# Water Security Through Wetland Restoration India's Hydrological Imperative for the 21st Century

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## AN ABSTRACT

Water security — defined as reliable access to sufficient, safe, and affordable water for human well-being, economic development, and ecosystem health — is India's most urgent national challenge (NITI Aayog, 2019). Home to over 1.4 billion people and ranked 120th out of 122 countries in the EIU's Water Quality Index, India confronts a deepening freshwater crisis wherein 600 million citizens face high to extreme water stress annually. At the heart of this crisis lies a fundamental, often overlooked truth: the systematic destruction of India's natural water security infrastructure — its wetlands.

India's wetlands — encompassing vast floodplains, coastal mangroves, highland lakes, seasonal ponds (talaabs), sacred groves (kunds), urban lakes, and trans-Himalayan marshes — are not peripheral ecological features. They are the functional backbone of the country's water security system (Millennium Ecosystem Assessment, 2005). They store and regulate water flows, recharge aquifers upon which 85% of rural India depends for drinking water, agricultural needs, mitigate monsoonal floods that kill over 1,600 people annually, purify drinking water naturally, and sustain livelihoods for over 200 million people. India has forfeited an estimated 30–40% of its wetland area since independence (SAC-ISRO, 2011), with losses exceeding 70% in states like Punjab and Haryana — directly translating into aquifer depletion, increased flooding, deteriorating water quality, and shrinking water availability.

This paper makes a clear, evidence-based argument: wetland restoration is building water security. Grounded in national hydrological data, remote sensing studies, ecological evaluations, and policy analysis, this paper demonstrates that the four pillars of water security — availability, access, quality, and resilience — are each directly and measurably supported by healthy wetland systems. From the groundwater-recharging tank cascades of Tamil Nadu to the flood-attenuating floodplains of the Brahmaputra, from the water-purifying East Kolkata Wetlands to the coastal water protection provided by Sundarbans mangroves, the nexus between wetland health and water security is empirically irrefutable.

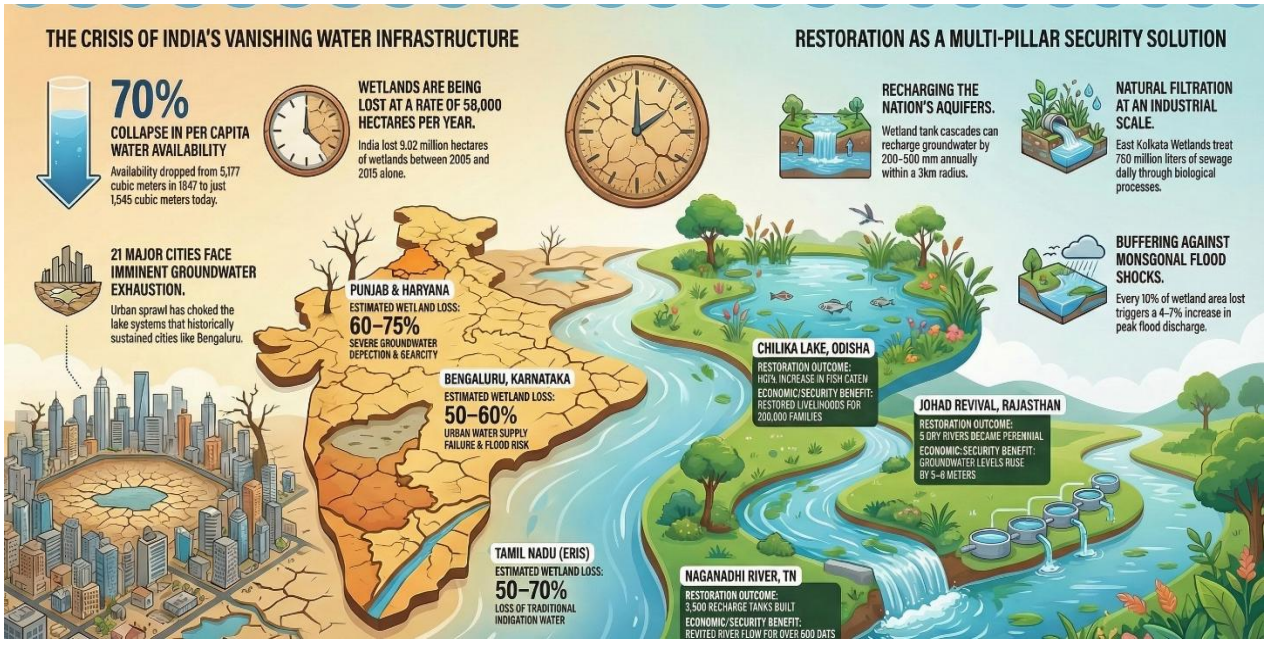
The paper scrutinises India's policy framework — including the Wetlands (Conservation and Management) Rules 2017, the National Wetland Conservation Programme, and Ramsar Convention commitments (98 sites as of 2026) — and identifies critical governance gaps. It showcases restoration successes at Chilika Lake, Harike Wetland, East Kolkata, and through the Johad revival in Rajasthan as proven models for water security co-benefits. Finally, it charts an integrated water security roadmap, weaving wetland management into the Jal Jeevan Mission, the National Water Policy revision, and India's

National Action Plan on Climate Change— arguing that securing India's water future demands treating wetland restoration as a national water infrastructure investment, not merely an environmental objective.

**Keywords:** *water security India, wetland restoration, Ramsar sites, monsoonal hydrology, groundwater recharge, Jal Jeevan Mission, mangroves, urban lakes, National Water Policy, ecosystem services, nature-based solutions, climate resilience, flood attenuation, water quality*

## I. INTRODUCTION: INDIA'S WATER SECURITY EMERGENCY

India faces a critical water security crisis, holding just 4% of global freshwater resources while supporting 18% of the world's population (Kumar et al., 2005). Per capita availability has plummeted from 5,177 cubic meters in 1947 to about 1,545 today—nearing the 1,700 cubic meter water stress threshold—and is projected to drop to 1,340 by 2025 and 1,140 by 2050 (CWC, 2019). These trends threaten farmers, urban households, industries, and ecosystems nationwide. This paper argues that wetland restoration offers the most effective solution. These ecosystems serve as natural infrastructure, delivering groundwater recharge, flood control, and water purification. Yet India has lost nearly one-third to urbanization, pollution, and farming expansion, intensifying water scarcity for millions. Case studies like Chilika Lake and Johad revival show how restoration boosts community livelihoods and climate resilience. The authors urge a national policy elevating wetlands as core economic and infrastructural assets, not mere environmental afterthoughts. India stands at a defining juncture in its relationship with water, possessing just 4% of the world's freshwater resources while supporting 18% of the global population (Kumar et al., 2005). Per capita availability has plunged from 5,177 cubic metres in 1947 to 1,545 today—perilously near the 1,700 cubic metre water stress threshold—and the Central Water Commission projects further declines to 1,340 by 2025 and 1,140 by 2050 (CWC, 2019). These stark figures signal a real-time emergency affecting farmers, urban households, industries, and ecosystems. This paper contends that wetland restoration is India's most vital strategy against escalating water insecurity. These ecosystems act as natural infrastructure, providing groundwater recharge, flood mitigation, and purification. Despite their value, nearly one-third have vanished due to urbanization, pollution, and agricultural expansion, leaving millions in severe stress. Successes at Chilika Lake and through Johad revival demonstrate how habitat recovery restores livelihoods and climate resilience. The authors advocate a unified national policy that prioritizes wetlands as essential economic and infrastructural investments, not secondary environmental concerns.




The subcontinent's monsoonal climate — delivering approximately 80% of annual rainfall within a compressed three-to-four-month window — demands sophisticated water management strategies.

For millennia, Indian civilisations sustained these strategies through a dense, culturally embedded network of wetland ecosystems: step wells (baoris and vavs), interconnected tank cascades (eri systems), floodplain lakes (jhils), tidal marshes, mangrove forests, sacred ponds, and highland wetlands that collectively governed the storage, filtration, and distribution of water across the subcontinent's extraordinary climatic diversity (Rajendra Singh, 2010).

Today, this natural water security infrastructure is in crisis. According to the Ministry of Environment, Forest and Climate Change (MoEFCC, 2023), India has approximately 757,060 wetlands covering 15.26 million hectares. But these figures mask an alarming decline: the Space Applications Centre (SAC-ISRO, 2011) documented a 3.02 million hectare net loss of wetlands between 2005 and 2015 alone, driven by agricultural expansion, urban sprawl, industrial effluents, groundwater over-extraction, and weakly enforced environmental regulation.

The consequences for water security are already catastrophic: 600 million Indians face high to extreme water stress annually (NITI Aayog, 2019); 200,000 people die each year from inadequate access to safe water; 21 major cities, including Delhi, Bengaluru, and Chennai, face groundwater exhaustion; and India ranks 120th out of 122 countries in the EIU's Water Quality Index. The destruction of India's wetlands is not merely an ecological loss — it is a direct, measurable dismantling of the country's water security infrastructure.

This paper's central argument is unequivocal: wetland restoration is water security restoration. India's ambitious water programmes — the Jal Jeevan Mission (JJM), the Atal Mission for Rejuvenation and Urban Transformation (AMRUT), the National Water Mission under the National Action Plan on Climate Change, and the Namami Gange Programme — cannot achieve their water security objectives without restoring the ecological foundations that wetlands provide. The evidence, presented in the sections below, is comprehensive and compelling.

### 1.1 Key Insights from the Literature

A review of the literature reveals that wetland loss and water-resource degradation in India are driven by a complex mix of demographic pressure, policy gaps, and climate change, but also mediated by emerging governance instruments and successful restoration experiences (Hiremath et al., 2013). Across case studies from Assam, Chilika, the Sundarbans, and other Indian wetlands, the literature identifies consistent water security impacts: encroachment and agricultural conversion reduce flood buffering and groundwater recharge; unregulated sand mining lowers water tables and reduces dry-season river flows; and diffuse pollution severely compromises drinking water quality (Subramanian, 2008; CPCB, 2021).

The NITI Aayog Composite Water Management Index (2019) and Kumar et al. (2005) document that India's wastewater treatment infrastructure remains far below the volume of waste generated, exacerbating the eutrophication and degradation of urban and peri-urban wetlands that serve as natural water treatment systems. The Central Ground Water Board (CGWB, 2022) confirms that over 1,000 assessment units are classified as 'over-exploited,' with direct implications for base flows to rivers and wetlands that sustain both ecosystems and water supply. The overarching consensus of the reviewed literature is that sustainable water management in India requires treating wetland protection as core water infrastructure investment — not a peripheral environmental concern (Millennium Ecosystem Assessment, 2005; Ramsar Convention Secretariat, 2021).

## II. WATER SECURITY AND WETLANDS: CONCEPTUAL FRAMEWORK

### 2.1 Defining Water Security in the Indian Context

Water security is defined here as the capacity of a population to safeguard sustainable access to adequate quantities and acceptable quality of water to sustain livelihoods, human well-being, and socio-economic development, while ensuring protection against water-borne pollution and water-related disasters, and preserving ecosystems in a climate of peace and political stability (UN-Water, 2013). In India's context, this definition encompasses four interconnected pillars: (1) Availability — sufficient freshwater in the right place at the right time; (2) Access — physical and economic access to safe

water for all populations; (3) Quality — water free from biological, chemical, and physical contaminants; and (4) Resilience — the capacity to absorb and recover from hydrological shocks including floods, droughts, and pollution events.

India's water security challenge is compounded by extreme spatial and temporal variability. The Brahmaputra basin in Assam receives over 3,000 mm of annual rainfall while Rajasthan's Thar Desert receives less than 100 mm (IMD, 2023). Monsoon dependency means that 70–90% of river flows occur in the four months between June and September, creating chronic water scarcity for the remaining eight months. Climate change is intensifying this variability, with more frequent and intense rainfall events alternating with prolonged dry spells — simultaneously stressing water infrastructure and increasing both flood and drought risk (IMD, 2023). Against this backdrop, the ecosystem services of wetlands are not supplementary to India's water security — they are foundational. Table 1 (below) demonstrates how each of the four water security pillars is directly and measurably served by wetland ecosystem functions, with India-specific evidence.

**Table 1: Wetland Functions and India's Four Water Security Pillars**

| Water Security Pillar | Wetland Function | India-Specific Evidence |
|---|---|---|
| **Availability** | Groundwater recharge; dry-season streamflow regulation | Tank cascades recharge aquifers by 200–500 mm/yr within 3 km radius (NIH, 2019) |
| **Access** | Rural and peri-urban water supply; traditional water body networks | 500,000+ traditional tanks supply drinking/irrigation water to millions (SAC-ISRO, 2011) |
| **Quality** | Natural filtration; water purification ; eutrophication buffering | East Kolkata Wetlands treat 750 MLD of sewage daily (Ramsar, 2002) |
| **Resilience** | Flood attenuation; drought buffering; climate adaptation | 10% wetland loss = 4–7% increase in peak flood discharge (NIH, 2019) |

*Sources: NIH (2019); SAC-ISRO (2011); Ramsar Convention Secretariat (2021); NITI Aayog (2019)*

### 2.2 Classification of India's Wetlands

India's wetlands are extraordinarily diverse, reflecting the country's climatic, topographic, and cultural variety. The National Wetland Inventory and Assessment (SAC-ISRO, 2011) categorises them into 19 types across five broad classes. Each category provides distinct, measurable water security services:

• Himalayan and Trans-Himalayan Wetlands: High-altitude lakes and marshes in Ladakh (Tsomoriri, Pangong Tso), Himachal Pradesh (Chandratal, Renuka), and Sikkim; critical for regional water storage and regulation of perennial river flows that sustain downstream water supply for hundreds of millions.

• Indo-Gangetic and Brahmaputra Floodplain Wetlands: Seasonal floodplain lakes (chaurs, beels, haors) in Bihar, West Bengal, and Assam; vital for groundwater recharge, fisheries, and flood attenuation, directly securing water availability and reducing flood risk for hundreds of millions of people.

• Deccan Plateau Tank Systems: Artificial but ecologically functional tanks (eris, kuntas, cheruvu) numbering over 500,000 across peninsular India; historically the backbone of irrigation and drinking water supply, representing a distributed water security infrastructure of immense national value (Rajendra Singh, 2010).

• Coastal and Estuarine Wetlands: Mangroves (Sundarbans, Bhitarkanika, Pichavaram), salt marshes, coral reefs, and tidal flats; critical for coastal water security, protection of freshwater aquifers from saltwater intrusion, and storm protection for India's 7,517-km coastline.

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• Urban and Peri-Urban Wetlands: Lakes, tanks, and marshes within or adjacent to major cities; historically the primary water supply and storm water management infrastructure of cities including Bengaluru (240+ lakes), Hyderabad, Chennai, and Kolkata.

### 2.3 Key Hydrological Functions Supporting Water Security

Wetlands support India's water security through multiple, interconnected hydrological mechanisms. At the watershed scale, floodplain wetlands along the Ganga, Brahmaputra, Krishna, Godavari, and Mahanadi rivers regulate monsoonal flood pulses, attenuating peak flows and extending the duration of post-monsoon streamflow — directly improving water availability during the lean season (NIH, 2019). At the local scale, village tanks and seasonal ponds maintain soil moisture, support shallow groundwater tables, and provide dry-season water for domestic use and supplementary irrigation. At the coastal scale, mangrove forests buffer river deltas and estuaries from tidal and saltwater intrusion, maintaining the freshwater quality of coastal aquifers and estuarine systems that sustain the livelihoods of over 14 million coastal fishing families (Gopal & Chauhan, 2006).

## III. STATUS AND LOSS OF WETLANDS IN INDIA: A WATER SECURITY CRISIS

### 3.1 National Wetland Inventory and Loss Assessment

India's first comprehensive National Wetland Inventory and Assessment (NWIA), completed by the Space Applications Centre (SAC-ISRO, 2011) using satellite imagery, identified 201,503 wetlands in the country covering 15.26 million hectares. A subsequent comparative analysis found that between 1970 and 2014, India lost approximately 2.68 million hectares of wetland area — an average annual loss rate of 58,000 hectares per year (SAC-ISRO, 2011). Each hectare of wetland lost represents a quantifiable loss in water storage capacity, groundwater recharge potential, flood buffering capacity, and water purification services. State-level assessments reveal even more alarming water security implications: Punjab has lost over 70% of its historical wetland area, directly correlating with groundwater depletion rates of 0.3–1.5 metres per year; and rapid urbanisation in Karnataka has eliminated the interconnected lake system that once constituted Bengaluru's primary water supply infrastructure (Hiremath et al., 2013).

**Table 2: The table compares estimated wetland losses across Indian states and regions based on data primarily from 1970 to 2014**

| State/Region | Key Wetland Systems | Est. Loss (%) | Primary Threat | Water Security Impact |
|---|---|---|---|---|
| Punjab & Haryana | Harike, Kanjli, seasonal lakes | 60–75% | Agricultural drainage, encroachment | Groundwater depletion, drinking water scarcity |
| West Bengal & Bihar | Floodplain beels, chaurs | 40–55% | Agriculture, embankment construction | Reduced flood buffering, aquifer recharge loss |
| Assam | DeeporBeel, Kazirangabeels | 30–45% | Encroachment, drainage, floods | Increased flood risk, fisheries decline |
| Karnataka (Bengaluru) | Bellandur, Varthur, 240+ lakes | 50–60% | Urban encroachment, sewage | Urban water supply failure, flood risk |

| State/Region | Key Wetland Systems | Est. Loss (%) | Primary Threat | Water Security Impact |
|---|---|---|---|---|
| Telangana (Hyderabad) | Hussain Sagar, Osman Sagar | 35–50% | Urbanisation, industrial effluent | Drinking water source degradation |
| Rajasthan | Sambhar, Keoladeo, Siliserh | 25–40% | Water diversion, tourism pressure | Aquifer stress, dry-season water scarcity |
| Kerala (Kuttanad) | Vembanad, backwater system | 30–40% | Agriculture, conversion, pollution | Saline intrusion, coastal water quality loss |
| Odisha | Chilika, Bhitarkanika | 20–30% | Fisheries intensification, siltation | Estuarine water quality decline, livelihoods at risk |
| Tamil Nadu | Tank cascade systems (eris) | 50–70% | Agricultural neglect, urban sprawl | Loss of traditional irrigation water supply |
| Jammu & Kashmir | Dal, Wular, Hokera | 30–50% | Encroachment, weed infestation, siltation | Reduced freshwater storage, tourism water stress |

**Source:** Primarily compiled from Ministry of Environment, Forest and Climate Change (MoEFCC) list "RAMSAR SITES OF INDIA (as on 30.01.2026)" and updated compilations by PWOnlyIAS and PMFIAS, confirming 98 sites with state-wise details

### 3.2 Key Drivers of Wetland Loss and Water Security Degradation

#### 3.2.1 Agricultural Encroachment and Drainage

Agricultural expansion — particularly the Green Revolution-era conversion of wetland margins into paddy and wheat fields — is the single largest historical driver of wetland loss and associated water security degradation in India (Hiremath et al., 2013). The Punjab–Haryana agricultural heartland, once dotted with thousands of seasonal wetlands that recharged the Bari Doab and Bist Doab aquifers, has seen near-total conversion of its natural water bodies. The tragic irony is acute: the drainage of these wetlands has accelerated the depletion of the very groundwater that now sustains irrigation-dependent agriculture, where water tables are declining at 0.3 to 1.5 metres per year (CGWB, 2022). This illustrates how wetland loss directly translates into water availability crises.

#### 3.2.2 Unplanned Urbanisation

India's explosive urbanisation — adding an average of 10 million urban residents per year — has transformed urban water landscapes at a pace that environmental governance cannot match. Bengaluru's urban lake system, once comprising over 262 interconnected lakes that constituted the city's primary water supply and storm water management infrastructure, has been reduced to fewer than 80 functioning water bodies through encroachment, sewage discharge, and drainage (Hiremath et al., 2013). The direct water security consequence: Bengaluru now faces one of India's most acute urban water crises, with the city dependent on costly long-distance water transfers. Chennai's Pallikaranai marshland — once over 5,000 hectares — contracted to fewer than 600 hectares by 2010, directly contributing to the catastrophic 2015 floods that caused losses exceeding ₹20,000 crore and left the city's water supply infrastructure severely damaged (CPCB, 2021).

### 3.2.3 Industrial and Agricultural Pollution

India's wetlands receive the discharge of poorly treated industrial effluents, agricultural runoff laden with fertilisers and pesticides, and vast quantities of untreated municipal sewage, directly undermining water quality security (CPCB, 2021). The Central Pollution Control Board estimates that India generates approximately 72,368 million litres per day (MLD) of sewage, of which only about 28% receives adequate treatment before discharge into water bodies. The resulting eutrophication, oxygen depletion, toxic algal blooms, and heavy metal contamination render thousands of wetlands unable to support safe water supply or biodiversity, creating water quality emergencies across the country. Bengaluru's Bellandur Lake — once a functional wetland supplying the city — has periodically burst into flames due to the build-up of phosphorus-rich foam from untreated sewage (Hiremath et al., 2013), symbolising the water quality cost of wetland neglect.

### 3.2.4 Sand Mining

Rampant and largely unregulated sand mining from riverbeds, floodplains, and wetland margins — driven by India's construction boom — severely disrupts wetland hydrology, destabilises channel morphology, lowers water tables, and degrades aquatic habitats with direct water security consequences (NIH, 2019). Rivers including the Mahanadi, Banas, Betwa, and dozens of others show clear signs of channel incision, bed degradation, and reduced dry-season flows attributable to excessive sand extraction — directly reducing the water available for drinking, irrigation, and industrial use during the dry season when water scarcity is most acute.

### 3.2.5 Climate Change

India is among the most climate-vulnerable countries in the world, and climate change is amplifying every dimension of the water security crisis (IMD, 2023). The Indian Meteorological Department documents clear trends toward increased frequency of extreme precipitation events and prolonged dry spells — making both floods and droughts more severe. The Hindu Kush Himalaya cryosphere — the source of perennial flows in the Indus, Ganga, and Brahmaputra — is undergoing accelerated glacier retreat, threatening the long-term water security of over 500 million people. High-altitude wetlands in Ladakh, Spiti, and Sikkim are drying as glaciers retreat, while the monsoon-fed floodplain wetlands of the Gangetic plain face both more intense flood pulses and longer inter-flood dry periods. Sea level rise — projected at 3–4 mm per year along India's coasts — threatens low-lying coastal mangroves and estuarine wetlands that protect freshwater coastal aquifers from saltwater intrusion (Ramsar Convention Secretariat, 2021).

## IV. WETLANDS AS PILLARS OF INDIA'S WATER SECURITY: EMPIRICAL EVIDENCE

### 4.1 Groundwater Recharge and Aquifer Water Security

India is the world's largest user of groundwater, extracting approximately 253 billion cubic metres (BCM) per year — more than the United States and China combined (CGWB, 2022). Groundwater accounts for approximately 63% of irrigation water and 85% of rural drinking water supply. Yet India's aquifer systems are in critical overdraft: the CGWB (2022) estimates that approximately 17% of India's groundwater assessment units are 'overexploited' and a further 5% are 'critical.' In Punjab, Rajasthan, Haryana, and Tamil Nadu, the situation constitutes a water supply emergency directly affecting millions of people's access to safe drinking water and irrigation.

The relationship between surface wetlands and groundwater recharge — and therefore between wetland health and drinking water security — is direct and well-documented. Studies in the Gangetic alluvial plains show that floodplain wetlands account for 15–25% of shallow aquifer recharge in their catchments (NIH, 2019). Research in Tamil Nadu's tank cascade systems demonstrated that a single large tank in a cascade can recharge groundwater by 200–500 mm per year within a 3-kilometre radius, directly supplying drinking water to surrounding villages (Prasad et al., 2002). The restoration of the Surajkund tank in Delhi's Aravalli foothills increased local groundwater levels by 2–4 metres within three years — translating directly into restored water availability for surrounding communities. India's existing Atal Bhujal Yojana (ATAL JAL) — the national groundwater management scheme — now increasingly integrates wetland restoration as a recharge

strategy in seven priority states, explicitly recognising the water security value of wetland ecosystems. The water security implication is unambiguous: every wetland lost from India's landscape is a diminished recharge zone for the aquifers that supply drinking water to hundreds of millions of rural Indians. Wetland restoration is groundwater security restoration.

### 4.2 Flood Attenuation and Water Resilience

India experiences some of the world's most severe monsoonal flooding, with annual flood losses averaging ₹5,469 crore in direct damages and 1,600 deaths (National Flood Commission). The economic and human costs are catastrophic: the 2013 Uttarakhand floods killed over 6,000 people and caused losses exceeding ₹10,000 crore; the 2015 Chennai floods caused losses of over ₹20,000 crore; and the 2017 and 2019 Kerala floods each caused damages exceeding ₹20,000 crore. In each of these disasters, the destruction or degradation of upstream wetlands was identified as a contributing factor to the severity of flooding — directly demonstrating the water resilience services that wetlands provide (NIH, 2019).

Research by the National Institute of Hydrology (NIH, 2019) has quantified the flood regulation function of floodplain wetlands in the Ganga basin: a 10% reduction in floodplain wetland area corresponds to a 4–7% increase in peak flood discharge. The natural flood storage capacity of Assam's Brahmaputra floodplain wetlands — estimated at several billion cubic metres — provides critical water resilience for the state's 32 million people during peak monsoon flows (Baruah et al., 2020). Yet these same wetlands have contracted by over 35% since 1975 due to embankment construction and agricultural drainage, directly increasing flood hazard and reducing the state's water security resilience. Restoring these wetlands is not merely an ecological imperative — it is a cost-effective, nature-based flood defence and water resilience investment.

### 4.3 Water Quality and Drinking Water Security

The water quality regulation functions of wetlands are of acute, measurable importance for India's drinking water security. The National Green Tribunal has documented severe water quality degradation across India's river and lake systems, with Biological Oxygen Demand (BOD), faecal coliform, heavy metals, and nitrate levels exceeding safe limits in hundreds of water bodies (CPCB, 2021). The Ganga Action Plan and its successor Namami Gange Programme specifically identify the restoration of floodplain and riverine wetlands as essential to achieving water quality targets for the river — recognising that natural wetland filtration processes are irreplaceable components of drinking water treatment infrastructure. The East Kolkata Wetlands (EKW) provide the world's most compelling demonstration of wetland-based water quality security. This 12,500-hectare system of sewage-fed fish ponds on Kolkata's eastern fringe serves as the city's natural sewage treatment system, processing approximately 750 million litres of wastewater per day through natural biological processes — replacing the need for constructed sewage treatment plants at an estimated value of over ₹2,000 crore annually (Ramsar Convention Secretariat, 2021). Simultaneously, it produces approximately 13,000 tonnes of fish per year, sustaining the food security of over 50,000 livelihoods. The EKW is not merely a wetland — it is critical water treatment infrastructure that directly safeguards Kolkata's drinking water security and environmental health.

### 4.4 Coastal Water Security and Mangroves

India's 7,517-kilometre coastline is home to approximately 4,975 square kilometres of mangrove forest, concentrated in the Sundarbans, Bhitarkanika, Pichavaram, Gulf of Kachchh, and the Andaman and Nicobar Islands (MoEFCC, 2023). Mangroves serve as living coastal water security infrastructure: they protect estuarine freshwater systems from saltwater intrusion that would render coastal aquifers undrinkable; they filter sediment and pollutants from upstream agricultural and industrial drainage; and they sustain the nursery habitats that support the livelihoods of over 14 million coastal fishing families (Gopal & Chauhan, 2006).The 2004 Indian Ocean Tsunami provided a natural experiment in the water security value of mangroves: villages behind intact mangrove belts in Tamil Nadu and Andhra Pradesh suffered significantly lower casualties and infrastructure damage than those in deforested coastal stretches. Subsequent studies have quantified mangrove wave attenuation at 70–90% per 100 metres of mangrove width (Gopal & Chauhan, 2006). With sea levels rising and cyclone intensity increasing under climate change, the restoration and protection of India's coastal mangroves is an

urgent coastal water security and disaster risk reduction imperative — directly protecting the freshwater resources and livelihoods of hundreds of millions of coastal Indians.

### 4.5 Traditional Knowledge and Cultural Dimensions of Water Security

India's relationship with wetlands is inseparable from its cultural and spiritual heritage and from its traditional water security systems. The over 500,000 traditional tanks and ponds of peninsular India — many maintained by local communities under customary tenure — represent a vast, distributed water security infrastructure whose engineering sophistication rivals modern constructed systems (Rajendra Singh, 2010).

Their systematic neglect since the colonial period has caused widespread water insecurity in rural areas, but community-led revival efforts demonstrate the power of integrating traditional water wisdom with modern restoration ecology. The johad revival by Tarun Bharat Sangh in Rajasthan transformed chronically water-scarce villages into water-secure communities through traditional wetland and water body restoration — providing a scalable model for rural water security through wetland rehabilitation.

## V. WETLAND RESTORATION FOR WATER SECURITY: CASE STUDIES

### 5.1 Chilika Lake, Odisha: Restoring Water Security at Scale

Chilika Lake, spanning over 1,100 square kilometres along the Odisha coast, is India's largest coastal lagoon and a Ramsar Site of international importance. By the 1990s, decades of unregulated aquaculture, siltation from the Mahanadi catchment, and weed proliferation had severely degraded the lagoon's water security services. Fish catches declined by over 50%, and the livelihoods and water security of over 200,000 fisher families were in crisis (CDA, 2018). The Chilika Development Authority (CDA, 2018) implemented a comprehensive restoration programme: hydrological reconnection with the sea through an engineered new mouth opened in 2000; weed removal and aquaculture regulation; and catchment watershed management to reduce siltation. The water security outcomes were transformative: salinity levels normalised, restoring the estuarine ecosystem's water quality functions; fish diversity recovered from 58 to over 225 species; fish catches recovered by over 180%, directly restoring food and livelihood security for over 200,000 families; and Irrawaddy dolphins returned in increased numbers, signalling ecosystem health recovery. The Chilika restoration demonstrates that investing in wetland restoration directly yields measurable, sustained water security and livelihood benefits at scale.

### 5.2 Harike Wetland, Punjab: Water Security Through Multi-Stakeholder Restoration

Harike Wetland — formed by the confluence of the Beas and Sutlej rivers in Punjab and declared a Ramsar Site in 1990 — is the largest wetland in northern India. By the early 2000s, it suffered severe water quality degradation from agricultural drainage, industrial discharge, and water hyacinth proliferation covering over 70% of the water surface, rendering the wetland unable to fulfil its water security functions (WWF-India, 2018).A multi-stakeholder restoration programme involving the Punjab government, NABARD, and WWF-India implemented water hyacinth mechanised removal, effluent interception from upstream drains, online water quality monitoring, and a water quality management plan. Progressive improvements in water quality have been documented, bird diversity has partially recovered, and the river dolphin population has stabilised (WWF-India, 2018). The Harike experience demonstrates both the feasibility and the necessity of wetland restoration for water quality security — and highlights that achieving sustained water security benefits requires integrated catchment management that addresses upstream pollution sources.

### 5.3 East Kolkata Wetlands: Wetland as Urban Water Security Infrastructure

The East Kolkata Wetlands (EKW) represent the world's most innovative example of using a natural wetland ecosystem as critical urban water security infrastructure. This 12,500-hectare mosaic of sewage-fed ponds, vegetable gardens, and paddy fields on Kolkata's eastern fringe has treated the city's sewage for over a century using natural biogeochemical processes, safeguarding the water quality of the broader Bengal delta system (Ramsar Convention Secretariat, 2021). Sewage

channelled into shallow oxidation ponds is processed by sunlight, algae, macrophytes, bacteria, and fish — collectively removing biological oxygen demand, nutrients, and pathogens. The treated water irrigates vegetable farms; fish grown in the ponds supply approximately 40% of Kolkata's fish consumption.

The EKW provides water treatment services equivalent to a modern sewage treatment plant at a fraction of capital and operating cost, while simultaneously providing food production, employment for over 50,000 people, and biodiversity habitat. Ramsar designation in 2002 provides some legal protection, but the EKW faces relentless pressure from real estate development. Its continued protection is one of the most important urban water security challenges facing not only Kolkata, but India's entire approach to nature-based urban water management.

### 5.4 Bengaluru's Lake Restoration: Progress and Persistent Challenges

Bengaluru was built on a foundation of over 262 interconnected lakes engineered by the Kempegowda dynasty in the 16th century — a cascading tank system designed to capture every drop of the city's limited rainfall and route it progressively through chains of water bodies that recharged aquifers and supplied the city's water needs. By 2000, fewer than 80 lakes remained functional, the rest encroached upon, drained, or choked with sewage and industrial effluents — directly contributing to Bengaluru's current acute water security crisis and its complete dependence on distant river transfers (Hiremath et al., 2013).Since 2015, a combination of High Court orders, citizen activism, and the Lake Development Authority (LDA) have undertaken restoration of select lakes including Sankey Tank, Puttenahalli, Kaikondrahalli, and Jakkur. Community-led restoration programmes have improved water quality and revived bird populations. However, the critical challenge of intercepting sewage inflows remains largely unaddressed, and the water security benefits of isolated lake restoration without systemic catchment-level wastewater management are limited. The Bengaluru experience underscores a fundamental lesson: urban water security requires treating lake and wetland restoration as integrated urban water infrastructure investment, not isolated ecological projects.

### 5.5 Johad Revival, Rajasthan: Community-Led Wetland Restoration for Water Security

In the drylands of Alwar district, Rajasthan — an area that had experienced severe groundwater depletion, stream drying, and village abandonment by the 1980s — a grassroots movement led by the Tarun Bharat Sangh (TBS) and Rajendra Singh began reviving traditional earthen check dams (johads) from the early 1990s (Rajendra Singh, 2010). Over 8,600 johads and related water structures were constructed or restored across 1,000 villages in the Arvari, Ruparel, and Sarsa river catchments.The water security results were transformative: five seasonal rivers that had run dry became perennial, directly restoring water availability for agriculture and domestic use; groundwater levels rose by 3–6 metres across the catchment, restoring well water access to thousands of households; irrigated area expanded by over 35,000 hectares; and communities that had abandoned their villages returned, their water security restored. The Johad revival demonstrates three critical principles for water security through wetland restoration: the power of traditional wetland knowledge for water security; the effectiveness of distributed small-scale wetland restoration for achieving watershed-scale hydrological recovery; and the scalability of community-led approaches. This initiative received international recognition when Rajendra Singh was awarded the Stockholm Water Prize in 2015, validating community-led wetland restoration as a global water security model.

### 5.6 Naganadhi River Restoration in Tamil Nadu

The Naganadi River (also spelled Nagnadhi), a seasonal waterway spanning 48 km from Amirthi through Vellore and Thiruvannamalai districts in Tamil Nadu, dried up for over 20 years due to overexploitation, deforestation, and erratic monsoons. Farmers lost irrigation, groundwater plunged to 1 meter, and villages like Kammavanpettai saw women trek miles for water amid unemployed husbands and family strife. In 2014, The Art of Living Foundation launched a River Rejuvenation Project. Scientists and geologists surveyed the 366 sq km catchment, pinpointing interventions like recharge wells and boulder check dams. Self-development programs built women's confidence, drawing 20,000 volunteers—expanding to 44,000 under MGNREGA across 14 districts—who constructed 3,500 recharge tanks, 354 wells, and 207 check dams over four years. Groundwater rose dramatically to 8 meters, refilling dry wells (e.g., a 32-foot well reached 26 feet) and reviving Naganadhi to perennial flow for over 600 days—now exceeding three years. Farmers now harvest three

crops annually, bore wells run continuously, and villages like Salamanthanam celebrate water after 15 years. Women like Anandi and Chitra gained financial independence, technical skills, and community pride. Prime Minister Narendra Modi praised the effort multiple times on *Mann kiBaat*, Vellore won a 2019 Best District award for river revival, and Tamil Nadu's Governor honoured the initiative. This women-led, nature-based model revived 23 rivers state-wide, aligning with national water security goals and inspiring scalable solutions for drought-prone region

### 5.7 Kumudavathi River Restoration in Karnataka

The Kumudvathi River, a key tributary of the Arkavathi in Bengaluru Rural and Ramanagara districts, once sustained 278 villages across 460 sq km but dried up by the early 2000s. Originating from Shivagange Hills, it fed the Thippagondanahalli (TG Halli) Reservoir, which supplied 30-40% of Bengaluru's drinking water until depleting in 2007 amid a 20% city shortage. Eucalyptus plantations since the 1960s, promoted for industry, guzzled groundwater; quarrying, urban sprawl, and bore well over-extraction obliterated 100 streams. Farmers shifted to water-guzzling crops then eucalyptus for survival, sparking soil erosion, plummeting water tables, migration, and socio-economic collapse in villages like Tavarekere and Makankuppe. In 2013, The Art of Living's International Association for Human Values (IAHV), led by hydrologist launched a community-driven revival. Inspired by the Art of Living Foundations Leadership, volunteers mapped 18 mini-watersheds and piloted recharge wells, boulder checks, and desilting, proving results to sceptical locals.

They secured Rs 40 crore via MGNREGA from Zilla and Gram Panchayats, with nine panchayats pledging support. Corporates like Hindustan Aeronautics Limited (HAL) joined through CSR by 2017, funding efforts in key areas. A holistic strategy restored the hydrological cycle: 885 recharge wells, 54 deep injection wells (350-500 ft), and 44 bore wells replenished aquifers; 1,749 boulder checks and 223 water pools (20x20x5m) slowed runoff and boosted percolation; desilting revived 20+ kalyanis and tanks. Afforestation planted 86,000 indigenous saplings (neem, tamarind, jackfruit), shunning exotics. Farmers' clubs promoted organic farming, while youth training and stress workshops built stewardship. By 2025, 2,513 structures covered the basin, with Bengaluru volunteers training locals Sundays. Outcomes transformed the landscape: groundwater rose 1-8m, wells held summer water, tanks sustained levels, and agriculture yielded three crops yearly in pilots like Makankuppe. Soil erosion stopped, biodiversity surged, migration fell, and economies revived. TG Halli saw inflows, easing Bengaluru's crisis. This scalable model, now inspiring Vedavathi revival with 17,224 structures, proves grassroots science and participation can reverse ecological collapse.

### 5.8 Sembakkam lake Restoration for Water security in Tamil Nadu

Chennai, the bustling largest city in India's southern state of Tamil Nadu, relies on 474 wetland complexes as its vital lifeline for people, nature, and wildlife. These ecosystems have sustained the metropolis for generations, providing essential services like water storage, purification, and habitat support. However, over the past few decades, rapid urbanization has taken a heavy toll. Human encroachment, untreated sewage discharges, rampant garbage dumping, and unchecked economic expansion have degraded most of these wetlands, lakes, and rivers. While urban development has elevated living standards for millions, it has simultaneously eroded the city's fragile water sources, exacerbating vulnerabilities to water scarcity and flooding. Among the most affected is Lake Sembakkam, one of 54 lakes that feed into the Pallikaranai Marshland—a critically important and fragile wetland in Tamil Nadu. This marshland stands as one of Chennai's last natural refuges, harbouring rare and threatened species while serving as a key breeding ground for thousands of migratory birds, including the Wood Sandpiper, Comb Duck, Northern Shoveler, pintail ducks, cormorants, spoonbills, and Spot-billed Pelicans. Originally spanning over 8,000 hectares, only about 10% of the marshland remains today, now safeguarded against further development.

Until recent decades, it functioned as a powerhouse for groundwater recharge and flood mitigation during monsoons, absorbing excess rainwater to prevent urban inundation. Lake Sembakkam itself, encircled by dense residential neighbourhoods, exemplifies this decline. Invasive aquatic weeds choke its waters, while untreated wastewater from nearby homes flows directly into it, mixing with thick sludge, silt, and solid waste accumulations. These pollutants have transformed the once-vibrant lake into a stagnant, health-hazardous site, diminishing its capacity to support aquatic life and

recharge aquifers. Encroachment has further shrunk its boundaries, amplifying risks to both human health—through contaminated water and vector-borne diseases—and the broader ecosystem connected to Pallikaranai. In 2018, efforts by The Nature Conservancy along with Care Earth Trust and IIT Madras began to restore Lake Sembakkam, aiming for multifaceted benefits: bolstering water security for local communities, reviving biodiversity, and enhancing environmental resilience. By clearing silt, removing invasive, and curbing waste dumping, these initiatives not only rejuvenate the lake but also improve the health of interconnected lakes and the Pallikaranai Marshland. Putting wetlands back to work promises safer drinking water, reduced flood risks, healthier habitats, and better public health outcomes for Chennai's residents.

## VI. INDIA'S POLICY AND INSTITUTIONAL FRAMEWORK FOR WETLAND-WATER SECURITY

### 6.1 Wetlands (Conservation and Management) Rules, 2017

The Wetlands (Conservation and Management) Rules 2017, notified under the Environment Protection Act 1986, represent India's primary legislative instrument for wetland governance and, by extension, for protecting the water security services these ecosystems provide (MoEFCC, 2017). The Rules prohibit reclamation, construction, hazardous substance storage, and industrial activity within notified wetlands. They establish State Wetland Authorities (SWAs) in each state and union territory with the mandate to identify, notify, and manage wetlands within their jurisdiction.However, the implementation of the 2017 Rules falls critically short of what India's water security demands (Hiremath et al., 2013). The Rules apply only to notified wetlands, leaving the vast majority of India's 200,000+ wetlands — and their water security services — unprotected. As of 2024, only 95 wetlands have been notified — a fraction of those whose water security functions urgently require legal protection. Penalties for violations are weak, and the capacity of State Wetland Authorities to undertake scientific monitoring and enforcement is severely limited, undermining the protection of wetlands as water security infrastructure.

**6.2 India's Ramsar Sites: Progress and Water Security Gaps:** India hosts Asia's largest network of Ramsar sites, vital wetlands designated under the Convention on Wetlands for their ecological significance in biodiversity conservation, flood control, and water security. As of March 2026, the country boasts 98 such sites spanning over 1.5 million hectares, reflecting both remarkable growth since the first designation in 1981 and ongoing challenges for some under the Montreux Record.

**Table 3: Key Facts about India's Ramsar Sites as of 2026**

| Attribute | Details |
|---|---|
| Total Ramsar Sites (March 2026) | 98 sites — highest count in Asia |
| Total Ramsar Site Area | Over 1.5 million hectares |
| States with Most Sites | Tamil Nadu (20), Uttar Pradesh (11), Punjab (6) |
| Largest Ramsar Site | Sundarbans, West Bengal (423,000 hectares) |
| Highest Altitude Site | Tsomoriri, Ladakh (~4,522 meters) |
| Smallest Ramsar Site | Renuka Wetland, Himachal Pradesh (20 hectares) |
| First Site Designated | Chilika Lake, Odisha (1981) |

| Attribute | Details |
|---|---|
| Sites Under Montreux Record | Keoladeo National Park (Rajasthan), Loktak Lake (Manipur), Wular Lake (Jammu & Kashmir) |

Despite the impressive expansion in site numbers, Ramsar designation alone does not guarantee protection of water security services: many Ramsar sites lack management plans, adequate buffer zones, or sufficient funding.

The monitoring of ecological character changes — including critical water security indicators such as water quality, groundwater recharge rates, and flood buffering capacity — is inadequate, and annual reporting to the Ramsar Secretariat is often delayed or incomplete (Ramsar Convention Secretariat, 2021).

### .3 National Programmes with Water Security-Wetland Dimensions

Several national programmes have direct implications for water security through wetland conservation. The National Wetland Conservation Programme (NWCP), implemented by MoEFCC since 1985, has provided financial and technical support for wetland conservation. However, its coverage and funding remain inadequate relative to the water security services at stake (MoEFCC, 2023). The Namami Gange Programme — a flagship ₹20,000 crore initiative — includes floodplain and riverine wetland restoration as a component of river rejuvenation, recognising that restoring wetlands along the Ganga is essential to restoring the river's water quality for the 500 million people who depend on it. AMRUT 2.0 specifically mandates Water Bodies' Rejuvenation Plans for cities, acknowledging the water security role of urban wetlands — though implementation capacity at the municipal level remains the critical constraint (Shraavana et al., 2009).

### 6.4 India's Climate Commitments and Wetland Water Security

India's Nationally Determined Contributions (NDCs) under the Paris Agreement commit to creating an additional carbon sink of 2.5–3 billion tonnes of $CO_2$ equivalent through additional forest and tree cover by 2030. Wetlands — particularly peatlands and mangroves — are significant carbon sinks that are not yet adequately integrated into India's NDC accounting (Ramsar Convention Secretariat, 2021). More critically from a water security perspective, wetland restoration delivers co-benefits across water availability, water quality, and water resilience that are not captured in current climate finance metrics. Integrating wetland water security services into India's climate adaptation finance frameworks — including the National Adaptation Fund for Climate Change (NAFCC) — would unlock significantly greater investment in wetland restoration as a climate-resilient water security strategy.

## VII. CHALLENGES AND BARRIERS TO WETLAND WATER SECURITY GOVERNANCE

### 7.1 Governance Fragmentation

Wetland governance in India suffers from severe institutional fragmentation that directly undermines water security outcomes (Saravanan et al., 2009). Depending on location and type, a wetland may fall under the jurisdiction of MoEFCC, the Ministry of Jal Shakti, the Ministry of Agriculture, state forest departments, urban local bodies, the National Biodiversity Authority, the Coastal Regulation Zone notification, or the Ministry of Fisheries. This jurisdictional fragmentation creates regulatory gaps, conflicting mandates, and perverse incentives — making coordinated management effectively impossible and allowing the water security services of wetlands to be sacrificed to sectoral development interests.

### 7.2 Land Tenure, Encroachment, and Political Economy

Land pressure is among the most powerful drivers of wetland loss and associated water security degradation in India. Wetland margins are commonly encroached upon by farmers, real estate developers, and local political actors, driven by land values that do not reflect the water security services being destroyed (Hiremath et al., 2013). The weak documentation of wetland boundaries and the absence of cadastral records distinguishing wetland from dryland make legal water security

protection difficult to enforce. High land values in urban areas create enormous incentives for corruption, and many 'lake restoration' projects have in practice served as pretexts for formalising encroachments — destroying the very water security infrastructure they purport to protect.

### 7.3 Inadequate Funding and Economic Valuation of Water Security Services

The total annual investment in wetland conservation and restoration in India is estimated at approximately ₹500–800 crore — a fraction of what is needed to protect the water security services these ecosystems provide (NITI Aayog, 2019). The fundamental problem is the absence of systematic economic valuation of wetland water security services in national accounts. If the water purification, flood regulation, groundwater recharge, and fisheries services of India's wetlands were fully valued in GDP accounting, the economic case for wetland protection over development would be unambiguous. The East Kolkata Wetlands alone provide water treatment services valued at over ₹2,000 crore annually (Ramsar Convention Secretariat, 2021) — yet this value is invisible in standard economic planning frameworks. Integrating natural capital accounting of wetland water security services into India's planning frameworks is an essential prerequisite for rational investment in wetland conservation.

### 7.4 Scientific Capacity and Data Gaps

Despite India's considerable scientific capacity, critical data gaps persist that hamper evidence-based wetland water security governance (NIH, 2019). There is no systematic, regular national wetland condition assessment; ecological and hydrological monitoring networks for major wetlands are inadequate; and long-term datasets needed for adaptive water security management are largely absent. The National Wetland Inventory mapped wetland extent but does not assess water security functions including water quality, groundwater recharge rates, flood buffering capacity, or ecosystem service provision (SAC-ISRO, 2011). Developing India's capacity in wetland hydrology science — through the National Institute of Hydrology, Wildlife Institute of India, and university research centres — is a strategic investment in evidence-based water security governance.

## VIII. RECOMMENDATIONS: AN INTEGRATED WATER SECURITY ROADMAP

### 8.1 Enact a Comprehensive National Wetlands Act

India urgently needs a standalone National Wetlands Act that provides a strong, unified legal framework recognising wetlands explicitly as national water security infrastructure, not merely ecological features requiring conservation (Hiremath et al., 2013). The Act should define wetlands clearly, establish a National Wetland Registry with legal force, create a National Wetlands Authority with dedicated funding and scientific capacity, and provide stringent penalties for encroachment and pollution. Critically, the Act must explicitly recognise the water security services of wetlands and make their protection a national water security obligation — aligning wetland governance with India's water security goals rather than treating them as separate policy domains.

### 8.2 Integrate Wetlands into the Jal Jeevan Mission and National Water Policy

The Jal Jeevan Mission — India's programme to provide tap water connection to every rural household — must explicitly recognise that sustainable water supply depends on functioning watershed wetland systems (NITI Aayog, 2019). Source sustainability assessments for all JJM schemes should include wetland inventory and health assessment, treating wetland restoration as a water source protection investment. The forthcoming revision of India's National Water Policy should include a dedicated chapter on wetlands as water infrastructure, establishing minimum ecological flows for wetland-dependent water systems and integrating wetland management into basin-level water allocation frameworks — ensuring that water security planning accounts fully for the contributions of natural wetland systems.

### 8.3 Scale Up the National Wetland Conservation Programme

The NWCP budget should be increased tenfold — from approximately ₹50 crore per year to ₹500 crore per year — with investment explicitly directed toward measurable water security outcomes (MoEFCC, 2023). Priority restoration should target floodplain wetlands in the Ganga, Brahmaputra, Mahanadi, and Krishna basins that provide measurable flood

attenuation, groundwater recharge, and water quality benefits; coastal mangroves that protect freshwater aquifers from saltwater intrusion; and urban lake systems that serve as critical storm water management and water supply infrastructure. All restoration investments should be evaluated against water security indicators including groundwater levels, flood reduction, and water quality improvement, making water security co-benefits central to programme accountability.

### 8.4 Recognise and Support Community-Based Wetland Water Security Stewardship

India's millions of village ponds, tanks, and seasonal water bodies — when managed by local communities — provide cost-effective, distributed water security infrastructure at a scale that government programmes alone cannot replicate (Rajendra Singh, 2010). Formal legal recognition of community wetland rights under the Panchayati Raj Institutions, Joint Forest Management, and the Forest Rights Act would provide communities with institutional authority and economic incentives to restore and manage local water bodies as community water security assets. MGNREGS should actively promote tank desiltation, bund repair, and wetland restoration as priority works — simultaneously providing rural employment and investing in distributed rural water security infrastructure.

### 8.5 Urban Wetland Protection as Urban Water Security Strategy

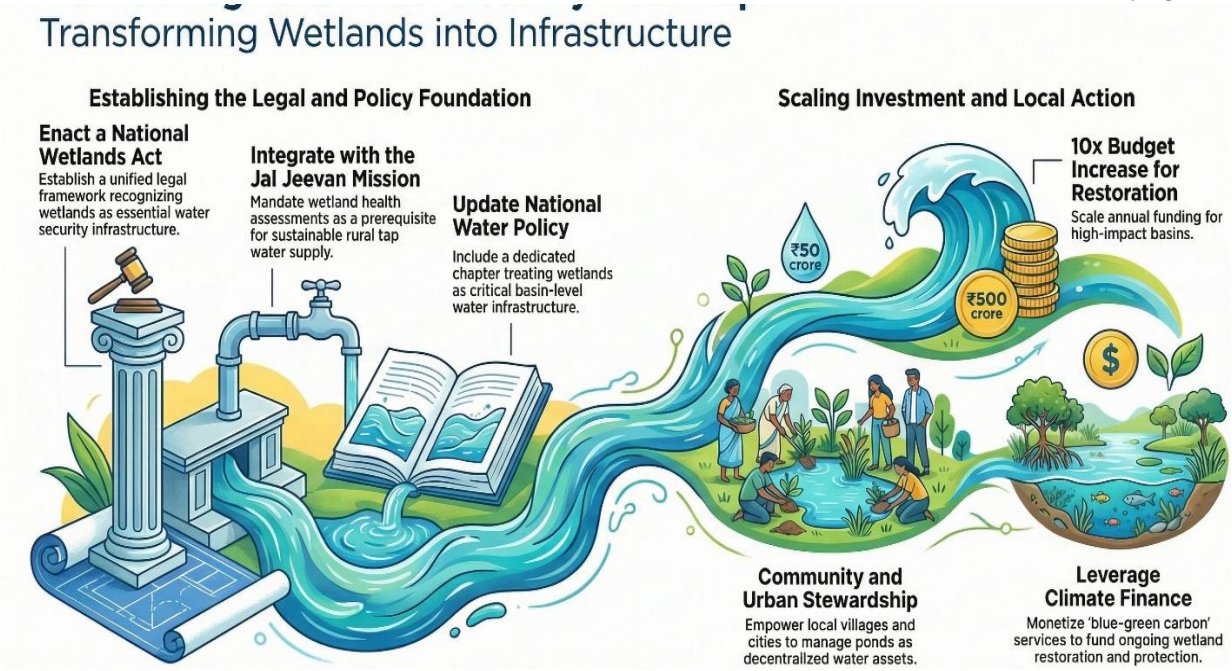
Every major Indian city should develop a comprehensive Urban Wetland Conservation and Restoration Plan, integrating lake and pond management into master plans, storm water management strategies, and urban water supply planning — treating urban wetlands explicitly as urban water security infrastructure (Hiremath et al., 2013).

The plan should: legally demarcate all urban water bodies and strictly prohibit encroachment; mandate sewage interception as a precondition for restoration; establish community stewardship committees for each water body; and integrate urban wetlands into green building and storm water management codes. The economic value of urban wetlands as water security assets — storm water detention, aquifer recharge, water quality improvement — should be formally incorporated into urban planning cost-benefit analysis, making the water security case for wetland protection financially transparent.

### 8.6 Mainstream Wetland Water Security in India's Climate Finance Architecture

India should accelerate the development of a national blue-green carbon and water security framework that quantifies and monetises the water security, carbon sequestration, and storage services of mangroves, peatlands, and freshwater wetlands (Ramsar Convention Secretariat, 2021). Revenue generated from wetland carbon and water security credits should flow to wetland restoration funds and community stewards, creating sustainable financing for the protection of natural water security infrastructure. The inclusion of coastal mangrove and inland peatland functions in India's NDC accounting would both strengthen India's climate ambition and ensure that wetland water security services receive the investment they merit. India's National Water Mission and National Adaptation Fund should establish dedicated wetland water security restoration funding streams as a priority adaptation investment.

Infographic outlines India’s Integrated Water Security Road Map for safeguarding India's future by treating wetlands as vital water security infrastructure rather than just ecological sites. It advocates for the creation of a comprehensive National Wetlands Act to establish unified legal protections and dedicated funding for these natural assets. The recommendations emphasize integrating wetland health into major initiatives like the Jal Jeevan Mission and urban planning to ensure sustainable water supplies and flood mitigation. Furthermore, the source suggests scaling up financial investments and empowering local community stewardship to manage decentralized water bodies effectively. Finally, it proposes utilizing climate finance and carbon credits to monetize the environmental services provided by these ecosystems, positioning their restoration as a primary strategy for climate adaptation




## IX. CONCLUSION: WETLAND RESTORATION IS WATER SECURITY

India's water future will be determined, in no small measure, by how the nation treats its wetlands in the coming decade. The evidence presented in this paper is unambiguous: India's wetlands are not peripheral ecological features but foundational national water security infrastructure. They recharge the aquifers that supply drinking water to 85% of rural India and support the irrigation of half of India's farmland (CGWB, 2022). They attenuate the monsoonal floods that kill thousands and displace millions each year (NIH, 2019). They filter the agricultural and industrial pollutants that would otherwise render India's rivers and groundwater undrinkable (CPCB, 2021). They protect India's coastlines from storm surges and saltwater intrusion that threaten coastal freshwater supplies in an era of rising seas (Gopal & Chauhan, 2006). And they sustain the fisheries, livelihoods, and cultural identities of hundreds of millions of Indians who have coexisted with these water-giving ecosystems for millennia.

Every metric of India's water crisis — the 600 million facing high water stress, the 21 cities approaching groundwater exhaustion, the 200,000 deaths annually from unsafe water, the escalating costs of floods and droughts — reflects, in part, the accumulated cost of wetland destruction (NITI Aayog, 2019). The trajectory of the past fifty years — relentless wetland loss driven by encroachment, drainage, pollution, and neglect — represents not merely an environmental failure but a systemic, quantifiable undermining of national water security. The cities flooding with each monsoon, the farmers drilling ever deeper for water, the coastal communities watching their mangrove shields erode — all are paying the price of treating wetlands as wasteland rather than as the water infrastructure they are.

The path forward requires an immediate policy reorientation: from treating wetland restoration as an environmental objective to recognising it as a water security investment with measurable, economically quantifiable returns. The tools are established and proven: community-based restoration as demonstrated in Rajasthan's Johad revival (Rajendra Singh, 2010); large-scale ecological restoration as achieved at Chilika Lake (CDA, 2018); nature-based urban water infrastructure as exemplified by the East Kolkata Wetlands (Ramsar Convention Secretariat, 2021); integrated catchment management as piloted at Harike (WWF-India, 2018); and the mainstreaming of wetland functions into water, climate, and development policy frameworks as recommended across the reviewed literature (Hiremath et al., 2013; NITI Aayog, 2019).

What is required is the political will to deploy these tools at the speed and scale that India's water security emergency demands. India has always understood, at the deepest cultural level, that water is life — Jal Hi Jeevan Hai. Its wetlands are the custodians of that life. Their restoration and protection is not an environmental luxury. For India, in the 21st century, securing water security means securing its wetlands. They are one and the same.

## X. ACKNOWLEDGMENT

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## XI. ETHICAL CONSIDERATION

This research uses publicly available secondary data with ethical adherence to proper citations and the avoidance of confidentiality breaches. The use of Google scholar for select sections of drafting and references and synthesis is hereby acknowledged, in keeping with emerging norms of academic transparency.

## XII. LIST OF ACRONYMS

AMRUT — Atal Mission for Rejuvenation and Urban Transformation
ATAL JAL — Atal Bhujal Yojana (national groundwater management scheme)
BBMP — Bruhat Bengaluru Mahanagara Palike
BCM — Billion Cubic Metres
BOD — Biological Oxygen Demand
CDA — Chilika Development Authority
CGWB — Central Ground Water Board
$CO_2$ — Carbon Dioxide
CPCB — Central Pollution Control Board
CWMI — Composite Water Management Index
EIU — Economist Intelligence Unit
EKW — East Kolkata Wetlands
GDP — Gross Domestic Product
GIS — Geographic Information System
IMD — Indian Meteorological Department
ISRO — Indian Space Research Organisation
IWRM — Integrated Water Resources Management
JJM — Jal Jeevan Mission
LDA — Lake Development Authority
MLD — Million Litres per Day
MoEFCC — Ministry of Environment, Forest and Climate Change
MGNREGS — Mahatma Gandhi National Rural Employment Guarantee Scheme
NABARD — National Bank for Agriculture and Rural Development
NAFCC — National Adaptation Fund for Climate Change
NAPCC — National Action Plan on Climate Change
NDC — Nationally Determined Contribution
NGT — National Green Tribunal
NIH — National Institute of Hydrology
NITI Aayog — National Institution for Transforming India (Policy Commission)
NWCP — National Wetland Conservation Programme
NWIA — National Wetland Inventory and Assessment
SAC — Space Applications Centre (of ISRO)
SACON — Salim Ali Centre for Ornithology and Natural History

SWA — State Wetland Authority
TBS — Tarun Bharat Sangh
WII — Wildlife Institute of India
WWF — World Wildlife Fund

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