WETLANDS

Chapter 4

Wetlands Ecosystem

Look deep into nature and you will understand everything better

-Albert Einstein

Introduction

4.1 Life is sustained on planet Earth by various kinds of natural resources. With the growing or flourishing economy, the vital natural resources are excessively used which causes the depletion of natural resources. It is increasingly being realized that the planet Earth is facing grave environmental problems, with fast depleting natural resources threatening the very existence of many ecosystems. Wetlands is considered one of the most important threatened ecosystems.

4.2 Wetlands are considered the world's most productive ecosystem – they provide food, sequester carbon, help in flood control, recharge groundwater. Also, vegetation that grows in wetlands is consumed in various ways viz. to build mats, houses, as wildlife refuge, and as food. Wetlands are the areas of land that are either seasonally and permanently covered by water, or nearly saturated by water. Following are the definitions[1] of wetlands provided by the different agencies:

(i) *Ramsar Convention, 1971, Article 1.1*: "Areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters".

(ii) *International Union for the Conservation of Nature and Natural Resources (IUCN,1965):* "Submerged or water saturated lands, both natural and man-made, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters".

(iii) *Ramsar Convention Modified Ramsar/IUCN Definition Amenable to Remote Sensing*: "All submerged or water saturated lands, natural or manmade, inland or coastal, permanent or temporary, static or dynamic, vegetated or non-vegetated, which necessarily has a land- water interface".

(iv) As per the Ramsar Convention: 'In addition, to protect coherent sites especially waterflow habitat, Article 2.1 of the Convention provides that 'wetlands may include riparian and coastal zones adjacent to the wetlands, and islands or

[1] Wetlands Decadal Change Atlas

bodies of marine water deeper than six meters at low tide lying within the wetlands.'

4.3 There exist marine and coastal wetlands such as open coasts, coral reefs, estuaries, tidal flats, mangroves and coastal lagoons; Inland wetlands such as permanent and seasonal rivers, inland deltas and floodplains, permanent and seasonal lakes and ponds, marshes, freshwater swamps and peatlands as well as Human-made wetlands such as reservoirs, barrages and dams, aquaculture ponds, excavations and burrow pits, wastewater treatment ponds, irrigation canals, ditches, irrigation ponds and rice fields. Often these wetland types are interlinked hydrologically and ecologically, merging into one another and the larger landscapes. Wetlands should, therefore, be considered as part of the river basin or coastal zone.

4.4 Wetlands are central to meeting many of the United Nation's 17 Sustainable Development Goals (SDGs) and 169 associated targets, focusing on poverty, hunger, health, energy, consumption and climate change. One of the difficulties most frequently faced for decision-making is lack of scientific data of our natural resources. Often the data are sparse or unconvincing, rarely in the form of geospatial database (map), thus open to challenges. Thus, the current thrust of every country is to have an appropriate geospatial database of natural resources that is based on unambiguous scientific methods[2]. Regular updation of the status of the wetlands is more significant in view of accelerating pressure on the very existence of these resources due to developmental activities and population pressure being witnessed currently. Over a period of time, the database of wetlands has been widely used in developmental activities that require environmental clearances etc. Aquatic biodiversity is dependent on hydrologic regime; geological conditions and efforts are being made to conserve the biodiversity found in wetlands, streams and rivers. The goal of this irreplaceable biodiversity is to minimize its loss through sustainable management and conservation practices (Groombridge & Jenkins 1998)[3]. In India, lakes, rivers and other freshwaters support a large diversity of biota representing almost all taxonomic groups[4]. Algae in open waters represent the floristic diversity and macrophytes dominate the wetlands. Wetlands are also important as resting sites for migratory birds. Aquatic vegetation is a valuable source of food, especially for waterfowl. In the winter, migratory waterfowl search the sediment of wetlands for nutritious seeds, roots and tubers (Tiner, 1999)[5].

[2] National Wetland Atlas: Jharkhand
[3] Groombridge, B., & Jenkins, M. (1998). Freshwater biodiversity: a preliminary global assessment.
[4] Ramachandra T.V. and Ahalya N., Conservation and Management Of Wetland Ecosystems In Karnataka
[5] Tiner, R. W. 1999. Wetland Indicators: a Guide to Wetland Identification, Delineation, Classification, and Mapping. Lewis Publishers

Indian Wetlands

4.5 Indian land mass is characterised by highly diversified climate, landforms and landscapes spreading over high altitude mountain system, long coastline, surface and subsurface geological formations, forests types and various land cover systems. The interactive processes among these natural regions lead to formation of wetland ecosystems. Natural wetlands in India consists of the high-altitude Himalayan lakes, followed by wetlands situated in the flood plains of the major river systems, saline and temporary wetlands of the arid and semi-arid regions, coastal wetlands such as lagoons, backwaters and estuaries; mangrove swamps; coral reefs and marine wetlands etc.

4.6 India supports [6] unique geographical diversity and different climatic zones, which in turn supports diverse wetland habitats throughout the subcontinent and covers nearly 58.2 million hectares. India is one of the Contracting Parties to Ramsar Convention, signed in Ramsar, Iran, in 1971. India signed it on 1st Feb, 1982 and since then designated 75 Wetlands[7] under the list of Wetlands of International Importance.

4.7 Wetlands of the Indian continent are unique due to their interaction with human populations for several millennia. Wetlands and their resources have been an integral part of the social and cultural ethos of human societies in this region.

Types of Wetlands

4.8 The first national level wetlands inventory was prepared in 2006-07. Since, almost a decade has already been passed, a need was felt to reassessing the current status of wetlands at national level in comparison with the database of 2006-07. Space Applications Centre, Indian Space Research Organization (ISRO), Ahmedabad has carried out project on "National Wetland inventory and Assessment-2nd Cycle". The major objectives of the project are to generate a current status of existing (2006-07) wetlands and geo-database of National wetlands (1:50k scales and area >= 2.25 ha) using Resourcesat-2/2A, LISS-III sensor data of 2017-18. The project has followed similar methodology as used in the case of earlier 2006-07 inventory. A wetland classification system based on IUCN/RAMSAR definition and amenability on remotely sensed data is used to categorize the wetlands. The wetland classification categorizes inland and coastal wetlands as level-I followed by natural and man-made wetlands as level-II, which were further categorized using a hierarchical system into 20 types of wetlands as level-III classes, excludes rice fields. Each wetland type also exhibits a wide diversity in terms of shape, size, distribution, water quality etc., which are well captured on the satellite imagery. The methodology to create the wetland database is adhered to NWIA technical

[6] Invasive Alien Species: threat to inland wetlands of India: Centre for Biodiversity Policy and Law (CEBPOL)
[7] https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1851484

guidelines manual (Garg and Patel, 2007)[8]. Wetlands inventory of 2006-07 (for wetlands area >= 2.25 ha) was updated for interpretational changes by using time series google images and ground information, after which updated figures of wetland number and area have been estimated. The details of National Wetlands Classification System are given in the **Table 4.1** and different wetlands types presented in the **Figure 4.1** below:

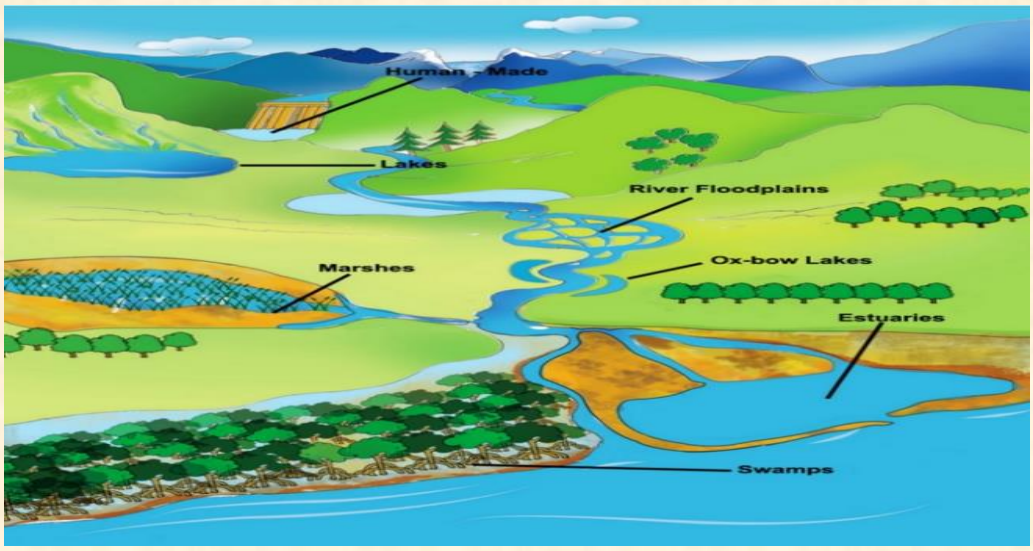
Table 4.1: Classification of India's Wetlands System

Level-I	Level-II Code	Level-III Code
Inland Wetlands	**Natural (1100)**	**1101:** Lakes
		1102: Ox-Bow Lakes/Cut-off Meanders
		1103: High altitude Wetlands
		1104: Riverine Wetlands
		1105: Waterlogged (natural)
		1106: River/Stream
	Man-made (1200)	**1201:** Reservoirs/Barrages
		1202: Tanks/Ponds
		1203: Waterlogged (man-made)
		1204: Salt Pans (inland)
		1205: Aquaculture ponds (inland)
Coastal Wetlands	**Natural (2100)**	**2101:** Lagoons/Backwaters
		2102: Creek
		2103: Sand/Beach
		2104: Intertidal mud flats
		2105: Salt marsh
		2106: Mangroves
		2107: Coral Reefs
	Man-made (2200)	**2201:** Salt Pans (Coastal)
		2202: Aquaculture ponds (coastal)

Source: Wetland Classification System (Ref: Garg J.K. and Patel J. G., 2007)

[8] Garg J K and Patel J G, (2007). National Wetland Inventory and Assessment, Technical Guidelines and Procedure Manual, Technical Report, SAC/EOAM/AFEG/NWIA/TR/01/2007, June 2007, Space Applications Centre, hmedabad.

Figure 4.1: Wetland Types



Source: https://indianwetlands.in/wetlands-overview/wetland-types/

4.9 At level II, Indian wetlands are classified into two major groups namely Natural and Man-made and details are given below. According to the Wetland Decadal Change Atlas (2006-07 to 2017-18), the total natural wetlands area is 10.64 Mha (66.6%) whereas 5.34 Mha area (33.4%) is covered under man-made category. In comparison to the man-made wetlands area, natural wetlands area is approximately two times.

i. **Natural Wetlands:** It consist of the high-altitude Himalayan lakes, wetlands in the flood plains of the major river, saline and temporary wetlands of the arid and semi-arid regions and coastal wetlands including lagoons, backwaters, estuaries, mangrove swamps and coral reefs.

ii. **Man-made Wetlands:** These are wetlands built for a purpose, such as storing water for irrigation and drinking or for producing fish or for recreation. Reservoirs, aquaculture ponds, salt pans, dams, barrages, inland lakes and impoundments, traditional village ponds are some examples of human-made wetlands.

4.10 The definition and description of different types of wetlands at Level III are defined[9] as follows:

- ***1101-Lakes*:** Larger bodies of standing water occupying distinct basin. These wetlands occur in natural depressions and normally fed by streams/rivers. On satellite images, lakes appear in different hues of blue interspersed with pink (aquatic vegetation), islands (white if unvegetated, red in case of terrestrial vegetation). Vegetation if scattered, make the image texture rough. Lakes and ponds (also known as the lentic systems) are a diverse set of inland fresh water

[9] Space based observation of Indian Wetlands, Space Application Centre, ISRO, Ahmedabad, Gujarat

habitats that provide essential resources and habitats for both terrestrial and aquatic organisms.

- ***1102-Ox-Bow Lakes/Cut-off Meanders*:** A meandering stream may erode the outside shores of its broad bends and in time, the loops may cut-off, leaving basins. The resulting shallow crescent shaped lakes are called Ox-bow lakes. On the satellite image Ox-bow lakes occur near the rivers in plain areas. Some part of the lake normally has aquatic vegetation (red/pink in colour) during pre-monsoon season.
- ***1103-High altitude Wetlands*:** These lakes occur in the Himalayan region. Landscapes around high lakes are characterized by hilly topography. Otherwise they resemble lakes in the plain areas. The wetland is a distinct ecosystem that is flooded by water, either permanently (for years or decades) or seasonally (for weeks or months). For keeping uniformity in the delineation of these lakes, contour line of 3000 m above msl is taken as reference and all lakes above this contour line are classified as high-altitude lakes.
- ***1104-Riverine Wetlands*:** Along the major rivers, especially in plains, water accumulates leading to formation of marshes and swamp. Marshes are dominated by herbaceous plants and are sustained by water sources other than direct rainfall like surface runoff, groundwater or tidal flow. Swamps are 'Wetland dominated by trees or shrubs'. They have poor drainage and sufficient water supply to keep the ground waterlogged and level of minerals to stimulate decay of organism and prevent accumulation of organic materials.
- ***1105-Waterlogged (natural)*:** An area in which water stands near, at, or above the land surface, so that the roots of all plants except hydrophytes are drowned and the plants die. Sometimes, man-made activities like canals cause waterlogging in adjacent areas due to seepage especially when canals are unlined. Floods or unlined canal seepage and other irrigation network may cause waterlogging. Spectrally, during the period when surface water exists, waterlogged areas appear more or less similar to lakes/ponds. However, during dry season large or all parts of such areas dry up and give the appearance of mud/salt flats (grey bluish).
- ***1106-River/Stream*:** Rivers are linear water features of the landscape. Rivers that are wider than the mapping unit will be mapped as polygons. Its importance arises from the fact that many stretches of the rivers in Indo-Gangetic Plains and peninsular India are declared important national and international wetlands (Ex. The river Ganga between Brajghat and Garh Mukteshwar, is a Ramsar site, Ranganthattu on the Cavery river is a bird sanctuary etc.). Wherever, rivers are wide and features like sand bars etc. are visible, they are mapped.
- ***1201-Reservoirs*:** A pond or lake built for the storage of water, usually by the construction of a dam across a river. On Remote Sensing images, reservoirs have irregular boundary behind a prominent dyke. Wetland boundary in case of reservoir incorporates water, aquatic vegetation and footprint of water as well. In the accompanying images aquatic vegetation in the reservoir is seen in bright pink tone. Tone is dark blue in deep reservoirs while it is ink blue in case of shallow

reservoirs or reservoirs with high silt load. These are annotated as Reservoirs/Dam.

- ***1201-Barrages*:** Dykes are constructed in the plain areas over rivers for creating Irrigation/water facilities. Such water storage areas develop into wetlands (Harike Barrage on Satluj – a Ramsar site, Okhla barrage on the Yamuna, a bird sanctuary etc.). Water appears in dark blue tone with a smooth texture. Aquatic vegetation appears in pink colour, which is scattered, or contiguous depending on the density. Reservoirs formed by barrages will be annotated as reservoir/barrage.
- ***1202-Tanks/Ponds*:** A term used in Ceylon and the drier parts of Peninsular India for an artificial pond, pool or lake formed by building a mud wall across the valley of a small stream to retain the monsoon. Ponds generally, suggest a small, quiet body of standing water, usually shallow enough to permit the growth of rooted plants from one shore to another. Tanks appear in light blue colour showing bottom reflectance. In this category, Industrial ponds/mining pools mainly comprising 'Abandoned Quarries' are also included. 'Ash pond' are the water body created for discharging effluents in industry, especially in thermal power plants and 'Cooling pond' is an artificial lake used for the natural cooling of condenser-cooling water serving a conventional power station. These ponds can be of any shape and size. Texture is rough and tonal appearance light (quarry) to blue shade (cooling pond).
- **1203-Waterlogged(man-made):** Man-made activities like canals cause waterlogging in adjacent areas due to seepage especially when canals are unlined. Such areas can be identified on the images along canal network. Tonal appearance is in various hues of blue. Sometimes, such waterlogged areas dry up and leave white scars on the land. Texture is smooth.
- ***1204-Salt Pan (inland)*:** Salt Pans are shallow rectangular man-made depressions in which saline water is accumulated for drying in the sun for making salt.
- ***1205-Aquaculture ponds*:** Aquaculture is defined as "The breeding and rearing of fresh-water or marine fish in captivity, Fish farming or ranching". The water bodies used for the above are called aquaculture ponds. Aquaculture ponds are geometrical in shape usually square or rectangular. Tone is blue.
- ***2101-Lagoons/Backwaters*:** Such coastal bodies of water, partly separated from the sea by barrier beaches or bass of marine origin, are termed lagoons. As a rule, lagoons are elongated and lie parallel to the shoreline. They are usually characteristic of, but not restricted to, shores of emergence. Lagoons are generally shallower and more saline than typical estuaries. Backwater is an arm of the sea or series of connected lagoons, usually parallel to the coast, separated from the sea by a narrow strip of land but communicating with it through barred outlets.
- **2102-Creeks:** A notable physiographic feature of salt marshes, especially low marshes. These creeks develop as do rivers "with minor irregularities sooner or

later causing the water to be deflected into definite channels". Creeks will be delineated however their area will not be estimated.

- ***2103-Sand/Beach*:** Beach is an unvegetated part of the shoreline formed of loose material, usually sand that extends from the upper berm (a ridge or ridges on the backshore of the beach, formed by the deposit of material by wave action, that marks the upper limit of ordinary high tides and wave wash) to low water mark. Beach comprising rocky material is called rocky beach.
- ***2104-Intertidal mud flats*:** Most unvegetated areas that are alternately exposed and inundated by the falling and rising of the tide. They may be mudflats or sand flats depending on the coarseness of the material of which they are made.
- ***2105-Salt Marshes*:** Natural or semi-natural halophytic grassland and dwarf brushwood on the alluvial sediments bordering saline water bodies whose water level fluctuates either tidally or non- tidally. Salt marshes look in grey blue shade when wet.
- ***2106-Mangroves*:** The mangrove swamp is an association of halophytic trees, shrubs, and other plants growing in brackish to saline tidal waters of tropical and subtropical coastlines. They are the coastal swamps bordering major deltas of the country. On the satellite images mangroves occur in red colour if in contiguous patch. When mangrove associations are scattered or are degraded then instead of red colour, brick red colour may be seen.
- ***2107-Coral Reefs*:** Consolidated living colonies of microscopic organisms found in warm tropical waters. The term coral reef, or organic reef is applied to the rock-like reefs built-up of living things, principally corals. They consist of accumulations of calcareous deposits of corals and corraline algae with the intervening space connected with sand, which consists largely of shells of foraminefera. Present reefs are living associations growing on this accumulation of past. Reefs appear in light blue shade.
- ***2201-Salt Pans (coastal)*:** An undrained usually small and shallow rectangular, man-made depression or hollow in which saline water accumulates and evaporates leaving a salt. Salt pans are square or rectangular in shape. When water is there appearance is blue, while when salt is formed, the tone is white.
- ***2202*-Aquaculture ponds (coastal): FAO has defined Aquaculture as the farming of aquatic organism, including fish, molluscs, crustaceans and aquatic plants. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. The water bodies used for the above are called aquaculture ponds. Aquaculture ponds are geometrical in shape usually square or rectangular. The tone is blue.

Services provided by the Wetlands

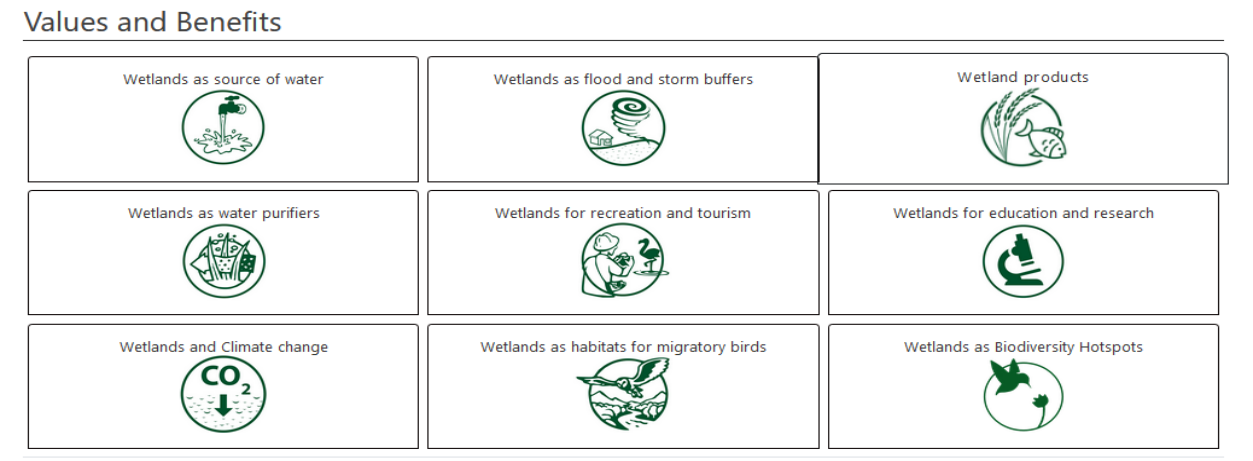
4.11 India has a large variety of freshwater, saline and marine wetlands. A vast majority of the inland wetlands are temporary and/or man-made. Not only have wetlands

influenced ways of human life, the people have traditionally depended on wetlands for millennia. Thus, even the most natural of the wetlands of the region, whether floodplains (e.g., those of the Brahmaputra basin) or marshes (e.g., Chaurs of Bihar, lake Kolleru in Andhra Pradesh), swamps (e.g., in the foothills of Himalaya and in south India), coastal lagoons (like Chilika and Pulicat) or mangroves (including Sundarbans) have been influenced by human use and management. The continued interaction between wetlands and the humans in various ways keeps their characteristics always changing, often unpredictably.

4.12 The diverse eco-climatic regimes extent in the country resulted in a variety of wetland systems ranging from high altitude cold desert wetlands to hot and humid wetlands in coastal zones with its diverse flora and fauna. India, with its annual rainfall of over 115 cm, varied topography and climatic regimes support and sustain diverse and unique wetland habitats. Natural wetlands in India consists of the high-altitude Himalayan lakes, followed by wetlands situated in the flood plains of the major river systems, saline and temporary wetlands of the arid and semi-arid regions, coastal wetlands such as lagoons, backwaters and estuaries; mangrove swamps; coral reefs and marine wetlands, and soon. In fact, with the exception of bogs, fens and typical salt marshes, Indian wetlands cover the whole range of the ecosystem types found. In addition to the various types of natural wetlands, a large number of man-made wetlands also contribute to the faunal and floral diversity. These man-made wetlands, which have resulted from the needs of majority of the inland wetlands are directly or indirectly dependent on the major rivers like, Ganga, Brahmaputra, Narmada, Godavari, Krishna, Kaveri, Tapti. They occur in the hot arid regions of Gujarat and Rajasthan, the deltaic regions of the east and west coasts, highlands of central India, wet humid zones of south peninsular India and the Andaman and Nicobar & Lakshadweep islands. India has a wealth of wetland ecosystems that support diverse and unique habitats. These wetlands provide numerous ecological goods and services but are under tremendous stress due to rapid urbanization, industrialization and agricultural intensification, manifested by the decline in the hydrological, economic and ecological functions they perform.

4.13 Wetlands constitute a vital ecosystem among all the terrestrial ecosystems occurring on land. The enormous diversity of wetlands ecosystems plays a crucial role in regulating the hydrological process, carbon-fixation, flood control, nutrient cycling, water quality, stores carbon dioxide and helps in climate change etc. These wetlands facilitate the recharge of the ground-water and fulfils the dietary requirements such as food and fisheries. They act as a filter through storing, assimilating and transforming the contaminants washed away from the land before reaching natural river systems. Utility wise, wetlands directly and indirectly support millions of people in providing services such as food, fibre and raw materials, storm and flood control, clean water supply, scenic beauty and educational, aesthetic and recreational benefits.

Figure 4.2: Values and Benefits of Wetlands



Source: https://indianwetlands.in/wetlands-overview/values-and-benefits/

Threats to the Wetlands

4.14 Globally wetlands and its biodiversity are getting depleted due to habitat destruction, pollution, overexploitation of aquatic resources, tourism and the introduction of invasive exotic species along with alien pathogens and parasites. Some of the major causes that can be attributed for the acute and chronic wetland losses are as follows:

Acute wetlands losses	Chronic Wetland Losses
Agricultural conversions	Alteration of upper watershed
Direct deforestation in wetlands	Degradation of water quality
Hydrological Alterations	Ground water depletion
Inundation by dammed reservoirs	Introduced species and extinction of native biota

4.15. Recognizing the importance of protecting such waterbodies, the Government of India has taken up wetland conservation programme in 1985/86 and onwards in close collaboration with concerned State Governments. Several steps were taken to arrest further degradation and shrinkage of water bodies due to encroachment, siltation, weed infestation, catchment erosion, surface run-off carrying pesticides and fertilizers from agricultural fields, and discharge of domestic sewage and effluents, which resulted in deterioration of water quality, prolific weed growth, decline in biodiversity and other associated problems.

4.16 India is signatory to the Ramsar Convention for management of the wetlands, thus extending the scope of conserving the biodiversity and wise use to a wide variety of habitats including rivers and lakes, coastal lagoons, mangroves, peatlands, coral reefs as well as numerous human-made wetlands. The government has identified a number of wetlands for conservation and management under the National Wetlands Conservation Programme and helps the local government implement the Management Action Plan for these wetlands.

Extent of Wetlands in India

4.17 The extent of an ecosystem is the starting point for the compilation of the accounts. It records the total area of each ecosystem classified by type within the ecosystem accounting area. Ecosystem extent accounts are measured over time by ecosystem type, thus illustrating the changes in extent from one ecosystem type to another over the accounting period. During the past two decades, wetlands have received increasingly greater attention, from the view point of their hydrology, ecology as well as conservation. Large seasonal and year to year variations occur in the water level of rivers, lakes and reservoirs. In terms of wetland habitats, a large majority of wetlands in the region is therefore not only seasonally temporary but many of them often appear and disappear in successive years.

4.18 The concern for conservation and management of wetlands is increasing all over the globe including India, due to burgeoning population pressure and developmental activities. In order to manage wetlands effectively, information of its spatio-temporal variations is a pre-requisite, which can be generated over a period of time using images acquired by orbiting satellite. Earth observation from orbiting satellites has been highly effective for providing wealth of data and information over the earth surface with wide spatial coverage and temporal revisits. Systematic approaches involving judicious combination of conventional ground measurements and remote sensing techniques pave way for achieving optimum planning, conservation and sustainable exploitation of wetland systems. The first ever scientific database of 2006-07 on Indian wetlands was prepared by ISRO at the behest of Ministry of Environment, Forest and Climate Change (MoEF&CC) which is considered as benchmark in the wetland information of India. The digital database created under this mapping included the island territories. The objective of the project was to generate a current status of the existing wetlands and geo-database of National wetlands using remote sensing data.

4.19 Over the years it was realised to update the first wetlands inventory and therefore "National Wetland Inventory and Assessment- 2nd cycle" was undertaken by Space Applications Centre (SAC), Ahmedabad at the request of Ministry of Environment, Forests and Climate change in 2019. The summary of the results of this satellite-based mapping activities has been brought out in the form of an Atlas. This National Atlas highlights current status of wetlands along with decadal changes in terms of statistics, maps, satellite images, field photographs etc., for the entire country to provide useful

understanding the status and distribution of wetlands. The category-wise distribution of wetlands in India in 2006-07 and 20178-18 along with the change in the area during the period is given in the **Table 4.2** below:

Table 4.2: Area of Wetlands in India

(Area in Hectare)

Sr. No.	Wetland Type		2017-18		2006-07		Change
			Wetland Area	% of wetland area	Wetland Area	% of wetland area	Wetland Area
1	Inland	Natural	7015718	43.9	6931772	45.2	83946
2		Man-made	4834232	30.2	4311366	28.1	522866
3	Coastal	Natural	3620451	22.7	3694412	24.1	-73961
4		Man-made	511115	3.2	402284	2.6	108831
Total			**15981516**	**100**	**15339834**	**100**	**641682**

Source: Space based observation of Indian wetlands, SAC

4.20 The total wetland area estimated is 15.98 million hectare (Mha), which is around 4.86 percent of the total geographic area of the country. A total of 2,31,195 wetlands having area more than 2.25 hectare have been mapped at 1:50,000 scale during 2017-18. The extent of wetlands in India by type in 2017-18 and in 2006-07 are shown in **Table 4.3** along with the changes that occurred during the decade. The state-wise opening and closing extent of wetlands with changes therein between the years 2006-07 and 2017-18 are given in **Table 4.4. Table 4.5** shows decadal wetland inventory and change analysis in major river basins in India and the distribution is shown for the biogeographic zones in **Table 4.6**. State-wise and Class-wise details on extent of wetlands are given in **Annexure 4.1**. The total addition in wetland's area can be attributed to new wetlands added as well as the area expansion of existing wetlands.

Table 4.3 Extent of Wetlands and Decadal Changes

Wetland Type	2006-07 (Opening Stock)	New	Disappeared	Net Other Changes	2017-18 (Closing Stock)
Level -III	Area (ha)	Area (ha)	Area (ha)	Area (ha)	Area (ha)
INLAND Natural					
Lake/Pond	6,88,507	0	0	3,616	692,123
Ox-bow lake/ cut-off meander	1,10,812	1,448	158	1,327	113,429
High altitude lake	1,21,490	140	33	8,848	130,445
Riverine Wetlands	98,328	11,057	115	-9,870	99,400
Waterlogged	2,78,318	5,442	5,880	-6,119	271,761
River/Stream	56,34,317	0	0	74,243	5708,560
INLAND Natural: Total	**69,31,772**	**18,087**	**6,186**	**72,045**	**7015,718**
INLAND Man-made					
Reservoir/Barrage	24,25,119	1,86,006	0	1,24,244	27,35,369
Tank/Pond	16,69,134	85,155	4,334	64,247	18,14,202

Wetland Type	2006-07 (Opening Stock)	New	Disappeared	Net Other Changes	2017-18 (Closing Stock)
Waterlogged	95,240	5,428	4,558	96	96,206
Salt pan	13,105	1,683	0	4,769	19,557
Aquaculture Pond	1,08,768	43,099	5,276	22,308	1,68,899
INLAND Manmade Total	**43,11,366**	**3,21,371**	**14,168**	**2,15,664**	**48,34,233**
INLAND: TOTAL	**1,12,43,138**	**3,39,458**	**20,354**	**2,87,709**	**1,18,49,951**
COASTAL Natural					
Lagoon	2,15,827	0	0	113	2,15,940
Creek	2,28,039	0	0	26,929	2,54,968
Sand/Beach	44,726	171	73	-3	44,821
Intertidal mud flat	24,19,416	966	185	-1,17,678	23,02,519
Salt Marsh	1,53,835	1,462	473	-6,636	1,48,188
Mangrove	4,87,318	1,987	553	17,228	5,05,980
Coral Reef	1,45,251	0	0	2,784	1,48,035
COASTAL Natural Total	**36,94,412**	**4,586**	**1284**	**-77,263**	**36,20,451**
COASTAL Man-made					
Salt pan	1,60,672	2,483	207	90,863	2,53,811
Aquaculture pond	2,41,612	15,141	3,444	3,995	2,57,304
COASTAL Man-made Total					
	4,02,284	**17,624**	**3,651**	**94,858**	**5,11,115**
COASTAL Total	**40,96,696**	**22,210**	**4,935**	**17,595**	**41,31,566**
TOTAL	**1,53,39,834**	**3,61,667**	**25,289**	**3,05,304**	**1,59,81,516**

Source: Gupta, P K, J G Patel, R P Singh, I M Bahuguna, R Kumar et al. (2021). Satellite based observation of Indian wetlands, Space Applications Centre, ISRO, Ahmedabad. ISBN: 9789382760436. Available on VEDAS web portals (vedas.sac.gov.in)

It may be noted that the 'Net Other Changes' Include the changes in the wetland area occurring due to changes other than occurrence of a new wetland or disappearance of existing wetlands.

(i) The positive changes explain that the spreading out of the existing wetlands is greater than the shrinkages and vice versa.

(ii) Expansions may be due to conversion of one class of wetland to another, river changing its course, shift in precipitation patterns etc.

(iii) The shrinkages of the wetlands may be attributed to conversion of one class of wetland to another, development activities etc.

(iv) Further analysis can be attempted with the availability of the change matrix for these categories of wetlands.

Table: 4.4: Extent of wetlands and decadal change in different States

Sr. No.	State Name	2017-18			2006-07			Decadal Change
		Number	Area (ha)	Area (% of wetland)	Number	Area (ha)	Area (% of wetland)	Area (ha)
1	Andhra Pradesh	24,104	1141606	7.14	23,022	10,75,099	7.01	66,507
2	Arunachal Pradesh	1,182	1,51,104	0.95	1,164	1,47,914	0.96	3,190
3	Assam	5,902	8,49,078	5.31	5,596	7,89,217	5.14	59,861
4	Bihar	4,526	3,74,766	2.34	4,555	3,89,713	2.54	-14,947

Sr. No.	State Name	2017-18			2006-07			Decadal Change
		Number	Area (ha)	Area (% of wetland)	Number	Area (ha)	Area (% of wetland)	Area (ha)
5	Chhattisgarh	11,457	3,42,443	2.14	10,863	3,27,274	2.13	15,169
6	Goa	742	24,749	0.15	537	21,934	0.14	2,815
7	Gujarat	17,613	34,99,429	21.9	14,734	34,49,413	22.49	50,016
8	Haryana	1,905	33,649	0.21	1,546	29,710	0.19	3,939
9	Himachal Pradesh	215	94,011	0.59	204	93,383	0.61	628
10	Jharkhand	2,635	1,87,045	1.17	2,477	1,80,668	1.18	6,377
11	Karnataka	14,936	7,87,127	4.93	14,457	7,87,104	5.13	23
12	Kerala	1,399	1,58,336	0.99	1,396	1,54,453	1.01	3,883
13	Madhya Pradesh	13,947	8,61,736	5.39	10,570	7,59,016	4.95	1,02,720
14	Maharashtra	25,935	11,52,625	7.21	20,735	9,82,620	6.41	1,70,005
15	Manipur	132	67,408	0.42	139	62,657	0.41	4,751
16	Meghalaya	225	31,002	0.19	222	30,875	0.2	127
17	Mizoram	127	19,476	0.12	103	13,791	0.09	5,685
18	Nagaland	148	21,118	0.13	142	21,050	0.14	68
19	Odisha	13,331	7,19,942	4.5	12,003	6,92,027	4.51	27,915
20	Punjab	1,190	47,024	0.29	1,245	48,389	0.32	-1,365
21	Rajasthan	13,321	7,78,824	4.87	12,638	7,51,274	4.9	27,550
22	Sikkim	259	7,049	0.04	245	6,587	0.04	462
23	Tamil Nadu	26,883	9,25,712	5.79	27,011	9,24,848	6.03	864
24	Telangana	12,338	5,66,680	3.55	10,058	4,99,563	3.26	67,117
25	Tripura	416	18,438	0.12	402	14,196	0.09	4,242
26	Uttar Pradesh	18,555	11,04,562	6.91	19,069	10,94,024	7.13	10,538
27	Uttarakhand	172	1,12,882	0.71	173	1,01,771	0.66	11,111
28	West Bengal	12,955	11,30,127	7.07	12,830	11,14,729	7.27	15,398
29	Andaman&Nicobar	2,774	1,43,238	0.9	2,445	1,53,611	1	-10,373
30	Chandigarh	11	336	0	10	335	0	1
31	Dadra NagarHaveli	12	2,063	0.01	11	2,016	0.01	47
32	Daman and Diu	59	2,728	0.02	55	2,834	0.02	-106
33	Delhi	123	2,773	0.02	114	2,537	0.02	236
34	Jammu & Kashmir	404	1,64,110	1.03	403	1,64,230	1.07	-120
35	Lakshadweep	50	79,716	0.5	1,036	79,728	0.52	-12
36	Ladakh	1,073	3,73,049	2.33	50	3,65,294	2.38	7,755
37	Puducherry	139	5,555	0.03	125	5,950	0.04	-395
	Total	2,31,195	1,59,81,516	100	2,12,385	1,53,39,834	100	6,41,682

Source: Gupta, P K, J G Patel, R P Singh, I M Bahuguna, R Kumar et al. (2021). Satellite based observation of Indian wetlands, Space Applications Centre, ISRO, Ahmedabad

Table 4.5: Decadal wetland inventory and change analysis in different River basins

Sr. No.	Basin	2017-18			2006-07			Decadal Change		Disappeared		New	
		Number	Area (ha)	Area (% of wetland)	Number	Area (ha)	Area (% of wetland)	Numbers	Area (ha)	Number	Area (ha)	Number	Area (ha)
1	Indus	3,003	555631	3.48	2995	553106	3.61	8	2525	124	850	153	3602
2	Ganga	56,002	3751891	23.48	53460	3648472	23.78	2542	103419	478	10143	3263	86662
3	Luni and Rivers of Saurastra	14,135	3178527	19.89	11824	3131167	20.41	2311	47360	27	1508	1047	16114
4	Sabarmati	3,489	172311	1.08	3067	168967	1.10	422	3344	12	212	410	3032
5	Mahi	4,113	171407	1.07	3660	165976	1.08	453	5431	0	0	440	4819
6	Narmada	3,892	448969	2.81	3055	425482	2.77	837	23487	10	115	854	18702
7	Tapi	3,900	263613	1.65	3230	240676	1.57	670	22937	23	98	466	12776
8	Godavari	24,029	1235931	7.73	20120	1110521	7.24	3909	125410	59	348	2592	93006
9	Krishna	31,688	1668866	10.44	27520	1530349	9.98	4168	138517	324	7190	2853	74132
10	Cauvery	8,457	305463	1.91	8351	304729	1.99	106	734	5	90	104	687
11	Rivers Between Krishna and Cauvery	15,426	563947	3.53	15513	565234	3.68	-87	-1287	126	2306	137	1883
12	Mahanadi	16,628	505512	3.16	15932	486482	3.17	696	19030	29	337	525	15957
13	West South Coast Rivers	21,168	975614	6.10	20119	936001	6.10	1049	39613	47	678	634	8511
14	Rivers Between Mahanadi and Godavari	8,873	318760	1.99	8226	303507	1.98	647	15253	6	123	474	5689
15	Brahmini-Baitrani	2,939	191934	1.20	2448	184528	1.20	491	7406	3	10	378	3234
16	Subernrekha	1,567	74420	0.47	1346	68473	0.45	221	5947	1	2	176	1331

Sr. No.	Basin	2017-18			2006-07			Decadal Change		Disappeared		New	
		Number	Area (ha)	Area (% of wetland)	Number	Area (ha)	Area (% of wetland)	Numbers	Area (ha)	Number	Area (ha)	Number	Area (ha)
17	Brahmaputra Barak & others	9,032	12,44,752	7.79	8925	1157773	7.55	107	86979	22	339	303	11436
18	Others	2,854	3,53,969	2.21	2594	358394	2.34	260	-4425	46	941	14	94
Total		**2,31,195**	**1,59,81,516**	**100**	**212385**	**15339834**	**100**	**18810**	**641682**	**1342**	**25289**	**14823**	**361667**

Source: Gupta, P K, J G Patel, R P Singh, I M Bahuguna, R Kumar et al. (2021). Satellite based observation of Indian wetlands, Space Applications Centre, ISRO, Ahmedabad (ISBN: 9789382760436)

Note: wetlands database of 2006-07 was updated by incorporating interpretational changes

Table 4.6: Decadal wetland inventory and change analysis in different Bio-Geographic zones

Sr. No.	Bio-Geographic zones	2017-18			2006-07			Decadal Change		Disappeared		New	
		Number	Area (ha)	Area (% of wetland)	Number	Area (ha)	Area (% of wetland)	Numbers	Area (ha)	Number	Area (ha)	Number	Area (ha)
1	Trans Himalaya	1,318	3,96,669	2.48	1,276	3,88,039	2.53	42	8,631	7	37	27	141
2	Himalaya	1,769	3,11,404	1.95	1,762	2,99,415	1.95	7	11,989	0	0	23	1,003
3	Desert	4,098	3,31,475	2.07	3,749	3,15,931	2.06	349	15,544	7	1,209	316	6,772

Sr. No.	Bio-Geographic zones	2017-18			2006-07			Decadal Change		Disappeared		New	
		Number	Area (ha)	Area (% of wetland)	Number	Area (ha)	Area (% of wetland)	Numbers	Area (ha)	Number	Area (ha)	Number	Area (ha)
4	Semi-arid	30,629	17,23,351	10.78	27,523	16,50,777	10.76	3,106	72,574	224	2,029	2,989	58,123
5	Western Ghats	4,829	4,16,887	2.61	4,134	3,81,330	2.49	695	35,557	12	95	519	7,802
6	Deccan Peninsula	1,30,940	52,81,133	33.05	1,19,637	49,32,452	32.15	11,303	3,48,681	396	6,215	8,347	2,09,416
7	Gangetic Plain	25,896	16,61,198	10.39	26,341	16,57,187	10.80	-445	4,012	359	8,860	419	15,988
8	Coasts	22,232	47,11,533	29.48	18,987	46,30,838	30.19	3,245	80,695	269	5,550	1,902	51,147
9	North-East	6,798	9,99,076	6.25	6,642	9,24,503	6.03	156	74,573	22	335	278	11,259
10	Islands	2,686	1,48,789	0.93	2,334	1,59,362	1.04	352	-10,573	46	959	3	14
Total		**2,31,195**	**1,59,81,516**	**100**	**2,12,385**	**1,53,39,834**	**100**	**18,810**	**6,41,682**	**1,342**	**25,289**	**14,823**	**3,61,667**

Source: Gupta, P K, J G Patel, R P Singh, I M Bahuguna, R Kumar et al. (2021). Satellite based observation of Indian wetlands, Space Applications Centre, ISRO, Ahmedabad (ISBN: 9789382760436)

Note: wetlands database of 2006-07 was updated by incorporating interpretational change

4.21 The decadal change in the extent of different wetlands types may be attributed to the anthropogenic activities and natural cycle processes. Some observations related to major changes in the area of different wetland classes are listed below:

Inland Wetlands: There is significant increase (approx. 5.4%) in inland wetlands category. This may be due to development of soil and water conservation structures such as reservoirs/Barrages, tank & ponds etc.

***Inland Natural Wetlands*:** There is no significant change but slight increase (1.2%) in the extent of inland natural wetlands, and this may be due to spreading of existing wetlands, shift in precipitation pattern over land due to climate change etc.

- The area under Oxbow Lakes/Cut off meanders has increased and this may be due to shifting in the river course (mainly in major rivers such as Brahmaputra, Ganga, Godavari etc.) in last 10 years (2006-07 to 2017-18).

- The extent of High-Altitude wetlands area has increased by 7.8% probably due to the melting of Glacier & snow and change in precipitation pattern which might have contributed for the formation of fresh natural Lakes.

- Slight increase in the extent of riverine wetlands may be due to the spreading of existing wetlands in the major rivers flood plains for example river Ganga.

- Reduction in the waterlogged-natural and increase in waterlogged-man-made classes may be attributed to developmental activities such as canal network, mining works etc.

***Inland Man-made Wetlands*:** significant increase in the area (Approx. 12%) of man-made wetlands are observed and this change may be due to new reservoirs/barrages, Tank & pond etc. which have come up in last 10 years.

- Under man-made category such as reservoirs/Barrages and Tank & Ponds, number as well as area have increased significantly. Tank & Pond is mainly constructed for irrigation purposes whereas reservoirs are for multi-purpose activities (Irrigation, drinking water supply etc.) including hydro-power.

- Significant increase in number as well as area of salt pans and aquaculture ponds is due to new salt pans nearby Sambhar Lake in Rajasthan and new aquaculture ponds nearby Loktak Lake in Manipur.

Coastal Wetlands

There is no overall significant change (< 1%) in the area of coastal wetlands. This is because of transition of one class to another in the coastal regions due to economic, local needs, natural processes etc.

***Coastal Natural*:** There is a slight reduction in the area (approx. 2%) of wetlands under coastal natural category which may be due to conversion of natural wetlands to man-made categories for example intertidal mud flat converted to salt pans, aquaculture ponds in Gujarat coastal regions.

- More than 10% increase in the area of creeks may be attributed to merging of creeks between mangroves for example in Gujarat coast.

- Significant decrease in the area (Approx. 4.8%) of intertidal mudflats. This change is mainly due to conversion of large area of intertidal mudflats to mangroves, saltpan and aquaculture ponds classes.

- Reduction in the area (approx. 3.7%) of Salt marshes is primarily due to conversion to other wetland classes such as salt pans, aquaculture ponds, intertidal mudflats etc.

- Minor increase in the area (< 2%) of coral reefs. This may be due to consolidation of fragmented coral reefs. There is slight increase of coral area in Gujarat, slight decrease in A&N and stable in Gulf of Munnar in Tamil Nadu.

- Increase in mangrove areas (approx. 3.8%) is due to conversion of intertidal mud flats, salt marsh etc. to mangroves along with new mangrove plantation/rejuvenation.

***Coastal Man-made*:** significant increase in the area (Approx. 27%) of man-made wetlands is observed in coastal regions, the reason being conversion of some of the natural wetlands to man-made category.

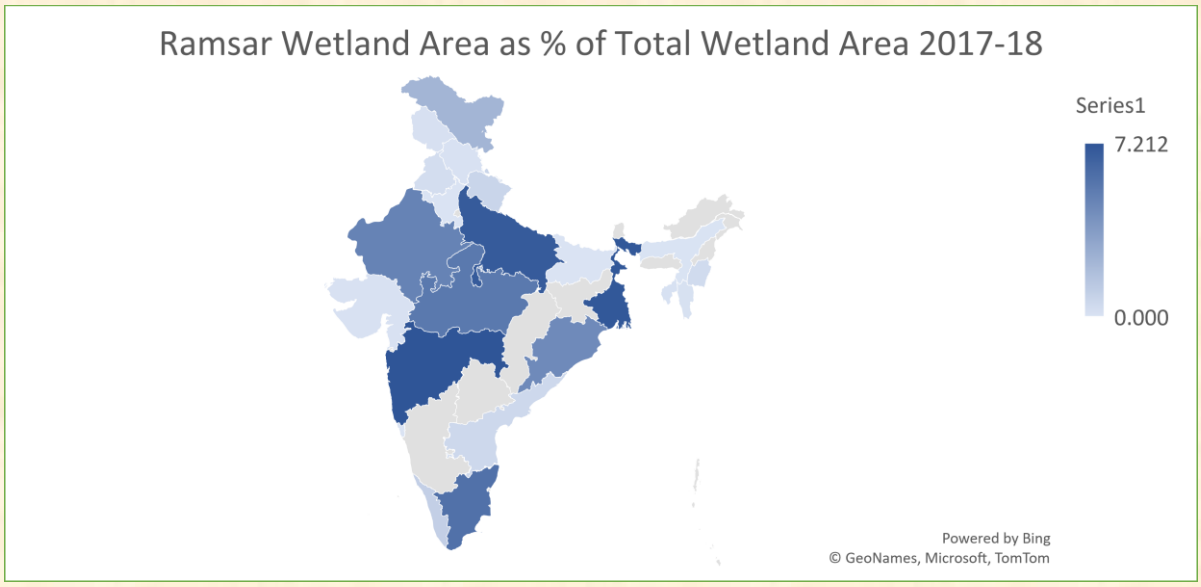
- Most Significant increase in the area (approx. 58%) of salt pans (coastal) is observed and this may be due to conversion of intertidal mud flats and salt marsh into salt pans.

- There is an increase in the area (Approx. 6.5%) of aquaculture ponds in the coastal region. Major contribution in the area has come up through transition of Salt pans, Salt marsh, coastal agriculture regions etc. into aquaculture ponds.

Ramsar Sites (Wetlands) in India

4.22 The Ramsar Convention[10] is an international treaty for the conservation and sustainable utilization of wetlands, recognizing the fundamental ecological functions of the wetlands and their economic, cultural, scientific and recreational value. According to the Ramsar Convention wetlands ecosystem in India constitute most of the natural water bodies (such as river, lakes, coastal lagoons, mangroves, peat land, coral reefs) and man-made wetlands (such as ponds, farm ponds, irrigated fields, sacred groves, salt pans, reservoirs, gravel pits, sewage farms and canals). The Ramsar Convention, in line with its mission to conserve and promote wise use of all wetlands, designates suitable wetlands for the list of Wetlands of International Importance (the "Ramsar List"), so as to bring focus on their effective management. After India became a party to the Ramsar Convention on Wetlands of International Importance in 1982 as an endorsement of its resolution to conserve the wetlands of the country, it has designated 75 Ramsar sites of international importance covering an area of 13,26,678 hectares as on 6th September, 2022. State-wise details of these Ramsar sites of India which are being managed as per the Ramsar mandate are given in **Annexure 4.2. Figure 4.3** shows Ramsar wetland area of the state as percentage of total wetland area of the country for the year 2017-18.

Figure 4.3: State wise Ramsar wetland as percentage of Wetlands Area



4.23 Wetlands provide habitat and refuge for biodiversity, and help build resilience of species to protect them from population decline. While India's National Biodiversity Action Plan (NBAP) acknowledges the importance of wetlands and aquatic systems for supporting biodiversity, it is important that the value of wetland ecosystems in helping to halt and reverse biodiversity decline is recognized more widely. The proper data on

[10] Faunal diversity in Ramsar Wetlands of India

the current status especially with regard to the endangered species are very important. In the endeavour to have the baseline data on the current status, the Chilika Development Authority (CDA) in collaboration with the Fishing Cat Project (TFCP) and Indian wing of Fishing Cat Conservation Alliance (FCCA)) conducted the world's first population estimation of the fishing cat done outside the protected area network. The study revealed having 176 fishing cats which are the only wild cat species in India that is a wetland specialist[11] and which is one of the globally threatened species. The Fishing Cat is a Schedule I species according to the Wildlife (Protection) Act, 1972[12], generally indicates the health of wetlands and coastal ecosystems, which are considered one of the major safeguards against climate change. Fishing cats are the apex predator in coastal areas. If they survive, it means the area is climate resistant. Fishing cats deserve conservation measures of the highest accord in India like the Tiger and Elephant. Unfortunately, marshland and mangrove ecosystems, which are Fishing Cat habitat are in decline. In view of this, CDA prioritized the need to conserve the habitat and its population in future. These kinds of tracking provide an indication of what might be happening to these ecosystems, which are safeguards against climate change and droughts. In order to have further information about the condition of the wetlands, Biodiversity for the Wetlands especially for the Mangroves and Estuaries have been provided later in this chapter.

Mangroves

4.24 India has a rich coastline which spans across 7,500 kilometres distributed along 9 coastal areas, 2 groups of islands and 4 union territories. These regions support coastal and marine ecosystems that are rich in biodiversity[13]. Mangroves are an essential part of these ecosystems. These[14] ecosystems occupy the boundary between land and sea. They consist of trees or large shrubs, including ferns and palms that normally grow in or adjacent to the intertidal zone. The Mangrove ecosystem is a distinct saline woodland habitat characterized by deposition of fine sediments on the coastal environment protected from high energy wave action. They are the woody halophytes growing in the boundary of land and the sea in the tropical and sub-tropical regions of the world[15].

4.25 Mangroves, also known as the 'Tidal Forests', 'Coastal Woodlands', 'Walking Forests in the Sea', 'Root of the Sea', 'Only Blue Carbon Forests' and 'Oceanic Rain forest' are the symbiotic links between the land and the sea. Mangrove Ecosystem forms one of

[11] https://www.chilika.com/documents/newsevents_1609467056.pdf
[12] https://legislative.gov.in/sites/default/files/A1972-53_0.pdf
[13] Conservation of Mangrove Forests- For fighting Coastal Disasters and Carbon Emissions; Terra Green, Volume 10, Issue 11, February 2018
[14] http://www.unesco.org/new/en/natural-sciences/environment/ecological-sciences/specific-ecosystems/mangroves/#:~:text=Mangroves%20are%20rare%20but%20spectacular,in%20saline%20coastal%20sediment%20habitats.
[15] Faunal Diversity of Mangrove Ecosystem in India, ZSI

the ecological sensitive marine habitats at the niche between the fresh water and marine environment. Mangrove[16] forests make up one of the most productive and biologically diverse ecosystems on the planet. They grow in a variety of depths of salt water, their roots sticking out of the mud, with fish crustaceans and a host of other species living between tree trunk.

4.26 Mangroves protect the coasts from ruinous effects of erosion and stabilize coastline thereby protecting the coastal population from cyclones and other natural calamities. They also serve as one of the most efficient carbon sequesters, and by sinking the carbon termed as 'Blue carbon', help in mitigating the impact of climate change[17]. They are the source of some highly valued commercial products and fisheries. They are also an attracting site for ecotourism. Their complex roots help in binding the soil and filter the pollutants reaching to the oceans.

4.27 According to the Forest Survey of India (FSI[18]), mangroves are salt tolerant plant communities found in tropical and sub-tropical intertidal regions of the world. Such areas are characterized by high rainfall (between 1000-3000 mm) and temperature (ranging between 26-35 degrees). Mangrove species exhibit a variety of adaptations in morphology, anatomy and physiology to survive in water logged solid, high salinity and frequent cyclonic storms. Succulent leaves, sunken stomata, aerial breathing roots called 'pnumatophores', vivipary, stilt roots, buttresses etc. are some of the adaptations exhibited by the mangroves.

4.28 Mangroves are important refuges of coastal bio-diversity and also act as bio-shields against extreme climatic conditions. Mangroves have the ability to absorb upto four times more carbon dioxide by area than upland terrestrial forests (Donato *et al.*, 2011)[19]. The remarkable traits of the mangrove ecosystem translate into a wide variety of goods and services that we benefit from. These play a critical role in supporting human well-being by delivering the necessities of life like food, shelter and livelihoods. At the same time mangroves reduce loss of property and vulnerability of local communities.

4.29 As per the Biennial Update Report[20] to UNFCC, the incremental annual mitigation potential 2020 for the restoration of the mangroves and wetlands catchment (M/W) of area 0.2 million hectares is 1.6 $MtCO_2$. As regards the environment protection of India, the private parties have also joined hands together with the Government agencies. For

[16] https://www.iucn.org/theme/marine-and-polar/our-work/climate-change-and-ocean/mangroves-and-coastal-ecosystems
[17] https://www.iucn.org/resources/issues-briefs/blue-carbon
[18] https://fsi.nic.in/isfr-2021/chapter-3.pdf
[19] https://www.researchgate.net/profile/John-Kauffman-4/publication/285109220_Mangroves_among_the_most_carbon-rich_forest_in_the_tropics/links/569cf2f908ae2f0bdb8d48c8/Mangroves-among-the-most-carbon-rich-forest-in-the-tropics.pdf?origin=publication_detail
[20] Third Biennial Update Report to UNFCCC

instance, initiatives taken by the Tata Chemicals with respect to the mangroves planted in the areas of Sundarbans and Mithapur in 2018-19 is 60,000.

4.30 Bearing in mind the enormous benefits of mangroves, it is important to have a regular and timely assessment of the conditions and the quality of the mangroves. As far as the monitoring of the mangroves are concerned, Remote Sensing is an efficient method of assessing the spread of the mangroves especially in the inaccessible areas. Mangrove bearing States are implementing different measures for conservation and management of the mangroves. Some important techniques adopted in Gujarat for restoration of degraded mangrove habitats are the direct seeds sowing, raised bed plantation and the fishbone channel plantation. In Andhra Pradesh, Forest Department has formed Eco-Development Committees and Van Samrakshan Samithis for joint implementation of projects in mangrove areas. Regular trainings are also being conducted for sustainable mangrove conservation. In Maharashtra, steps have been taken to conserve ecology and biodiversity of mangroves by protection, restoration, regeneration and maintenance.

Extent Accounts

4.31 Considering the ecological and economic role of mangroves, the mangrove cover in India are monitored periodically by Forest Survey of India (FSI) since 1987 using remote sensing. The Mangrove Cover has been compiled by the FSI into following categories:

(i) Very Dense (canopy density of 70% and above)
(ii) Moderately Dense (canopy density of 40% and more but less than 70%)
(iii) Open categories (canopy density of 10% and more but less than 40%)

4.32 The State wise extent of the Mangrove cover (in sq kms.) from 1987 to 2020-21 is presented in **Table 4.8**. The state-wise mangrove cover in different canopy classes has been shown in **Table 4.9**. The Mangroves cover in the country is 4992 sq. km which is 0.15% of the country's geographic area. West Bengal has the largest share in total mangrove cover followed by Gujrat and A & N Islands. The total mangrove cover has been increasing over the years.

Table 4.8: State wise Mangrove Cover

(Sq Km)

State/UT	1987	1989	1991	1993	1995	1997	1999	2001
Andhra Pradesh	495	405	399	378	383	383	397	333
Goa		3	3	3	3	5	5	5
Gujarat	427	412	397	419	689	901	1,031	911
Karnataka					2	3	3	2
Maharashtra	140	114	113	155	155	124	108	118

State/UT	1987	1989	1991	1993	1995	1997	1999	2001
Odisha	199	192	195	195	195	211	215	219
Tamil Nadu	23	47	47	21	21	21	21	23
West Bengal	2,076	2,109	2,119	2,119	2,119	2,123	2,125	2,081
A & N Islands	686	973	971	966	966	966	966	789
Puducherry								1
Total	**4,046**	**4,255**	**4,244**	**4,256**	**4,533**	**4,737**	**4,871**	**4,482**

Table 4.8: State wise Mangrove Cover (Contd.)

(Sq Km)

State/UT	2003	2005	2009	2011	2013	2015	2017	2019	2021
Andhra Pradesh	329	354	353	352	352	367	404	404	405
Goa	16	16	17	22	22	26	26	26	27
Gujarat	916	991	1,046	1,058	1,103	1,107	1,140	1,177	1,175
Karnataka	3	3	3	3	3	3	10	10	13
Kerala	8	5	5	6	6	9	9	9	9
Maharashtra	158	186	186	186	186	222	304	320	324
Odisha	203	217	221	222	213	231	243	251	259
Tamil Nadu	35	36	39	39	39	47	49	45	45
West Bengal	2,120	2,136	2,152	2,155	2,097	2,106	2,114	2,112	2,114
A & N Islands	658	635	615	617	604	617	617	616	616
Daman & Diu	1	1	1	2	2	3	3	3	3
Puducherry	1	1	1	1	1	2	2	2	2
Total	**4,448**	**4,581**	**4,639**	**4,663**	**4,628**	**4,740**	**4,921**	**4,975**	**4,992**

Table 4.9: State wise Mangrove Cover in Different Canopy Classes (Sq Km)

Very Dense Mangroves

State/UT	2003	2005	2009	2011	2013	2015	2017	2019	2021
Maharashtra	8								
Odisha			82	82	82	82	82	81	81
Tamil Nadu						1	1	1	1
West Bengal	892	892	1,038	1,038	993	990	999	996	994
A & N Islands	262	255	285	283	276	399	399	398	399
Total	1,162	1,147	1,405	1,403	1,351	1,472	1,481	1,476	1,475

Moderately Dense Mangroves

State/UT	2003	2005	2009	2011	2013	2015	2017	2019	2021
Andhra Pradesh	15	15	126	126	126	129	213	213	213
Goa	10	14	14	20	20	20	20	20	21
Gujarat	198	195	188	182	175	174	172	169	169
Karnataka	3	3	3	3	3	3	2	2	2
Kerala	3	3	3	3	3	5	5	5	5

Maharashtra	44	58	69	69	69	79	88	88	90
Odisha	160	156	97	97	88	95	94	94	94
Tamil Nadu	18	18	16	16	16	18	25	27	27
West Bengal	894	895	881	881	699	700	692	692	692
A & N Islands	312	272	262	261	258	168	169	169	168
Total	1,657	1,629	1,659	1,658	1,457	1,391	1,480	1,479	1,481

Open Mangroves

State/UT	2003	2005	2009	2011	2013	2015	2017	2019	2021
Andhra Pradesh	314	314	227	226	226	238	191	191	192
Goa		2	3	2	2	6	6	6	6
Gujarat	762	741	858	876	928	933	968	1,008	1,006
Karnataka							8	8	11
Kerala	5	5	2	3	3	4	4	4	4
Maharashtra	64	100	117	117	117	143	216	232	234
Odisha	47	47	42	43	43	54	67	76	84
Tamil Nadu	17	17	23	23	23	28	23	17	17
West Bengal	334	331	233	236	405	416	423	424	428
A & N Islands	97	110	68	73	70	50	49	49	49
D&N Haveli and Daman & Diu	1	1	1	1	1	3	3	3	3
Puducherry	1	1	1	1	1	2	2	2	2
Total	1,642	1,669	1,575	1,601	1,819	1,877	1,960	2,020	2,036

4.33 The district wise mangrove cover for the different categories of mangrove forests are as given in the **Annexure 4.3**.

Wetland Ecosystem Condition-Biodiversity

4.34 The ecosystem condition accounts record the condition of ecosystem assets in terms of selected characteristics at specific points in time. Over time, they record the changes to their condition and provide valuable information on the health of ecosystems. These accounts are part of System of Environmental Economic Accounts – Ecosystem Accounts (SEEA-EA). These accounts contain aggregated statistical information about the overall abiotic and biotic characteristics of an ecosystem over a spatial scale.

4.35 Mangroves are ecologically fragile ecosystems that are repositories of rich biodiversity. These forests provide habitat and refuge to a wide array of species, both aquatic and terrestrial. They also act as a nursery for fishes, shell fish and molluscs etc. Information on biodiversity is scattered in nature in Indian context, particularly in context of specific ecosystem. According to Champion & Seth Classification (1968)[21], Mangroves are included in type Group-4 Littoral & Swamp Forests and are covered under

[21] Champion H.G. and Seth S.K (1968): A revised survey of The Forest Types of India. Forest Research Institute, Dehradun

4A/L1 Littoral forest, 4B/TSI Mangrove scrub, 4B/TS2 Mangrove Forest, 4B/TS3 Saltwater mixed forest (Hertiera) and 4B/TS4 Barckish water mixed forest (Heritiera) types. Some of the important species of mangrove ecosystems in India include Avicennia officinalis, Rhizophora mucronate, Sonneratia alba, Avicennia alba, Bruguiera cylindrica, Heritiera littoralis, Phoenix paludosa, Morinda citrifolia and Ceriops tagal.

Sundarbans-world's largest Mangrove Forests

4.36 Sundarbans, located in the northern Bay of Bengal is the world's largest single patch of Mangrove Forests. Spread over approximately 10,000 sq km, in Bangladesh and India, Sundarbans is the first Mangrove Forest in the world, which was brought under scientific management, as early as in 1892. Appreciating the importance of mangroves, the Government of India set up a National Mangrove Committee in 1976, to advise the Government about the issues related to conservation and development of mangroves in the country. Different states are carrying out practices for the conservation of mangrove cover with the active involvement of local communities. Recently, during a bilateral discussion with Bangladesh, the Hon'ble Prime Minister of India reaffirmed the support to cooperate on climate change and on preserving common heritage [22] like the Sundarbans.

Biodiversity of Mangroves

4.37 Mangroves are one of the most productive ecosystems of the world. They encompass a complex interacting function unit of planet, animal and microbial communities and their non-living environment. The tidal forest serve as a nursery ground for several organisms, protects from coastal erosion, sequestrates the carbon and provides livelihood to millions of people besides harbouring an array of faunal elements in its habitat. Information on biodiversity is scattered in nature in Indian context, particularly in context of specific ecosystem. Understanding mangrove biodiversity is of utmost important for the effective conservation and sustainable utilization of its services.

4.38 The total number of mangrove species in different regions of coastal India and floral diversity are given in the **Table 4.10 and Table 4.11. Annexure 4.4** provides the faunal diversity of mangroves of India. **Annexure 4.5** provides the State-wise distribution of faunal species of different taxa in mangrove ecosystems in India. **Annexure 4.6** provides IUCN Conservation Status of Fishes known from Mangroves in India. As per the Faunal Diversity of Mangrove Ecosystem in India, 2019 brought out by Zoological Survey of India, more than one lakh species exists in India as against the existing number of species (Protista and Animalia) in the world. Of which, 4822 number of species exist in the mangroves ecosystems. West Bengal has maximum number of species in mangroves ecosystems followed by Andaman & Nicobar Islands, Tamil Nadu and Odisha.

[22] https://mea.gov.in/Speeches-Statements.htm?dtl/35676/English+Translation+of+Press+Statement+by+Prime+Minister+Shri+Narendra+Modi+during+the+visit+of+Prime+Minister+of+Bangladesh+to+India

Table 4.10: Faunal diversity of Mangrove Ecosystem of India

Kingdom	Number of Species				
	World	India	%	Indian Mangrove Ecosystem	%
Protista	50,012	3,557	7.1	349	9.8
Animalia	16,29,511	99,701	6.1	4,473	4.5
Total (Protista+Animalia)	**16,79,523**	**1,03,258**	**6.1**	**4,822**	**4.7**

Source: 1. Faunal Diversity of Mangrove Ecosystem in India, ZSI, 2019; 2. Animal Discoveries, 2021, ZSI

Table 4.11: Floral Diversity in mangrove ecosystem in India

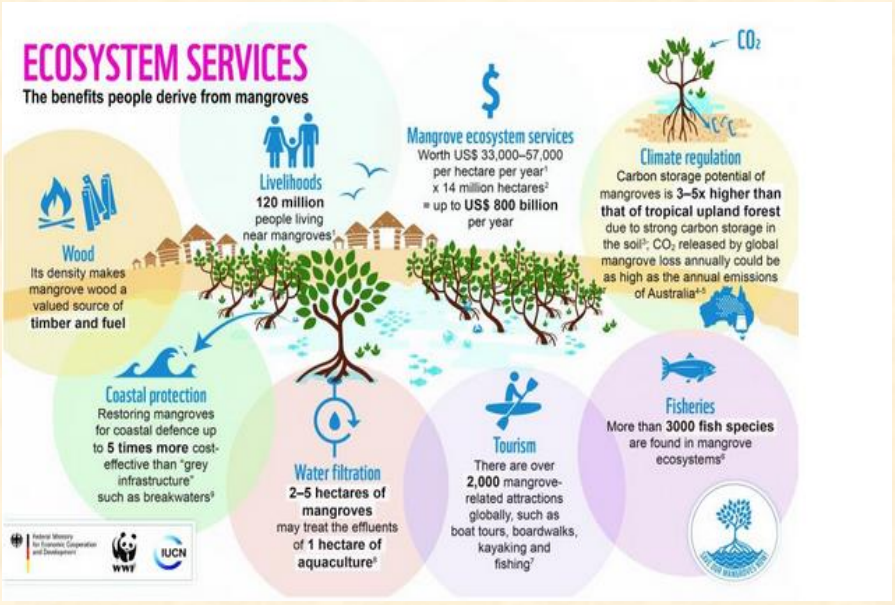
Sl. No.	Kingdom	Groups	No. of Species
1	Bacteria (Monera)	Actinomycetes	23
2		Other Bacteria	69
3	Fungi	Fungi	103
4		Lichens	32
5	Plantae	Marine algae (Phytoplankton and seaweeds)	557
6		Sea-grass	11
7		Mangrove associate plants	86
8		Mangrove plants	44
Total floral species			**925**

Source: Faunal Diversity of Mangrove Ecosystem in India, ZSI, 2019

Ecosystem Services

4.39 Mangroves Ecosystems provide a host of benefits to the human community through their natural functioning. These benefits in the form of goods and services accrued by the human community are called ecosystem services. Since the ecosystem services are freely available from nature, the significance of conservation of biodiversity and its role in provisioning these services has never been appropriately appreciated by human society. Valuation of the ecosystem services enables us to understand the role of the ecosystem in the livelihoods and sustenance of human community in the landscape.

4.40 Mangroves support coastal biodiversity, fishery resources and fisher livelihoods. A large number of globally endangered species ranging from plankton to invertebrates; amphibians and reptiles to birds and mammals thrive in these mangroves. They are crucial for not only providing forest products such as fuel-wood, fodder, and honey but are also important for removing pollutants such as carbon and heavy metals.



Source: Intergovernmental Platform on Biodiversity & Ecosystem Services (IPBES)

Drivers and Pressures on the Mangroves

4.41 Biotic pressures and natural calamity play a major role in negatively impacting Mangroves ecosystems. Growing land reclamation for agriculture and industrialization along the coastlines and discharge of untreated domestic sewage and industrial effluents are damaging to these forests. Up-steam activities related to river training and natural erosion and accretion also have an effect on the health of Mangroves since an adequate ecological flow in the rivers is essential for flushing of the Mangroves of silt and other wastes. Mangrove forests continue to be stressed by various factors like conversion for urbanization, aquaculture, agriculture, salt farming and other developmental activities such as tourism, mining, refineries, oil pipeline passages, port/harbour, dam and road constructions; changes in hydrological regimes; increasing salinity; coastal pollution; siltation; exploitation of fishery resources; cattle grazing; private ownership and ineffective institutional regimes. Specific stressors are: (i) agriculture and prawn seed collection in the Sundarbans, West Bengal, (ii) prawn farming and encroachment in Andhra Pradesh and Odisha, (iii) cattle feed in Tamil Nadu and Gujarat, (iv) industrial developments in Gujarat, (v) cyclone and floods along east coast, (vi) mangrove areas under private lands in Kerala, Maharashtra and Karnataka; and (iv) urbanization in Mumbai. The most significant threats to mangroves are human pressures and sea-level rise.

4.42 The Ministry of Environment Forest and Climate Change is implementing a Central Sector Scheme on conservation and management of Mangroves and Coral Reefs in Coastal States/UTs of India. Under the scheme, 38 mangroves and 4 coral reef sites have been identified for on-ground intervention. The objective of the scheme is to essentially ensure

conservation and management of mangroves and coral reefs. The 38 Mangrove sites identified in the States/UTs are given in the **Table 4.12** below[23]:

Table 4.12: State-wise Conservation and Management of Mangroves Sites

State/UT	Mangrove Area
West Bengal	Sundarbans
Odisha	Bhaitarkanika, Mahanadi, Subernarekha, Devi, Dharma, Mangrove Genetic Resources Centre, Chilka
Andhra Pradesh	Coringa, East Godavari, Krishna
Tamil Nadu	Pichavaram, Muthupet, Ramnad, Pulicat, Kazhuveli
Andaman and Nicobar	North Andaman, Nicobar
Kerala	Vembanad, Kannur (Northern Kerala)
Karnataka	Coondapur, Dakshin Kannada/Honnavar, Karwar, Mangalore Forest Division
Goa	Goa
Maharashtra	Achra-Ratangiri, Devgarh-vijay Durg, Veldur, Kundalika Revdanda, Mumbra-Diva, Vikroli, Shreevardhan, Vaitarna, Vasai-Manori, Malvan
Gujarat	Gulf of Kutch, Gulf of Khambhat, Dumas-Ubhrat

Source: Press Information Bureau, Ministry of Environment, Forest and Climate Change

Estuaries in India

4.43 Estuaries are semi enclosed waterbodies where freshwater from coastal streams and rivers runs into and mixes with seawater[24] .(Pritchard, 1967). [25]Estuaries and their surrounding lands are the transition zones between the land and the sea. These are found around the global coastal zone, wherever rivers, large or small, enter the sea. Estuaries with their surrounding lands are places of transition from land to sea[26]. The water level and salinity of estuaries are affected by the tide. Tide provides the flow of seawater and river mouth provide the flow of fresh water. The salinity of the estuaries ranges from 0% to 35% at the river end to the sea mouth respectively.

4.44 India has long coastline of 7516.6 km with an Exclusive Economic Zone of 2.02 million sq km. A total of 14 major, 44 medium and 162 minor rivers drains into the sea through various estuaries. Most of the major estuaries of India are situated in the east coast and join Bay of Bengal. The estuaries on the west coast are usually smaller.

[23] https://pib.gov.in/newsite/PrintRelease.aspx?relid=67525

[24] Pritchard, D.W.,1967. What is an estuary: physical viewpoint. In: G.H. Lauff (Editor), Estuaries. AAAS Washington, DC. Pub. 83, pp. 3-5.

[25] https://www.sciencedirect.com/topics/earth-and-planetary-sciences/estuary

[26] Chandra, K., Raghunathan, C. and Swetapadma Dash, 2018. *Current Status of Estuarine Biodiversity in India,* 1-576, Zoological Survey of India

4.45 Most of the major estuaries of India are situated in the east coast and joining with Bay of Bengal. The important estuaries of east coast are Hoogly-Malta, Subernarekha, Brahmani-Baitarani complex, Mahanadi, Rushikulya, Bahuda, Vamsadhara, Nagavali, Godavari, Krishna, Pennar, Ennore, Adyar, Vellar and Cauvery while the Western coast represents Cochin, Zuari, Mandovi, Tapi and Narmada are the major estuaries connecting with Arabian Sea. The map below shows the major estuaries of India.

Figure: 4.4: Estuaries in India

Source: Current Status of Estuarine Biodiversity in India, Zoological Survey of India, 2018

4.46 Estuaries are one of the promising and self-sustaining ecosystems supporting all forms of aquatic flora and fauna. They are a home to a wide variety of organism which impacts the biotic and abiotic features of estuaries. These are reliable productive ecosystem caused by nutrient trap which shows eutrophication as a result of nutrient rich riverine waters combining with warmer, light imparted shallow coastal waters which enriches the primary production. Among all the estuaries, Hoogly-Matla estuary is highly diversified in faunal and floral components. Floral and Faunal diversity of major Estuaries in India is provided in the **Annexure 4.7**.

Conclusion

4.47 Wetlands are the areas of critical ecological importance that are cradles of biodiversity and nurture a wide variety of flora and fauna. They are one of the most productive ecosystems and their significance has increased considerably in the 21st Century. Their complexity, which make them difficult to be assessed with reference to any scale or levels, along with the importance of the many ecosystem services they provide, highlights the need for development programmes to take more cognizance of these rich and invaluable ecosystems. A well designed and timely wetland monitoring

and assessment activities are critical for better management and protection of wetland resources.

4.48 The Mangroves and the Estuaries are an essential part of the ecosystem providing innumerable services to the humanity. The proper management[27] of these can be effectively concretized only by involving local communities and by creating awareness amongst the people. Thousands of species of birds, mammals, fish and other wildlife depend on mangroves and estuarine habitats as places to live, feed and reproduce. Understanding the biodiversity of estuaries is important for their conservation and sustainable utilization.

4.49 The SEEA framework defines a coherent system to help integrate these concerns, which in turn, is envisaged to provide a tool for enhanced decision-making capabilities. The current publication provides data that would facilitate efficient monitoring of the wetlands of India. Also, stock taking of the biodiversity in the two most important wetlands- mangroves and estuaries provides insights into the health of these wetlands.

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[27] Conservation and Management of mangroves in India, with special reference to the State of Goa and the middle Andaman Island