

The flow of tradition: Indigenous and folk approaches to water conservation in India

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Abstract

Water being always crucial to India's civilizational ethos, ancient and traditional systems had context-specific, sustainable, communal solutions. The paper traces the centuries-old heritage of water management in India, which includes the advanced hydraulic engineering of the Indus Valley Civilization and the *Grandala and Kuti* systems, to temple tanks, anicuts and agroforestry practices. It demonstrates how every ecological zone, from the scorching Rajasthan deserts with *Johads* and *Kunds*, to the northeastern *Zabo* and bamboo drip irrigation systems, evolved its own set of solutions to tackle water scarcity. The research also juxtaposes traditional systems with contemporary, infrastructure-heavy centralized water and shows vital contrasts regarding sustainability, resilience, participation and social justice. Traditional systems highlight ecological harmony, inclusiveness and resilience to climatic fluctuations, as opposed to modern concerns about scale and efficiencies. In highlighting water-stressed India, particularly West Bengal, it throws up critical challenges of over-exploitation, pollution, climate change and unequal distribution of groundwater. It believes that revitalizing, integrating and modernizing traditional ways would go a long way in enhancing the resilience and sustainability of India's water management. In so doing, the paper contributes critical knowledge for policymakers, academics and communities aiming to confront and mediate the escalating water crisis of our times through the wisdom of tradition.

Keywords: Agroforestry, Groundwater, Indigenous water systems, Sustainability, Traditional water management, Water scarcity

1. Introduction

At the heart of Indian civilization, water played a decisive role in agricultural productivity, settlement patterns and cultural practices. The advanced drainage and storage techniques of the Indus. Be it the sophisticated drainage and storage systems of the Indus Valley Civilization (2600–1900 BCE), or the temple tanks, *baolis* and canals created by medieval kings, India has traditionally depended on indigenous water management (Kapadia K., 2011; Murthy, 2022). These are systems, certainly, but they are also social institutions created through collective will and community participation (Singh, 2004; Sambrani and Jayadatta, 2017). Traditions like the *grandala tanks* in Maharashtra, *Kutis* in the Gangetic plains and the *Johads* of Rajasthan portray how communities working within local contexts designed solutions that were sensitive to their climates and ecological needs (Jain and Neha, 2019;

Rawat A., 2023). The eastern Himalayan *Apatani* terraces and the northeastern *Zabo system*, which integrated forestry, farming and rainwater capture, are instances of advanced ecological knowledge (Chandrasekara *et al.*, 2025). Continuing this legacy, India at present is grappling with an acute water stress as a consequence of a rapidly growing population, industrialization and urbanization and climate variability (Naz and Subramanian, 2010). Overexploitation of groundwater, pollution of rivers and lakes, irrigation mismanagement and inequitable access have exacerbated the crisis (Sharma, 2009). Dams, canals and similar control structures have increased supply but often disturbed ecosystems, displaced communities and did not guarantee sustainability (Kapadia K., 2011). The case in point is that the West Bengal's water body census (2023) reveal that more than 7,47,000 water bodies are

there, with a mere 5% of them lying unused, pisciculture (fishing) is the major contributor with 85.9% of the water body use, following that are irrigation and domestic uses (Murthy, 2022).

Precolonial hydro social relations were formed around a fragmented, locally adjudicated and ecologically adaptable water management matrix that promoted resilience to droughts, flooding and climate variability (Singh, 2004; Sambrani and Jayadatta, 2017). Today's water infrastructures, for all their technological sophistication, are capital intensive, energy dependent and frequently exclusionary. Though meritocracy is claimed under large scale structures, they do not match the scale of inclusion and ecological integration as the traditional system (Jain and Neha, 2019; Chandrasekara *et al.*, 2025). Balancing this struggle provides marvellous possibility for rethinking indigenous systems not as residues of the past but as water-forms for the future.

Amid India's water preoccupations stress in arid zones (Rajasthan and Tamil Nadu), aquifer overdraft in farming regions (Punjab and Haryana) and urban water scarcity (Howrah and North 24 Parganas), there is still much to learn from what has worked, what struggled and what is still in use. This study contributes to the literature and fills a critical gap in studies on highland water by systematizing and contextualizing these largely neglected irrigation systems. It argues that traditional systems are not simply anachronistic histories but real, culturally embedded methodologies that have the potential to inform and complement contemporary infrastructure for a sustainable and just water future (Rawat A., 2023; Chandrasekara *et al.*, 2025).

Although there is extensive literature, several issues remain under investigation. There are still few direct comparisons between traditional and modern systems, particularly in relation to sustainability, resilience and equity (Kapadia K., 2011; Murthy, 2022). Like almost every aspect of formal water governance, indigenous knowledge is itself poorly incorporated and, in many instances, has been relegated to being characterized as backward (Singh, 2004). As subnational studies like that of West Bengal with its multiple water bodies are missing from the research discourse (Murthy, 2022). In addition to the already mentioned problem of ethnographic representation of clients and clients' communities being underreported, there is the problem that much of the focus on customary systems agency and equity two crucial ingredients in the usual spin of customary systems has been under analysed in contrast to technical (Sambrani and Jayadatta, 2017). Finally, the potential contributions of indigenous water practices to global development initiatives, such as SDG 6, remain largely unexamined (Rawat J., 2023; Chandrasekara *et al.*, 2025).

1.1. Significance of the study

This research is significant in three ways. For one, it restores the ecological and cultural significance of

indigenous water management into the realm of possible solutions to India's dire water situation (Jain and Neha, 2019). Second, it creates a comparative structure for policy consideration, illustrating how traditional practices can work in tandem with modern water infrastructures (Kapadia V.P., 2011). Thirdly, by examining West Bengal as a case, the study enables a discernment of water body sustainability and usage trends at a micro level which can help tailor region specific solutions. Overall, the research informs theory, policy and practice for sustainable water governance at the grassroots.

1.2. Purpose of the study

- a) Survey and investigation of the traditional and folk methods of water conservation practiced in different parts of India.
- b) To assess traditional with modern systems for their sustainability, resilience and inclusivity.
- c) To understand the challenges of water stress and scarcity in India, especially West Bengal.
- d) To assess the prospects for using traditional methods in contemporary water management and policy.

1.3. Research questions

- a) What are the traditional water conservation methods practiced in India and their variation in different ecological zones of the country?
- b) Are traditional systems more sustainable, resilient and socially inclusive than (modern) centralized systems?
- c) This panel will address the question of "water stress and scarcity" in India, with a focus on West Bengal.
- d) Can traditional knowledge be mainstreamed in modern water governance to promote sustainability and equity?

2. Materials and methods

2.1. Research approach

The current study is based on an analysis of qualitative research to explore indigenous and folk practices of water conservation in India. The research, which is mostly exploratory and descriptive, seeks to gain an insight into the way traditional ecological knowledge and community-based practices might have provided historically sustainable means of water use. A cultural-ecological framework was used to assess the local community, traditional knowledge and the management of water resources.

2.2. Research design

The study is descriptive cum analytical in nature based on the information gathered from primary as well as secondary sources. A comparative case study approach was adopted to study traditional water harvesting systems in different states of India. *Johads* (Rajasthan), *Ahar-Pyne* (Bihar), *eri tanks* (Tamil Nadu), *bamboo drip irrigation* (northeast India) and *Bheri* (West Bengal), were chosen from among the traditional water management

systems as case studies for comparative analysis. This design made possible the discovery of commonalities, contrasts and the sustainable aspects of traditional water conservation systems.

2.3. Data sources

2.3.1. Primary data: Field visits, informal interviews, participant observations and ethnographic recording of traditional water management practices served as sources of primary data. Interactions were also held with local people, community elders and practitioners that capture the indigenous knowledge on water harvesting and water conservation.

2.3.2. Secondary data: The part information was obtained from journal articles, books, historical documents, government reports and publications of institutions and were all peer reviewed. Key documents from the Central Ground Water Board (CGWB), Jal Shakti Abhiyan, Centre for Science and Environment (CSE) and INTACH were examined to gain insights into the historical and policy dimensions of traditional water conservation systems.

2.4. Study area

The whole study was conducted in the Birbhum District of West Bengal, India, an area with strong cultural traditional affinity and dependence on natural resource management. Data were collected from March to May in 2025. Forty expert informants including local practitioners and community members that possessed knowledge (native and nonnative) about the indigenous water management practices were involved. Before data collection, the research was conducted in accordance with the Declaration of Helsinki and Prior Informed Consent (PIC) was obtained from all the participants ensuring ethical research practice.

2.5. Methods of analysis

2.5.1. Literature and document analysis: A systematic review of the findings from related literature, policy documents, and archives was conducted to trace the development, organization and operation of indigenous water management practices.

2.5.2. Case study analysis: A number of traditional water management systems were studied using a case study approach to understand their design, operation and socio-ecological importance.

2.5.3. Thematic content analysis: Thematic content analysis was used to analyse qualitative data derived from interviews, field observations and text. Themes, including sustainability, community participation, indigenous ecological knowledge and adaptive management were identified and interpreted.

2.5.4. Classification and comparative analysis: Traditional regimes were mapped, described and tabulated along lines of region, structure and function (e.g., irrigation, rainwater harvesting and recharge of groundwater). A comparison study was performed to assess the sustainability, community participation and resilience of traditional water management systems versus modern water management systems.

2.6. Qualitative comparison

Based on sustainability, community engagement and adaptation, the comparison was qualitative for indigenous versus contemporary.

2.7. Analysis of data

The data were analysed thematically under such categories as historical development, geographical variation, cultural aspects, ecological sustainability and contemporary availability of use. Descriptive analysis focused on the unique aspects of each traditional system, while the comparative analysis considered what they had in common at the regional and contemporary levels, and differences and interpretive analysis explored the cultural beliefs and ecological ethics underlying folk practices.

3. Results and discussion

3.1. Techniques of water management in ancient India

Ancient India had a high standard of water management. Several water-related inventions and innovations emerged, were developed over time and still influence modern water conservation practices showing the long-term endeavours toward sustainable resource use (Singh P.K., 2020; Dales, 1966).

3.1.1. Grandala system: The *Grandala* system was based on collecting rainwater runoff on hill slopes and forming large hilltop reservoirs. These reservoirs were linked to smaller tanks and canals which took water to villages and rural homes and farm fields for irrigation during dry spells (Chowdhury A., 2023).

3.1.2. Kuti system: Common in the Gangetic plains, the *Kuti* system comprised of circular pits (*kutis*) dug on the sides of riverbanks and canals to trap monsoon water which would be used for irrigation in the lean seasons (Singh R., 2020).

3.1.3. Indus Valley civilization: The Indus Valley Civilization of 2600–1900 BCE had complex drainage systems, rainwater harvesting and water supply systems depicting remarkable hydraulic engineering.

3.1.4. Nagara temple architecture: Temples made in the Nagara style in the northern region of the Indian subcontinent commonly featured water tanks or reservoirs that catered the religious and at times community water requirements.

3.1.5. Anicut system: The Cholas constructed *anicuts* (dams) across rivers like the Kaveri to divert the flow of water for irrigation. The Kallanai Dam, constructed circa 150 CE, is still one of the oldest functioning water-diversion or water-regulation structures.

3.1.6. Vastu shastra: There were suggestions within ancient *vastu* principles about the way water should be placed within houses and public spaces, keeping maximum utility in mind and minimizing wastage with natural light and air flow.

3.1.7. Nalanda University: Ancient Nalanda University in Bihar had sophisticated water management, canals, reservoirs and wells in place that sustained its academics

and workers with dependable supply of water (Naz and Subramanian, 2010).

3.2. Traditional practices of water conservation in India

India has a rich tradition of indigenous water management systems, most of which are specific to certain locations and dependent on the community, thus facilitating sustainable water management (Kapadia V.P., 2011; Jain and Neha, 2019). Traditional practices to water conservation in India are given in Table 1.

3.2.1. Tanks and reservoirs: Large tanks or reservoirs were used to hold rainwater and monsoon runoff for domestic and agricultural applications, such as the Kalyani tanks of Andhra Pradesh (Murthy, 2022).

3.2.2. Tanks and canals: In the Deccan plateau, there emerged an art of rainwater management using tanks and canals. Those in Hampi, Karnataka of the Vijayanagara Empire represent perhaps the best-known example (Singh, 2004).

3.2.3. Water management in temples: Rainwater harvesting, subterranean channels, water storage and water management were not uncommon in ancient Indian temples and helped sustain religious as well as community activities (Sharma and Kanwar, 2009).

3.2.4. Johads and Aflaj: *Johads* are small community-built check dams that capture rainwater and are prevalent in the dry regions of Rajasthan, *Aflaj* are underground water channels in Rajasthan and Gujarat that transport water from aquifers to fields and villages (Sambrani and Jayadatta, 2017).

3.2.5. Baolis (stepwells): *Baolis* are reservoirs and storage structures that are accessed through a series of steps leading to the water. Gujarati architecture exhibits sophistication and brilliance through the iconic Rani ki Vav in stepwell pattern of carving (Chowdhury S., 2023).

3.2.6. Harvesting rainwater for irrigation: Rainwater that is harvested on traditional rooftops is channeled into underground storage pits or tanks, still a common practice in India's villages (Rawat A., 2023).

3.2.7. Ponds: Farm ponds are farm infrastructure to capture and store rainfall for irrigation, livestock and sometimes human consumption, acting as a small local water reservoir in farming regions (Jain and Neha, 2019).

3.2.8. Agroforestry: Systems like the "*Sali*" system under the agroforestry umbrella in Assam the "*Mulberry*" system in the Deccan plateau zone, integrate trees with crops to conserve soil, capture water, recharge groundwater (Kapadia K., 2011; Murthy, 2022).

These age-old solutions reveal the ecological and social brilliance of India's native water wisdom and still provide solutions to modern water problems.

3.3. Discussion

3.3.1. Himalayan and hill regions: The hilly and mountainous people have evolved water augmenting systems, suitable to the rugged relief and extreme climates of these latitudes. These are mainly based on terracing, gravity flow channels and indigenous water storage systems, they minimize energy use and have a low environmental footprint and efficiently use water

Table 1. Traditional water conservation practices in India (Source: "Manual on Rainwater Harvesting" Department of Drinking Water and Sanitation (DDWS: Government of India)

Sl. No.	Name of the practices for water conservation in India	Description
1	<i>Zing</i>	Tanks for collecting water from melted ice in Ladakh.
2	<i>Kul</i>	Water channels in mountain areas of Jammu, Himachal Pradesh.
3	<i>Apatani system</i>	Terraced plots connected by inlet and outlet channels in Arunachal Pradesh.
4	<i>Bamboo drip irrigation</i>	Water from streams in the hills is brought to the plains via bamboo pipes for drip irrigation in Meghalaya.
5	<i>Naula</i>	Small ponds in Uttarakhand
6	<i>Dungs or Jampoos</i>	Small irrigation channels linking rice fields to streams in the Jalpaiguri district of West Bengal.
7	<i>Dongs</i>	Ponds in Assam.
8	<i>Dighis</i>	Small square or circular reservoir fed by canals from rivers in Delhi.
9	<i>Baolis</i>	Secular structured stepwells from which everyone could draw water and use for washing and bathing in Delhi.
10	<i>Johads</i>	Earthen check dams in Alwar district, Rajasthan.
11	<i>Kund</i>	Circular underground well having a saucer-shaped catchment area that gently slopes towards the center where the well is situated.
12	<i>Tankas</i>	Underground tank Bikaner in Rajasthan.
13	<i>Zabo</i>	Impounding runoff in Nagaland.
14	<i>Baoris/Bers</i>	Community wells in Rajasthan.

resources (Bhatnagar and Singh, 2002; Bhatnagar and Srivastava, 2003).

3.3.2. Northeastern and eastern India: Water conservation in the northeast and east is strongly tied to agro-ecology and community management. The *Zabo* system, for example, combines forest management, irrigation and soil conservation among other elements at the landscape level, as a comprehensive tool for sustainable water management (Amenla and Shuya, 2021; Gupta, 2025).

3.3.3. Northern and central plains: On the plains, indigenous water systems were nimbly engineered to capture and store river water for use as needed with keen regard for social equity and community welfare. *Baolis* and stepwells are a fusion of architecture, community utility and water conservation and represent the cultural aspects of water management (Chowdhury A., 2023; Bainbridge, 2025).

3.3.4. Dry and semi-dry regions: In Rajasthan and the arid regions, water conservation knows how represents an astute mix of traditional and modern engineering techniques to address uncertain rainfall patterns. Community-managed, not government developed systems such as the *Johads* and *Kunds*, are numerous and offer low-cost, practical solutions that support livelihoods in the most extreme climatic conditions (Sehgal Foundation, 2014; Singh, 2021).

3.4. Implications for contemporary water management

- a) Sustainability: Traditional systems experience demonstrates as to how ecological and low-cost solutions (technological as well as social) can be extremely effective in water conservation (Singh, 2021).
- b) Resilience: Participatory water resource management contributes to increased resilience of communities to climate variability, mainly in arid and high-altitude regions (Singh, 2021).
- c) Policy coherence: The recovery and reapplication of traditional water methods can support modern infrastructure, while fostering cultural and communal ties (Singh, 2021).
- d) Traditional methods: Traditional water harvesting methods in India are a synthesis of ecology, community engagement and technology. They offer culturally relevant and practical approaches to guide contemporary water management policy and practice for enhancing sustainability, equity and resilience in water-stressed regions (Singh, 2021).

The traditional and modern water management systems can be contrasted in terms of management philosophies and processes, scale, social organization and relationship with the environment. Implications on sustainability, participation and resilience under climatic uncertainties of these would be far-reaching. A comparative analysis

between traditional and modern systems in water conservation is depicted in Table 2.

A significant number of these traditional water harvesting systems are proven sustainable by their inbuilt ecological and social indicators. A lot of indigenous systems are aimed at slowing down groundwater recharge, controlling runoff and increasing moisture availability in the dry months of the year. For example, *Johads* and temple tanks allow for natural percolation thus helping in raising the water table in nearby regions. Like their bamboo counterparts, bamboo drip irrigation systems allow for an even distribution of water, with just a few drops reaching the ground at a time.

Further, they are predicated largely on community involvement and local management, which results in sustainability and collective custodianship of water resources. Unlike the conventional massive public water infrastructure, traditional systems are often low impact, made from locally sourced materials and require very little energy, making them more ecologically sustainable.

3.5. Water conservation in India: Status and future challenges

India is facing a multiscale water crisis driven by interconnected factors such as rapid urbanization, climate change, weak governance, pollution, inadequate infrastructure, groundwater overexploitation and unequal water distribution (Fig. 1; Fig. 2). These challenges significantly affect water availability, quality and accessibility, posing serious risks to sustainability and public health. Addressing these issues requires integrated and adaptive water management strategies. As shown in Table 3, multiple interrelated factors contribute to the growing water crisis in India.

3.5.1. Urbanization and industrialization: Sweeping urbanization and expanding industry have resulted in a growing demand on water body which is deteriorating water sources through excessive drawing, pollution and drying up. The increasing pressure on this resource is leading to further water scarcity and land degradation (Rahman, 2021; Sridhar and Parimalarenganayaki, 2025).

3.5.2. Climate change: Climate variability, mainly unpredictable monsoons, more frequent droughts and floods, affects the availability and distribution of water. These trends bring new challenges to water resources management, and will require increasingly agile solutions (Bharambe *et al.*, 2023; World Bank, 2023).

3.5.3. Poor management of water resources: Poor water management and weak infrastructure lead to wastage of water and under exploitation of the available supplies. These prevent true water savings (Ghosh, 2022; Takshashila, 2025).

3.5.4. Pollution: Sewage, industrial and agricultural runoff, contaminate rivers, lakes and aquifers, so that many water bodies are no longer safe for drinking. Nearly

Table 2. Comparative analysis: Traditional vs. modern systems in water conservation

Sl. No.	Aspect	Traditional systems	Modern systems	Interpretation
1	Ownership & Governance	Community-based governance that exercises collective ownership and control. Village councils or customary laws administer them and access is ensured.	Controlled by governments or private organizations, have a centralized decision-making system and minimal local input.	Responsibility and sustainability are ensured by community ownership, but centralized control can result in neglect, mismanagement and unfairness.
2	Resilience	Robust, evolved over time in response to climate fluctuations (e.g., the Apatani system, Eri tanks).	Vulnerable to system failures ranging from hardware malfunctions, power outages to software errors.	The resilience and adaptability of these traditional systems arise from their local knowledge and long-term access to ecological infrastructure, whereas modern systems are predicated upon engineered infrastructure.
3	Scale	Decentralized, functionally specific and suited to local micro-watersheds (e.g., Johads, Eri tanks, bamboo drip irrigation). Local climate and landscape, local biodiversity are incorporated in the design.	Systems of dams and reservoirs and canal networks on the scale of large regions, with centralized operation.	Conventional systems have evolved to be responsive to change, flexible and sustainable, modern systems can be rigid and wasteful when they are not adapted to the local context.
4	Social Inclusion & Participation	High community involvement in collective work such as shramdaan and local governance practices.	Constrained public engagement; mainly top-down bureaucratic route.	Conventional systems bring about equity, participation and continuity of knowledge, while modern systems are noninclusive.
5	Sustainability & Environmental Adaptation	Eco-friendly, conducive to groundwater recharge, minimizes soil erosion and protects water quality (for example, Johads, Zabo system).	Frequently results in disturbance of ecosystem, decrease in ground water recharge, sedimentation and pollution of environment.	Traditional practices tend to be more sustainable and resilient to climate fluctuations while modern systems risk having "time-limited viability".
6	Technology & Cost	Utilizes traditional knowledge and available resources; is low-cost, simple and easily practicable (e.g., kunds, bamboo pipelines, johads).	Large and tech heavy systems in need of substantial investment, energy and upkeep.	Conventional system is sustainable and environmentally friendly, while the modern system relies on the exploitation of resources and can harm the environment.

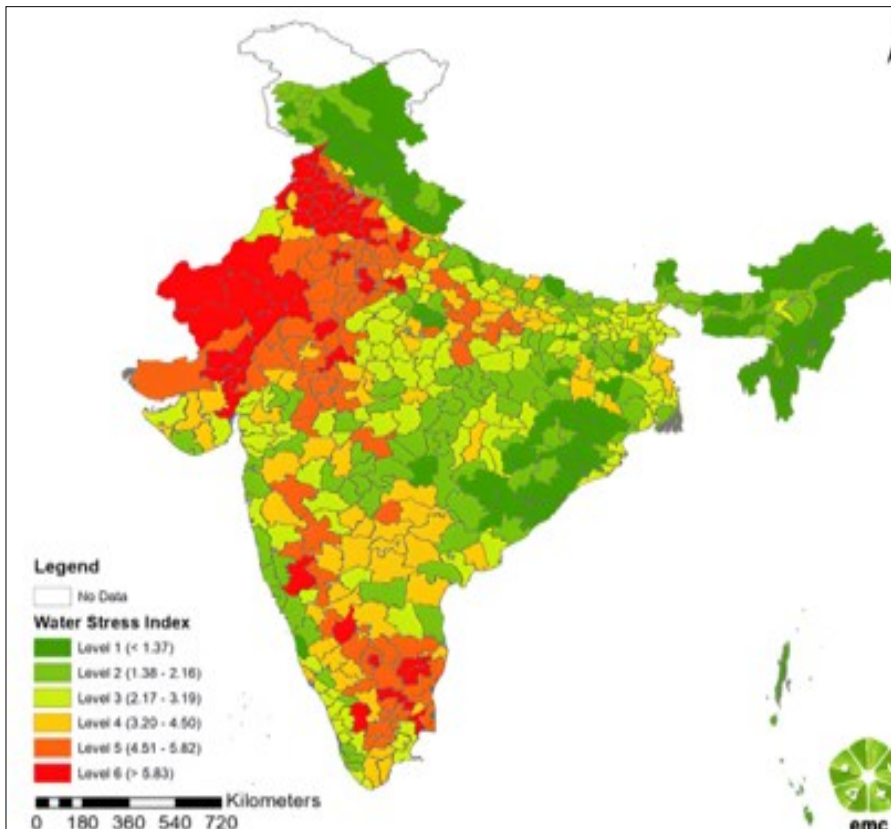


Fig. 1. Water stress and water scarcity areas of India (Source: National Compilation of Dynamic Ground Water Resources, 2024” Ministry of Jal Shakti, Government of India)

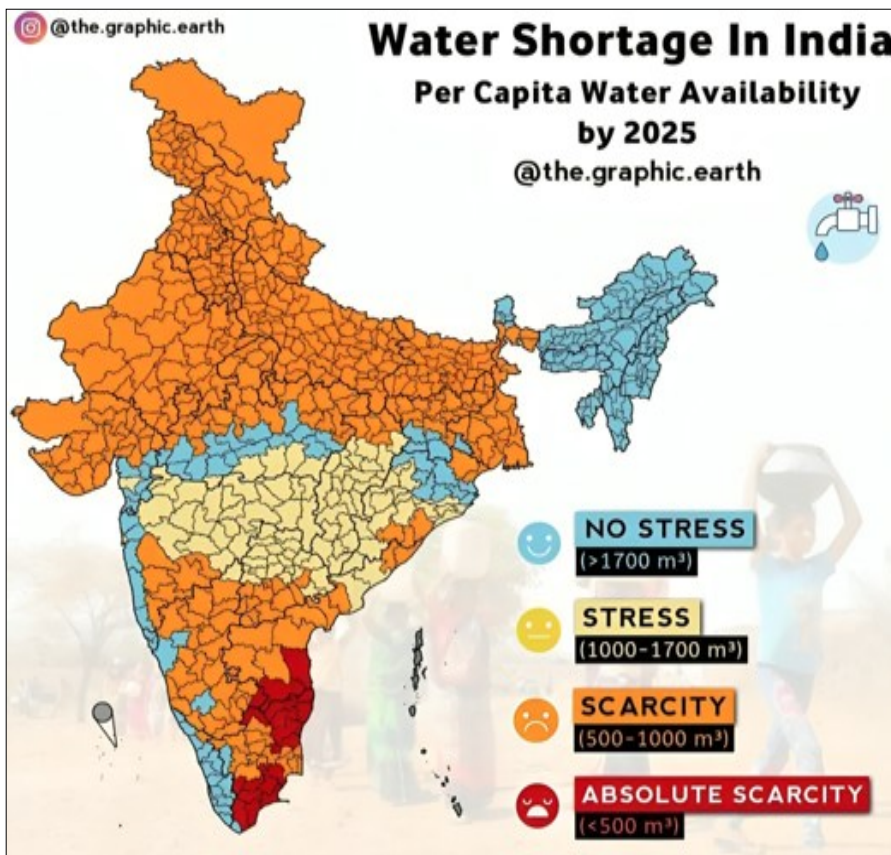


Fig. 2. Water shortage areas in India (Source: Indian Climate & Energy Dashboard, Niti Aayog)

40 million litres of untreated waste enter Indian water bodies each day, worsening pollution (Development Aid, 2025)

3.5.5. Poor infrastructure: A lack of investment in water treatment plants, sewer systems and distribution lines can cause water scarcity and boil water advisories. Urban sprawl development can be much faster than that of urban infrastructure, leading to increasing problems in water provision (India Water Portal, 2023; Ion Exchange, 2025a).

3.5.6. Groundwater over exploitation: As a result of over-pumping to meet the agricultural, domestic and industrial demands, vast tracts of land are affected by groundwater depletion. An alarming 81% of rural Indians do not have access to clean drinking water (NASA, 2024; Srivastava, 2025) over 68% of groundwater needed for domestic and industrial use has been depleted since 2004, jeopardizing the prospects for water security of the future.

3.5.7. Unequal access to safe drinking water: There are wide rural-urban gaps in access to safe drinking water and sanitation. Rural communities, in particular, struggle to find clean water, causing epidemics of public health (Biswas *et al.*, 2024; PMNCH, 2024). Table 3 describes the major drivers of the water crisis in India and their impacts.

3.6. Water stress and scarcity in India

India experiences large-scale regional variations in water availability. Several regions are confronted with water

stress and water scarcity. These challenges are primarily driven by overexploitation of water resources, inadequate infrastructure and climate variability. These regional variations are discussed below under the major geographical zones of India, namely northern, southern, western, eastern and northeastern regions.

3.6.1. Northern India: Agriculture in states such as Punjab, Haryana, Uttar Pradesh and Rajasthan have also been under water stress with the growth of water intensive crops like rice and wheat. Groundwater is being exhausted at a frightening pace, with some areas losing over 700 TMC of water per year over the last two decades (Ray, 2025). Overextraction of groundwater, combined with inefficient irrigation system, aggravate the problem and lead to precipitous fall in water tables.

3.6.2. Southern India: Southern states of Tamil Nadu, Karnataka and Andhra Pradesh are seeing worst drought conditions and have long been water-stressed states mostly due to excessive groundwater exploitation and unpredictable rainfalls patterns attributed cited to climate change. Its dependency on groundwater for irrigation and drinking water has caused water levels to fall and that is hurting urban and rural residents alike (Bureau, 2024).

3.6.3. Western India: Water shortage is a common problem in parts of Maharashtra, Gujarat and Madhya Pradesh, especially in summer. Although water should be available in the monsoon season, water scarcity arises in the dry season because of absence of rainwater harvesting and inefficient water management in many areas (Drought-prone areas in India, 2025).

Table 3. Major drivers of the water crisis in India and their impacts

Sl. No.	Driver	Description	Key impacts	References
1	Climate change	Erratic monsoons, increased frequency of droughts and floods affect water availability and distribution	Uncertainty in water supply, increased vulnerability of water resources	Bharambe <i>et al.</i> , 2023; World Bank, 2023
2	Groundwater overexploitation	Excessive extraction for agricultural, domestic and industrial purposes	Declining groundwater levels, long-term water insecurity	NASA, 2024; Srivastava, 2025
3	Pollution	Discharge of untreated sewage, industrial effluents and agricultural runoff contaminates water bodies	Deterioration of water quality, public health risks	Development Aid, 2025
4	Poor infrastructure	Inadequate investment in water treatment, storage and distribution systems	Inefficient water supply, increased scarcity, urban water stress	India Water Portal, 2023; Ion Exchange, 2025b
5	Poor management of water resources	Inefficient governance and weak institutional frameworks lead to mismanagement of water systems	Water wastage, underutilization of available resources	Takshashila, 2025
6	Unequal access to safe drinking water	Disparities in water access between rural and urban populations	Social inequality, health risks, limited access to safe drinking water	Biswas, 2024; PMNCH, 2024
7	Urbanization and industrialization	Rapid urban growth and industrial expansion increase water demand and exert pressure on water bodies through over-extraction, pollution and depletion	Water scarcity, degradation of water bodies, land degradation	Rahman, 2021; Sridhar, 2025

3.6.4. Eastern India: States of Bihar, Jharkhand and West Bengal are grappling with water scarcity owing to weak infrastructure, poor water efficiency and growing population pressure. For instance, in West Bengal 33.69% of the household use improved source of drinking water, which speaks of the infrastructural problems of the state (Ghosh, 2022).

3.6.5. Northeastern India: Even though the northeastern states are rain-rich (including Assam and Meghalaya), they are water-starved in the lean season (*doga, dandimama*) because of disintegrated water-harvesting systems and absence of requisite infrastructures). As a result of the seasonal rains, it is difficult to provide the people with a stable supply of water throughout the year (Panda, 2022).

3.7. Status of water bodies in West Bengal

West Bengal is located in eastern India and is bounded by five states. Its capital Kolkata is known as the cultural capital of India. The state of West Bengal reflects a diverse amalgamation of languages, religions, customs, traditions, cuisine and lifestyle. The present condition of water bodies in West Bengal (Table 4; Fig. 3) has been depicted and interpreted by statistical tools.

3.7.1. Distribution of water bodies by type: There are 7,47,480 water bodies enumerated in the state of West Bengal, which is very close to that in Bihar (Table 4; Fig. 3). These include rural (7,19,654) and urban (27,826) water bodies, with 96.3% comprising rural water bodies. The majority of water sources include ponds, tanks, reservoirs, lakes and water conservation structures.

Interpretation: There are 7,47,480 water bodies enumerated in the state of West Bengal, which is very close to that in Bihar. These include rural (7,19,654) and urban (27,826) water bodies 96.3% are the share of rural water bodies. Majority of water sources are ponds, tanks, reservoirs lakes, water conservation schematic, etc.

3.7.2. Distribution of water bodies by type of use: A total of 6.98 lakh (6,98,944) the water bodies are in use, constituting 93.5%, while the remaining 6.5% (4,85,36) are not in use due to drying up, siltation, salinity, destruction beyond repair and other reasons. Among the water bodies in use, a very large majority of water bodies are used in pisciculture (85.9%), as reflected in the percentage distribution shown in Fig. 4.

3.7.3. Water scarcity districts in West Bengal: Several districts in West Bengal experience water stress and scarcity due to factors such as groundwater overextraction, inadequate rainfall, pollution and increasing demand from agricultural, domestic and industrial sectors. Districts such as Murshidabad, Birbhum, Bankura, Purba Medinipur, Paschim Medinipur, Hooghly, Howrah and North 24 Parganas are particularly affected (Table 5).

3.8. Initiatives taken for water conservation

3.8.1. Global perspective: Water management is important for life and the environment on earth. Various such actions, ambitious, have been undertaken at different levels by governments, organizations and even

Table 4. Total number of water bodies by type in West Bengal (Source: State wise reports of First Census of Water bodies (Volume -2: Government of India, 2023.)

Sources	Value	Percentage to total (%)
Lakes	1,349	0.18
Others	77	0.01
Ponds	4,57,274	61.18
Reservoirs	2,80,585	37.54
Tanks	7,585	1.01
Water Conservation Schemes/ Percolation tanks/ Check dams	610	0.08

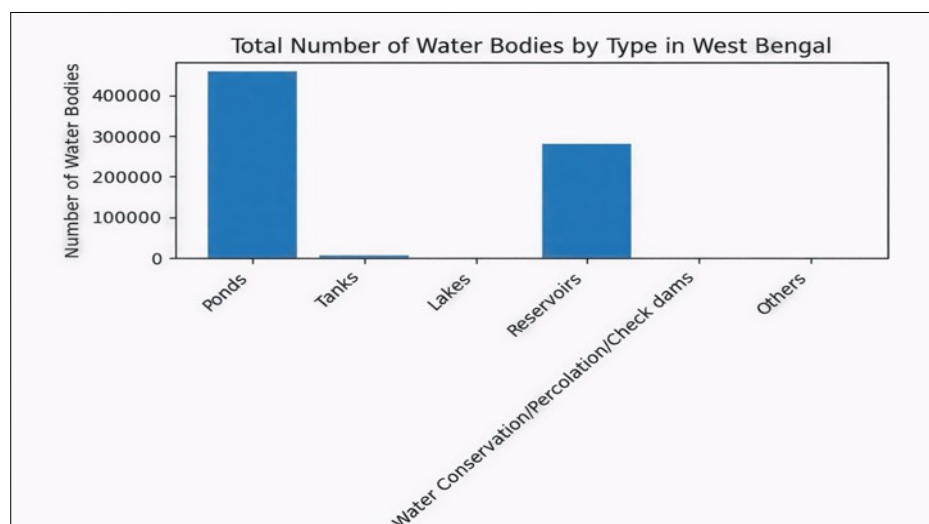


Fig. 3. Distribution of total number of water bodies by type in West Bengal

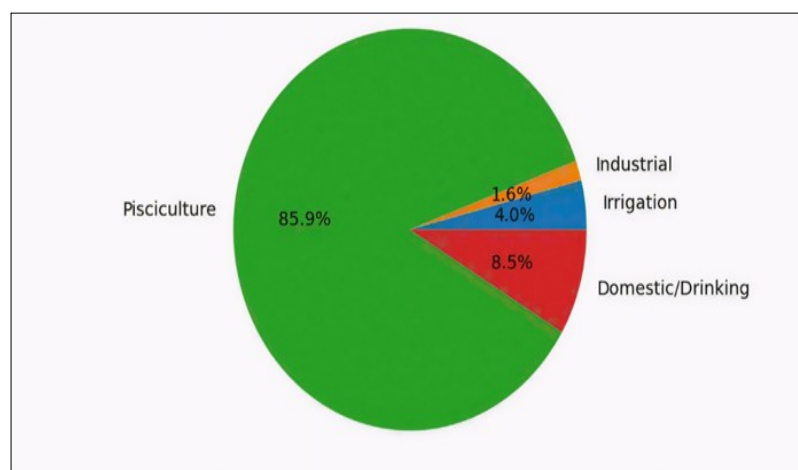


Fig. 4. Distribution of Water Bodies by type of use in West Bengal (Source: State wise reports of First Census of Water bodies (Volume -2), Government of India, 2023)

individuals, to address the issue of demand management and responsible use of water. Some of them are:

- a) United Nations Sustainable Development Goal-6: The United Nations has created Sustainable Development Goal-6 to “ensure availability and sustainable management of water and sanitation for all” by 2030. This target relates to the sustainable development of water use, water quality and the prevention of water related disasters (United Nations, 2015).
- b) Water Efficiency Labelling and Standards Scheme (WELS): The WELS scheme enables consumers in Australia to compare the water consumption and, in some cases, the energy consumption of a range of household products such as washing machines and showerheads. The campaign builds on awareness of water and urges folks to purchase more water efficient products, such as kitchen and bathroom essentials, for less water consumption (Australian Government Department of Climate Change, Energy, the Environment and Water, 2025).
- c) Global Water Partnership: Global Water Partnership (GWP) is a non-profit organization that works in water resources management. It aspires to promote sustainable water management through capacity building, policy development and knowledge sharing on water conservation (Global Water Partnership, 2025).
- d) World Bank's Water Resources Management: The World Bank helps countries under stress to make water use sustainable, to build climate resilience and to

Table 5. Water Scarcity Districts of West Bengal (Source: State Water Policy – West Bengal. Water Resources Investigation and Development Department (WRIDD), Kolkata. & Central Ground Water Board (CGWB), 2022; Government of West Bengal, 2023; Ground Water Yearbook 2021–22: West Bengal. Ministry of Jal Shakti, Government of India.)

Sl. No.	Districts	Probable cause of water stress and scarcity
1	Murshidabad	Murshidabad district severe water scarcity during the summer season, primarily due to extraction of groundwater for agricultural purposes.
2	Birbhum	Birbhum district faces water stress due to the over-extraction of groundwater for agricultural purposes and the depletion of surface water sources.
3	Bankura	Bankura district is affected by water scarcity, particularly during the summer season, due to the over-extraction of groundwater and inadequate rainfall.
4	Purba Medinipur	Purba Medinipur also experiences water stress due to over-extraction of groundwater and depletion of surface water sources.
5	Paschim Medinipur	Paschim Medinipur faces water scarcity due to the over-extraction of groundwater for agricultural purposes and the depletion of surface water sources.
6	Hooghly	The Hooghly River, which serves as a primary water source for Hooghly district, faces pollution and over-extraction, resulting in water scarcity during the summer months
7	Howrah	Howrah, a densely populated district, also experiences water stress due to high demand from domestic, industrial and agricultural sectors.
8	North 24 Parganas	Rapid urbanization and industrialization have led to increased water demand, causing stress on available water resources in North 24 Pargana district

pursue integrated water resources management. It provides financing and technical support to governments for projects that aim to improve water infrastructure and water management (World Bank, 2025).

e) Alliance for Water Stewardship (AWS): AWS is a dynamic global membership organization with a multi-stakeholder approach to responsible water use and management. It has created a global framework for water stewardship, assisting industries, businesses and communities to make sure that use of water is sustainable (Alliance for Water Stewardship, 2025).

f) The Coca-Cola Company's Water Stewardship Program: The Coca-Cola Co is running a global campaign to reduce water use in its business operations and to support joint water conservation efforts in areas at risk. The initiative is meant to "give back for every drop of water" that is consumed in its beverages by helping fund community water projects. (The Coca-Cola Company, 2025)

g) Greening the Supply Chain Initiative: This campaign encourages companies to adopt water management within their supply chains. It allows companies to analyse their direct operations and supply chains to quantify water risks and challenges, such as excessive water use, growth in water consumption, sufficiency issues and pollution of water (U.S. Environmental Protection Agency, 2025).

h) World Water Day 2024: Leveraging Water for Peace: World Water Day – 22 March – highlights the water-related issues and urges people to act for the sustainable management of water resources. The theme of the UN's World Water Day 2024 is "Leveraging Water for Peace" to focus on the importance of water in creating peace and cooperation (United Nations, 2024a&b).

3.8.2. Indian perspective: India has undertaken several initiatives to address water scarcity and encouraging sustainable water use:

a) Per Drop More Crop (PDMC): Under the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), the scheme incentivizes adoption of micro irrigation, such as drip and sprinkler systems, for increasing water use efficiency in agriculture (Government of India, 2015).

b) National Water Mission: This mission was launched in 2011 with the objective of conserving water, reducing wastage and ensuring equitable distribution across states and also within them, through integrated development of water resource and management (Ministry of Jal Shakti, 2011).

c) Jal Shakti Abhiyan: Initiated in 2019, this campaign centers on water conservation, rainwater harvesting, rejuvenation of traditional water bodies, with community participation as the core (Ministry of Jal Shakti, 2019b).

d) Atal Bhujal Yojana: The scheme was launched in 2019 and it for the participatory and area focused sustainable groundwater management in some of the worst affected States (Ministry of Jal Shakti, 2019a).

e) Watershed Development Component of PMKSY: This programme pertains to the restoration of degraded lands through soil and moisture conservation work promoting on-farm productive activities, as well as improved rural livelihoods (Department of Land Resources, 2021).

f) Har Khet Ko Pani (HKKP): A part of PMKSY, the scheme envisages an expansion of irrigation coverage under it, restoration of traditional water bodies and construction of tanks and ponds to render targeted fields more resilient against drought (Ministry of Agriculture and Farmers Welfare, 2015).

g) Swajal Doot: This scheme is to encourage people's participation in water conservation, facilitating construction of the household tap connection and in creating toilets in rural villages for access to potable drinking water (Ministry of Rural Development, 2021).

h) National River Linking Project (NRLP): NRLP is a gigantic scheme for linking the rivers of India and is expected to renovate various ecologies, control floods, facilitate effective use of waters, augment water supply and make possible navigation across the length & breadth of the country (Government of India, 2025).

3.9. Limitations and future direction

This study has several limitations. The historical record of indigenous water use practices is sometimes fragmented, limiting the ability to accurately reconstruct how these systems operated. The generalizability of findings is constrained by the regional focus on West Bengal, as the practice of others in the region (from arid Rajasthan to the northeastern India) is largely unknown and not studied. Moreover, the studies are primarily qualitative and descriptive rather than quantitative, focusing on modelling water yields or recharge rates, or system efficiency. Additionally, the scalability of traditional practices in contemporary urban and industrial contexts has not been addressed. In the future, several of these gaps could be addressed through quantitative analyses utilizing tools such as GIS mapping, hydrological modelling and remote sensing to evaluate the effectiveness of traditional systems. From a policy and practice perspective, studies examining avenues to bringing indigenous water systems into greater alignment with state-led water governance programmes such as *Jal Shakti Abhiyan* and *Atal Bhujal Yojana*. Water conservation through local participatory research could reveal more about the social governance structures, cultural values and lived experiences associated with water management. Additionally, comparative studies with global indigenous systems such as Iran's qanats or Oman's aflaj, could provide broader insights into groundwater sustainability. Finally, research exploring how traditional practices can be adapted to enhance

climate change resilience, particularly in response to challenges such as erratic monsoons, droughts and floods, is essential to ensure their continued relevance in contemporary contexts.

4. Conclusion

The study concludes that the traditional forms of water management in India are an example of what indigenous knowledge systems can offer. From the hydraulic prowess of ancient cultures to local adaptive interventions, these methods illustrate how traditional knowledge can provide viable solutions to water scarcity. The research demonstrates that indigenous water management strategies are not merely a relic of the past but provide sound models for the governance of water in the future. The application of traditional knowledge, in combination with contemporary technological approaches, could potentially result in novel solutions to current water problems such as groundwater mining, climate variability and rural water insecurity. Future studies should focus on empirical field work and the quantitative assessment of traditional modalities, which could bridge further the gap with contemporary environmental planning and policymaking.

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