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CHAPTER **5**

**Wetland Ecosystem Services and its
Valuation with Special Reference to India
*A Review***

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ABSTRACT

Wetlands have been described as the kidneys of the landscape, because of the functions they perform in the hydrological and chemical cycles, and as biological supermarkets, because of the extensive food webs and rich biodiversity they support. Globally, a lot of research has been done to study ecosystem service potential of wetlands viz., provisioning, regulating, cultural and supporting services. However, our review in the Indian context revealed that studies on wetland ecosystem services are limited to provisioning and cultural aspects. The information on supporting and regulating services provided by the wetlands are very limited. Therefore, detail ecological studies on different aspects of

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wetland ecosystem structures and functions, and attempts to link wetland ecology with human welfare and economy of the region is suggested. Such studies on the wetland ecosystem, people and management authorities would help to understand and appreciate the link between healthy ecosystem and human well-being. This would motivate the involvement of the local masses in safeguarding and managing the wetland resources in a sustainable manner. It would also help the policy makers in designing diverse management strategies for the wetlands.

Key words: Wetland, ecosystem services, India.

Introduction

Ecosystem service is a collective term for the goods and services produced by ecosystems that benefit humankind (Jenkins *et al.* 2010). According to Barbier (2011), ecosystem services are natural assets produced by the environment and utilized by humans, such as clean air, water, food etc. Ecosystem services contribute to social and cultural well-being (Fischer *et al.* 2009), and have high economic value (Barbier *et al.* 1997, Emerton and Bos 2004, Turner *et al.* 2008). During the past decade, progress has been made in understanding how ecosystems provide services, and how service provision translates into economic value (Daily 1997, MA 2005, NRC 2005). In one of the most widely cited ecosystem service valuation studies, Costanza *et al.* (1997) estimated the value of the services provided by Earth's ecosystems to be at least \$33 trillion per year. However, these services have traditionally been undervalued as they often fall outside conventional markets. In this regard, monetary valuation will let the common people realize the actual value of natural ecosystems and here comes the role of ecosystem service studies.

Since the release of Brundtland Report in October, 1987, where the concept of sustainable development gained the momentum, there has been much enthusiasm on the notion that standard measures of economic output should be extended to account for the loss of natural resources i.e., our natural capital. Now, there is a global concern over the disappearance of natural ecosystems and habitats due to conversion of the land to other uses, degradation of the functioning and integrity of natural ecosystems through resource exploitation, pollution, biodiversity loss, and habitat fragmentation (MA 2005). All these have prompted policymakers to consider the 'value of ecosystem services' in environmental management decisions.

Valuation is particularly useful in institutional systems like markets and common property resources (viz., forestlands, grasslands, wetlands etc.), which are not functioning well to reflect the social costs of environmental degradation. When not guided by the concept of 'value', decisions about

conservation or restoration actions can lead to the misuse of resources. The processes of production and consumption not only derive inputs from natural systems, but also alter those systems through land-use change and the discharge of waste. Keeping track of how the transformation of ecosystems affects human welfare in both the short and long run is an important accounting activity. Therefore, economic valuation of ecosystem services (which otherwise remain outside the economic decision making) can contribute positively to the formulation and evaluation of environmental policies in sustainable ways (MA 2005). Accordingly, MA (2005) identified four types of ecosystem services *viz*, provisioning services, regulating services, cultural services and supporting services which are briefly described in Table 5.1.

Table 5.1: Broad Classification of Ecosystem Services

Provisioning Services	Regulating Services	Cultural services
<i>Products obtained from ecosystems e.g.</i>	<i>Benefit obtained from regulation of ecosystem processes e.g.</i>	<i>Non-material benefits obtained from ecosystems e.g.</i>
<ul style="list-style-type: none"> • Food • Fresh water • Fuel wood • Fiber • Biochemicals • Genetic resources 	<ul style="list-style-type: none"> • Climate regulation • Disease regulation • Water regulation • Water purification • Pollination 	<ul style="list-style-type: none"> • Spiritual and religious • Recreation and ecotourism • Aesthetic • Inspirational • Educational • Sense of place • Cultural heritage
Supporting Services <i>Services necessary for the production of all other ecosystem services e.g.,</i>		
<ul style="list-style-type: none"> • Soil formation 	<ul style="list-style-type: none"> • Nutrient cycling 	<ul style="list-style-type: none"> • Primary production

Source: MA 2005

Wetlands and the Wetland Ecosystem Services

As per the definition adopted at Ramsar Convention (1971), *Wetlands are areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing; fresh, brackish, or salty, including areas of marine water the depth of which at low tide does not exceed six meters.* Wetlands are categorized as inland (also known as non-tidal, freshwater wetlands) and coastal (also known as tidal, salt water or estuarine wetlands) (Barbier *et al.* 1997). Wetlands have been described as the *kidneys of the landscape*, because of the functions they perform in the hydrological and chemical cycles, and as *biological supermarkets*, because of the extensive food webs and rich biodiversity they support (Mitsch and Gosselink 1993). Wetland ecosystems have long been recognized as providing a range of benefits for people and society (Maltby 1986, Dugan 1990, Turner and Jones 1990, Davis 1993). Wetlands support millions of people, not only to those living in their periphery but

also to those who reside far away through its various goods (e.g., fishery products etc.) and services (e.g., maintenance of habitats for various aquatic and terrestrial communities of human use etc). According to Costanza *et al.* (1997), the wetland all over the world occupying only 6.5% of the earth's surface area and contributes about 14.7% of the world's ecosystem service values with a global average value of \$6,000 per acre. The various ecosystem services provided by or derived from wetlands is shown in Table 5.2.

Table 5.2: Ecosystem Services Provided by or Derived from Wetlands

Ecosystem Services	Examples
I. Provisioning	
Food	Production of fish, wild game, fruits and grains.
Fresh water	Storage and retention of water for domestic, industrial and agricultural uses.
Fiber and fuel	Production of logs, fuel wood, peat, fodder.
Biochemical	Extraction of medicines and other materials from biota.
Genetic materials	Genes for resistance to plant pathogens, ornamental species, and so on.
II. Regulating	
Climate regulation	Source and sink for greenhouse gases; influence temperature, precipitation, and other climatic processes.
Water regulation (hydrological flows)	Groundwater recharge/discharge.
Water purification and waste treatment	Retention, recovery, and removal of excess nutrients and other pollutants.
Erosion regulation	Retention of soils and sediments.
Pollination	Habitat for pollinators.
Natural hazard regulation	Flood control, storm protection.
III. Cultural	
Spiritual and inspirational	Source of inspiration; many religions attach spiritual and religious values to aspects of wetland ecosystems.
Recreational	Opportunities for recreational activities.
Aesthetic	Many people find beauty or aesthetic value in aspects of wetland ecosystems.
Educational	Opportunities for formal and informal education and training.
IV. Supporting	
Soil formation	Sediment retention and accumulation of organic matter.
Nutrient cycling	Storage, recycling, processing, and acquisition of nutrients.

Source: MA 2005.

Ramsar Convention on Wetlands (1971) has promoted wise use of wetlands which is responsible for better delivery of the ecosystem functions especially for maintaining diverse habitats of waterfowl mainly the migratory

birds. Accordingly, the Convention classified wetlands into 42 types under the following three major categories: (i) marine and coastal wetlands, (ii) inland wetlands and (iii) human-made wetlands. Worldwide distribution of the wetlands of international importance under the Ramsar Convention is represented in Figure 5.1.

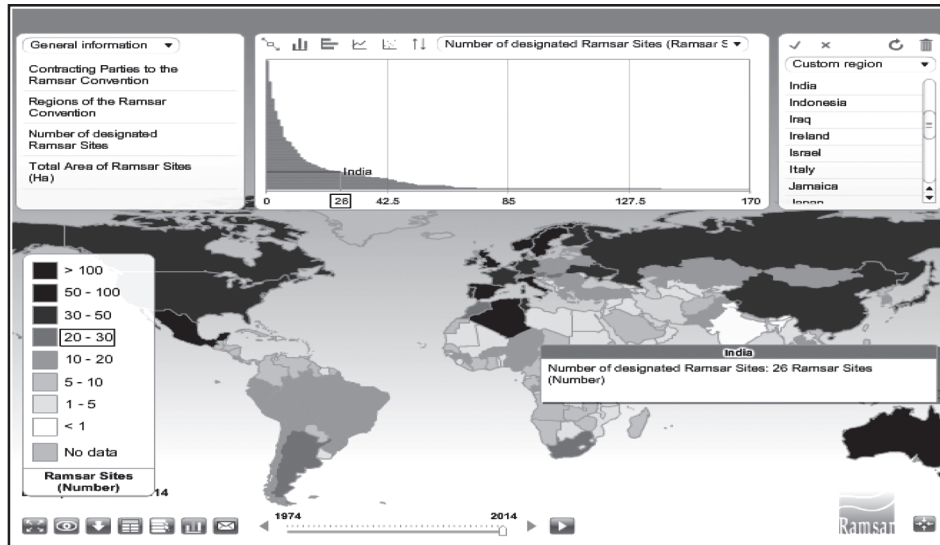


Fig. 5.1: Map showing worldwide distribution of wetlands of international importance under the Ramsar Convention

Source: www.sites.wetlands.org.

The figure reveals that there are 2000 Ramsar wetlands around the globe, most of which belong to the United Kingdom (170) followed by Mexico (139), and there are only 26 Ramsar sites in India (Source: <http://sites.wetlands.org>). After this Convention on Wetlands (1971), the Millennium Ecosystem Assessment (1997) moved some steps forward in context of assigning wetlands' importance and its wise use. It revealed that wetlands cover only 7% of the earth's surface but deliver 45% of the world's natural productivity and ecosystem services of which the benefits are estimated to be \$20 trillion a year (www.maweb.org). This recognition of the ecosystem services of wetlands led to appreciation of their economic value due to proper ecosystem functions (like production, consumption and decomposition) through interactions of its various bio-physical structures (e.g., interactions of plants, animals, and microbes with air, water, soil and sediments within the wetland habitats). All these fundamental understandings of ecosystem service value provided a powerful tool for placing wetlands on agendas of conservation and development by the decision-makers ([Barbier et al. 1997](#), [Emerton and Bos 2004](#), [de Groot et al. 2006](#) and [Turner et al. 2008](#)).

Wetlands in India

The wetlands in India vary from high-altitude Himalayan lakes to the flood plains of the major river systems, from saline and temporary wetlands of the arid and semi-arid regions to coastal wetlands such as lagoons, backwaters and estuaries, mangrove swamps, coral reefs and marine wetlands, and so on. In fact, with the exception of bogs, fens and typical salt marshes, Indian wetlands cover the whole range of the global wetland ecosystem types. India has various man-made wetlands, too, which have been constructed for the needs of irrigation, water supply, electricity, fisheries and flood control, etc. According to the Directory of Asian Wetlands (Scott, 1989), India has a total of 27,403 wetlands, of which 23,444 are inland wetlands and 3,959 are coastal wetlands. Indian wetlands are estimated to occupy 18.5% of the country's total geographical area of which 70% of the area is under paddy cultivation (<http://www.gktoday.in/india-ramsar-convention/>).

Studies on Wetland Ecosystem Service in India

India has a wealth of wetland habitats of immense ecological importance and exhibit enormous diversity based on origin, geography, hydrological regime and substrate types (Verma 2001, National Biodiversity Action Plan 2008). However, in recent decades India has lost an estimated 38% of its wetlands (Vijayan *et al.* 2004) which highlight the need for implementation of wetland conservation and management measures at the earliest. In this regard, studies on wetland ecosystem services, incorporating ecological information of the wetland in association with socio-cultural practices of the ecosystem/riparian people and the economic evaluation of the goods and services would substantiate the existing knowledge base on the wetland resources. Such studies would likely enlighten the stakeholders and policy makers for scientific and sustainable management of the wetland and its resources.

Review of Literatures on Status of Wetland Ecosystem Service Studies in India

In India, efforts on studying the ecosystem services of wetlands have started recently. Although the functions and values of some of the wetlands in India are recognized, but these have not been effectively listed and evaluated in terms of their ecology and economy. In the present review, we have compiled the research work conducted in the field of wetland ecosystem services studies in India in the last two decades. For this purpose, articles related to studies on different aspects of wetland ecosystems in India were collected from different sources *viz.*, Google Scholar, Research Gate, academia.edu, shodhganga.inflibnet, Science Direct and Scholars Archive@OSU. Our literature collection comprise of published literature till the year 2014. A total of 52 articles related to various aspects of wetland studies (ecology, economy, and managements) available from different sources, were collected and the various information are compiled in the table below (Table 5.3).

Table 5.3: Wetlands Ecosystem Service Studies in India

Author(s)	Parameters Studied	State	Type of Ecosystem Service Studies	Economic Valuation of the Wetland done (Yes/No)
Verma (2001)	Benefits from wetland due to its direct uses (drinking water, fish production, boating, <i>Trapa</i> cultivation etc.) and indirect uses (water quality purification cost, recreation etc.).	Madhya Pradesh (Bhoj Wetland; Ramsar site)	Provisioning, regulating and cultural services	Yes
Das <i>et al.</i> (2002)	Benefits from wetland due to fishery, irrigation and jute retting	West Bengal	Provisioning service	Yes
Aaranyak (2003)	Benefits from wetland due to fishing, agriculture, pottery, and selling of firewood.	Assam (Deepor Beel; Ramsar site)	Provisioning service	No
Ramachandra and Sreekantha (2006)	Benefits from wetland due to direct uses (fishery and agriculture) and indirect uses (nutrient retention, flood control, groundwater recharge and biodiversity values)	Karnataka	Provisioning, regulating, supporting and cultural services	Yes
Prasar <i>et al.</i> (2006)	Benefits from wetland due to fishery and production of wheat, fodder and thatch grasses, recreation value etc.	Himachal Pradesh (Pong dam wetland; Ramsar site)	Provisioning and cultural services	Yes
Jerath <i>et al.</i> (2008)	Benefits from wetland due to sustainable utilization of wetland resources	Punjab (Harike, Kanjli and Ropar wetlands; Ramsar sites)	Provisioning service	No
Ganguli <i>et al.</i> (2008)	Benefits from wetland due to ecotourism	Assam	Cultural service	No
Leima <i>et al.</i> (2008)	Benefits from wetland due to fishing and harvesting aquatic plants	Manipur (Loktak lake; Ramsar site)	Provisioning service	Yes

(Contd...)

Author(s)	Parameters Studied	State	Type of Ecosystem Service Studies	Economic Valuation of the Wetland done (Yes/No)
Mukherjee (2008)	Benefits from wetland due to cultivation, irrigation, fisheries, domestic uses of water (e.g., bathing and washing), jute retting and fodder	West Bengal	Provisioning service	Yes
Sreeja <i>et al.</i> (2009)	Nutrient retention capacity and its economic valuation in wetland	Kerala	Regulating service	Yes
Khan and Shah (2010)	Biomass changes and nutrient lock-up efficiency of macrophytes in wetland	Jammu and Kashmir	Supporting service	No
Srinivasan (2010)	Ecological and economic importance of wetland	Kerala	Provisioning service	No
Sarma and Saikia (2010)	Various use of wetland plants, fishing, recreation and religious practices	Assam	Provisioning and cultural services	No
Singh <i>et al.</i> (2010)	Biomass dynamics of macrophytic species in wetland	Manipur	Supporting service	No
Biswas <i>et al.</i> (2010)	Human dependency on wetland	West Bengal	Provisioning service	Yes
Kumar and Narain (2010)	Medicinal properties of wetland plants	North Central India	Provisioning service	No
Deka (2011)	Potentiality for ecological research in wetland	Tripura (Rudrasagar lake; Ramsar site)	Cultural service	No
Jain <i>et al.</i> (2011)	Edible wetland plants	Manipur	Provisioning service	Yes
Ramachandra <i>et al.</i> (2011)	Benefits from wetland due to domestic use, agriculture, fisheries, firewood, fodder etc.	Bengaluru	Provisioning service	Yes
Bhatt and Abdullah (2011)	Bio-diversity preservation in wetland	Jammu and Kashmir (Hokera Wetland; Ramsar site)	Cultural service	Yes

(Contd...)

Author(s)	Parameters Studied	State	Type of Ecosystem Service Studies	Economic Valuation of the Wetland done (Yes/No)
Panda and Misra (2011)	Medicinal values of wetland plants	Orissa	Provisioning service	No
Verma and Negandhi (2011)	Multiple functions provided by wetland	Madhya Pradesh; (Bhoj Wetland; Ramsar site)	Provisioning service	No
Kumar <i>et al.</i> (2011)	Relationship between wetland ecosystem services and poverty reduction	Orissa (Chilika lake; Ramsar site)	Provisioning service	No
Biswasroy <i>et al.</i> (2011)	Utilization of various wetland resources	West Bengal	Provisioning service	No
Kensa (2011)	Utilization of wetland plants	Tamil Nadu	Provisioning service	No
Puste <i>et al.</i> (2012)	Utilization of wetland ecosystem through integration of fish-crop diversification	Indian sub-tropics	Provisioning service	No
Chaudhury <i>et al.</i> (2012)	Direct and indirect benefits of the wetland	West Bengal (East Kolkata wetlands; Ramsar site)	Provisioning, regulating and cultural services	No
Kumar <i>et al.</i> (2012)	Wetland resource utilization	Bihar	Provisioning service	No
Bhattacharya <i>et al.</i> (2012)	Biodiversity, traditional practices and sustainability issues of wetland	West Bengal (East Kolkata Wetlands; Ramsar site)	Provisioning and regulating services	No
Debroy and Jayraman (2012)	Role of mangroves against natural calamities like heavy rainfall and floods and contribution of mangroves to its ecosystem people for fishery and firewood collection	Tamil Nadu	Provisioning and regulating services	Yes

(Contd...)

Author(s)	Parameters Studied	State	Type of Ecosystem Service Studies	Economic Valuation of the Wetland done (Yes/No)
Kataki <i>et al.</i> (2012)	Potential of wetland plant (<i>Ipomoea carnea</i>) for bio-energy generation	Assam	Provisioning service	No
Khaleel (2012)	Various services provided by mangrove wetlands	Kerala	Provisioning, regulating and cultural services	Yes
Banerjee <i>et al.</i> (2012)	Utilization of macrophytes in the wetland	West Bengal	Provisioning service	No
Misra <i>et al.</i> (2012)	Wetlands plants for different uses	Orissa	Provisioning service	No
Phangchopi <i>et al.</i> (2012)	Wetland plants and animals	Assam	Provisioning service	No
Roy <i>et al.</i> (2012)	Income generation to the ecosystem people through wetland farming, fishing, animal husbandry, cottage industry and daily wage laborer	West Bengal	Provisioning service	Yes
Bordoloi (2013)	Benefits from wetland due to fishery and mustard oil seed production	Assam	Provisioning service	No
Laishram and Dey (2013)	Benefits from wetland due to source of drinking water, fishing and firewood collection for the ecosystem people of the wetland	Manipur (Loktak Lake; Ramsar site)	Provisioning service	No
Singh <i>et al.</i> (2013)	Benefits from wetland due to maintenance of water level of the floodplain, control of floods, maintenance of moisture regimes during lean periods, bioaccumulation of key nutrients for pollution regulation, biodiversity support, tourism and income generation of the ecosystem people	Delhi	Regulating, supporting, cultural and provisioning services	No

(Contd...)

Author(s)	Parameters Studied	State	Type of Ecosystem Service Studies	Economic Valuation of the Wetland done (Yes/No)
Sarmah <i>et al.</i> (2013)	Medicinal uses of wetland plants	Assam	Provisioning service	No
Vanaja (2013)	Benefits from wetland due to rice cultivation and aquaculture	Kerala	Provisioning service	No
Jyothi and Sureshkumar (2013)	Potential of wetland floral resources in healthcare	Kerala	Provisioning service	No
Mukherjee and Palit (2013)	Wetland resource utilization	West Bengal	Provisioning service	No
Pathak and Sharma (2013)	Bioresources of the wetland	Assam	Provisioning service	No
Kar <i>et al.</i> (2014)	Various uses of wetland macrophytes	Assam	Provisioning service	No
Das <i>et al.</i> (2014)	Potential for concurrent rice-fish culture in wetland rice fields	Assam	Provisioning service	No
Das <i>et al.</i> (2014)	Biodiversity conservation	West Bengal	Cultural service	No
Deka and Sharma (2014)	Utilization of wetland resources	Assam	Provisioning service	No
Mirra and Khan (2014)	Carbon storage patterns in the wetland sediments as 'carbon sink'	Pondicherry	Regulating service	No
Abdar (2014)	Role of birds which visit wetlands in delivery of ecosystem services like pest control, pollination and seed dispersal in wetlands	Maharashtra	Regulating service	No
Gupta and Debnath (2014)	Use of wetland for irrigation, pisciculture and domestic purposes	West Bengal	Provisioning service	No

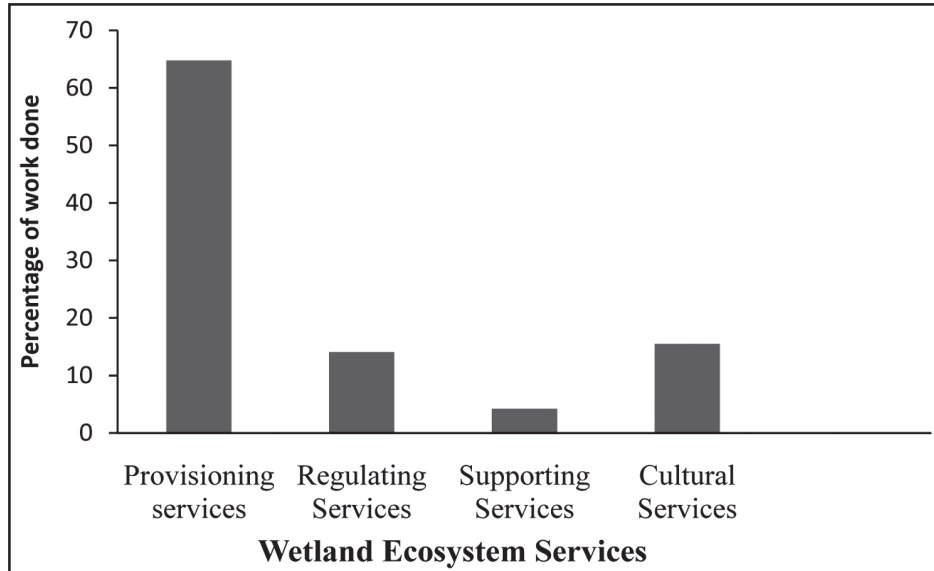


Fig. 5.2: Status of wetland ecosystem services studies in India

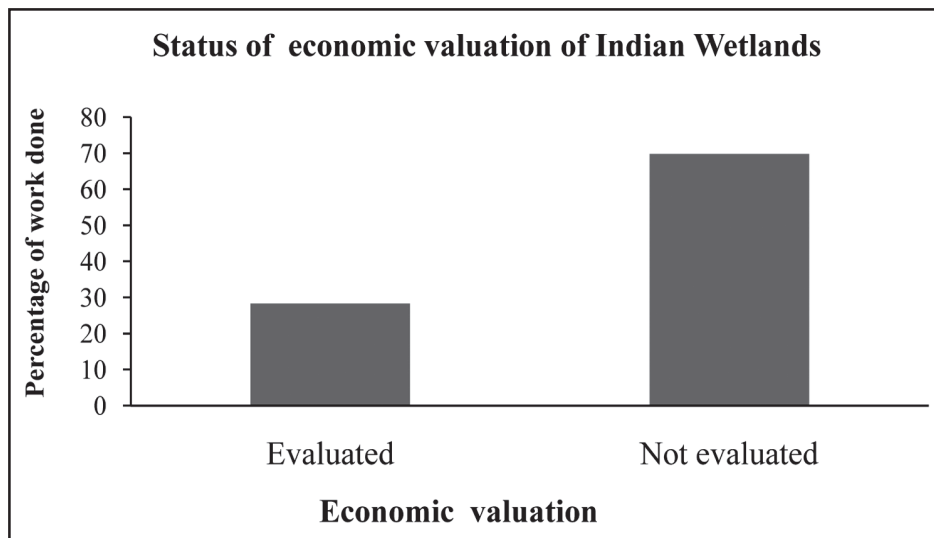


Fig. 5.3: Economic valuation in context of wetland ecosystem services studies in India

The review reveals that some studies investigated the ecological aspects of wetlands such as wetland plant and animal diversity, role of wetland sediments as sink for carbon, biomass dynamics and nutrient lock up efficiency of wetland plants, and nutrient retention efficiency of wetland, while others stressed on its economy and its contribution to human welfare through its various biophysical components (Table 5.3). Very little research

work has concentrated on the link between the wetland ecology and human welfare particularly its ecosystem people (which in fact, show how the ecosystem people of the wetlands get benefit, from functioning of such ecosystems, free of cost). Such kind of studies can be regarded as comprehensive in the perspective of 'ecosystem service' studies. However, if we categorize the type of wetland ecosystem service studies in India till the year 2014, we can see that most of the studies were done on provisioning services (Figure 5.2), and in most of the studies economic evaluation of the services have not been done (Figure 5.3). A majority of the studies conducted on wetlands have emphasized its importance on socio-cultural aspect and very few studies have established the true perspective of 'ecosystem services'.

Based on the above review, it can be concluded that the wetlands in India have received inadequate attention from ecosystem service perspective. Till date, the research on wetlands in India has mainly focused on limnology and ecological/environmental economics. However, the physical alterations in wetlands in term of changing land use at micro-level and the associated change in the socio-economy of its ecosystem people have not been explored substantially. The study also reveals that out of 26 Ramsar Wetlands in India, only 11 wetlands viz., Bhoj Wetland (Madhya Pradesh), Deepor Beel (Assam), East Calcutta Wetlands (West Bengal), Harike wetland (Punjab), Hokera Wetland (Jammu and Kashmir), Kanjli wetland (Punjab), Loktak Lake (Manipur), Pong Dam Lake (Himachal Pradesh), Roopar (Punjab), Rudrasagar Lake (Tripura) and Chilika Lake (Orissa), have been studied to understand some aspects of ecosystem service. There are limited studies related to the supporting and regulating services provided by the wetlands in India. Besides, our analysis also revealed that in most of the studies economic analysis has not been done. It may be mentioned that all wetlands, irrespective of their designation as Ramsar sites, have their own intrinsic value. The importance of wetlands needs to be acknowledged and revealed through various scientific studies. Such in-depth research would be able to link up overall ecology of the wetland with human welfare. Through such studies, the ecosystem people and management authorities would be able to appreciate the link between healthy ecosystem and human well being. This would motivate the involvement of the local masses in safeguarding and managing their wetlands and various wetland resources in a sustainable way. It would also help the policy makers in designing diverse management strategies for different wetlands based on their potential ecological functions in the region.

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