CHAPTER

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Economic valuation of ecosystem goods and services with special reference to estuarine wetlands

DR. K VINOD
ICAR-Central Marine Fisheries Research Institute

Economic valuation of biodiversity is performed for three important reasons *viz*., (i) to facilitate cost-benefit analysis, (ii) to integrate with the system of national accounts i.e. 'green accounting' and (iii) for proper pricing of biological resources. Cost-benefit analysis of investments and policies, that incorporate environmental costs and benefits, are essential to enable planners and policy makers to choose the investment that would bring in maximum net benefits to the society. Environmental accounting adjusts the standard gross domestic product (GDP) measure to take into account any depreciation in the environmental base of the economy. In the absence of markets for the biodiversity or the services, valuation of loss in biological diversity is necessary to maintain a balance between conservation and economic development.

The biological diversity, irrespective of the type of ecosystems, are largely in danger due to constant pressures exerted on them for economic development. Therefore, economic valuation helps to place a value on changes in biodiversity and paves way to introduce incentives for conservation. Valuation does not entail measuring the economic value of biodiversity as such (Pearce and Moran, 1994). Instead, valuation focusses on the economic values of goods and services generated by biodiversity and functions. Economic valuation recognizes that individuals may assign value for different reasons and not only for the immediate benefits of commercial exploitation of resources. Economics generally assign value on the basis of direct or indirect trade-offs, that is, actions that show people revealing their willingness to pay for goods and services by exchanging them on markets. Environmental economics has extended demand theory to goods and services that are not traded in markets, including most ecosystem services. Considerable efforts have been made by economists to develop methods that can also elicit hidden value of non-marketed natural resources.

Kahn et al. defines ecological services as "functions that ecosystems perform, that provide the basis for all ecological and economic activity, and include services like carbon sequestration, nitrogen fixation, hydrological cycles, nutrient cycles, biodiversity, production of oxygen, maintenance of global climate, soil formation and primary productivity". The economic valuation of non-use benefits is difficult, but crucial since these contribute substantially to the total value of biological diversity. Valuation usually attempts to measure the value of ecosystem services in monetary terms in order to provide a common metric in which to express the benefits of the variety of services provided by ecosystems.

Importance of valuing coasts and estuaries

The ocean is abound with wealth of resources which man has been exploiting since ages for food, medicines and products of industrial applications. The marine and coastal ecosystems including the estuarine wetlands are priceless assets that contribute significantly to human survival, well-being and quality of life. However, humans generally underestimate the importance and value of these ecosystems and often ignore the anthropogenic impacts on these sensitive ecosystems. Our

coasts and estuaries are seen as bottomless pits for dumping of municipal and industrial wastes and as a result, many of our coastal and estuarine wetlands have become highly polluted and uncongenial for the survival of biota. This also affects the livelihood of coastal people who are dependent solely on these ecosystems.

Estuaries since long have been focal points for human activity as these formed important areas for the harvest of food and fibre. Due to varied uses and anthropogenic interferences, most of the estuaries are under serious threat. The increasing population and the commercial developments are exerting tremendous pressure on the estuaries which calls for creating a balance between conservation and development.

Coasts and estuaries have both direct and indirect effects on our physical, emotional and personal well-being. Therefore, protection and restoration of these coastal areas will affect the personal and economic well-being of people. Economic well-being means different things to different people. For some, it may be having a good income, while for some it may mean happiness that sometimes comes at a financial cost, while for public officials, economic well-being may be economic activities or development programmes that benefit a society. Therefore, the quality of coastal and estuarine areas and access to these areas influence all of these measures of economic well-being.

Total Economic Value (TEV)

Value is a part of everyday life and ranges from spiritual value to religious and moral values. For economists, the definition of value is much narrower. Economic value is the quantification of the resource use for improvement of the economic well-being of a person or society. The framework commonly used for describing different types of economic value with regard to natural resources is the 'Total Economic Value' (TEV). This framework encompasses use values and non-use values. The use values are again categorised into direct use values and indirect use values.

Direct use value: Direct use value is the value we place on goods and services that we use directly, e.g. timber, firewood, fisheries, recreation etc. They involve commercial, subsistence, leisure or other activities associated with a resource.

Indirect use value: The coasts and estuaries also provides many goods and services that we do not use directly; but they become instrumental or support the production of goods that we use. For example, the estuarine wetlands provide a good nursery ground for many commercially important fishes and shellfishes that are consumed. Also, seaweeds, seagrass and mangrove vegetation draws carbon from the atmosphere and sequester in their biomass and marsh soils, reducing the effect of greenhouse gases. While these functions have long been recognized, precise field experimentation has often been lacking to show more precisely the relationships between ecosystem functions and the services they generate.

Non-use values: Many people value the coastal areas and estuarine wetlands even if they are living far away from the coasts or even if they never plan to visit or use the goods and services provided to these ecosystems. They may value in such a way they may be willing to pay in order to protect the coast and its inhabitants. This non-use value is called the '**existence value**' because these people value the ecosystem goods and services because they just know that these goods and services exist (birds, otters, mangroves, whales, dolphins etc.). The existence value are derived

neither from the current direct or indirect use of the environment. Some people may also be willing to pay so that they have an opportunity in future to enjoy the coast and its services; such a value is called an '**option value**'. While some people may be willing to pay to protect and preserve the coasts and estuaries for future generations which is called the '**bequest value**'. Of all the categories, existence or passive value is most complex in terms of quantification and its role in decision-making. Yet, it is a type of economic value that is important in defining both national and global biodiversity management priorities.

The term 'value' is the amount society benefits from something beyond what it costs the society to make it or protect it. Thus the difference between the maximum that people would be willing to pay for something and the cost of providing the same is what the economists call 'value'. Many coastal activities are available at little or no cost, especially to the local coastal communities/users, while the non-residents/tourists have to pay to travel and enjoy the coastal area benefits. Thus the local users usually enjoy the greatest economic benefit from the provisional coastal goods and services. In coastal areas, generally attention is paid to the services that produce marketable goods; while services like bird watching or leisure visits is not quantified from an economic perspective.

Ecosystem goods and services provided by estuaries

Estuaries are highly dynamic ecosystems as they are the areas of confluence of sea and the river. These ecosystems are well known for their complex hydrodynamic and nutrient fluxes that result from the intermixing of saline and freshwater. This intermixing creates salinity gradients which allows the survival of wide range of flora and fauna. The medium to low saline conditions in estuaries support the growth of specialized plants called mangroves which have specialized characteristic features for salt-tolerance. Some of the common mangrove species found along the Indian coast include *Avicennia marina, Avicennia officinalis, Sonneratia alba, Rhizophora mucronata, Bruguiera cylindrica, Bruguiera sexangula, Excoecaria agallocha, Aegiceras corniculatum* and *Acanthus ilicifolius*. In addition to these, there are also many mangrove associates. The mangrove habitat is highly productive and provides a good nursery ground for numerous fauna. Estuaries are also home to many fauna including finfishes, shrimps and oysters, and their prey organisms.

Ecosystem goods and services as categorised by the Millennium Ecosystem Assessment

Provisioning	**Regulating**	**Cultural**
Goods produced or provided by ecosystems	*Benefits obtained from regulation of ecosystem processes*	*Non-material benefits from ecosystems*
• Freshwater • Food • Firewood • Genetic resources	• Flood regulation • Climate regulation • Disease regulation	• Educational • Recreational • Aesthetic • Spiritual • Inspirational
Supporting		
Services necessary for production of other ecosystem services		
• Nutrient cycling	• Primary production	• Soil formation

The physical transport of sediments and nutrients results in unique geophysical features such as wetlands, lagoons, mud flats and sand bars which offers habitat for wide range of organisms. The mud flats which are rich in polychaetes and other benthic organisms are preferred habitats for many avian fauna.

The estuaries which are characterised by diverse geophysical features and the presence of wide range of flora and fauna provides a mixture of goods and services useful to mankind. An ecosystem service, by definition, supports 'the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life' (Daily, 1997). Ecosystem goods and services occur at different scales, from local and regional levels to global levels. While control of soil erosion, flood control, nutrient cycling, waste regulation and pollination occur at local and regional scales, carbon sequestration and climate regulation occur at the global scale (DeGroot *et al*., 2002; Heal *et al*., 2005).

The ecosystem goods are the products that are available from natural systems for human use (DeGroot *et al*., 2002). The three important ecosystem services are provisioning, regulating and cultural services. However, the Millennium Ecosystem Assessment classification introduced one more type of service called the 'supporting services' which comprises of primary production, nutrient cycling and soil formation which are all necessary for the other ecosystem services *viz*., provisioning, regulating and cultural services.

Provisioning services

The estuaries provide a number of natural resources and raw materials which we essentially require and value. It includes mainly food like the edible plants, fishes, shrimps, oysters etc. as well as arable land for cultivation and grazing land for domestic animals. Worldwide estuaries are also known to provide raw materials such as lumber, fuel wood and organic matter for building as well as supplying fuel and energy (Semesi, 1998; Barbier, 2000). The estuaries also provide medicinal plants and extracts which can be used for pest and disease control. Provisioning services of estuaries also include supply of potable water and they are also medium of transportation of materials.

Provisioning services provided by estuaries

Services	Sources/Avenues
Food	Fishing, crops, grazing, aquaculture
Water	Potable water, provision for irrigation and industrial use, as medium for transportation of materials
Medicinal plants	Estuarine flora as sources of medicines and pest-control chemicals
Genetic resources	Variety of gene pools in fishes
Ornamental resources	Dried grasses, shells used as curios
Raw materials	Plant fibres, oils and dyes for building and fodder and fertilizer

Regulating services

Regulating services include regulation of climate, gas regulation, and protection from natural calamities, control of pollution and control of soil erosion. The biochemical processes in estuaries

also helps in the detoxification of anthropogenic wastes generated by coastal urbanisation. The vegetation, particularly the mangroves help in control of floods as well as aid in preventing soil erosion. Estuaries can also regulate the local climatic conditions which may moderate climate gradients for people living near the coast (Johnston *et al*., 2002).

Regulating services provided by estuaries

Services	Sources/Avenues
Climate regulation	Regulation of hydrological cycle, regulation of local and global energy balance
Gas regulation	Regulation of chemical composition of atmosphere and oceans
Protection from natural calamities	Control of floods, protection from cyclonic storms
Control of erosion	Prevention of soil loss
Control of pollution	Detoxification, water purification, carbon sequestration

Cultural services

Cultural services rendered by estuaries include recreation which is measurable by the number of people using estuaries for a variety of recreational purposes (Farber, 1988). The economic valuation of such services reflect economic concepts such as willingness to pay for the recreation or willingness to accept compensation for its loss. The aesthetic value can be better understood by people's preference for proximity to the estuary. It is easier to directly measure the aesthetic value through housing market price premiums for location (Smith *et al*., 1991). The estuaries are excellent place for education and research. The estuarine wetland is a learning arena for people of all age groups on diverse areas including the dynamics in physical processes, dynamics in biological processes, biological diversity etc.

Cultural services provided by estuaries

Services	Sources/Avenues
Recreation	Eco-tourism, bird watching, leisure beach visits, game fishing etc.
Education	Ideal platform/centre for learning the physical and biological processes including soil erosion, formation of sand bars, mud flats; biological diversity including mangroves, fishes, mammals and avifauna.
Aesthetic	Wetlands add value to the houses constructed alongside.
Historic	Use of estuaries as motifs in paintings, books, folklore etc; natural features with religious or historic values

Supporting services

Although supporting services do not provide direct services themselves, it is necessary for the production of other three services namely provisioning, regulating and cultural services. The supporting services include habitat which serves as a breeding and nursery ground for large number of species of finfishes, shell fishes and other invertebrates. It helps to enhance the net primary productivity and helps in the recharge of aquifers. Supporting services also encompass soil formation including accumulation of organic matter, formation of sand bars and mud flats. Supporting services also ensures species interactions, pollination and biological control of pests and diseases.

Supporting services provided by estuaries

Services	Sources/Avenues
Habitat	Spawning and nursery ground for many species of finfishes, shell fishes and other invertebrates; refuge for both resident and migratory species.
Hydrological cycle	Helps in the recharge of aquifers,
Nutrient cycling	Enhanced net primary productivity
Soil formation	Capture of sediments, substrate formation, accumulation of organic matter, formation of sand bars, mud flats etc.
Biological regulation	Species interactions, biological control of insect pests and diseases, pollination in plants.

An understanding of the links between ecosystem services and functions is important in the management of estuarine ecosystems and the delivery of ecosystem services. The ultimate goal would be to sustain the flow of services in a fair and sustainable manner, taking into consideration the complex interactions within the ecosystems, between the humans and their supporting ecosystems (Farber *et al*., 2006). Any change in ecosystems may lead to changes in mix of services through changes in ecosystem processes (Palmer *et al.*, 2004). For example, the level of some services may decrease while the level of other services may increase. If dredging is done to increase the width of water way for transportation, it may on the other hand reduce the aesthetic beauty of the ecosystem. Similarly, increasing the mangrove plantations for combating the natural calamities and soil erosion may reduce the fisheries habitats. Therefore any development plans in estuaries essentially involves trade-offs between competing ecosystem services over time. It is necessary to characterize and measure the changes in service flows when we contemplate a development or a restoration project.

Some of the methods used for valuation

The Contingent Valuation Method (CVM)

Valuation of biodiversity and ecosystem services is riddled with many challenges, mainly due to the non-market nature of many of the goods and services. Under these circumstances, CVM stands out as one of the most appropriate methods and is used widely across the globe. The National Oceanic and Atmospheric Administration (NOAA) panel of the United States after evaluation says that "CVM studies or the application of CVM method can produce estimates reliable enough to be the starting point of a judicial process of damage assessment, including lost passive values" (Arrow *et al*., 1993). Pearce and Moran (1994) believe that CVM is the only means available for valuation of non-use values and the estimates obtained from CVM surveys are as good as estimates from other methods. Stevens *et al*. (1991) mentioned that CVM is the only technique capable of measuring existence values which Spash *et al*. (2000) opined that CVM has the ability to estimate option, existence and bequest values in addition to direct use values.

The different stages involved in CVM studies include designing and pre-testing the survey, conducting the main survey, estimating the Willingness to Pay (WTP) and/or Willingness to Accept (WTA), bid curve analysis, data aggregation and final assessment (Spash *et al*., 2000).

Contingent valuation is an example of stated preference technique. It is carried out by asking the consumers about their willingness to pay in order to obtain an environmental service. It is done by asking the respondents whether they would be willing to pay a specific amount (dichotomous or polychotomous choice) or telling them to choose from a number of options (choice modelling). Contingent valuation method can be used to value any environmental benefit by phrasing the question appropriately to the respondents. However, the limitation is that the respondents cannot make informed choices, if their understanding on the issue is limited.

Choice modelling

Attribute based methods called conjoint analysis or choice experiments (CE) or choice modelling (CM) have emerged due to their ability to analyse preference heterogeneity of consumers in environmental valuation. Choice modelling is a newer approach for obtaining stated preferences. It consists of asking respondents to choose their preferred option from a set of alternatives, where the alternatives are defined by attributes. This method minimizes some of the technical problems associated with contingent valuation, such as strategic behaviour of respondents. The disadvantage is that the responses are hypothetical and would suffer from hypothetical bias and the choices can be complex if there are many attributes.

Hedonic analysis

Hedonic pricing depends on the kind of environmental attributes which it has. For example, a house in a clean environment should command a higher price for a similar house available in a polluted environment. Thus hedonic price analysis compares the price of similar goods to attain the implicit value that buyers attach for the environmental attributes. This method requires a large sample size and therefore has limited application. Moreover, hedonic price analysis works well only when there exists a transparent market, not distorted by market failures.

Travel cost method

The travel cost method is used to understand the value from observed behaviour in a surrogate market. It generally uses information on the total expenditure incurred by the tourists or visitors to visit the place in order to obtain their demand curve for the site's services. The total benefit that the visitors obtain can be calculated from the demand curve. The travel cost method is used extensively to value the benefits of sites of recreation or tourism importance.

Benefits transfer

Benefit transfer is actually not a methodology. It refers to the use of estimates obtained in one context to estimate the values in a different context. For example, an estimate obtained by tourists viewing avifauna in one sanctuary might be used to estimate the benefit obtained from viewing birds in a different sanctuary, by using adjusted data in conjunction with some data collected from the site of interest. Benefit transfer method has been the subject of controversy as it has been often used inappropriately. As the condition of the two sites are unlikely to be identical, it is likely to have some errors.

The above techniques are widely used in economic valuation. When applied carefully, following the best practice, valuation tools provide reliable information on the changes in value of non-

marketed ecosystem services that would result from anthropogenic activities or from certain management interventions. Most of the valuation tools require enormous data and if data requirements are satisfied, more reliable values can be expected. Nevertheless, the choice of valuation technique will depend on the characteristics of the case, including its scope and data availability.

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