

Naren Pasupalati, Megha Nath, Abhijit Sharan,  
Priya Narayanan, Ramachandra Bhatta,  
Ramesh Ramachandran, and Purvaja Ramachandran

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## Abstract

The degradation of wetland resources including waterbodies, marshy coastal cropland, mangroves and salt marshes due to a variety of human activities within and outside the wetlands is a major environmental concern in India. Despite their importance, these ecosystems are under severe threat of degradation due to both natural and anthropogenic factors primarily due to the lack of awareness of the link between human support systems and natural ecosystems. Unless our natural capital is systematically accounted for, coupled with the knowledge of its total economic value, the probability of unsustainable exploitation leading to loss of human well-being would be significantly high. This necessitates a thorough understanding on the tools and techniques used in economic valuation and the ecosystem goods and services of a wetland ecosystem. The present chapter provides comprehensive information on the typology of various tools used in economic valuation of wetland resources. A synthesis of available information from published literature is also included, which provides a snapshot of monetary values of this natural resource.

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## Keywords

Benefit transfer • Economic valuation • Ecosystem management • Ecosystem services • Total economic value

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N. Pasupalati • M. Nath • A. Sharan • P. Narayanan (✉) • R. Bhatta • R. Ramachandran  
P. Ramachandran

National Centre for Sustainable Coastal Management (NCSCM), Ministry of Environment  
Forest & Climate Change, Anna University Campus, Chennai 600 025, Tamil Nadu, India  
e-mail: [narenp14@gmail.com](mailto:narenp14@gmail.com); [meghanath23@gmail.com](mailto:meghanath23@gmail.com); [sharan.abhijit@gmail.com](mailto:sharan.abhijit@gmail.com);  
[priyarika@gmail.com](mailto:priyarika@gmail.com); [rcbhat@gmail.com](mailto:rcbhat@gmail.com); [rramesh\\_au@yahoo.com](mailto:rramesh_au@yahoo.com) [purvaja.ramachandran@gmail.com](mailto:purvaja.ramachandran@gmail.com)

## 14.1 Introduction

Coastal wetland is one of the most biologically productive ecosystems in the world (UNEP 2006). The degradation of wetland resources such as waterbodies, marshy coastal cropland, mangroves and salt marshes due to a variety of anthropogenic activities within and outside the wetlands is a major environmental concern in India (Prasad et al. 2002). The change of landscape ecology due to change in land use pattern is inevitable (Hu et al. 2014). Industrial and urban pollution, conversion of wetlands for urban expansion and development of coastal aquaculture are some of the major causes of degradation. The fact that the wetlands have multiple uses leads to competition among users where each user tries to dominate the use of this scarce resource depending on their political power. A strict ecological and economic interest will guide the policymakers as well as social planners in the decision-making process. The value attached to each of these ecological systems depends on a multitude of factors including the institutions and culture from where communities/societies evolve (Mitsch and Gosselink 2000). Despite their importance, these ecosystems are under severe threat of degradation due to both natural and anthropogenic factors primarily due to the lack of awareness of the link between human support systems and natural ecosystems (Newcome et al. 2005; Venkataraman 2007). Unless our natural capital is systematically accounted for with the knowledge of its total economic value (TEV), which we shall get into greater detail later in the chapter, the probability of unsustainable exploitation leading to loss of human well-being would be significantly high (Cosier 2011; Provins 2013). The major threats to coastal wetland ecosystems are the use of water for irrigation, domestic and industrial needs, fisheries and recreational uses. The other major threat is global climate change and its interrelated sea level rise (SLR) (WWF 2010).

India has a land mass of 328.7 million ha, a land frontier of 15,200 km and exclusive economic zone of 202 million ha. Peninsular India and the island territories comprise six states and four union territories. Coastal population in India is around 300 million (out of 1.20 billion) as per 2011–2012 Census and is growing at the rate of 2.0% that is higher than the average annual population growth rate of 1.5% during 2001–2011. The 73 coastal districts (out of 593) have a share of 20% of the national population, and nearly 300 million people live within 50 km of the coastline. In India, wetlands account for 4.7% of the geographical space and support one-fifth of the biodiversity (Bassi et al. 2014). These wetlands are under unsustainable human pressure. Even though wetlands have been better understood now, owing to advancements in science and technology, the monetary value of wetlands and their functions is still not incorporated in policymaking, planning, construction and expansion of development projects (SAC 2011). The National Environmental Policy (NEP) of 2006 recognized the importance of wetlands in providing numerous ecological services and also pointed towards the absence of any formal system of regulation in India apart from the international commitments made with respect to the Ramsar sites (MoEF 2006).

Across India, coastal states are increasingly dependent on coastal ecosystems such as estuaries, mangroves, beaches, wetlands, mudflats and open spaces. These ecosystems provide critical services to the growing urban areas and industrial settlements and many heavy industries such as oil refineries, coal-fired power plants, atomic power plants, ports and harbours, pipelines, chemicals and fertilizers. However, mainly the coastal resources are used as a source of inputs as well as a sink for pollutants. The need to value these resources will help develop a pragmatic approach to maximize the socioecological benefits and to maintain these resources for both extractive and preservation uses. Understanding the economic value of coastal resources, particularly wetlands, can ensure a fair trade-off between development and conservation needs. The absence of valuing both tangible and nontangible benefits derived from such ecosystems will put local communities, which depend on them for livelihoods, at risk.

The Coastal Regulation Zone (CRZ) Notification 2011 (Ministry of Environment and Forests, Government of India) has identified certain ecosystems that are ecologically sensitive and whose geomorphological features play an important role in maintaining habitat stability. These areas are designated as *protected areas*, and if the services provided by these ecosystems are not measured or valued, they cannot be managed efficiently. A policy tool known as the ‘payment for ecosystem services’ (PES) creates a market using valuation of ecosystem services and aims at rightfully transferring property rights and incentivizing conservation and protection programmes among coastal communities (Le Quesne and McNally 2005). To get an understanding of how to value coastal wetland ecosystem, it is necessary to understand the ecosystem in general and then the different services it provides.

### 14.1.1 Definition of Ecosystem Services

A natural ecosystem is a biological environment that is found in nature (e.g. a forest) rather than created or altered by humans (a farm). Ecosystems can be terrestrial (coastal, forest, desert, grassland, mountain, etc.) and aquatic (freshwater, marine, etc.). They can also vary in scale – global, regional and local (Defra 2011). Naturally, ecosystems have no strict geographical boundaries, and in many cases, ecosystems overlap and interact with one another.

Ecosystem services are the beneficial outcomes that result from ecosystem functions. They form beneficial outcomes to either the environment or the dependent communities. Some examples of ecosystem services are support of the food chain, harvesting of animals or plants and the provision of clean water or scenic views (Costanza et al. 1997). The Millennium Ecosystem Assessment (MEA) was set up during 2003, to assess the consequences of ecosystem change for human well-being and the scientific basis for action needed to enhance the conservation and sustainable use of those systems and their contribution to human well-being. The MEA (2005) identifies four main categories of ecosystem services: (1) provisioning services, (2) regulating services, (3) cultural services and (4) supporting services.

#### 14.1.1.1 Provisioning Services

These include all physical material and energy outputs from ecosystems; they are tangible things that can be exchanged or traded, as well as consumed or used directly by people (MEA 2005). For example, the coral reefs in the Gulf of Kachchh (GoK), Gujarat, constitute important breeding as well as nursery grounds for large varieties of fish, prawns and molluscs especially pearl oyster and windowpane oyster. This is an example of a productive economic sector that is purely dependent on the health of the coral ecosystem (Dixit et al. 2010).

#### 14.1.1.2 Regulating Services

These are defined as the benefits obtained from the regulation of ecosystem processes such as climate regulation, natural hazard regulation, water purification and waste management, pollination or pest control (MEA 2005). For example, according to a recent study (DebRoy and Jayaraman 2012), the Pichavaram mangroves in India were found to be the most useful in providing regulatory services such as protection against tsunamis, floods and heavy winds. Marine algal samples found along the coast of Visakhapatnam have been found to be effective sequesters of carbon thereby curbing global warming (Kaladharan et al. 2009).

#### 14.1.1.3 Cultural Services

These are the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experiences (MEA 2005). Cultural services are tightly bound to human values and behaviour, as well as to patterns of social, economic and political organizations. For example, the state of Kerala is one of the most popular tourism destinations in India, and some of the most prominent tourism assets in its possession are the beaches, backwaters and lagoons, which generate a substantial volume of Kerala's tourism revenue. The total revenue earned by Kerala's tourism sector was over INR 220 billion in 2013 alone ([www.keralatourism.org](http://www.keralatourism.org) 2013).

#### 14.1.1.4 Supporting Services

They are services necessary for the delivery of all other ecosystem services. They differ from provisioning, regulating and cultural services in that their impacts on people are either indirect or occur over a very long period of time (MEA 2005). For example, the Gulf of Mannar Marine Biosphere Reserve hosts one of the highest concentrations of seagrass in India. Of the 11 species of seagrass recorded in the area, three are endemic species. The seagrass meadows in the reserve support complex ecological communities and serve as one of the largest feeding grounds for several species of marine turtles, fish, seahorse, mollusc, crustacean and the widely endangered *Dugong dugon* in India ([www.seagrasswatch.org](http://www.seagrasswatch.org) 2013).

### 14.1.2 Typology of Coastal Wetland Ecosystem Services

The various coastal wetland ecosystem services, classified under provisioning, regulating, supporting and cultural services, are explained in Table 14.1.

**Table 14.1** Typology of coastal wetland ecosystem services<sup>a</sup>

Services	Description	Examples
<i>Provisioning services</i>		
Food	All available fauna and flora extracted from coastal/marine environments for the purpose of direct human consumption as food	Fish, shellfish, rice, salt, minerals, honey
(Fresh)water	Marine water that is extracted for use in human industry and as supply of potable water	Transportation, industrial cooling, desalinization, irrigation
Raw materials	The extraction of any material from coastal/marine environments	Algae (non-food), sand, seaweed
Medicinal resources	Any material that is extracted from the coastal/marine environment that contains medicinal benefits	Marine-derived pharmaceuticals
Ornamental resources	Any material extracted for use in decoration, handicrafts and souvenirs	Shells, aquarium fish, pearls, coral
<i>Regulating services</i>		
Air purification	Ecosystems both contribute chemicals to and extract chemicals from the atmosphere, influencing air quality	Removal from the air of pollutants like fine particular matter, sulphur dioxide, carbon dioxide, etc.
Climate regulation	Coastal ecosystems influence climate both locally and globally. For example, at a local scale, changes in land cover can affect both temperature and precipitation. At the global scale, ecosystems play an important role in climate by either sequestering or emitting greenhouse gases	Production, consumption and use by marine organisms of gases such as carbon dioxide, water vapour, nitrous oxides, methane and dimethyl sulphide
Disturbance prevention	The contribution of marine ecosystem structures to the dampening of the intensity of environmental hazards such as storm floods, tsunamis and hurricanes as well as coastal erosion	Reduction in the intensity of and/or damage caused by environmental disturbances resulting directly from marine ecosystem structures like salt marshes, seagrass beds and mangroves
Water regulation	The timing and magnitude of run-off, flooding and aquifer recharge can be strongly influenced by changes in land cover, including, in particular, alterations that change the water storage potential of the system	The effect of macroalgae on localized current intensity; maintenance of deep channels by coastal currents for shipping
Waste treatment	The removal by coastal/marine ecosystems of pollutants added to coastal/marine environments by humans through processes such as storage, burial and biochemical recycling	Breaking down of chemical pollutants by marine microorganisms; filtering of coastal water by shellfish

(continued)

**Table 14.1** (continued)

Services	Description	Examples
Nutrient cycling	Nutrients – essential for life – cycle through ecosystems and are maintained at different concentrations in different parts of ecosystems	Nitrogen and phosphorus – fish mineralize nitrogen and phosphorous through excretion <sup>b</sup>
<i>Biological control</i>	The contribution of marine/coastal ecosystems to the maintenance of natural healthy population dynamics to support ecosystem resilience through maintaining food web structure and flows	Support of reef ecosystems by herbivorous fish that keep algal populations in check; the role that top predators play in limiting the population sizes of opportunistic species like jellyfish and squid
<i>Supporting services</i>		
Life cycle maintenance	The contribution of a particular habitat to migratory species' populations through the provision of essential habitat for reproduction and juvenile maturation	Reproduction habitat for commercially valuable species that are harvested elsewhere
Pollination and seed dispersal	Movement of plant genes	Seed dispersal by aquatic animals and insects
Gene pool protection	The contribution of marine habitats to the maintenance of viable gene pools through natural selection/evolutionary processes	Inter- and intraspecific genetic diversity that is supported by marine ecosystems which enhances adaptability of species to environmental changes
Habitat	The physical place where organisms reside	Refugia for resident and migratory species; spawning and nursery grounds
Hydrological cycle	Movement and storage of water through the biosphere	Evapotranspiration; stream run-off; groundwater retention
<i>Cultural services</i>		
Recreation and leisure	Provision of opportunities for recreation and leisure that depend on the health of marine/coastal ecosystems	Bird/whale watching, sailing, recreational fishing, scuba diving, etc. directly depend on the state of the ecosystems
Aesthetic value	Contribution that a coastal/marine ecosystem makes to the existence of an 'attractive' surface or subsurface landscape that generates a noticeable response within the individual observer	Examples are 'seascape', like open 'blue' water, a 'reef-scape' with abundant and colourful marine life, a 'beachscape' with white sand, etc.
Cultural heritage and identity	Contribution that a coastal/marine ecosystem makes to cultural traditions and folklore. This covers the appreciation of a coastal community for local coastal/marine environments and ecosystems as well as the global importance that may be associated with a particular marine landscape	Mahabalipuram is a designated UNESCO World Heritage site

Adopted from Böhnke-Henrichs et al. (2013) and Harte Research Institute for Gulf of Mexico Studies, Texas A&M University

<sup>a</sup><http://www.greenfacts.org/en/ecosystems/toolboxes/box2-1-services.htm>

<sup>b</sup>[http://www.marbef.org/wiki/Nutrient\\_cycling](http://www.marbef.org/wiki/Nutrient_cycling)

## 14.2 Analytical Framework for Economic Valuation

Although conventional economic appraisals such as cost-benefit analysis (CBA) and cost-effective analysis (CEA) are effective ways to gauge the trade-offs of any policy or project, they are often the cause of much debate when it comes to incorporating the implicit benefits delivered by natural ecosystems or negative externalities caused by the policy or the project (Defra 2011; Wegner and Pascual 2011). For example, a conventional CBA may not capture and quantify the benefits of improved biodiversity status of a particular area of forest cover that has been granted reserved forest status or a loss in recreational services offered by a beachfront because of port development. Therefore, incorrect determination of the true value of benefits and costs to the natural environment may cause poor distribution of funds and ultimately result in failure of the policy. Thus, the valuation of ecosystem services will contribute to a better-informed decision-making process, ensuring policy appraisals take full account of all costs and benefits to the natural environment.

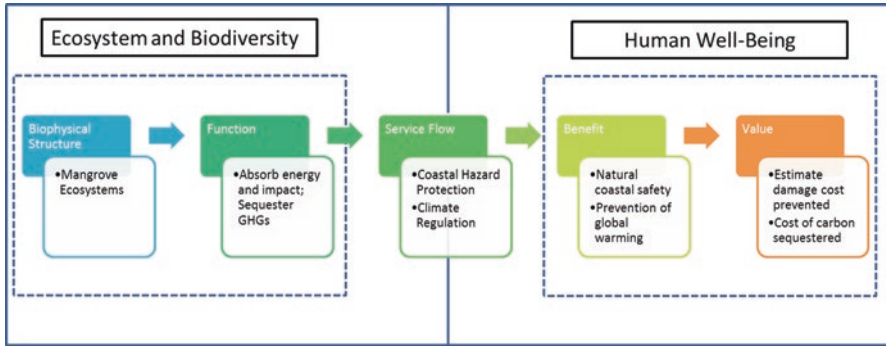
Thus, understanding the economic value of ecosystem services is useful for informed decision-making. The regulatory framework governing coastal zone (CRZ 2011) and NEP (MoEF 2006) contains the directions for considering all types of benefits and costs, both market and non-market, to the extent they are quantifiable. Assessment of economic value of ecosystem services is relatively a new phenomenon. The non-market valuation research does not always address ecosystem services explicitly.

Monetization of an ecosystem requires a clear and comprehensive understanding of the interactions of both ecological and economic elements of the ecosystem. Most ecosystems, including wetland ecosystems, are highly interdependent where the health of multiple components of one ecosystem influences the survival of its own and of another. Equally, it is important to note the linkages and dependencies of changes in ecosystem services (tangible or intangible) on socio-economic welfare. The socio-economic assessment must clearly focus on not just the ecosystem services but the benefits the stakeholders derive directly or indirectly from the same. Therefore, by combining an ecological and economic perspective to valuation, the benefits accrued are valued rather than the services per se.

The most appropriate valuation technique may be adopted based on the understanding of the interactions between ecosystem services and their economic endpoints. This is illustrated in Fig. 14.1 as adopted from Rasul et al. (2011).

### 14.2.1 Stocks and Flows

For the purposes of economic valuation, an ecosystem is categorized by two related concepts – stocks and flows. The flow of goods and services from an ecosystem is provided by the stock of natural resources from a single or multiple habitats. For example, a standing mangrove forest is the stock of trees, while the carbon sequestered annually by the forest represents the service flow. Depending on the appraisal process and policy context, it would be necessary to acknowledge either the flow or stock value:



**Fig. 14.1** Interactions between services and their economic endpoints – a framework

- Flow value: It is defined as the value that can be derived from a resource over a specific interval of time.
- Stock value: It is considered as the net present value sum of all flow values that could be derived from an ecosystem/resource over all future periods.

In addition, estimating economic values depends upon whether the practitioner measures the marginal changes in the flow of ecosystem goods and services or the total stock value of goods and services for a given coastal resource:

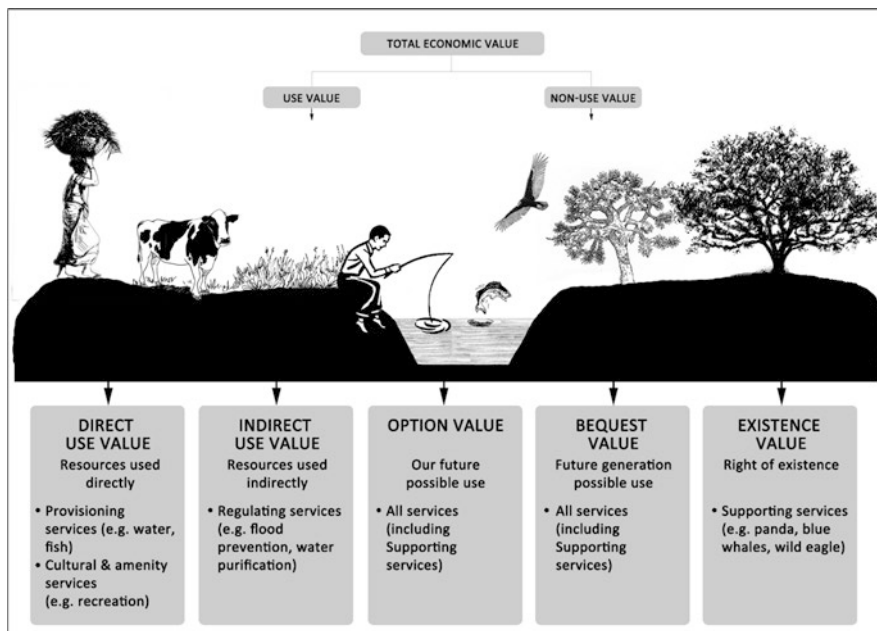
- Total value: It refers to the entire value of flow of goods or service during a defined time period or the entire value of a stock at a given point in time.
- Marginal value: It is the additional value gained or lost by an incremental change in provision of a flow or in the level of stock.

## 14.2.2 Total Economic Value

The value of natural resources is often considered within the framework of TEV, and this framework can be used to value ecosystem services. Generally, the term TEV refers to the aggregate value of all types of flows of services provided by a particular resource rather than the total value of the stock of that resource. Therefore, the TEV of a small change in the flow of services from the resource can be estimated and is referred to as marginal TEV. In terms of policy relevance, the assessment of marginal TEV of a particular ecosystem is more relevant because environmental management decisions are made in response to incremental changes (positive or negative) in the health of the ecosystem which in turn affects the flow of services contributing to human well-being (Defra 2011).

In general, individual preferences for ecosystem goods and services are captured with the help of the TEV framework. As illustrated in Fig. 14.2, TEV is primarily composed of ‘use’ and ‘non-use’ values. In the case of use values, individuals express their preferences through their purchasing patterns and behaviours for





**Fig. 14.2** Total economic value (TEV) and its components (Adopted from Smith et al. 2006)

goods and services that are openly traded in markets. The price of the product is an indicator of the value of the benefit derived from the consumption of that particular good or service. In the case of non-use values, values of environmental goods and services preferred by individuals are not directly observable either because they are not traded in actual markets or market data for their prices are missing. The methods of valuation discussed below capture both use and non-use values depending on the adopted approach and goods/services considered. The concept behind the components of TEV being expressed in monetary terms for a given ecosystem good or services is critical in assimilating relevant information for an informed and effective decision-making process (Newcome et al. 2005).

#### 14.2.2.1 Components of Total Economic Value (TEV)

The components of TEV, namely, use value, non-use value and option value, and their further subcomponents are described in Table 14.2.

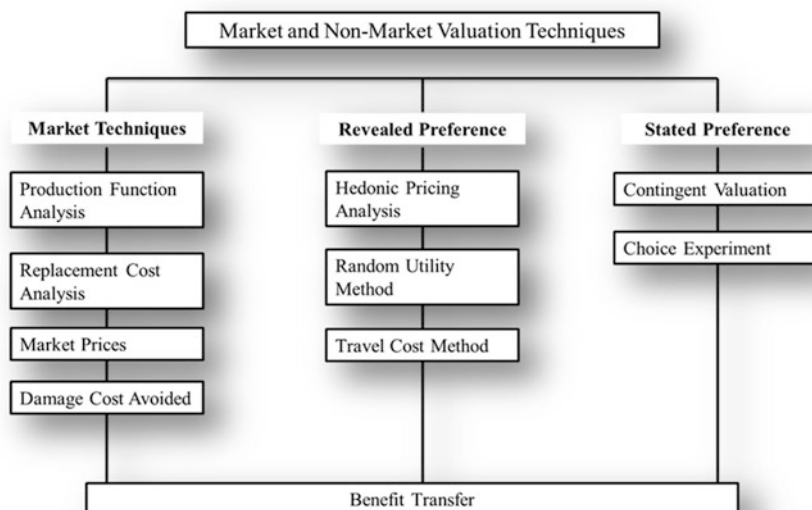
Several valuation techniques are there to determine the monetary value of market and non-market environmental goods and services. The valuation approach is chosen based on the good or service to be valued, the availability of data and the applicability of the value. There are essentially three broad categories of valuation approaches – market techniques, revealed preference and stated preference. Techniques that value certain environmental goods or services traded in open markets with a predetermined price are referred to as market techniques. Revealed preference techniques are those techniques whose data source is observations on

**Table 14.2** Components of total economic value (TEV)

<i>Use value:</i> This involves some interaction with the resource either directly or indirectly	
Direct use value	Values associated with the actual use of an ecosystem resource or service. This can be in the form of consumptive use which refers to the use of resources extracted from the ecosystem (e.g. food, timber) and nonconsumptive use, which is the use of the services without extracting any elements from the ecosystem (e.g. recreation, landscape amenity). Most use values are associated with goods and services that are, in some way, traded in the open market. Such goods are known as ‘market goods and services’
Indirect use value	Values associated with the benefits derived from the ecosystem services supported by a resource rather than directly using it. Benefits derived from regulating or supporting services such as soil retention and provision, nutrient cycling, waste decomposition, pollination, etc. are examples of indirect use value. It is significantly more challenging to monetize indirect use values than direct use values as changes in such regulating and supporting functions affecting human well-being are insufficiently understood, thus hard to capture. In other words, those goods and services associated with indirect use benefits and that have no ready market for its trade are known as ‘non-market goods and services’
<i>Non-use value:</i> Although this value is not directly associated with the use of the good or service, the benefit to the individual arises from simply knowing that the ecosystem is maintained for his/her potential current and future use	
Existence value	The values derived from the existence of an ecosystem resource, even though an individual has no actual or planned use of it
Bequest value	The values individuals attach to the fact that the ecosystem resource will be passed on to future generations
Altruistic value	The values that individuals attach to the availability of the ecosystem resource to others in the current generation
<i>Option value:</i> It is the value that individuals place on having the option to use an ecosystem good or service in the future even if they are not presently using it. These future uses may be either in the form of direct or indirect uses	

people’s choices in reality and include a variety of methods such as production function, replacement cost, travel cost and hedonic prices. If economists rely on data that is obtained from people’s willingness to pay for a change in the provision of particular environmental good or service, then these methods are termed stated preference methods such as contingent valuation and choice modelling. In addition to these, a number of methods such as meta-analysis and benefit transfer rely on secondary information under similar contexts, which are then applied to areas where there is limited or no data available. Figure 14.3 illustrates the three broad categories of valuation approaches.

Appendix A.14.1 describes the different valuation techniques, their applicability and limitations. Each of the valuation techniques has its advantages and disadvantages, and the choice of one technique over the other is, as mentioned above, usually dependent on what needs to be valued (use, non-use or TEV values), the purpose and assumptions of the valuation and availability of information.



**Fig. 14.3** Valuation methodologies within TEV framework

**Table 14.3** Wetland ecosystem service values (US\$) in South Asia – consolidated

	Regulating	Provisioning	Supporting	Cultural
Max	\$47,700	\$14,100	\$10,700	\$23,900,000
Min	\$0.35	\$3.45	\$26	\$0.07
Mean	\$4624	\$1,213.75	\$1605	\$541,365
Median	\$389	\$198	\$342	\$305

Source: Harte Research Institute (Texas A&M University)

### 14.2.3 Review of South Asian Ecosystem Services

Some descriptive statistics of the values of the ecosystem services from wetlands in South Asia are presented in Table 14.3. The data in Table 14.3 was filtered based on two criteria:

- The country of origin, which predominantly was South Asian owing to similarities in geography, climate and levels of economic development with India
- The two types of wetland ecosystems – freshwater and saltwater wetlands

The original database lists various services provided by these ecosystems, but for the purposes of the table above, they are classified into four main groups as per the MEA, namely, provisioning, regulating, supporting and cultural services. The definitions for these groups are discussed in detail in the previous chapters. All values in Table 14.3 and the original database have been normalized to US\$ (2012) for meaningful comparisons and assessment.

### 14.2.3.1 Provisioning Services

Harte Research Institute (Texas) mentions 41 studies that have calculated the provisioning values of South Asian wetlands. The mean value of provisioning services from South Asian wetlands was calculated to be US\$ 1213.73/ha/year with values ranging from US\$ 3.45 to 14,100/ha/year.

Many species of fish, spices and herbs are abundantly available in wetlands. Salt is a major product that is extracted from coastal saltpans in the country that is used by both food and chemical manufacturing industry. Wetlands also provide favourable conditions for paddy cultivation. More than 70% of the wetland area in India is under paddy cultivation (Prasad et al. 2002). For example, a value of US\$ 74.90/ha/year has been assigned to the food material from the mangroves of Bhitarkanika Conservation Area in Odisha (Hussain and Badola 2010).

Coastal wetlands are a major source of raw materials to the industry, contributing significantly to the economic growth of the country. Minerals and sands, which hold a strategic importance to the country, are mined from the sand dunes and beaches. Algae such as *Botryococcus braunii*, *Chlorella* sp., *Dunaliella tertiolecta*, *Gracilaria* and *Pleurochrysis carterae* are also extracted from coasts, which can be used for purposes such as micro-algal biofuel, a potential alternate fuel. Apart from this, mangroves and estuaries provide a range of products such as timber, fuel wood and fertilizers. Coastal wetlands, especially mangroves, are rich in resources with medicinal properties. The honey produced from mangroves is said to have medicinal properties, due to which it is priced higher than the regular honey in the market. A study employing the market price method arrived at a value of US\$ 115/ha/year (2012 US\$) for the medicinal resources derived from the mangroves of Tapean forests in Cambodia (Bann 2003). Coastal wetlands are also a rich source of ornamental materials such as pearls, shellfish, aquarium fish and corals. Owing to its rich biodiversity, coastal wetlands are a reservoir of genetic resources. The saltwater wetlands of Chongming Island, China, using the benefit transfer method, were valued to have US\$ 4.56/ha/year (2012 US\$) worth of coral reefs under their provisioning services (Zhao et al. 2004).

### 14.2.3.2 Regulating Services

There are two reasons for valuing regulating services. One, it enables us to assign values for those non-market services delivered by wetland ecosystems that indirectly contribute to human well-being and where policymakers could make use of these values to better-informed decision-making regarding conservation and habitat management schemes. Two, it also enables us to estimate the extent of damage to a particular wetland by valuing the loss in services delivered. For example, the East Kolkata Wetlands located on the south-eastern fringe of the Kolkata city in India have been used for discharging municipal and industrial untreated sewage since the 1930s. On the other hand, local companies have been generating income and employment by using water from this wetland for crops and fish production. However in recent years, there has been a steady decline in the profitability of rice farming in these wetlands due to increased metal and nutrient content (Mukherjee and Gupta 2013). Some of the most important regulating services of coastal wetland

ecosystems are air purification, climate regulation, disturbance prevention, water regulation, waste treatment and nutrient cycling.

The highest regulating service value recorded on the database was estimated to be US\$ 47,700 which was the annual unit value for disturbance protection per hectare of mangrove cover in Malaysia (Rönnbäck 1999). The lowest regulating service recorded was also for mangroves and was estimated to be US\$ 0.35/ha/year for the provision of greenhouse gas regulation (Padilla 2009). Of the studies, Sri Lanka has the highest number of values (21%) associated with regulating services closely followed by the Philippines (17%) and China (15%). The relevant studies from India were by Hirway and Goswami (2007), Das and Vincent (2009) and Das (2011) that mainly observed the disturbance regulation services by mangroves in Gujarat and Odisha, respectively. There are over 400,000 ha of mangrove forests spread across the coastal states (SAC 2011) with the potential of sequestering anywhere between 17 and 24 tons CO<sub>2</sub>-e/ha/year depending on the density and species of mangroves (Ray et al. 2011). Assuming each ton of CO<sub>2</sub>-e is valued at US\$ 10 (Nordhaus 2011; Verma et al. 2013), the value of climate regulation/air purification by mangrove ecosystems would be around US\$ 170–\$ 240/ha/year.

#### 14.2.3.3 Cultural Services

These are services providing benefits of non-material nature. These benefits can be recreational, leisure, aesthetic, educational and spiritual values. These services also include benefits that have a heritage or an identity value attached to them. The mean value of cultural services from South Asian wetlands was estimated to be US\$ 541,365.10/ha/year with the values ranging from US\$0.07 to 23,900,000/ha/year (Table 14.3) based on the synthesis of 45 studies on valuing the cultural services by Harte Research Institute. Cultural services are purely dependent on how much value human institutions attach to them, and they may vary from individual to individual. For example, recreation and leisure values are positively related to the health of the given ecosystem. People attach a heritage and cultural value to ecosystems that have been supporting them since centuries.

Using the travel cost method, a value of US\$ 213/ha/year (2012 US\$) has been attached to the saltwater wetland of Olango Island, Philippines, for its recreational value (White et al. 2000). In Malaysia, using the benefit transfer and expenditure method, a value of US\$ 137/ha/year (2012 US\$) has been assigned to the coral reefs for their science and educational services (Chua and Nancy 1999).

#### 14.2.3.4 Supporting Services

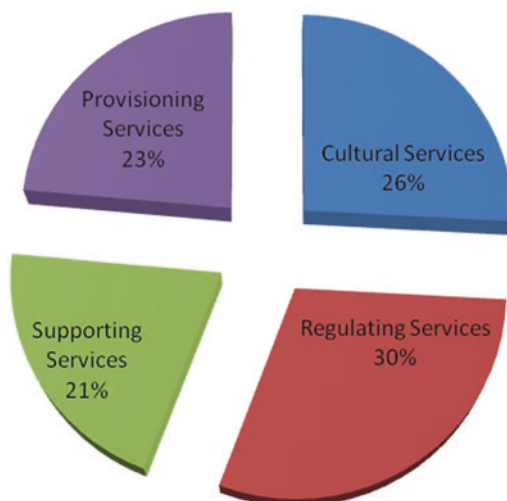
Coastal wetlands provide several important supporting services such as life cycle maintenance, biological control of the ecosystem and gene pool protection that mostly affect humans indirectly and mainly promote conservation of the ecosystem. The mean value of supporting services from South Asian wetlands was computed to be US\$ 1605.22/ha/year with the values ranging from \$25.60 to 10,700/ha/year (Table 14.3) from the 36 studies that have estimated the supporting values for South Asia.

Life cycle maintenance means the provision of essential habitat for reproduction and juvenile maturation of certain species, especially the migratory ones. Biological control is the contribution of marine/coastal ecosystems to the maintenance of natural healthy population dynamics to support ecosystem resilience through maintaining food web structure and flows. The support of reef ecosystems by herbivorous fish that keep algal populations in check and the role that top predators play in limiting the population of opportunistic species like jellyfish and squid are some examples of the biological control in coastal wetland ecosystems. The service of gene pool protection deals with the contribution of marine habitats to the maintenance of viable gene pools through natural selection/evolutionary processes. Inter- and intra-specific genetic diversity that is supported by marine ecosystems enhances adaptability of species to environmental changes.

In terms of disturbance/hazard protection, coastal wetlands such as beaches, dunes, estuaries and mangroves are naturally adept for protecting against the full effects of climate change which includes the increased frequency of storms, changing rainfall patterns, rising sea levels and coastal erosion (Barbier 2007). For example, Das (2011) has systematically estimated the value of storm/hazard protection provided by mangroves in Kendrapara District in the event of the supercyclone that hit the Eastern Indian state of Orissa in the year 1999. In this case, the value was estimated using a regression analysis incorporating the number of human lives and livestock saved and damages to buildings avoided by mangroves. Further, Das (2011) estimated that a hectare of mangrove forest mitigated damages worth US\$ 43,352 (INR 1.8 million) in the district during the supercyclone. Using the former value along with the probability of occurrence of very severe storms in Orissa over the last three decades, it was estimated that US\$ 8670/ha/year (1999 US\$) was the annual protection value of a hectare of intact mangrove forests. Coastal and inland wetlands also play a significant role in purifying water. Nutrients such as phosphorous and nitrogen seen in high levels in agricultural and municipal run-offs are effectively removed by wetlands. Because of this, eutrophication is effectively prevented further downstream, which in turn curbs the rapid plant and algal growth that affects other species. Acting as waste recycling system, it can prevent high concentrations of nutrients reaching groundwater aquifers and other potable water sources. In this regard, a study (Emerton and Kekulandala 2003) estimated the value of the wetlands' domestic and industrial sewage treatment potential to be INR 4.3 million/year and INR162 million/year based on costs avoided to build improved latrines for households and two major joint industrial treatment plants.

The break-up of evaluation studies conducted on coastal wetlands in South Asia on the basis of the four ecosystem services is depicted in Fig. 14.4.

**Fig. 14.4** Distribution of economic valuation studies on coastal wetlands in South Asia



## 14.3 Challenges and Issues with Environmental Valuation

Environmental valuation, like any science, is not without its fair share of challenges and uncertainties. Many ecologists and conservationists strongly believe that the commoditization of nature through market instruments as discussed in earlier sections ignore the intrinsic value that our environment provides whether or not we derive tangible benefits from it (Chiesura and de Groot 2003; Braat and de Groot 2012; Schröter et al. 2014).

### 14.3.1 Uncertainty

Valuing environmental services (both market and non-market) is often argued to be difficult, if not impossible, considering its infinite intrinsic value to human well-being. Ecologists and conservationists believe that science alone should guide policymaking. Thus, in a bid to integrate biophysical and economic parameters, ecological economists are constantly evolving and improving tools to effectively capture nature's monetary value. One of the most fundamental issues for both ecologists and economists in environmental management and, in particular, valuation is uncertainty. Although current knowledge on ecological processes and economic theory is well documented, understanding causal links among parameters such as changes in biophysical processes, ecosystem health, demographic conditions and policy reforms is not fully known (Waite et al. 2014). Effective ecosystem service valuation can better inform environmental policy, but valuation as such has become increasingly difficult and uncertain because modelling the flow of ecosystem services depends on data that are often vague and inaccurate and, in some cases, direct monitoring data on ecosystem services are missing altogether (Johnson et al. 2012).

In terms of the valuation methodology used, most contingent valuation techniques assume all individuals and groups as rational entities and have full knowledge of their preferences when assessing their willingness to pay/accept for a change in the flow of an environmental service; but in reality it is not always the case (Bingham et al. 1995). The choice of valuation tool, which comes with its own set of technical challenges, is subject to the researcher's expertise and conceptual clarity of the issue. Thus, the value of a particular ecosystem service/good could be substantially different based on the method used.

### 14.3.2 Double Counting

The risk of double counting occurs when an 'intermediate' ecosystem service is first separately valued and its corresponding final benefit (e.g. provisioning service) is valued subsequently. The final benefit value of an ecosystem services/good is the aggregation of the values of 'intermediate' services. For example, timber from mangrove forests, which is directly consumed by households, is dependent on a range of intermediate ecological services. If, in an appraisal process, the values of such intermediate supporting services are considered separately in addition to the value of timber, it may result in double counting. Hence, it is often desirable to identify and differentiate intermediate ecosystem services from final ecosystem goods and services so that overestimation of an ecosystem service may be avoided (Boyd and Banzhaf 2007). Inconsistent classification of ecosystem services, poor understanding of ecosystem functions and interlinkages and spatiotemporal dependence are just some of the reasons why double counting occurs (Fu et al. 2011).

### 14.3.3 Valuation at Environmental Thresholds

When a particular ecosystem is deteriorated upon use, the services delivered by that ecosystem will diminish either rapidly or gradually depending on the level of supply and demand, conservation efforts and socio-economic conditions. Every environmental resource has a certain ecological threshold limit or a critical level below which the health of the ecosystem must not be permitted to fall. If, due to some unsustainable use, the resource falls below the ecological threshold limit, it could lead to catastrophic effects and irreversible damages, and the ecosystem in that region could be lost forever. Estimating marginal values of ecosystem services is considered most appropriate for appraisal purposes. It may be meaningless to estimate marginal values at such threshold points; because resources are severely exploited, their existence itself is of utmost importance. Thus, it makes their intrinsic value and benefits to people immeasurably high or infinite (Daily et al. 1997).



### 14.3.4 Spatial and Temporal Variability of Values

An important limitation of ecosystem service valuation (benefit transfer) is the variability in spatial and temporal impacts of any particular service. Values of a particular ecosystem service in different locations may vary owing to differences in ecological processes, economic conditions, infrastructure conditions and behavioural patterns and cultural norms of local people who depend on that service. In addition, spatial variations in the supply of a particular service may alter values accordingly. For example, values for coastal protection services of mangroves in Asia may be different from those in North America. Hence, while applying benefit transfer method, validation of the study is essential. Comparing certain studies assessing a particular service could exhibit significant variations in value and errors to the tune of 30% (for routine coastal and flood defence projects) to as much as 7028% (for meta-analysis) (Spash and Vatn 2006).

Some valuation techniques may try and value future benefits accrued by relevant stakeholders over a specific period. Besides the location, the value of an ecosystem service also depends on at which point in time the service is assessed. There are a couple of reasons why ecosystem services and their values change over time (Fisher et al. 2011). First, ecological conditions of wetland ecosystems are dynamic in nature. In addition to changing land use patterns and human interventions, there are inherent natural drivers that affect the topography and the ecological succession<sup>1</sup> of the habitat over time. This, in turn, affects the goods and services delivered from the respective ecosystem, and the value associated with quantum of service/good provided will not necessarily remain static over a period. For example, the value of regulating services associated with an estuary will increase over time if effective conservation programmes are implemented on site. Alternatively, if mangrove forests either are highly degraded due to human exploitation or increased occurrences of storms and other natural hazards, the value of same regulating services tend to decline over time. Second, social and individual preferences and utilities vary across time and space. A rupee or dollar is worth more today than it would in the future. In such cases, irrespective of the flow of ecosystem services, its value will either appreciate or decline depending on current social and financial conditions. The social rate of time preference would be used to value future benefits at current price levels. The social rate of time preference, also known as the discount rate, is a rate used to convert future benefits and costs of environmental services to 'present value' so that relevant and accurate comparisons can be made (Khan and Greene 2013). Apart from being a point of considerable debate, the choice of discount rate plays a very

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<sup>1</sup>Ecological succession: Many ecosystems experience a phenomenon known as ecological succession, a slow process in which the species inhabiting an ecosystem fluctuate or change completely. Some species increase in population, while others decrease or even disappear altogether. These shifts can be due to new species entering the ecosystem, current species impacting the ecosystem, or evolutionary changes within a certain species allowing them to better adapt to the ecosystem.

important role in determining unit values for particular ecosystem services. Low discount rates reflect higher emphasis on future costs and benefits and normally encourage conservation strategies that enable sustainable and constant flow of ecosystem services. On the other hand, higher discount rates reflect greater emphasis on short-term costs and benefits and, in general, discourage conservation efforts.

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## 14.4 Conclusion

The importance of coastal wetlands in providing provisioning, cultural or recreational, supporting and regulating services was known to ecologists for many decades. However, the studies by social scientists particularly related to economic valuations are very few. Thus, appropriate policies to address the issue of wetland degradation are negligible. The review of studies on the valuation of coastal wetland services reveals that there are very few comprehensive assessments of value of coastal wetlands especially in the South Asian context. The literature search from international database on valuation especially The Economics of Ecosystems and Biodiversity (TEEB), Harte Research Institute, etc. shows that there are limited studies which quantify the different provisioning, regulating and cultural services from coastal wetlands. Further, there is wide variation between the studies ranging from a minimum of US\$ 3.00 to 14,100 for provisioning services, from US\$ 0.35 to 47,700 for regulating services, from US\$ 0.07 to 23,900,000 for cultural services and from US\$ 26 to 10,700 for supporting services. Thus, the valuation of the provisioning services varies substantially making it difficult for using benefit transfer method to value the coastal wetlands.

In this chapter, an attempt is made to address these issues related to the value of different services provided by coastal wetlands. By presenting the estimates made by researchers in the South Asian context, the importance of valuing the ecosystem services is highlighted for the policymakers as well as the producers to aid them in decision-making.

In order to address threats to wetlands, many developed countries adopt a combination of command and control and market-based (charges/subsidies) methods. In India, there are only regulatory controls to protect wetlands, and there is no scope for market-based approach within the existing legal framework, as there is no foundation for valuing an ecosystem service. A pricing mechanism where we give value to the ecosystem as an entity so that we can bring a holistic system of evaluation of services with a bottom-up approach needs to be considered.

## Appendices

### Appendix A.14.1: Valuation Methodologies within TEV Framework

Valuation technique	Applicability to Indian wetland ecosystems	Examples of wetland ecosystem application	Limitations
<i>Revealed preference techniques</i>			
<p><b>Hedonic pricing method (HPM):</b> The value of an environmental amenity (such as a view) is obtained from readily available property or labour markets. The basic assumption is that the observed property value (or wage) reflects a stream of benefits (or working conditions) and that it is possible to isolate the value of the relevant environmental amenity or attribute</p>	<p>Hedonic pricing has potential for valuing certain wetland functions (e.g. aesthetic beauty, landscapes and open spaces from sandy beaches) in terms of their impact on land values, assuming that they are fully reflected in land prices</p>	<p>Landry and Hindsley (2011) conducted a study to explore the influence of beach quality on coastal property values. It was estimated that property values within 300 m of HTL are positively impacted by the width of the beach and dune field</p>	<p>Application of this approach to value wetland services requires these values to be reflected in proxy markets. The approach may be limited by unstable real estate markets, choices constrained by income and unequal distribution of information about environmental conditions</p>
<p><b>Travel cost approach (TC):</b> The travel cost approach derives willingness to pay for environmental benefits at a specific location by using information on the amount of money and time that people spend to visit the location</p>	<p>Widely used to estimate the value of recreational, religious and cultural sites in coastal and wetland areas. It could also be used to estimate willingness to pay for ecotourism</p>	<p>Raybould et al. (2011) estimated the value of recreational benefits (AU\$365 million to AU\$1.7 billion) to Gold Coast residents depending on their travel costs including time and fuel costs</p>	<p>The approach is data intensive; it is restrictive on the assumptions about consumer behaviour (e.g. multifunctional trips); its results are highly sensitive to statistical methods used to specify the demand relationship</p>

(continued)

Valuation technique	Applicability to Indian wetland ecosystems	Examples of wetland ecosystem application	Limitations
<p><b>Random utility method (RUM):</b> This is an extension of the travel cost method and is used to test the effect of changing the quality or quantity of an environmental characteristic at a particular site</p>	<p>The travel cost RUM analyses a person's discrete choice of one recreation site over other sites. The site choice is assumed to depend on the features of the site and to reveal the person's preferences for those features</p>	<p>Parsons et al. (2000) estimated a (TC) random utility model of recreation demand. The model evaluates the loss in mean welfare value per trip per person if select beaches were too close to its residents</p>	<p>The random utility model is an extremely complicated and expensive (in terms of man-hours required) approach to value ecosystem service benefits</p>
<i>Stated preference techniques</i>			
<p><b>Contingent valuation method (CVM):</b> constructs a hypothetical market to elicit respondents' willingness to pay for a particular environmental service. It can be used to estimate use and more importantly non-use values</p>	<p>It is the only method that can measure existence values and provide a true measure of total economic value. Most regulating and cultural services of wetland ecosystems are estimated using CVM. E.g. protection from extreme weather events by estuaries and recreational benefits from coral reefs</p>	<p>Bann (1999) estimated the willingness to pay values (US\$7512/Ha) of protecting mangroves for its nursery and biodiversity services in Malaysia</p>	<p>The results of this approach are sensitive to numerous sources of bias in survey design and implementation</p>
<p><b>Choice experiments:</b> estimate implicit values of different use and non-use environmental services. Since it is based on the trade-off between options with different specified characteristics, it is best suited to better-informed policy decisions</p>	<p>CE method, just like the CVM, attempts to measure all use and non-use values including biodiversity and cultural values of wetland ecosystems</p>	<p>Birol and Cox (2007) used the choice experiment approach to investigate whether the communities living around the Severn wetland derived positive economic values if the wetlands were sustainably managed</p>	<p>Some of the critical issues for choice experiments are the technical and behavioural uncertainties in monetizing the actual value of responses taken on a particular good or service. It may cause biases in responses or decision-making</p>

(continued)

Valuation technique	Applicability to Indian wetland ecosystems	Examples of wetland ecosystem application	Limitations
<i>Market-based techniques</i>			
<b>Production function approach (PFA):</b> estimates the value of a non-marketed resource or ecological function in terms of changes in economic activity by modelling the physical contribution of the resource or function to economic output	Widely used to estimate the impact of wetlands and reef destruction, deforestation, water pollution, etc. on productive activities such as fishing, hunting and farming	The study utilized the production function method to value the mangrove forests to a local community. The method was particularly used for the value of fisheries (~US\$50) supported by local mangroves in the Gulf of Thailand region (Sathirathai and Barbier 2001)	Requires explicit modelling of the 'dose-response' relationship between the resources and some economic output. Application of the approach is most straightforward in the case of single-use systems but becomes more complicated with multiple-use systems. Problems may arise from multi-specification of the ecological-economic relationship or double counting
<b>Replacement cost (RPC):</b> this method uses cost of artificial substitutes for environmental goods or services	RPC: useful in estimating indirect use benefits when ecological data are not available for estimating damage functions with first-best methods	McAllister (1991) estimated the value of coastal protection provided by the coral reefs in the Philippines using the replacement cost method. The study estimated US\$22 billion, based on construction costs of concrete tetrapod breakwaters to replace 22,000 km <sup>2</sup> of reef protection	RPC: difficult to ensure that net benefits of the replacement do not exceed those of the original function. May overstate willingness to pay if only physical indicators of benefits are available

(continued)

Valuation technique	Applicability to Indian wetland ecosystems	Examples of wetland ecosystem application	Limitations
<p><b>Market prices (MP):</b> are those that capture the value of goods and services that are traded in the open market. Market prices can act as proxies for direct and indirect use values</p>	<p>Market prices reflect the private willingness to pay for several use values. For example, the value of fish nurseries provided by mangroves is measured by the market price of all fish harvested from that area</p>	<p>Emerton and Kekulandala (2003) used market price to value the economic benefits associated with fishing, agriculture and handicraft production activities in Muthurajawela wetland. The market value of firewood obtained from Muthurajawela was INR 7.96 million/year</p>	<p>Market imperfections and/or policy failures may distort market prices, which will therefore fail to reflect the economic value of goods or services to society as a whole. Seasonal variations and other effects on prices need to be considered when market prices are used in economic analysis</p>
<i>Benefit transfer</i>			
<p><b>Benefit transfer</b> (Rosenberger and Loomis 2003): the process by which the economic value of an environmental good or service generated in one context – the ‘study site’ – is applied to another context known as benefit transfer or value transfer. In principle, a value from any economic valuation methodology may be used as long as the contexts of both sites are the same</p>	<p>This technique is used when primary valuation studies are not feasible in terms of timelines and budgets. Also policy and conservation schemes predominantly use macro-level monetary estimates, and benefit transfer offers an effective solution to include environmental values to the appraisal process</p>	<p>Gujarat Ecology Commission (Dixit et al. 2010) estimated the values of coastal protection (INR 2.89 million/km<sup>2</sup>/year) and biodiversity maintenance (INR 0.32 million/ km<sup>2</sup>/ year) of coral systems in the Gulf of Kachchh region in India using benefit transfer methodology</p>	<p>One of the critical issues with the use of benefit transfer is the validity and accuracy of secondary data</p>

## Appendix A.14.2: Online Databases on Valuation

Institute	Particulars
Marine Ecosystem Services Partnership (MESP)	MESP is a virtual centre for information and communication on the human uses of marine ecosystems around the world, including an extensive database of marine and coastal valuation studies with nearly 2000 value estimates
Harte Research Institute – Texas A&M University-Corpus Christi	The two main goals of the GecoServ database are to allow for the distribution and sharing of information about ES valuation studies and to identify current gaps in the ES literature. The studies summarized here are for habitats that are relevant to the Gulf of Mexico region even though they may have been conducted elsewhere
National Ocean Economics Program (NOEP)	NOEP provides economic and socio-economic information on changes and trends along the US coast and will soon expand its scope internationally. NOEP includes databases on market and non-market values of coastal and marine resources
Environmental Valuation Reference Inventory (EVRI)	EVRI is a searchable storehouse of more than 2000 empirical studies on the economic value of environmental benefits and human health effects. It has been developed as a tool to help policy analysts use the benefit transfer approach
The Economics of Ecosystems and Biodiversity (TEEB)	Ecosystem Service Valuation Database (ESVD), initially developed for TEEB initiative, contains more than 1300 data points from more than 300 case studies on both marine and terrestrial ecosystem services
Lincoln University, New Zealand	This database provides users with a large (850+) bibliography of valuation studies. The economic value of many of these studies is also analysed and reported. These values have been standardized temporally and spatially so the application of the values is adequately robust
Beijer Institute of Ecological Economics	The Valuation Study Database for Environmental Change in Sweden (ValueBaseSWE) was developed at the Beijer Institute of Ecological Economics within a project funded by the Swedish Environmental Protection Agency. The database is the result of a survey of empirical economic valuation studies on environmental change in Sweden

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