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Wetlands Regulation

Wetlands International South Asia

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About Us

Wetlands International South Asia is a non-government organisation committed to the conservation and restoration of wetlands in the South Asia region. The organisation was established in 1996 in New Delhi as part of the Wetlands International network. Wetlands International is a global, independent, non-profit organisation dedicated to the conservation and restoration of wetlands. With a global office in the Netherlands, Wetlands International presently works in over 100 countries through a network of 19 regional and national offices and expert networks. Wetlands International is one of the six International Organisation Partners of the Ramsar Convention. In 2005, Wetlands International South Asia was registered under the Societies Registration Act of the Government of India.

Wetlands International South Asia strives to achieve its mission of inspiring and mobilising society to safeguard and restore wetlands for people and nature using three interconnected strategies, namely providing science and evidence-based tools and knowledge, delivering on-ground outcomes through effective field demonstrations, and fostering collaborations and partnerships to support long-term conservation outcomes. The organisation focuses on creating an enabling environment for wetlands conservation through developing skills and capacities, training systems, collective mechanisms, and supporting effective institutions.

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From the Chief Editor's Desk

I am pleased to present the tenth volume of Sarovar A Newsletter of Wetlands International South Asia, in your hands. This volume focuses on the regulatory framework for wetlands in India. The articles delve into the rationale for wetlands regulation, strengthening strengthening multidisciplinary and symbiotic intersectoral ties, and developing effective implementation mechanisms. An emphasison livelihoods, capacity building, monitoring systems, and on establishing a closer interface between research findings and management actionplans is also recommended, to ensure quantifiable deliverables and tangible outcomes. Contributions from different countries on the development and implementation of the regulatory framework are also included in this volume.

India has made significant progress in the designation of Ramsar sites. The network of Ramsar Sites has now increased to 96 and is the highest in Asia at present. While the designation of more Ramsar Sites from India is a matter of great satisfaction, it also needs fulfilment of keeping up the ecological character of these sites, which needs a lot of dedicated efforts at the ground level. Serious efforts are needed to ramp up investment in wetlands conservation at all levels, especially to clarify and effectively implement the regulatory framework. Several issues around wetland definitions, ambiguities between human-made and natural wetlands, and expectations from States to frame effective regulation are to be handled carefully.

Recently, the Rajya Sabha Committee on Subordinate Legislation, in its report on the Wetlands (Conservation and Management) Rules, 2017, expressed a dim view of the rules' ability to regulate developmental pressures on wetlands. This report of the Committee may provide the necessary window of opportunity to bring changes to the regulatory framework for wetlands, making it more comprehensive and effective. However, we caution that any revision of the current regulatory framework must be structured around the principles of wetland ecology, as securing a wetland boundary and preventing non-wetland uses are, in most cases, insufficient.

The current regulatory architecture suffers from two major weaknesses: fragmented authority across levels and conflicts of interest, as states play dual roles as developers of projects in and around wetlands, and also as regulators of these ecosystems. Addressing these would require putting in place empowered institutions that can function independently without political interference, with strong legal backing. An independent national wetlands authority under an Act of Parliament may serve this purpose. Also, equally important is putting in place a National Wetlands Policy that can combine the various aspects of regulation, management, governance, and financing into one umbrella and provide a solid foundation for national efforts.

We are also conscious that stemming wetlands loss and degradation needs actions beyond regulation and management plans. There is a need to build an environment wherein the society at large appreciates the diverse values of wetlands and takes affirmative steps towards their conservation and wise use. There are emerging examples of local level action wherein an environmentally conscious community is taking action to rejuvenate water regimes of wetlands, address pollution and siltation and build local level institutions to protect these ecosystems. These innovations are particularly taking place in small wetlands. We are making conscious efforts to map these interventions and identify enabling mechanisms so that such approaches can be replicated and upscaled.

I hope you will enjoy reading the newsletter. We look forward to your comments and insights to improve the publication. We also solicit your contributions for the next issue.

Dr Sidharth Kaul
President

New Delhi
January, 2026



Exploring Fragile Carbon Vaults: Field Teams in the High-Altitude Peatlands of Tso Kar, Ladakh

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THEMATIC ISSUE

Establishing a Regulatory Framework for Wetlands in India

The Journey So Far and Road Ahead



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Wetlands are critical natural assets sustaining societal well-being through a multitude of ecosystem services. To safeguard these assets from developmental pressures, the Central Government, exercising the powers conferred under The Environment (Protection) Act, 1986, notified the Wetlands (Conservation and Management) Rules on December 4, 2010, and subsequently amended these in 2017. In this article, the process towards development and revision of these rules, progress and challenges in implementation, and the way ahead are discussed.

The development of rules for regulating wetlands

Wide variation in rainfall, physiography, geomorphology and climate creates a rich diversity of wetlands in India. The country is bestowed with a diverse wetland regime, ranging from high-altitude wetlands in the Himalayas to floodplains of the Ganga and Brahmaputra rivers, saline flats in the Great Indian Desert, lagoons and mangrove marshes on the coastline, and reefs in the marine environment. These ecosystems are vital to the country's hydrological cycle and are highly productive, supporting diverse species and communities at various life stages. Despite their immense importance, these unique ecosystems face considerable pressure from encroachment, pollution, invasive species, water-regime fragmentation, unsustainable harvesting of wetland resources, and unregulated tourism.

India is a signatory to the Convention on Wetlands, an intergovernmental treaty that provides a framework for conservation and wise use of wetlands and their resources. The Ministry of Environment, Forest and Climate Change (MoEFCC) established a National Wetlands Programme in 1985 to support state governments in formulating and implementing management plans for priority wetlands and undertaking various technical and conservation actions through approved

management action plans.

India's Environment Policy of 2006, recognising the significance of wetlands in supporting societal well-being and biodiversity, articulated the need for a regulatory framework for wetlands. The policy recommended that this framework be consistent with the Ramsar Convention's definition of wetlands, preserve their ecological character, and develop a national wetland inventory. The regulation was proposed to strengthen a multidisciplinary, symbiotic and intersectoral approach to wetlands conservation, develop an effective implementation mechanism, and place greater emphasis on livelihoods, capacity building, and monitoring systems.

In 2008, the MoEFCC constituted a multidisciplinary expert group, under the chairmanship of the Secretary, to draft a regulatory framework for wetlands. The expert group suggested a graded regulation approach for wetlands. At the highest level were Category 'A' wetlands, placed within the regulation remit of the central government, and comprising wetlands listed as Ramsar Sites, wetlands recognised as or located within a World Heritage Site or National Heritage Site, high-altitude wetlands having an extent of 5 ha or more, transboundary wetlands and wetlands serving as a major source of drinking water for Class A cities. The second tier was Category 'B' wetlands, whose regulation was proposed to be entrusted to the state government. These included wetlands recognised as, or located within, a State Heritage Site, high-altitude wetlands with an extent of less than 5 ha, and wetlands that served as a major source of drinking water for a Class B town. At the third tier were Category 'C' wetlands, which were to be regulated by the District-level Authorities. The coverage of this category included wetlands other than those covered in 'A' or 'B', wetlands that serve as a major source of drinking water for local communities with atleast 100 households, and wetlands that are socially or culturally important to local communities.

The expert group recommended enlisting prohibitions and regulations for wetlands and developing processes and procedures for wetland identification. The group also recommended the establishment of a Central Wetland Regulatory Authority, chaired by the Secretary, MoEFCC, with members drawn from various line ministries and departments, to enforce the provisions of the regulatory framework, appraise proposals for the identification of new wetlands, and grant clearances for regulated activities. State Governments were entrusted with the responsibility of designating nodal agencies to oversee the implementation of the regulatory framework at the ground level and to constitute appropriate committees for such purposes. Finally, the expert group suggested creating



overlapping provisions by regulation of wetlands located in protected areas by Wildlife (Protection) Act, 1972; wetlands within notified forests by the provisions of Indian Forest Act, 1927, Forest (Conservation) Act, 1980, and Environment (Protection) Act, 1986, and gaps if any be plugged by the provisions of the Environment (Protection) Act, 1986.

The institutional architecture proposed by the committee included the Central Wetland Regulatory Authority, State Wetland Regulatory Authority, and District Wetland Regulatory Authority to support the implementation of the regulatory provisions. Appraisal committees at the central, state and district levels were also proposed. However, during its final vetting, the Ministry of Law approved only the establishment of the Central Wetland Regulatory Authority.

A series of deliberations were held to finalise the national regulatory regime for wetlands. The duties and responsibilities of different entities were defined, and a list of prohibited and regulated activities was prepared. Finally, under the exercise of the powers conferred by section 25, read with section and clause 5 of subsection (2) and subsection(3) of section 3 of The Environment (Protection) Act, 1986, the Central Government notified the Wetlands (Conservation and Management) Rules, 2010 as a subsidiary legislation under the Act.

The 2010 Rules provided for the protection of wetlands notified as per its provisions. The scope included Ramsar Sites, wetlands designated as World Heritage Sites, wetlands located in ecologically sensitive areas, high-altitude wetlands (located at an elevation of 2500 m above mean sea level) of area 5 ha and above, for the remaining parts of the country 500 ha and above, and other wetlands so notified by the Central Government. The Rules list activities prohibited and regulated within notified wetlands and are enforced by the Central Government through the Central Wetland Regulatory Authority.

By 2015, it was apparent that very limited implementation of the Act could be achieved. No wetlands were notified under the provisions of the said Rules, thereby limiting its application to the 25 designated Ramsar Sites of the country (as mentioned in the Schedule). In various consultation meetings held with the state governments, limitations in the form of concentration of powers in Central Wetland Regulatory Authority with limited role of State Government; application of a uniform set of regulatory actions without considering site specific characteristics; threshold of 500 ha



A review of recent wetland related judgments



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The Wetlands (Conservation and Management) Rules, 2017, are the cornerstone of wetland regulations in India. Additionally, wetlands receive protection under laws governing forests, wildlife, the environment, fisheries, biodiversity, and related areas. This framework sits within a superstructure provided by the provisions of the Indian Constitution and wetland jurisprudence, as reflected in judgments of Indian Courts in matters related to the environment, specifically wetlands. Wetlands jurisprudence in India has continued to evolve through the enactment of various environmental laws and their interpretation by the Courts. Notable among these have been the judgments of the Indian Supreme Court and the National Green Tribunal on wetland-related issues.

A review of 24 wetland-related cases has been conducted to understand how India's wetland regulatory framework, particularly the Wetlands (Conservation and Management) Rules, 2010/2017, has been interpreted by the Courts in adjudicating wetland-related conflicts.

Reasons for conflict

In the cases examined, conflicts emerged due to (a) violations of constitutional provisions by the developmental projects; (b) violations of the provisions of Wetlands (Conservation and Management) Rules, 2010/2017 and other extant regulations; and (c) ownership and jurisdiction over the wetland in focus.

In six of the 24 cases, a breach of constitutional provisions was reported. It was submitted that developmental activities were being pursued in violation of the state's responsibility to guarantee the fundamental right to life and personal liberty enshrined in Article 21, as well as the state's duty to protect the environment as stipulated in Article 48A of the Indian Constitution.

In 20 of the 24 cases, petitioners alleged violations of the Wetlands (Conservation and Management) Rules, 2010/2017, and/or other extant regulations. These included prohibitions on reclamation, permanent construction, industrial activities, and development within prescribed buffer zones, and non-compliance with laws under the Environment (Protection) Act, 1986, Coastal Regulation Zone (CRZ) Notifications, forest and wildlife, pollution control statutes, and eco-sensitive zone regulations.

In eight of the 24 cases, conflicts arose from issues of ownership and jurisdiction. These disputes focused on whether the land in question constituted wetlands or commons as per revenue or planning records; the competence of local authorities to grant permissions; the legality of land acquisition or leasing for development

purposes; and challenges to the classification of land under coastal zone or zonal management plans.

Legal interpretation of the term 'Wetlands'

In nine of the 24 cases, the issue of whether the area in question was a wetland or not came to the fore. In these cases, respondents argued that the areas were not wetlands because they were human-made, seasonal, classified as wastelands or barren land in revenue records, or not notified under the Wetlands (Conservation and Management) Rules, 2010/2017. Conversely, petitioners relied on ecological characteristics, hydrological functions, revenue records, or statutory obligations to assert wetland status. However, the judicial decisions reflected varied approaches. In some cases, Courts ruled that even non-notified or human-made wetlands are protected under environmental laws, especially when they perform vital ecological functions or exceed prescribed size thresholds. The Courts mandated that the state has a duty to protect the wetland, in line with the directions in M.K. Balakrishnan v. Union of India, which states that all wetlands above 2.25 hectares fall under Rule 4 of the Wetlands (Conservation and Management) Rules, 2010, regardless of notification status. In certain cases, such as Nirma v. MoEFCC, M/s Vardha Enterprises Pvt. Ltd v. Rajendra Kumar Razdan, and Syamantak Trust v. State of Maharashtra, the Courts were of the opinion that the area had not been formally notified as a wetland, the rules could not be applied retrospectively, or the wetland was explicitly excluded from the statutory definition of wetlands.

Key arguments made for wetland protection and preservation

In the 24 cases examined, the arguments in favour of wetlands conservation rested on four major approaches and principles: (a) the public trust doctrine, (b) the precautionary principle, (c) the principle of sustainable development, and (d) the polluter pays principle.

The judgment in nine of the 24 cases relied on the public trust doctrine, a legal principle holding that the government acts as a trustee, obligated to protect and preserve essential natural resources for the benefit and use of the public, rather than allowing private ownership or exploitation. The Courts applied the doctrine to prevent encroachment, leasing, or diversion of wetlands for private or commercial purposes, emphasising the obligation of the State to protect, maintain, and restore these ecosystems.

In seven out of the 24 cases, the precautionary principle formed the basis of the arguments. Petitioners highlighted that developmental activities in or around wetlands should be restricted or halted when there is a risk of serious or irreversible environmental damage, even without complete scientific certainty. Arguments in seven out of the 24 cases directly mentioned the violation of the principle of sustainable development, especially considering the ecology and environment of the areas in question. These cases emphasised the need to balance development with environmental protection, particularly through maintaining buffer zones, enforcing no-construction zones, protecting eco-sensitive areas, and ensuring compliance with environmental laws so the ecological integrity of wetlands is not irreversibly compromised.

Arguments in eight out of the 24 cases highlighted the importance of the principle of polluter pays. The Courts directed the imposition of environmental compensation, restoration costs, demolition of illegal structures, and remedial measures where wetlands and associated ecosystems were damaged due to industrial accidents, unlawful construction, or environmentally harmful activities, reinforcing accountability for environmental harm and the obligation to restore degraded ecosystems.

Key arguments made for non-wetland usage

In 14 of the total 24 cases, arguments were advanced to support the conversion of wetlands for non-wetland usage. These submissions mainly relied on claims of economic development, employment generation, public interest, tourism promotion, and compliance with existing regulatory frameworks. In matters relating to tourism and recreation, it was argued that activities such as cruise operations or resort development were temporary in nature, environmentally controlled through advanced technology, or aligned with state tourism policies aimed at socio-economic development. In a number of cases, parties questioned the applicability of environmental regulations by contending that the land was not a wetland in reality, was wrongly classified in revenue or coastal zone records or was only seasonally waterlogged. Others contended that larger or alternative wetlands would be created in lieu of the affected land, or that the land had historically been used for non-wetland purposes like salt manufacturing. Some arguments also rested on temporal and procedural grounds, including that permissions, leases, or environmental clearances were granted before the Wetlands (Conservation and Management) Rules, 2010/2017, or prior to the extension of CRZ regulations to certain areas, and therefore could not be retrospectively invalidated.

being too large for several wetlands, particularly urban wetlands; and lack of clarity of application of Rules in the case of coastal wetlands were cited.

In 2016, the MoEFCC introduced an amendment to the 2010 Rules in response to comments from the State Governments. These draft rules were placed in the public domain for 60 days, after which the Wetlands (Conservation and Management) Rules, 2017, were notified.

The coverage of the 2017 Wetlands Rules was extended to all wetlands (excluding river channels, paddy fields, human-made water bodies/tanks specifically constructed for drinking water purposes, and structures specifically constructed for aquaculture, salt production, recreation and irrigation purposes). Protection was made applicable to all Ramsar Sites and to other wetlands notified under the process laid down in the Rules. The Rules also established wise use (defined as the maintenance of ecological character) as the basis for regulation, to be achieved by prohibiting and regulating activities that induce adverse changes in wetland ecological character.

The Rules also clarified the institutional mechanism for wetland regulation at the state and UT levels. Wetland Authorities are constituted at the State / UT level as the nodal institutions for policy-making, regulation, and management. At the national level, the National Wetlands Committee is constituted to inter alia: advise the Central Government on appropriate policies and action programmes for the conservation and wise use of wetlands; evolve norms and guidelines for integrated management of wetlands based on the wise use principle; and monitor implementation of these rules by the Authority.

While there has been some progress in implementing the 2017 Wetlands Rules, overall implementation remains considerably limited. The Supreme Court had to intervene to expedite the foundational steps of ground-truthing and boundary demarcation of wetlands. In its order dated December 11, 2024, the Court directed the states to complete these steps, firstly for all wetlands having an area greater than 2.25 ha by March 2025. As per the data published on the National Wetlands Portal, of the 0.231 million wetlands with an area greater than 2.25 ha, ground truthing of 0.198 million wetlands and boundary demarcation of 0.112 million wetlands were completed as of January 15, 2026. Similarly, to date, only 102 wetlands in Rajasthan, Goa, Chandigarh, and Uttar Pradesh have been notified under the Rules to date (excluding the 96 wetlands designated as Ramsar Sites). Another 569 wetlands have been identified for notification by the states. None of the states has ensured the development of integrated

management plans for notified wetlands to outline wise use pathways. The management plans are submitted only for funding support to the MoEFCC under the centrally sponsored scheme on the National Plan for Conservation of Aquatic Ecosystems.

In 2023, the Rajya Sabha Committee on Subordinate Legislation, in its Report on the 2017 Wetlands Rules, concluded that these may facilitate the legal exploitation and conversion of wetlands rather than their protection. The Committee has recommended reinstating protection for high-altitude wetlands larger than 5 Ha, or those above 2,500m above mean sea level and covering 500 Ha, located in ecologically sensitive areas, and for salt pans, and laying down clear criteria for identifying wetlands requiring protection. The Committee also recommended protecting the paddy fields lying idle for many years and currently serving as water storage, flood mitigation, aquifer recharge, silica mining, granite mining sites, and quarries with good water-holding capacities. The Committee also called for providing sufficient authority to the National Wetlands Committee to enforce its recommendations, and for defining the term 'wise use' and laying down clear parameters to prevent ambiguity or multiple interpretations.

Several recent court directions have added further dimensions to wetland regulation. The Supreme Court of India, in its order dated July 14, 2017, reminded the Central Government of its responsibility to implement the Ramsar Convention and entrusted the High Courts with monitoring the status of Ramsar Sites and the effectiveness of rejuvenation and management efforts. The National Green Tribunal (NGT), in its order dated November 18, 2020, directed the State to designate a nodal agency for the restoration of water bodies where none has



The lay of the land in Kabartal, a Ramsar site in Bihar, has been extensively altered, reducing its capacity to hold water / Harsh Ganapathi

been designated. In the same case, a prior order dated May 10, 2019, directed the restoration of water bodies in compliance with the Municipal Solid Waste Rule 2016. The NGT, in its order of November 25, 2021, directed the inclusion of wetlands in the District Environment Plans, with a specific focus on prohibiting the discharge of sewage, solid waste, and other wastes; preventing siltation; boundary demarcation; and removal of encroachments.

Observations from a review of judgments from wetlands-related cases

Wetlands International South Asia recently reviewed 24 cases involving wetlands adjudicated by the Supreme Court of India and the National Green Tribunal during 2010-2023. The review outlined the following issues:

Multiplicity of laws has created a differential regulatory regime for wetlands. The Indian Forest Act 1927, The Wildlife (Protection) Act, 1972, The Forest (Conservation) Act 1980, the State Forest Acts, and the Coastal Regulation Zone Notification (CRZ), 2011, as amended from time to time, take precedence over the implementation of the 2017 Wetlands Rules in cases where wetlands have already been covered under the notifications under the said rules. The Acts on Forest and Wildlife do not explicitly account for wetlands in their design and primarily focus on regulating human interaction, control, and access to notified areas. This also limits, in several cases, human disturbance (in the form of low-intensity harvesting of wetland products or vegetation management) necessary to maintain ecosystem vitality and resilience. The 2017 Wetlands Rules, on the other hand, are based on the principle of wise use, emphasising the maintenance of ecological character. Thus, only the wetlands located outside protected areas, forests and coastal zones can have wetland use aligned with natural ecosystem functions.

The buffer zone around wetlands located within protected areas designated under the Wildlife (Protection) Act, 1972, is governed as per the provisions of the Eco-Sensitive Zone Notification. The definition of this zone does not necessarily account for the need to maintain the wetland's ecological character, for example, the need to align the land use in the drainage basin with the wetland functioning. The 2017 Wetlands Rules, by contrast, require the demarcation of a zone of influence within which regulation is required to preserve the ecological character of the notified wetlands.

Complex governance architecture and fading accountability at the site level. The regulatory framework for forests and protected areas entrusts their management, including wetlands located within, to the Department

of Forests. The CRZ Notification 2011 mandates the creation of a State Coastal Zone Management Authority, in addition to the Rules requiring the preparation of Coastal Zone Management Plans to support the implementation of the coastal zone regulatory framework, including those for coastal wetlands. The 2017 Wetlands Rules mandate the constitution of State/UT level wetland authorities as nodal agencies for regulation, conservation and management of these ecosystems. Within States, the Departments of Fisheries, Agriculture, Rural Development, Water Resources, Irrigation and Flood Control, and several others have mandates to address wetlands under the authority of central and state laws. Ultimately, this complex governance structure and overlapping mandates pose challenges of harmonisation and inter-agency coordination to secure an alignment with wetlands conservation and wise use.

In particular, there is a gap in site-level governance and management arrangements for wetlands located outside forests, protected areas and coastal zones. This lack of clarity also reduces accountability towards conservation and wise use. Equally lacking within the regulatory framework is a monitoring system to assess whether conservation and wise use are being achieved on the ground. A weak penal system for environmental damages further disincentivises effective site-level governance.

Ambiguities in the definition of wetlands. While India, being a signatory to the Ramsar Convention, subscribes to a wider definition of wetlands and uses the same for designating wetlands of international importance or structuring the national programme, for regulatory purposes, a narrower definition, which leaves out river channels, paddy fields, and human-made waterbodies and tanks constructed for specific purposes has been adopted. In several cases, it is implicit that an ecosystem is treated as a wetland only when notified as such (as per procedures in Rule (6) of Wetlands (Conservation and Management) Rules, 2017), and not on account of its ecological characteristics as is defined by the Ramsar Convention. A number of cases have been used to determine where the 'land in question' is a wetland, including the National Wetlands Atlas, Revenue records, and even expert opinion.

The National Wetlands Atlas indicates the total extent of wetlands in the country. The Atlas is based on a wetland classification system that has been modified from the one used by the Ramsar Convention to designate Wetlands of International Importance. The Atlas has a minimum mapping unit of 2.25 ha, a threshold defined by the accuracy of the remote sensing images used to prepare the Atlas. The 2017 Supreme Court judgment has

relied on the Atlas to direct the application of Rule (4) of 2017 Wetlands Rules pertaining to prohibited activities in the Wetland. Notably, the Atlas categories do not fully align with the regulatory definition of wetlands; there is considerable room for misinterpretation of the Atlas or of existing records. The Atlas itself is not a comprehensive statement of the status of wetlands, given that it is largely based on remote sensing images and several wetland types, such as peatlands, find no mention in the atlas.

Distinction between natural and human-made wetlands. The Wetlands (Conservation and Management) Rules, 2017 distinguish between natural and human-made wetlands, on the rationale that the latter may not be regulated, as human uses of the wetlands may be compromised. This view is maintained in several of the judgments. However, the Supreme Court's February 8, 2017, order in M.K. Balakrishnan v. Union of India favours the comprehensive conservation of wetlands, regardless of whether they are natural or human-made. Rather, an affirmation of their existence by the fact of their inclusion in the National Wetland Atlas is used as a basis.

While human-made wetlands, at the time of their construction, have a designated use as the primary motivation, over a period of time, ecological processes such as water, sediment, and nutrient flux and the creation of diverse habitats make the system acquire properties similar to those of natural systems. In such cases, leaving human-made wetlands outside the ambit of regulation does not deserve merit. Notably, this exclusion leaves out a large part of the wetland regime of central and southern India, which, owing to the landscape's geomorphology, is mostly human-made but known to sustain rich biological diversity.

Ambiguities around wetland wise use and integrated



Constructions inside the shorelines of Tampara Lake, a Ramsar Site of Odisha / Harsh Ganapathi

management. Rule 4(1) of the Wetlands (Conservation and Management) Rules, 2017 specifies that wetlands are to be conserved and managed in accordance with the principle of wise use, with Rule 2 (1)(i) adopting the Ramsar Convention's definition of wise use. However, the Rules delegate the responsibility of determining wise use to the State Wetlands Authorities. The guidelines for the implementation of the 2017 Wetlands Rules discuss wetlands' wise use and ecological character in Section 7, wherein guidance on developmental activity adhering to the wise use principle is provided. Implementation of wise use is prescribed within the guidelines through graded restrictions on activities in terms of being completely prohibited and regulated with respect to specific wetland zones of specific levels.

Notably, the Rules only lists prohibited activities within notified wetlands (Rule 4(2)), site-specific activities to be regulated and permitted within the wetland and its zone of influence are to be notified by the concerned State Wetland Authorities. In the case of Dr. Subhash C Pandey v. State of Madhya Pradesh, wherein the petitioner questioned the State Government's decision to ply cruise boats in Bhoj wetland, a Ramsar Site, the NGT struck down the State Government's proposal on the grounds that the act of plying of motorised boats violated the provisions of Section 24 of Water Act, 1974, Air Act, 1981, EPA 1986 and Noise Pollution Rules, 2000, and Hazardous Waste Management Rules of 2016. Yet, the Kochi Water Metro project in Vembanad-Kol Wetlands has been in operation since December 2021. In the case of Tampara Lake in Odisha, the Tourism Department constructed tourism huts within the Ramsar Site boundary, under the premise that these activities were aligned with the wise use principle.

Maintaining a buffer around notified wetlands has been a critical issue, especially in urban areas. The 2017 Wetlands Rules stipulate that a fifty-meter buffer would be a 'no permanent construction zone' for the notified wetlands, wherein only construction of boat jetties has been permitted. The NGT in 2016 ordered the maintenance of a buffer of 75 meters for the lakes of Bangaluru; however, the Supreme Court set aside this decision and reinstated the buffer at 30 meters, as per the provisions of the City Master Plan.

In all cases, the courts have come down heavily on non-wetland usages such as conversion or encroachment of any kind, construction of a permanent nature (except boat jetties within 50 m of mean HFL), setting up of an industry, or expansion of any industry, solid waste dumping, manufacture or handling, storage or disposal of waste (with specific mention of construction and demolition waste, hazardous waste and electronic waste) and discharge untreated waste and effluents from various sources.

However, the judgments do not necessarily refer to the Wetlands (Conservation and Management) Rules, 2017. In several cases, the issuance of environmental clearances to the developmental projects in wetlands indicates procedural lapses in recognising impacts on these ecosystems.

Way ahead

While some gains have been made in implementing the 2017 Wetlands Rules, there is an urgent need to revisit them, given issues around wetland definition, ambiguities between human-made and natural wetlands, and expectations from States to frame effective regulation based on wise use. The fact that wetlands attract differential regulations based on their location in forest areas, designated protected areas, and coastal zones further complicates regulation. The directions of the courts since the notification of Wetlands Rules 2017 may also need to be internalised in the revision.

Any revision of the current regulatory framework must be structured around the principles of wetland ecology, as, in most cases, securing a wetland boundary and preventing non-wetland uses are insufficient. It is essential to ensure that natural hydrological regimes, secure habitats and ecological corridors, and wetland livelihood systems are aligned with the wetlands' natural regimes.

Addressing gaps in regulation. Modifying the globally accepted definition of wetlands, as used by the Ramsar Convention, has introduced considerable ambiguity regarding which areas can be considered wetlands. It may be pertinent to maintain the definition of wetlands as set out in the Ramsar Convention. Any exclusions from the regulation may be considered in the section on the applicability of the Rules.

Provisions may be created for the graded regulation of wetlands by enlisting them under the jurisdiction of the Central Government, State Government, and District Administration. Also, proper explanations for terms such as 'wise use' and 'integrated management' may be incorporated, along with clarification of penal provisions for violations of the Rules. Provisions for Environmental Impact Assessment for developmental activities affecting wetlands and their zone of influence may be included, alongwith stringent monitoring mechanisms at the central, state and district levels. Mechanisms for public consultation to finalise management plans and monitor implementation also needs to be considered.

Regulation mechanisms at state and district levels. The regulatory mechanism at the state and district levels needs to be clarified. The provision for State Wetlands Authorities contained in the 2017 Wetlands Rules may be continued; however, they may also be entrusted with the constitution of district-level authorities responsible for regulating wetlands within their jurisdictions, under the supervision of the respective State Wetlands Authorities. Wetlands spanning two or more districts may be placed under the mandate of a site-specific wetland authority or the state wetlands authority. The district wetlands authority, in turn, must liaise with the concerned Panchayati Raj Institution or the Urban Local Body for regulation and management of wetlands. Unless people at the grassroots level are involved, conserving wetlands is not possible.

National Wetlands Inventory to track the status of wetlands. A dedicated and periodic National Wetlands Inventory Programme should be established to track the status of wetlands and the effectiveness of various management and regulatory measures. The inventory should categorically identify wetlands that are regulated under the Wetlands Rules and other acts and legislation. The inventory may be repeated every decade to confirm trends in wetland extent and associated changes.

Addressing the issue of private rights. The issue of private rights within wetlands has been sidestepped in the Wetlands Rules 2017 despite the fact that most wetlands outside the protected areas and forest areas have such rights. The omission of wetlands from the land-use classification system is a major

lacuna that must be addressed to prevent misclassification as wasteland and conversion to alternative non-wetland uses.

Development of supplementary guidance. Some of the issues emerging from the review in this article can be resolved by developing supplementary guidance on specific aspects. These include: a) a code for wetland delineation for different biogeographic zones, b) guidelines for designing regulations and management for wetland-wise use, and c) a comprehensive national inventory of wetlands, which could be used as a baseline for enforcing regulations.

Development of national policy. It is high time that a National Wetlands Policy were developed that integrates the various elements of wetlands regulation, management, institutional development, financing, and related issues to provide a solid foundation for national efforts in wetlands conservation. An important purpose of the policy should be to prevent sectoral and siloed approaches to wetlands, arising from the multiplicity of ministries and organisations with programmes related to wetlands.

In conclusion, strengthening the regulatory architecture would need addressing two major weaknesses: fragmented authority across levels and conflicts of interest, as States play dual roles as developers of projects in and around wetlands, and as regulators of these ecosystems. For rules to be effective, they need to be backed by empowered institutions. One way is to establish a National Wetlands Authority as the country's nodal regulatory agency for wetlands. The Authority may have the responsibility of monitoring the implementation of provisions of the wetlands' regulatory framework, monitoring the condition of Ramsar Sites and other wetlands of national importance, framing regulations for interstate and international transboundary wetlands, providing technical guidance and support on matters referred by the States and UTs, and taking suo-moto cognisance of violations of wetland rules. The authority must have the power to issue binding directions to states, halt development projects that adversely affect wetlands, impose penalties, and order restoration. Creating the authority through enacting a law by the Parliament will provide the much-needed permanence, autonomy, and judicial backing.



Khajjiar Wetland, Himachal Pradesh / Dayadra Mandal

THEMATIC ISSUE

Wetlands Regulation in the United States



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In November 2025, the Trump administration issued a proposed rule that, if finalized in its current form, would formally remove federal protections for millions of hectares of wetlands and millions of miles of streams. How we got here is a complicated story of history, science, and politics. At its heart is the statutory term "waters of the United States" or "WOTUS". If a wetland or other waterbody is considered to be a WOTUS, then it falls under the Clean Water Act, a federal law that applies nationwide. Discharges of pollutants to WOTUS are prohibited without a federal permit. If a waterbody does not qualify as a WOTUS, then the responsibility for protection of these aquatic ecosystems falls to state and local governments.

Throughout most of the country's history, water quality was a matter for state or local governments. The federal government's role initially focused on navigable waters—waters such as rivers that were used for purposes of commerce. Since the 1890s, activities that might affect the navigable capacity of these waters require a permit from the U.S. Army Corps of Engineers. The federal government's concern was keeping waterways open for commerce purposes.

The states, however, proved largely incapable of ensuring clean water for its citizens. (The flames on the Cuyahoga River in Ohio are frequently pointed to as an example of the failure of the states.) In 1972, Congress enacted the Clean Water Act, asserting a federal role in water quality. The overall objective of the Clean Water Act is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. It prohibits the discharge of pollutants to WOTUS, unless the U.S. Environmental Protection Agency or the Corps of Engineers (depending on the type of pollutant) grants permission. At the same time, the Clean Water Act recognizes the "primary responsibility" of states to prevent water pollution and to make land use decisions. Indeed, the law embodies the concept of "cooperative federalism" and allows states to take over the federal permitting programs if they

demonstrate they have sufficiently robust regulatory programs.

From the start, questions arose over the scope of jurisdiction of the Clean Water Act. Did it cover non-navigable intermittent and ephemeral streams? To what extent were wetlands included? Throughout the years, the Environmental Protection Agency and the Corps of Engineers promulgated regulations defining WOTUS. Each time, the rules were challenged in court by regulated industries or environmental groups, or both. The result was a pendulum of protections, with much uncertainty over precisely which waters constituted WOTUS.

In 2023, in *Sackett v. Environmental Protection Agency*, the U.S. Supreme Court issued its most significant WOTUS decision, severely constricting the reach of the Clean Water Act. The case arose out of an enforcement action where a property owner in the Idaho panhandle had filled a wetland without a permit; the wetland had a shallow, subsurface connection to Priest Lake (a navigable water), less than 100 meters away. In deciding whether wetlands are protected under the Clean Water Act, the Court declared a two-part test. First, for purposes of the Clean Water Act, the term "waters" within WOTUS refers to "only those relatively permanent, standing or continuously flowing bodies of water," such as oceans, rivers, streams, and lakes. Wetlands failed to make the list.

Second, wetlands could only qualify as WOTUS if they have a continuous surface connection to a waterbody that is a WOTUS in its own right, making it difficult to determine where the "water" ends and the "wetland" begins. Because the Sacketts' wetland did not have continuous surface connection with and was clearly distinguishable from the lake, it did not meet the test to be a WOTUS.

Although the case involved a specific wetland, the principles articulated by the Supreme Court apply nationwide. Taken to its (il)logical extreme, almost no freshwater wetland can be considered a WOTUS. [See **Fig. 1** for its impact on the greater Everglades ecosystem in south Florida.] Such wetlands can be delineated, as wetland consultants do every day. If they can be delineated, they are distinguishable from the other waterbody. And if they are distinguishable, then they are not WOTUS. In my view, for the reasons explained in my book "*Waters of the United States: POTUS, SCOTUS, WOTUS, and the Politics of a National Resource*", the *Sackett* decision has no basis in statute, practice, or science. Yet that is what the Supreme Court has decreed.

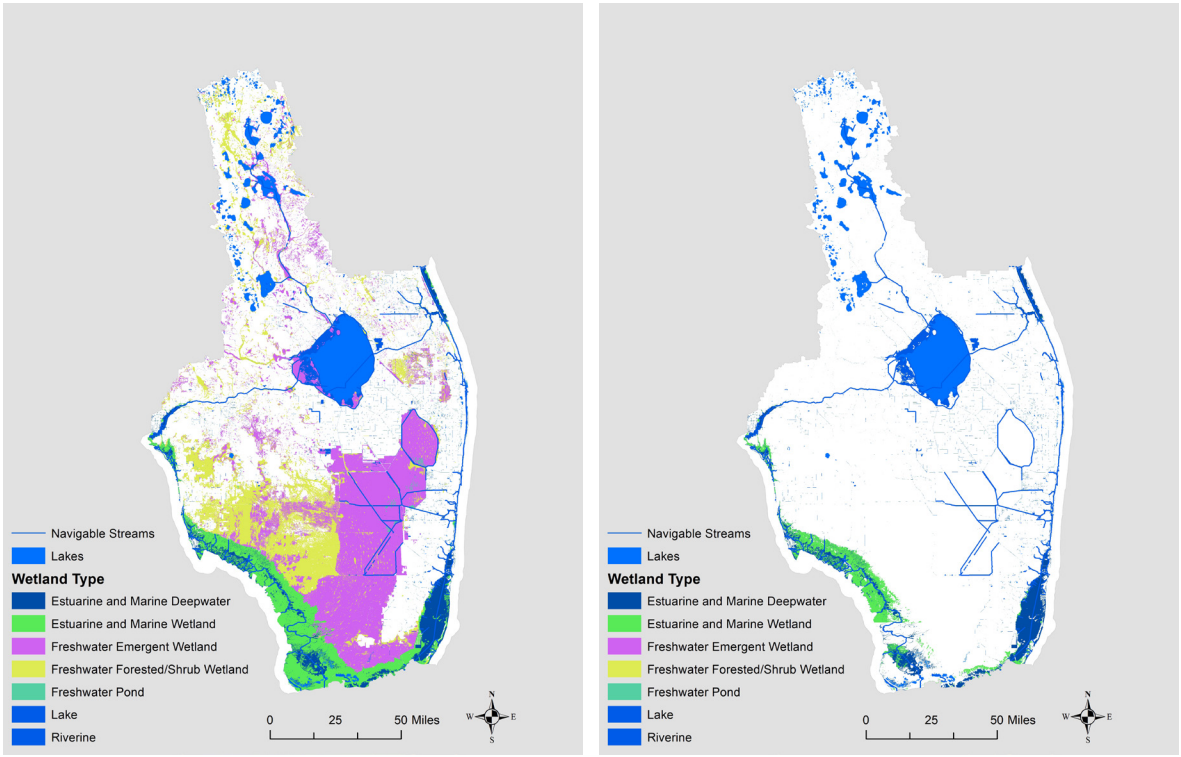
How much more damage can the Trump administration do with the current proposed WOTUS rule? Any new WOTUS rule that the Environmental Protection Agency or Corps of Engineers issues must be consistent with the Supreme Court's ruling.



....wetlands could only qualify as WOTUS if they have a continuous surface connection to a waterbody that is a WOTUS in its own right, making it difficult to determine where the "water" ends and the "wetland" begins.

BOOK Waters of the United States: POTUS, SCOTUS, WOTUS, and the Politics of a National Resource

https://islandpress.org/books/waters-united-states#desc



(a) National Wetlands Inventory (USFWS 2024) polygons identified as meeting the Scenario 1 scenario analysis criteria for likely jurisdictional status under the pre-*Sackett* "significant nexus" test

(b) National Wetlands Inventory (USFWS 2024) polygons identified as meeting the Scenario 2 scenario analysis criteria for likely jurisdictional status under a restrictive "indistinguishable" *Sackett* test

Fig.1 | WOTUS, pre- and post-*Sackett* (Source: Evans, Adetoro, and Hill (2024))

With respect to wetlands, the Trump administration was not as aggressive as it could have been. For example, the proposed rule suggests that a wetland that has a continuous surface connection with a WOTUS during the "wet season" (a new regulatory term that will be sure to generate more litigation) meets the Supreme Court's test. The agencies could have required a continuous surface connection throughout the entire year. Nevertheless, the proposed rule limits Clean Water Act coverage to streams that have a continuous flow during the entire wet season, which eliminates all ephemeral streams and many intermittent streams. Moreover, any wetlands adjacent to those streams would also not qualify as WOTUS.

To be sure, the proposed rule is just that: a proposal. And the Supreme Court had already inflicted a grave injury upon the corpus of the Clean Water Act. The Trump administration may yet exacerbate the harm when it finalizes the next iteration of the WOTUS rule. Congress could step in and clarify the matter by clearly defining what waters should be covered by the Clean Water Act. In the current climate, that scenario is unlikely. Instead, the responsibility for protecting wetlands and many streams has shifted back to the states. One can only hope that they do a better job this time.



THEMATIC ISSUE

Regulatory Framework on Wetlands in China



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High-altitude peatlands of China

Currently, China has 56.35 million ha of wetlands. Wetlands have always been at the center in China's development and its civilization processes. However, like the rest of the world, wetlands in China have also experienced significant decline due to reclamation for land, hydrological engineering and over exploitation of water resources. Loss of wetlands became a major environmental issue towards the late 1990s. With the ratification of Ramsar Convention in 1992, China initiated development of national wetland policy, including the development of national action plans for wetland conservation in 2000, and then, in 2003,

developed and implemented national wetland conservation plans (2002-2030). Since then, wetlands conservation and management have been the key performance indicators for governments at all levels. To ensure effective conservation and wise use of wetlands, a comprehensive wetlands regulatory framework has been developed. It consists three tiers of legislation system, e.g., national wetland protection law (ecosystem approach), national laws that related to wetlands resources, and regulations on wetland conservation and wise use.

National Wetland Protection Law

On December 24, 2021, President Xi Jinping officially announced the promulgation of National Wetland Protection Law, which was brought into effect on June 1, 2022. The law's implementation marked a new stage of law-based wetlands protection in China. This law defined wetlands as described by the Ramsar Convention, with emphasis on its key ecological functions. This clarified the historical misunderstanding among different government agencies who focused and appreciated only the social and economic functions of a wetland ecosystem. The definition of the wetland as proposed under the law enabled all government agencies to duly take their responsibility to protect and manage wetlands and as well advocate for the 'wise use' of wetlands as proposed under the Ramsar Convention. The key features of the national wetland protection law include following aspects:

1. Wetlands with key ecological functions should be specially protected under an integrated ecosystem conservation and management approach.

Table 1 | List of National Laws Related to Wetlands in China

National laws	Main Objectives	Articles related to wetlands	Promulgation Year	Leading ministries
Water Law	Water resource protection, management and use efficiency	Water relocated for ecological (wetlands and biodiversity) use	1988, revised in 2009 and 2016	Ministry of Water Resources
Flood Control Law	Control flood, prevent and mitigate flood disasters	Strictly control reclamation of wetlands, or damage wetlands	1997, revised in 2009, 2015 and 2016	Ministry of Water Resources
Water Pollution Control Law	control water pollution and protect aquatic ecosystem to safeguard public water security	Protect aquatic ecosystems	1984, revised in 1996, 2008 and 2017	Ministry of Environment Protection
Wildlife Protection Law	Protection of rare and endangered wild animals	Waterbirds and their habitats	1998, revised in 2022	NFGA
Fisheries Law	Protection of fishery resources, fishery production, development and wise use	Protection of fish resources and fish habitat and aquatics ecosystems	1986, revised in 2025	Ministry of Agriculture and Rural Affairs

Table 1 (contd.) | List of National Laws Related to Wetlands in China

National laws	Main Objectives	Articles related to wetlands	Promulgation Year	Leading ministries
Forest Law	Forest resource protection, ecological restoration, forestry and forest land management	Conservation of forested wetlands, peatland and marshes, mangroves	1984, revised in 1998, 2009, and 2019	NFGA
Grassland Law	Protect, and wise use of grassland, conserve biodiversity, development of animal husbandry	Conservation of wet meadows, non-forested peatland	1985, revised in 2002, 2009 and 2021	NFGA, Ministry of Agriculture and Rural Affairs
Water and Soil Conservancy Law	Control water and soil erosion through vegetation recovery, and engineering project	Catchment management to improve wetlands	1991, revised in 2010	Ministry of Water Resources
Land Management Law	Regulate land use change, protect basic farmland	The revised version recognises the importance of wetlands	1986, revised in 1998, 2004 and 2019	Ministry of Nature Resources
National Park Law	To protect integrity and authenticity for critical ecosystems	Wetland ecosystem is one of the key objective for national park	2025	NFGA
Environment Protection Law	To protect and improve environment, prevent environmental pollution, secure public health	Wetlands, water and wildlife are major objective for environmental protection	1989, revised in 2014	Ministry of Environment and Ecology
Marine Environmental Protection Law	To protect and improve marine environment, prevent marine and coastal pollution, and secure clean fishery as well as public health	Coastal wetland conservation and wise use	1982, revised in 1999, 2013, 2017 and 2023	Ministry of Nature Resources
Environmental Impact Assessment Law	To prevent negative environmental impacts from planning and projects, and ensure harmony between economy, social and environment development	Any project related to wetland ecosystem, hydrology and ecology should conduct EIA	2003, revised in 2018	Ministry of Environment and Ecology

Biodiversity conservation, particularly the habitats of globally threatened species form a primary focus, followed by consideration of the value of ecosystem services when assessing the effectiveness of law enforcement.

2. Management responsibilities for wetlands are distributed among national authorities overseeing nature conservation, agriculture, water resources, environmental and ecological protection, and urban and rural development. The National Forestry and Grassland Administration (NFGA) holds overall responsibility for implementing wetland protection and coordinating the work of the National Wetland Committee.

3. A comprehensive management mechanism is established to support law enforcement, encompassing inter-sectoral coordination, the no net-loss policy for natural wetlands, monitoring and evaluation, wetland conservation and restoration, performance inspections, eco-compensation, and environmental impact assessments.

4. Wetland ecosystems are classified, and conservation responsibilities are outlined for central and local governments. Wetlands of international and national importance fall under the primary responsibility of the central government, whereas wetlands of local importance (provincial or municipal) are the responsibility of local governments. The National Forestry and Grassland Administration (NFGA) is responsible for publishing the official list of wetlands.

5. The costs of violating wetland protection laws are no longer affordable. A comprehensive wetland damage protocol, based on ecosystem service valuation, has been applied, under which the cost of reclaiming or damaging natural wetlands ranges from 130 USD -1300 USD/m2.

National Laws Related to Wetlands

Before the promulgation of national wetland protection law, wetlands were protected through more than 15 national laws addressing different components and functions of wetland ecosystems and ecosystem services. These laws remain in force and continue to be implemented.

Regulations and Protocol (Standard)

All national laws are enacted by the National People's Congress. Once a law enters into force, People's Congresses at the provincial level develops implementation protocols, often in the form of regulations. Meanwhile, the relevant leading ministries formulate law enforcement protocols, guidelines, and national standards.

THEMATIC ISSUE

Navigating the Carbon Giants:

The Evolving Regulatory Framework for Indonesia's Wetlands



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Indonesia, a vast archipelago nation, holds one of the planet's most significant reservoirs of ecological wealth: its tropical wetlands. Dominated by expansive peatlands and critical mangrove forests, these ecosystems function as global climate regulators, storing gargantuan amounts of carbon. Indeed, the fate of these wetlands is central to Indonesia's commitment under the Paris Agreement; the country's Nationally Determined Contribution (NDC) targets rely heavily on the Forestry and Other Land Use (FOLU) sector, and wetlands are the largest natural component of that strategy. They are crucial for Indonesia to achieve its ambitious FOLU Net Sink 2030 goal, where the land sector is projected to become a net carbon sink by the end of the decade. Yet, this vital asset remains deeply imperilled by large-scale land conversion, resulting in rapid degradation and the devastating transboundary haze crises.

The ongoing crisis forced a profound regulatory response, marking a crucial shift in Indonesian environmental governance. The legislative journey aims to strike a precarious balance between economic development and ecological survival. This exploration delves into the pillars of Indonesia's wetland regulations, examining the dynamic policy shifts and the formidable implementation challenges that lie ahead.

The Foundation of Peatland Protection

The overarching legal framework for environmental management in Indonesia is provided by Law No. 32/2009 on Environmental Protection and Management. This law establishes the principles of sustainability, precaution, and the "polluter pays" doctrine, forming the legal backbone for ecosystem-based management, including wetlands. It mandates the integration of environmental considerations into spatial planning, development licensing, and natural resource utilization, an important basis for wetlands governance across sectors.

The core of Indonesia's wetland legislation emerged from the urgent need to halt the destruction of its carbon-rich peat swamps.

The initial framework was established through Government Regulation (PP) Number 71 of 2014 on the Protection and Management of Peat Ecosystems, which was subsequently strengthened by PP Number 57 of 2016. This revised regulation introduced principles that radically redefined land use on peat.

Crucially, the regulation mandated that peatland management must be based on the Peat Hydrological Unit (KHG), an ecological boundary defined by the natural hydrological flow between two rivers or the sea, rather than arbitrary administrative lines. It requires the delineation of protected zones and cultivation zones within each KHG, emphasizing water table management, rewetting, and fire prevention. The regulation also mandates the rewetting of drained peatlands with a target to maintain groundwater levels at less than 0.4 meters below the surface. Compliance mechanisms include restoration obligations for concession holders and penalties for those failing to prevent fires or degradation.

This holistic approach was intended to ensure proper water management across the entire ecosystem. The law further decreed that all areas designated as Peat Protection Function, especially those with peat layers measuring three meters or deeper, and peat dome peaks, must be conserved. Most significantly, the regulation explicitly outlawed any activity that causes peat to dry out, placing a mandatory ban on illegal drainage canal construction, which is the primary root cause of subsidence and vulnerability to fire.

Despite its strong ecological logic, implementation has faced obstacles, especially regarding monitoring, enforcement, and coordination across ministries and local governments.

A New Chapter for Mangrove Governance

In parallel with peatland efforts, the protection of coastal ecosystems has been solidified. Mangrove forests, essential for coastal defence, fisheries, and carbon sequestration, were historically covered by various sectoral laws. However, recognizing their unique value and vulnerability, the government ushered in a consolidated legal instrument, Government Regulation (PP) Number 27 of 2025 on the Protection and Management of the Mangrove Ecosystem.

This landmark regulation provides a comprehensive guide for zoning, sustainable utilization, and conservation efforts. It mandates detailed national mapping and delineation of both Mangrove Protection Areas and Mangrove Cultivation Areas, providing legal clarity and certainty for both conservationists and coastal communities. This move underlines the nation's strategy to leverage its vast

mangrove resources not only for environmental security but also as a core component of its climate mitigation agenda. It also supports community-based management and sustainable use through silvofishery and ecotourism models, aligning conservation with local economic benefits. This regulatory evolution reflects Indonesia's recognition that mangrove protection is not merely an ecological necessity but a socio-economic opportunity.

The Institutional Dynamics of Restoration

To aggressively tackle the restoration mandate, the government initially established the Peat and Mangrove Restoration Agency (BRGM), an ad-hoc body with a ministerial-level mandate, established in 2016. The BRGM was instrumental in coordinating the national "3R" program: Rewetting (re-saturating dried peat), Revegetation (replanting with native species), and Revitalization (empowering local livelihoods).

However, in a significant shift illustrating the fluid nature of Indonesian policy, the BRGM has concluded its mandate and been effectively dissolved. The torch of technical restoration implementation has now passed to more permanent, integrated units within the central bureaucracy. Specifically, the responsibility for continuing the technical aspects of wetland management is now largely handled by regional units such as the newly formed Balai Pengelolaan Ekosistem Gambut dan Mangrove (BPEGM), which operates under the purview of the Ministry of Environment (Kemen LH). This transition reflects an attempt to embed restoration into the permanent bureaucratic structure, moving it from a crisis-response operation to a foundational government function.

Implementation Challenges and the Road Ahead

Despite the powerful legal and institutional instruments now in place, the path to full wetland recovery is fraught with difficulty. The most enduring challenge remains the perpetual conflict between economic imperatives and environmental protection. Large tracts of land designated for protection still overlap with existing, economically vital concessions, creating legal and political friction. Furthermore, the mandatory harmonization of detailed Peat Ecosystem Function maps with local Spatial Planning (RTRW) across provinces and districts is a slow and often contentious process, leading to delays and loopholes at the regional level.

The organizational transition from the high-level BRGM to the technical BPEGM within the Ministry of Environment also introduces new coordination hurdles. The former enjoyed an elevated position that facilitated



cross-sectoral collaboration with agencies responsible for agriculture, public works, and spatial planning. The BPEGM, operating as a technical unit, must now work diligently to maintain the momentum and secure the extensive resources required for the 3R programs across a diverse array of competing ministerial interests. Effective law enforcement against illegal drainage and burning, especially within corporate concessions, continues to demand rigorous supervision and decisive legal action.

Ultimately, Indonesia's success in regulating its wetlands is directly proportional to its ability to meet its global climate obligations. The restoration programs on both peat and mangroves are projected to be the single largest contributors to achieving the NDC target. Moving forward, policy must embrace innovative, community-based solutions, such as Paludiculture, cultivating crops on wet peatlands to maintain hydrological function while providing income, and integrating the deep knowledge of local and indigenous communities in water management. Indonesia's regulatory framework is robust; its ultimate success now hinges on unwavering political will, transparent enforcement, and sustainable governance capable of transforming ambitious policy into enduring ecological reality.

Conclusion: Toward a Future of Shared Responsibility

Indonesia's wetlands are both a national heritage and a global trust. They anchor the country's ecological resilience, cultural identity, and contribution to global climate stability. The evolution of its regulatory framework, from the foundational environmental law to specialized peat and mangrove regulations, shows a clear commitment to balancing development and conservation.

However, the journey is far from complete. Implementation remains constrained by economic pressures, institutional fragmentation, and spatial conflicts. The challenge ahead is to translate these robust legal texts into living regulations, anchored in local realities, supported by science, and sustained by public participation.

In the end, the future of Indonesia's wetlands will depend not only on the strength of its laws but on the collective will to uphold them. Protecting these ecosystems is more than a regulatory obligation, it is a moral and global responsibility, ensuring that the lungs and carbon vaults of the tropics continue to breathe for generations to come.

THEMATIC ISSUE

Challenges in Saving Urban Wetlands



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Wetlands: lifelines through time

Wetlands have been immensely crucial for the human existence throughout history, from the earliest stages of human evolution. As populations continue to burgeon across the Indian sub-continent, wetlands will play an increasingly defining role in the future, as the demand for water will grow exponentially.

Water is a finite and precious resource, and humanity largely depends on rainfall for its availability. So far, no industrial innovation has succeeded in replacing water as a commodity for sustaining society and the environment. While some Gulf countries have succeeded in converting sea water into freshwater through desalination, the importance of conserving wetlands within our expanding cities has yet to be fully appreciated by urban planners. The reality that water is not an infinite resource has still not adequately dawned upon the educated society of the 21st century.

I have been involved in the conservation of urban wetlands in Madhya Pradesh in central India, and from my over 40 years of experience in this field, I can say that the existing regulatory framework for integrating wetlands into urban planning needs to be further strengthened if urban wetlands are to be preserved for posterity. Left largely to themselves, barring a few exceptions across India, people are unlikely to bring about the behavioural changes necessary to protect natural water sources.

Wetlands conservation in the Indian context

The Indian scenario is perhaps distinct from that of other countries, particularly because wetland ownership patterns vary widely, posing a significant challenge to their conservation. The urban planning process is generally not in favour of conserving wetlands. For instance, the Bhopal Municipal

Corporation has largely failed to safeguard Madhya Pradesh's first Ramsar Site — the Bhoj wetland. At one point, it covered an area of ~ 250 km^2 as noted by the historian B. L Basham. Some wetlands fall under municipal local bodies, others under the forest department, while many, especially in rural India are managed by panchayats. As a result, their conservation poses serious practical and administrative challenges.

Historically, Indians have revered waterbodies and wetlands for religious reasons; rivers in particular were accorded the status of a mother. However, as industrialisation expanded towards the end of the 19th century with machines being invented availability of resources became easier. As societies began to modernise, water requirements rose dramatically. Together, these developments pushed water demand beyond imagination, yet urban planning departments remained largely oblivious to this reality.

Present-day wetlands conservation status

About 50 years ago, availability of water was sufficient for domestic and agricultural use. Many cities enjoyed uninterrupted tap water supply in households. Wetlands that are now battling for survival were largely clean and free from encroachments. They were not treated as dumping grounds for garbage or plastics waste. However, the picture changed rapidly post economic liberalisation. As rural-to-urban migration witnessed an unprecedented upward trend, wetlands came under stress, making it imperative to introduce laws and regulations to govern water use and protect urban wetlands.

Regulatory phase

It took the Bhopal Gas Tragedy of 1984 for lawmakers to awaken to the urgency of environmental protection and introduce strong legislation such as the Environment (Protection) Act, 1986, which heralded a new era. Although the Water (Prevention and Control of Pollution) Act was enacted in 1972, public awareness about the pollution of water sources, such as what we see today was minimal at the time. Even so, wetland protection per se did not become a priority until 2010, when the Wetland Rules were framed by the central government and later amended in 2017.

In late 1980's, I became involved in cleaning up a 100-year-old Sirpur wetland in Indore. The largest city and a flourishing trading center of Central India, was designed in 1916 by the Scottish urban planner Sir Patrick Geddes, a strong advocate of nature. Concepts such as lake conservation, wetlands carbon sink etc. were not part of our lexicon when we began this work. Driven by passion for our

city, a group of enthusiasts led by Padma Shri Bhalu Mondhe, a renowned nature photographer, took the initiative to saving this urban lake. Our limited objective was to protect the urban biodiversity, particularly birds and their habitats. The Sirpur wetland was recognised as a Ramsar Site in 2022. It spreads over an area of 600 ha. The wetland is an invaluable asset and has been saved after the sustained conservation efforts of ~ 30 - 40 years by a non-profit organization, The Nature Volunteers (TNV) Society in Indore.

After working for about a decade, almost aimlessly, we realized that we lacked legal support and guidance to protect this iconic wetland created by the Holkar royal family. Initially, the Madhya Pradesh Forest Department refused to take any responsibility despite the presence of dense, old-growth trees in the area (many of which have been lost over the past 30 years). When we approached the owners, the Indore Municipal Corporation (IMC), successive officials appeared largely apathetic to the wetland's problems, including illicit tree felling, washing of clothes, fishing and encroachments.

Despite its vast sprawling area and rich and diverse biodiversity, officials were not forthcoming in offering support. It was not merely an issue of environmental protection; it was a governance failure compounded by the absence of a legal framework to address the problem. Urban managers neither possessed the expertise nor showed the interest required to protect this important wetland. While the Wetland Rules of 2010 and 2017 and the Biodiversity Act of 2002 have, to some extent, helped strengthen the regulatory framework for wetland conservation, there is another side to the story. The State Wetland Authority established in recent years, despite having a clear mandate, appear largely toothless. They lack both experienced personnel and adequate funds to deal with the magnitude of the challenge.

In a large state like Madhya Pradesh, ~ 13,500 wetlands have been identified for conservation, many of them located in urban areas. One can imagine how many exist in other states! If the regulatory framework is strengthened with clearly defined goals, wetland conservation can still offer hope for India's rapidly growing cities. For meaningful outcomes, the Department of Town and Country Planning must work in close coordination with the Environment Department.



Kareri Wetland, Himachal Pradesh / Harsh Ganapathi

TECHNICAL NOTE

Impact of Climate Change on Ecosystem Services and Livelihood of People:

Case Study of Kol Ramsar Site - A Humid Tropical Coastal Wetland of Kerala



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Kol wetlands of Kerala, part of the Vembanad-Kol Ramsar site forms one of the largest coastal wetland complexes of the country. It is located 0.5–1 m below mean sea level and remains flooded for most of the year (Figure 1). The hydrology and ecosystem services of the Thrissur Kol wetland, particularly in the context of climate change and people's livelihoods, were investigated under a project funded by the Ramsar Regional Centre-East Asia.

The rice-cultivated area of Thrissur Kol covers 11,936.4 ha; the farming activities in the wetland coexist with its biodiversity. Where rice cultivation is not practised, other urban development activities predominate, reducing the wetland area. Two rivers, namely Keecheri and Karuvannur, discharge directly into the wetland, transporting water and sediment. The wetland has three main openings to the sea; most of the wetland below mean sea level is inundated year-round. The water level in this floodplain goes up to 5.5 m during the peak of the southwest monsoon season. It was previously a shallow lagoon, most likely formed by sand bars due to river-sea interaction. Early Portuguese and Dutch maps support this hypothesis. Canal networks connect the Kol's various locations to rivers and ensure adequate drainage. Earthen dykes separate the canals from the rice-polder fields. Freshwater diverted from rivers by dams is pumped into the polders during the cultivation season and dewatered when flooding occurs. The primary source of freshwater is the Chimoni reservoir on the Karuvannur River, which was initially intended for rice cultivation in the Kol. The rural technicians have modified the centrifugal pump to suit their purpose; it is locally known as ‘petty and para’.

The major land-use categories in the wetland ecosystem include rice cultivated areas, mixed crops, built-up land, water bodies, waterlogged areas, and barren land. In general, the area under rice cultivation has declined from 46% to 44% during 1981-2021 in the State of Kerala. The area under rice declined by 1.07 % per annum in the wetland, whereas the area under built-up land increased by 2.45 % during 1989-2007. The so-called 'wastelands' also increased sharply during this period, at an annual rate of 12.9%; ground verification confirms that these lands were once used for mining sand for construction and soil for brick-making, and were later abandoned as unfit for cultivation.

The intensification of agriculture, which started a century ago, imposed significant pressure on the wetland. Several engineering interventions to improve drainage and water management have been implemented to facilitate double cropping. Although the construction of farm roads has facilitated the movement of tillers and tractors, seeds and fertilizers at reduced cost, it has led to the conversion of part of the Kol lands to non-agricultural uses and to the expansion of mining and other activities, thereby causing drastic changes in the ecosystem.

Decadal data from 1980 to 2020, derived from Landsat and supplemented with Sentinel imagery data for 2020, were obtained and filtered for cloud cover. Training samples were created for classification, and the images were classified using a Random Forest classifier. An error matrix has been generated, and the classification accuracy has improved. Figure 2 shows the rapid changes in the Land Use Land Cover (LULC) of the Thrissur Kol between 2000 and 2020. Within the wetlands, the built-up area has been assessed at 109.5 ha, 169.35 ha, and 195.18 ha in 2010, 2015, and 2020, respectively. The increases in the percentage of built-up area are 285.13%, 495.46%, and 586.28% in 2010, 2015, and 2020, respectively, relative to the area under the same class in 2000. Conversion of rice-cultivated land into plantations has also been observed in Irinjalakuda and Cherpu in the south, as well as in the Thrissur Corporation area. The adverse effects of urbanization include a loss of land under cultivation and an increase in the amount of solid waste deposited and domestic sewage discharged into the wetland.

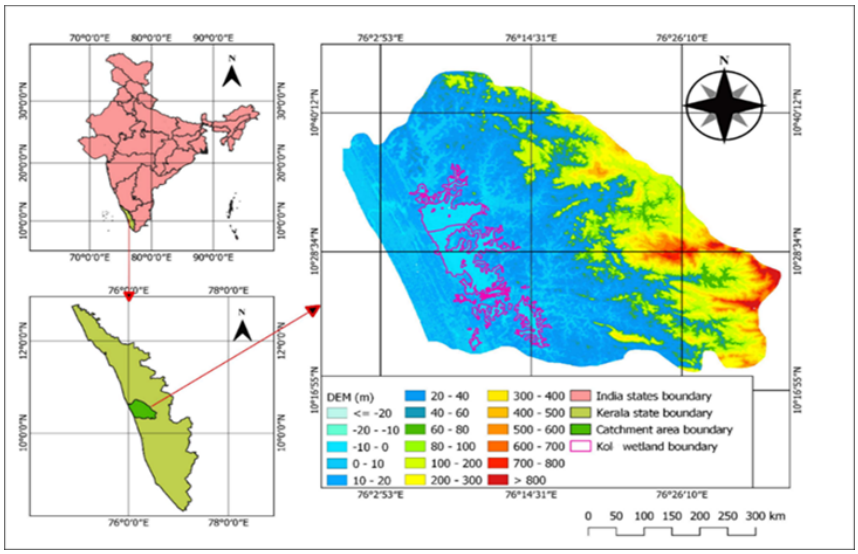


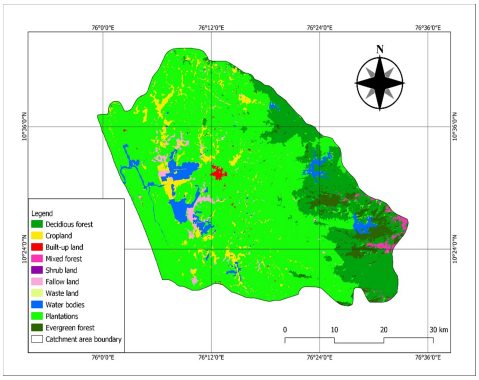
Fig.1 | Thrissur Kol wetlands, Kerala

Regulators, Canals and other interventions

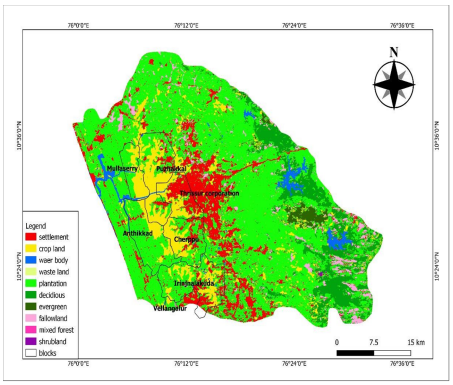
The locations of major regulators and canals in the wetland are given in Figure 3. The main communication with the Lakshadweep Sea and the exit for water from the South Kol is through the Enamakkal regulator with 13 shutters, which also controls saltwater intrusion into the rice fields. The regulator, constructed in the 1950s, is situated across the Enamakkal phase canal. The farmers collectively report that, due to leakage from the Enamakkal regulator, rice yields have declined as saline water intrudes into the fields. Therefore, as a temporary measure, earthen ring bunds are constructed annually; this practice, which entails recurring expenditure, has been in use for several years. The Idiyanchira regulator was built in 1998 with 33 shutters across the Mullassery canal. It serves as the primary exit for water from the North Kol to the sea via the Chettuva water body.The regulator prevents saltwater intrusion into the rice fields; however, it is currently severely degraded and no longer functions efficiently. In addition to these, there are seven other important regulators and a lock at Karanchira, most of which require renovation and modernisation. The primary sources of irrigation water for the Kol lands are Peechi, Vazhani, and Chimoni irrigation reservoirs. Water released from the Chimoni dam, a primary water source of the Kol, is stored and diverted to Kol lands through the regulators at Illikkal and Kottenkottuvalavu. The water flowing upstream is primarily diverted to the North Zone via various natural and artificial canals. Irrigation water supply to the South Kol is mainly through the Neerolithodu and Nandithodu. The total length of these canals is approximately 170 km.

Canals in the Kol act as drainage channels during the flooding season, conveying floodwater to the outlets at Enamakkal, Idiyanchira, and Koothumakkal.

From a socioeconomic perspective, it is notable that Kol's agricultural land is owned by approximately 50,000 individual farmers, most of whom hold less than 0.5 ha. The farmers are organized into approximately 150 farming societies. Since the 1960s, owners of contiguous fields, known as a padasekharam (in Malayalam), have formed joint-farming cooperative societies. The Government is providing support to farmers through the Kol Land Development Corporation, particularly in light of the policy objective of achieving self-sufficiency in food grains.



a) 2000



b) 2020

Fig.2 | Land Use Land Cover changes in the wetland and drainage basins

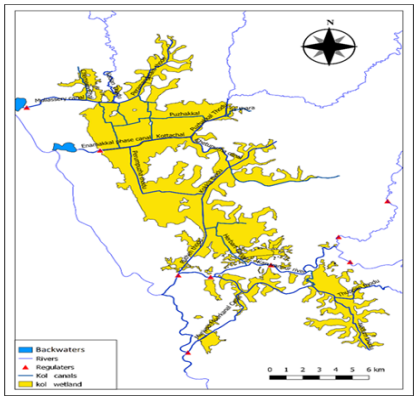


Fig.3 | The regulators and canals in the river basins and wetland

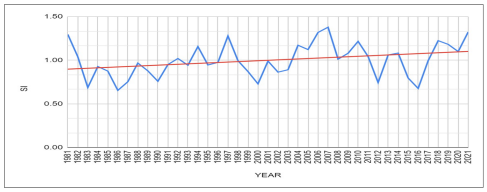


Fig.4 | Seasonality Index of rainfall

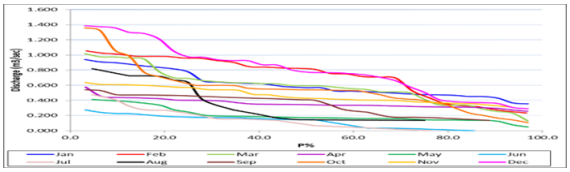


Fig.5 | Average monthly flow duration curves-reservoir releases

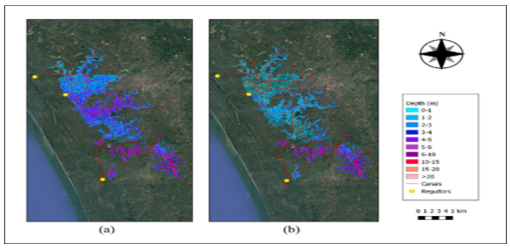
Flood modelling considering climate change

The floods of 2018 and 2019, which inundated and damaged large areas on the periphery of the Kol, prompted a study of floods and their implications, both present and future. Seasonality Index (degree of monthly variability in rainfall over a year), and flow-duration curves of reservoir releases from upstream are shown in Figure 4 and 5 respectively.

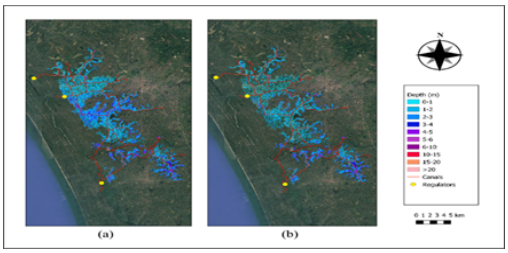
The Rain on Grid (RoG) model in HEC–RAS was used to assess flood levels and velocities within the wetland and the drainage-basin boundary. 200 × 200 m cells were created to form the rainfall grid. Daily rainfall data for the southwest monsoon season (June–September) were used as input to the model.The model was run using two approaches: rainfall at the wetland boundary only and rainfall within the wetland and at the basin boundary. The model was run for two conditions: i) when the regulators were opened, and ii) when the regulators were closed, to understand the variations in water depth and water spread area due to flooding.The regulators considered for the modelling are those at Enamakkal, Idiyanchira, and Koothumakkal, which function as exit controls at the wetland-sea openings. Figure 6 shows that the percentage of area flooded in the wetland and buffer zone was 87.36% and 57.97%, respectively, when regulators were closed and open during the 2018 floods, and 63.83% and 47.24% during the 2023 floods, indicating inundation in both areas.

The different socioeconomic pathways for emissions, as provided by the IPCC, are shown in Figure 7, and the estimated variations in daily rainfall are shown in Figure 8, indicating the importance of regulator operation.

Figures 9-11 illustrates the predicted flooded areas for different scenarios and time targets for the wetland and buffer zone, when the regulators are closed and open and and for the basin as a whole in Figure 12.



August 2018



June-August 2023

(a) Regulators closed (b) Regulators open

Fig.6 | Estimated flood depth considering the rainfall in the wetland boundary

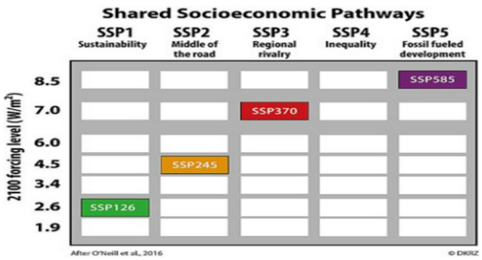
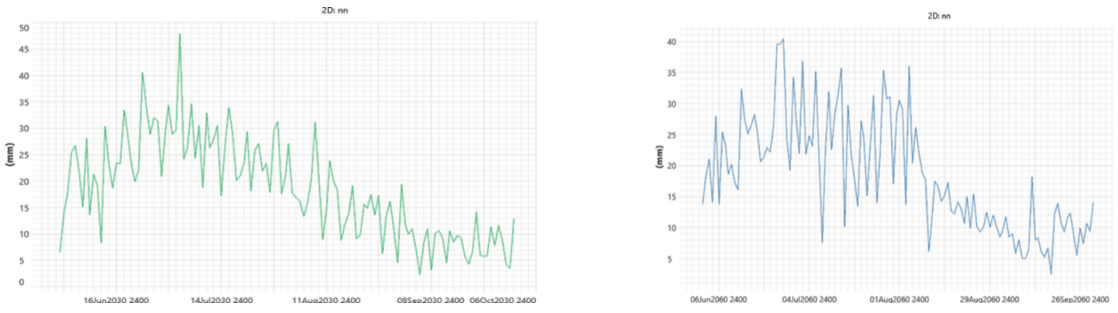
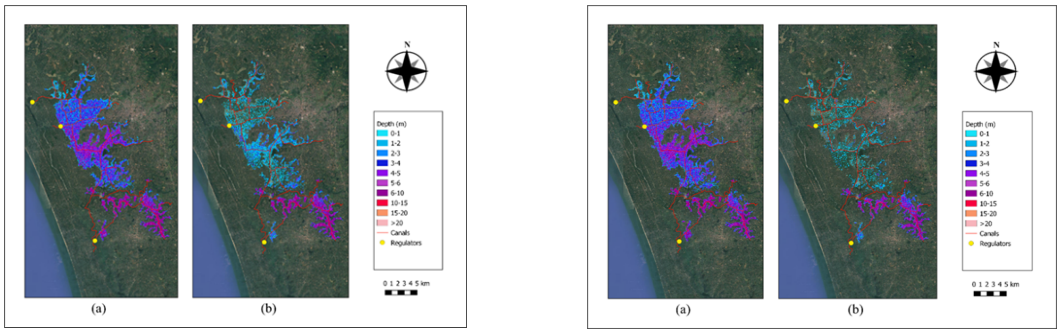


Fig.7 | Shared socioeconomic pathways: IPCC



June - October 2030 June - September 2060

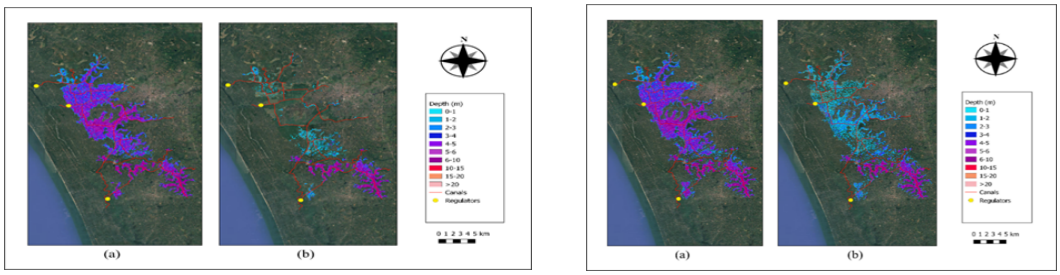
Fig. 8 | Variations in daily rainfall



Precipitation in 2030: SSP 245 Precipitation in 2060: SSP 245

(a) Regulators closed (b) Regulators open

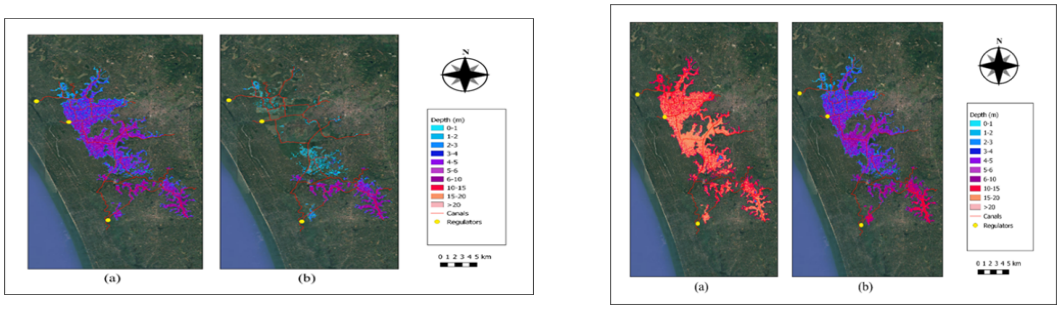
Fig. 9 | Estimated flood-depth considering the rainfall in the wetland boundary



Precipitation in 2030: SSP 585 Precipitation in 2060: SSP 585

(a) Regulators closed (b) Regulators open

Fig. 10 | Estimated flood depth considering the rainfall in the wetland boundary



Precipitation 2090: SSP 585

(a) Regulators closed (b) Regulators open

Fig. 11 | Estimated flood-depth considering the wetland

Fig. 12 | Estimated flood-depth considering the basin

In the SSP 245 scenario, submergence due to wetland rainfall exceeds 50% when the regulators are open and 90% when they are closed.

Considering rainfall across the entire basin, the submergence percentage exceeds 99% under closed-regulator conditions and exceeds 90% under open-regulator conditions. The flood depth is higher when the regulators are closed in the south of Puzhakkal in Thrissur Corporation, west of Cherpu, south of Anthikad, and east of Irinjalakuda, all under town municipalities. While the regulators are open east of Irinjalakuda and Anthikad, flood depths range from 4 to 6 m, owing to rainfall in the wetland. When the regulators are closed, considering the basin boundary, the flood depth was 15 m at Puzhakkal in Thrissur Corporation and at the towns of Cherpu and Irinjalakuda.

In SSP 585 scenarios, flood depth is higher in Puzhakkal, Thrissur Corporation, Anthikad, Cherpu, and Irinjnalakuda when the regulators are closed. In the open condition, Irinjnalakuda and Anthikkad experience flood depths of 4-6 m. For SSP 585, the flood depth in 2090 increases in the central Puzhakkal and Mullassery Blocks when the regulator is closed, considering the wetland boundary for flood modelling. When the regulators are closed, a flood depth of 15 m is observed in Puzhakkal, Anthikkad, Cherpu, and Irinjalakuda, based on precipitation across the entire basin.

For a sea-level rise of 0.5 m, most of the KoI will be submerged, namely 9,909.67 ha (83.02%) above the mean sea level (Figure 13). In the drainage basins, around 13207 ha (7.32%) of the total area will be submerged, in addition to the wetland per se.

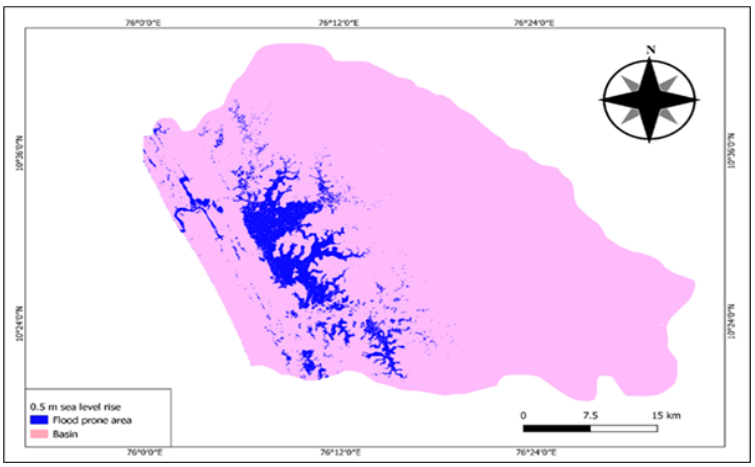


Fig. 13 | Inundated area when the sea level rises to 0.5

Modelling future agriculture yield

The soil parameters and percentage organic carbon content at different locations along the KoI are presented in Tables 1 and 2. The pH value is near normal at Chettupuzha on the upstream side, where freshwater discharge is greater. The NPK values indicate the relative magnitudes of fertilizer application in different parts of the wetland. The organic carbon content is generally high across all areas of the wetland, with the notable observation that it is particularly high in the soil at Enamakkal, which has somewhat dense mangrove growth. Observations from other mangrove wetlands further support this.

The DSSAT CERES-Rice model is a process-based crop simulation model within the Decision Support System for Agrotechnology Transfer (DSSAT) software, used to predict rice growth, development, and yield by integrating weather, soil, crop genetics, and management data (like water/fertilizer). It simulates daily plant processes (phenology, growth, biomass), soil water, and nitrogen balance, helping researchers assess climate change impacts, optimize nutrient management, analyze yield gaps, and forecast yields without extensive field trials.

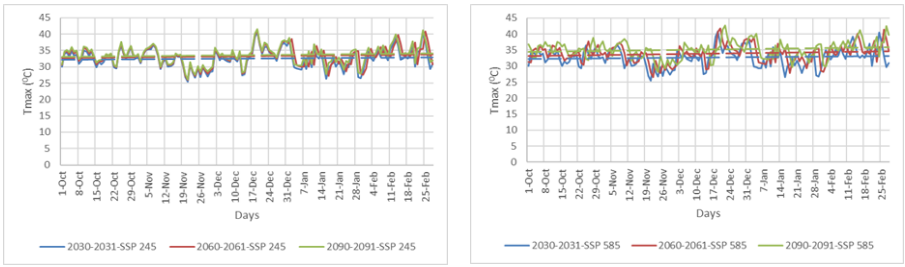
Table 1 | Soil parameters at different locations in the wetland

S. No.	Sample	pH	EC(dSm^{-1})	N (kg/ha)	P (kg/ha)	K (kg/ha)
1	Chettupuzha	6.61	1.54	188.16	42.56	549.92
2	Arimpur	3.60	1.50	360.64	33.94	77.28
3	Anthikkad	3.93	1.23	297.92	21.17	263.20
4	Chiyyaram	3.51	2.70	172.48	8.40	362.88

Table 2 | Soil parameters at different locations in the wetland

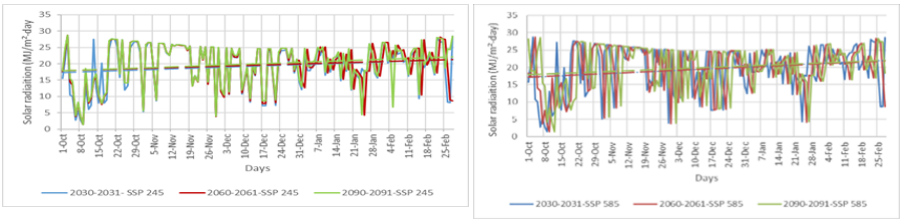
S. No	Sample	Organic Carbon (%)	Level
1	Enamakkal	16.81	High
2	Chettupuzha	2.09	High
3	Kanjany Padam	3.60	High
4	Pullazhi (1)	1.73	High
5	Pullazhi (2)	2.90	High
6	Arimpur (1)	1.14	High
7	Arimpur (2)	1.50	High
8	Anthikkad	1.09	High
9	Chiyyaram (1)	5.52	High

The maximum temperature and radiation projections for different years and scenarios are shown in Figures 14 and 15. The DSSAT-generated weather man chart is given in Figure 16. Observed yields versus predicted values for 2020–21 is shown in Table 3. Predicted yields for different years and scenarios in different padasekharams are given in Figure 17 and Table 4. Changes in climate parameters during the cropping season across different years and scenarios are presented in Table 5.



(a) (b)

Fig. 14 | Maximum temperature – 2030, 2060, 2090 cropping seasons (a) SSP 245, (b) SSP 585 Scenarios



(a) (b)

Fig. 15 | Solar radiation – 2030, 2060, 2090 cropping seasons (a) SSP 245, (b) SSP 585 Scenarios

An increase in temperature may reduce crop duration by 8% and yield by 6%. It is observed that although precipitation increases, temperature reduces yield: a 1 °C increase in temperature reduces yield by 6%. It is inferred that the yield will decrease by 20% and 53.5%

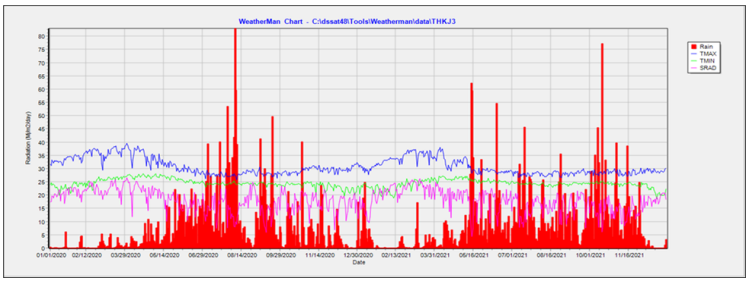
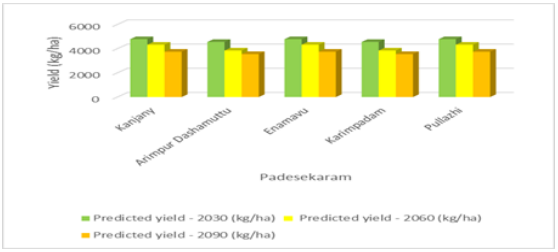


Fig. 16 | The DSSAT-generated weather man chart (2020-2021)

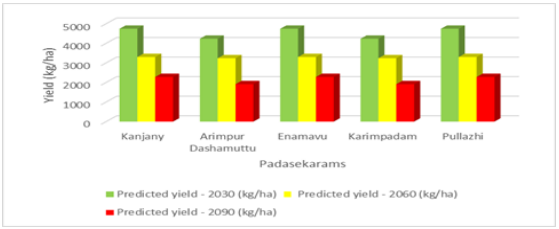
for SSP 245 and SSP 585, respectively, corresponding to 2090. Solar radiation received during the reproductive phase has a decisive influence on the yield. Sunlight for 45 days prior to harvest is crucial for yield. Rice plants respond quickly to even slight variations in light intensity during the day. It is most pronounced at low latitudes. A deficiency of light during the vegetative stage of rice plants will affect yield. Further studies are needed to elucidate how increases in temperature and solar radiation, and changes in rainfall patterns related to crop periods, crop maturity, grain weight, and soil salinity, affect rice yield in the Kol lands.

Table 3 | Observed yield vs predicted yield in different Padasekharams (2020-2021) and percentage of difference

S No.	*Padasekekaram*	Observed Yield (kg/ha)	Predicted Yield (kg/ha)	% of Difference
1	Kanjany	4448	4935	10.38
2	Arimpur Dashamuttu	4695	4613	-1.76
3	Enamavu	7414	4946	-39.94
4	Karimpadam	4695	4761	1.40
5	Pullazhi	3954	4946	22.29



(a)



(b)

Fig. 17 | Predicted yield in different Padasekharams: (a) SSP 245, (b) SSP 585 Scenarios (2030, 2060, 2090)

Table 4 | Predicted yield for different scenarios

S. No.	Year	Predicted Yield (ton/ha)	% of Reduction in Yield from 2023
1	2030-2031 - SSP245	54072.34	1
2	2060-2061 - SSP245	49237.51	9.9
3	2090-2091 - SSP245	43733.39	20
4	2030-2031 - SSP585	54072.34	1
5	2060-2061 - SSP585	39085.31	28.5
6	2090-2091 - SSP585	25381.86	53.5

Table 5 | Changes in climatic parameters during the crop season for various scenarios

S. No.	Year	Time span (Physical Maturity) (days)	Rain (mm)	Tmax (^{0}C)	Tmin (^{0}C)	Tmean (^{0}C)	Solar Radiation (MJ/m^2-day)	CO_2 (ppm)
1	2020-2021	122	436.1	30.8	22.7	26.7	18	415
2	2021-2022	123	456.4	30.5	22.9	26.7	17.6	417.1
3	2022-2023	124	419.2	31.4	22.3	26.8	18.2	419.2
4	2030-2031- SSP245	121	215.6	32.5	23.6	28	20.2	420.5
5	2060-2061- SSP245	121	232.7	33.1	24.2	28.7	20.4	420.5
6	2090-2091- SSP245	119	249.3	33.4	24.5	29	20.5	420.5
7	2030-2031- SSP585	121	238.9	32.6	23.7	28.1	20.4	420.5
8	2060-2061- SSP585	119	246.8	33.7	25	29.4	20.4	420.5
9	2090-2091- SSP585	119	297.3	34.9	26.4	30.6	20.6	420.5

Evaluation of ecosystem services

Economic valuation provides a tool to assist in conservation decision-making; understanding the Total Economic Value (TEV) of the ecosystem is necessary to make economically justifiable decisions. The TEV framework is increasingly used to assess the value of ecosystem services by combining monetary and non-monetary dimensions of overall value. Within the Millennium Ecosystem Assessment (MEA, 2005), the TEV is a widely used framework for identifying and quantifying the contributions of ecosystem services; the TEV comprises use values, non-use values, and option values. Table 6 presents details of ecosystem services of the Kol.

Data were obtained from local self-governments, interviews, and social surveys. The Market Value Method (MVM) used in the study is a widely employed tool worldwide for estimating the value of natural ecosystems and for implementing policy measures to conserve them from adverse human activities.

Direct Benefits

Evaluation of the benefits from rice cultivation is given in Table 7. The total economic value of rice cultivation is ₹1,05,21,34,528, and the net return per hectare is ₹67,044. The benefit-cost ratio for Kol farmers is as high as 1.92, compared with the average for Kerala rice farmers, 1.10 (Srinivasan, 2012). In addition to the usual infrastructure costs for rice cultivation, initiating prompt seedbed preparation requires draining waterlogged areas. The annual pumping cost is estimated at ₹ 9.6 lakh for the 50 hp petty and para pump, ₹ 6.95 lakh for the 50 hp vertical submersible pump, and ₹ 7.21 lakh for the 50 hp vertical propeller pump. At present, the revenue from rice cultivation is approximately ₹1,43,192/ha; this may decrease to ₹1,15,360 and ₹1,02,480 by 2090 under the SSP 245 scenario, and to ₹ 91,560 and ₹59,360 under the SSP 585 scenario.

Returns from fish farming are given in Table 8. Frequent floods, such as those in 2018 and 2019, would adversely affect fish farming, as evidenced by statistics and stakeholder reports.The returns from duck rearing are given in Table 9.

Indirect Benefits

Flood storage, carbon sequestration, tourism, and groundwater recharge fall under supporting services and are also considered indirect benefits in the context of the Kol lands. Biodiversity is one of the primary criteria that qualified the Kol for Ramsar status. The aesthetic Kol lands of Thrissur, with its lush foliage and abundant bird and fish wealth, are a popular tourist destination.

Table 6 | Ecosystem services of the Kol lands based on the MEA

Type of Service	Category
Provisioning Service	Fisheries support
	Direct food production
Regulating Services	Water quality improvement
	Flood mitigation
	Carbon sequestration
	Habitat for rare and endangered species
Cultural Services	Landscape aesthetics
	Sites for human relaxation
	Ecology education
	Sustenance of human cultures
	Ecotourism, bird watching
Supporting Services	Serving as chemical sources, sinks
	Water storage
	Hydric soil development

Table 7 | Estimated economic value of rice cultivation in Thrissur Kol

S. No.	Components	Quantity
1.	Area under rice cultivation (ha)	11,936
2.	Area of cultivable fallow wetland (ha)	1,108
3.	Rice yield per hectare (kg)	5,114
4.	Market price of rice per kg (₹)	28
5.	Revenue from rice per hectare (₹)	1,43,192
6.	Revenue from straw per hectare (₹)	12,014
7.	Cost of cultivation per hectare (₹) (includes lime, fertilizers/pesticides, rental of harvester, transport charges)	88,148
8.	Net returns from rice cultivation per hectare (₹)	67,044
9.	Total economic value from rice cultivation (₹)	1,05,21,34,528

Table 8 | Returns from fish farming per year from Kol lands

S. No.	Components	Quantity
1.	Area under fish farming (ha)	187
2.	Net return per hectare (₹)	8,702
	Total economic value from pisciculture (₹)	16,27,274

Table 9 | Returns from duck rearing per year from Kol lands

S.No.	Components	Quantity
1.	Money received by the farmer for one hectare (₹)	673.9
2.	Total area under activity (ha)	461
3.	Total economic value from land leasing for duck rearing (₹)	3,10,667.90
4.	Estimated economic returns from leasing land for duck rearing (₹)	73,95,378.60

The Government has proposals to develop the inland waterway constructed through the wetland more than a century and a half ago, and further develop the Pullu and Vilangan hills as ecotourism centres.

The investigations revealed that the water sample collected at Karanchira lock is polluted, with a BOD level of 5.82 ppm. HEC-RAS was applied to determine salinity levels in the Enamakkal channel along a stretch from the regulator to assess the structure's performance. TDS was approximately 268 mg/l at the regulator and decreased gradually upstream during high tide, reaching 10 mg/l at 10 km, indicating that the shutters, and especially the temporary barrage, prevent salinity intrusion.

The wetland can store 305.61 Mm^3 of water, assuming an average depth of 3 m under complete submergence. The economic valuation of flood storage function is done using the replacement cost method. The Kol lands provide natural storage, similar to an artificially constructed large tank.

Carbon sequestration is the long-term removal, capture, or storage of carbon dioxide from the atmosphere to prevent or reverse CO_2 emissions and mitigate climate change. The average sequestration rate of tropical wetlands is 1.29 t-C per ha^{-1} $year^{-1}$.

The area under Thrissur Kol lands is 11,936 ha. India's country-level social cost of carbon emission was estimated to be the highest at $86 per ton of CO_2. One ton of carbon equals 3.67 tonnes of carbon dioxide. Overall, the amount of carbon sequestered in the Kol lands is approximately 15,397 tonnes.

The presence of freshwater at the periphery of the wetland essentially maintains the groundwater table, as 70% of households rely on it for domestic use. According to the reports, the water levels in the representative sample wells averaged 6.32 m over the 12 years from 1996 to 2007. Although water consumption has increased substantially in recent years, with an average population density of over 1000/km^2, the groundwater level has remained essentially unchanged. This can be attributed to the wetland's groundwater recharge function. The GALDIT Index was applied to assess salinity levels in the wells located on the periphery of the wetland. Large areas in the Puzhakkal, Irinjalakuda, and Vellangalur Blocks are classified as 'highly vulnerable', as also the east of Anthikkad and west of Cherpu Blocks.

The biodiversity of this Ramsar site co-exists with its other ecosystem services. If farming in this wetland ceases, it could be filled and used for other ecosystem services. If farming in this wetland ceases, it could be filled and used for other commercial purposes, as in areas near urban conglomerations on the periphery of the Kol. The Kol is among the highest-ranked Indian wetlands in terms of bird numbers. The wetland is located in the Central Asian Flyway, and several long-distance migrants are found here. There has been a decline in the bird population over the past five years. As per the 2021 IUCN status, the steppe eagle found in this wetland is classified as an 'Endangered'(EN) species, and the greater spotted eagle as 'Vulnerable' (VU). The status of the river tern observed in the Kol moved from 'Near Threatened' (NT) to 'Vulnerable' (VU). The black-capped kingfisher population has drastically decreased, moving from 'Least Concern' (LC) to 'Vulnerable' (VU). The black-billed tern found in the wetland is classified as 'Endangered' (EN) as of 2021. Studies highlight that 66 species of indigenous fish have been identified in the wetland. According to IUCN, *Hypselobarbus curmuca* found in this wetland is classified as 'Endangered (EN), *Horabagrus brachysoma* and *Carinotetraodon travancoricus* as 'Vulnerable', and *Wallago attu*, *Clarias dussumieri* and *Mystus malabaricus* as 'Near-Threatened '. Around 20 species migrate from the sea through the estuary for a short time. Small fish with a maximum length of 3 cm, such as

Horadandia brittani and *Horacichthys setnai*, are also found in this wetland. Mangroves, or kandal kaadukal, as locally known, are available at the mouths where the wetland has free communication with the sea; at Chettuva mouth, an area of 2.025 ha is covered by the mangroves (Figure 3). The mangroves in these patches were predominantly *Rhizophora mucronata* and *Bruguiera cylindrica*, the other species found in the wetland are *Avicennia officinalis, Excoecaria agallocha*, and *Aegiceras corniculatum*.

Studies show that mangroves can store more carbon than tropical forests, helping sequester carbon to combat climate change. Carbon stocks in the Chettuva mangroves have been estimated as 569.3 t C per ha. These carbon stocks were equivalent to 2,089.33 t CO_2 per ha.

The soil samples collected from Mangrove areas in Chettuva, as part of the present study, show that the percentage of Organic Carbon ranges from 1.06% to 2.35%. It indicates the role of mangroves as carbon sinks.

The management action plan

A management action plan was drafted for the Kol wetland, situated in the humid tropical southwest coast of India, considering the current hydroecology and livelihood status, as well as projected scenarios, particularly in light of climate change. The drivers of change, indicators, and the management action plan are shown in Figure 18. The Ramsar guidelines, which recommend a diagnostic approach based on a critical evaluation of ecological, economic, and socio-cultural features to identify objectives and operational limits, including factors for effective restoration and management of the wetland ecosystem, have been followed in drafting the management action plan.

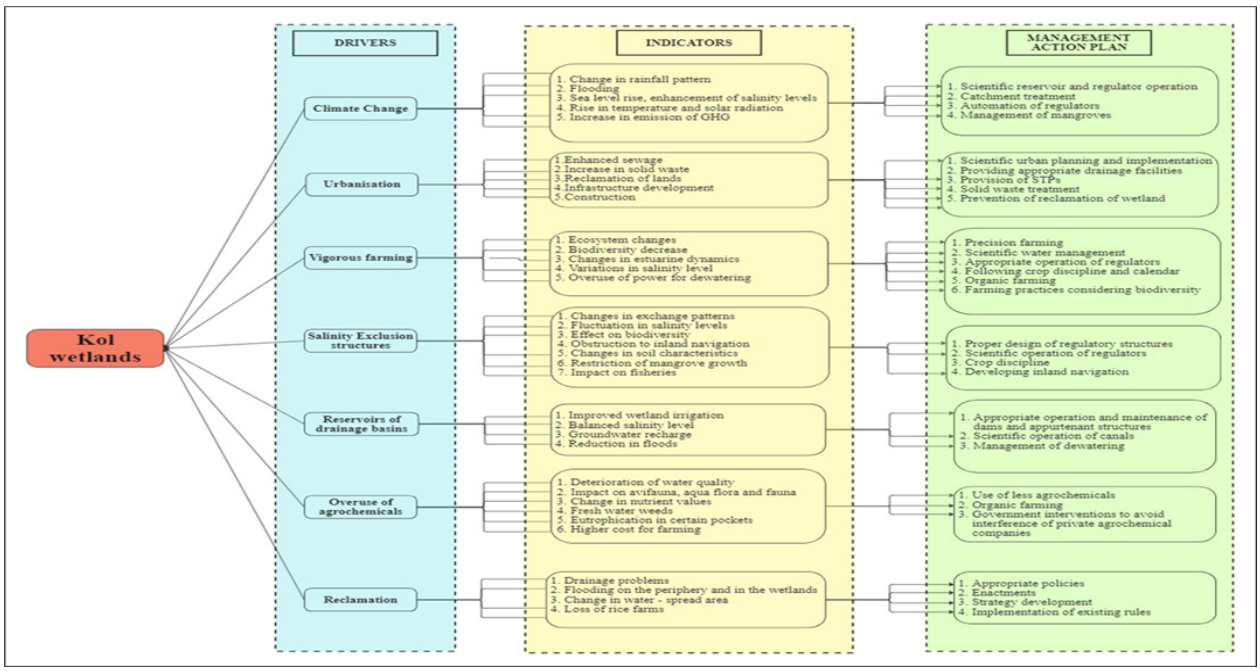


Fig. 18 | The drivers of change, indicators, and management action plan

TECHNICAL NOTE

Development of Monitoring and Evaluation Framework for Impact Assessment of Rejuvenated Wetlands



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Wetlands play a significant role in maintaining water security of a region, particularly in areas where water scarcity is a major issue. In the last two decades or so wetlands have degraded and several being lost to unplanned urbanisation and infrastructure development. Realising this major ecological loss, the government came into action to revive and rejuvenate wetlands. Since several government programmes and schemes are now linked with the revival and rejuvenation of wetlands, there is a need to establish a monitoring and evaluation (M&E) framework and the standard operating procedure (SOP) to assess the impacts of management interventions. The M&E framework effectively captures the progress towards numerous targets achieved and the deviations made. This forms a critical learning step which further strengthens the SOP guidelines for future development and changes while documenting procedures and accomplishments.

Monitoring and Evaluation (M&E) Framework for impact assessment of rejuvenated wetlands

Uttar Pradesh is a large and diverse state with varying geographical, climatic and socio-economic conditions. Different regions of the state face unique challenges and opportunities concerning wetlands rejuvenation. Thus, an assessment framework in place would help guide and tailor interventions to suit specific situations. Collectively, the framework will function as a robust decision-support tool, enabling systematic monitoring of ecosystem performance, identification of gaps, and evidence-based planning for sustainable wetland management.

The Monitoring and Evaluation (M&E) Framework presented below provides a comprehensive, indicator-based assessment matrix to evaluate the full

spectrum of ecosystem services delivered by a wetland. Structured around six major service categories—Cultural, Supporting, Regulating, Provisioning, and Socio-Economic services—the framework assigns a total weight of 100 points, ensuring balanced representation of ecological, social, and economic values. Each service category is further broken down into parameters, indicators, and measurable success criteria, allowing both qualitative and quantitative evaluation. Performance is assessed using a standardized four-tier scoring system (High, Medium, Low, Absent), with clearly defined assigned and assessed values to ensure objectivity and comparability over time.

Cultural services capture spiritual, educational, recreational, tourism, and aesthetic benefits through indicators such as religious significance, educational visits, volunteer engagement, tourism infrastructure, and scenic appreciation. Supporting services emphasize biodiversity, soil formation, nutrient cycling, and food web support, focusing on species diversity, habitat quality, soil health, and ecological resilience. Regulating services assess climate moderation, hydrological regulation, erosion control, flood mitigation, and biological regulation using indicators related to groundwater recharge, water quality, sediment retention, and hazard reduction. Provisioning services quantify tangible outputs such as food production, freshwater availability, fuel and fiber resources, biochemical products, and genetic materials. Finally, socio-economic services evaluate community participation, policy support, and livelihood enhancement through indicators linked to governance, economic empowerment, and social inclusion.



Fig.1 | A comprehensive classification of wetlands ecosystem services and associated parameters

Table | A indicator-based assessment matrix to evaluate the full spectrum of ecosystem services delivered by a wetland

M&E (Assessment Matrix)				Total Value	Assigned Value				Assessed Value
Services	Parameters	Indicator	Measurement of success		High	Medium	Low	Absent	Score
Cultural, Educational and Recreational services: 15	Spiritual & Religious: 3	Personal feelings and well-being :1	Books, paintings etc., using ecosystems as inspiration	1	1.00	0.5	0.25	0	
		Religious significance:2	People attach religious significance to ecosystems	1	1.00	0.5	0.25	0	
			Existing cultural activities within waterbodies	1	1.00	0.5	0.25	0	
	Educational and outreach:4	Opportunities for formal and informal education and training :4	Educational visits	2	2.00	1	0.5	0	
			Visitor in core sites in the waterbody	1	1.00	0.5	0.25	0	
			Volunteers engaged in management activities	1	1.00	0.5	0.25	0	
	Recreational & Tourism:6	Opportunities for recreational activities:2	Presence of landscape and wildlife features with stated recreational value	1	1.00	0.5	0.25	0	
			Green cover area	1	1.00	0.5	0.25	0	
		Opportunities for tourism activities:4	Availability of tourism infrastructure including water sports or activities	2	2.00	1	0.5	0	
			Fishing/angling permits issued	1	1.00	0.5	0.25	0	
			People engaging in Picnics, outings and touring, boating or cycling	1	1.00	0.5	0.25	0	
	Aesthetics: 2	Appreciation of natural scenery based on structural diversity, “greenness” tranquility:2	Users of scenic routes/Houses bordering natural areas : Expressed aesthetic value	1	1.00	0.5	0.25	0	
			Presence of landscape features with stated appreciation	1	1.00	0.5	0.25	0	
Supporting Services : 25	Biodiversity 1. Species (Native/ Non-native) 2. Habitat :13	Habitat for residents and transient species:13	Presence/Diversification of locally important plant species	2	2.00	1	0.5	0	
			Presence/Diversification of locally important bird species	1	1.00	0.5	0.25	0	
			Presence/Diversification of locally important aquatic (invertebrae) species	1	1.00	0.5	0.25	0	
			Presence/Diversification of Amphibian populations	1	1.00	0.5	0.25	0	
			Stopover and wintering grounds for birds of international conservation importance	1	1.00	0.5	0.25	0	
			Instances of wild animals using the pond/ wetland	1	1.00	0.5	0.25	0	
			Water body free from invasive plant species and weeds, including native and non-native species	2	2.00	1	0.5	0	

M&E (Assessment Matrix)				Total Value	Assigned Value				Assessed Value
Services	Parameters	Indicator	Measurement of success		High	Medium	Low	Absent	Score
Supporting Services : 25	Biodiversity 1. Species (Native/ Non-native) 2. Habitat :13	Habitat for residents and transient species:13	Level of species rich habitat	1	1.00	0.5	0.25	0	
			Act as breeding grounds and habitat for reptiles/birds/animals	1	1.00	0.5	0.25	0	
			Provide refuge in drought/summer	2	2.00	1	0.5	0	
	Soil Formation :5	Sediment retention and accumulation of organic matter:5	Value of Physio-Chemical Composition of soil	2	2.00	1	0.5	0	
			Denitrification (kg N/ha/y)	2	2.00	1	0.5	0	
			Soil organic carbon	1	1.00	0.5	0.25	0	
	Nutrient Cycling:5	Storage, recycling, processing, and acquisition of nutrients:5	Seasonal regulation of nutrients	5	5.00	2.5	1	0	
	Food Web Support:2	Support for pollinators:2	Key species available: Dragonfly, frogs, bees etc.	2	2.00	1	0.5	0	
Regulating Services :25	Climate Regulation:4	influence local temperature, precipitation, and other climatic processes:3	Temperature variations around the water body	2	2.00	1	0.5	0	
			Humidity variations around the water body	1	1.00	0.5	0.25	0	
	Hydrological regime:13	Groundwater recharge and discharge:12	Quantity of water stored	2	2.00	1	0.5	0	
			Improvement in groundwater level	2	2.00	1	0.5	0	
			Water availability during low flow/rainfall periods	2	2.00	1	0.5	0	
			Improved water quality for surrounding households and downstream uses	2	2.00	1	0.5	0	
			Soil water table	2	2.00	1	0.5	0	
			Status /condition of inflows and outflows	1	1.00	0.5	0.25	0	
			Quantity and quality of inflow and outflow	1	1.00	0.5	0.25	0	
	Erosion Prevention:4	Retention of soils and sediments:4	Soil retained or sediment captured	4	4.00	2	1	0	
Regulating Services :25	Natural hazard regulation: 4	Flood control, storm protection:4	Reduction of flood danger and prevent damage to infrastructure	1	1.00	0.5	0.25	0	
			Annual flood events	1	1.00	0.5	0.25	0	
			Area under vegetated buffer space in Ha.	2	2.00	1	0.5	0	
	Biological regulations:2	Control of pest species:2	Reduction of human diseases	1	1.00	0.5	0.25	0	
			Reduction of livestock pests	1	1.00	0.5	0.25	0	
Provisioning Services:20	Food:4	Production of fish:2	Fish produced	2	2.00	1	0.5	0	

M&E (Assessment Matrix)				Total Value	Assigned Value				Assessed Value
Services	Parameters	Indicator	Measurement of success		High	Medium	Low	Absent	Score
Provisioning Services:20	Food:4	Production of fruits and grains:2	Fruits and grains produced	2	2.00	1	0.5	0	
	Fresh water:8	Storage and supply of water for domestic, industrial, and agricultural use :8	Access to water for livestock	1	1.00	0.5	0.25	0	
			Access of water for irrigation practices	1	1.00	0.5	0.25	0	
			Increase in crop yield (quintal/ha)	1	1.00	0.5	0.25	0	
			Increase in area under cultivation (in ha)	1	1.00	0.5	0.25	0	
			Beneficiaries associated with water supply	1	1.00	0.5	0.25	0	
			Water supply for secondary use	1	1.00	0.5	0.25	0	
			Value of Physio-Chemical properties of water	2	2.00	1	0.5	0	
	Fiber & fuel:4	Production of logs, fuelwood, peat, fodder, aggregates:4	Quantity of timber produced in tons or kg	1	1.00	0.5	0.25	0	
			Area of pastureland in Ha.	1	1.00	0.5	0.25	0	
			Number of cattle dependents on water body	1	1.00	0.5	0.25	0	
			Area of peat land in Ha.	1	1.00	0.5	0.25	0	
	Biochemical Products:2	Extraction of other materials from biota:2	Useful substances, that can be extracted	1	1.00	0.5	0.25	0	
			Availability and/or access to alternatives	1	1.00	0.5	0.25	0	
	Genetic Materials:2	Genes for resistance to plant pathogens; ornamental species, etc.:2	Presence of species with useful genetic material (medicinal value etc)/ 'genebank' value (e.g. number of species and subspecies)	1	1.00	0.5	0.25	0	
			Presence of species with ornamental use	1	1.00	0.5	0.25	0	
Socio-Economic Services: 15	Community partnership and inclusive ownership :6	Social empowerment of community:6	Membership of local organisations linked to the management of wetland	2	2.00	1	0.5	0	
			Stakeholder meeting conducted	2	2.00	1	0.5	0	
			Stakeholders involved decision making	2	2.00	1	0.5	0	
	Policy support: 3	Institutional development :3	New policies (if any)	1	1.00	0.5	0.25	0	
			Changes in existing policies plans and schemes	1	1.00	0.5	0.25	0	
			Feedbacks received from beneficiaries	1	1.00	0.5	0.25	0	
	Livelihood support:6	Economic empowerment of community :6	Resource users	1	1.00	0.5	0.25	0	
			Increase in savings pattern	1	1.00	0.5	0.25	0	
			Potential effects on property value (in/around waterbody)	1	1.00	0.5	0.25	0	

M&E (Assessment Matrix)				Total Value	Assigned Value				Assessed Value
Services	Parameters	Indicator	Measurement of success		High	Medium	Low	Absent	Score
Socio-Economic Services: 15	Livelihood support:6	Economic empowerment of community :6	Reduction in migration pattern	1	1.00	0.5	0.25	0	
			Increase in economic opportunity associated with tourism and recreation	1	1.00	0.5	0.25	0	
			Market and price of ecosystem products	1	1.00	0.5	0.25	0	
Total				100	100	50	25	0	0



Methodology

A pilot study was conducted in 9 districts (Aligarh, Bijnor, Gonda, Jaunpur, Lalitpur, Meerut, Shrawasti, Sitapur and Sonbhadra) across the Gangetic plains in the west and central regions to the Bundelkhand plateau in the south and the eastern alluvial zones of Uttar Pradesh. One rejuvenated pond (Amrit Sarovar) was selected from each zone as a representative site for detailed field assessments. A mixed approach including stakeholder consultations and field visits was adopted to collect data on wetlands condition and the implementation process. Primary data was collected using a pre-designed questionnaire complemented by qualitative techniques to ensure comprehensive insights which were based on M&E Framework.

The different tools adopted for the study are described below:

- **Structured survey and questionnaire:** stakeholder perspectives were assessed on the impact of the rejuvenation of the wetland based on social, economic, ecological, and institutional parameters.
- **Focused group discussion (FGD):** Local perceptions were mapped on the change in wetlands condition, its potential benefits, socio-cultural values and the dependency of local communities.
- **Community mapping:** Key informant interviews were conducted with PRI members, block officials and community institutions to map distribution of water and allied resources, usage patterns and demand-supply dynamics.
- **Data assessment tools - M&E assessment matrix:** Different wetlands ecosystem services were assessed using the matrix, which had been finalised basis a state-level stakeholder workshop involving government officials, academicians, practitioners and major CSR partners.

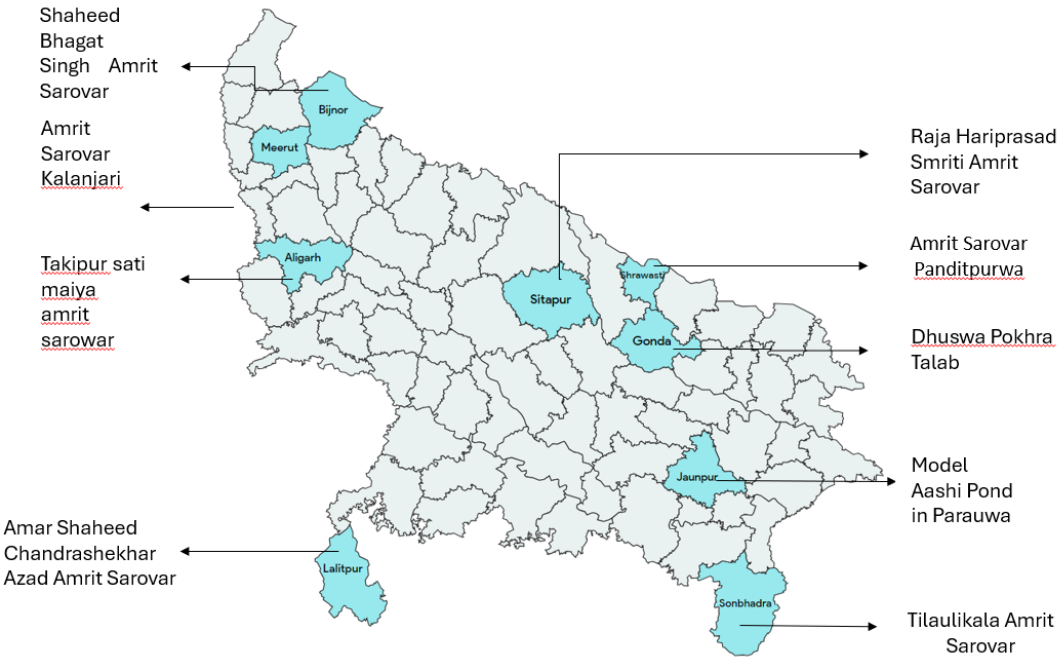


Fig.2 | Spatial distribution of rejuvenated pond (Amrit Sarovar) selected as a representative site for detailed field assessments



Village level consultative meetings were held at the representative sites

Case studies where pilot testing of the M&E Framework was conducted

Taquipur wetland, Aligarh



The wetland was evaluated by the Divisional Forest Officer, Aligarh, and assigned a score of 50, indicating moderate functional performance with evident ecological degradation. Proliferation of invasive vegetation and restricted water circulation have adversely affected the wetland's ability to support biodiversity. While groundwater recharge and seasonal water retention were observed, these hydrological functions are compromised by siltation and poorly designed inflow and outflow structures. Local community members expressed concern over declining fish and bird populations, reflecting ongoing habitat degradation. Additionally, the wetland's cultural and recreational potential remains largely underutilized.

Recommended interventions include the systematic removal of invasive species, reconfiguration of inlet and outlet channels, phased desiltation, and the establishment of bio-fencing to limit human and livestock intrusion. Enhanced inter-departmental coordination, particularly between the Forest department and the Panchayat is also recommended to promote village-level stewardship and sustainable management.

Amheda wetland, Bijnor

The wetland was assessed by the NEER Foundation and assigned a score of 37, identifying it as a degraded wetland. Multiple threats including encroachment, inflow of untreated wastewater, reduction in water spread area,



and heavy sedimentation have severely compromised the wetland's ecosystem services. Biodiversity presence was recorded at the lowest level among all assessed wetlands.

Restoration of this wetland will require intensive management interventions, including boundary demarcation, removal of encroachments, large-scale desiltation, and installation of inlet filtration systems. The development of constructed wetlands for treating surface runoff is also recommended. These technical measures must be complemented by catchment protection, improved sanitation, and strengthened community governance mechanisms. Integrating livelihood-based activities such as plant nurseries

or composting initiatives can further enhance local stewardship. Given its low assessment score, Amheda wetland necessitates a phased yet intensive restoration programme.

Sanjhawal wetland, Gonda



Sanjhawal wetland was assessed by Turtle Survival Alliance and assigned a score of 36 indicating high ecological fragility. Once characterized by rich biodiversity, the wetland now faces severe ecological degradation due to pollution, sedimentation and poor habitat structure. Declining water quality has significantly reduced its hydrological and provisioning functions.

Immediate ecological restoration is critical and should include deep desiltation, habitat enhancement for turtle species (such as creation of nesting areas and basking sites), diversion of wastewater inflows, and establishment of vegetative buffer zones. Strong community participation already exists and can be effectively leveraged for stewardship. Eco-tourism-based livelihood initiatives should be considered only after ecological recovery to avoid additional pressure on the system.

The low assessment score underscores the urgent need for coordinated, multi-stakeholder intervention to ensure the wetland's long-term sustainability.

Parauwa wetland, Jaunpur



Parauwa wetland was assessed by Development Alternatives and was assigned a score of 65, indicating a strong potential for achieving full ecological restoration. The wetland exhibits hydrological functioning, water storage capacity and moderate provisioning services, including livestock use and limited irrigation. Supporting ecosystem services were recorded to be relatively strong and reflected in the occurrence of native biodiversity. Community focus group discussions (FGDs) revealed high levels of local engagement and a strong willingness to participate in rejuvenation and plantation initiatives.

Recommended management interventions include targeted desiltation, installation of inlet filtration structures, improved runoff management, and the establishment of community-based monitoring systems. Integrating livelihood options

such as fisheries or eco-tourism can further enhance socio-economic benefits. Institutional and governance aspects require further strengthening, as current management practices remain largely informal.

Gevragundera wetland, Lalitpur



Gevragundera wetland was assessed by Development Alternatives and assigned a score of 44, indicating significant ecological stress. The assessment identified key threats, such as; extensive siltation, reduced water retention capacity and low biodiversity. Hydrological and provisioning services were recorded poor and existing inflow–outflow structures are in degraded condition. Community response suggested declining dependence on the wetland due to its degrading condition.

Recommended management interventions should adopt a catchment-wide approach, encompassing soil and water conservation measures, deep desiltation, repair of bunds, establishment of vegetative buffer zones, and regulation of livestock grazing. In parallel, socio-economic measures such as capacity-building, training programs, and the formation of user groups can enhance long-term management, community ownership, and ecological stewardship.

Kalanjari wetland, Meerut



Kalanjari wetland was assessed by the NEER Foundation and assigned a score of 53, indicating a functional yet vulnerable ecosystem. The assessment found that hydrological stability is compromised by siltation and inefficient drainage channels, leading to reduced water retention and negatively affecting both regulating and provisioning services. Cultural services remain moderately strong, driven by community interest in awareness and outreach activities. Occurrence of aquatic biodiversity is limited. Key threats include wastewater inflows, agricultural runoff and water stagnation during dry periods, all of which contribute to declining water quality. Focus group discussions revealed strong interest among youth and school groups in participating in restoration efforts, providing valuable social support.

Recommended interventions include catchment treatment measures, establishment of vegetative buffer strips, installation of sediment traps and improved drainage system. The introduction of community-led monitoring systems and livelihood-oriented initiatives can substantially enhance the wetland's ecological condition and long-term resilience.

Ahladnagar wetland, Shrawasti



Ahladnagar Wetland was assessed by the Gorakhpur Environmental Action Group and assigned a score of 46, indicating significant stress on key ecosystem services, particularly provisioning, supporting and regulatory. Encroachment and a reduction in water spread emerged as major concerns during community consultations. Seasonal deterioration in water quality has further contributed to low regulating services.

Recommended interventions include clear demarcation and protection of wetland boundary, desiltation, improved inlet management and catchment protection through plantation activities. Establishing monitoring committees and integrating livelihood options such as fisheries and nursery development

can strengthen community ownership and stewardship. A comprehensive, integrated intervention approach can help reverse the ecological decline reflected in the wetland's mid-to-low assessment score.

Bermi wetland, Sitapur



Bermi wetland was assessed by the Vashudha Foundation and assigned a score of 59, reflecting strong structural stability and overall functional value. Provisioning services, including fisheries and water availability for livestock remain largely intact. Hydrological and regulating services are moderately effective; however, seasonal deterioration in water quality due to monsoon runoff continues to pose a concern. Additional challenges include the proliferation of invasive weeds and a decline in biodiversity.

Recommended management priorities include shoreline stabilization, reconfiguration of inlet and outlet structures, periodic desiltation and the implementation of nature-based solutions such as buffer plantations. Strengthening governance through the formation of formal village-level committees and the adoption of data-driven monitoring systems can significantly improve both the socio-economic and ecological performance of the wetland.

Tilauli wetland, Sonbhadra



Tilauli wetland was assessed by Development Alternatives and assigned a score of 52, indicating moderate performance. It was recorded that while the wetland remains in acceptable physical condition its ecological functioning has weakened. Seasonal hydrological fluctuations have reduced groundwater recharge potential and siltation has diminished overall storage capacity. Biodiversity and provisioning services are low, evidenced by reduced fish populations and limited irrigation support. Embankment erosion and increased turbidity during the monsoon were key concerns raised during focus group discussions. Socio-economic indicators further pointed to limited formal community engagement and the absence of structured, community-led management.

Restoration priorities include deep desiltation, embankment stabilization and the establishment of vegetative buffer zones to reduce sediment inflow.

The formation of community committees, promotion of managed fisheries, and periodic monitoring can strengthen socio-economic outcomes and long-term stewardship.

Conclusion

The assessment of rejuvenated wetlands across the diverse agro-climatic zones of Uttar Pradesh demonstrates that, while rejuvenation initiatives have generated positive ecological, hydrological, and socio-economic outcomes, their benefits remain uneven and highly site-specific. Performance variations ranging from high-performing wetlands such as Parauwa (Score = 65) to severely stressed wetland ecosystems like Sanjhawal (Score = 36) underscore the decisive influence of catchment conditions, governance effectiveness, encroachment pressures, community ownership and the effectiveness of management interventions. The pilot Monitoring and Evaluation (M&E) Framework has proven effective in capturing the multidimensional performance of wetlands by integrating hydrological regulation, biodiversity support, provisioning services, and socio-economic indicators. Community feedback through FGDs and surveys further confirms that long-term sustainability depends not only on engineering interventions but also on inclusive governance structures, livelihood integration, and catchment-scale planning. Persistent challenges such as siltation, wastewater inflow, invasive species, weak biodiversity recovery, degraded inlet–outlet structures, seasonal water fluctuations, and the absence of formal management institutions continue to undermine ecological resilience. Addressing these challenges requires a strategic, multi-level approach that institutionalizes the M&E Framework across implementing departments and schemes, strengthens catchment-level planning through soil and water conservation measures which advances the ecological restoration of these critical ecosystems. Formalizing community governance through village-level waterbody management committees, building local capacities, and linking rejuvenation efforts with sustainable livelihoods are critical to reinforcing stewardship and socio-economic value. Complementary engineering improvements, standardized maintenance protocols, and cross-departmental policy convergence are equally essential to ensure long-term functionality and accountability. Collectively, the findings establish a strong evidence base for scaling the M&E Framework across Uttar Pradesh and eventually at the national level guiding policy reforms toward integrated, resilient and community-managed wetlands capable of delivering sustained ecological and developmental benefits.

TECHNICAL NOTE

Mapping India's Hidden Carbon Stores

A Journey Across Peatlands



SHIVANI NEGI

Technical Officer



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Peatlands occupy only a small fraction of the Earth's surface, but they quietly hold one of the planet's largest carbon reserves. Covering just 3-4% of global land area, these waterlogged ecosystems store nearly one-third of the world's soil carbon, regulate water flows, and support unique biodiversity. In India, knowledge of peatland ecosystems has remained fragmented, largely derived from isolated studies, site-specific reports, and coarse-resolution global datasets that produce widely varying estimates. In the absence of systematic and nationally consistent documentation, peatlands were often misclassified as other wetland types or grasslands, leading to their omission from climate action initiatives, wetland management frameworks, and land-use planning processes. Although global assessments such as the Global Peatlands Assessment (GPA), Xu et al. (2018), FAO (2020), and Melton et al. (2022) have provided indicative estimates, they do not offer a clear, spatially explicit, or context-specific picture of peatland distribution in India, resulting in persistent uncertainties regarding their national extent, condition, and ecological significance.

Recognising this critical gap, Wetlands International South Asia (WISA), in collaboration with partners Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and the Ministry of Environment, Forest and Climate Change (MoEFCC), undertook a nationwide effort to understand where peatlands occur in India, how extensive they are, and what condition they are in. The work marks an important step towards building a baseline peatland inventory across India's diverse biogeographic zones - the Himalaya, Trans-Himalaya, North-East, and Western Ghats.

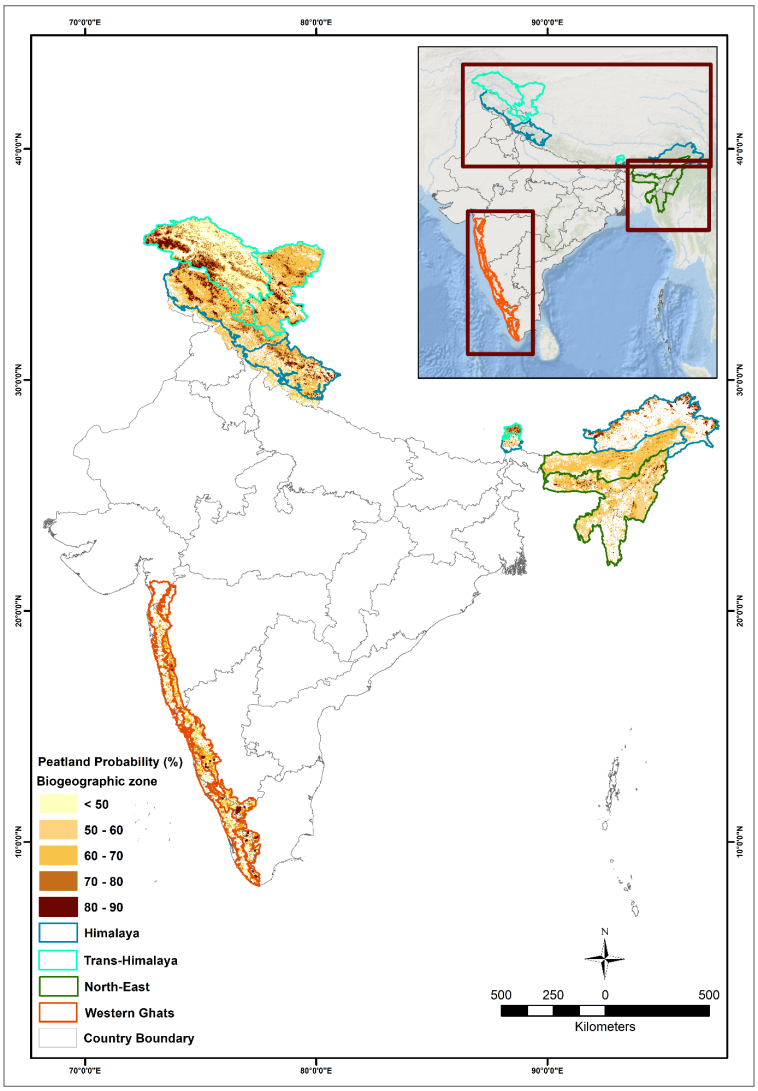
From scattered knowledge to a national picture

The journey from scattered knowledge to a national picture began with a phased approach, beginning with a comprehensive review of peatland occurrence and key environmental variables to understand the conditions under which peatlands are likely to

form. This informed the selection of indicators related to water, vegetation, soil, topography, and climate that collectively influence peat accumulation. Using these indicators, peatland probability maps were developed through geospatial analysis. Rather than identifying peatlands outright, these maps highlight locations where peats are most likely to occur. The analysis identified probable peatland areas across the biogeographic zones, covering approximately 280,000 ha. These maps then guided field surveys, ensuring that ground assessments were focused, efficient, and representative of India's varied environments.

Ground-truthing across biogeographic zones

Ground-truthing across biogeographic zones played a central role in refining the maps and improving understanding of peatland conditions on the ground. Surveys were conducted across a wide elevation range from low-lying wetlands to high-altitude systems approximately 5,000 metres above mean sea level covering various biogeographic zones. Field assessments were carried out at 83 locations across 11 states and union territories within the four biogeographic zones across different seasons to capture variability in hydrology, vegetation, and soil characteristics.



Peatland probability map of India

Carbon stores beneath our feet

In the Himalaya and Trans-Himalaya, peatlands are most commonly associated with high-altitude wetlands, alpine marshes, and valley bottoms, where cold temperatures and persistent waterlogging slow the decomposition of organic matter.

This region exhibits the highest per-hectare carbon stocks from the top 1 m of soil (median: 92.5 t/ha), approximately 1.5 times higher than the Trans-Himalayas (62.27 t/ha). Field assessments confirmed shallow to deep peat deposits with soil organic carbon (SOC) values ranging from 11% to over 40%. Key peatland sites include Khecheopalri, Tso Kar,

Hanle and Chushul marshes, Chandertal, Miyar Valley, and western Himalayan wetlands such as Hokersar, Mirgund, and Saat Tal. These peatland systems are typically dominated by mosses and sedges, forming continuous organic layers indicative of sustained peat accumulation.

In the Northeast region, peat occurrence exhibited considerable spatial variability. Peatland sites in the Northeast were lower than those observed in the Himalayan region. They were primarily identified in high-elevation meadows and valley systems such as the Jowai meadows and Dzukou Valley, where shallow peat layers (~30 cm) with soil organic carbon (SOC) values ranging from 6% to 27% were recorded. In contrast, the Loktak Lake system presented a distinct peat-forming environment, where floating phumdi deposits consisted of dense, fibrous organic material indicative of peat formation under unique hydrological and ecological processes, with SOC values ranging from 10% to 44% (~2 m). Conversely, riverine floodplains across the region were largely devoid of surface peat due to frequent sediment deposition and highly dynamic hydrological regimes.

In the Western Ghats, peatland occurrences were carried out across wet montane grasslands, forested wetlands, and swamp systems. While these locations initially appeared favourable for peat formation, field investigations revealed a more nuanced pattern. Surveys across Shola grasslands and associated wetlands (Vayals) in Devikulam, Uthiran Chira, Idukki, Palakkad, Wayanad, Myristica swamps in Kulathupuzha and Shendurney were characterized by shallow, patchy organic layers confined to the upper 30 cm of soil, with soils largely mineral-rich despite elevated organic content and SOC values ranging from 8% to 20%. These sites recorded the lowest soil organic carbon among the assessed regions indicating environments that support organic matter accumulation but do not sustain long-term peat formation, potentially due to hydrological constraints or degradation.

Learning, refining, and looking ahead

Across all regions, field observations also highlighted common pressures such as altered water regimes from drainage and abstraction, grazing in high-altitude rangelands, and disturbances from dredging, tourism, and land-use change. These pressures underscore the need to recognise peatlands not only as carbon stores but as living ecosystems dependent on intact hydrological and ecological processes. Overall, results from the integrated mapping and field assessments suggest that peatlands constitute a small but ecologically significant fraction of India's geographical area, particularly in mid- and high-altitude regions where climatic and



Peatland field assessment locations (Clockwise: **Mirgund** (Jammu & Kashmir), **Tso kar wetland** (Ladakh), **Dzukou Valley** (Nagaland), **Chandertal** (Himachal Pradesh), **Loktak Lake** (Manipur), **Khedatal** (Uttarakhand), **Sattal** (Uttarakhand), **Khecheopalri** (Sikkim))

hydrological conditions favour peat formation. By linking geospatial analysis with ground observations, the work provides a clearer picture of peatland occurrence, their ecological characteristics, and priority areas for conservation and monitoring. As mapping expands to underexplored regions, this growing evidence lays the foundation for integrating peatlands into climate action, wetland management, and long-term sustainability planning.

TECHNICAL NOTE

Recognising Wetlands as OECMs

Unlocking their Conservation Potential in India



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ARGHYA CHAKRABARTY

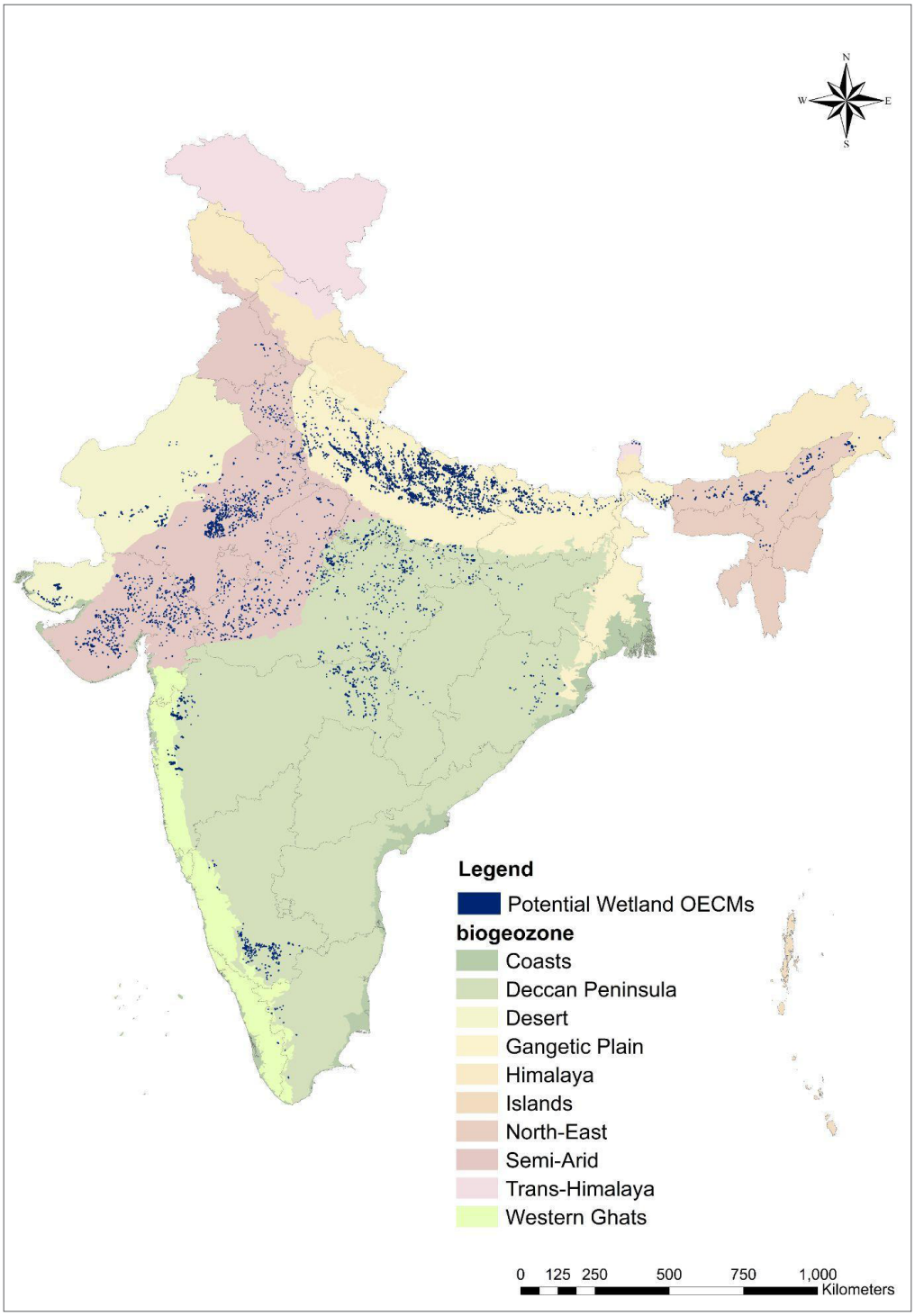
Technical Officer
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India's commitment to the Kunming–Montreal Global Biodiversity Framework, particularly the 30×30 target, has drawn renewed attention to conservation beyond formally designated protected areas. These areas have long anchored biodiversity conservation in India, especially a considerable number of ecologically significant wetlands beyond formal protection boundaries. Recognising wetlands as OECMs (Other Effective Area-based Conservation Measures) helps address this gap in a manner that is both policy-consistent and adaptable to diverse governance contexts.

Unprotected wetlands and conservation opportunity

National-scale spatial analysis shows that 130,630 wetlands, accounting for nearly 72% of India's mapped wetlands, lie outside protected areas, covering approximately 2.76 million ha. Within this unprotected extent, around 6,000 wetlands spanning about 677,500 ha emerges as high-priority OECM candidates based on high beta richness values, indicating strong species turnover and landscape-level biodiversity importance.

These OECM wetlands are unevenly distributed across the country. The Deccan Plateau, Gangetic Plains, and semi-arid regions together account for the largest number and area of high-priority sites, highlighting conservation opportunities in landscapes that remain under-represented within India's protected area (PA) network. Crucially, these wetlands are not isolated islands; they are the vital connective tissue of India's landscape. The spatial analysis revealed that 751 of these wetlands are located within one kilometre of existing PAs, thereby serving as immediate buffers. Further out, 1,295 wetlands are located within two kilometres of PAs, serving as essential corridors that facilitate species movement and genetic flow across fragmented landscapes. These findings reinforce that wetland conservation outcomes are inherently landscape-scale and cannot be secured through isolated site-based protection alone.



Potential wetland OECMs across India, showing high beta-richness wetlands outside the protected areas



Foxnut (*makhana*) harvesting by local community members from a candidate wetland OECM in Uttar Pradesh, reflecting traditional livelihoods sustained through wise use of wetland resources / Arghya Chakrabarty

OECMs as a policy instrument for wetlands

The OECM framework considers how areas are managed and what conservation outcomes they deliver, rather than their legal designation. Many wetlands in India are governed by local bodies and community institutions, where biodiversity is maintained through customary use and regular management.

Recognising these wetlands as OECMs helps bring such areas into national conservation accounting, even though they fall outside PAs. For wetlands, this is especially pertinent given mounting pressures from pollution, altered hydrology, invasive species, and land-use change.

Anchoring wetland OECMs within NPCA

From an implementation perspective, the National Plan for Conservation of Aquatic Ecosystems (NPCA) offers a strong institutional anchor for operationalising wetland OECMs. The scheme's emphasis on Integrated Management Plans, Framework Management Plans, Wetland Health Cards, and periodic monitoring aligns closely with OECM requirements related to governance continuity, biodiversity outcomes, and ecosystem services.

NPCA's provisions for funding convergence with allied schemes further enhance its relevance for multi-use landscapes. However, current guidelines under-emphasise community institutions and customary



Kewana Wetland, a candidate wetland OECM in Unnao district of Uttar Pradesh, situated within two kilometres of Shahid Chandra Shekhar Azad Bird Sanctuary / Nikita Mishra

governance systems, which play a central role in managing many potential wetland OECMs. Strengthening their formal recognition and integrating locally grounded monitoring practices would significantly improve the credibility and inclusiveness of wetland OECM implementation.

Closing perspective

OECMs should be seen as complementary to PAs rather than as an alternative. They provide a means to account for conservation outcomes in wetlands located within human-dominated landscapes and governed through diverse local arrangements.

TECHNICAL NOTE

Wetlands Traditional Knowledge and Cultural Heritage in the Hindu Kush Himalaya



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The Hindu Kush Himalaya: Water Towers Shaped by Culture

Wetlands cover approximately 10% of the Hindu Kush Himalaya (HKH), a region often described as the “Water Tower of Asia” and the “Third Pole.” Stretching across eight countries, the HKH contains the largest volume of ice and snow outside the Arctic and Antarctic and gives rise to ten major Asian river systems, including the Amu Darya, Indus, Ganges, Brahmaputra, and Yangtze. These rivers sustain the food, energy, and water security of nearly 1.4 billion people downstream. Yet the importance of HKH wetlands extends far beyond hydrology. High-altitude lakes, marshes, peatlands, and floodplains located above 3,000 metres regulate seasonal water flows, store significant amounts of carbon, buffer floods and droughts, and provide habitat for globally significant biodiversity. Equally important but often overlooked are the cultural, spiritual, and knowledge systems that have evolved around these wetlands. For centuries, mountain communities have understood wetlands not as extractive resources, but as living landscapes imbued with spiritual significance. Many wetlands are believed to be abodes of deities, ancestral spirits, or protective beings. Across the HKH, several iconic wetlands illustrate how spiritual values have long shaped conservation outcomes. Lake Manasarovar, revered in Hindu, Buddhist, Jain, and Bon traditions, is believed to be the abode of Lord Shiva and Goddess Parvati, with ritual bathing and circumambulation practices reinforcing strict norms against pollution and overuse. In Nepal, the Gokyo Lakes are considered sacred by Sherpa communities, where belief in protective deities, ritual calendars, and community taboos regulate access and resource use, contributing to the long-term protection of this fragile alpine wetland system. Through taboos, rituals, pilgrimage cycles, grazing calendars, and customary



Sacred lake Manasarovar, located in Ngari Prefecture in Tibetan Autonomous Region, China / Jitendra Bajracharya

laws, these belief systems have governed access, use, and stewardship of wetlands, often achieving conservation outcomes long before the emergence of formal environmental policies. However, such cultural dimensions remain largely overlooked in contemporary wetland governance, conservation planning, and climate adaptation strategies. As climate change accelerates glacier melt, alters hydrological regimes, and intensifies pressures from infrastructure development and tourism, these cultural frameworks offer essential lessons for resilient, inclusive, and ethical wetland stewardship.

Wetlands as sacred landscapes

Across the HKH, wetlands are closely linked to local beliefs that guide how people should behave. Many communities see lakes as sacred places that can reward people or punish communities depending on how respectfully they are treated. Such beliefs have translated into strong norms against pollution, overuse, and ecological disrespect. Traditional ecological knowledge (TEK) operates through practice rather than prescription. Instead of written regulations, communities rely on oral histories, seasonal observations, ritual calendars, and social sanctions. Grazing is restricted during sensitive periods, access is limited to pilgrims at specific times, and extraction is governed by restraint rather than maximisation. These systems are not static relics of the past. They are adaptive, context-specific, and deeply embedded in livelihoods particularly pastoral and agro-pastoral systems that depend on the health of alpine wetlands for fodder, water, and climate regulation.

In the Indian Himalaya, especially in Ladakh and Himachal Pradesh, high-altitude wetlands are inseparable from Buddhist and Hindu belief systems and nomadic pastoral livelihoods. Tso Moriri and Tso Kar are valued by Changpa pastoralists as sacred lakes. These wetlands are also critical breeding grounds for the black-necked crane (*Grus nigricollis*), locally known as Cha thung thung, regarded as a symbol of good fortune and spiritual purity. The bird features prominently in monastery murals and local folklore, reinforcing protective attitudes toward wetland habitats. Local belief systems strongly discourage pollution, loud behaviour, and disrespect near these lakes. Seasonal grazing calendars developed through generations of ecological observation regulate herd movements to prevent trampling and overgrazing during ecologically sensitive periods.

In practice, these customs function as de facto conservation mechanisms. Similarly, Chandra Taal, in Spiti valley, Himachal Pradesh is embedded in Hindu mythology, particularly narratives from the Mahabharata. It is believed to be the site where Yudhishthira ascended to heaven, taken by Lord Indra after the Pandavas' final journey. Local legends describe fairies visiting the lake at night, and cultural taboos strictly prohibit polluting its waters. Even as tourism increases, these beliefs continue to regulate behaviour and reinforce restraint. Deoria Tal, also called Devariya Tal, in Garhwal Himalaya is believed to be a sacred lake. In Hindu mythology, the lake is regarded as "Indra Sarovar," associating it with Indra, the god of heaven. Fishing is strictly forbidden due to a strong taboo that violators will suffer from leprosy, and such mythological beliefs, practices, and ethnomedicinal values play an important role in preserving traditional beliefs and local biodiversity. Parvati Sarovar, located at the base of Adi Kailash in India, is regarded by locals as comparable in sanctity to Manasarovar Lake in Tibet. According to Hindu mythology and local belief, Goddess Parvati, consort of Lord Shiva, is believed to have bathed in this sacred lake, giving it the name Parvati Kund or Parvati Sarovar. The water of Parvati Sarovar is believed to possess divine healing properties that purify the mind, body, and soul.

Nepal's high-altitude wetlands are among the most culturally valued in the HKH, holding profound significance for Hindu, Buddhist, and Bon traditions. Gosaikunda is sacred to Lord Shiva and deeply embedded in Hindu cosmology. Ancient scriptures such as the Bhagawat Purana and Vishnu Purana, as well as epics like the Ramayana and Mahabharata, link the lake's origin to the myth of Samudra Manthan (the churning of the cosmic ocean). Thousands of pilgrims visit Gosaikunda during Janai Purnima and Gangadashahara, following strict ritual calendars that limit access to specific periods and reinforce water purity norms. Parbatikunda is believed to be a creation of Shiva (God) for the Parbati (Goddess) and considered a sacred place where a large number of Hindu and Buddhists of nearby places visit and take a holy bath and rituals during Janai Purnia (Full Moon) festival. Panch Pokhari in Sindhupalchowk district is a spiritually important site for local communities and visitors, drawing thousands of pilgrims each year during the Janai Purnima festival in mid-August for ritual bathing and worship of Lord Shiva, as well as many devotees during the Dasahara celebration in March or April. The area's rich cultural heritage is shaped by the Tamang community, whose traditional dances, weaving practices, and distinctive way of life add to the unique cultural identity of Panch Pokhari. Dudhpokhari pond, is a site of religious significance in the



Parvati Kunda in Rasuwa district of Nepal - people visit during Janai Purnia (Full Moon) festival for holy bath / Srijana Joshi

western part of Lamjung district, it attracts hundreds of visitors on the day of Janai Purnima. It is believed that taking a dip in the ponds will relieve one of all his/her sins. The Gokyo lakes are believed to be the abode of Naag Devata (serpent deities). Sherpa and Tibetan Buddhist communities speak of powerful Lake Gods and a guardian goddess, Gokyo Ma, who rewards respectful travellers and punishes those who harm the land. Shamans and Lamas perform rituals here before major festivals, and the freezing waters are believed to have healing powers. Shey Phoksundo Lake in Dolpa is protected by Bon and Buddhist taboos that prohibit fishing and pollution, while Rara Lake remains central to local spiritual geography. Across Nepal, social sanctions against contamination continue to shape stewardship, even where formal enforcement is limited.

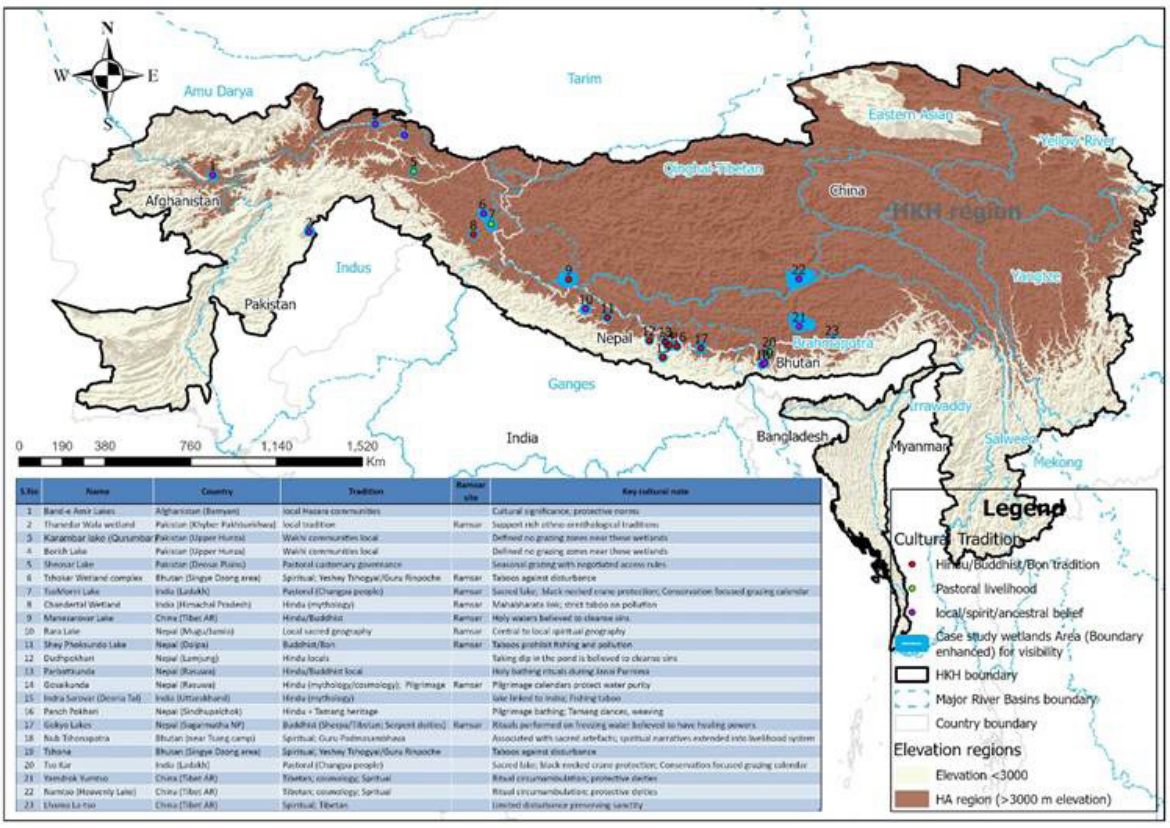
Across the Tibetan Plateau, lakes play a central role in cosmology and spiritual life. They are not seen simply as bodies of water, but as sacred places inhabited by deities and shaped by centuries of belief, ritual, and reverence. Namtso, often called the “Heavenly Lake,” and Yamdrok Yumtso are closely linked to protective deities. Pilgrims walk around these lakes in a ritual known as kora, a form of circumambulation believed to bring spiritual merit and protection. Lhamo La-tso is especially sacred, known as an oracle lake where spiritual visions are sought. Access to these lakes is carefully regulated through strict ritual rules. These protocols guide how and when people may visit, helping to reduce disturbance while preserving the spiritual purity and sanctity of the sites. Further west, Lake Mansarovar holds deep importance for pilgrims from several faiths. Its waters are believed to cleanse sins and purify the soul, making the lake a strong moral and spiritual anchor in the region. In contrast, Rakshastal, also known as the “Lake of the Demon,” is surrounded by very different meanings. The lake is salty, with barren and lifeless shores, and is linked to myths of darkness and evil. Unlike the pure stories associated with Mansarovar, Rakshastal represents a symbolic opposite, highlighting how spiritual beliefs shape the

understanding of landscapes across the Tibetan Plateau.

In Bhutan, high-altitude wetlands are widely considered sacred and closely aligned with the national philosophy of Gross National Happiness, which emphasises harmony between spiritual wellbeing and nature. Tshokar and Tshona are believed to be offerings made by Dakini Yeshey Tshogyal to Guru Rimpoche during meditation at Singye Dzong. These lakes are thought to contain hidden spiritual treasures (rinchen terma), reinforcing strong taboos against disturbance. Nub Tshonapatra is associated with Guru Padmasambhava and the revelation of sacred artefacts. Local legends link the lake to the origin of Nublang cattle, illustrating how spiritual narratives extend into livelihood systems.

In northern Pakistan, particularly in Gilgit-Baltistan, high-altitude wetlands are closely linked to transhumant pastoral systems. The Deosai Plains, including Sheosar Lake, support seasonal grazing governed by customary rules and negotiated access rights. Wakhi communities in Upper Hunza maintain community defined no grazing zones near sensitive wetlands like the Borith Lake and Karambar lake, demonstrating adaptive local governance that balances biodiversity conservation with livelihoods. In Khyber Pakhtunkhwa, wetlands also support rich ethno-ornithological traditions, where waterbirds are used in cultural practices and traditional medicine highlighting both knowledge richness and emerging conservation challenges.

The Band-e-Amir Lakes are the series of six deep blue lake wetland in Afghanistan's first National Park. They are considered sacred by local Hazara



S.No	Name	Country	Tradition	Ramsar site	Key cultural note
1	Band-e Amir Lakes	Afghanistan (Bamyan)	local Hazara communities		Cultural significance, protective norms
2	Thandar Wula wetland	Pakistan (Khyber Pakhtunkhwa)	local tradition	Ramsar	Support rich ethno-ornithological traditions
3	Karambar lake (Qurumbar)	Pakistan (Upper Hunza)	Wakhi communities local		Defined no grazing zones near these wetlands
4	Borith Lake	Pakistan (Upper Hunza)	Wakhi communities local		Defined no grazing zones near these wetlands
5	Sheosar Lake	Pakistan (Deosai Plains)	Pastoral customary governance		Seasonal grazing with negotiated access rules
6	Tshokar Wetland complex	Bhutan (Singye Dzong area)	Spiritual; Yeshey Tshogyal/Guru Rinpoche	Ramsar	Taboos against disturbance
7	Tso/Moriri Lake	India (Ladakh)	Pastoral (Changpa people)	Ramsar	Sacred lake; Black necked crane protection; Conservation focused grazing calendar
8	Chandertal Wetland	India (Himachal Pradesh)	Hindu (mythology)	Ramsar	Mahabharata link; strict taboo on pollution
9	Mansarovar Lake	China (Tibet AR)	Hindu/Buddhist	Ramsar	Holy waters believed to cleanse sins
10	Rara Lake	Nepal (Mugu/Jumla)	Local sacred geography	Ramsar	Central to local spiritual geography
11	Shey Phoksundo Lake	Nepal (Dolpa)	Buddhist/Bon	Ramsar	Taboos prohibit fishing and pollution
12	Dudhpokhari	Nepal (Lamjung)	Hindu locals		Taking dip in the pond is believed to cleanse sins
13	Parbatikunda	Nepal (Rasuwa)	Hindu/Buddhist local		Holy bathing rituals during Janai Purnima
14	Gosaikunda	Nepal (Rasuwa)	Hindu (mythology/cosmology); Pilgrimage	Ramsar	Pilgrimage calendars protect water purity
15	Indra Sarovar (Deoria Tal)	India (Uttarakhand)	Hindu (mythology)		lake linked to Indra; Fishing taboo
16	Panch Pokhari	Nepal (Sindhupalchok)	Hindu + Tamang heritage		Pilgrimage bathing; Tamang dances, weaving
17	Gokyo Lakes	Nepal (Sagarmatha NP)	Buddhist (Sherpa/Tibetan); Serpent deities)	Ramsar	Rituals performed on freezing water believed to have healing powers
18	Nub Tshonapatra	Bhutan (near Tsang camp)	Spiritual; Guru Padmasambhava		Associated with sacred artefacts; spiritual narratives extended into livelihood system
19	Tshona	Bhutan (Singye Dzong area)	Spiritual; Yeshey Tshogyal/Guru Rinpoche		Taboos against disturbance
20	Tso Kar	India (Ladakh)	Pastoral (Changpa people)		Sacred lake; black necked crane protection; Conservation focused grazing calendar
21	Yamdrok Yumtso	China (Tibet AR)	Tibetan; cosmology; Spiritual		Ritual circumambulation; protective deities
22	Namtso (Heavenly Lake)	China (Tibet AR)	Tibetan; cosmology; Spiritual		Ritual circumambulation; protective deities
23	Lhamo La-tso	China (Tibet AR)	Spiritual; Tibetan		Limited disturbance preserving sanctity



The Gokyo lake in Everest region is believed to be the abode of Naag Devata / Shashish Maharjan

communities. Legend holds that they were created by the Prophet Muhammad's son-in-law, Ali, striking the ground with his sword to bring water to a parched land (hence the name "Band-e-Amir" or "Dam of the Leader,"). This sacred status has historically fostered protective norms. These lakes are a crucial water source in an arid region and support local tourism.

Revitalising traditional knowledge for the future

Across the Hindu Kush Himalaya, high-altitude wetlands are shaped by belief systems, customary institutions, and traditional ecological knowledge that function as invisible conservation frameworks. These systems regulate access, moderate use, and foster stewardship rooted in respect rather than enforcement. As seen in sacred lakes and pastoral landscapes across the region, cultural values often act as everyday rules that discourage pollution, limit disturbance, and guide sustainable use. As climate change reshapes mountain hydrology and socio-economic pressures intensify, safeguarding wetlands will require more than technical interventions. A practical way forward is to integrate these values into wetland management through co-designed stewardship plans with local communities, culturally sensitive tourism and pilgrimage guidelines, and intergenerational transmission of knowledge through schools, monasteries, and community institutions. When combined with science, these living traditions can strengthen resilience and legitimacy of conservation efforts. Recognising, respecting, and revitalising traditional knowledge and cultural values is essential for effective, inclusive, and durable conservation ensuring that the sacred waters of the high mountains continue to sustain both nature and culture for generations to come.

TECHNICAL NOTE

Asian Waterbird Census

A 40 Years Legacy of Citizen Science in India



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Counting pink in the marshes of Gujarat / Dr Dhaval Vargiya

Every winter, as the first chill sweeps across the Indian subcontinent, a remarkable spectacle unfolds across its wetlands. The changing season is marked not only by the arrival of the calls and the vibrant hues of winged visitors, but also by the gathering of people at the wetland edges. Armed with binoculars, cameras, and an abiding curiosity, nature enthusiasts spread out across lakes, rivers, marshes, and mudflats to count the feathered nomads that knit continents together through epic migratory

journeys, an effort known as the Asian Waterbird Census (AWC).

Initiated in 1987 on the Indian subcontinent, the AWC forms a part of the global International Waterbird Census, which began nearly six decades ago and remains the longest-running internationally coordinated citizen-science initiative for biodiversity monitoring. In 2026, the Asian Waterbird Census completes 40 years, marking four decades of dedicated monitoring of waterbirds and their habitats across the Central Asian Flyway and the East Asian–Australasian Flyway.

India's long-standing participation in the Asian Waterbird Census has resulted in surveys of over 5,000 wetland sites across the country, documenting millions of individuals from more than 200 species of waterbirds and other wetland-dependent birds.This long-term monitoring has been crucial in understanding wetland ecological conditions and changes that sustain these species, and changes in their population sizes. Each annual count adds another thread to a growing tapestry of data, strengthening collective understanding and supporting informed decision-making by conservation practitioners, policymakers, and concerned citizens.

Strengthening Conservation, Policy, and Wetland Governance

The long-term, site-based evidence generated through the AWC has played a significant role in advancing wetland conservation and governance in India. The AWC initiative has contributed to the identification of wetlands of international importance by meeting multiple Ramsar criteria, including sites that support threatened waterbird species (Criterion 2), maintain biological diversity (Criterion 3),host large congregations of waterbirds (Criterion 5), and regularly hold internationally important populations (Criterion 6). Notable examples include Point Calimere in Tamil Nadu, Vembanad-Kol in Kerala, as



Watching Birds, Reading Pressures: Monitoring anthropogenic drivers of change (Ujani Reservoir, Maharashtra) / Nikita Mishra



Volunteers in action: Counting wings at Ujani Reservoir, a key site along the Central Asian Flyway

well as more recent designations such as Udhwa Lake in Jharkhand and Udaipur Jheel in Rajasthan.

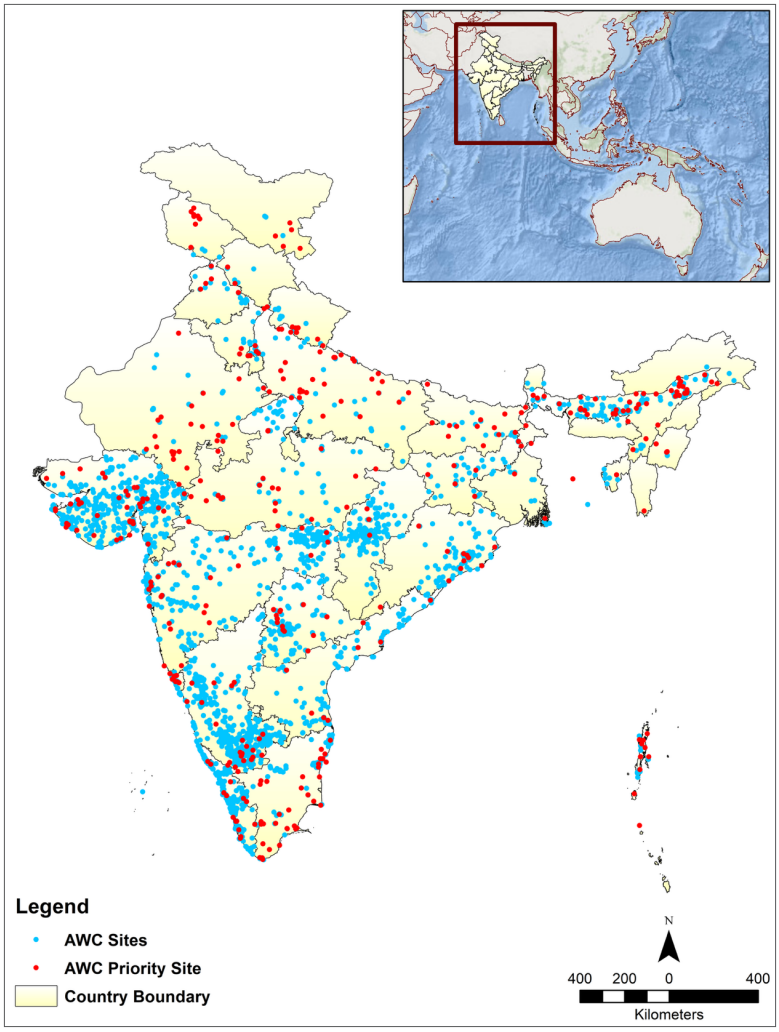
The AWC India has been contributing to various editions of the Waterbird Population Estimates (WPE) that enable long-term population trend analysis of waterbird groups which are used for preparation of IUCN Red List and flyway scale population estimates. At national scale, the AWC data reveals varying population trends across waterbird groups, for example, certain duck species such as the Common Pochard and waders including the Great Thick-knee and Eurasian Curlew have shown slight population declines, while other species, such as the Lesser Flamingo, have exhibited increasing trends over the census period. Furthermore, the importance of such long-term datasets has been reinforced through the recent Ramsar Resolution XV.11 on establishment of the Global Waterbird Estimates Partnership and delivery of the 2027 edition of WPE.

Beyond Ramsar processes, the AWC outputs have been informing the Integrated Wetland Management Plans prepared under the National Plan for Conservation of Aquatic Ecosystems (NPCA) and support implementation of the Central Asian Flyway National Action Plan (CAF-NAP). Since 2022, the National Biodiversity Authority (NBA) acknowledged AWC as an important instrument to foster biodiversity monitoring and conservation in India.

Several states have institutionalised the AWC as a mechanism for long-term monitoring of waterbird populations, movement trends and wetland health. In Bihar, the census has been led by the state government since 2022, with coverage expanding from 68 wetland sites to 125 sites by 2026, supported by pre- and post-census activities to ensure standardised data collection. In Kerala, the AWC has been instrumental in shaping the state's vision for bird monitoring, driven by strong participation from citizen science networks. In Goa, AWC outputs and learnings have informed several decisions pertaining to implementation of coastal regulation zones and wetlands management in the state. The AWC has also been made an annual affair for over a decade for wetlands of ornithological importance such as Pong Dam, Chilika, Harike, Vembanad-Kol where winter counts are undertaken jointly by government departments, dedicated site management units, AWC coordinators and citizen science networks.

To strengthen coordination, state-level coordinators have been appointed across 23 States and Union Territories, improving site coverage and facilitating collaboration among local networks. Partnerships for technological advancements have further strengthened the AWC programme as a dedicated AWC project on the eBird platform has been developed, facilitating data collection, sharing and access for conservation purposes. Furthermore, the presence of designated eBird representatives in every State and Union Territory provides on-ground and technical support to observers. Together, these regional initiatives have significantly strengthened evidence-based wetland management while building public awareness and stewardship.

By linking citizen science with institutional frameworks and



Nationwide network of Asian Waterbird Census sites in India

policy processes, the AWC has evolved from an annual counting exercise into a cornerstone of wetland science and governance. Sustaining and expanding this effort is therefore critical for informed decision-making for waterbirds conservation and wetlands management. As the Asian Waterbird Census marks four decades in 2026, it stands as a testament to the power of sustained observation and collective action. Rooted in wetlands and powered by people, the AWC continues to give voice to migratory waterbirds and to the ecosystems that connect them across continents.

TECHNICAL NOTE

Wetlands:

A Missing Link in India's Greenhouse Gas Inventory



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Teal carbon ecosystem of Miyar Valley / Dayadra Mandal

Wetlands and Greenhouse Gases

Wetlands function as a critical "fine line" in the global climate system, operating simultaneously as vital long-term carbon sinks and potential sources of greenhouse gas (GHG) emissions. Coastal ecosystems such as mangroves, seagrasses, and tidal marshes, along with various inland wetlands, are among the planet's most effective natural systems for sequestering organic carbon. However, environmental stressors such as anaerobic conditions, nutrient enrichment, and hydrological alterations can trigger the release of substantial amounts of methane (CH_4) and nitrous oxide (N_2O). The ultimate

balance of whether a wetland acts as a net sink or net source is dictated by a complex interplay of water regimes, oxygen availability, vegetation composition, and nutrient dynamics. Accurate quantification of this balance is essential for assessing the proper role of wetlands in climate change mitigation.

This complexity is most visible in the fundamental distinction between coastal "blue carbon" and inland "teal carbon" systems. Despite preserving similar amounts of soil carbon, their emission profiles differ radically: coastal wetlands are known to emit 10 to 100 times less CH_4 and N_2O than inland systems. This is primarily due to salinity; coastal sediments are rich in sulfate-reducing bacteria that outcompete methane-producing microbes, effectively suppressing CH_4 production. Conversely, inland water bodies often become greenhouse gas sources due to heavy supplies of organic matter from terrestrial runoff, which fuels microbial decomposition.

Improving guidance to assess wetlands'contribution to greenhouse gas fluxes

Globally, increased attention is being drawn to the role of wetlands in the greenhouse gas fluxes. In the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, wetlands were included under the category of "Flooded Land," focusing on managed wetlands where water tables are artificially altered, such as through drainage or flooding, and including reservoirs and peatlands drained for peat extraction. This guidance provided methodologies for estimating CO_2 and CH_4 emissions from these flooded lands, but had a limited scope regarding other wetland types.

In response to the need for more comprehensive coverage, the 2013 Supplement to the 2006 IPCC Guidelines significantly expanded its scope. It included inland organic soils, wetlands on mineral soils, coastal wetlands such as mangrove forests, tidal marshes, seagrass meadows, and constructed wetlands for wastewater treatment. It introduced updated emission factors and methodologies for estimating anthropogenic emissions and removals from a broader range of wetland types and management conditions.

Further refinement came with the 2019 Refinement to the 2006 IPCC Guidelines, which updated methodologies for flooded lands, including improved guidance on CO_2 and non-CO_2 emissions from both land converted to flooded land and flooded land remaining flooded. It also introduced the Managed Land Proxy approach to enhance transparency and consistency with other AFOLU (Agriculture, Forestry and Other Land Use) reporting, addressing emissions from waterbodies altered by human



Blue carbon ecosystem of the Sundarbans / Dayadra Mandal

activities such as reservoirs, canals, and constructed ponds.

Together, these successive guidelines and supplements have progressively broadened and deepened the treatment of wetlands in national greenhouse gas inventories reported under the UNFCCC, enabling countries to estimate better and report emissions and removals from diverse wetland ecosystems.

Meta-analysis of studies on Indian Wetlands

The scale of India's wetland network is vast, driven by diverse physiography and climatic conditions that support a wide range of ecosystems. The most recent estimate of wetland extent is 16.89 million hectares, representing approximately 5% of India's geographical area. This landscape is dominated by rivers and streams (34%), followed by tanks and ponds (18%), reservoirs (16%), and intertidal mudflats (13%).

We reviewed published studies to assess current knowledge of the role of wetlands in greenhouse gas fluxes in India. A meta-analysis of 21 studies (2000-2022) across 32 sites, mostly along eastern and southern coasts, shows mangroves as the highest carbon sinks (>250 tonnes C/ha), followed by marshes and estuaries (150-200 tonnes C/ha). Lakes, peatlands, and ponds store moderate amounts (50-150 tonnes C/ha), while seagrasses store the least (<50 tonnes C/ha).

The findings also indicate that inland wetlands, particularly tropical peatlands, serve as significant sources of emissions, contributing an estimated 0.62 million tonnes C yr^{-1} and 1.12 million kg N_2O-N yr^{-1}. Methane emissions from mineral soils were calculated at 125.4 million kg yr^{-1} while flooded lands, specifically reservoirs older than 20 years, were found to be substantial methane sources, emitting approximately 341.9 million kg CH_4 annually. In coastal regions, land-use changes like drainage have led to significant carbon losses in mangroves and tidal marshes of nearly 0.113 million tonnes C $yr^{-1}$and 0.051 million

tonnes C yr^{-1}, respectively, though rewetting and revegetation have helped restore sequestration. Furthermore, aquaculture has emerged as a notable source of N_2O, with emissions estimated at 31.1 million kg N_2O-N yr^{-1}.

Including wetlands in Indian Greenhouse Gas Inventories

National greenhouse gas inventories are crucial for tracking climate progress, developing effective policies, ensuring transparency, and meeting international commitments, such as the Paris Agreement, by providing a comprehensive accounting of a country's greenhouse gas emissions and removals, identifying key sources, and monitoring policy effectiveness. While India has gradually improved coverage of sectors in its national greenhouse gas inventories, wetlands have remained on the margins. Only mangroves are considered part of the flux estimate from the forestry sector.

With recent advancements in wetland inventories, it is possible to atleast strive for a Tier I assessment of wetlands, wherein changes in wetland extent over time are used to generate information on greenhouse gas fluxes using default IPCC emission factors. This can subsequently be improved by assessing country-specific emission factors and using finer activity data.



TECHNICAL NOTE

An Emerging Invader Along India's Coastal Wetlands

The Case of *Mytella strigata*



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Lesser Sand Plover foraging on the mudflats of Thane Creek amidst dense aggregations of the invasive mussel *Mytella strigata* / Ravi Naidu

Coastal wetlands such as estuaries, mangroves, creeks, and mudflats are among the most productive ecosystems on Earth. They support fisheries, protect shorelines, provide feeding grounds for birds, and sustain the livelihoods of millions of people. However, these valuable ecosystems are increasingly facing pressures from pollution, infrastructure development, climate change, and biological invasions. In recent years, a new and relatively lesser-known challenge has begun to emerge along India's coastline, the spread of an invasive bivalve mollusk species called *Mytella strigata*, commonly called the Charru mussel.

Unlike oil spills or large construction projects, the invasion of this mussel is subtle and often goes unnoticed. Yet, its presence has the potential to bring long-term changes to coastal wetlands if left unaddressed. Understanding what *Mytella strigata* is, how it spreads, and why it matters is an important first step towards protecting our wetland ecosystems.

What is *Mytella strigata*?

Mytella strigata is a yellow-green to dark brown-black elongated, small bivalve mussel originally native to parts of Central and South America. Like other mussels, it attaches itself to submerged hard surfaces such as rocks, mangrove roots, concrete structures, and even shells of other organisms. What makes this species different is its remarkable ability to spread rapidly and form dense clusters.



Invasive mussels (*Mytella strigata*) separated from their byssal threads - byssal threads are fibrous filaments produced by mussels to attach firmly to surfaces / Dakshata Gaikwad

The mussel is believed to have entered Indian coastal waters through human-mediated pathways, particularly shipping and port activities. Larvae released into ballast water or attached to ship surfaces can travel long distances and settle in new environments. Once established, *Mytella strigata* reproduces quickly and can tolerate a wide range of environmental conditions, including changes insalinity and temperature. These traits allow it to thrive in estuaries and coastal wetlands, where conditions are naturally variable.

Why are coastal wetlands vulnerable?

Coastal wetlands provide ideal conditions for invasive species like *Mytella strigata*. Estuaries and creeks often have calm waters, abundant nutrients, and a mix of freshwater and seawater, creating favourable conditions for mussel larvae to settle and grow. In many places, wetlands are also located close to ports, harbours, aquaculture sites, and industrial areas, which increases the chances of non-native species being introduced.

Once *Mytella strigata* establishes itself in a wetland, it can spread along natural and artificial surfaces. Mangrove roots, embankments, boat hulls, bridges, and jetties become suitable attachment sites, allowing the mussel to expand its range steadily. Because coastal

wetlands are dynamic systems that are not always regularly monitored, early invasions can easily go unnoticed.

Why should we be concerned?

At first glance, a small mussel may not seem like a serious threat. However, the impacts of invasive species are often cumulative and long-lasting. Dense colonies of *Mytella strigata* can cover large areas of the wetland substrate, leaving little space for native species to survive. This can lead to a decline in native mussels, oysters, and other bottom-dwelling organisms that play important roles in the ecosystem.

By altering the natural composition of the wetland floor, invasive mussels can also change sediment characteristics and water flow patterns at a local scale. These changes can affect the availability of food for fish, crabs, and other organisms that depend on benthic communities. Over time, such alterations may influence the overall functioning of the wetland ecosystem.

Coastal wetlands are also crucial feeding grounds for many resident and migratory waterbirds. Shorebirds and waders rely on healthy benthic communities for food. Any change in species composition or abundance at the base of the food web can indirectly affect these birds. While direct impacts on birds may not be immediately visible,



Mudflat of Thane creek covered with dense clusters of *Mytella strigata* / Dakshata Gaikwad

long-term changes in wetland ecology can reduce the suitability of these habitats for avifauna.

From a human perspective, *Mytella strigata* can create practical challenges as well. Dense mussel growth can foul fishing nets, clog water intake pipes, and increase maintenance costs for coastal infrastructure. For fishing communities that depend on clean and accessible wetlands, such changes can affect daily activities and livelihoods.

Why does the invasion often go unnoticed?

One of the reasons *Mytella strigata* has received limited attention is that it closely resembles native mussel species. Without careful observation, it is easy to overlook or misidentify. In addition, monitoring efforts in coastal wetlands often focus on larger or more visible issues such as pollution, land-use change, or declining bird numbers. Smaller organisms, despite their ecological importance, tend to receive less attention.

Another challenge is the lack of widespread awareness about marine and estuarine invasive species. Unlike terrestrial invasions, which are often more visible, invasions in wetlands occur quietly, below the waterline or on submerged surfaces. By the time their impacts become noticeable, the species may already be well established.

What can be done?

Addressing the spread of *Mytella strigata* does not require complex solutions alone; it begins with awareness and early detection. Regular monitoring of coastal wetlands, especially near ports and industrial areas, can help identify new invasions at an early stage. Simple field observations by researchers, wetland managers, and even local communities can play a valuable role in reporting unusual or dense mussel growth.

Collaboration between scientists, government agencies, and coastal communities is essential. Sharing information, documenting occurrences, and integrating invasive species monitoring into existing wetland management programmes can help build a clearer picture of the spread and impacts of *Mytella strigata*. Importantly, responses should focus on long-term ecosystem health rather than short-term removal alone.

Looking ahead

Coastal wetlands are resilient systems, but their resilience has limits. The emergence of invasive species like *Mytella strigata* is a reminder that ecological changes often begin quietly. Recognising these early signs provides an opportunity to respond before irreversible impacts occur.

By paying attention to small but significant changes in our wetlands, we can better protect these ecosystems for the aquatic organisms, birds, wildlife, and communities that depend on them. Raising awareness about emerging invasions is a crucial step toward ensuring the long-term health and sustainability of India's coastal wetlands.

TECHNICAL NOTE

Interlinking Sightings, Resources and Wetlands

Amalgamation of Citizen Science and Geospatial Analysis to Delineate Waterbird Habitats Around India's Ramsar Sites



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Why waterbirds and wetlands are inseparable

Waterbirds rely on wetlands for almost everything: food, shelter, breeding, and rest during long migrations. Migratory birds that arrive in India each winter may travel thousands of kilometres and look for safe places to land, feed, and recover. Resident waterbirds, too, move between wetlands depending on seasons, water availability, and disturbance.

Healthy waterbird populations usually mean healthy wetlands. That is why protecting waterbirds also means protecting water, livelihoods, and ecosystems.

India joined the Ramsar Convention in 1982 and has since designated 96 Ramsar Sites covering about 1.36 million ha. These sites are chosen because they are ecologically unique or support large numbers of birds and other biodiversity. While Ramsar Sites are crucial, they cover only about 8% of India's wetland extent. Waterbirds, however, use far more than that.

Saving waterbirds needs more than protected wetlands

When we think about protecting waterbirds in India, names of Ramsar sites such as Chilika, Keoladeo, or Thane Creek often come to mind. These renowned wetlands are designated as Ramsar Sites and are recognised for their rich avifaunal diversity. But an important question remains: are these protected wetlands alone enough to conserve waterbirds?

The study suggests that the answer is 'No'. Waterbirds depend not just on a few large wetlands, but on a whole network of wetlands spread across the landscape, many of which lie outside notified boundaries under extant regulations and often go unnoticed.

The hidden importance of "satellite wetlands"

Beyond Ramsar Sites lies a vast network of smaller wetlands, including village ponds, floodplain wetlands, marshes, mangroves, and seasonal water bodies. These are often called satellite wetlands. They may not have legal protection, but they play a critical role.

Satellite wetlands provide feeding and resting areas, especially when major wetlands are crowded or disturbed. They serve as stopover sites that enable birds to move safely across landscapes and facilitate genetic exchange between populations. Most importantly, they reduce pressure on heavily used Ramsar Sites.

Ignoring these wetlands breaks the ecological network that waterbirds depend on.

Using citizen science to see the bigger picture

To determine which wetlands are actually used by waterbirds, it was necessary to combine citizen science data with geospatial data. Thousands of birdwatchers across India upload sightings to global platforms such as eBird, iNaturalist, the India Biodiversity Portal, etc and all this information is collated in the Global Biodiversity Information Facility (GBIF). Each observation records the species, location, and date, creating a powerful picture of bird presence across the country.

Upon combining these waterbird sighting records with satellite-derived wetland maps from the Space Applications Centre (SAC), along with information on land use and land cover (2008 and 2018), elevation, slope, aspect and hillshade, allowed us to identify Areas of Habitat (AOH), i.e., wetlands that birds actively use, regardless of whether they are officially notified under extant





High-altitude winter travellers at rest: Flock of Bar-headed Goose at Pong Dam Lake (Ramsar Site) and the Gobind Sagar Wetland, highlighting the role of satellite wetlands in supporting waterbirds.

regulations.

In this study, catchment boundaries are derived from the HydroSHEDS dataset, specifically HydroLAKES watershed units. At this level, HydroSHEDS defines hydrologically connected drainage areas, which are commonly referred to as catchments in hydrological and landscape-scale analyses.

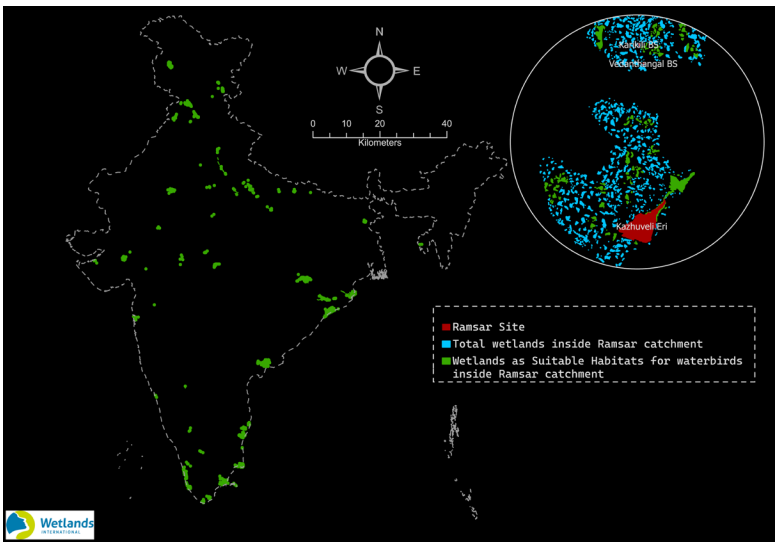
The focus was on the catchments of 94 Ramsar Sites in India, looking at the wider landscapes connected to these wetlands rather than just their notified boundaries.

What the analysis revealed

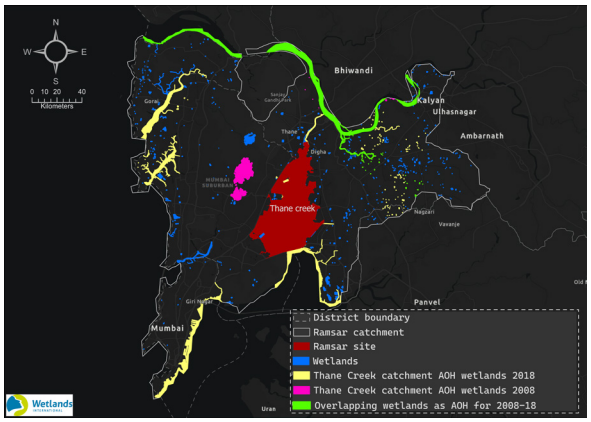
Across India, 39,089 wetlands were mapped within the catchment of Ramsar sites. Out of these, 3,220 wetlands were identified as important habitats for waterbirds. This shows that wetlands in the Ramsar Site catchment play a crucial role in supporting waterbird diversity.

At the individual landscape level, the pattern became even clearer. Around Thane Creek, the number of wetlands used by waterbirds increased sharply between 2008 and 2018, highlighting the growing importance of surrounding satellite wetlands. In Nalsarovar, only a handful of wetlands were consistently used over time, making them especially important. In Samaspur Bird Sanctuary, many wetlands supported birds across both years, showing a stable and well-connected habitat network.

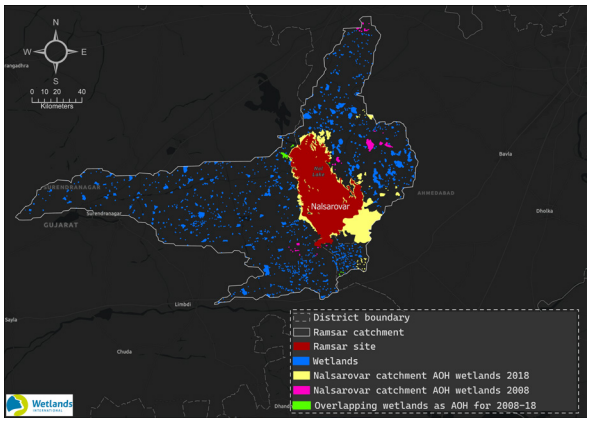
These examples demonstrate that waterbirds depend on clusters of wetlands, not only on isolated sites.



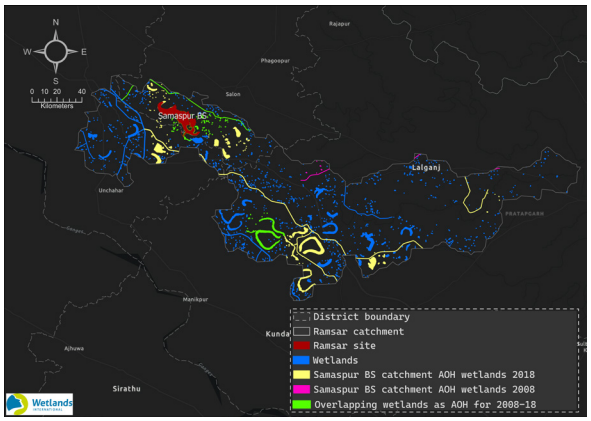
Wetlands as area of habitat (AOH) in Ramsar site catchments



(a) Thane Creek



(b) Nalsarovar



(c) Samaspur Bird Sanctuary

Site level area of habitat (AOH) for waterbirds

What this means for wetland biodiversity conservation

The findings highlight a simple yet powerful idea: protecting only Ramsar Sites is insufficient. Conservation efforts must also recognise and safeguard the surrounding wetlands that support Ramsar sites.

This approach can help strengthen evidence-based nominations for new Ramsar Sites and Wetlands of National Importance. It can guide funding and monitoring towards wetlands with the highest ecological value. It also supports India's long-term vision under the Viksit Bharat Mission @2047. Beyond policy, this work supports global commitments such as the Global Biodiversity Targets (30×30), designating wetlands as other effective area-based conservation measures (OECMs) and the Sustainable Development Goals related to water, climate, and ecosystems. It also provides a scientific foundation for corporate and community-led wetland restoration efforts.

A role for everyone

One of the most encouraging aspects of this work is the role played by ordinary people. Every bird sighting uploaded by a citizen scientist helps reveal hidden habitats and fills data gaps. Future analyses could use species-specific habitat models instead



Okhla Bird Sanctuary, Delhi-NCR / Kamal Dalakoti

of a single generalised model to better capture differences in habitat preferences among waterbird species. Incorporating climate variability and extreme events, such as droughts and floods, would help assess how suitable habitats may shift under changing climatic conditions. In addition, strengthening field validation and citizen science participation in data-poor regions would improve the accuracy and representativeness of habitat identification. The more people participate, the clearer the picture becomes.

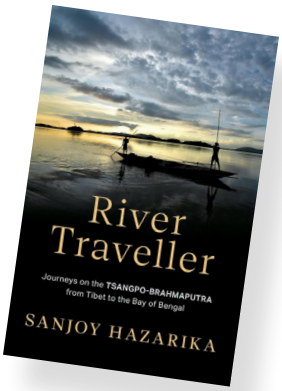
Waterbird conservation is not just about protecting famous wetlands. It is about viewing the landscape as a connected whole, in which wetlands in the catchment matter as much as large ones. By combining citizen science and satellite data with thoughtful planning and integrating other aspects of wetlands (such as habitats, species-specific ensemble modelling), we can protect the wetlands that protect waterbirds and, in turn, protect ourselves.





Putting citizen science in the spotlight at CitSci Conference 2025, IISER Tirupati
Access at: *https://citsci-india.org/citsci-india-2025/*

BOOK Review

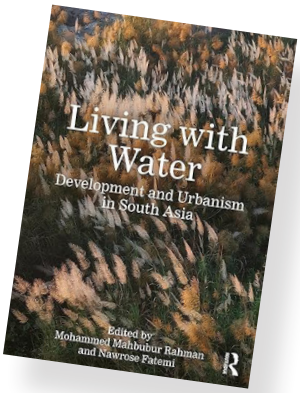


River Traveller: Journeys on the Tsangpo-Brahmaputra from Tibet to the Bay of Bengal

AUTHOR: Sanjoy Hazarika

PUBLISHER: Speaking Tiger (2025)

To write about the Brahmaputra is to write about a shapeshifter. In this sweeping new narrative, veteran journalist and North East expert Sanjoy Hazarika moves beyond the static maps of geopolitics to chart the living, breathing reality of the "Great River". From its glacial silence in Tibet (as the Yarlung Tsangpo) to its roaring descent through the Namcha Barwa gorge, and finally into the deltaic embrace of Bangladesh, Hazarika chronicles a water body that defies containment. This is not just a travelogue; it is a biography of the river itself, told through the voices of the boatmen, farmers, and insurgents who live on its precarious banks. It challenges the reader to see the river not as a resource to be dammed or divided, but as an ancient, untamed ancestor common to three nations.



Living With Water: Development and Urbanism in South Asia

EDITORS: Mohammed Mahbubur Rahman & Nawrose Fatemi

PUBLISHER: Routledge (2025)

In Living with Water, editors Rahman and Fatemi present a critical survey of how South Asia's built environment interacts with its most vital resource. Moving beyond the 'dry city' model of modern planning, this collection of case studies spanning the floodplains of Bangladesh to the riverfronts of India and Pakistan advocates for 'hydrological urbanism'. The book argues that the region's historical architecture, from stepwells to canal systems, holds the key to climate resilience, offering a blueprint for cities that adapt to water rather than attempting to conquer it.



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NEWS ROUNDUP

Mangrove Breakthrough Gains Momentum at COP30

The Global Mangrove Alliance (GMA) and UN Climate Change High-Level Champions reached a major milestone at COP30 in Belém, Brazil. The Mangrove Breakthrough, originally launched at COP27, has now secured endorsements from 46 national and subnational governments, representing approximately 40% of the world's total mangrove coverage.

The initiative aims to safeguard 15 million hectares of mangroves globally by 2030 through a USD 4 billion investment. Key progress in 2025 includes:

- **Financial Architecture:** The launch of the Mangrove Catalytic Facility (MCF), designed to bridge financing gaps and prepare mangrove-positive businesses for large-scale investment.
- **Regional Readiness:** Publication of three Regional Readiness Reports for Asia, the Americas, and West Africa to guide funders and governments toward high-impact restoration sites.
- **Investment Tracking:** Since 2020, the Breakthrough has tracked over USD 750 million in mangrove-positive investments across 40 large-scale operations.

Source: Global Mangrove Alliance COP30 Updates | Mangrove Breakthrough Official Site

Global Wetland Outlook 2025 Warns of Economic Risks

Released in July 2025, the Global Wetland Outlook (GWO) report provides a stark assessment of the world's remaining marshes, peatlands, and mangroves. The report reveals that 25% of remaining wetlands are now in a poor ecological state.

- **Financially, the stakes are immense:** the cumulative loss of wetland ecosystem services between 1975 and 2025 is estimated at USD 5.1 trillion. However, the GWO 2025 emphasises that restoring 123 million hectares required to meet the Kunming-Montreal Global Biodiversity Framework targets is an "economically rational strategy" that generates high returns through flood protection, carbon sequestration, and fisheries support.
- **The "Economic Rational Strategy":** The report highlights that every $1 invested in restoration yields $5 to $35 in ecosystem benefits.

Source: Global Wetland Outlook 2025 Report | Wetlands International Summary

Global Milestone: Ramsar COP15 in Victoria Falls

The 15th Meeting of the Conference of the Contracting Parties (COP15) to the Convention on Wetlands was held in Victoria Falls, Zimbabwe, in July 2025. Under the theme " *Protecting Wetlands for Our Common Future* " the conference resulted in 13 landmark resolutions.

- **Global Restoration Mandate:** Parties committed to developing national legislation to restore degraded freshwater ecosystems, aligning with the "Freshwater Challenge" to restore 300,000 km of rivers and 350 million ha of wetlands globally.
- **Sustainable Lifestyles:** A resolution spearheaded by India on " *Promoting Sustainable Lifestyles for the Wise Use of Wetlands* " was adopted, emphasising the role of individual and community choices (the "LiFE" movement) in ecosystem conservation.
- **New Strategic Plan:** The conference adopted the 5th Strategic Plan (2025–2030), which integrates wetland targets directly with the UN Sustainable Development Goals (SDGs).

Source: UNEP at Ramsar COP15 | PIB: India's Resolution at COP15

FOCUS ON SOUTH ASIA



HIGHLIGHTS FROM INDIA

India: Expanding the Ramsar Network to 96 Sites

India has solidified its position as a global leader in wetland conservation, reaching a milestone of 96 Ramsar Sites as of late 2025. This network now spans over 1.5 million hectares, the largest in South Asia and the third-largest in the world. This rapid expansion reflects the "Amrit Dharohar" vision, aiming to protect these "kidneys of the landscape" for ecological and economic security.

New Designations:
Spotlighting Biodiversity

In 2025, several critical wetlands were added to the List of Wetlands of International Importance, including:

> Siliserh Lake (Rajasthan): A historic man-made lake in Alwar, constructed in 1845. It serves as a vital water source in a semi-arid region and is a key habitat for the River Tern and Black Stork, while acting as a buffer for the Sariska Tiger Reserve.

> Kopra Jalashay (Chhattisgarh): Marking a milestone as the first Ramsar Site in Chhattisgarh, this reservoir near Bilaspur supports over 140 bird species, including the endangered Egyptian Vulture.

> Bihar's Oxbow Trio: Joining the list in late 2025 were Gokul Jalashay (Buxar), Udaipur Jheel (West Champaran), and Gogabeel Lake (Katihar). These oxbow lakes are remnants of the Ganga-Gandaki River systems and are critical for flood buffering and supporting the Central Asian Flyway.

GMA India Chapter: A New Era for Mangrove Coordination

In June 2025, the Global Mangrove Alliance (GMA) officially launched its India National Chapter, convened by SaciWATERs and Wetlands International South Asia. This initiative brings together government agencies, NGOs, and researchers to create a unified national roadmap for mangrove restoration.

Key Achievements:

> Goal-Setting Workshop (Goa, November 2025): The chapter's first in-person gathering established a six-month roadmap focusing on "restoration science" and "institutional readiness."

> East vs. West Coast Strategies: Recognising that "one size does not fit all," the Chapter is developing distinct management plans for the high-biodiversity Sundarbans on the east coast and the resilient, urban-proximate mangroves of Maharashtra and Gujarat on the west coast.

> Community-Led Monitoring: Through the GMA, local "Blue Guards" and women's self-help groups (SHGs) are being trained in scientific monitoring and nursery management, ensuring that conservation translates into sustainable local livelihoods.

National Schemes: From "MISHTI" to "Amrit Dharohar"

The government's dedicated programs have shifted from mere mapping to active "Wise Use" and capacity building.

> Amrit Dharohar Capacity Building: Launched in collaboration between the Tourism and Environment Ministries, this scheme has transitioned 16 pilot Ramsar sites—including Chilika Lake and Sultanpur National Park—from high-volume tourism to high-value nature tourism. This focuses on specialised experiences like birdwatching and "stargazing" to generate local income without degrading the ecosystem.

> MISHTI (Mangrove Initiative for Shoreline Habitats & Tangible Incomes): By 2025, MISHTI has facilitated the planting of mangroves across nearly 540 sq km in 11 states and two Union Territories, leveraging MGNREGS funds to create green jobs while protecting shorelines from intensified cyclones.

> Wetland Health Cards: As of 2025, over 680 wetlands have been issued "Health Cards", a system that tracks water quality, encroachment, and biodiversity health, allowing for data-driven interventions.

Regional Collaboration: The Central Asian Flyway (CAF)

A major regional win was the formalisation of the CAF Institutional Framework. South Asian nations, led by India, agreed to:

> Transboundary Corridors: Establish protected "safe zones" for migratory birds traveling from the Arctic to the Indian Ocean.

> Joint Monitoring: Launch a shared digital platform in 2025 for real-time tracking of migratory species like the Bar-headed Goose and Siberian Crane, allowing for coordinated habitat management across borders.



HIGHLIGHTS FROM SRI LANKA

Sri Lanka has become a global voice for "hidden" wetlands like seagrasses and mangroves, recognized by the UN as a World Restoration Flagship.

> Mangrove Restoration Milestone: As of mid-2025, Sri Lanka has successfully restored 8,000 hectares of mangroves using a "community-first" model. Unlike failed mass-planting attempts of the past, this program emphasizes scientific site selection and nursery care led by local women's groups.

> Colombo: The Wetland City: Building on its status as a Ramsar Accredited Wetland City, Colombo launched the "Urban Blue-Green Corridor" in 2025. This project integrates the city's canal systems and marshes into a flood-mitigation network designed to handle the 1-in-50-year storm events that have become more frequent.

HIGHLIGHTS FROM BHUTAN

In the Hindu Kush Himalaya region, wetlands are being recognized as "Water Towers" that regulate the flow of the subcontinent's major rivers.

> Bhutan's Climate Adaptation: In 2025, Bhutan completed a comprehensive inventory of its high-altitude peatlands. These areas are critical carbon stores; the government has now integrated peatland protection into its Carbon Negative strategy, ensuring these bogs are not drained for agriculture or grazing.

HIGHLIGHTS FROM BANGLADESH

Bangladesh has transitioned from disaster management to "proactive ecosystem adaptation," focusing heavily on the Sundarbans and its inland haors (wetland bowls).

> Sundarbans Protection & Restoration: In 2025, the Forest Department introduced drone-based monitoring to track the health of the Heritiera fomes (Sundari tree) canopy and detect early signs of "top-dying" disease caused by increased salinity.

> National Haor Development Plan 2025: The government has accelerated the rejuvenation of the Tanguar Haor (a Ramsar site). The 2025 updates focus on "submersible roads" and community-based sustainable fishing cooperatives to prevent over-extraction during the dry season.

HIGHLIGHTS FROM PAKISTAN

Pakistan is currently implementing one of the world's most ambitious Nature-based Solutions (NbS) projects to combat the dual threats of floods and droughts.

> By late 2025, the project 'Recharge Pakistan' has initiated the restoration of six key wetland sites that act as natural sponges to absorb excess floodwater and refill depleted aquifers.

> Astola Island Management: The 2025 management plan for Astola Island (Pakistan's first Marine Protected Area and a Ramsar site) was updated to include strict "no-take zones" to protect coral reefs and the nesting grounds of the endangered Green Turtle.

Sources & Further Reading:

MoEFCC India: List of Ramsar Sites (2025) | Global Mangrove Alliance: 2025 Success Stories | WWF: Recharge Pakistan Project Implementation | IUCN: Astola Island Marine Protected Area Management Plan

IMPORTANT JUDGEMENTS RELATED WITH WETLANDS

National Green Tribunal Directs the Wetlands Authority of Delhi to Trace Missing Waterbodies and Undertake Restoration Measures

The Principal Bench of the National Green Tribunal, in Original Application No. 633/2024, directed the Wetlands Authority of Delhi to locate the missing waterbodies and commence restoration efforts. The matter arises from the lack of comprehensive data on 1,045 waterbodies recorded in revenue documents and 322 waterbodies identified through satellite imagery by Geospatial Delhi Limited, a significant number of which were not found during on-ground verification.

Source: https://greentribunal.gov.in/gen_pdf_test.php?filepath=L25ndF9kb2N1bWVudHMvbmd0L2Nhc2Vkb2Mvb3JkZXJzL0RFTEhJLzIwMjUtMDUtMjEvY291cnRzLzEvZGFpbHkvMTc0Nzk4NDg3NTE3NjUwMTU1ODU2ODMwMjFlYjk1NWMwLnBkZg==

National Green Tribunal Directs the State to Take Remedial Action On River Pollution in Punjab

The National Green Tribunal, while hearing Original Application No. 105/2025 on encroachments along the banks of the Ishan River, a tributary of the Ganga and the conservation of Rohtam Lake in Punjab, has ordered the state to undertake corrective measures for polluted stretches of the river and to restore affected waterbodies. In response to these directions, the Punjab Pollution Control Board has set up a monitoring committee to supervise implementation and ensure compliance with the Tribunal's directives.

Source: https://greentribunal.gov.in/gen_pdf_test.php?filepath=L25ndF9kb2N1bWVudHMvbmd0L2Nhc2Vkb2Mvb3JkZXJzL0RFTEhJLzIwMjUtMDMtMjAvY291cnRzLzEvZGFpbHkvMTc0MjY0MDA5MjE3MDk3NzM5NTY3ZGU5M2RjMWIzOWQucGRm

Supreme Court Directs States / UTs to Expedite the Process of Ground Truthing and Boundary Demarcation

The Supreme Court, in a Writ Petition (Civil) No. 304/2018, has directed all States and Union Territories, especially those that have completed less than 40% or 50% of ground truthing or boundary demarcation of wetlands, to finish the process within two months from its order dated August 19, 2025. The case pertains to nationwide compliance with the verification and demarcation of wetlands larger than 2.25 hectares, as identified in the SAC Atlas. The Court warned that failure to comply would require the concerned Secretaries of the State Departments of Environment and Ecology to appear personally at the next hearing. Additionally, States and UTs have been instructed to publish the list of identified wetlands on their official government websites and to fast-track the notification of wetlands under the Wetlands (Conservation and Management) Rules, 2017. The Court further clarified that wetlands smaller than 2.25 hectares must also be identified following the same procedure applicable to larger wetlands.

Source: https://api.sci.gov.in/supremecourt/2018/4365/4365_2018_15_34_63445_Order_19-Aug-2025.pdf



National Green Tribunal Seeks Responses for Illegal Construction of Jetty on Chilika Lake, Odisha

The National Green Tribunal taking into consideration the Original Application No. 122/2025/EZ, issued notices to the Odisha State Coastal Zone Management Authority, the Odisha State Pollution Control Board, the Wetland Authority, the Chilika Development Authority, and the private entity executing the jetty project on the banks of Chilika Lake. All parties have been directed to file their responses within four weeks. The order followed a petition filed by the Maa Kalijaee Motor Boat Workers' Union alleging illegal construction of a jetty by Vikash Eco Resort Pvt. Ltd. The project is located within CRZ-IIIA and CRZ-IVB zones, which are governed by strict provisions under the Coastal Regulation Zone Notification, 2019, and has reportedly proceeded without approval from the State Coastal Zone Management Authority. Acknowledging the potential adverse environmental impact, the Tribunal has called for detailed replies from the concerned authorities.

Source: https://www.greentribunal.gov.in/gen_pdf_test.

Kerala High Court Directs Constitution of Ashtamudi Wetland Management Unit

The Kerala High Court, in the matter related WP(C) No. 18400/2024, directed the State Government and the State Wetland Authority Kerala (SWAK) to set up an Ashtamudi Wetland Management Unit within two months of its order dated July 29, 2025, and to complete an Integrated Management Plan for the wetland within six months of its notification. The directions were issued in a public interest litigation addressing issues such as waste dumping, encroachments, water pollution, and depletion of mangrove cover in the Ashtamudi wetland, which is Kerala's second-largest wetland and has been designated a Ramsar Site since 2002. The Court observed that effective conservation necessitates a dedicated management body and a site-specific, science-based management plan in accordance with the Ramsar Convention. It further ordered the development of a standard operating procedure for the management unit, detailing coordination frameworks and meeting protocols, along with the creation of a digital public feedback mechanism through a dedicated website to be hosted by SWAK.

Source: https://hckinfo.keralacourts.in/digicourt/Casedetailssearch/

National Green Tribunal Halts Development Around Pallikaranai-Perumbakkam Marshland

The National Green Tribunal, while considering Original Application No. 91/2023 (SZ), ordered that no clearances, sanctions, or permissions that could change the nature of the Pallikaranai marshland or its zone of influence shall be issued until the Integrated Management Plan is completed. The proceedings stemmed from a suo motu action taken by the Tribunal on the basis of a New Indian Express report dated June 30, 2023, which alleged that a private developer had constructed a road within the Perumbakkam marshland by dumping debris and deploying heavy machinery. The Tribunal directed authorities such as the Chennai Metropolitan Development Authority, the Tamil Nadu State Wetland Authority, and the Water Resources Department to work in coordination to fast-track the preparation of the management plan, grounded in a comprehensive survey of the Ramsar Site and in accordance with the Wetlands (Conservation and Management) Rules, 2017. The Tribunal observed that the Pallikaranai Marsh, declared a Ramsar Site in 2022, has already lost close to 90% of its original area due to urban expansion, and underscored that even patta lands within the zone of influence cannot be considered separately from wetland conservation efforts.

Source: https://www.greentribunal.gov.in/gen_pdf_test.



Supreme Court Upholds Recreational Projects with Safeguards at Futala Lake

The Supreme Court rejected an appeal in Special Leave Petition (C) No. 1420/2024 that questioned the recreational and beautification initiatives carried out at Futala Lake in Nagpur, while directing that no permanent structures be erected within the lake and that its ecological integrity be preserved. The dispute arose from a public interest litigation filed by the Swachh Association, which opposed the installation of facilities such as a musical fountain, viewing gallery, parking area, floating restaurant, and related amenities in and around Futala Lake, arguing that the lake qualified as a "wetland" under the Wetlands (Conservation and Management) Rules, 2017. After reviewing the statutory definition of wetlands, historical documentation, and approvals issued by the competent authorities, the Court concluded that Futala Lake is an artificial waterbody created for drinking water supply and irrigation, and therefore does not fall within the scope of wetlands as defined under the 2017 Rules. Nevertheless, invoking the precautionary principle and the public trust doctrine, the Court affirmed the High Court's directions mandating that the lake remain free of permanent constructions and that its environment and surroundings be safeguarded, maintained in a clean condition, and kept ecologically balanced while permitting sustainable public access.

Source: https://api.sci.gov.in/supremecourt/2024/551/551_2024_16_1501_64835_Judgement_07-Oct-2025.pdf

National Green Tribunal Seeks Action Report on Encroachment of Bhoj Wetland

The National Green Tribunal's Central Zone Bench, in Original Application No. 12/2025, has instructed the Bhopal Municipal Corporation (BMC) to remove encroachments from the Bhoj Wetland within a fixed timeframe and to submit a compliance report detailing the actions taken. The Tribunal further ordered that an ecological study and a bird population survey be carried out in coordination with the State Wetland Authority and the Forest and Environment Department. The matter relates to claims of unauthorized construction, continuing encroachments, and the release of untreated sewage into the Bhoj Wetland, which is designated as a Ramsar Site. Additionally, the Tribunal directed BMC to undertake a joint inspection of the site along with the applicant and to initiate stringent measures not only against the encroachers but also against officials who neglected their statutory responsibilities.

Source: https://www.greentribunal.gov.in/gen_pdf_test.



Puga Marshes, Ladakh/ Suchita Awasthi



Painted Storks in Keoladeo National Park, Rajasthan / Harsh Ganapathi



Endnote
From the Director

In 2025, coordinated national programming in India marks forty years. Emerging from a focus on designating wetlands as protected areas to preserve wildlife, especially migratory waterbirds, the national programme has gradually broadened to focus on wetland-wise use and integrated landscape-scale management. India is one of the few countries globally to have a national inventory of wetlands, most recently mapping wetlands up to 0.1 ha in extent. Support to the State Governments for the preparation and implementation of integrated management plans through the National Plan for Conservation of Aquatic Ecosystems and its predecessors, the National Wetlands Conservation Programme and the National Lake Conservation Plan, has reached more than 200 wetlands. Newer tools for supporting integrated management have been developed, which enable holistic wetland management and effectiveness assessment, integrating climate risks and implementing wise use. In recent times, wetlands have found a place in plans and programmes for sectors beyond conservation, such as water resources, urban development, and tourism, to mention a few. India has, to date, designated the largest network of Ramsar Sites in the country.

The fragmented references to wetlands across various laws have been consolidated in the Wetlands (Conservation and Management) Rules, 2017. With an endorsement of a 'whole-of-society' approach to conservation, a participatory architecture for wetlands conservation has been elaborated in Mission Sahbhagita.

Yet, there are signs that the efforts above do not align with the country's extent and scale of wetland degradation. Numerous reports and datasets indicate that wetlands have continued to be degraded, damaged, and converted for alternative uses. The integrated management plans are few and far between and are seldom financed and implemented at the scale needed to stem wetlands degradation. The complex information requirements and the capacity to prepare an integrated management plan have severely slowed uptake and implementation. The available public sector finances are a minuscule fraction of the sector's needs. The Wetlands Authorities face a lack of human resources, institutional capacity, and mandates to enable inter-agency convergence and ensure effective functioning.

Sector plans and programmes seldom take an ecosystem view of wetlands; rather, they use disparate terms and conceptualisations of these ecosystems and, in several instances, have adversely impacted wetlands through hydrological fragmentation, conversion of natural shorelines, and other activities. The courts have often taken a dim view of the current condition of wetlands and have frequently spotlighted the inability of States to implement integrated management. While there has been a push to broaden partnerships and resource mobilisation, including from the private sector, the absence of guidance and platforms has impeded actual action in this direction.

In the last five years, the Government of India has established several policy and programmatic priorities under climate change, biodiversity and river basin management that provide immense opportunities to scale up and leapfrog the ambit of wetlands conservation and its integration into sector plans and programmes. Benefitting from the above opportunities would require a significant reshaping of the approach to wetlands conservation, which is currently focused on a few sites, most of which are within the protected area network. As the national wetland programme completes four decades of implementation, it is pertinent that the national wetlands programme is structured around national targets for wetland extent condition, integrated across sectors, supported by robust science-management interface, is enabled by governance that is effective, inclusive and accountable and is backed by a resource mobilisation strategy complementing public sector resources with investments from the private sector and philanthropies.

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