Journal of Water Resource Engineering and Pollution Studies
Volume 2, Issue 1, January-April, 2017

Sustainable Strategies for Groundwater Management in Drought-Prone Regions

Dr. Meenal Rathi
Associate Professor
Department of Environmental Engineering
Coastal Institute of Technology
Email: *meenal.rathi@cit.edu.in*

Vikram Shekhawat
M.Tech Scholar
Department of Environmental Engineering
Coastal Institute of Technology
Email: *vikram.shekhawat@cit.edu.in*

Abstract

Drought-prone regions often face critical challenges in groundwater depletion, threatening water security and agricultural sustainability. This paper addresses key strategies for sustainable groundwater management with a focus on recharge enhancement, efficient usage, community engagement, and policy reforms. Through a blend of traditional wisdom and modern technology, such as aquifer mapping, drip irrigation, and managed aquifer recharge (MAR), this study emphasizes holistic approaches that ensure equitable, long-term groundwater availability. Case examples and practical tools are presented to highlight the integration of science, policy, and local participation in water management.

Keywords: Groundwater Recharge, Drought Management, MAR, Water Policy, Community Participation, Aquifer Sustainability

INTRODUCTION

Groundwater is a vital resource for domestic, agricultural, and industrial purposes, especially in regions affected by prolonged droughts. In India, over 60% of irrigation and 85% of rural drinking water needs are met through groundwater. However, unsustainable extraction, coupled with climate change and declining rainfall patterns, has led to severe groundwater stress in states like Rajasthan, Maharashtra, and Tamil Nadu.

Sustainable groundwater management involves a multi-pronged approach—recharging aquifers, improving usage efficiency, policy enforcement, and community participation. The success of these interventions lies in tailoring solutions based on hydrogeological conditions and social dynamics.

CAUSES OF GROUNDWATER DEPLETION

Key factors responsible for groundwater depletion in drought-prone regions include:

- **Over-irrigation and flood-based farming practices**
- **Lack of regulation on borewell drilling and abstraction**
- **Declining monsoon rainfall and surface runoff**
- **Deforestation and urbanization reducing recharge zones**
- **Poor community awareness and policy enforcement**

Agriculture remains the largest consumer of groundwater. The widespread cultivation of water-intensive crops like sugarcane and paddy, even in arid regions, exacerbates aquifer stress.

SUSTAINABLE RECHARGE METHODS

Artificial recharge structures can significantly restore groundwater balance. Techniques include:

- **Check dams**: Small barriers built across streams to store runoff, improving infiltration.
- **Percolation tanks**: Shallow depressions that capture rainwater and allow slow percolation.
- **Recharge wells**: Vertical shafts that deliver water directly into aquifers.
- **Rooftop rainwater harvesting (RWH)**: Collects rainwater for household or recharge use.

The National Water Mission and various state-level watershed programs promote these methods. Proper site selection using soil and aquifer studies is essential for maximum efficiency.

TECHNOLOGICAL INTERVENTIONS

Modern technology plays a vital role in groundwater sustainability:

- **Remote sensing and GIS**: Mapping aquifer characteristics and recharge zones.
- **IoT-enabled water meters**: Monitoring withdrawal at the farm and urban levels.
- **Mobile apps**: Providing farmers with water availability and scheduling data.
- **Decision Support Systems (DSS)**: Integrating meteorological, hydrological, and social data for policy-making.

The **Bhuvan portal** by ISRO and aquifer mapping by CGWB enable granular groundwater visualization for planning.

POLICY AND INSTITUTIONAL FRAMEWORK

Without effective governance, technical interventions cannot achieve sustainability. Key components of an enabling framework include:

- **Groundwater legislation**: Defining rights, limits, and licensing protocols.
- **Water Users Associations (WUAs)**: Empowering local governance of aquifer usage.
- **Subsidies for micro-irrigation**: Promoting drip and sprinkler systems.
- **Monitoring and enforcement**: Real-time tracking of borewell activity.

The **Atal Bhujal Yojana (ABHY)**, funded by the World Bank, emphasizes participatory groundwater planning with performance-based funding.

CASE EXAMPLE: RAJASTHAN'S COMMUNITY TANKAS

In the Thar Desert region of Rajasthan, traditional **tankas** and **kunds** have been integral to water security for centuries. These underground storage structures collect and store monsoon rainwater. Revival efforts by NGOs and government schemes under MGNREGA have resulted in:

- **Increase in groundwater levels by 1.2–1.5 meters**
- **Reduced dependency on tankers and borewells**
- **Improved drinking water quality and access**

These examples underscore the potential of blending traditional knowledge with modern planning.

Table 1: Recharge Methods and Their Features

Method	Description	Suitable Region
Check Dams	Small barriers across seasonal streams	Hilly & Semi-Arid
Percolation Pits	Shallow dug pits to promote infiltration	Rural and Agricultural
Recharge Wells	Vertical shafts injecting water into aquifers	Urban & Hard Rock Areas
Rooftop Harvesting	Captures rainwater for domestic/recharge use	Urban and Institutional

Table 1 presents commonly adopted recharge methods, their operational description, and preferred geographical applicability.

COMMUNITY PARTICIPATION AND BEHAVIORAL CHANGE

Community involvement is the cornerstone of sustainable groundwater usage. Key strategies include:

- **Awareness campaigns** on water-saving techniques and aquifer health
- **School-level water literacy programs**
- **Village water budgeting** based on recharge-extraction analysis
- **Women-led water management committees** promoting equitable access

Studies from Maharashtra show that water-literate communities achieve better conservation outcomes. Building a **"water citizenship"** culture ensures compliance and innovation at the grassroots level.

FUTURE DIRECTIONS

The future of groundwater sustainability in drought-prone areas depends on:

- **Integrated Water Resources Management (IWRM)**: Coordinating land, water, and environmental resources.
- **Data-driven policy-making**: Leveraging satellite and IoT-based analytics.
- **Climate-resilient infrastructure**: Designing recharge systems that endure variability.
- **Recycling and reuse**: Utilizing treated urban wastewater for agriculture.
- **Collaborative research and citizen science**: Engaging local people in aquifer monitoring.

By combining participatory governance, modern science, and policy reform, India can mitigate the growing risks of groundwater depletion.

CONCLUSION

Groundwater management in drought-prone regions must evolve beyond infrastructure to embrace community, behavior, and data. The adoption of recharge-enhancing structures, supported by smart technologies and policy incentives, can reverse aquifer decline. Case studies prove that empowered communities and localized governance drive sustainable outcomes. With adequate investment, education, and monitoring, groundwater can remain a resilient buffer against future droughts.

REFERENCES

1. CGWB. (2020). *National Aquifer Mapping Report*. Central Ground Water Board, India.
2. MoWR. (2019). *Atal Bhujal Yojana Guidelines*. Ministry of Jal Shakti.
3. Bouwer, H. (2002). "Artificial Recharge of Groundwater: Hydrogeology and Engineering." *Hydrogeology Journal*.
4. IWMI. (2018). *Groundwater Governance in India: Stumbling, Blocked, and Uncharted Pathways*.
5. Garg, N. K., & Hassan, Q. (2007). "Alarming Scarcity of Water in India." *Current Science*.
6. ISRO. (2021). *Bhuvan Geoportal for Aquifer Mapping*.
7. Shah, T. (2009). *Taming the Anarchy: Groundwater Governance in South Asia*. RFF Press.
8. Reddy, V. R., & Syme, G. J. (2021). *Integrated Groundwater Management for Livelihood Security in India*. Springer.