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Exploring the Best Possible Solutions Towards Wetland Conservation and Management: A Review

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Abstract

Around 4.63 % of the geographical area of India is covered by wetlands. Wetlands are transition zones between land and water, including land which is either covered or saturated with water, either seasonally or throughout the year. Wetlands are significant ecosystems that provide numerous ecological, economic and social benefits. However, the significance and need of wetlands has been often avoided and forgotten. They are facing unprecedented threats from human activities, climate change and other factors. It has become a common practice to drain them, fill them or treat them as dumping grounds. This has led to a drastic depletion in these wetlands all over the world. Coastal zones and river deltas are being urbanized, further contributing to wetland loss. This research focuses on the approaches to conserve and manage wetlands in India. The aim of this research is to find solutions and ways to manage wetlands in India by studying examples of wetlands sites throughout the world. The objectives include analyzing the conditions of wetlands before and after being part of the Ramsar list of wetlands, studying case studies of sustainably managed wetlands. This research has explored the possibilities of conservation of wetlands, highlighting the importance of integrated approaches that involve government agencies, local communities and stakeholders. After analyzing the impact of Ramsar designation and examining successful international case studies, the study concludes that there is an urgent need for effective conservation and management strategies to reverse this trend. The findings of this research will contribute to developing sustainable management frameworks that ensure the long-term health of India's wetlands, securing their ecological and social benefits for future generations and also help for further studies.

Keywords— Ramsar Sites, Sustainable, Climate Change, Ecosystem, River Deltas

Ii. Introduction (Heading 1)

Wetlands are semi-aquatic ecosystems; including land which is covered or saturated with water, either throughout the year or seasonally. These are transitional areas between water bodies and dry lands. These include marshes, swamps, bogs, mangroves, lakes, floodplains, fens, peatlands, estuaries and many others. Man-made or constructed wetlands are also another sub-type of wetlands. There are three main types of wetlands as shown in figure1. The characteristics of various types of wetlands are given in Table1. Wetlands cover around 12.1 million square kilometers which is approximately 6% of the Earth's surface, a vast and ecologically significant area. Wetlands in India covers about 1,52,600 sq. km of area; which is about 4.63% of India's total area.

Wetlands are vital ecosystems, providing various ecological, social and economic benefits. These are habitats for numerous plants, animals and microorganisms. Migratory species rely on wetlands for breeding, feeding, and shelter. These are essential for the survival of various endangered and threatened species. Wetlands are also called the 'kidney of landscapes', since these filter water and improves water quality. Wetlands also help regulate the flow of water by storing and slowly releasing water into the environment, which helps maintain stream flow during dry periods and prevents flooding during heavy rains. These also play an important role in mitigating floods. This function is particularly important in areas prone to floods, protecting both human settlements and ecosystems. Wetlands, particularly peatlands, store large amounts of carbon in the form of organic matter. By sequestering carbon, wetlands
help mitigate the effects of climate change, acting as carbon sinks that prevent excess greenhouse gases from being released into the atmosphere. Wetlands provide significant resources that help provide livelihood to millions of people.

These resources include fishes, shellfishes, reeds and other aquatic plants which help local communities, especially the rural and the coastal areas. Moreover, wetlands provide great opportunity for eco-tourism as these are rich in wildlife and beautiful sceneries. Cultural, educational as well as recreational activities like birdwatching, boating, and nature tourism in wetland areas also provide economic benefit.
Despite their immense importance, the condition of wetlands in India is concerning.

Agricultural expansion is another major cause because wetlands are further drained to expand farms, disturbing the natural hydrological cycle and biodiversity. Dumping of industrial effluents and untreated sewage into wetlands affect the quality of water and aquatic life. Moreover, agricultural runoffs of chemicals including fertilizers and pesticides leads to eutrophication, which causes depletion of oxygen, proliferation of certain algal species, and loss of biodiversity.

Figure 1 Classification of Wetlands

The significance and need of wetlands has been avoided and forgotten. There has been widespread degradation, exploitation, and neglect towards wetlands; leading to significant ecological, environmental, and socio-economic consequences. Worldwide, wetlands are experiencing an alarming loss, having lost about 35% since 1970 and are vanishing three times faster than forests.
These resources include fishes, shellfishes, reeds and other aquatic plants which help local communities, especially the rural and the coastal areas. Moreover, wetlands provide great opportunity for eco-tourism as these are rich in wildlife and beautiful sceneries. Cultural, educational as well as recreational activities like birdwatching, boating, and nature tourism in wetland areas also provide economic benefit.
Despite their immense importanLand-use conversion, including agriculture and urban development, and climate effects such as sea-level rise and altered hydrology are common threats to wetlands. Wetlands in India have been continuously subjected to degradation due to various human activities, environmental pressure, and lack of effective conservation efforts. Encroachment and urbanization emerged as one of the main causes for wetland destruction. Rapid urban expansion transformed wetlands into residential and commercial areas. Urban areas such as Bengaluru, Chennai, and Mumbai have drained and filled wetlands for the purpose of development, while ignoring their serious ecological implications.

Over- exploitation of resources such as overfishing depletes aquatic species, causing an imbalance in these ecosystems. Equally concerning is the excessive extraction of water for irrigation and industrial uses, which depletes water levels in the wetlands and often causes them to dry up during the summer season. This loss of natural wetlands, nearly 30% over the past four decades, highlights the urgent need to tackle these challenges to protect India's wetlands.

Case Studies:

1. Meishan Dongpo Urban Wetland Park - Sichuan Province
Location: Meishan City, Sichuan Province, China. Wetland Type: Riverine wetland (Inland wetland) associated
with natural water systems such as rivers and lakes Meishan Dongpo Urban Wetland Park is an example of an urban wetland park developed to attain ecological sustainability within urban development in China. The park is located in the city of Meishan, a region with historical and cultural significance in Sichuan. Being situated in the northwest of Dongpo Island, Meishan Dongpo Urban Wetland Park covers an area of 69.48 square hectometres.
The park facilitates mixed usage including- wetland conservation, science and cultural education as well as recreation. It is designed to offer a new open and green leisure place for urban citizens.

Table 1 Description about different types of wetlands

Sr no.	Wetland Type	Definition	Example	Flora	Fauna
1	**Marshes**	low-lying and seasonally waterlogged wetland with herbaceous plants	Terai in northern India and southern Nepal runs parallel to the lower ranges of the Himalayas.	grasses, sedges, cattails, bulrushes, reeds	Greater One-horned Rhinoceros,Asian Elephants,Tigers,Himalayan Goral, Gangetic dolphin, Gharial, and crocodiles
2	**Swamps**	forested wetlands permanently saturated with water; covered by trees and aquatic plants.	Myristica swamps in Western Ghats of Karnataka, Kerala and Maharashtra	trees belonging to the family Myristicvaceae; Trees like white cedar, northern white cedar, eastern hemlock, eastern white pine, pitch pine, loblolly pine, and black spruce	white-tailed deer, minks, racoons, pileated woodpeckers, purple gallinules, egrets, herons, alligators, frogs, turtles, and snakes
3	**Fens**	a type of peat-accumulating wetland fed by mineral-rich ground or surface water	particularly found in the Northeast Indian states of Assam, Tripura, and Manipur due to high rainfall and accumulation of organic matter, leading to the formation of peat layers	sedges, grasses, and other grass-like vegetation	water beetles, dragonflies, moor frogs, natterjack toads, grass snakes, water voles, mosquitoes, horseflies and various bird species
4	**Vernal Pools**	seasonal wetlands that fill with water in the spring and dry up in the summer and fall	occur in the Mediterranean climate conditions of the West Coast and in glaciated areas of northeastern and mid-western states.	herbaceous plants dominate the middle and shores, while mosses and shrubs appear when the pools dry up	frogs, salamanders, raccoons, skunks, bears
5	**Bogs**	a wetland with spongy ground and peat deposits	found in parts of Ladakh, Himachal Pradesh, Uttarakhand, Sikkim, and Kerala	peat mosses (Sphagnum), heaths, sedges, grasses (like cotton grass), and carnivorous plants like sundews and pitcher plants	insects like the hairy canary fly and bog copper butterfly, as well as mammals like beavers, moose, and raccoons, and reptiles like the bog turtle and viviparous lizard
6	**Riverine wetlands**	wetlands that are found along the banks of rivers, streams, and other bodies of flowing water	occur in the floodplain along the sides of non-tidal streams; found along riverbanks	grasses, sedges, rushes, and certain trees and shrubs adapted to saturated soils and waterlogged conditions	Platypuses, birds such as galahs, sulphur-crested cockatoos, ganggang cockatoos, cockatiels

The existing natural wetland has been conserved to sustain regional biodiversity and to enhance the quality of water in the region. Better health of residents by building urban forest wetland and greater biodiversity in urban environments is seen. It also offers locations for environmental education, like accessible sunken wetlands, that can be utilized to monitor habitats in underwater wetlands. The park's spatial structure planning falls into one axis (water moon central cultural axis in Dongpo), two belts (walking belt along the Bin Lake and water moon science and culture ecological belt), and five zones (wetland resting zone, wetland science and culture zone, recreational activity zone, ceremony activity zone and cultural activity zone). The area features rich biodiversity, including various aquatic plants and bird species, and serves as a habitat for migratory and resident birds.

It supports biodiversity by providing critical ecosystems for waterfowl, amphibians, fish, and plant species. Though not officially a Ramsar site, Meishan Dongpo Urban Wetland Park likely meets Ramsar criteria in terms of biodiversity support and its role in the migration of bird species. The park also contributes to water management by improving the local hydrological cycle and mitigating urban flooding. However, for official Ramsar recognition, further study and verification of its significance on a global scale would be necessary. Wetland such as this one must undergo regular biodiversity assessments and monitoring to meet Ramsar criteria fully. The park could benefit from more research into the status of migratory species, plant diversity, and the ecosystem services provided.

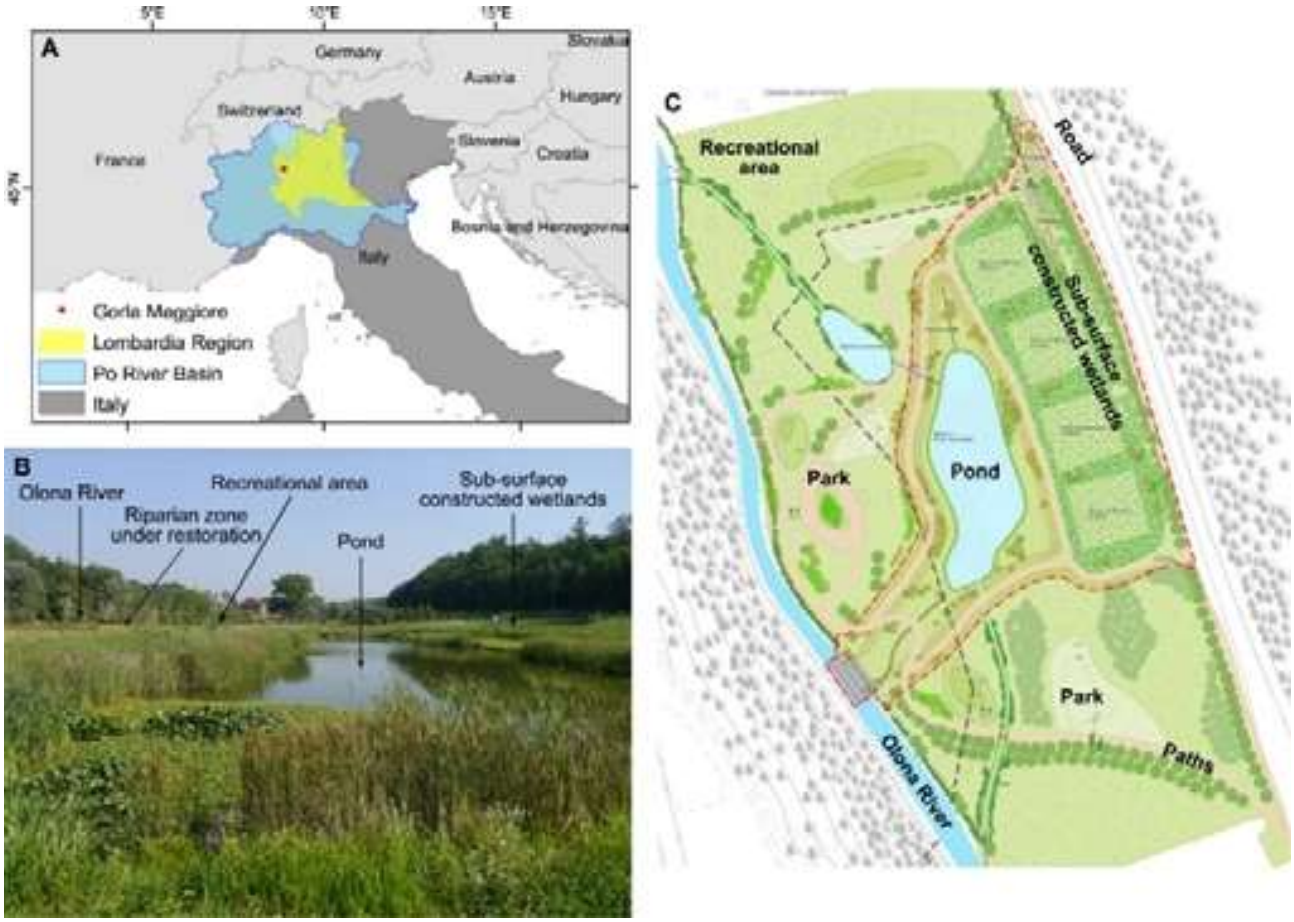

Figure 3 loca on of constructed wetlands in Gorla Maggiore, Ita with its view

The primary aim of the constructed wetland system in Gorla Maggiore was to enhance wastewater treatment and stormwater management while providing additional environmental and recreational benefits to the community. A set of constructed wetlands were to be built to treat combined sewer overflows. It an innovative nature-based solution to treat water pollution from the adjacent urban area. It consists of a green infrastructure that was specifically designed to treat the water discharged into the Olona River. The project aimed to improve the quality of wastewater, manage stormwater to reduce flooding risks, enhance local biodiversity and create green public spaces, provide educational and recreational opportunities for residents. Treating of direct first flush of effluents; partially treating of the second flush; storing the second flush for the protection of the receiving Olona river is done. This infrastructure was an experiment to test the applicability of constructed wetlands for the treatment of CSO (Combined Sewer Overflow).

The treatment of overflows during heavy rains is a crucial issue in the Lombardy Region, as there are some thousands of CSOs discharging in significant quantities to the overall pollution load to surface water. The water park is an artificial ecosystem constructed on the bank of the Olona River consisting of a pollutant removal section, a sedimentation tank and four artificial wetlands; a multipurpose section with a surface flow, an artificial wetland or pond with several functions, a flood event buffer tank, a biodiversity maintenance and recreational area; a recreational park with restored riparian trees, green open space, pedestrian and bicycle paths and other facilities.

The wetlands in Gorla Maggiore are built as multi-purpose green infrastructure systems. The wetland zones are made up of a series of artificial ponds, channels, and vegetated zones that replicate natural wetland processes. The wetlands are capable of treating wastewater and stormwater runoff, utilizing plants, microorganisms, and substrate filtration to purify the water. The system is divided into two main components:

a. Ve cal Flow Wetlands: These are used for the primary treatment of wastewater. Water is passed ve cally through different layers of soil

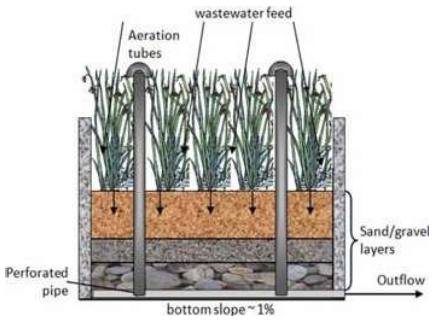

Figure 4 Schema c diagram of Ver cal Flow

and plants, Wlich dhelp filter out contaminants and remove pollutants.

b. Horizontal Flow Wetlands: Used for stormwater management, these wetlands allow rainwater runoff to flow horizontally through vegetation, promoting filtration and reducing the impact of heavy rains. Incorporating native vegetation and designing water flows to create habitat areas have also increased local biodiversity, supporting a variety of species, particularly birds and aquatic life.

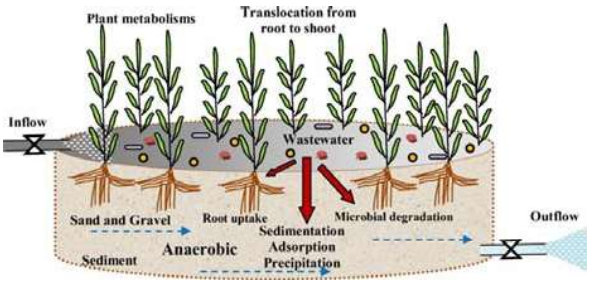

Figure 5 Schema c diagram of Horizontal Flow Wetlands

3. Mangroves in GoaLocation: Goa, IndiaWetland Type: Mangroves (Coastal wetland Mangroves in Goa, locating along the Mandovi and Zuari river systems, are among the most ecologically and economically significant coastal ecosystems in the state. These mangroves act as green guardians, and protect Goa's coastlines by supporting biodiversity, and sustaining livelihoods. Out of the total 2000 ha of mangrove forest, about 700 ha is along the 50 km span of the Mandovi estuary. The most prominent and extensive back-waters with mangroves are located to the east of Panaji. The total area of mangroves along the Mandovi and Cumbhajua canal is about 900 ha. Mangroves harbour wildlife which includes otter, fishing cats, monkeys and snakes. More common are birds like herons, storks, sea eagles, kites, kingfishers, sandpipers, tits, bulbul, whistlers, plankton, shrimps, prawns and small fishes. Diver island, approximately 11 km long, bifurcates the Mandovi into two channels. Before joining at the upstream end of the island, the two channels lead into an extensive network of narrow channels in a marshy area. Wetlands and tidal marshes form the ecosystems along course of river. These are currently used for irrigation facilities, tourism activity, dumping of domestic and industrial waste, fishing, agriculture and coastal resources. Threats to these wetlands are- conversion of land for developmental activities, felling of firewood, timber etc. and fishing using dragnets, which damages the younger regenerated mangrove crop. There is a lack of adequate and proper infrastructure for the protection of the ecosystem. Movement of barges carrying ores causing the uprooting of seedlings of mangroves and erosion is another issue faced by the ecosystem.

Analysis: In the first case study, a riverine or a riparian wetland has been studied; which is a sub-type of inland wetlands. Before the construction of the park, there was an existing natural wetland formed by the Minjiang River, which was later successfully preserved and integrated into the urban development area. Meishan Dongpo Urban Wetland Park is an example of sustainable urban planning where the wetland is used both for recreation and conservation. Local biodiversity habitats were also conserved. The water quality of the city improved. In the case of Meishan Dongpo, the integration of local communities through education programs and recreational activities would align well with the Ramsar approach to wetlands. Thus, this case provides a good reference for other cities to solve such contradictions in the process of urbanization. Meishan Dongpo Urban Wetland Park, while not a Ramsar site, embodies several principles of wetland conservation laid out in the Ramsar Convention. By implementing more stringent conservation measures and expanding community involvement, it could enhance its ecological functions, contributing to both local and global biodiversity conservation, while aligning with the Ramsar guidelines for sustainable wetland management. Ramsar designation would raise its international profile and bring additional support for conservation efforts. In the second case study, a constructed wetland has been studied. It used a green infrastructure, instead of a traditional grey infrastructure, to treat sewage overflows, and investigated its relevance for water management. It can be observed that the green infrastructure (constructed wetlands and park) performs equally or even better than the grey alternative for water purification and flood protection. It provides additional benefits like wildlife support and recreation valued by the local residents and stakeholders, and it has similar costs. The green infrastructure seemed to be a better alternative for local water management. The project has also served as an educational tool, helping to raise awareness about the importance of natural water management systems. This case study is a good example of urban wetlands where water pollution can be a concern due to runoff from surrounding developments. Overall, the case of constructed wetlands in Gorla Maggiore demonstrates how green infrastructure can be used to address a variety of environmental, social, and economic challenges in urban settings. The project is a successful example of integrating ecological sustainability into urban planning, offering a model that could be replicated in other municipalities aiming for sustainable development. The third case study of mangroves in Goa is a study of the coastal wetland type highlighting the importance

Avicenni Figure 6 plan showing

Figure 7 view of Mandovi

Figure 8 Mangroves along

of natural coastal wetlands in providing climate resilience and biodiversity, particularly through their role in coastal protection and carbon sequestration. However, they face significant threats from deforestation, climate change, pollution and industrial activities taking place in Goa.

Table 2 shows the comparison of the three case studies. The main combined objectives achieved by the three case studies are:

a. Water Quality Improvement: The constructed wetlands provide an effective natural treatment for wastewater. They significantly reduce pollutants such as nitrogen, phosphorus, and organic matter, ensuring that treated water is suitable for release into the environment.

b. Stormwater Management: The wetlands help manage excess stormwater during heavy rainfall, reducing flood risks, reducing pressure on the local drainage system. The vegetation and substrate in the wetlands absorb and filter the water, improving runoff quality.

c. Biodiversity Enhancement: By creating new wetland habitats, the project has supported a rich biodiversity, offering a refuge for aquatic plants, insects, and bird species.

d. Public Engagement and Recreation: The constructed wetlands also function as public open green spaces where residents can engage in outdoor activities, such as walking and bird watching. Educational programs about the benefits of wetlands and water management are also provided, raising awareness about sustainability.

e. Cost-Effectiveness: Compared to traditional treatment plants, the constructed wetland system has proven to be cost-effective with relatively low operational and maintenance costs. The wetlands rely on natural processes, requiring minimal energy inputs and periodic maintenance.

Criteria	Meishan Dongpo Urban Wetland Park	Constructed Wetlands in Gorla Maggiore	Mangroves in Goa
Loca on	Meishan, Sichuan, China	Gorla Maggiore, Lombardy, Italy	Goa, India
Type of Wetland	Natural riverine wetlands (Inland wetland)	Constructed wetlands for wastewater and stormwater management (man-made wetland)	Natural mangrove wetlands (coastal wetland)
Area	69.48 hectares	6.5 hectares	around 2000 hectares
Main Objec ve	Conserva on of exis ng wetland and biodiversity, water quality, recrea on	Wastewater treatment, stormwater management, biodiversity	Coastal protec on, biodiversity, carbon sequestra on
Func onality	Wetland conserva on, educa on, recrea on	Pollu on treatment, stormwater management, biodiversity enhancement	Coastal buffer, habitat for marine species, water filtra on
Bioindicators	Increase in aqua c plants, birds, especially migratory birds, macroinvertebrates, fish, amphibians, and algae	Increase in plants, macroinvertebrates, fish, and other organisms which are sensi ve to changes in water quality, pollu on etc.	Presence of diverse mangrove species, abundant fauna, and the overall health and resilience of the ecosystem
Biodiversity	wetland plants, aqua c invertebrates, mammals, rep les, and birds	Support for various plants like Phragmites australis (common reed), Typha la folia (common ca ail), and Iris pseudacorus (yellow flag), as well as animal species like birds, fish, and macroinvertebrates	Supports marine life, birds, and terrestrial fauna like mudskippers, crabs, o ers, crocodiles, lizards, turtles, mud clams, snakes, o ers, jackals, mud crabs, oysters, white clams, and ger prawns, some of which are listed as threatened or endangered. Flora includes mixed mangroves like Avicennia (grey mangrove), Sonner A a, and Rhizophora (red mangrove), along with associated plants such as Derris heterophylla
Water Management	Improves water quality in wetlands	Wastewater treatment, reduces stormwater flooding	Natural filtra on, stabilizes shorelines
Community Engagement	Public educa on, green recrea onal spaces	Public educa on, eco-tourism, flood reduc on	Local community protec on and sustainable livelihoods
Challenges	Urban pressures, long-term maintenance, pollu on	High setup costs, space constraints, ongoing management, high CSO and other effluents flow, pollu on	Deforesta on, climate change impacts, mining, industrial ac vi es, inappropriate means of agriculture, pollu on, restora on complexity

A. Each of these case studies promote integrating wetland ecosystems into city planning; offering biodiversity conservation, ecosystem services, and community benefits. However, these also highlight different challenges, from urbanization pressures to climate-related threats, necessitating long-term planning, restoration efforts, and public engagement for success. Some of these challenges include: availability of land, long-term monitoring and management and public participation. The development of extensive wetland systems faces land availability issues, especially in urban regions where space is limited. In the case of Gorla Maggiore too, the selection of land was done in such a way that ensured that the wetland systems would not interfere with other land use. This becomes challenging in densely populated areas. Furthermore, though constructed wetlands have low maintenance needs, they do require long-term management and monitoring in order to ensure they continue to treat wastewater and manage stormwater effectively. Public perception is another problem since some residents were not aware of the idea of constructed wetlands at first, resulting in skepticism. To resolve this, community outreach is necessary for making people aware of the advantages of such innovative solutions.

Table 1 Comparison of the case studies

Ramsar Convention

1) The Ramsar Convention on Wetlands is an international agreement to conserve and sustainably use wetlands. It was signed in 1971 in Ramsar, Iran, and came into force in 1975. The convention seeks to protect wetlands as crucial ecosystems that provide numerous environmental, economic, and social benefits. The treaty is widely regarded as one of the most important instruments for wetland conservation globally. Wetlands designated as Ramsar sites are considered to be of international importance. The list of wetlands of international importance included 2,531 Ramsar sites in February 2025 covering over 2.6 million square kilometers. India has designated 85 wetlands as Ramsar sites across 23 states and union territories. Some of the major Ramsar sites in India include - Bhitarkanika Mangroves, Wadhvana Wetland, Hokersar, Nal Sarovar Bird Sanctuary, Karikili Bird Sanctuary, Nawabganj Bird Sanctuary, Thol Lake Wildlife Sanctuary, Ashtamudi Wetland, Beas Conservation Reserve, Bhoj Wetland, Chandra Taal, Chilika Lake, Deepor Beel and East Kolkata Wetlands.

Case Study: Keoladeo National Park (Bharatpur Bird Sanctuary), India

Location: Rajasthan,
India Wetland Type: Freshwater marshes Ramsar **Designation Year: 1981**

Before Keoladeo National Park was designated as a Ramsar site, the park faced significant ecological challenges that threatened its biodiversity. Degradation of the ecosystem due to loss of water supply was one of the main issues. Alteration in the course of the Ajan and Gambhir rivers resulted in less flooding. As a result, hydrology in the wetland was altered, and the dependent species were impacted. Secondly, resource overuse like overgrazing by livestock and illegal cutting of wood began to destroy the vegetation in the park, creating habitat loss for other species. Agricultural encroachment was also a danger, with the diversion of water for the purposes of farming further jeopardizing the wetland's natural hydrological balance. These combined, resulted in a decline of bird populations, especially among migratory birds that used the wetland as a stopover on the Central Asian Flyway. Furthermore, there was limited government and public awareness regarding the wetland's significance.

Conservation efforts were fragmented, and the long-term protection of the park was not a priority. Awareness about the park's global importance as a bird habitat was low, and there was minimal institutional support for its preservation. However, after Keoladeo National Park was designated as a Ramsar site in 1981, the situation began to improve. Ramsar designation attracted international attention and initiated a large-scale effort to restore the natural water regime of the wetland. Water control and restoration works, such as the restoration of water sources from surrounding canals and lakes, were undertaken to restore seasonal flooding. Restoration works aimed at providing a stable water supply, which benefited the plant and animal communities, especially waterfowl species.

The Ramsar designation also brought about the establishment of a more effective legal framework for conservation. The park was further protected under the Indian wildlife conservation legislation, and conservation legislation was more effectively enforced. In 1982, Keoladeo was declared a National Park, which enhanced its protection through the law. Structured management plans introduced regulated human activities, like grazing and wood cutting, that were earlier disruptive to the ecosystem. Consequently, the park experienced a great enhancement in conserving biodiversity. Restoration of water levels and minimizing human impacts permitted Keoladeo to be restored to its status as a key habitat for migratory birds. More than 370 bird species, including critically endangered Siberian

Ramsar designation also provided economic and communal gain. Eco-tourism was a key source of income for the park and surrounding communities. Global recognition lured eco-tourists, offering new economic opportunities in addition to generating funds to be reinvested in conservation. Together with tourism, community education programs educated local communities about the value of the wetland and their part in conserving it. Local communities took a greater stake in the park's sustainable use and conservation. In addition, international collaboration and funding were also central to the success of the park. Keoladeo qualified for international funding and technical assistance from institutions such as the United Nations Environment Programme (UNEP). These funds assisted in the support of restoration activities and management. The park also emerged as a location for scientific research, specifically targeting migratory bird populations and wetland ecology, and aiding in the global understanding of wetland conservation. The Ramsar recognition was significant in transforming Keolodeo National Park from a threatened wetland into an internationally recognized wetland sanctuary.

Analysis:

The Ramsar designation of Keoladeo National Park helped transform the site from a declining, overexploited wetland into a thriving ecosystem. The restoration of its water resources, better legal protection, and increased awareness led to the rejuvenation of bird populations and the development of eco-tourism, benefiting both the local community and global biodiversity. This case demonstrates how Ramsar sites can play a crucial role in the conservation of critical wetland habitats, leading to positive environmental, social, and economic outcomes. Table 2 Analysis of cond ons of Keoladeo Marshes Wetland before and er being designated as Ramsar site

Approaches to Conserve and Manage Wetlands in India

Buffer Zones: Creating buffer zones around wetlands protects them from pollution, encroachment, and other disturbances by providing a transition zone between the wetland and surrounding land uses. One of the ways to do so is by clearing off the wetland boundary of farming activities or temporary settlements by declaring a certain distance from the periphery of the wetland. These zones could be planted with native species to avoid erosion.

Table 2 Analysis of condi ons of Keoladeo Marshes Wetland before and a er being designated as Ramsar site

Criteria	Before Ramsar Designation	After Ramsar Designation
Water Management	Reduced water availability and irregular flooding.	Improved water management, seasonal flooding restored.
Biodiversity	Decline in bird populations, especially migratory species.	Increased bird populations, including endangered species.
Legal Protection	Limited protection, some illegal activities.	Stronger legal protection, formal management plan in place.
Community Involvement	Limited local awareness and involvement in conservation.	Increased local engagement, eco-tourism benefits.
Tourism	Low levels of tourism due to lack	Boost in eco-tourism, supporting
	of awareness.	local economies.
International Recognition	Limited global recognition.	International recognition as a Ramsar site, opening avenues for funding and support.

Restoration of Wetlands: Altered hydrology of wetlands due to water flow changes, for example, dams, agriculture, or land reclamation, affects numerous wetlands. Restoring the natural flow regimes and seasonal flooding can help regain the ecological equilibrium of wetlands. Restoring degraded or damaged wetlands by means like replanting native vegetation and re-establishing natural hydrological connections, can improve their ecological function and biodiversity.

Water Resource Management: Implementing sustainable water management practices, such as reducing water consumption, preventing pollution, and restoring natural water flows, is crucial for maintaining the health and functionality of wetlands.

Community Engagement: Community involvement and participation are important for effective wetland conservation. Involving local communities in wetland conservation efforts, through education, training, and participation in management activities, can develop a sense of ownership and responsibility for protecting these valuable ecosystems. Local communities can help monitor the health of wetlands, enforce regulations, and support sustainable utilization of resources. Creating public awareness of the ecological value of wetlands through campaigns will encourage people to understand their importance. Communities would thus implement sustainable practices, including sustainable fishing, eco-tourism, and sustainable agriculture. By engaging local people in the management of resources such as fisheries or reed cutting, wetland ecosystems can be maintained while also maintaining the economic health of the communities. This method ensures that the environment and the surrounding communities are benefitted simultaneously.

Constructed Treatment Wetlands: Architects and engineers can construct systems that replicate some of the functions of natural wetlands to remove pollutants from water that flows through them. In addition to water purification, constructed wetlands also provide a habitat for wildlife. Just like natural wetlands, they support a variety of species, including birds, amphibians, insects, and fish, contributing to local biodiversity. Policy and Legal Frameworks: Developing and enforcing strong policies and legal frameworks that protect wetlands from development, pollution, and other threats is essential for ensuring their long-term sustainability. Effective legal systems that give protection from illegal conversion of land, extraction of water, and pollution are essential. For instance, national legislation must ban harmful practices such as draining out wetlands for agricultural use or for urban development.

Ramsar Convention and National Frameworks: India is a signatory to the Ramsar Convention. Based on international treaties such as the Ramsar Convention on Wetlands, a scheme for conserving and sustainably using wetlands, national policies can be guided. India's Wetland Conservation Rules (2017) establish a framework for safeguarding wetlands in the country. Establishing

Protected Areas: Declaring threatened wetlands as protected areas, for example, Ramsar sites, national parks, or wildlife sanctuaries, can provide legal protection and controlled management.

Research, Monitoring, and Data Collection: Monitoring the wetland biodiversity, such as plants, animals, and microorganisms, on a regular basis helps in understanding the well-being of these ecosystems their management. The monitoring of water quality, such as the measurement of important parameters such as pH, dissolved oxygen, nutrients, and contaminants, is critical for determining wetland health and identifying problems early. Scientific researches improve our knowledge about wetland ecosystems, their functions, and their services assists in creating specific and well-informed conservation policies.

Eco-tourism Development and Livelihood: Promoting ecotourism such as guided tours and educational programs, can generate revenue while raising awareness about their importance. Eco-tourism has the potential to bring revenue to local communities while ensuring the conservation of wetlands. Sustaining the development of eco-tourism ensures that wetlands are appreciated and conserved. Management of fisheries that controls fishing methods, seasonal prohibitions, and employs sustainable harvesting strategies can assist in safeguarding fish population and wetland biodiversity. Eco-tourism and other activities that would promote economic benefit, while conserving wetlands would help attract more attention towards the wetland's conservation and thus gain more funds to further safeguard the wetland.

Tourism, Recreation and Education Tourism is one of the world's largest and fastest growing sector of the global economy. Nature-based tourism is a rapidly expanding portion of the world's travel market. Many of the destinations are national parks and protected areas. Nature tourism is a very important export industry. It is an evolving concept.

Mangrove ecosystems can provide ecotourists with unique habitats and biodiversity opportunities, with many potential activities, including recreational fishing, bird watching, viewing wildlife and scenic boat trips. Figure 9 shows one such action plan that can be adopted for implementing eco-tourism in the wetland ecosystem. The research highlights that integrated measures involving the initiative of government organizations, local residents, and stakeholders are critical to achieve the long-term sustainability of these valuable ecosystems.

Figure 9 an example of proposed ac on plan for promo ng eco-tou rism in wetlands

By studying the effects of Ramsar designation and effective international case studies, the study presents insightful analysis into the optimum practice of conserving wetlands. It seems that issues like urbanization, pollution, and climate change; responsible for causing depletion or damage to wetlands need to be addressed soon enough so as to save the wetlands. The analysis of the case studies showcased different approaches taken towards the conservation and management of these wetlands. It also was observed that there is a huge lack of observation, monitoring and data collection regarding the wetlands ecosystem which needs to be addressed. Further, the study highlighted the importance and feasibility of constructed wetlands in contributing to sustainability; as well as threw light on sustainable and economically benefitting ways to manage wetlands like eco-tourism. The results are expected to help for further research and to help assist in the formulation of approaches and integrated management guidelines that will turn around the current trend of wetland degradation and ensure their future benefits for generations to come.

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