WATER BEYOND BORDERS

To: Shri C R Paatil, Hon'ble Minister of Jal Shakti, India

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Subject: Reforming Water Sharing Institutions for Equitable Irrigation Access

Summary: India's state-led water management system creates severe inequities between head-end and tail-end farmers, with irrigation efficiency at just 38% [1]. Decisions made in distant capitals ignore local realities, leading to systemic water access disparities. This brief proposes three interconnected solutions - stakeholder-led water-sharing institutions, IoT-enabled monitoring, and dynamic water rights auctions - to be piloted in the Kaveri Basin.

Background

India's water governance has historically been dominated by state-level bureaucracies, with water-sharing agreements often becoming political battlegrounds between states [2]. This approach emerged post-independence when states were reorganized along linguistic lines, inadvertently creating artificial boundaries across natural watersheds.

The current system relies heavily on fixed interstate water treaties, some dating back to colonial times[6], that fail to account for changing climate patterns, evolving agricultural needs, and growing water demands. Studies show that politically driven water management has led to inefficient resource allocation, with some regions receiving excess water while others face severe shortages.

Current State and Challenges

The challenges are compounded by:

1. Political Interference: Water allocation decisions are frequently influenced by electoral politics rather than scientific assessment or local needs.

2. No unified legislative framework to manage water bodies: Entry 56 of the Union list and Article 262 empower the Central Government but ad-hoc River Boards and Authorities have been set up

3. Water management based on state boundaries that do not match basin boundaries: Entry 17 empowers State Govts to do water management but there is a mismatch between river basin and administrative boundaries

4. Severe inequities between head-end and tail-end farmers: State-dominated and fragmented approach leaves downstream communities at a disadvantage

5. Limited Stakeholder Participation: Current systems provide minimal opportunities for affected communities like farmers to participate in decision-making processes.

Case: The Kaveri Basin Crisis as a Model for Water Management Reform

The Kaveri Basin crisis exemplifies how fragmented governance and lack of local participation leads to systemic water management failures.

Key Problems that Mirror National Challenges:

- Disparity in rainfall, irrigation & dam infrastructure and water consumption between head and tail
- Ongoing disputes between Karnataka and Tamil Nadu highlight the limitations of state-led management
- Policies made in states and Central tribunals ignore the specific needs of different zones (Western Ghats, Mysuru-Mandya, Erode-Tanjore, and Delta regions) inside the basin
- Despite schemes like PMKSY (Pradhan Mantri Krishi Sinchayee Yojana), small farmers struggle with infrastructure maintenance

This case demonstrates how the absence of stakeholder-led institutions and modern technology perpetuates systemic inequities in water management, making it an ideal testing ground for proposed reforms.

Geospatial Analysis for Head and Tail regions of Kaveri River Basin

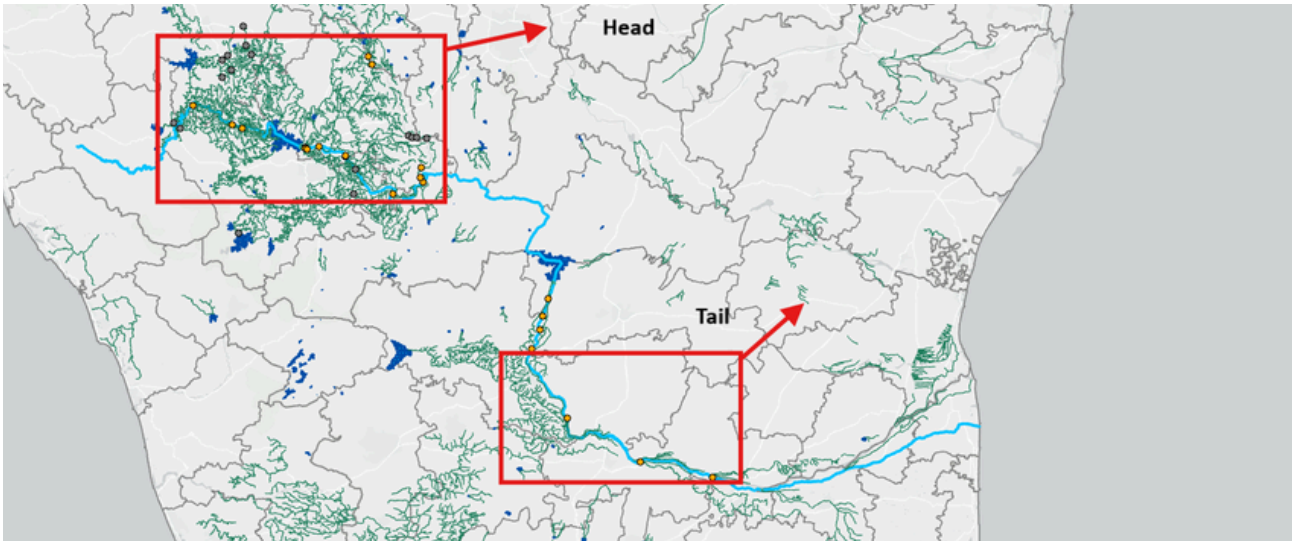


Figure 4: GIS Analysis of Irrigation Infrastructure across the Head and Tail region of Kaveri river. Green lines indicate canals. Dots indicate smaller dams and dark blue indicates big dams across the Kaveri river.

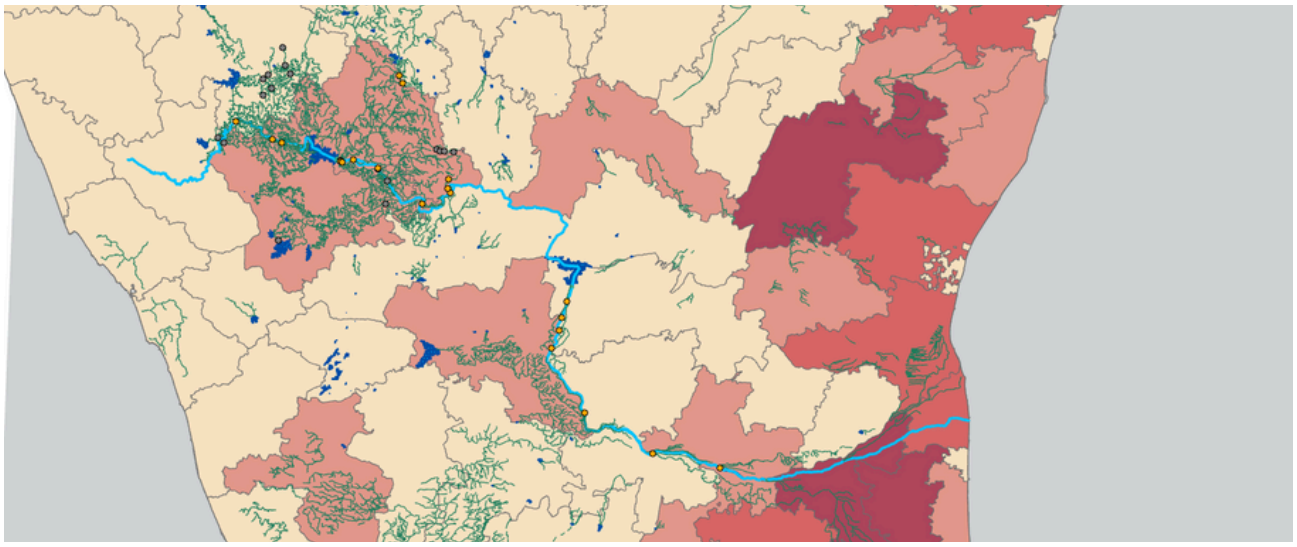


Figure 5: GIS Analysis of Rice Production in tonnes show that it is primarily concentrated in the upstream while it is low in several districts of Tamil Nadu. It increases in the delta region of the river.

We analyzed the spatial distribution of rice production in the Kaveri Basin in relation to irrigation infrastructure, identifying disparities between head and tail regions.

Findings

1. **Concentration in Head Regions:** Rice cultivation is predominantly concentrated in the upstream and midstream regions where irrigation infrastructure, such as canals and small dams, is denser. This allows consistent water access, supporting rice farming.
2. **Infrastructure Disparities:** The spatial distribution of irrigation systems is heavily skewed toward upstream areas, leaving tail-end farmers reliant on large reservoirs that often fail to meet their water needs effectively. This results in underutilization of fertile land downstream.
3. **Policy Shortcomings:** Centralized decision-making and rigid water allocation treaties fail to address regional variances in agricultural needs, perpetuating inequities between upstream and downstream stakeholders.

Our findings underline the importance of implementing Zone-Specific Watershed Management Councils (Policy Recommendation 1) and Dynamic Water Allocation Systems (Policy Recommendation 2) to ensure equitable access to irrigation resources and promote sustainable rice cultivation practices.

Policy Recommendation 1 : Establish Stakeholder-Led Water Sharing Institutions

The government should establish Watershed Community Councils (WCCs) as formal institutions for water governance, bringing together stakeholders from across the catchment area regardless of state boundaries.

Goal 1: Establish Zone-Specific Management Councils

The distinct zones of the Kaveri Basin require targeted management approaches that address their unique challenges, from monsoon variation in the Western Ghats to salinity issues in the Delta region.

Key Components:

- Create separate councils for each district most dependent on water from the Kaveri basin.
- Ensure representation from all water user groups within each zone
- Mandate inclusion of small and marginal farmers
- Include technical experts in hydrology and agriculture
- Rotate leadership between upstream and downstream communities

Goal 2: Create Legal and Institutional Framework

A robust legal framework is essential to empower these councils with clear authority while ensuring integration with existing governance structures and providing mechanisms for conflict resolution.

Key Components:

- Mandate basin as a unit for watershed governance
- Consolidate various Authorities formed under individual river board Acts, flood control commissions, State re-organization Acts, etc.
- Form unified basin management authorities using the Entry 56 and Article 262 under a common legislation
- Integrate citizen voices by integrating basin management authorities with existing Panchayati Raj institutions

Goal 3: Implement Operational Systems

Effective day-to-day operations require standardized procedures and modern tools to ensure transparent, efficient, and inclusive decision-making processes.

Key Components:

- Regular monthly stakeholder meetings
- Digital platform for real-time communication
- Multilingual support for cross-state collaboration
- Transparent decision-making processes
- Regular performance monitoring and reporting

Benefits:

- Direct dialogue between affected communities
- Local ownership of water management decisions
- Faster dispute resolution at a community level
- Better adaptation to local conditions
- Improved coordination during water stress

India's Projected Water Consumption by Sector 2025:

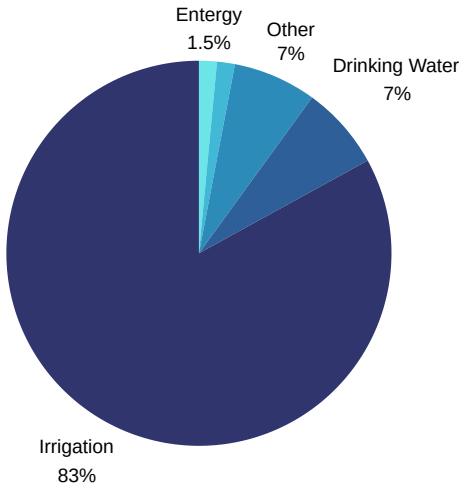


Figure 1. Source: Ministry of Water Resources and Reuters [7]

Policy Recommendation 2

Establish a Water Trading system

India's Central Provinces Irrigation Act of 1931 established that ownership of all water resources within the country is under government control, and the state-level water resource departments oversee the specific use and regulation of water rights.

- There is no single, unified platform for trading water rights in India.
- Existing water markets are localized, fragmented, and uneven across regions.
- The functions of the Water User Associations (WUAs) are mostly implementing warabandi, not directly trading water with other users.

The objective is to develop a unified, transparent, and efficient water trading system that enables farmers and other stakeholders to trade water rights while promoting sustainable agriculture and resource conservation.

Key Actions: Setting Clear Trading Rules

Countries like Australia have established clear trading rules to reduce communication gaps and discrepancies among farmers. India needs to implement clear and well-defined rules for water trading to encourage greater farmer participation.

The trading rules should be able to:

- Provide participants with **water withdrawl permits** based on users' location (e.g, upstream/downstream), water usage efficiency, and crop type.
- Mandate that the pricing information of water be fully transparent. (e.g., sellers must declare their sale price to local authority prior to trading)
- Limit the water transactions when there are negative impacts on the third parties (e.g., wildlife and neighboring land)
- Mandate that a certain percentage of the profit generated through water trading must be reinvested in water-saving technologies for sustainable agriculture.
- Request the participants to **install meter** and report water usage

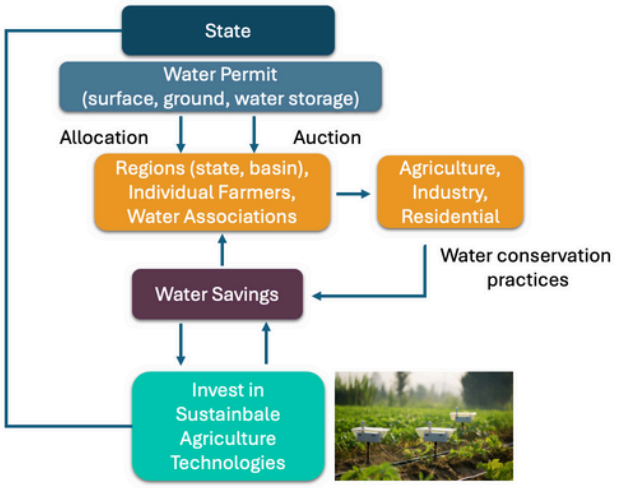


Figure 2. Proposed Water Trading Framework

Key Actions: Building a Water Trading Platform

Building a trading platform for water rights can significantly streamline and modernize the water trading process, replacing traditional methods such as word of mouth communication.

The platform needs to follow the guidelines:

- Mid-to-large scale water-trading activities must be conducted on this platform
- It will match buyers and sellers within the same region, prioritizing those sharing the same canal system or in close physical proximity.
- It will allow farmers to easily **filter options** based on criteria such as location, price, and user types
- Sellers will be able to post their bids
- Buyers and sellers will be able to sign contracts.
- It will provide information services such as news updates and consulting services

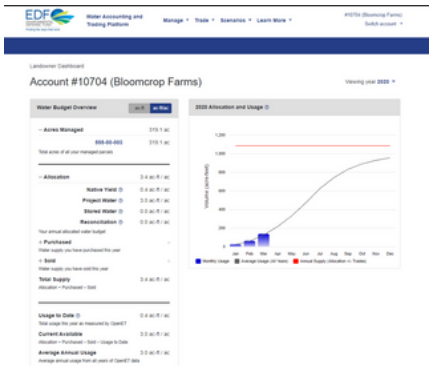


Figure 3. Rosedale-Rio Bravo Water Accounting and Trading Platform in California

Policy Recommendation 2

Establish a Water Trading system

Key Actions: Innovating the Pricing Mechanism

There is a widespread lack of understanding about the true value of water resources and the importance of ecological compensation. This can result in situations where farmers sell their water rights at prices far below their actual worth. Like electricity pricing, **water must have a different economic value in different uses** to incentivize trade.

Some key components of the pricing mechanisms are:

- Provide financial incentives to **promote the flow of low-value irrigation water to high-water-demand, high-value uses** (e.g, fruits and vegetables)
- Encourage industries to purchase water from farmland at competitive rates
- Giving different prices to recycled water, surface water, and groundwater

Key Actions: Improving Water Accounting

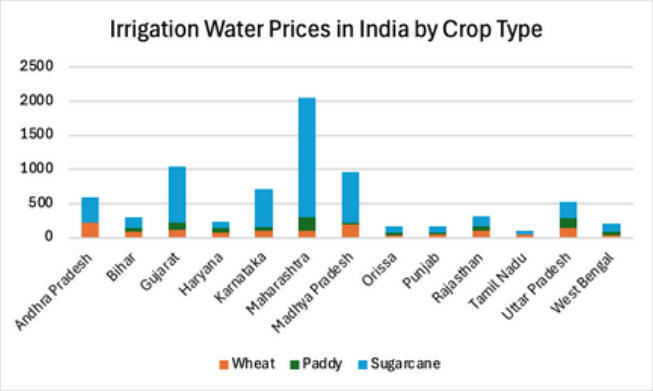
A water audit is essential to ensure that the recipient receives an adequate water supply. It helps determine water losses due to drought, storage o

The monitoring and reporting of water usage must be transparent, consistent, and accurate, as these are fundamental principles for establishing and maintaining a reliable water trading system.

The monitoring system should be able to:

- Identify regions with high water quality to prioritize them for initial trading activities. This is because research indicates that over 10 Indian states have excessive levels of arsenic (As), in their groundwater (Kumar & Singh, 2020).
- Irrigation districts with poor water quality should be subject to stricter regulations or limitations on participating in water rights trading.

Table 1. Irirrigation Price in India



Source: Ghosh, N. (2023)

Case: Crop Transformation Driven by Water Markets in the Rio Grande Valley, Texas

After the Rio Grande Valley established a water market in 1971, farmers shifted toward cultivating high-value crops (vegetables and fruits), driven by the leasing of water rights from growers of low-value crops (hay). Research showed that this reallocation of water rights not only enhanced resource efficiency but also promoted greater diversification of cropland, resulting in economic gains.

Source: (Debaere & Li, 2020)

Key Actions: Leveraging Existing Markets

- Acknowledge and integrate the informal water market practices already in use by farmers and associations to ensure a smoother transition to the official platform.
- Build trust by demonstrating how the formal platform aligns with current informal systems and addresses their inefficiencies by workshops or handbooks

Policy Recommendation 3

Smart Monitoring Solutions with IoT Sensors

Effective water rights management can greatly benefit from IoT sensors that track dam output pressure, water quality, and surface water levels. Whether by adopting Watershed Community Councils (WCCs) to ensure accountability through real-time data on water supply, usage, and quality or by implementing a water-trading platform that relies on transparent regional water monitoring, these solutions depend on accurate and consistent data collection.

A comprehensive monitoring system will measure and downstream water heights, flow volume and velocity through dams, groundwater impacts, and water quality in rivers and aquifers. Data collected will be transmitted to a public dashboard via LoRaWAN and 5G protocols.

Sensors Used: A cloud-based supervisory control and data acquisition system will integrate the following sensors to enable real-time monitoring, alerts, and trust in water-sharing agreements (Liu, 2024):

- **Ultrasonic Sensors:** Measure upstream and downstream water levels using sound waves.
- **Electromagnetic Flow Meters:** Track water flow velocity through dam pipes.
- **Soil Moisture Sensors:** Assess soil infiltration efficiency.
- **pH & Conductivity Sensors:** Monitor water quality and detect contamination or chemical changes.
- **Surface Level Radar Sensors & ML Cameras:** Track aquifer water levels.

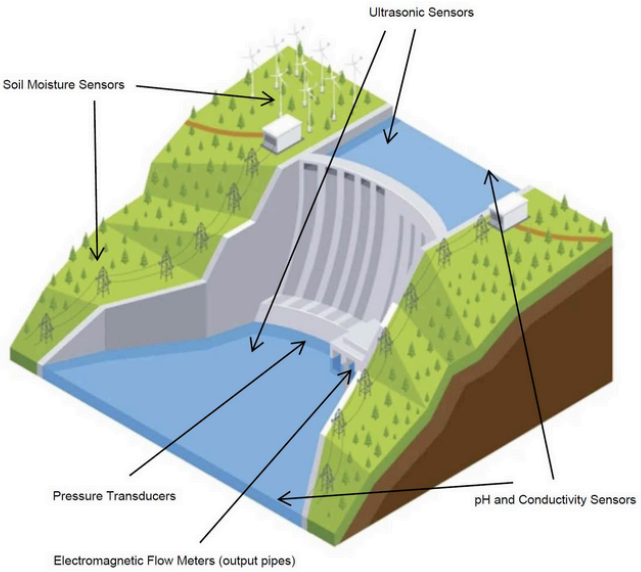


Figure 3: Simple Check Dam Model
Source - www.shutterstock.com

System Requirements

1. **Durability:** Sensors must operate reliably for over a year in varying weather conditions with minimal maintenance.
2. **Energy Efficiency:** Sensors should last at least a year on one battery or use solar recharging.
3. **LoRaWAN Deployment:** Routers should be placed strategically, with a transmission range of up to 10 miles.
4. **5G Integration:** IoT devices may use 5G chips where coverage and power constraints allow, likely in combination with LoRaWAN.
5. **Public Dashboard:** A real-time, cloud-based dashboard will process sensor data to provide insights into water usage and quality, ensuring transparency.

Technical Analysis

We analyzed the disparity in irrigation infrastructure across the Kaveri Basin, focusing on the head and tail regions. The dataset includes:

- Irrigation Infrastructure: Spatial distribution of canals, small dams, and large reservoirs.
- Agricultural Dependence: Regional crop patterns and irrigation reliance.

Findings

1. **Infrastructure Concentration:** Analysis reveals that head-end regions have a significantly higher density of canals and small dams, whereas tail-end regions are dependent on fewer, larger reservoirs. This disparity is exacerbated by inefficient water delivery systems and reduced flow in the tail regions due to over-extraction upstream.
2. **Hydrological Inequity:** The flow patterns in the Kaveri River show substantial reduction downstream, intensifying water scarcity in the delta regions. Farmers in the tail regions report delayed and inconsistent water availability, directly impacting crop yield and economic stability.
3. **Policy Ineffectiveness:** Centralized governance and rigid treaties fail to account for spatial and temporal variabilities in water flow, perpetuating inequities between upstream and downstream stakeholders.

Our findings underscore the critical need for Zone-Specific Watershed Management Councils (Policy Recommendation 1) and IoT-Based Monitoring Systems (Policy Recommendation 3) to ensure equitable water distribution. The Kaveri Basin offers a vital testing ground for these reforms.

Digital Stakeholder Engagement Tool

To facilitate broader understanding and buy-in for these water management reforms, we have developed an initial prototype of an interactive digital engagement tool. This minimum viable product (MVP) demonstrates how technology can be used to communicate complex policy reforms in an accessible format.

Interactive Policy Reform Game

Visit: https://akinbjoseph.github.io/waterpolicy/

or scan the QR code below

This retro-styled educational game serves multiple purposes:

1. **Policy Introduction:** Introduces stakeholders to the three key reforms (Watershed Community Councils, IoT-based monitoring, and water trading systems) in an engaging format
2. **Scenario-Based Learning:** Uses real scenarios from the Kaveri Basin to illustrate how these reforms address current challenges
3. **Stakeholder Education:** Helps various stakeholders, from farmers to local officials, understand the benefits and mechanisms of the proposed reforms

Alternatives Considered

1. Relying Solely on State-Level Management
- Continue with existing state water resource departments managing the allocation
- Why we Rejected: The current state-centric approach has led to political conflicts, inefficient resource allocation, and systemic inequities between head-end and tail-end farmers. Maintains artificial administrative boundaries across natural watersheds.

2. Centralized National Water Authority
- Establish a single national body to oversee all interstate water-sharing
- Why we Rejected: It would further remove decision-making from local communities and ground realities. Adding another layer of bureaucracy could increase administrative delays and reduce flexibility in responding to local conditions.

Conclusion

India's water management challenges require a comprehensive transformation that balances local autonomy with coordinated oversight. Our three-pronged approach - establishing Watershed Community Councils, implementing a formal water trading system, and deploying IoT-based monitoring - provides an integrated solution to longstanding issues of inequitable access and inefficient resource allocation. By bringing together stakeholders across state boundaries, creating transparent market mechanisms, and leveraging modern technology, these recommendations will improve water governance while maintaining accessibility for all users. The success of similar institutional reforms in managing common resources, as seen in participatory forest management programs, demonstrates that well-designed local institutions supported by clear legal frameworks and modern technology can effectively manage shared resources. Implementation in the Kaveri Basin will serve as a model for reforming water management across India's river systems

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