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Classification, Distribution, Features, Biodiversity and Functions of Wetlands: A Review

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ABSTRACT

Wetlands include a wide variety of habitats such as marshes, peatlands, floodplains, rivers and lakes and coastal areas such as salt marshes, mangroves and seagrass beds, but also coral reefs and other marine areas no deeper than 6 m at low tide, as well as human-made wetlands such as paddy lands, waste-water treatment ponds and reservoirs. According to Ramsar convention the wetlands are classified as three types *viz*., coastal/marine wetlands, inland wetlands and human made wetlands. According to UNCC, the estimated wetland cover of world is more than 1210 Million hectares and in that 13-18% are on the Ramsar List of Wetlands of International Importance, which are protected sites. In India 49 major wetland sites) are recognized as Ramsar sites of international importance. India has a variety of wetland ecosystem that support diverse and unique habitats because of diverse climatic condition and it is one amongst the 17 mega diverse countries. Total wetland area of Tamil Nadu is 9.02 lakh ha which is 6.92% of the geographic area and out of them Kancheepuram district is having highest total wetland area of about 8.91%.

Key words: Coastal, Fresh water, Self purification, Wetland.

Wetlands are a valuable natural resource. They are areas of land that are covered in water, either temporarily or permanently. This means that a wetland is neither truly aquatic nor truly terrestrial; depending on seasonal variability, wetlands may be both at the same time. As a result, wetland varies in terms of their origins, geographic location, water regime and chemistry, dominant plants and soil or sediment characteristics. Wetlands' boundaries are often difficult to define due to their transitional nature. The nature of a wetland system is most fundamentally determined by hydrological structure (the dynamics of water supply, throughput, storage and loss). A wetland is primarily formed by the presence of water for an extended length of time. They have always played an important part in human history. Wetlands, whether perennial rivers or vast bodies of water, have always been settings for water supply and, as a result, civilization development. They are among the world's most productive ecosystems. Wetland depletion and degradation have occurred all over the world as a result of fast population increase and economic development. At the same time, the concern about wetlands is also uplifted globally. Since the dawn of time, climate activists and groups have raised their voices to protect wetlands (Panigrahy *et al.,* 2012).

Definition of wetland

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 6 meters [International Union for Conservation of Nature (IUCN), 1965].

Wetlands include a wide variety of habitats such as marshes, peat lands, floodplains, rivers and lakes and coastal areas such as salt marshes, mangroves and sea grass beds, but also coral reefs and other marine areas no deeper than 6 m at low tide, as well as human-made wetlands such as paddy lands, waste-water treatment ponds and reservoirs (Ramsar Convention Secretariat, 2013).

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

Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water level (U.S. Fish and Wildlife Service's Official Classification System).

Classification of wetlands

Ramsar classification system for wetland (Murthy *et al.,* 2013)

Marine/coastal wetlands

A). Permanent shallow marine waters in most cases less than six meters deep at low tide; includes sea bays and straits.

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B). Marine sub tidal aquatic beds; includes kelp beds, sea-grass beds and tropical marine meadows.
C). Coral reefs.
D). Rocky marine shores; includes rocky offshore islands, sea cliffs.
E). Sand, shingle or pebble shores; includes sand bars, spits and sandy islets; includes dune systems and humid dune slacks.
F). Estuarine waters; permanent water of estuaries and estuarine systems of deltas.
G). Intertidal mud, sand or salt flats.
H). Intertidal marshes; includes salt marshes, salt meadows, saltings, raised salt marshes; includes tidal brackish and freshwater marshes.
I). Intertidal forested wetlands; includes mangrove swamps, nipah swamps and tidal freshwater swamp forests.
J). Coastal brackish/saline lagoons; brackish to saline lagoons with at least one relatively narrow connection to the sea.
K). Coastal freshwater lagoons; includes freshwater delta lagoons.
Zk (a). Karst and other subterranean hydrological systems, marine/coastal.

Inland wetlands

L). Permanent inland deltas.
M). Permanent rivers/streams/creeks; includes waterfalls.
N). Seasonal/intermittent/irregular rivers/streams/creeks.
O). Permanent freshwater lakes (over 8 ha); includes large oxbow lakes.
P). Seasonal/Intermittent freshwater lakes (over 8 ha); includes floodplain lakes.
Q). Permanent saline/brackish/alkaline lakes.
R). Seasonal/intermittent saline/brackish/alkaline lakes and flats.
Sp). Permanent saline/brackish/alkaline marshes/pools.
Ss). Seasonal/intermittent saline/brackish/alkaline marshes/pools.
Tp). Permanent freshwater marshes/pools ponds (below 8 ha), marshes and swamps on inorganic soils with emergent vegetation water-logged for at least most of the growing season.
Ts). Seasonal/intermittent freshwater marshes/pools on inorganic soils includes sloughs, potholes, seasonally flooded meadows, sedge marshes.
U). Non-forested peatlands includes shrub or open bogs, swamps, fens.
Va). Alpine wetlands includes alpine meadows, temporary waters from snowmelt.
Vt). Tundra wetlands includes tundra pools, temporary waters from snowmelt.
W). Shrub-dominated wetlands shrub swamps, shrub-dominated freshwater marshes, shrub carr, alder thicket on inorganic soils.
Xf). Freshwater, tree-dominated wetlands includes fresh water swamp forests, seasonally flooded forests, wooded swamps on inorganic soils.
Xp). Forested peatlands; peat swamp forests.
Y). Freshwater springs; oases.
Zg). Geothermal wetlands.
Zk (b). Karst and other subterranean hydrological systems, inland.

Human-made wetlands

1). Aquaculture (*e.g.,* fish/shrimp) ponds.
2). Ponds; includes farm ponds, stock ponds, small tanks; (less than 8 ha).
3). Irrigated land; includes irrigation channels and rice fields.
4). Seasonally flooded agricultural land (including intensively managed or grazed wet meadow or pasture).
5). Salt exploitation sites; salt pans, salines, *etc*.
6). Water storage areas; reservoirs/barrages/dams/impoundments (generally over 8 ha).
7). Excavations; gravel/brick/clay pits; borrow pits, mining pools.
8). Wastewater treatment areas; sewage farms, settling ponds, oxidation basins, *etc.*
9). Canals and drainage channels, ditches.
Zk (c). Karst and other subterranean hydrological systems, human-made.

For better understanding the pictures of different types of wetlands was represented in Fig 1.

Wetland categories (Gupta *et al.,* 2021)

i. Marine (coastal wetland; coastal lagoons, rocky shores and coral reefs).
ii. Estuarine (including deltas, tidal marshes and mangrove swamps).
iii. Lacustrine (wetlands associated with lakes).
iv. Riverine (wetlands along rivers and streams).
v. Palustrine (marshes, swamps and bogs).

Distribution of wetlands

World

There are more than 12.1 million km^2 of projected wetland area on the planet, with 54 percent constantly flooded and 46 percent flooded seasonally. The Ramsar List of Wetlands of International Importance, which includes protected areas (2,300 sites), covers 13-18% of the world's wetland area (UNCC, 2018). The Pantanal, which covers more than 42 million acres and is located in South America, is the world's largest wetland. Renuka Lake in India (49.42 acres) is the world's smallest wetland.

India

Freshwater and marine wetlands abound throughout India. The country's different eco-climatic regimes resulted in a wide range of wetland systems, from high altitude cold desert wetlands to hot and humid wetlands in coastal zones, each with its own unique flora and fauna. India's varied topography and climate regimes support and preserve different and unique wetland habitats, with an annual rainfall of around 115 cm. The high altitude lakes in Himalayan are followed by wetlands in the flood plains of major river systems, saline

Marine/Coastal wetland

Permanent shallow marine waters



Straits



Sea Bays

Marine subtidal aquatic beds



Kelp beds



Sea-grass beds





Coral reefs **Rocky marine shores**





Rocky offshore island



Sea cliffs

Sand, shingle or pebble shores **Estuarine waters**





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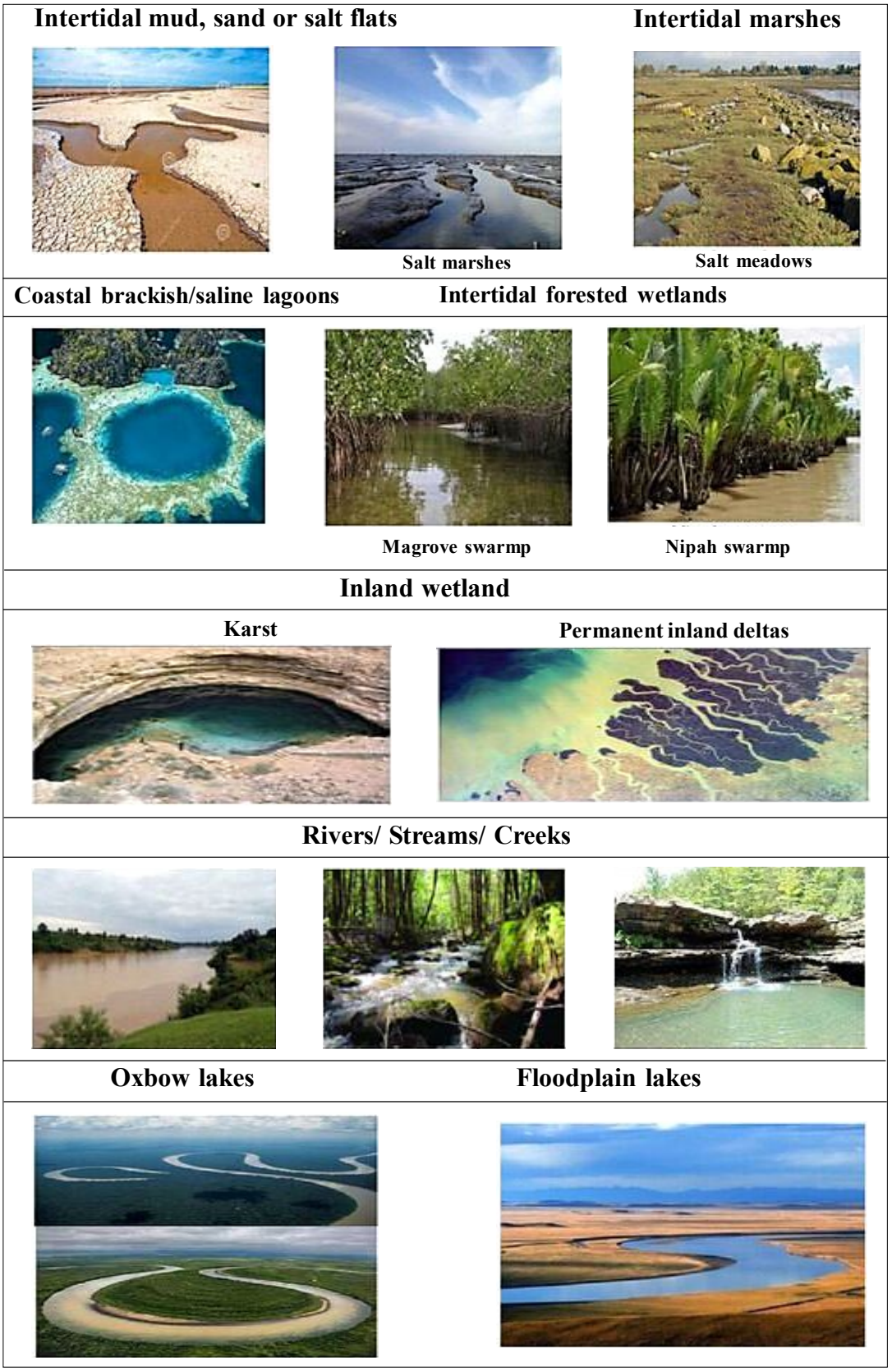

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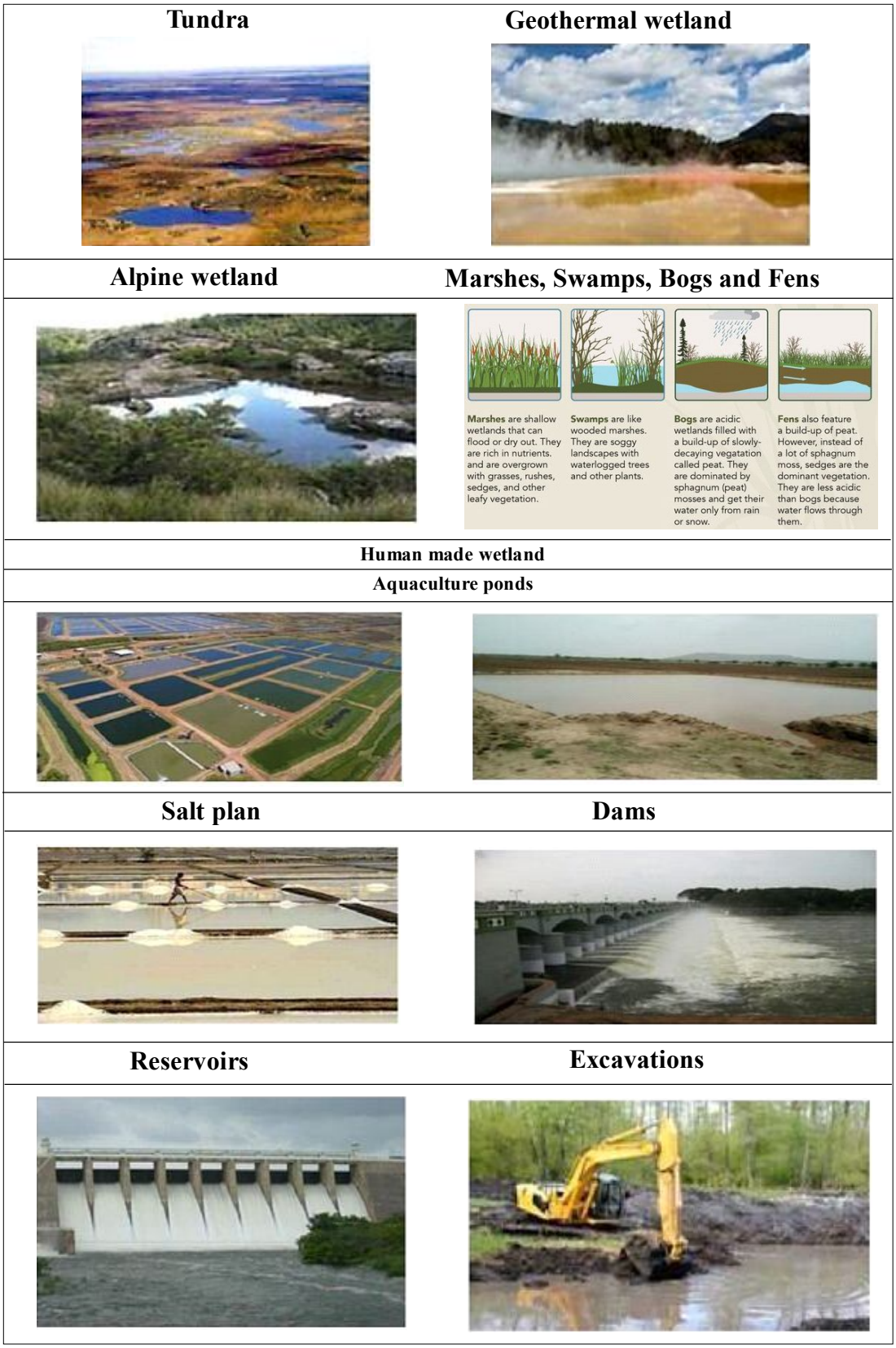

Fig 1: Ramsar classification of wetland.

and temporary wetlands in arid and semi-arid regions, coastal wetlands such as lagoons, backwaters and estuaries; mangrove swamps; coral reefs and marine wetlands and so on. India has 757.06 thousand wetlands covering 15.3 million hectares, or 4.7 per cent of its total land area, according to the National Wetlands Atlas (SAC, 2021). In terms of population, West Bengal (1.47 lakhs) and Uttar Pradesh (1.2 lakhs) are the two states with more than 1 lakh wetlands. Odisha and Madhya Pradesh are the next two states, with 78 and 62 thousand wetlands, respectively. Gujarat has the biggest proportion (17.5%) of its geographical area covered by wetlands, while Mizoram has the lowest proportion (0.66%). Lakshadweep has the highest proportion of wetlands (approximately 96%) and Chandigarh has the lowest (3%) geographical area covered by wetlands among India's UTs (Chandra *et al.,* 2021).

Tamil Nadu

Tamil Nadu's entire wetland area is 9,02,534 acres, or 6.92 percent of the state's total geographic area. Wetlands cover as much as 18.05 per cent of the land area in Ramanathapuram and as little as 1.08 percent in Coimbatore. Kancheepuram has the most total wetland area, with 80,445 ha, while Chennai has the least, with only 917 ha (www.tnswa.org).

Features of wetland

According to ministry of environment forest and climate change

The features of a wetland are characterized as, saturated soils or permanent or intermittent inundation throughout the year or parts of the year. The presence of macrophytes that are adapted to moist environments (Hydrophytes). Soil that has been waterlogged or flooded for an extended period which favors the development of anaerobic conditions (Hydric). This is the transition zone between terrestrial and aquatic ecosystems. They exist in a variety of climates, with the exception of Antarctica and are found near shores and inland. During a typical monsoon year, the entire area is flooded for a minimum of 15 days, or the earth is saturated to around one foot below the surface. Exclude places that are only occasionally flooded during big floods (such as one-in-a-hundred-year floods) or extreme disasters (such as storm surges of extreme intensity). Two or more wetlands can be classified as a single complex if they have a high degree of hydrological connectivity (wetlands connected during the monsoon) or biological connectivity (sharing waterbird habitats or being near migratory fish routes).

Biodiversity in wetlands

Wetlands and deep freshwater ecosystems are extraordinarily bio-diverse, despite the fact that they only cover a small portion of the earth's surface. Due to a wide range of climatic circumstances, India has one of the world's most diverse flora, with over 15,000 plant species, 730 of which are wetland flowering plants, including 114 endemics (www.bsienvis.nic.in). There are around 1200 species of aquatic plants. Mangrove vegetation varies greatly depending upon the region. Only eight mangrove species have been identified in Pakistan's Indus delta, compared to roughly 60 species in the Ganges delta's Sundarbans. The Bhitarkanika area of Orissa has been reported to have high species diversity (65) (Giri and Chalise, 2008).

Aquatic and wetland plants are divided into various groups (Christopher, 1996)

1. Helophytes (terrestrial plants that tolerate submergence)
2. Haptophytes (plants attached to but not penetrating the substrate).
3. Tenagophytes (plants in their juvenile stage submerged, usually becoming terrestrial when adult).
4. Plankton (plants free-swimming below the water surface).
5. Rosemary (plants submerged, bottom rooted, leaves in a rosette).
6. Vititate (plants submerged, bottom-rooted, leaves cauline).
7. Pleustophytes (free-floating plants).
8. Epihydates (plants bottom-rooted with floating leaves).
9. Hyperhydates (emergent aquatic plants with lower parts almost always in water).
10. Rheophytes (plants those grow on rocks or trees by streams, rivers).

In South Asian wetlands, the fauna is equally diversified. There are over 14,000 species of mammals, 1250 species of birds, 10,000 types of insects, 2546 species of fish, 197 species of amphibians and 408 reptile species in the country's faunal count, with 40 per cent of the world's species living and breeding in wetlands, despite the fact that more than 25% of all wetlands plants and animals are now threatened with extinction (NWIA, 2011).

The Bengal tiger, *Panthera tigris*, the jungle cat *Felis chaus*, the leopard cat *Felis bengalensis* and the fishing cat *Prionailurus viverrinus* all live in the Sundarbans. The Imperial heron *Ardea insignis*, Greater Adjutant *Leptoptilos dubius*, Jerdon's bush-chat *Saxicola jerdoni*, Painted bush-quail *Perdicula manipurensis* and other vulnerable bird species are found in the wetlands of the eastern Himalayas, which stretch all the way to Bangladesh. *Rhinoceros unicornis*, the one-horned rhinoceros, has been relegated to Assam's remnant marshes. The Brow-antlered deer Cervus eldi eldi has found a new home in Loktak Lake in Manipur. In the 76-kilometer-long Keoladeo National Park wetland in India, about 370 species of birds, including the critically endangered Siberian Crane *Grus leugeranus*, can be found.

Functions of wetlands

Flood control

Controlling floods by absorbing floodwater and slowing the flow, wetlands play a significant role in flood management. Wetland vegetation also slows the spread of floodwaters across floodplains by obstructing their movement. Bassi *et al.* (2014) investigated the flood protection function of wetlands in India's Bhitarkanika region and found that the loss per household in villages not sheltered by mangroves (US $ 153.74 = Rs. 11,376.76) is higher than in villages sheltered by mangroves (US $ 33.31 = Rs. 2,464.94).

Pollution abatement

The wetland is a sink; contaminants are sucked into the wetland. Pollutants from the surface and subsurface runoff from the catchment are captured and prevented from entering streams and rivers. These lands are eliminating pollutants by a variety of mechanisms like nitrification, sedimentation, adsorption and aquatic plant uptake. In temperate regions, the maximum possible rates of nitrogen and phosphorous removal by wetlands vary from 1000 to 3000 kg N/ha/year and 60 to 100 kg P/ha/year (Bassi *et al*., 2014). Wetlands also help to prevent environmental issues like algal blooms, dead zones and fish kills, which are all caused by excess nutrients. According to Rai (2008), Typha, Phragmites, Eichhornia, Azolla and Lemna are some of the most effective marsh plants for heavy metal removal. However, as a result of rising urbanization and land-use changes, wetlands' capacity to store pollutants and eliminate them via nitrification, sedimentation, adsorption and uptake by aquatic plants is considerably exceeded. This harms wetland water quality and biodiversity. Such wetlands are subjected to substantial changes in nutrient cycling rates, as well as a loss of species.

Carbon sequestration

Swamps, mangroves, peatlands and marshes are examples of wetlands that store more carbon. It stores carbon in long-term carbon stores, such as wetland sediments, as well as short-term carbon stores, such as existing biomass (plants, animals, bacteria and fungus) and dissolved components in surface and groundwater. Wetlands sequester carbon through high organic matter inputs and slow breakdown rates. Wetland soils can have upto 200 times the amount of carbon as vegetation. Mangroves can absorb nearly 1.5 metric ton of carbon per hectare per year and the highest layers of mangrove sediments have a high carbon concentration, with conservative estimates of 10%. However, significant tracts of wetlands were drained and then planted, making them a net CO_2 source in many places. Wetlands can be restored to become a CO_2 sink in the atmosphere (Lal, 2008). According to estimates (IPCC, 2000), the carbon sequestration capability of restored wetlands (over 50-years) is estimated to be around 0.4 ton C/ha/year,

Atmospheric maintenance

Globally, wetlands contribute to moderate global climate conditions by storing carbon in live and preserved (peat) plant biomass rather than releasing it into the sky as a greenhouse gas.

Economic benefits

Wetland ecosystems cover an area of 917 million hectares to more than 1275 million hectares worldwide, with an estimated economic worth of US $15 trillion each year. Controlling floods with wetlands saves roughly US $30 billion per year, whereas water filtering saves around US $ 1.6 billion per year.

Shoreline erosion protection

Wetlands absorb the force of waves and break up the flow of a stream or river currents, as well as protecting shorelines and stream banks from erosion by holding the soil in place with their roots. Further some other functions of wetlands was given in the Table 1.

Table 1: Major functions of wetlands.

Services	Examples
Provisioning	
Food	Production of fish, fruits and grains
Freshwater	Storage and retention of water for domestic, industrial andagricultural use
Fiber and fuel	Production of logs, fuelwood, peat, fodder
Biochemical	Extraction of medicines and other materials from biota
Regulating	
Climate regulation	Source of and sink for greenhouse gases; influence local and regional 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 otherpollutants
Erosion regulation	Retention of soils and sediments
Natural hazard regulation	Flood control, storm protection
Supporting	
Soil formation	Sediment retention and accumulation of organic matter
Nutrient cycling	Storage, recycling, processing and acquisition of nutrients
Cultural and amenity	
Recreation, Cultural, Artistic, Spiritual and Historic Information, Science and Education	Ecosystems are a source of inspiration for human culture and education

Source: (Millennium Ecosystem Assessment, 2005).

Table 2: Terminologies - differentiation of inland wetland types *viz*., marshes, swarmps, bogs and fens.

Marshes	Swamps	Bogs	Fens
Are shallow wetlands that can flood or dry out. They are rich in nutrients and are overgrown with grasses, rushes, sedges and other leafy vegetation	Are like wooded marshes. They are soggy landscape with waterlogged trees and other plants	Freshwater wetland of soft, spongy ground consisting mainly of partially decayed plant matter called peat. They are dominated by sphagnum (peat) mosses and get their water only from rain or snow	Also feature a buildup of peat. However, instead of lot of sphagnum moss, sedges are the dominant vegetation. They are less acidic then bog because water flows through them
Types:	**Types:**		
➢ Tidal salt marshes	➢ Fresh water swamps		
➢ Tidal fresh water marshes	➢ Salt water swamps		
➢ Inland fresh water marsh	➢ Cypress swamps		
	➢ Hardwood swamps		

Terminologies

➢ Coastal wetland

- Sea Bay - a coastal body of water that is depressed and connects to another main water body.
- Straits - a landform connecting two seas or other large areas of water.
- Kelp beds - large brown seaweeds that grow on under water rocks.
- Sea grass - sea grass meadow or sea grass bed is an underwater ecosystem formed by sea grasses.
- Coral reefs - is an underwater ecosystem characterized by reef building corals.
- Rocky offshore island / sea cliffs - is the varying degree of architectural landscape.
- Estuarine - is where freshwater from rivers and streams mixes with salt water from the ocean.
- Intertidal mud - that formed or affected by the rising and falling of the tides.
- Salt marshes - are coastal wetlands that are flooded and drained by salt water brought in by the tides. They are marshy because the soil may be composed of deep mud and peat.
- Salt meadows - found wherever muddy sands and fine vases can be deposited parallel to the shore.
- Brackish/Saline lagoons - is a body of water separated from larger bodies of water by a natural barrier (Brackish is a transitional points of water where fresh water meets sea water).
- Karst - type of landscape where the dissolving of the bed rock by ocean, sea tides created sinkholes, sinking streams, caves, springs and other characteristic features. It is also present in underground wetland system with or without a surface water component.

➢ Inland wetland

- Deltas - is a landform which is formed by river deposition of sediment. This occurs where river water enters an ocean or sea *etc*.
- Oxbow - remains of the bends in the river and these are still water lakes.
- Flood plain - low lying areas bordering large rivers, which are inundated by the over spill from main river channel.
- Alpine - is the mountainous area whose ecosystem is predominantly settled with the presence of excess water. The source of excess water is from rainfall or melted glaciers, ice and snow.
- Tundra - is a Russian word means upland or treeless mountain tract where the tree growth is hindered by low temperature and short growing seasons. Mostly found in North poles of the world and it is rich in Nitrogen and Phosphorus. This stores CH_4 and CO_2 in the permafrost. If global warming increases cause soil thawing which leads to release of much of Green House Gases.
- Geothermal wetland - are created by hot water and mud flowing from thermal streams, hot water springs and geysers. The fern *Cyclosorus* is commonly found in New Zealand's geothermal wetlands.
- The definitions of wetlands like Marshes, Swarmps, Bogs and Fens was differentiated in Table 2.

Conclusion

Wetland ecosystems support a vast range of habitats and are found throughout a wide range of geographical and climatic zones. They are an important part of the hydrological cycle and, in their natural state, are extremely productive systems. Wetlands provide a vast range of ecosystem goods and services in addition to supporting a diverse range of biological diversity. Wetlands in India provide a variety of functions, including irrigation, domestic water supply, freshwater fishery and recreational water. They also contribute to groundwater recharge, flood management, carbon sequestration and pollution reduction. Wetland management, on the other hand, has received insufficient attention on the national water agenda. As a result, anthropogenic pressures such as land use changes in the watershed, pollution from industry and homes, encroachments, tourism and overexploitation of natural resources affect many wetlands in urban and rural locations. Hence, we need to conserve wetland ecosystem by implementing effective management strategies.

Conflict of interest

Authors do not have any conflict of interest to declare.

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