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A Review of Wetlands from India's Perspective

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Abstract

The worldwide distribution of biodiversity is unequal. The qualities and sustenance of an organism's habitats and food sources determine its dependence on them. Wetlands boost biodiversity in these habitats. Numerous studies have examined varied ecological conditions to preserve biodiversity. However, wetland research is scarce due to a lack of distribution and significance data. This review focuses on India's wetlands and their importance. Wetland biodiversity is abundant in India. Ecological, social, and economic benefits come from wetlands. However, urbanization, industrialization, and unregulated agriculture have reduced wetlands in India. This study examines India's wetland ecosystems' location, distribution, bird diversity, and ecological relevance. Wetland ecosystems are also threatened by climate change, land-use change, and agricultural and municipal waste. It also emphasizes Indian government conservation efforts such the National Wetland Conservation Programme, National Environmental Policy, and National Aquatic Ecosystem Conservation Plan. Based on earlier studies on wetlands, stakeholders' involvement greatly contributes to wetland ecosystem preservation.

Keywords: Ecological, India, Pollution, Restoration, Wetlands.

1. Introduction

Wetlands are extremely productive ecosystems, according to Ghermandi *et al* [1]. Many organisms, including birds, support them. Prasad *et al*. (2002) [2] and SAC (2011) [3] estimate that India has 15.26 million hectares of wetlands. In general, wetlands are shallow water environments that support a variety of flora and fauna, including reptiles, amphibians, fish, and invertebrates (Mitsch and Gosselink, 2000) [4]. Birds thrive in marshes, reports say. According to Ali and Ripley in 1987 [5] and Grimmett *et al*. in 2016 [6], India contains 1340 bird species. Praveen *et al*. (2016) [7] found 38 Indian-endemic species. About 310 species are marsh birds, according to Kumar *et al*. (2005) [8]. According to Buckton (2007) [9], wetland species composition depends on water and plant quality.

Ancient literature states that wetlands were important to human civilization, as many settlements were located near riverine systems or wetland zones. Water, protein, water purification, biodiversity, flood control, recreation, research, and education are all provided by wetlands. According to Ramachandra *et al*. (2002) [2], wetlands are cultural, social, ecological, and economic. Wetlands in India are degrading rapidly. Multiple variables have been linked to wetland degradation in India. Unsustainable agriculture, animal grazing, communities near wetlands, and dams are among these factors. Population increase, unsustainable development, and a lack of knowledge also contribute to wetland degradation (Ramachandra *et al*., 2002) [10]. A study by Bennett *et al*. (2018) [11] found that natural catastrophes can degrade wetlands. Agriculture sometimes alters wetland ecosystems, affecting biodiversity. Changes in land use have caused habitat destruction and biodiversity loss worldwide (Butchart *et al*., 2010; Sala *et al*., 2000) [12, 13]. The distribution of wetlands in India is reviewed in this research, along with their importance and conservation strategies.

Marshes, bogs, swamps, fens, pocosins, and other wetlands represent different ecosystems (Tiner, 1999) [14]. Seasonal fluctuations distinguish wetlands from aquatic and terrestrial ecosystems. Wetlands are transient, making boundary definition difficult. In contrast, the place's geography and ecology enrich its flora and fauna. Various people, institutions, and agencies have defined wetlands using different observations and objective views, resulting in a varying understanding of these habitats. Additionally, many countries have defined wetlands according to their internal laws (MOEF, 2007) [27]. The 1971 Ramsar Convention mandates national and international action plans to safeguard wetlands and their resources (Bassi *et al*., 2014). The Ramsar Convention, founded in 1971, listed 2300 sites globally to conserve them (Ramsar, 2013).

According to Article 1.1 of the Ramsar Convention, wetlands are marshes, fens, peatlands, or bodies of water, whether

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natural or man-made, permanent or temporary. Wetlands may have fresh, brackish, or saltwater flowing or standing. This definition includes maritime water up to six metres deep at low tide (Ramsar Convention, 1971, Article 1.1).

2. Distribution and Extent of Wetlands in India

India is home to a diverse array of wetlands distributed across the country, varying in size, type, and ecological significance. As of November 2022, the map in figure 1 depicts the RAMSAR Wetland Sites in India. (Source: Ministry of Environment and Forests, Indian Government)These wetlands can be broadly categorized into several types, including coastal wetlands, inland wetlands, riverine wetlands, and man-made wetlands. Here is an overview of the distribution and extent of wetlands in India:

i). Coastal Wetlands:

a) India's extensive coastline, spanning over 7,500 kilometers, is dotted with coastal wetlands.
b) Mangrove forests are a prominent feature of many coastal wetlands, providing critical habitat for various species.
c) Important coastal wetland areas include the Sundarbans in West Bengal, Gulf of Mannar in Tamil Nadu, and Chilika Lake in Odisha.

ii). Inland Wetlands:

a) Inland wetlands can be found across the country and are associated with rivers, lakes, and other freshwater bodies.
b) The northern region of India has numerous wetlands, including those in the Indo-Gangetic plain.
c) Prominent inland wetlands include the Dal Lake in Jammu and Kashmir, Vembanad-Kol wetlands in Kerala, and Loktak Lake in Manipur.

iii). Riverine Wetlands:

a) Riverine wetlands are typically found along the banks of rivers and their floodplains.
b) The Ganges-Brahmaputra delta is a vast riverine wetland system, with numerous oxbow lakes and floodplain wetlands.
c) Other riverine wetlands are associated with rivers like the Yamuna, Godavari, and Brahmaputra.

iv). Man-Made Wetlands:

a) Some wetlands in India are man-made, created for purposes like irrigation, water supply, and aquaculture.
b) Reservoirs and tanks, such as the Bhakra Nangal Dam reservoir in Himachal Pradesh and the tanks in South India, fall into this category.

v). High Altitude Wetlands:

a) India's mountainous regions, particularly the Himalayas, have high-altitude wetlands.
b) These wetlands are important for maintaining freshwater sources and sustaining unique high-altitude ecosystems.
c) Examples include the Tso Moriri Lake in Ladakh and Hemis National Park wetlands.

vi). Saline Wetlands:

a) Saline wetlands are found in arid and semi-arid regions and are often characterized by high salt content.
b) The Rann of Kutch in Gujarat is a significant saline wetland known for its unique ecosystem.

The exact extent and distribution of wetlands in India can vary due to factors such as seasonal changes in water levels, urbanization, and land-use changes. Table 1
It's important to note that wetlands provide crucial ecosystem services, including habitat for wildlife, groundwater recharge, and flood control. Conservation efforts are ongoing to protect and preserve these valuable ecosystems, with some wetlands designated as Ramsar Sites under the Ramsar Convention to receive international recognition and conservation support.
Wetlands are of utmost significance for the nutrition of the human population. Despite the presence of various water resources such as rivers, streams, and coastal zones, India exhibits a significant extent of wetland coverage.

3. Importance of Wetlands

Wetlands are ecologically important ecosystems that offer a wide range of benefits and services to both the environment and human society. Here are some of the key reasons why wetlands are important:

i). Multiple-Use Water Services:

- **Water Supply:** Wetlands act as natural water reservoirs, helping to recharge groundwater and supply fresh water to rivers, lakes, and aquifers. They play a critical role in ensuring a sustainable source of freshwater for various human activities.
- **Water Purification:** Wetlands filter and purify water by trapping sediments and removing pollutants. They act as nature's water treatment systems, improving water quality and making it safe for consumption and irrigation.

ii). Carbon Sequestration:

- Wetlands, especially peatlands, are highly effective at storing carbon. They accumulate organic matter in waterlogged conditions, preventing the decomposition of organic material and the release of carbon dioxide into the atmosphere. This makes wetlands important for mitigating climate change by sequestering carbon.
- In the carbon cycle, wetlands are important carbon sinks for climate regulation. Mangroves, swamps, and marshes help this process. The biomass of aquatic plants, fauna, and microorganisms in wetlands absorbs carbon. Sediment and surface and groundwater dissolvable carbon enter wetlands. Wetlands produce 40% of global methane (CH_4) emissions. Wetland soil is more carbon-rich than plants. Indian coastal wetlands, especially mangroves, sequester carbon. Wetlands can reduce greenhouse gas emissions significantly.

iii). Pollution Abatement:

- Wetlands serve as natural buffers against pollution. They absorb and detoxify various pollutants, including nutrients, heavy metals, and agricultural chemicals, thereby reducing the negative impacts of pollution on downstream ecosystems and human health.

iv). Flood Control:

- Wetlands act as natural sponges during heavy rainfall or flooding events. They absorb and store

excess water, reducing the risk of downstream flooding. Wetlands can play a crucial role in mitigating flood damage in regions prone to seasonal floods.

v). **Biodiversity Hotspots:**
- Wetlands support a rich diversity of plant and animal species. They provide essential habitats for a wide range of wildlife, including migratory birds, amphibians, fish, and many endangered or specialized species. Wetlands are critical breeding and feeding grounds for various wildlife, making them biodiversity hotspots.

vi). **Aquafarming:**
- The presence of wetland biodiversity plays a vital role in enhancing fish output. Approximately 66% of fish are obtained from Level I wetland habitats, which include various aquatic environments such as water channels, rivers, ponds, naturally occurring reservoirs, and lakes. The fish production in India has exhibited a consistent upward trend, with a notable surge of 9.04 million tonnes from 2012 to 2013, followed by a substantial increase of approximately 12.59 million tonnes from 2017 to 2018. According to the 2021-22 report from the Ministry of Fisheries, Animal Husbandry, and Dairying, Andhra Pradesh emerges as the frontrunner in fish production, accounting for 27% of the overall output.
- Subsequently, Gujarat, Orissa, Tamil Nadu, and Uttar Pradesh follow suit in terms of their respective contributions to the total yield. The fishing industry makes a significant contribution to both the agricultural GDP, accounting for 7.27%, and the national GDP, accounting for 1.24%.

Wetlands are valuable ecosystems with ecological, economic, and social benefits. Wetlands are crucial for sustainable water management, climate change mitigation, biodiversity conservation, and cultural preservation. Wetland conservation and restoration are essential for ecosystem and human health.

4. Effect of Pollution on Wetlands

Pollution in wetlands can have significant and detrimental impacts on the flora and fauna that inhabit these ecosystems. The effects of pollution can manifest in various ways, affecting different species and elements of the ecosystem. Here are some of the key impacts of pollution on wetland flora and fauna:

i). **Water Quality Degradation:** Pollution, particularly from industrial discharges, agricultural runoff, and untreated sewage, can lead to the degradation of water quality in wetlands. This can result in decreased oxygen levels, changes in pH, and the accumulation of harmful chemicals in the water, making it unsuitable for many aquatic species.

ii). **Harm to Aquatic Plants:** Pollution can directly harm aquatic plants in wetlands. Elevated levels of nutrients, such as nitrogen and phosphorus, can lead to eutrophication, causing excessive growth of algae and aquatic plants. This can reduce light penetration into the water, limiting the growth of submerged vegetation and disrupting the habitat for fish and other organisms.

iii). **Altered Food Webs:** Pollution-induced changes in water quality and nutrient levels can alter the structure of food webs in wetlands. Some species may benefit from increased nutrients, while others may decline. This disruption can lead to imbalances and affect the populations of various flora and fauna, including fish, amphibians, and invertebrates.

iv). **Toxic Effects:** Pollutants like heavy metals, pesticides, and industrial chemicals can have toxic effects on both aquatic and terrestrial organisms in wetlands. These substances can accumulate in the tissues of plants and animals, leading to physiological and reproductive problems and sometimes even death.

v). **Loss of Biodiversity:** Pollution can lead to a decline in biodiversity in wetland ecosystems. Sensitive species may be unable to tolerate the altered environmental conditions caused by pollution, leading to their decline or disappearance from the ecosystem.

vi). **Disruption of Migration and Reproduction:** Wetlands are critical for the breeding, migration, and feeding of many bird species. Pollution can disrupt these essential activities by degrading the quality of nesting sites and food resources, ultimately affecting the reproductive success and survival of avian species.

vii). **Impacts on Amphibians:** Amphibians, such as frogs and salamanders, are particularly vulnerable to pollution in wetlands. Chemical pollutants can be absorbed through their sensitive skin, leading to deformities, reproductive issues, and population declines.

viii). **Loss of Fish Habitat:** Polluted waters can reduce the availability of suitable habitat for fish species in wetlands. Declines in water quality and the availability of prey organisms can limit fish populations.

ix). **Changes in Behavior:** Pollution can alter the behavior of wetland species, making them more susceptible to predation or less effective at finding food or mates. For example, increased turbidity from pollution can affect the hunting ability of fish and waterfowl.

x). **Long-Term Effects:** Pollution can have long-lasting and cumulative effects on wetland ecosystems. Even after pollution sources are removed or reduced, it may take years or decades for ecosystems to recover fully.

Efforts to mitigate the impacts of pollution on wetland flora and fauna include improved wastewater treatment, better agricultural practices, stricter environmental regulations, and the restoration of degraded wetland habitats. Public awareness and conservation initiatives are also crucial in protecting these vital ecosystems from pollution and its associated consequences.

5. The Restoration of Wetlands and its Implications for the Future Global Landscape

Restoration of degraded wetlands is essential to improve their ecological services. Clarkson *et al*. (2014) report that 50% of the world's wetlands are gone and the rest are declining. Despite their little aerial coverage, wetlands are rich in biodiversity and benefit humans. However, public attention has not adequately addressed their conservation and management (Gopal, 2015) [19]. Meli *et al*. (2014) [20] found that restored wetlands provide, regulate, and condition environmental services better than degraded ones. Wetlands must be restored to their native state to protect watersheds, which are fragile. Wetlands are essential and beneficial for humanity's sustainability and environmental protection (Halls, 1997) [21]. The effectiveness of conservation initiatives

depends on site characteristics, methods, and ecosystem services. The effectiveness of the restoration technique depends on the disturbances' nature in addition to the other variables. Zedler (2005) [22] claims that restoration can recover a large amount of biodiversity and ecological services. The 1992 National Research Council highlighted three main methodologies for restoring degraded wetlands.

Restoring or managing wetland hydrology: Management of chemicals and other contaminants that affect wetlands to eliminate or regulate them; and Indigenous biota restoration and management.

The 1992 Wetland Restoration Programme report outlines the basis for wetland ecosystem restoration (Figure 2).

6. Wetland Management India

- The Indian MoEF administers all critical wetland ecosystems. In rare cases, most follow government wetlands protection policies.
- Ramsar Convention: India has 41 wetland sites. India signed this pact February 1982. No other worldwide agreement conserves and uses wetlands (Sarkar, 2011) [23].
- **NWCP:** National Wetland Conservation Programme It was launched in 1985 to safeguard Indian wetlands. This campaign addressed partially damaged wetlands in Himachal, Whoolar, Hokersar, and Sambhar. This programme conserves partially degraded wetlands (Roper, Nangal in Punjab, and Loktak in Manipur) for local community use and biodiversity conservation (NWCP, 2009).

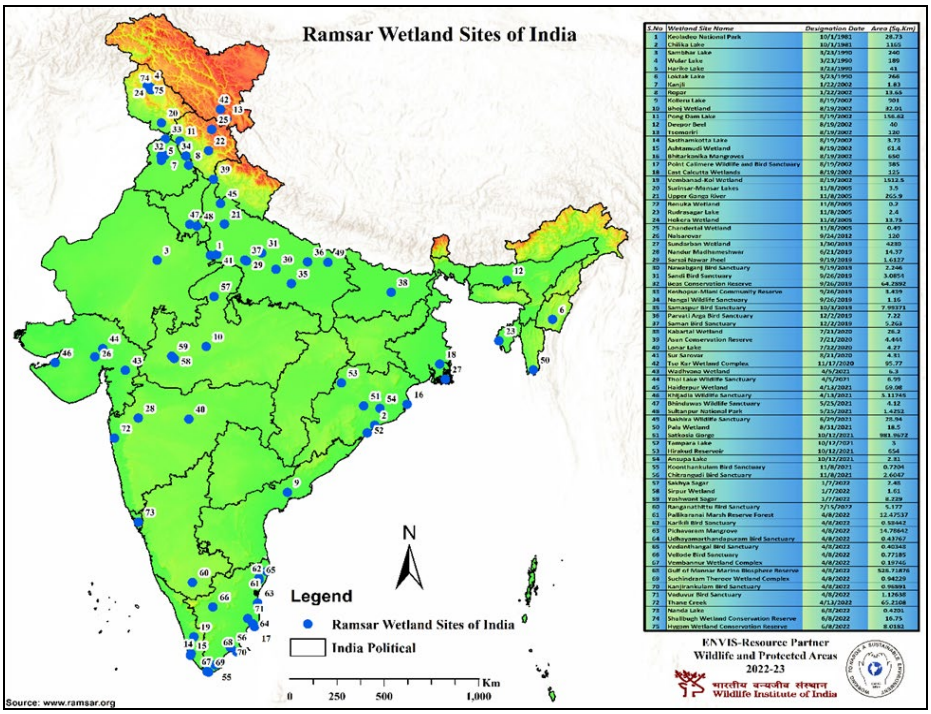
Central Wetlands Management and Conservation Rules: India introduced these rules in 2010 to control and maintain wetlands. These regulations founded the Central Wetlands Regulatory Authority (CWRA) to conserve and regulate wetlands in India. The 2010 wetlands rule was updated in 2016 and 2017. The 2010 Wetland (Conservation and Management) rules were replaced by 2017. Many operations in Indian wetlands are banned. All Indian states and union territories have Wetland Authorities under the CWRA amendment. The state government will hire wetlands ecology, fisheries, hydrology, and landscape ecology experts to establish conservation and management measures. 2017 Wetlands Conservation and Management Rules

National Environment Policy, 2006: This policy valued wetlands and planned their conservation. Valuable wetlands should be regulated legally to prevent degradation and boost conservation. To develop and implement a sustainable tourism staging policy with partners and communities. (MoEF, 2007) [27].

NPCA: National Aquatic Ecosystem Conservation Plan This 2015 strategy improved wetland management policies and state government cooperation. This programme combines the NWCP and NLCP. The NPCA creates and maintains healthy wetlands that provide ecosystem services and biodiversity to human health. Find wetlands and build a national policy framework for protection and sustainable management with NPCA. NPCA envisions a network of well-conserved, sustainably managed wetlands that support biodiversity and essential ecosystem services. National capacity building for wetlands managers and stakeholders and State and Union territory administration in wetlands protection through anthropogenic activities are supported by NPCA (NPCA, 2019).

Table 1: Categorization of wetlands and their relevant percent as compared to the total area.

S. No.	Categorizes of Wetlands	Area Covered in Acres	Percentage of total Area
1.	Coastal wetlands	4140116	27.13
2.	Inland wetlands	10564899	69.23
3.	Riverine wetlands	91682	0.60
4.	And man-made wetlands	436145	2.85
5.	High altitude wetlands	124253	0.81



Source: *Ministry of Environment & Forests, Government of India*

Fig 1: Map of RAMSAR Wetland Sites in India (As on November, 2022)

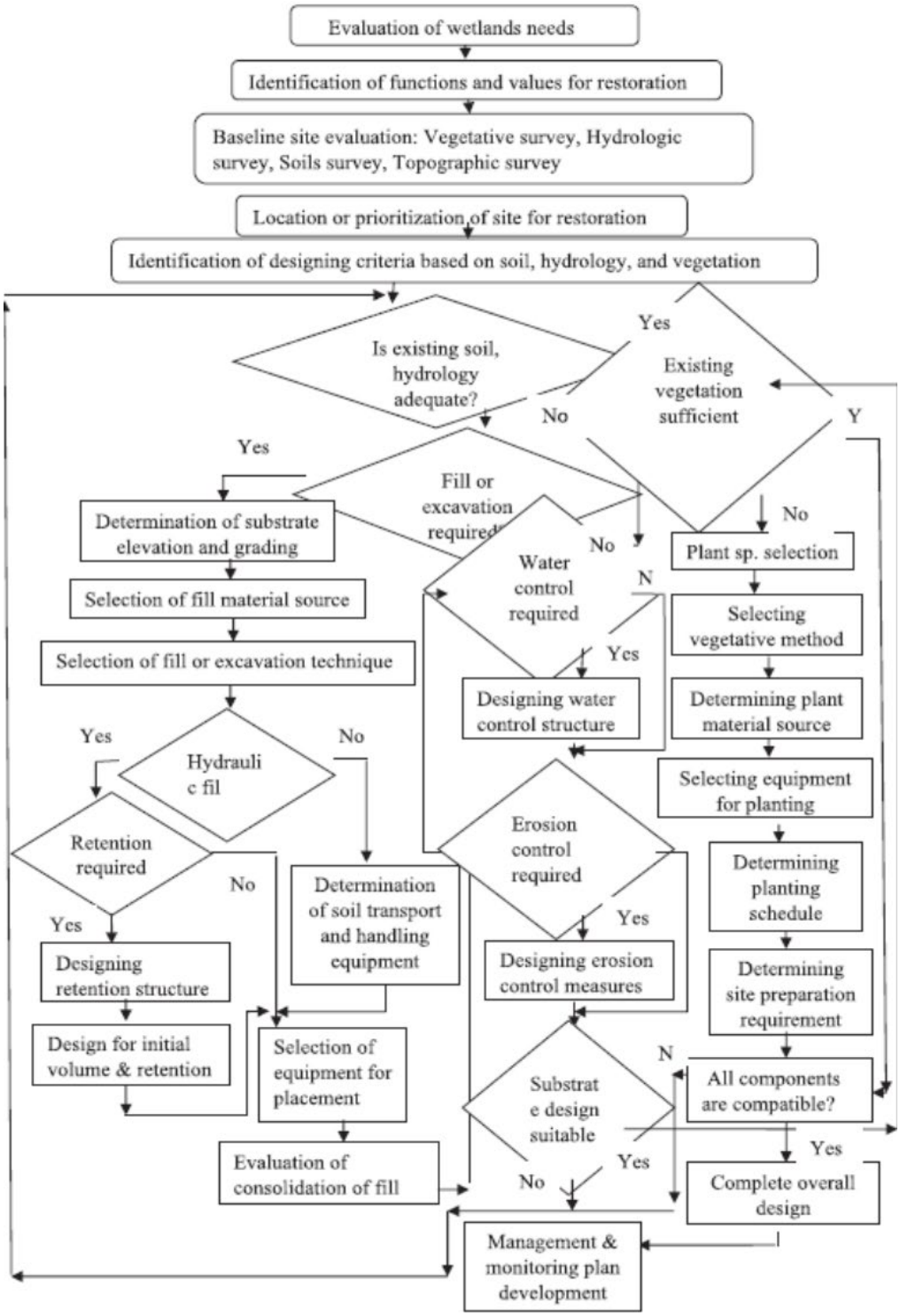


Fig 2: The fundamental framework for the restoration of a wetland ecosystem is outlined in a publication by the Wetland Restoration Programme in 1992.

7. Conclusion

The study found that Indian wetlands were rich in biodiversity and ecological importance due to their distinct geographical and climatic characteristics. Wetlands protect the hydrological cycle and support a variety of flora, animals, and microorganisms. Wetlands support many bird species. They also provided water, irrigation, and freshwater fisheries. Groundwater recharging, flood regulation, carbon sequestration, and pollution reduction depend on wetlands. Nainitallake, Vollar, Loktak, and Chilka are among the Indian wetlands and lakes that face anthropogenic pressures such land use changes, industrial pollution, encroachments, and overuse of natural resources. Thus, wetland habitat conservation should be prioritised in the current setting. However, government initiatives like protecting wetlands may not fully protect these ecosystems. The strict execution of government rules, educational campaigns, and community engagement can improve wetland biodiversity conservation.

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