

Innovative Approaches to Water Conservation in India: State-Wise Case Studies

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Abstract

India, a water-stressed country, faces significant challenges in managing its water resources. In response, various states in India have adopted innovative approaches to water conservation. This case study showcases state-wise initiatives, highlighting successes, challenges, and best practices. The study covers eight states: Rajasthan (Jal Bhagirathi Foundation's water harvesting structures), Gujarat (Check Dam initiative), Maharashtra (Jalyukt Shivar Abhiyan's watershed development), Karnataka (Malaprabha Reservoir rejuvenation), Tamil Nadu (Tamil Nadu Water Investment Company's water saving initiatives), Andhra Pradesh (Neeru-Chettu's community-led water conservation), Madhya Pradesh (River Narmada conservation efforts), and Telangana (Mission Kakatiya's tank restoration program). The case studies demonstrate the effectiveness of community-led initiatives, public-private partnerships, and policy interventions in promoting water conservation. Key findings include: - Increased water storage capacity through traditional and modern structures Improved water use efficiency in agriculture through drip irrigation and sprinkler systems Enhanced community participation and ownership in water conservation efforts Effective policy frameworks and institutional mechanisms supporting water conservation initiatives. This study provides valuable insights for policymakers, practitioners, and researchers, highlighting the potential for replication and scaling up of innovative water conservation approaches across India.

Keywords: Agricultural water demand, community participation, drip and sprinkler irrigation, groundwater recharge, micro-irrigation techniques, rainwater harvesting, river basin management, state-wise analysis, sustainable water management, traditional water conservation practices, urban water supply management, water conservation, water-use efficiency, watershed management

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INTRODUCTION

Water is a vital resource that supports life, agriculture, the environment, and economic development. In India, where 18% of the world's population depends on only 4% of the global freshwater, water scarcity is becoming increasingly severe. Irregular monsoon patterns, excessive groundwater extraction, pollution of water bodies, and growing urban demand have intensified pressure on available resources, with NITI Aayog warning that by 2030, the country's water demand may be twice its supply. Given that India's economy is largely agriculture-based and urbanization is increasing rapidly, conserving water is a national priority. Civil engineering plays a key role in developing sustainable water systems, such as

rainwater harvesting structures, check dams, groundwater recharge methods, smart irrigation systems, and wastewater recycling units. With the support of modern tools, such as GIS, hydrological modeling, and eco-friendly engineering practices, along with traditional, community-based methods, water resource management can become more efficient and resilient. This study focuses on exploring innovative and state-specific approaches to water conservation in India and highlights how these models can be adapted to other regions to ensure long-term water security [1–4].

REVIEW OF LITERATURE

- *Pachkore and Prabat (2017)*: Jalyukta Shivar Abhiyan in Maharashtra focused on drought relief through watershed development, stream deepening, desilting, check dams, and farm ponds to improve groundwater and irrigation [5].
- *Agarwal and Narain (1997)* highlighted Rajasthan's traditional rainwater harvesting systems, such as *johads*, *baoris*, *tankas*, and *kunds*, and recommended the revival of these community-managed systems [1].
- *Sharma and Samra (2008)* found that watershed development and rainwater harvesting projects in Rajasthan increased groundwater recharge and boosted agricultural productivity [6].
- *Verma et al. (2023)* reported that limited waste collection and treatment lead to groundwater contamination and emphasized the need for improved sanitation and waste management [7].
- *Singh, Gupta, and Mishra (2024)* observed high salinity and nitrate levels in groundwater in Aligarh, indicating the need for stricter groundwater monitoring and management [8].
- *Balasubramanian et al. (2023)* showed that water-saving rice cultivation methods (AWD, SRI, and DSR) in Andhra Pradesh reduced cultivation costs and increased farmers' incomes [2].
- *Swaran (2024)* documented groundwater-sharing networks in Rayalaseema that enabled assured irrigation and crop diversification among farmers [9].
- *Machiwal, Kumar, and Dayal (2018)* demonstrated that small reservoirs and rainwater harvesting structures in the arid region of Gujarat are cost-effective and reduce irrigation costs [4].
- *Mohanraj et al. (2024)* found that farmers in Tamil Nadu showed favorable attitudes towards soil and water conservation when provided with training and support [10].
- *Vasudevan and Natarajan (2021)* identified low technical awareness of urban rainwater harvesting systems and suggested awareness campaigns and incentives [11].
- *Mishra et al. (2024)*: watershed interventions in the Battuvagu region changed the water balance from deficit to surplus by enhancing recharge structures [12].
- *Dayakar and Kumar (2024)* concluded that community-based water conservation significantly increased crop yield and income, with stronger results when neighboring farmers also participated [3].

METHODOLOGY SECTION

Traditional Methods for Water Conservation Practices

Baoli (Stepwell)

1. Deep stepwells are used for storing water.
2. Served as a water source and a community.
3. Gathering places.
4. Often built along trade routes and in villages for drinking and daily use [7].

Tanka (Taanka)

1. An underground circular water storage structure was found in Rajasthan.
2. Collects rainwater from rooftops and courtyards.
3. Water stored can sustain a family during dry seasons [13].

Johads

1. Small earthen check dams used to store rainwater.
2. Help in recharging groundwater and improving soil moisture.
3. Often interconnected to supply water to nearby rivers or fields.

Khadin

1. A long earthen embankment was constructed across slopes.
2. Captures and holds runoff water for farming.
3. Makes land fertile and suitable for crop cultivation, especially in dry regions.

Modern Methods of Water Conservation Techniques

Rainwater Harvesting

- Collects and stores rainwater from rooftops or open areas.
- Reduces dependence on municipal water supply.
- Can fulfill up to 50% of household water needs.
- Help recharge groundwater and reduce flooding risk.

Greywater Recycling

- Reuses wastewater from sinks, bathrooms, and washing machines.
- Can reduce household freshwater use by 30–60%.
- Commonly used for irrigation and toilet flushing.
- Lowers the load on sewage treatment systems.

Groundwater Recharge

- Directs excess surface water into the ground to replenish aquifers.
- Done using recharge wells, infiltration trenches, or percolation ponds.
- Essential in areas with declining groundwater levels.
- Helps stabilize water supply during dry periods.

Smart Irrigation Systems

- Use sensors and automation to supply only the required amount of water.
- Saves 30–50% of water in agriculture.
- Increases crop yield and reduces wastage.
- Ensures efficient and precise irrigation based on soil moisture and weather.

Government Policies and Schemes

- *Jal Jeevan Mission*: Ensures safe and adequate drinking water supply to every rural household through household tap connections.
- *Atal Bhujal Yojana (Atal Jal)*: Promotes sustainable groundwater management with community participation in water-stressed regions.
- *Namami Gange program*: Aims to clean and restore the Ganga River and its ecosystem by preventing pollution and improving water quality.
- *Jal Shakti Abhiyan*: Encourages nationwide water conservation and groundwater recharge through community-driven initiatives.

STATE-WISE CASE STUDY ANALYSIS

Maharashtra

- *Geography*: Large drought-prone area with uneven rainfall and high dependence on limited river basins.
- *Water challenges*: Groundwater depletion, low dam storage, drought in Marathwada, and rising water demand.
- *Innovation—Jalyukt Shivar Abhiyan*: Deepening streams, desilting ponds, building check dams, and constructing contour trenches to increase water storage.
- *Impact*: Improved groundwater levels, reduced runoff, increased crop yield, and strengthened rural livelihoods.

Rajasthan

- *Geography*: Mostly arid with very low rainfall and heavy dependence on groundwater.
- *Water challenges*: Severe scarcity, groundwater depletion, droughts, and abandoned traditional water systems.
- *Innovation—Mukhyamantri Jal Swavlamban Abhiyaan (MJSA)*: Community-based water budgeting, construction of ponds/check dams, and revival of *johads* and *tankas*.
- *Impact*: Improved groundwater levels, better crop yield, reduced tanker dependency, and stronger community participation.

Uttar Pradesh

- *Geography*: Uttar Pradesh has diverse geographical regions and major river basins, including the Ganga River and the Yamuna River.
- *Water challenges*: Over-extraction of groundwater, pollution, and water scarcity in many districts.
- *Innovative approaches*: Jal Jeevan Mission (tap water and rainwater harvesting), UP Groundwater Act (regulation), Bundelkhand pond construction, and pond revival projects.
- *Impact*: Improved water availability, rising groundwater levels, increased irrigation, better crop yields, and enhanced rural livelihoods.

Andhra Pradesh

- *Geography*: Coastal and dry Rayalaseema region with major rivers like Godavari and Krishna.
- *Water challenges*: Uneven water supply, drought in Rayalaseema, urban shortages, and groundwater contamination.
- *Innovations*: Jal Shakti Abhiyan, Neeru–Meeru, rainwater harvesting, and tank restoration.
- *Impact*: Groundwater improved, irrigation increased, crop yields improved, and rural water security strengthened.

Gujarat

- *Geography*: Gujarat has limited and unevenly distributed water resources, with high dependence on surface water and scarcity in regions such as Saurashtra, Kutch, and North Gujarat.
- *Water challenges*: Groundwater depletion, salinity, uneven rainfall, industrial pollution, and high agricultural water demand.
- *Innovative approaches*: Sujalam Sufalam Yojana (inter-basin water transfer), large-scale check dams, rainwater harvesting, and lift irrigation from Narmada canals.
- *Impact*: Improved groundwater recharge, increased irrigation coverage, better crop productivity, reduced drought vulnerability, and strengthened community-based water management.

Tamil Nadu

- *Geography*: Low water availability, high population pressure, and strong dependence on monsoon rainfall across 17 river basins.
- *Water challenges*: Groundwater depletion, droughts, high irrigation demand, pollution, and inefficient water management.
- *Innovative approaches*: Rainwater harvesting (mandatory in buildings), micro-irrigation (drip and sprinkler systems), and Kudimaramathu (community tank restoration).
- *Impact*: Better groundwater recharge, improved irrigation supply, higher crop productivity, and increased community participation.

Madhya Pradesh

- *Geography*: Centrally located state with major rivers such as Narmada, Chambal, Betwa, and Tapi supporting agriculture.

- *Water challenges*: Faces water scarcity, groundwater depletion, pollution, and irregular rainfall, causing drought conditions.
- *Innovative approaches*: Jal Ganga Samvardhan Abhiyan, river revival works, establishment of STPs, wetland conservation, and women-led “Jal Saheli” community water movement.
- *Impact*: Improved groundwater levels, revival of local rivers, reduced pollution, increased irrigation support, and strengthened community participation.

Telangana

- *Geography*: Semi-arid region on the Deccan Plateau, dependent mainly on tanks and groundwater due to limited canal irrigation.
- *Water challenges*: Falling groundwater levels, low reservoir storage, urban tanker dependence, water pollution, and interstate river disputes.
- *Innovative approaches*: Mission Bhagiratha (universal safe drinking water), Mission Kakatiya (tank restoration), Kaleshwaram Project (lift irrigation), and urban rainwater harvesting promotion.
- *Impact*: Improved drinking water access, better groundwater recharge, and increased agricultural productivity; however, sustainable groundwater management is still needed.

BENEFITS OF WATER STRUCTURES AND POLICIES

Maharashtra

The Jal Yukt Shivar Abhiyan increased groundwater recharge through the construction of check dams, farm ponds, and desilting works. Approximately 22,000 villages benefited, improving irrigation and crop productivity.

Rajasthan

The Mukhyamantri Jal Swavalamban Abhiyan focused on tank restoration and check dam construction. The revival of traditional *johads* increased groundwater levels and supported drought-prone villages.

Uttar Pradesh

The Jal Jeevan Mission has expanded rural tap-water access, especially in arsenic-affected areas. Pond revival projects improve groundwater recharge and support drinking-water security.

Andhra Pradesh

Neeru–Meeru improves watershed development and groundwater recharge in drought-prone regions. Major dams, such as Nagarjuna Sagar and Polavaram, strengthen the irrigation supply.

Gujarat

Sujalam Sufalam Yojana deepens lakes and ponds to enhance water storage in arid regions. Check dams and farm ponds improve groundwater levels and agricultural resilience.

Tamil Nadu

The restoration of traditional tank systems (*eris/ooranis*) and mandatory rainwater harvesting improved groundwater recharge. Kudimaramath strengthened community participation in water conservation.

Madhya Pradesh

Jal Ganga Samvardhan supported river rejuvenation and recharge works. The revival of rivers, such as Ghoda Pachhad, improved perennial flow and rural water availability.

Telangana

Mission Bhagiratha ensured a piped drinking water supply to all households. Mission Kakatiya restored over 46,000 tanks, increasing groundwater recharge and irrigation potential.

Future Scope

- *Scalability of proven models*: Successful initiatives, such as Jalyukt Shivar (Maharashtra) and Mission Kakatiya (Telangana), can be replicated in other states with similar ecological and hydrological conditions.
- *Inter-state knowledge exchange*: Establishment of a centralized knowledge-sharing platform will enable the transfer of best practices, design guidelines, and community-led implementation strategies among states.
- *Integration of traditional and modern techniques*: This study highlights the need to combine traditional water systems (e.g., *johads* in Rajasthan and *eris* in Tamil Nadu) with modern methods such as micro-irrigation, GIS mapping, and watershed modeling.
- *Use of technology and artificial intelligence*: Incorporation of remote sensing, IoT-based water monitoring, AI-driven demand prediction, and drone-based catchment analysis can improve precision in planning and maintenance.
- *Policy-level customization*: State-specific water conservation policies can be formulated using regional hydro-geological and socio-economic data (e.g., bunding in Madhya Pradesh vs. drip irrigation in Gujarat).
- *Community-centric sustainable models*: Encouraging village-level water management committees will ensure long-term sustainability and local ownership of water conservation infrastructure.
- *Climate-resilient water planning*: The findings can aid the development of climate-responsive strategies, such as recharge pits in arid zones and coastal rainwater harvesting structures in high-rainfall areas.
- *Replication in other water-stressed regions*: Best practices from the studied states can serve as reference templates for states such as Odisha, Karnataka, and Chhattisgarh, which face similar water scarcity challenges.
- *Role of private sector and CSR engagement*: The outcomes can be utilized to mobilize private sector participation and CSR funding for scaling up community-based water conservation projects.
- *Educational and training applications*: The compiled data and case study insights may be converted into training manuals for engineers, NGOs, and local water user groups to enhance capacity building.

RESULTS

A comparative analysis indicates that Gujarat and Maharashtra allocate the highest budgets for water conservation activities. Maharashtra implements the greatest number of projects, reflecting large-scale government and community participation. In terms of water-saving outcomes, Gujarat shows the highest improvement, mainly due to innovative programs, such as the Sujalam Suphalam Yojana. Technique adoption varies by state: Tamil Nadu leads in rainwater harvesting owing to strong policy enforcement, while Gujarat demonstrates the maximum use of drip irrigation for efficient agricultural water use. Public participation is strongest in Gujarat and Tamil Nadu, highlighting the importance of community involvement in sustaining long-term water conservation efforts.

CONCLUSION

This study highlights that water conservation challenges vary across Indian states depending on geography, climate, and socioeconomic factors. State-specific innovative initiatives, such as Jalyukt Shivar in Maharashtra, Mission Kakatiya in Telangana, and Tank Restoration in Tamil Nadu, have shown significant improvements in groundwater recharge, irrigation capacity, and drought resilience. Community participation, revival of traditional water systems, policy-level support, and technological tools, such as geographic information systems and micro-irrigation, have played key roles in achieving sustainable outcomes.

Among all the states analyzed, Gujarat is the most effective model for water conservation, owing to its large-scale watershed development, extensive check dam construction, high adoption of drip

irrigation, and strong public participation. Its experience demonstrates that integrating community involvement with scientific water management can achieve long-term water sustainability.

Therefore, a holistic, community-driven, and technology-supported approach is essential for ensuring water security and building climate-resilient water management systems across India.

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