services are obtained for free. Valuation can be a powerful tool to recognise the actual values of the precious natural resources which in turn can contribute towards shaping the policies governing their conservation and sustainable utilisation. The study attempted to value selected goods and services of 22 km stretch of Bramhaputra River in Assam. Primary and secondary data were collected from the different stakeholders during 2012. Out of the several goods and services identified in the selected stretch, six categories of goods and services *viz.*, fisheries, navigation, water for domestic use, irrigation, tourism and pilgrimage and sand mining were considered for the valuation exercises. For valuation of the goods and services, the market price method, revenue generation and travel cost method were considered, depending on the situation. It was estimated that the minimum value of these six goods and services were ₹47.8 crores per annum. Tourism, water for domestic use and sand mining were assessed to be the major components.

Keywords: Bramhaputra, Economic valuation, Ecosystem services, River

### Introduction

Human beings at large rely heavily on the environment and natural resources for their existence and livelihood. Natural resources *inter alia*, include agriculture, forests, mineral deposits, fisheries, wildlife and water resources. India possesses rich inland open water fisheries resources in the form of 14 major, 44 medium rivers and their innumerable tributaries, 1.2 million ha of floodplain wetlands, more than 3.0 million ha of reservoirs (including 8253 km of riverine length and 41600 ha of lakes and reservoirs in the cold water fisheries sector). These aquatic resources play an important role in maintaining the equilibrium of the ecosystem including groundwater recharge, nutrient cycling, sustaining livelihoods and nutritional security of a large population. Aquatic resources like any other natural resources are complex, multi-functional, and many of the ecosystem services affecting human welfare are not yet fully understood. The economic value of goods and services provided by inland water bodies are not very well documented. Only a handful of exercises have been done to value the ecosystem services provided by the inland open waters.

Neil and Bene (2008) estimated the value of inland fisheries production from tropical rivers as 5.46 million t valued at US \$ 5.58 billion which is equivalent to 19% of the value of annual fish exports from developing countries during 2004. Barbier (1993) studied direct use values of certain goods provided by tropical wetland ecosystem like agriculture, fuel wood, fishing and demonstrated significant benefit when compared to irrigation projects. Better conservation practices were developed by modeling economy-ecology linkages in mangroves by valuation of ecosystem goods and services under different linkage scenarios (Ruitenbeek, 1992). Though our life and livelihood would be jeopardised without these goods and services, we continue to receive most of them for free. Aquatic resources hold enormous importance and hence their value in economic terms is quite high.

There is little quantitative data and information about the economic value of environmental resources and how these affect national economies and people's livelihoods. This lack of information militates against the consideration of possible economic policy instruments to influence behaviour of households, communities, private sector

and Governments at large towards effective conservation of the environment, its biodiversity and natural resources that will make a difference to livelihoods and national economies.

In economic valuation, quantitative values are assigned to goods and services provided by the resources. This principle is applicable to aquatic resources/ecosystems too. Everybody recognise the value of 'money' and when we put economic value to a resource its importance is identified. Winpenny (1991) explained that valuation allows measurement of the rate at which environmental resources are being consumed. When environmental impacts can be quantified in monetary terms (*i.e.*, valued) they will carry more weight with decision makers, who can then set this data alongside other quantitative information and under these circumstances, better decisions will be made. Further, assigning a tangible and comparable value to a resource reduces the number of occasions where decisions have to be made based solely on the decision maker's judgement. The tool of valuation can provide the basis for appropriate management or policy development. 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. Valuation is a powerful planning tool which helps in shaping the policies governing conservation and sustainable utilisation of precious natural resources. In the absence of valuation,

environmental resources will continue to be exploited for other social or economic objectives that are mistakenly estimated to be more valuable to society.

Valuation studies conducted in India mostly concentrated on wetlands (Kumar *et al.*, 2001; Sarkar, 2002; Ramachandra *et al.*, 2005) and estuarine ecosystems (Badola and Hussain, 2003; Guha and Ghosh, 2009; Ekka and Pandit, 2012). Keeping this in view, the present study was undertaken with the focal objective of assessing the economic value of key goods and services of an important stretch of Brahmaputra River in Assam, India.

## Materials and methods

### Study area

A 22 km stretch of Brahmaputra River in Assam from Palasbari (26.13° N and 91.5° E) to Chandrapur (26.23° N and 91.92° E) located in Kamrup Metropolitan District was selected for the study. The geographic area of the district is 127.84 sq km which comprises only one sub-division *i.e.*, Guwahati Sadar sub-division. From developmental angle, the rural area of the district is divided into 4 development blocks *viz.*, Bezera, Chandrapur, Dimoria and Rani. Below the block level set up, there are 22 Gram Panchayats, each comprising a number of villages governed by local self bodies. The river stretch selected for the study is located in and around Guwahati, the capital of Assam.

Table 1. List of common ecosystem services from the selected river stretch

Ecosystem services	Specification
<b>Provisioning</b>	
Food	Production of fish and other aquatic animals/plants
Freshwater	Storage and retention of water for domestic, industrial and agricultural use
Fiber and fuel	Production of logs, fuel wood, peat, fodder
Genetic material	Medicine, genes for resistance to plant pathogens, ornamental species
Biodiversity	Species and gene pool
<b>Regulating</b>	
Climate regulation	Greenhouse gases, temperature, precipitation and other climatic processes; chemical composition of the atmosphere
Hydrological flows	Groundwater recharge and discharge; storage of water for agriculture and industry
Pollution control and detoxification	Retention, recovery and removal of excess nutrients and pollutants
Habitat	Nursery and breeding grounds for fish
Natural hazards	Flood control, storm protection
<b>Cultural</b>	
Spiritual and inspirational	Personal feelings and wellbeing
Recreational	Opportunities for recreational activities
Aesthetic	Appreciation of natural features
Educational	Opportunities for studying the natural ecosystems
<b>Supporting</b>	
Carbon sequestration	Sediment retention and accumulation of organic matter
Nutrient cycling	Storage, recycling, processing and acquisition of nutrients

Source: Millennium Ecosystem Assessment, 2005; Roggeri (1995) modified; Forslund, *et al.* (2009) and Wang *et al.* (2010) modified

### Analytical technique

Six categories of goods and services *viz.*, fisheries, navigation, water for domestic use, irrigation, tourism and pilgrimage, and sand mining, from the 22 km river stretch were selected for the study, out of several ecosystem services (Table 1). Primary and secondary data were collected from the different stakeholders during 2012. For valuation of the goods and services, the market price method, revenue generation or travel cost method was considered, depending on the situation.

Among the goods provided by river, fish (including shellfishes and other aquatic animals) are of paramount interest. Market price method was employed to estimate the value of fish. The average fish catch per day was estimated based on focussed group discussions with lessees (fisheries) of the river stretch, auctioneers and fishers of the three landing centres located in the study area. The values so obtained were collated with the annual fish catch estimated by the Guwahati Regional Centre of ICAR-Central Inland Fisheries Research Institute, Guwahati at Uzanbazar (major) landing centre during the period from 2008 to 2011 following systematic sampling design. Surface water used for irrigation was valued in indirect way. Value of the crops grown using the surface water was taken as the value of the irrigation water, since no crops would be grown in the absence of this. The revenue generated was used as a proxy for valuing the water transport. For valuation of sand mining sites in the given stretch, market value of sand was considered.

Travel cost method (TCM) was applied to value the eco-tourism services operating in the bank of the river stretch. For valuation of tourism potential, two temples, three parks and one river cruise service were visited and data were taken from 50 respondents. Relationship between number of visits and travel costs was regressed using individual data. The regression equation gives the demand function for the visitors to the site. The socio-economic variables like age, gender, education and income of the respondents were also entered into the model. The method establishes a relationship between the costs (price) incurred by travellers to a site and the number of trips taken. This relationship is further exploited to derive Marshallian Consumer Surplus for access to the site, for a recreation experience, by simply integrating the area under the demand recreation curve, between two levels of price (costs): the actual and the choke price (cost). A choke refers to a price at which demand drops and becomes nil (Fischer, 1999). The general theoretical basis derives from the basic economic notion of an individual utility function subject to budget and time constraints. The representative visitor or household preferences are represented by the utility function (Pendleton and Mendelsohn, 2000):

$$U = U(x, r, q)$$

where, 'x' is a vector of market goods and services quantities, including those related with recreational outdoor activities; 'r' is a vector of recreational service including recreation, 'q' is a vector denoting the quality characteristics of the ecosystem.

### Data sources

The required secondary and primary data were collected from the following sources:

- Directorate of Fisheries, Agriculture, Water Resources, Inland Water Transport and Irrigation, Govt. of Assam, Guwahati
- The Brahmaputra 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
- Lessees of ferry operations and fisheries.

## Results and discussion

### *Socio-economic importance of Brahmaputra River*

Brahmaputra basin, encompassing the North-eastern Region of India, is one among the water rich basins in the world. The river has got profound socio-economic, cultural and economic importance. It originates from Mount Kailash in Tibet and flows down to Arunachal and Assam before falling into Bay of Bengal in Bangladesh. There is a very ancient place of pilgrimage in Guwahati, the temple of goddess Kamakhya on Nilachal Hill. The Brahmaputra also possesses the world's largest river delta 'Majuli' which is the abode of the Assamese neo-Vaisnavite culture.

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 cubic m per year, in comparison to the national per capita availability of 2208 cubic m per year (Kaman, 2011). The basin is also dotted with dense forests and natural parks and sanctuaries and also provides a unique habitat for exquisite variety of flora and fauna, including many endangered species. Among these are the one-horned rhinoceros, pygmy hog, hispid hare, Asiatic elephant, clouded leopard, marble cat, golden cat, binturong, hoolock gibbon, white-winged wood Duck. The flood plains of the Brahmaputra is dotted with a large number

of wetlands or beels, which provide unique habitats for a variety of flora and fauna. The beels also functions as floodwater retention systems and traditional fisheries. Tens of thousands of fishermen get their livelihood from this river and associated wetlands.

#### *Stakeholders and institutional involvement*

In the stretch of Brahmaputra River comprising the study area, fishing rights are leased out to private parties. There were five lessees for fishing in the selected stretch of Brahmaputra. The lessees allow fishermen to catch fish and in return give 40% of the catch to the lessees. With a view to promote uninterrupted, hygienic, 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 21<sup>st</sup> December 2011, in accordance with the Guwahati Metropolitan Drinking Water and Sewerage Board Act (2009).

Local Panchayat bodies are also facilitating 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. Certain private companies also arrange river cruise on payment basis. The State Government Department of Tourism also operates cruise services. Water resources department is mainly concerned with maintaining the record of water flow and implementing flood control measures.

Recognising the magnitude and complexity of the problem of floods and its disastrous consequences in the North-eastern Region, a statutory body, the Brahmaputra Board 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 to prepare master plan for control of floods, erosion of river banks, improvement of drainage as well as on development and utilisation of water resources of the Brahmaputra Valley for irrigation, hydropower, navigation and other beneficial purposes.

Among the NGOs *Aranyak* and North-East Development Foundation (NEDF) are the prominent players. *Aranyak* works to foster conservation of biodiversity in North-east India through research, environmental education, capacity building and advocacy for legal and policy reform to usher a new era of ecological security. NEDF is a not-for-profit development-focused consulting and participating organisation 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 and D organisations which work for the development and sustainability of the river basin including fisheries, are ICAR-Central Inland Fisheries Research Institute (CIFRI), Indian Institute of Technology (IIT), Guwahati, Gauhati University and Assam Agricultural University. Other stakeholders who are directly associated with the river are Guwahati Municipality, sand miners, visitors of parks, temples and picnic spots situated on the river bank.

#### *Economic values of the goods and services*

A river ecosystem provides numerous ecosystem services, among which the most tangible ones, include food, timber, energy, recreation and materials for which economic markets exists, can be most easily valued. The tangible goods and services offered by the river stretch under the present study comprised fish and other aquatic animals, plants, irrigation water, wood, inputs for brick kilns industry, sand and other natural goods. However, for majority of the other ecosystem services there is no existing economic market (*e.g.*, the ground water recharge, nutrient recycling, filtering pollutants and aesthetic values) and are intangible. Intangible impacts are those effects, which accrue to the 'well-being' of households but do not have a market price or where the price of the good and service is below what most households would pay to secure its provision. Regulating services pose much greater challenges (Kumar and Wood, 2010) to value and their valuation has to be done in indirect way (*e.g.*, travel cost method, the hedonic price method, contingent valuation method) by assigning monetary values to these non-market goods and services.

There may be many ecosystem services which are yet unknown and are helpful in maintaining the ecosystem balance of the river system. However, since it is difficult to work with too many goods and services, the present study considered only 6 categories of goods and services. As has been already stated, in the 22 km stretch selected for the study, there were five lessees for fishing. Fishing is an important activity in the study area and 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 total fisheries value comes at ₹46.21 lakh per year. There are 11 ferry service points in the selected stretch which is given by the government to private agencies for the ferry services. During 2011-12, the government earned ₹21.35 lakhs and the total revenue generated by the private agencies was around ₹32 lakhs. In addition to this, government provides boats for short term hiring and it was estimated that around ₹ 24 lakhs was earned from this source.

As per the census 2011, the total number of households in Guwahati was 1.87 lakhs. Assuming that all are getting drinking water and water for other purpose from the municipality supply and water tariff at the rate of ₹75 per household, the total value comes at ₹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 the estimated value was ₹23.71 lakhs.

By applying travel cost method (TCM) for valuation of the tourism potential of the temples, parks and river cruise service selected for the study, the consumer surplus generated was estimated to be ₹4046 per trip. Subsequently the total tourism potential was worked out to be ₹28.32 crores based on an estimated 70000 trips made by tourists in one year. TCM is a well recognised method and has been applied by many researchers for valuation of eco-tourism (Font, 2000; Carr and Mendelsohn, 2003, Herath and Kennedy, 2004). It provides a mean to estimate the monetary values of non-marketed commodities based on actual behaviour, using the individual's expenses with marketed commodities that are weakly complementary with the non-marketed ones; an indirect way to reveal individual preferences (Freeman, 2003). Although the recreation demand for a site may be modelled as aggregate of market demand, the most common practice is to estimate the recreation demand of the representative individual and then to calculate aggregate value measures as the sum of the individual's recreation values (Freeman, 2003).

Sand mining is another important service operating in the selected stretch of Bramhaputra River under study. There are 8 sand mining sites in the selected stretch which are in operation for 7 months in a year. It was found that on an average, about 380 mini truck loads of sand are mined daily and the value of this sector was estimated at ₹1.38 crores. Total value of the goods and services (6 categories studied) from 22 km stretch of Bramhaputra River was estimated as ₹47.8 crores annually (Table 2; Fig.1).

Table 2. Valuation of goods and services provided by 22 km stretch of Bramhaputra River

Goods and services	₹ (lakhs)	% share
Fisheries	46.21	0.97
Navigation	56.03	1.17
Municipality water supply	1683.00	35.23
Surface irrigation	21.21	0.44
Tourism and pilgrimage	2832.20	59.29
Sand mining	138.32	2.90
Total	4776.97	100.00

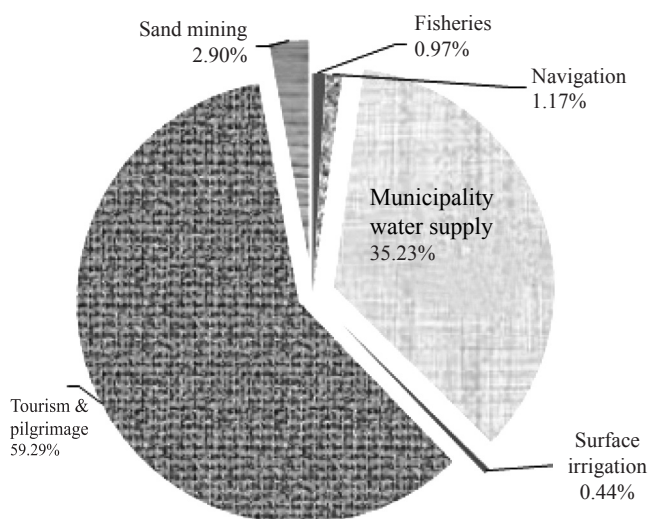


Fig. 1. Share of different components in total economic value

Among the goods and services studied in the selected river stretch, tourism and pilgrimage was the dominant component in terms of economic value followed by water for domestic use, sand mining, navigation, fisheries and surface irrigation. However, the relative values of these different goods and services of the river stretch may change in course of time. Besides, the river stretch (like any other natural ecosystem) provides numerous other goods and services *viz.*, flood attenuation, groundwater recharge, sediment retention, inputs to agriculture, water purification, nursery functions, micro-climate regulation and carbon sequestration, valuation of which are difficult but have profound impact on the ecosystem. Further, there is lack of suitable methodologies for valuation of all the ecosystem services. The estimated economic value can not be considered as the total economic value of 22 km stretch of Bramhaputra River. It is only the minimum value of six categories of goods and services of the river in the given stretch. From the ecosystem point of view, the river is invaluable and probably Guwahati City would not have been established in the absence of Bramhaputra River. Further, despite considerable progress over the past >20 years, the monetary valuation of natural resources (or environmental commodities) is still in its infancy. Hence, although monetary estimates of natural resource values are given, these should be regarded as approximations, at best the minimum value of the resource. Nevertheless, valuation will be helpful in understanding importance of the ecosystem goods and services which may help in shaping policies for conservation of natural resources.

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