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Review Paper

Biotics in wetland ecosystem

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Abstract

Wetlands are the most diverse and productive ecosystems on earth. Wetlands perform important functions like flood control, shore-line protection and protection against adverse global temperature increment which were hardly even recognised till now. They are home to diverse species of flora and fauna. Wetlands have been differentiated into different communities based on their ecological function and vegetative composition. Wetlands around the world are facing existence crisis, human activities have played a major role in the contamination, invasion and loss of endangered species of fauna and near extinction of wetlands.

Keywords Wetlands, Energy, Ecosystem, Communities, Invasion, Plants, Creatures.

Introduction

A widely accepted definition of wetlands was given by Cowardin[1] in 1979 which states that 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. Wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes, (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during, the growing season of each year." Wetlands are complex ecosystems. Wetlands form a hybrid of aquatic and terrestrial ecosystems and are, therefore, influenced by both. Wetlands are regions where water is present on the soil surface or within the root zone of plants, usually within about 18 inches of the soil surface. Wetlands have soil properties different from upland areas because of the presence of water for a major part of the year. The characteristics of wetlands are as follows:

1. Water- presence of water at or near the ground surface for a part of the year.
2. Hydrophytic plants- a preponderance of plants adapted to wet conditions.
3. Hydric soils- soil developed under wet conditions.

Function of Wetlands

Wetlands perform a variety of functions of vital importance to the environment and to the society:

1. Wetlands regulate water flow by detaining storm flows for short periods thus reducing flood peaks.
2. Wetlands protect lake shore and coastal areas by buffering the erosive action of waves and other storm effects.
3. Wetlands improve water quality by retaining or transforming excess nutrients and by trapping sediment and heavy metals.
4. Wetlands provide many wildlife habitat components such as breeding grounds, nesting sites and other critical habitat for a variety of fish and wildlife species as well as the unique habitat requirements of many threatened and endangered plants and animals.

5. Wetlands also provide a bounty of plant and animal products such as blueberries, cranberries, timber, fibre, finfish, shellfish, waterfowl, furbearers and game animals[2].

Ecosystem and flow of energy

A collection of individuals of the same species interacting with same or different species and also with the surroundings is called a population. A collection of different species living together and interacting in all these different ways is called a community. Finally, this collection of living organisms coexisting in a community will be interacting with the nonliving world that forms a setting for all life. Plants rooted in the soil absorb the minerals to grow and take up carbon dioxide gas from the atmosphere, which they convert into sugars in the process of photosynthesis. Animals also drink water and supplement their minerals in this way, some may even eat soil if they run short of certain elements. A community of different species of animals and plants living in the physical and chemical setting of the nonliving world is called an ecosystem. Energy flows through all ecosystems. The ultimate source of energy for most ecosystems is sunlight. This energy is made available to living organisms by photosynthesis carried out by green plants. The plants are primary producers (autotrophs), fixing solar energy into organic matter. Herbivores are primary consumers (heterotrophs), they are dependent on plants for energy. Predatory animals (secondary and tertiary consumers) are also heterotrophic. They too depend ultimately on plants, but they are indirectly dependent as they feed upon the herbivores or upon the animals that eat herbivores. They occupy different positions in a hierarchy of feeding which is referred to as a food web in the ecosystem. The waste material produced by living organisms and the dead parts or dead bodies of those organisms are used by the decomposer organisms. The ultimate decomposers in an ecosystem are the bacteria and fungi, which use up all the energy-rich materials that remain. In an ecosystem no energy gets wasted or destroyed.

Chemical elements are cycled while energy transfers takes place in an ecosystem. Energy passes once through the ecosystem and is finally dissipated, but chemical elements may cycle round and round the ecosystem indefinitely. This constantly turning wheel of element motion is called a nutrient cycle. Import and export of elements also takes place in an ecosystem [3].

Wetland Communities

Virginia Tidal Wetlands Act of 1972 defined 17 different types of wetlands based upon a combination of their vegetative composition and ecological function [4]. Some of the important features of these wetlands are mentioned in Table 1.

Table 1 Types of wetlands based upon a combination of their vegetative composition and ecological function

Wetland communities	Vegetative and ecological composition
Saltmarsh cordgrass community	*Spartina alterniflora,* killifish, anchovies, juveniles of striped bass, spot, croaker, blue crabs, shrimps, clapper rail and willet, muskrats and raccoon
Saltmeadow community	*Spartina patens*, *Distichlis spicata,* Saltmarsh cordgrass, marsh elder, groundsel tree, saltmarsh snail (Melampus), waterfowl, seaside sparrows and rice rats.
Black Needlerush Community	Black needlerush *(Juncus roemerianus)*, Saltmarsh cordgrass, saltmeadow hay and saltgrass
Saltbush Community	*Baccharis halimifolia,* marsh elder *(Iva frutescens)*, saltmeadow hay, saltgrass and marsh wren.
Big Cordgrass Community	Cordgrass *(Spartina cynosuroides)*, Muskrats, Geese, meadow vole and marsh rice rat and Marsh wren.
Cattail Community	Narrowleaf cattail *(Typha angustifolia),* broadleaf cattail *(Typha latifolia)*. marsh wrens, rice rats and muskrats.

Arrow Arum – Pickerel Weed Community	Arrow arum *(Peltandra virginica),* pickerelweed *(Pontederia cordata)*, sedges, smartweeds, cattails and pond lily.
Reed Grass Community	Reed grass *(Phragmites communis)*, some birds and small mammals.
Yellow Pond Lily Community	Yellow pond lily *(Nuphar luteum),* arrow arum, pickerelweed , spawning striped bass, white perch and river herring, wading herons, egrets, finfish, eastern painted turtle
Saltwort Community	*Salicornia virginica*, *Salicornia biglovii*, *Salicornia europa*. Wading birds, marsh birds, small fish and invertebrates.
Freshwater Mixed Community	Bulrushes, arrow arum, pickerelweed, smartweeds, wild rice and rice cutgrass, striped bass, shad and river herring, wildrice, arrow arum, smartweed, native and migratory waterfowl, sora rails, redwinged blackbirds, upland birds, insects, amphibians and reptiles.
Brackish Water Mixed Community	Saltmarsh cordgrass, saltmeadow hay, saltgrass, saltbushes, threesquares, big cordgrass, common reed, cattails, shorebirds and wading birds, fiddler crabs, marsh crabs, raccoons, crabs, shellfish, meadow vole and rice rat, foxes.
Intertidal Beach Community	Mole crabs, donax clams, haustorid amphipods, algae and phytoplankton, finfish and blue crabs, terns, plovers and skimmers.
Sand Flat Community	Sandworms, bloodworms, amphipods, clams, shorebirds, finfish, blue crabs, juvenile blue crabs and finfish.
Sand/Mud Mixed Flat Community	Hard clams, soft clams, mud snails, parchment worms, polychaetes , shorebirds, wading birds, waterfowl, molluscs, blue crabs and fish
Mud Flat Community	Spionid worms, mud snails, razor clams, bloodworms, waterfowl, wading birds, fintish and blue crabs.
Intertidal Oyster Reef Community	Oysters, hard clams, mud crabs, sand worms, barnacles sponges, small finfish and blue crabs.

Plant species of wetland ecosystem

Wetland is an area with predominance of water and anaerobic conditions, the rooted plants which grow in them adapt themselves to these conditions and deal with the stresses imposed by flooding. Fast-flowing waters may be rich in dissolved oxygen, but when the water is still, the oxygen movement depends on diffusion. The surface layers of the water-body are in contact with air, oxygen flows down from the top into the deeper layers, where it is consumed by the decomposers in the mud at the bottom of the wetland. In water oxygen diffuses 10,000 times more slowly than it does in air. The adaptations for surviving in wetlands include pressurized gas flow, formation of oxidized root zones, and anaerobic respiration, making wetlands among the most productive ecosystems in the world [5]. Pressurized gas flow is a mechanism in which oxygen flows from the atmosphere to the roots, and carbon dioxide and methane from the roots to the atmosphere, an adaptation to protect themselves from the anaerobic conditions[6]. The roots of some wetland plants have evolved air spaces, called aerenchyma, which allow oxygen molecules to move from the emergent portions of the plant to the underwater roots[7]. Some trees have prop roots with pores called lenticels. The prop roots are above the flood zone and supply oxygen to the submerged roots. Oxygen diffuses to the roots[8] . Wetland plant communities develop in this environment depending upon their individual abilities to tolerate flooding and anaerobic soils and also in response to biotic interactions with other species [9].

Alkaline bulrushes are a very important habitat plant of wetland ecosystem. Bulrushes provide food, cover, nesting, and shelter for ducks and other waterfowl. Alkaline grasses which occur in wetlands are an important source of both food and habitat for many animals. Bullthistle is an important food source for many animals and also provides shelter for some small birds. Cattail is the most recognizable of the wetland plants. Cattails provide food, nesting, shelter and cover for many wetland residents. The Red-winged Blackbirds are seen commonly perching in the tufted end of a cattail. Duckweed is a significant food source for ducks as well as other waterfowl. Duckweed floats on the surface of the water and is not

rooted to the bottom. Salt Grass is also very common. Fieldmint is one of the more pleasant aromatic plants of the wetland. It is a popular food source for refuge wildlife as well as a tempting nibble for the human visitors. The Floating Lady's Thumb is a beautiful wetland plant and forms a very important food source for wetland birds. Foxtail Barley is a very common sight and forms a common food source and a spectacular sight. Hardstem Bulrushes are another variety found in the widespread wetland bulrushes. Milkweed is also a very common plant species. Olney's Bulrush is one more variety of the bulrush family. Prairie Cordgrass is another grass variety which plays a significant food and shelter role. Puncture weed is also found in these ecosystems. Stinging Nettle is not very common but still found in these ecosystems. Various varieties of wild flowers are found blooming in the spring season. Wirelettuce is one more of the beautiful, abundant and diverse plant variety. Wetland plants such as cattails and bulrushes provide lodging for many fauna associated with wetlands. Blueberries and cranberries are examples of wetland plants that are important economically because of their use as food. Some of the submergent and floating plants found are pondweeds, wild celery, water milfoil, fanwort, water lilies, water shield, yellow pond lily and duckweed. The emergent plants found are cattail, woolgrass, reed canary grass, sedges, rushes, bulrushes, pickerel weed and burred. Shrubs found commonly include alder, high bush blueberry, viburnums, rhododendrons and dogwoods. Trees found are elms, green and black ash, swamp white oak, hemlock, black spruce, red and silver maple[8,10] .

Wetland vegetation functions

As primary producers, wetland plants have a vital role in wetland ecology. Chambers et al in 1995[11] described that wetland plants perform a number of significant functions which include:

- maintaining water quality by filtering out nutrients and sediments,
- providing food, shelter and breeding habitat for both aquatic and terrestrial fauna,
- preventing erosion,
- contributing to the organic “tea” colour in wetlands,
- reduces the frequency and severity of algal blooms.

Wetland Creatures

Apart from plants, wetlands serve as home for a wide variety of animals. Species such as waterfowl, herons, beavers, muskrats and river otters are termed *obligate* wetland species because they are dependent on wetlands for their survival. Species which are not dependent on wetlands for their survival are called *facultative* wetland species.

Countless species of birds use wetlands or are facultative wetland species. Waterfowl like ducks, geese and swans are common inhabitants of wetlands. Mallards, black ducks, hooded mergansers, buffleheads, goldeneyes, redheads, ruddy ducks, scoters and eiders are commonly found. Shorebirds and wading birds which includes species such as plovers, rails and sandpipers are found feeding in this environment by walking along and visually stalking their prey in shallow waters or along the edges of lakes, ponds, rivers or wetlands. Songbirds and raptors like the red-winged blackbird, marsh wren, song sparrow, swamp sparrow, belted kingfisher, northern harrier (marsh hawk), osprey and bald eagle are commonly found. Wet grasslands support robust populations of meadow mice which in turn attract harriers, short-eared owls and barn owls. Woodcock, ruffed grouse, wild turkey and ring-necked pheasant are species that are good examples of facultative wetland species with recreational and economic value.Beaver, muskrat, mink and otter are obligate mammalian species that have adapted their anatomy, physiology and behaviour to a life in and around water. Raccoons which are often associated with wetland and riparian areas can survive in upland habitats also. Beavers, cut trees, create openings, build dams and dig canals. Mink, raccoons and green herons search for frogs, crayfish. Deer, rabbit and hares are also inhabitants of this habitat. Wetlands provide shelter to meadow voles and certain other small mammals. Red and gray foxes visit these areas for food. Muskrats build two types of shelter, either lodges or burrows depending on the characteristics of the ecosystem. Minks prey on almost any kind of vertebrate animal, including muskrats, small mammals, birds, reptiles, amphibians and fish.

Other Wetland mammals like the water shrew is commonly found in the water and along streambanks. The semi-aquatic star-nosed mole, searches for food both in water and on land saturated with water. The southern bog lemming is also found inhabiting region near wetlands. The red-backed vole, meadow vole,

rock vole, meadow jumping mouse and woodland jumping mouse are some of the rodents which are found commonly near wetlands. The lush green vegetation, seeds and insects serve as food for these rodents. The long-tailed weasels, ermine and gray fox are found along the margins of wetlands. Black bear, bobcat and snowshoe hare seek shelter in dense, forested and shrub wetlands. Virtually all amphibians require water and wetlands during their breeding cycle because their delicate jelly-like eggs must be kept moist during development. Salamanders are a particularly diverse community in wetlands. Reptilian species such as the painted turtle and northern water snake live in water, but lay their eggs high and dry on land. Fishes such as sunfish and catfish are found nesting in the shallow open-water areas of wetlands, ponds and reservoirs. Species like bass, pickerel and pike require vegetated habitats with dense stands of emergent and submergent plants on which to lay their eggs and raise their young. Invertebrates like crane fly larvae and earthworms have important role in the decomposition of dead plants and animals in a wetland. Many invertebrates help the plants such as wetland orchids in pollination. Microscopic invertebrates serve as food for macroinvertebrates which in turn act as food for crayfish, mayflies, dragonflies, damselflies, caddisflies and stoneflies. Fish, amphibians, shorebirds, songbirds, waterfowl and insectivorous mammals prey on these macroinvertebrates[8].

Entry and Exit of Nutrients

No ecosystem exists in total isolation from all others. Wetlands are no exception, in exchanging energy and chemical elements and they both donate and receive energy and nutrients to and from other neighboring ecosystems which may be through biological or non-biological movement.

Carbon is one element that is obtained from the atmosphere by plants and used in the construction of their bodies. Carbon is a critical element for all living organisms because almost all energy storage and transfer involves compounds built using carbon atoms. The atmosphere carries carbon dioxide gas into a terrestrial ecosystem, and emergent plants in wetlands tap this resource for their photosynthesis. Carbon dioxide (CO_2) also enters the ecosystem in a dissolved form in rainfall and in the streams or rivers that flow into the wetland. This dissolved CO_2 is available for photosynthesis by submerged aquatic plants and phytoplankton. Carbon can enter a wetland as the hydrogen carbonate ion, HCO_3^- which may be derived from carbonic acid, formed by the reaction of carbon dioxide gas with water, or it may result from lime (calcium carbonate) dissolving in water. Once again, the hydrogen carbonate ion can be used by aquatic plants for their photosynthesis. Much of the carbon fixed by photosynthesis in a wetland ecosystem is lost in respiration, but some becomes locked in the sediments that accumulate, especially in the peat deposits of the temperate bogs. Peat deposits take up carbon and store it, preventing the build up of carbon dioxide in the atmosphere. The storage of carbon by wetlands is of global significance.

Nitrogen also enters wetland ecosystems from the atmosphere. The nitrogen gas composes 78 % of the atmosphere but it cannot be taken up directly by plants, it first has to be converted into ammonia and then to nitrates. Electrical discharge during storms can result in this reaction, but the quantities fixed in this way are very small. Some microbes convert the inert nitrogen gas into a form that can be used by plants. In wetlands blue-green bacteria (cyanobacteria) carry out this process. Some lichens also fix nitrogen because there is a close association between a fungus and an alga or a blue-green bacterium. In the latter case it is the microbe that fixes nitrogen.

Nutrient elements also reach wetlands during rainfall. Industrial pollution contributes to the chemistry of the rainfall which can have a significant effect on the nutrient cycling of wetlands. Nitrogen oxides and sulphur dioxide are amongst the most important of the aerial pollutants human generate by fossil fuel burning, including the combustion of gasoline by automobiles. When combined with water they form nitric acid and sulphuric acid—extremely corrosive compounds that attack buildings, human lungs, and plant tissues.

Nutrient elements are in very short supply in ombotrophic wetland ecosystem, the input of nitric acid through rainfall results in a rise in nitrates, which act as a fertilizer to the nitrogen-starved vegetation. This can change the competitive balance of the vegetation and can result in some robust species taking over dominance and eliminating smaller specialist species, such as the carnivorous plants.Animals may also bring nutrients into wetlands by grazing on the fertilized pastures rich in nutrients such as nitrogen and phosphorus that people use for cultivating domestic crops and defecating in the wetlands, by which they

enrich the nutrient content of the ecosystem. Animals can also take nutrients out of a wetland ecosystem. Another major exit route for nutrients from wetland ecosystems is the stream or river that drains from the wetland. The water leaving a wetland may contain a higher or a lower concentration of elements than the water that originally entered the ecosystem. This depends upon the various other sources of nutrients, the rate of growth of biomass and the rate of element storage in the sediments [3].

Present status of wetlands

Biological invasion occurs when a species acquires competitive advantage following the disappearance of natural obstacles to its proliferation, which allows it to spread rapidly and to conquer novel areas within recipient ecosystems [12].Humans have the ability to alter landscapes as well as in the introduction of species, especially to areas well outside their potential range as defined by their natural dispersal mechanisms and biogeographic barriers[13].Wetlands, that encompass diverse and heterogeneous assemblage of habitats ranging from lakes, estuaries, river flood plains, mangroves, coral reef and other related ecosystems, seem to be particularly vulnerable to invasions. Even though 6% of the earth's land mass is wetland, 24% of world's most invasive plants are wetland species[14] . Wetlands are landscape sinks where there is an excess of nutrients which allows the invasive species to flourish diminishing the already existing native species. The the most common invasive plant species in freshwater wetlands are *Sparganium erectum, Typha angustifolia* and *Phragmites australis* (rooted emergent life form), *Nymphoides peltata* and *Potamogeton nodosus* (rooted floating leaf type habit), *Potamogeton crispus* and *Myriophyllum- Ceratophyllum* complex (submerged growth habit) and *Lemna-Salvinia-Azolla* complex (free-floating life form).

Two of the species invasions have been briefly described below:

(a)*Alternanthera philoxeroides* (Alligator weed) of Amaranthaceae family is regarded as one of the worst weeds in world, because of its invasiveness, spreading potential and economic and environmental impacts. This weed invades both land and water and is very difficult to control. Alligator weed spreads its leaves across the water surface, forming dense mats. The stems are hollow, an adaptation for helping it to float and the roots are thin and stringy. Optimum growth occurs in fresh water with a high nutrient level but it can also tolerate brackish water. It is able to survive extreme dry periods. Due to its vigorous growth and ability to re-establish from stem fragments, this weed has the potential to establish in all wetland areas including water bodies of agricultural and urban areas[15]. Alligator weed is native to temperate regions of South America, especially Argentina but today it is found as a serious threat throughout the tropical and warm temperate regions, including the US, China, India, South-East Asia, Australia and New Zealand.

Phytoremediation

Alternanthera philoxeroides was used for removal of lead and mercury from polluted waters. It can also be used as a food supplement for essential elements like Zn and Fe [16].

Uses

Leaves of this weed are used as vegetable. Warm leaf extract is applied as hair tonic.

Problems

Alligator weed poses an extreme threat to waterways, wetlands and irrigated croplands. These thick, dense rafts can:

1. Restrict water flow in creeks, channels and drains,
2. Impede recreational water sports and boating access,
3. Damage pumping and irrigation equipment and other structural features,
4. Increase water loss through evapo-transpiration,
5. Reduce water quality by preventing light penetration and reducing oxygenation of water,
6. Create a favourable habitat for mosquitoes,
7. Reduce water bird and fish activity,
8. Make swimming dangerous,
9. Cause the death of native, submerged water plants and fish,
10. Replace native wetland plants [17].

(b) Water hyacinth, *Eichhornia crassipes* of family Pontederiaceae is a native of South America and one of the worst aquatic weeds in the world. It was introduced into India in 1896 as an ornamental plant at the botanical garden in West Bengal[18] . This plant has become an environmental and social menace in most of the water bodies of the country. The species has invaded almost all water bodies of the country leaving Himachal Pradesh, Jammu and Kashmir and Mizoram which is mainly attributed to the temperate climate in these regions.

Problems

1. Enormous growth rate, invades extensive areas of naturally open water and produce enormous amounts of biomass,
2. The mats of this plant block the air-water interface, reducing oxygen level leading to the degradation of the water quality which in turn reduces the species richness of the aquatic ecosystem,
3. The mats also eliminate submerged plants by blocking sunlight,
4. The mats provide shelter to the mosquitoes which spread certain deadly diseases such as schistosomiasis and malaria, encephalitis and filariasis,
5. Restricts primary productivity by reducing the photosynthesis of phytoplankton which will lead to de-oxygenation with a detrimental impact on fish,
6. Excludes native submerged and floating-leaved plants,
7. Its prolific growth affects fisheries, traffic, irrigation, water supply and the whole ecology of the infested lake,
8. Its death and decay within the wetland can lead to eutrophication[19] .

Utility of Water Hyacinth

The capacity of water hyacinth to accumulate heavy metals and organic contaminants and its wide tolerance to environmental conditions is well recognized. It is being used for various applications as an animal food, making paper and other products, or as compost[20] . Anaerobic digestion of water hyacinth produces biogas –methane[21] . Many studies reported the ability of water hyacinth for the accumulation of heavy metals such as lead (Pb), chromium (Cr), zinc (Zn), manganese (Mn), and copper (Cu) and are being used for cleanup of water contaminated with heavy metals[22] .

Present status of avian population in some Indian wetlands Mangalajodi village, Orissa

Mangalajodi village is located in Khurda District, Orissa. It is one of the villages situated along the banks of the Chilka lake and most of its inhabitants are fishermen. Thousands of migratory waterfowls and resident birds visit and breed each year in the wetland marshes of the village. This area is primarily a freshwater zone with marshes, emergent vegetation and reed beds consisting mostly of *Typha angustata* and *Phragmites karka*. The marshes around Mangalajodi, and the open waters attract a large congregation of waterfowls, especially dabbling ducks such as Northern Pintail (*Anas acuta*), Northern Shoveller (*Anas clypeata*), Garganey (*Anas querquedula*) and Brahminy Shelduck (*Tadorna ferruginea*). In addition, the wetland is frequented by Purple Moorhen (*Porphyrio porphyrio*), Asian Openbill Stork (*Anastomus oscitans*), Common Moorhen (*Gallinula coromandelicus*), Grey-headed Lapwing (*Vanellus cinereus*) and many other birds. Spot-billed Pelican (*Pelecanus philippensis*), which is placed in the Near Threatened category of IUCN Red List also migrates into this region[23] .This site has been recognized as one of India's important bird areas (IBA). Poaching is the major threat to the avi-fauna of Mangalajodi wetland. Poachers not only kill resident birds but even the migratory birds which visit the site between September and April. They sell the birds as well as the eggs in the nearby markets. People cut the *Phargmites* stems and use them for fencing purpose. Due to reed harvesting, the habitats of the waterbirds are diminishing day by day. Several collaborative efforts of the government and various NGO's and strict vigil is required to conserve the Mangalajodi waterfowl breeding habitat [24].

Andhra Pradesh

The Painted Stork, *Mycteria leucocephala* is a tropical bird species found in the South and South-East Asian region. The estimated number of these birds is 15,000 birds in South Asia and fewer than 10,000 in South-East Asia[25]. This species is placed as 'Near Threatened' in the IUCN Red List Category 2007, because it is undergoing a moderately rapid population decline owing to hunting, habitat destruction, local trade and agricultural pollution. A few birds have been spotted on the banks of Akeru stream at Chintapalli village and Chinna Maduru village, Warangal District, Andhra Pradesh. The birds usually nest

on top of tamarind trees (*Tamarindus indica*) nearby the village pond and banks of the stream. The breeding season of these birds is from January to late June or July. The birds as well as their habitats are in danger. Poachers kill the birds and sell them as meat in towns. The tamarind trees are being felled, as a result the birds stray to the open fields and rooftops, which make them an easy prey for poachers. Due to lack of suitable nesting trees, the breeding potential of the species is also affected. Other factors such as changes in prey species populations, the ecological condition of habitats (pollution), and human disturbances have undoubtedly played a role in the declining species population in this area. Protection of the species and conservation of their habitats is the need of the hour. Public awareness should be spread about the status of the threatened Painted Stork. Artificial construction of ponds/tanks may be undertaken with trees on the banks to provide the birds a natural habitat[26] .

Bharatpur wetland, Rajasthan

The Keoladeo National Park (KNP), better known as the Bharatpur Bird Sanctuary, is one of the world's most renowned wetlands, famous for its avifauna. It is located on the western edge of the Gangetic plains, at the confluence of rivers Gambhir and Banganga. It received a National Park status in 1981. Around 370 species of birds and 375 species of flowering plants have been recorded in the area. The rare Siberian crane (*Grus leucogeranus*), which migrated from Siberia to this Park during the winter months was the main attraction. But today, sadly not a single bird of this species migrates to the Park. The Park is renowned globally for its heronries and is called the 'Mecca of bird watchers'. KNP was selected as a Ramsar site in 1981[27]. In December 1985, it was declared as a World Heritage Site by UNESCO[28]. Rare birds from as far as Afghanistan, Turkmenistan, China and Siberia visit the Park during the winter months. The wetland is a home to many vulnerable and critically endangered species like Oriental white-backed vulture (*Gyps bengalensis*), Siberian crane, Spot-billed pelican (*Pelecanus philippensis*), Lesser adjutant (*Leptoptilos javanicus*), Indian skimmer (*Rynchops albicollis*), Sarus crane (*Grus antigone*), Baer's pochard (*Aythya baeri*), etc. This site is an eco-fragile area because water to the KNP is totally controlled by human. A unique feature of the wetland ecosystem of KNP is its origin from a natural depression, which was an evanescent rainfed wetland . Subsequently, the construction of Ajan Bandh and several sluice gates in the periphery of the KNP facilitated to contain and regulate the water level. Regular flooding and flushing of the wetlands is the only way to manage them. Today KNP is facing a huge shortage of water. With a growing shortage of water and feed, the birds no longer visit this park. UNESCO issued a notice to the Bharatpur wetland in 2008 that, if the water table continues to fall and the number of migratory and local birds keep falling, it will be forced to withdraw its World Heritage status. The rich diversity of avifauna is in jeopardy. Construction of the Panchana dam near Karauli in 2003, which is about 90 km upstream from KNP on the Gambhir river, has progressively decreased the water flow to the Park. Due to various irrigation practices no water is left for the KNP. Serious measures need to be taken to conserve this biodiversity. Lack of coordination and noncooperation from local people can result in an irreversible ecological loss and time is not far when the bird sanctuary will convert into a desert [29].

Conclusion

Wetlands play an integral role in the hydrologic cycle, and provide important ecosystem services that include flood prevention, water quality enhancement, carbon storage, wildlife habitat, and buffers during periods of heavy rain. Wetlands contain diverse range of plants which are adapted physiologically to grow in water in the deficiency of oxygen or in very low concentrations of oxygen. A wide range of animals are found inhabiting wetlands and the area near wetlands. Due to the entry of excess amount of nutrients into the wetlands as a result of human activities, plant, invertebrates, fish and bird communities are directly being influenced. Finally, the introduction of invasive species poses a threat to many wetlands. Wetlands are being lost and the population of migratory birds visiting the wetlands has reduced tremendously. Proper measures need to be taken in order to protect the wetlands. Collaboration of the government with villagers, a structured action plan for those violating the law, declaring wetland sites as community reserve will save both the wetlands as well as the birds related to them. Lack of proper attention and action can lead to the loss of wetlands forever.

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