

BIODIVERSITY, IMPORTANCE, THREATS AND CONSERVATION OF WETLANDS - A REVIEW

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Abstract

In India wetlands cover about 4.63% of the total geographical area. Wetland ecosystem provide a large number of economic, environment and social services. Wetland is of great importance and play a significant role in reducing the impact of floods, protect shores from wave action, improve water quality and absorb pollutants. The Wetlands are rich in biodiversity. They support a large species of plants and animals. Water fowls and fishes are the important fauna of the wetlands. Wetlands also provide a suitable habitat to plants and animals that are found nowhere else except wetlands. But the diversity of wetland is threatened by natural as well as man-made activities. Anthropogenic stress is degrading the wetlands day by day. Over fishing, hunting of water fowls, deforestation, dumping of industrial and domestic waste in wetlands and encroachment are main factors responsible for Wetland degradation. Government takes initiative for Wetland restoration and conservation. An international Convention named Ramsar convention was adopted to save wetlands. National policies and laws were made to conserve these wetlands. Sustainable development and ecotourism is followed to save the wetland from destruction. It is important to take care of existing ecosystem and ecology of wetland. The data and information mentioned in the review is collected from research papers, journals, thesis and books.

1. Introduction

In India 54 Wetlands are designated as Ramsar sites. The 1st wetland designated as Ramsar Sites in India is Chilika Lake in Orissa and Keoladeo National Park in Rajasthan. The largest Ramsar site in India is Sunderban Wetland and the smallest one is Renuka Wetland (Neha et al., 2022). Wetland is an area that is completely or partially saturated with water, whether throughout the year or for a species season. Wetland which is relatively a new term is a significant natural resource (Mitsch and Gosselink, 1986). In India there are three types of wetlands i.e Inland, Marine and coastal wetlands Farheen *et al.*, (2022). The inland wetlands generally receive water through sources such as river outflow, precipitation, seepage from the lakes, ponds, streams and irrigation systems (Ramachandra, 2001).

Wetlands are considered the most productive ecosystems on earth that provides a large number of services to humans, such as flood mitigation, food security and good water quality (Shivakrishna et al., 2021). Wetlands all over the world are dwelling places for several plants and animals. It has been observed that wetlands provide a worthy habitat for the avian species. In India there are total 1340 bird species. (Ali and Ripley, 1987; Grimmett et al., 2016), out of which about 310 species found in wetlands (Kumar et al., 2005). Wetlands provide suitable habitat to large number of fishes. India Wetlands serve as major source of fish production.

The Vegetation of Wetlands perform various tasks that are beneficial to our environment. The tasks includes:-Sediment trapping, nutrient Recycling, pollution removal, shoreline stabilization and management of dissolved oxygen that is present in waterbody (Barko et al., 1998). Wetlands are actually ecotones because these are transitional zones between the terrestrial and aquatic environments.

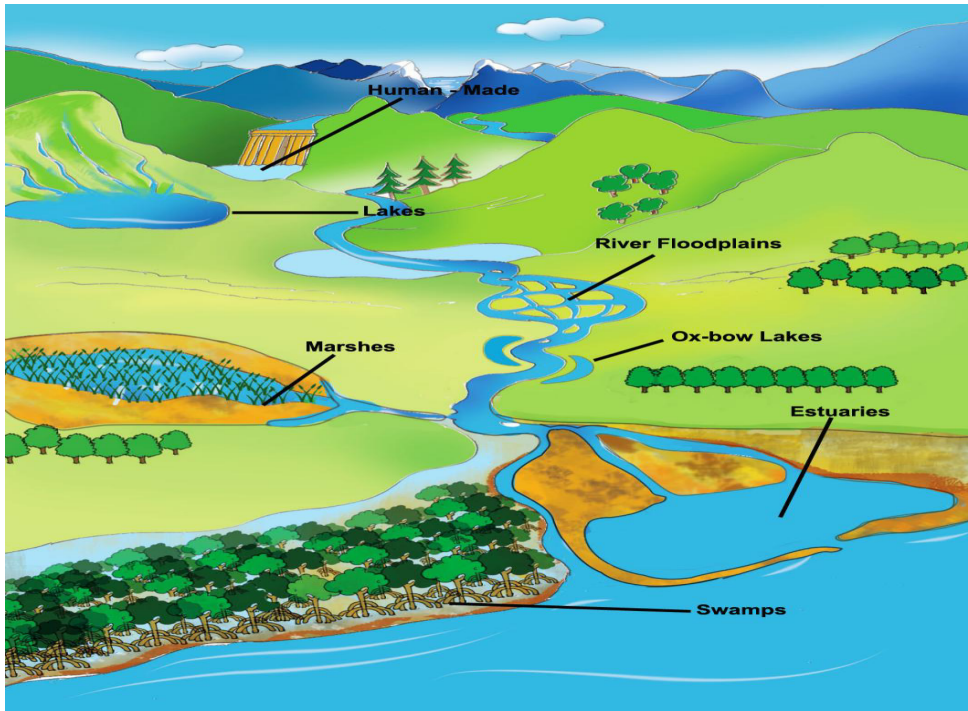


Fig 1. Different types of Wetlands (Source: MoEFCC)

Wetlands are generally classified as marshes, bogs, swamps etc on the basis of the plants and soil present there. Wetlands are found in every country of the world except Antarctica. The world's largest wetlands are Amazon River Basin and Peat Lands of Siberia (Fraser, L *et al.*, 2019).

The term wetland, was first used officially in 1953, in a report by the U.S. Fish and Wildlife Service (USFWS) that later provided framework for publications concerning waterfowl habitats in the United States. Since then, different ecologists and government official define wetlands variously. However, the definition provided by the Ramsar Convention, an intergovernmental treaty signed in Ramsar, Iran, in 1971 to guide all countries to conserve wetland of national and international importance, is mostly preferred:

1.1 Definition of wetland as per Ramsar convention:-

“Wetlands are 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”(Ramsar convention, article 1.1).

1.2 Main Objectives Of The Study:-

- To study biodiversity of wetlands.

- To study services provided by wetlands.
- To study importance of the wetlands.
- To study types of threats to Wetland
- To study conservation measures that are needed for wetlands restoration

1.3 Methodology of Study

The information and data is collected from the secondary sources such as thesis, journals, research papers and books.

2. Review Of Literature

2.1 Ecology Of Wetlands: -Mohammad Abdul Mazid(2019) carried out his study on wetlands and concluded that the most important factor responsible for production of wetland is flooding(Keddy et al., 2010).The duration of flooding and saturation of soil for a long time by groundwater decided whether the wetland has Aquatic,swamp or Marsh vegetation. Other factors responsible for formation of Wetland are natural disturbance, fertility, competition,herbivory and salinity.

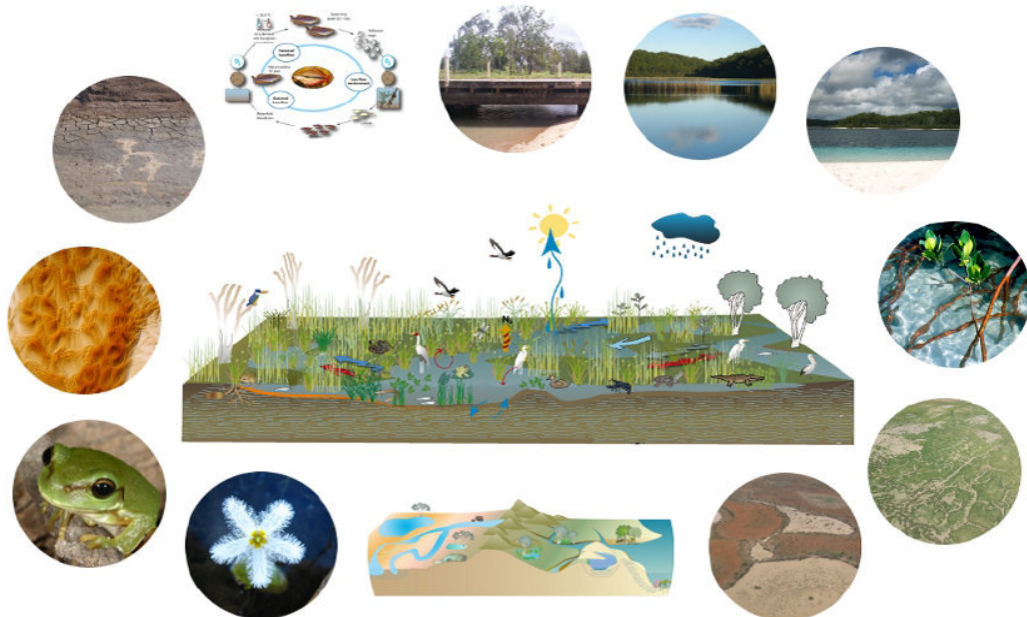


Fig 2. Aquatic Wetland Ecology (Source: WetlandInfo-Department of Environmental Science)

2.2 Biodiversity Of Wetlands :-

2.2.1 AlgaeAlgae vary in colour,shape and size.It occurs in naturally in all habitats such as inter-tidal zones,inland lakes etc and is a source of food for many free living animals.Invertebrates like turtles,frog and fish also feed on algae.

Mainly there are three groups of algae:-

A. Planktons:- These are free-floating and microscopic.Planktons are the basis of the food web

.

B. Filamentous Algae :- These have long strands and form floating mats.

C. Chara And Nitella :- These algae are upright and appear in lake submerged plants with roots.

2.2.2 Flora:- In wetland there are abundant of plant species.Throughtout the wetlands of world four groups of hydrophytes are common i.e submerged plants, floating plants,shurbs and trees.

In freshwater and saline conditions submerged vegetation is found example eel grass and sea grass.

Floating vegetation or floating plants are also found in almost every wetland.In Harike Wetland of Punjab submerged species like Vallisneria natans, Hydrilla Verticillata and Najas minor and floating plants like Pistiastratiotes,Eichhorniacrassipes and Nelumbonucifera are common(Gautamet al.,2021).Shrubs and trees are mostly found in swamps.Some swamps are dominated by single specie example Silver maple swamps around the Great lake(Wilcox etal.,2007).Amazon basin have more than 30 species of trees for example mangroves and Cypress (Goulding.,1980).



Fig 3.Mangroves (source:Google)

2.2.3 Fauna:- It has been observed that fishes are more depend on what habitat than any other habitat.It is seen that 31 Tropical species of fish use coralreefs as food and Mangroves as hatchery and nursery grounds.Frogs use both terrestrial and Aquatic habitat tofeed.Frogs are also indicator of ecosystem health because their thin skin absorb toxic nutrients present in their surroundings which lead to their death under unfavorable and over polluted conditions.Reptiles such as crocodiles and alligators are also found in freshwater as well as in estuaries and saltwater.Wetlands are extensively used by wading birds and (W.Milton.,1999).The most common species of turtle known as Snapping turtle is found in wetlands.Wetland attract a large number of mammalian species because of its abundance of vegetation,seeds and berries found there.Wetland also possess abundant of prey such as invertebrates, amphibians and small reptiles.In wetlands till now about more than half of 100000 known species of insects and invertebrates are found.TheNangal Wetland of Punjab about is dwelling place of about 146 species of these birds belong to 46 families and are classified under 17 orders(Singh *et al.*,2016).



Fig 4.Snapping turtle (source:Google)

3.Classificaton And Distribution Of Wetlands:-

Arya et al.,(2020)studied the types of wetland and their distribution in India as discussed below:-

3.1 Classification Of Wetlands:- The wetlands in India Immensely distributed from the region of Himalayas to Deccan knap. In India,there is different climatic types and topograpphy which is responsible for a large diversity of fauna and flora (Prasad et al., 2002).The National Wetland Atlas (2011) generally classified the wetlands of India into three levels i.

- Level 1
- level 2
- level 3

Indian Wetlands classification according to National Wetlands Atlas(2011)

Level 1	Inland wetlands		Coastal Wetlands	
Level 2	Natural	Man-made	Natural	Man-made
Level 3	Lake	Barrage/ Reservoirs	Creek	Aquaculture pond

	Oxbow lake		Sand/Beach	
	Rivers	Water loddged	Lagoon	Salt pan
	High altitude Wetlands	Tank/pond	Salt marsh	
	Rivarian Wetlands	Salt pan	Coral reef	
			Mangroves	

Table 1. Classification of Wetlands

Distribution of Wetlands in India:-

India total has 757,060 wetlands that cover an area of 15.26 million hectares which is about 4.63% of total geographical area of the country. Out of 757,060 about 46,68 are inland natural wetlands and 142,812 are inland man-made wetlands. India do have a large number of coastal Wetlands. About 10,204 And 2829 are natural and man-made respectively. Inland wetland cover 10.56 million hectares area and coastal Wetlands cover an area of 4.41 million hectares.

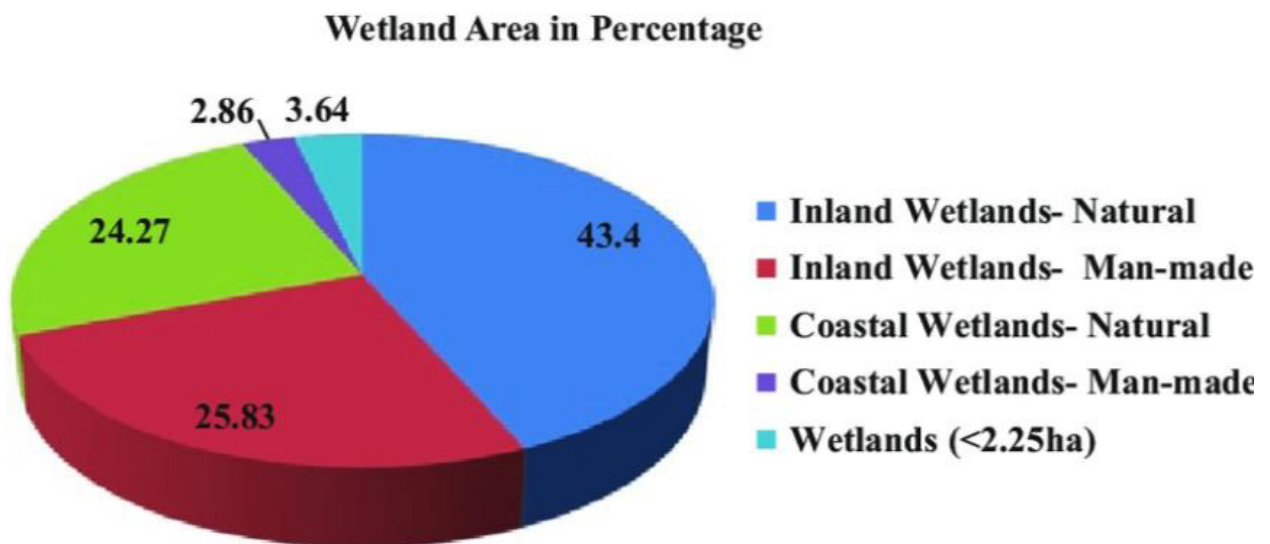


Fig 5. Pie diagram showing Wetland distribution (Source: MoEF, Government of India 2011)



Fig 6.-Indian Wetlands distribution (source :Bassi *et al.*/journal of hydrology : regional studies (2014)

4.List Of Ramsar Sites Of India:-

S.no.	Ramsar site	State location
1.	Sunderbans	West Bengal
2.	East Kolkata Wetland	West Bengal
3.	Asan Conservation Reserve	Uttrakhand
4.	Kolleru Lake	Andhra Pradesh
5.	Deeopar Beel	Assam
6.	Kabartal Wetland	Bihar
7.	Khijadia wetland	Gujarat
8.	Nalsarovar Bird sanctuary	Gujarat
9.	Thol Lake Wildlife Sanctuary	Gujarat
10.	Wadhvana Wetland	Gujarat
11.	Bhindawas Wildlife Sanctuary	Haryana
12.	Sultanpur National Park	Haryana
13.	Chandertal Wetland	Himachal Pradesh
14.	Pong Dam Lake	Himachal Pradesh
15.	Renuka Wetland	Himachal Pradesh

16.	Wular lake	Jammu and Kashmir
17.	Hokera wetland	Jammu and Kashmir
18.	Surinsar-Mansar Wetland	Jammu and Kashmir
19.	Tsomoriri Lake	Jammu and Kashmir
20.	Asthamudi Wetland	Kerala
21.	Sasthamkotta Lake	Kerala
22.	Vembanad Kol Wetland	Kerala
23.	Tso Kar Wetland	Ladakh
24.	Bhoj Wetlands	Madhya Pradesh
25.	Sakhya Sagar	Madhya Pradesh
26.	Lonar lake	Maharashtra
27.	Nandur Madhameshwar	Maharashtra
28.	Loktak lake	Manipur
29.	Pala Wetland	Mizoram
30.	Bhitarkanika Mangroves	Orissa
31.	Chilka lake	Orissa
32.	Beas conservation reserve	Punjab
33.	Harike Wetland	Punjab
34.	Kanjili wetland	Punjab
35.	Keshopur-Miani Community Reserve	Punjab
36.	Nangal wildlife sanctuary	Punjab
37.	Ropar lake	Punjab
38.	Upper Ganga River (Brijghat to Narora Stretch)	Uttar Pradesh
39.	Sur sarovar	Uttar Pradesh
40.	Sarsai Nawar Jheel	Uttar Pradesh
41.	Sandi Bird sanctuary	Uttar Pradesh
42.	Samaspur Bird Sanctuary	Uttar Pradesh
43.	Saman Bird sanctuary	Uttar Pradesh
44.	Parvati Agra Bird Sanctuary	Uttar Pradesh

45.	Nawabganj Bird sanctuary	Uttar Pradesh
46.	Haiderpur Wetland	Uttar Pradesh
47.	Bakhira Wildlife Sanctuary	Uttar Pradesh
48.	Rudrasagar lake	Tripura
49.	Pichavaram Mangrove	Tamil Nadu
50.	Karikili Bird Sanctuary	Tamil Nadu
51.	Pallikaranai Marsh Reserve Forest	Tamil Nadu
52.	Point Calimere Wildlife and Bird Sanctuary	Tamil Nadu
53.	Keoladeo Ghana NP	Rajasthan
54.	Sambhar Lake	Rajasthan

Table 2.-Ramsar sites of India(Source:Ministry of Environment and Forest, Government of India)

5.Importance Of Wetlands

Wetlands provide a large number of products and services to humans thus are considered to have specific and unique features (Prasad *et al.*,2002).

Sharma *et al.*,2020 Studied the benefits provided by wetlands.These provides a large number of services such as

- i. Flood control
- ii. Water irrigation
- iii. Fishes
- iv. Non-timber forest product
- v. Water supply
- vi. Recreational and tourism
- vii. Shoreline stabilization and storm protection
- viii. Groundwater recharge
- ix. Toxic retention
- x. Nutrient removal

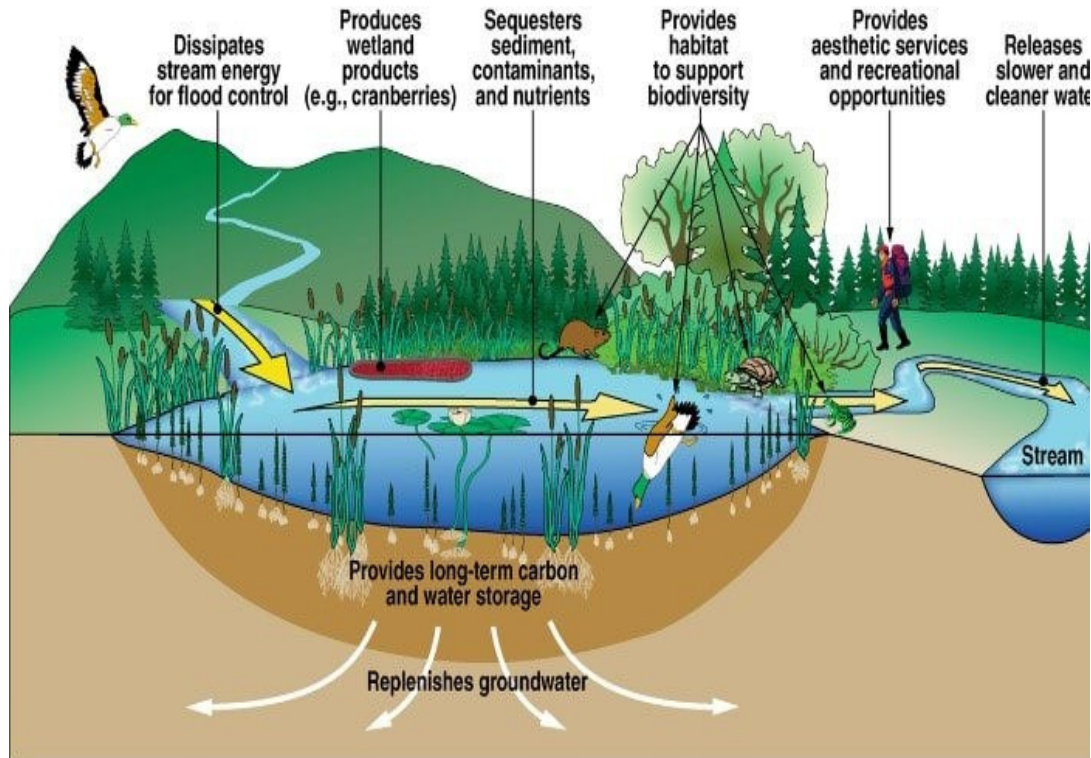


Fig 7. Services provided by Wetlands (Source:North America Marine Protection Association)

- i. **Flood control**:- Because of abundance of vegetation wetlands have more water retention capacity. Due to precipitation the water down flows from a mountain in form of a stream, the wetlands have capability to hold this water which prevents areas in downhill from flooding.
- ii. **Water irrigation**:- Wetlands provide irrigation for agriculture that takes place in its peripheral areas. Wetlands (Lakes) are extensively used for agriculture and domestic uses.
- iii. **Fishes** :- Wetlands are major sites and play a major role in production of fish in India. About 61% of fishes are produced by inland water bodies i.e. canals, ponds, tanks, rivers, reservoirs and lakes. The fish production in India has shown an increasing rate from 0.2 million tonnes in 1950-1951 to 5.1 million tonnes in 2010-2011.

- iv. **Non-timber forest products:-** A large number of forest products rather than timber are provided by wetlands such as fruits,berries,seeds,traditional medicines,salt (by water filtration from coastal wetlands),fuel wood,anima fodder,dyes and tannins,fibers etc (Mohammad Abdul Mazid., 2019)
- v. **Water supply:-**Wetlands such as Chilka lake (orissa) ,Carambolin(Goa) ,Dal jheel(jammu and kashmir) ,Khabartal(bihar) ,Deepar beel(Assam) ,Kolleru (Andhra Pradesh) ,Nainital(Uttarakhand) ,Loktak(Manipur) ,Vembanad(kerala) and Nal sarovar (Gujarat) provide water supply to the people living in their surroundings.
- vi. **Recreational Activities and Tourism:-** Wetlands now-a-days are common tourist sites because of its beautiful vegetation and fauna.Wetlands having different species of birds (migratory and native),fishes and other animals attract tourists.Different recreational activities have been started by the states which make tourist to visit wetlands.The generates income and the local people get benefits and employment.
- vii. **Shoreline stabilization and storm protection:-** The inter-tidal and tidal stabilize and protect coastal zones.The coral reefs acts as a barrier which protects coastal shorelines. Mangroves also play an important role in stabilizing coastal shorelines. Wetlands reduce the height and speed of wave which minimize the damage it may cause.
- viii. **Groundwater recharge:-** Wetlands are linked to groundwater directly and it regulates both the quality and quantity of water that lies below ground.Wetlands constitute sediments like limestone that play important role in water replenishment.Sediments are porous and filter the water when it flow down thorough the soil.

6. Threats To Wetlands:-

Ehsan daryadel *et al.* (2018) studied Threats to Wetlands and divided threats generally in two types:-

1.Natural threats

2.Human threats to wetlands

6.1Natural threats:- The natural threats can be in different forms.Some important ones are

- Flooding
- Subsidence
- Soil erosion
- Drought

a. Flooding:- Wetlands are like sponge that trap and release water. Wetland vegetation, Trees and roots gradually reduces the flood water speed and this water slowly get distributed over the Floodplains. (Costanza *et al.*, 2008) that are in close proximity to coastal and estuaries are more prone to floods while the intensity of flood differs (Kushner, 2009). Floods are hazardous and leads to loss of flood plains, vegetation and fauna.

b. Subsidence:- It is another hazardous threat to wetland. Subsidence is caused by excess oil extraction from land or by overexploitation of groundwater which slowly results in land settling down or sudden land shrinkage past few years more than 200 cases of land subsidence have been recorded all over the world (Ustun *et al.*, 2010).

c. Soil erosion:- It is another serious natural hazard. Soil erosion takes place in areas that are disturbed by anthropogenic activities. The runoff transfers the soil particles to areas of lower elevation when the velocity of water decreases the soil particles carried by run off starts depositing and it leads to sedimentation of wetlands. Sedimentation is the end result of soil erosion.

The losses caused by soil erosion are :-

- 1) Soil Degradation
- 2) Desertification
- 3) Loss of soil nutrients

Impacts of soil erosion on wetlands ecosystem:-

- Because of sedimentation wetlands lose the areas that contain water and with time there is excess growth of aquatic vegetation which choked the wetlands. These changes leads to wetland biodiversity loss
- The sedimentation also have worst affects on aquatic animals, sedimentation causes skin smoothening of aquatic invertebrates and destroy their habitat which is important for them to survive.
- Sedimentation turns the water color to Red. The water become cloudy that prevents sunlight from reaching the bottom Plants and algae it eventually reduces photosynthesis and there is decline in nutrition levels.

d.Drought:- Drought is caused by global warming and climatic changes. It is one of the most threatening challenges that wetlands are facing. Drought leads to shrinkage of wetland because plants and animals of a wetland don't get enough food and water for their growth and development. Drought has a serious impact on microorganisms also that are responsible to drive biogeochemical cycles. As we know wetlands serve as global carbon sinks but due to drought wetlands eventually are turned into a source of atmospheric methane and carbon (Tian *et al.*, 2012). Drought is responsible for decline in water quality.

6.2 Humans threats to wetlands:-

Throughout the world human interference are responsible for wetland degradation. Humans are spoiling wetland ecosystem in every possible way. The most common causes are :-

A. Wetlands Drainage and Conversion for Various Land uses.

B. Discharge of Hazardous Wastes

C. Unsustainable Ecotourism

D. Introduction of Alien Invasive Species

E. Intensification of the Greenhouse Effect

A. Wetland drainage and conversion for various land uses:- The wetlands all over the world are drained and are converted to crop lands (G. E. Hous., 1990). The conversion of wetlands to croplands leads to habitat destruction of various plant species, aquatic species and shrinkage of wetlands. Drainage of wetlands causes chemical, physical and biological changes in wetland. Effect on biota and increased pollution have bad impact on wetlands ecology and also conversion of wetlands for land use destroy the ecosystem of wetlands. The another cause of Wetland destruction is the sedimentation loads via streams that are connected to it (Walters *et al.*,)

B. Discharge of hazardous wastes:- The primary pollutions caused by humans are hazardous effluents that came from industrial and urban wastes, smelting and mining, agricultural activities, manufacturing and processing industries etc. Using insecticide and pesticides in agriculture around the area of wetlands cause damage to wetland flora and fauna in many known ways. The harm caused by pesticides to animals and plants either alter their population structure or alter ecosystem or it may alter community (S. Hamilton., 1993). These chemicals leads to growth of excess of aquatic plants, reduce production of water fowls and aquatic animals are also affected by these chemicals. All these chemicals have lethal effect on flora and fauna of the wetland. The residue of these heavy metals reside inside the flora and fauna of Wetland which eventually enters the food chain and cause health issues to humans (Shakeri *et*

al.,2010).Contamination of wetlands by Heavy metal is a worldwide problem and every country is dealing with it.

C. Unsustainable ecotourism:- Ecotourism is a source of income of almost all countries and adds to world's economy. The human activities intensively destroy and disturb wetland.Intensiveagriculture, urbanization ,hunting, fishing etc cause damage on a large scale to W These activities differ place to place and their impact may be direct or indirect (A. Kotios *et al.*,2009). Tourism generate income to local people living around wetlands but at the same time it causes serious damage to wetlands biodiversity.Ecotourism plays important role in wetlands destruction. Construction of tourism related infrastructure and roads, use of water, pressure on land use, agricultural activities etc are main threats to wetlands. The tourist trample the vegetation by using the same trail again and again which results in loss of vegetation of that region.This damage can be more extensive if the visitors move off the established trail (Ugur Sunlu.,2003).

D.Introduction of alien invasion species:- Alien species are actually organisms that introduced accidentally or intentionally to the wetlands. This is generally done for a specific purpose i.e to enhance fish resources of a wetland and for economic perspective. Alien species have extreme destructive impacts on native biodiversity of wetland and it cause an instant decline or even extinction of native species. Alien species are responsible for global biodiversity loss (Vitousek *et al.*, 1997). Inavasion of alien species destroys the habitat, behavior, food of native species and also spread incurable diseases.

E. Intensification of greenhouse effect:-The greenhouse effect is caused by the human activities.The excess of greenhouse gases emissions is a causative agent of global warming which eventually leads to climatic changes.The climatic changes have worst impacts on wetlands negative impacts of climate changes are observed during spring season for example it is seen that birds breed or sing early in spring before a fixed time, migratory birds arrive early, butterflies arrive before time and amphibians spawn early.

- It is concluded by intergovernmental panel on climate change (IPCC) that global sea level will rise Throughout the 21st century and beyond because of greenhouse gas induction into atmosphere (R. J. Nicholls.,2004).

- The Scientific researchers estimated that if 1m global-mean sea level rise(SLR) it will threaten more than half of coastal Wetlands of world(Blankespoor *et al.*, 2012).

7.Methodologies used for mapping, monitoring different features of wetlands and to detect changes in Wetlands:-

7.1 Mapping and Monitoring by using Remote Sensing Technique:-

Jing li *et al.*,(2017)studied The remote sensing techniques used for wetland mapping and monitoring and considered it the major source that gives spatial information about the wetland surface cover (Schmidt *et al.*, 2003). Remote sensing is used to study different features of wetlands such as:-

- a)changes in wetland area/land use (Schmidt *et al.*,2003;Wang, L *et al.*,2004;Giri, C *et al.*,2011).
- b)release of the carbon from peatland fires (Werf *et al.*,2006;S.E Page *et al.*,2002;Toriyama *et al.*,2014;Rappold *et al.*,2011)
- c)Climate warming and carbon cycle (Gorham *et al.*,1991;E.P Green *et al.*,1998;Nicholls *et al.*,2004;Park N.W *et al.*, 2003;Wang L *et al.*, 2004;Yuan *et al.*, 2005; Giri C *et al.*,2011;Holden *et al.*, 2005).
- d)hydrology processes in wetland(Li, S.-Net *et al.*,2009; Vörösmarty, C.Jet *et al.*, 1991;Slater *et al.*,2002).

Different aspects of wetlands that can we can study with the help of remote sensing are:-

- Flooding/inundation
- Habitat/biodiversity
- Biomass/carbon stock
- Water quality

A.Flooding/inundation:- Floodplains are transitional zones between the terrestrial and aquatic environments (Murray O *et al.*, 2006).Landsat data is used to study extent and location of inundated areas (Wang Y *et al.*,2002).Further,Landsat data is used to analyze flood prone areas and to build floods management models.

B Habitat/biodiversity:- Wetlands serve as habitat to a large number of flora and fauna. Many endangered species are restricted to a specific wetland. Loss of habitat and wetland degradation by human activities and climatic change can be detected by using remote sensing. Landsat data is generally used to detect wildlife habitat of a specific species. Tulbure *et al.*, (2014) used Landsat images to study water dependent organisms. Toral *et al.*, (2011) used the data from remote sensing to get information about stages of rice paddy and mapped the water birds and habitat available for them.

C. Biomass/carbon stock:- The status of wetland ecosystem is reflected by its biomass. Mostly Hyperion infrared bands and Landsat EMT+ are used for the estimation of biomass. Landsat data and survey both are used to estimate carbon content of wetland (Byrd *et al.*, 2014).

D. Water quality assessment:- The Landsat data used for water quality assessment is grouped into two categories:-

- the quality of water is assessed by monitoring reflectance changes of the Landsat bands (Mertes *et al.*, 1993).
- One use Landsat data for identification of land cover types and then relationship with water quality is determined (Choi *et al.*, 2013).

The sedimentation and geomorphic processes are analyzed by using Landsat data.

7.2 Mapping and Monitoring of Wetland by using Synthetic Aperture Radar(SAR):-

Adeliet *al.*, (2020) studied the application of SAR for mapping and monitoring of SAR. The SAR is emerged as a superb tool for accurate and rapid wetland monitoring. SAR acquire information by detecting the moisture contents and roughness of wetland surface. In SAR multiple sensors are used for accurate results. SAR specifications such as incidence angle, polarization and frequency are selected and used according to type of wetland. It creates two or three-dimensional image of an object.

7.3 Mapping and Monitoring of Wetland by using Unmanned Aerial system (UAS)

Jeziorska (2019) monitor changes in wetland by using unmanned Ariel system. The UAS is made and make accessible to everyone in order to ignite their interest. They obtain high resolution images of the land surface and water. These are used to study those wetlands that are difficult to access practically. These are mostly used for hydrological modeling.

8. Wetlands Conservation Strategies:- Time to time various laws and conventions were made to conserve Wetlands of National and International importance in India.

8.1 International Strategies for Wetlands Conservation:-

Due to human activities wetlands are degrading day by day. There is an urgent need to restore wetlands. A large number of conservation measures are suggested from time to time to save the Wetlands.

Ramsar convention

Paul *et al.*, (2011) studied the Ramsar conventions and its role in the conservation of wetlands. The Ramsar convention was an intergovernmental treaty that was adopted on 2nd February 1971 in the city of Iran that lies on the southern shore of the Caspian sea. This convention was made for the sustainable use of the natural resources and conservation of wetland. It includes the conservation of biodiversity of wetlands for example mammals, Aquatic plants, insects, birds, fishes, zooplanktons, phytoplankton etc. Ramsar convention is implemented at both regional and national level. In India, policies are made by government for wetland conservation.

8.2 Laws made by Indian Government to conserve Wetlands

kumari *et al.*, (2020) studied the laws made by the government of India in order to save Wetlands biodiversity, forest cover and water quality. The Indian policies that contribute in conservation of Wetlands are discussed below:-

- **Indian Fisheries Act, 1857** :- This act include the strategies for the conservation of fishes and ban the activities that degrade the water quality and destruct the fish habitat.
- **The Indian Forest Act, 1927**: The act was adopted to save the forest cover of the country and bann the activities like cutting of tress, collection of forest based products and destruction of habitat of forest animals.
- **Wildlife Protection act, 1972**: This act mainly provides protection to flora and fauna diversity of the country.
- **Water (control and prevention of Pollution) Act, 1974**: This act aimed to control water pollution and maintaining of the water quality.

- **Forest Conservation Act, 1980:** This act was passed in order to provide protection to forest . This act also contributes to the Wetland conservation by preventing siltation and soil erosion that is caused due to land degradation and deforestation.
- **Environment Protection Act, 1986:** This act made to save environment and tackle with the problems like pollution of soil,water and air.It also contribute to wetland conservation.
- **Coastal Zone Regulation Notification, 1991:** The main role of this act is to assist how to preserve the marine life and fresh water.According to this act the humans are prohibited to enter costal zones that are ecologically sensitive.

8.3 Articles And Some Recent Acts Added In Indian Constitution For Wetland Conservation And Measures Suggested For Wetland Conservation

Solanki *et al.*,(2021) Studied the recent article/acts that are passed in order to conserve wetlands of India and also suggested the measures of wetland conservation.

Acts/Article

<u>Act/Article</u>	<u>Description</u>
Article no. 51(A)	According to this article it is duty of every Indian citizen to Save forest,lakes and Wildlife
National environmental policy(2006)	The wetlands provide large number of ecosystem services,so to maintain their ecological character there is a need to set up a regulatory mechanism and support the integrated management of wetlands.
Wetlands(conservation and management)rules,2010	To manage and conserve wetlands of the country.
Wetlands (conservation and management) rules,2017	It includes complete prohibited of industries expansion, discharge of effluents and dumping of untreated waste into wetlands.

Table 3:-Articles /Acts (Source:MoEF)

8.4 Various key Measures Suggested for Wetland Conservation :-

- a. The encroachments that leads to wetlands transformation should be banned.
- b. Extension and establishment of industries in and around wetland areas should not be allowed.
- c. Disposal, production, storage and annihilation of waste under the Construction and Demolition waste management Rules, 2016.
- d. Dumping of solid waste should be banned completely.
- e. Ban release of unprocessed sewage or waste from towns, cities, industries, slums, villages and other human inhabitants.
- f. Illegal hunting of fauna of wetlands should be banned .

Ehsan Daryadal (2018) suggested some alternate ways of wetland Conservation and management.

- Establishment of natural reserves to save endangered flora and fauna.
- Education, research, personnel competent and transfer of data.
- Wise use of natural resources
- Sustainable management of wetland
- Promote ecotourism
- Aware people about wetland importance by holding seminars, organising workshop, celebrating the World wetland day etc
- Complete implementation of Ramsar convention
- Complete hunting and fishing in Wetlands
- Monitor the ecological changes that take place in wetland
- A strategic approach should be made to save wetland from deterioration
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9. Distribution of Wetlands in Punjab and Status Of Wetlands Conservation in Punjab State

9.1 Wetlands Of Punjab

Kumar *et al.*, 2018 in his review discuss the Wetlands of Punjab and the Laws made by state and centre government to conserve and restore Wetlands.

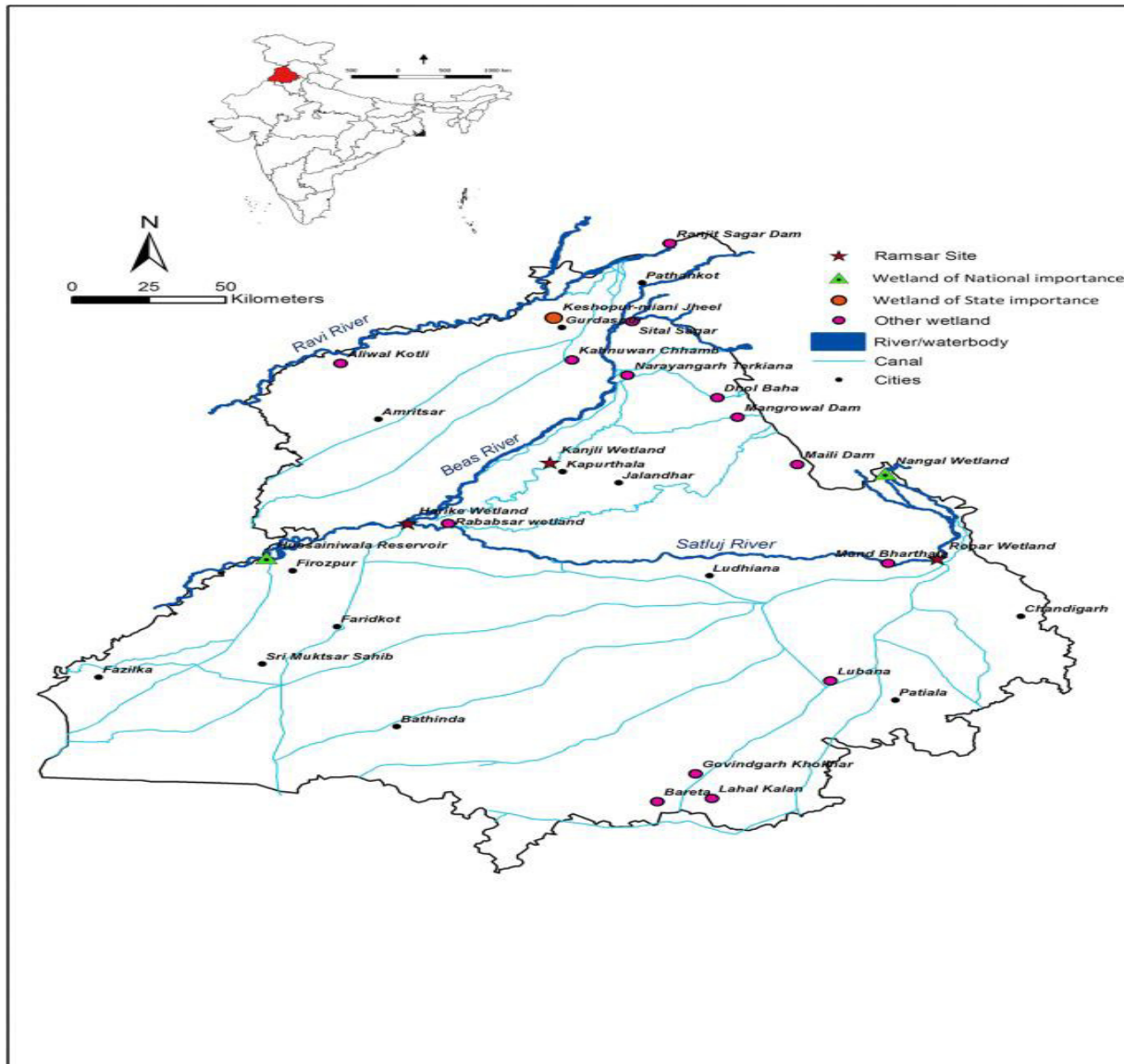


Fig 8:Distribution of Wetlands (Source:-Kumar *et al.*,2020)

9.2List of Wetlands of Punjab:-

Srno.	Wetlands	District	Nature of wetland
Large sized wetlands			
1.	Roparwetland	Ropar	Man-made
2.	Dolbahawetland	Hoshiarpur	Man-made
3.	Harikewetland	TaranTaran, Firozpur,kapurthala	Man-made

4.	RanjitSagar	Gurdaspur	Man-made
Small sized Wetlands			
1.	Keshorpurmianijheel	Gurdaspur	Natural
2.	Hussainiwala reservoir	Firozpur	Man-made
3.	Kahnuwannchhamb	Gurdaspur	Natural
4.	Mailidam	Hoshiarpur	Man-made
5.	NarayangarhTerkiana	Hoshiarpur	Natural
6.	Mangrowal Dam	Hoshiarpur	Man-made
7.	Kanjiliwetland	Kapurthala	Man-made
8.	MandBharthala	Nawanshahr	Natural
9.	Rabasar	Kapurthala	Man-made
10.	Berata	Mansa	Natural
11.	Lahailkalan	Sangrur	Natural
12.	Aliwalkotli	Amritsar	Natural
13.	Lobana	Patiala	Natural
14.	Nangal lake	Ropar	Man-made
15.	Sitalsagar	Hoshiarpur	Natural
16.	Gobindgarh khokhar	Sangrur	Natural
Table 4:-Wetlands of Punjab (Source:Jerath <i>et al.</i>,2014).			



Fig 9. Source:-Tribune India (Harike Wetland,Punjab)



Fig 10. Source:-Tribune India (Kanjili Wetland, Punjab)

9.3 Status of Wetland Conservation in Punjab:-

In Punjab three wetlands named Kanjli, Harike and Ropar are recognized as Ramsar sites. The very first conservation programme for wetlands in India was implemented by Ministry of Environment and Forests programme (MoEF) in 1985-1986 and was named as National Wetland Conservation Programme.

Under this convention about 115 wetlands were selected for the conservation and management, among these four wetlands of Punjab were selected i.e. Harike, Kanjli, Ropar and Nangal. In 1987 the Punjab government started to make efforts to conserve and manage Harike and Kanjli wetland with assistance of Ministry of Environment and Forests programme (MoEF).

In year 2013, the two separate plans for wetland and lake conservation were merged to form a single plan name National Plan for conservation of aquatic ecosystem (NPCA). For implementation of this plan Government provides funds to conservation activities like awareness, dealing with pollution, selection of area, survey, awareness and education. In Punjab, the Punjab state council for science and technology deals mainly with management and conservation of wetlands of the state.

Out of 20 wetlands of Punjab, three of them are recognised internationally that are Harike, Kanjli and Ropar. The other two are Ranjit Sagar and Nangal wetlands that are nationally recognised. The management and conservation action plans are made and implemented mainly on these wetlands.

Awareness campaigns are organized to make understand people the importance of wetlands.

10. Status of Wetlands Conservation In India

Chandrakar *et al.* (2020) studied the sustainable development of wetlands in India and work done by Indian government to conserve these wetlands. It was observed that, until 2000 very less support was given for wetland management virtually. The management of wetland was done through array of Ramsar convention and National policies like National Conservation Strategy and policy statement on Environmental and Development 1992; Natuo Policy and macro level action strategy on biodiversity, 1999; Regulation Notification, 1991 and National water policy 2002.

Under Ramsar convention initially Keoladeo National Park (Rajasthan) and Chilka Lake (Orissa) were considered as Wetlands of international importance and were designated as Ramsar sites in 1985.

After this, in 1985-1986 National Wetland Conservation Programme (NWCP) was launched in collaboration with state governments for management and conservation of Wetlands of each state of India.

In 1993, National Lake Conservation Plan (NLCP) was launched for the restoration and monitoring of wetlands. Under this plan urban lake that undergo anthropogenic stress were monitored, restored and managed.

In 1996, National River Conservation Plan was launched to save major rivers of the India from pollution. AS these rivers are source of water of wetlands. Polluted rivers eventually cause pollution to the Wetland. The draft the National water policy, 2012 was cleared by the National water resource council. This was made to make water bodies (wetlands also included in it) and river corridors free from pollution in a strategic way by making scientific plans.

According to 2022 scenario there are 49 Ramsar sites in India. There are 39 rivers under NRCP, 115 and 61 wetlands are under NWCP and NLCP respectively (source: MoEF 2012).

In 2017, the Wetland (conservation and management) rules were modifying the rules made in 2010, by the central government. According to new rules—paddy fields, river channels, salt production, aquaculture, recreation, irrigation purposes and water bodies that are constructed for drinking purposes are excluded from the definition of wetland.

India is considered as heart of Central Asian Flyway (CAF), about 71% migratory birds i.e. water fowls use India as a sojourn site (Kumar et al., 2020). In the year, 2018 MoEFCC make a Nation Action Plan for the Conservation of Migratory water birds and their dwelling place along the Central Asian highway.

In 2019, a scheme named Wetland health scheme was launched and the government of India identified and initiated to restore about 130 wetlands of the country in next five. According to this scheme, each Wetland should be given a health card that will denote the health of wetland. Individuals are selected and are named as ‘Wetland Mitras’ take part in spreading awareness among people about wetland importance and look after about 301 wetlands of the country.

11. List of Ramsar sites of India, threats to them and their conservation measures .

Sr.no	Wetland	Author's name and publishing date	Threats to wetland	Conservation measures
1.	Wular lake	Jamal <i>et al.</i> , (2022)	<p>Agriculture</p> <p>Human settlements around wetland</p> <p>Pollution</p> <p>High nutrients content</p>	<p>Avoid human interference</p> <p>Eco friendly development plan should be made and implemented by the government.</p>
2.	Hokersar wetland	Bano <i>et al.</i> , (2018)	<p>Change of wetland into agricultural land</p> <p>Discharge of domestic waste into wetland</p> <p>Excessive weed growth</p> <p>Eutrophication</p> <p>Water fowl hunting</p>	<p>Stop hunting</p> <p>Plant trees in Catchment area.</p> <p>Install Sewage treatment plant.</p> <p>Aware people by organising educational programs.</p>
3.	Surinsar and Mansar	Gupta <i>et al.</i> , (2017)	<p>Pollution caused by agricultural and domestic waste.</p> <p>Rapid growth of algal bloom</p> <p>Increased BOD and CO₂</p> <p>Siltation</p> <p>Eutrophication</p>	<p>Aware people by organising programmes in educational and public Institute.</p> <p>Fencing Of wetland.</p> <p>Establish green belt of plants on the peripheral region</p>

			<p>Killing of migratory birds</p> <p>Climatic changes</p> <p>Floods</p>	
4.	Harike wetland	Gupta <i>etal.</i> ,(2016)	<p>Decreased oxygen and alkalinity.</p> <p>Excess weed growth.</p> <p>Eutrophication.</p> <p>Pb, Cr, Ni, Cu, Cd concentration high.</p>	<p>Pilot project sahyog in 1999 was launched by the Punjab government for the conservation.</p> <p>Sustainable management of resources.</p>
5.	Kolleru lake	Dr.Demudu <i>et al.</i> , (2016)	<p>Encroachment</p> <p>Weed infestation</p> <p>Siltation</p> <p>Habitat destruction by people that reduce number of migratory birds.</p>	<p>Wetland should be more deepend.</p> <p>Sedimentation should be prevented.</p> <p>Minimize dumping of waste in wetland.</p>
6.	Loktak lake and Deeopar beel	Solanki., (2019)	<p>Reservoir development, crop rotation, dam building, unregulated fertilizer usage, excess fishing , dumping</p>	<p>Wetlands International-South Asia (WISA) works in association with Loktak Lake on Sustainable Development and Water Resources</p>

			<p>domestic waste etc are man-made causes.</p> <p>Siltation and erosion are also important and are natural threats to loktak lake.</p>	<p>Management.</p> <p>Guwahati water bodies conservation act 2008 was formed to preserve deeopar beel</p>
7.	Sunderban s	Kumar das., (2014)	<p>Cutting of tress for fuel, fodder, wood which leads to mangrooves depletion.</p> <p>People capture prawns by netting</p> <p>Hunting of royal bengal tiger.</p>	<p>UNESCO in Bangladesh that promote large-scale afforestation and conservations.</p> <p>Project tiger (1973is launched to save tigers.</p>
8.	East Kolkata wetland	Mondal., (2018)	<p>Exploitation due to human settlements around the lake.</p> <p>Agriculture</p> <p>Excess of fishing</p>	<p>Control pollution</p> <p>Lake should be desilted after fixed interval.</p> <p>Promote eco-aquacultures.</p>
9.	Kabar tal wetland	Singh <i>et al.</i> , (2021)	<p>Between two consecutive monsoon the lake undergoes: fragmentation, shrinkage and dry out.</p> <p>Water spoilage by runoff from</p>	<p>Monitor ground water and ban on extraction of ground water.</p> <p>Agriculture should be restricted in proximity of wetland.</p> <p>Manage drainage system to reduce siltation.</p>

			agriculture that contains insecticide and pesticides. Drying of ground water.	
10.	Bhoj wetland	Rather <i>et al.</i> , (2022)	Destruction of habitat by farming, harvesting, gazing and reclamation Hunting of fauna of the wetland	Limit human interference in in wetland. Monitor birds during breeding season.

11.	Lonar crater lake	Dabhade <i>etal.</i> ,0(2016)	<p>Decreased salinity</p> <p>Increasing biological oxygen demand</p> <p>Eutrophication</p>	<p>The micro flora and fauna of the lake should be investigated and assessed time to time</p> <p>Lower anthropogenic stress</p> <p>Assess water quality</p>
12.	Nal sarovar bird sanctuary	Vankar <i>etal.</i> ,(2018)	<p>The water is assessed and it is found that there is high concentration nitrites and nitrates.</p> <p>High alkalinity, turbidity, salinity, chlorides and acidity is threatening the aquatic fauna of sanctuary during monsoon season</p> <p>An increased pH and temperature during summer is observed that cause fluctuations</p>	<p>Limniological status of the lake needs to be improved.</p> <p>Management plans should be implemented to save birds of the nalsarovar</p> <p>There is need to take adequate steps to reduce pollution.</p>
13.	Sur sarovar Lake	Gopal <i>etal.</i> ,(2018)	<p>Lake is vulnerable to pollution because waste is dumped into it</p> <p>Industrial, agricultural and domestic waste is dumped into it</p> <p>Soil Erosion and siltation is also responsible for lake degradation</p>	<p>Reduce pollutant effluents dumping in lake</p> <p>Check water quality after a fixed time</p> <p>Treat waste before dumping it into lake</p>

14.	Haiderpur wetland	Arya <i>etal.</i> ,(2020)	The wetland is known for its birds species but it is declining day by day due to human interferences and agricultural activities in peripheral areas of the Wetlands.	<p>Regular monitoring of the wetland is important for the conservation of the birds and its ecosystem.</p> <p>Avain survey must be done in regular intervals to check their number.</p> <p>Human interferences must be reduced</p>
15.	Bakhira wetland	Mishra <i>etal.</i> ,(2019)	It an also an important site for both native and migratory birds,but due to agricultural runoff runis water quality and encroachment of area of Wetlands by local people is reducing the area of wetland	<p>Decrease agricultural activities Poaching needs to be controlled.</p> <p>Birds Scantuary should be fenced.</p> <p>Any illegal activity in the wetland should be banned</p> <p>Implement</p>

				laws for protection of this wetland.
16.	Ropar wetland	Saima <i>etal.</i> ,(2020)	<p>Anthropogenic stress from agricultural activities,domestic Wastewater</p> <p>Ash from thermal plant</p> <p>Silt from cement a plant</p> <p>Industrial effluents from National Fertilizer Limit plant Nangal affect the quality of water of Ropar wetland</p>	<p>Reduce dumping of any kind of waste without treating it into the wetland</p> <p>Aware people about wetland importance</p>
17.	Renuka Lake	Chodan <i>etal.</i> ,(2022)	The study revealed that ecological health of lake is medium because the water health is degrading due to natural and man made activities.This has a worst impact on its biodiversity q	Afforestation, organic farming, treatment of human , agricultural and industrial waste before disposal , continuous monitoring of lake and by awaring public through vedios, posters and seminars.
18.	Chilka lake	Peetabas <i>etal.</i> , (2015)	Eutophication, siltation, change in salinity, increased aquaculture activities, depletion of bioresources, proliferation of fresh water weed	For the sustainable development of it's bioresources Chilika Development

				Authority (CAD) was established to conserve and restore the Lake. CAD and the state Environment Department have taken many steps for chilka lake management and conservation.
19.	Rudrasagar wetland	Barman <i>etal.</i> ,(2013)	The cause of degradation is Autogenic succession, uncontrollable growth of weeds and Eutophication.	Project afforestation by forest department of Tripura. Tripura university and college of fisheries in association with some research project and thesis of students are working on how to restore lake and conserve its biodiversity.
20.	Sasthamcotta lake	Sreeraj <i>etal.</i> ,(2018)	In summer the temprature reaches upto 38°c which resulted in ground water reduction.	Government allocate a fund of 16.23 lakh rupees for the wetland

			<p>The sand, laterite and clay mining in the peripheral area of wetland force the groundwater to come out.</p> <p>Agricultural practices reduces the area of the wetland.</p> <p>Tourism also has adverse affect on the wetlands.</p>	<p>management in year 2009-2010</p> <p>Identify the main pollutant,reduce its protection and treat it before discharge</p> <p>No permission should be given by the govt.for construction of new industries in the catchment area.</p>
21.	Harike wetland	Gupta.,(2016)	<p>Cr,Pb,Cd,Cu and Ni are found above the permission quantity</p> <p>Eutrophication</p> <p>Excess demand of BOD and COD</p>	<p>In 1999 pilot project sahyog was launched by govt.of punjab to save harike</p> <p>Sustainable development</p> <p>Organize awareness camps</p> <p>Limit human interference</p>
22.	keoladeo ghana wetland	Verma., (2018)	<p>Because of urbanization around this wetland its sensetive ecosystem is</p>	<p>The buffer or core area of wetland should</p>

			<p>destroyed</p> <p>Tourism also have a negative impact on wetland ecology</p> <p>In vicinity of wetlands there are mobile towers that affects the health of birds</p> <p>The National Highway on one side of wetland is main cause of pollution</p>	<p>not be harmed</p> <p>Strategies should be made to deal with tourist and the number of tourist allowed at a time should be limited</p> <p>Laws and regulations should be made to save biodiversity of the wetland</p>
23.	Son beel wetland	Choudhury <i>etal.</i> ,(2020)	<p>Acute threats:-</p> <ul style="list-style-type: none"> • Filling of wetlands area • Removal of forest cover <p>Chronic threats:-</p> <ul style="list-style-type: none"> • Soil erosion • Sedimentation <p>GIS and remote sensing data shows the son beel is facing both natural and man-made threats</p> <p>Increasing pollution, population, deforestation</p>	<p>Promote ecotourism</p> <p>The wetland should be designated as wetland for its conservation or the govt.should provide funds for its development and safety.</p>
24.	Keshorpur community reserve	Mehta ., (2014)	<p>The local people here hire labour to scare the native and migratory birds</p> <p>The people use diesel engines in fish pond that</p>	<p>Urgent actions should be taken by government to save the wetland.</p>

			<p>damages the biodiversity of the lake</p> <p>Reclamation of land for agriculture and construction purposes</p> <p>Siltation and Weed growth also leads to wetlands degradation</p>	<p>Local people should come forward to manage and protect this natural heritage.</p>
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12. Conclusion

Wetland are true gifts by nature. It is duty of every individual living on this earth to make sustainable use of resources. Alone government cannot save the wetlands from depletion. People living in and around the Wetland should come forward and work in cooperation with government and NGO's to conserve the wetlands. Creating awareness by holding seminars, debates, educating people about wetland importance also plays an important role in Wetland restoration and conservation. It is an urgent need to conserve Wetland because they have a significant role and are most productive ecosystems on the earth.

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