Assessing the Water Crisis in Meghalaya, India: An Integrated Analysis through a Physical-Geography Lens

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ABSTRACT

Meghalaya, a state in north-eastern India renowned for its extreme rainfall, is paradoxically facing a severe water crisis, primarily driven by the depletion and degradation of its spring-based water resources. This research paper employs a physical-geography lens to analyze the hydro-geological, climatic, and anthropogenic drivers of this crisis. Through a desk-based review of government reports, project documents, and scholarly articles, this study synthesizes data on over 70,000 identified springsheds, of which approximately 55,000 have been mapped and 792 are critically degraded. The analysis reveals that the combination of seasonal monsoon rainfall, complex karst geology, steep slopes with thin soils, and human activities like deforestation, mining, and infrastructural development creates a system where high rainfall translates into rapid runoff with minimal groundwater recharge. The paper presents case studies of community-led interventions and state-level projects, highlighting the effectiveness of integrated springshed management. It concludes with concrete recommendations spanning technical measures, robust policy and governance frameworks, and innovative financing mechanisms to enhance water security. The findings underscore the critical need for spatially-targeted, geography-informed strategies that address both the physical and human dimensions of water scarcity in this fragile mountainous region.

Keywords: Meghalaya, Water Crisis, Springshed Management, Karst Hydrology, Physical Geography, Climate Resilience, Mining Impact, Community Participation.

INTRODUCTION

Meghalaya, home to the wettest places on earth (Mawsynram and Cherrapunji), presents a profound hydrological paradox: extreme rainfall coexists with acute dry-season water scarcity (Bhowmik & Hossain, 2025). The state's population is heavily dependent on springs, with over 70,000 springsheds identified so far. However, a recent inventory found 792 of these springs to be in a "critical" condition, with many having dried up or being beyond easy rejuvenation (India Today NE, 2025). Historical surveys of a sample of springs indicate a disturbing trend, with over 54% having experienced either complete drying or a major reduction in discharge (meghalayaccc.org, 2025).

This crisis is not merely a result of climatic variability but is deeply rooted in the state's unique physical geography and its interaction with human activities. The high-intensity, seasonal monsoon rainfall, coupled with steep slopes and specific geological formations like karst landscapes, predisposes the region to rapid surface runoff rather than sustained aquifer recharge (MBDA, 2025). Compounding these physical constraints are anthropogenic pressures such as deforestation, unsustainable mining practices, and soil compaction from development (INRM, 2025; ResearchGate, 2025).

This paper aims to comprehensively analyze the water crisis in Meghalaya through an integrated physical-geography framework. It seeks to: (1) delineate the physical drivers of water scarcity; (2) quantify the scale of the problem using available data; (3) examine the interplay of human drivers; (4) evaluate ongoing interventions; and (5) propose a multi-pronged strategy for sustainable water resource management.

METHODOLOGY

This study adopts a qualitative desk-based research methodology, synthesizing data from a wide range of secondary sources. Data was collated from:

1. Government and State Agency Reports: Documents from the Meghalaya Basin Development Authority (MBDA), Central Ground Water Board (CGWB), NITI Aayog, and NABARD were reviewed.

2. Project Documentation: Detailed reports from funded projects such as the NAFCC Springshed Rejuvenation Project, the ADB-funded Water Harvesting Project, and the Community-Led Landscape Management Project (CLLMP) were analyzed.

3. Academic and Scientific Literature: Research papers and conference abstracts discussing the hydrology, geology, and environmental issues of Meghalaya were incorporated.

4. Media and Institutional Briefs: Reputable news reports and briefs from organizations like the Integrated Mountain Initiative were used to gather recent data and case studies.

The data was thematically analyzed to identify key drivers, impacts, and responses. Quantitative data was synthesized into tables to provide a clear overview of the problem's scale. Case studies were developed to illustrate specific challenges and solutions.

RESULTS

The Physical-Geographic Setting of Scarcity.

The physical geography of Meghalaya is a primary determinant of its hydrology. The state's location on the Shillong Plateau subjects it to orographic lift, resulting in very high but highly seasonal monsoon rainfall. This seasonality, combined with steep slopes, promotes rapid surface runoff and flash flows, limiting the time for infiltration and groundwater recharge (MBDA, 2025). Geologically, the state is a mosaic, with extensive limestone/karst formations in the Jaintia and Khasi Hills. Karst terrain is characterized by complex underground flow paths (conduit flows), which are highly sensitive to land-use changes and subsurface disturbances like mining, often bypassing traditional aquifer recharge processes (CGWB, 2025). Furthermore, the region's thin soils on steep slopes, when denuded of forest cover, have low infiltration capacity, leading to significant rainfall being "lost" as immediate runoff (INRM, 2025).

Scale of the Problem: A Quantitative Overview

The scale of the water crisis is reflected in the following synthesized data:

Table 1: Scale of the Springshed Crisis in Meghalaya

Indicator	Value / Trend	Source
Springsheds Identified	>70,000	Uniindia, 2025
Springsheds Mapped	~55,000	The Times of India, 2025
Critical Springsheds	792	India Today NE, 2025
Sample Springs Dried/Reduced	>54% (sample of 714)	meghalayaccc.org, 2025
Springshed Works under MGNREGS (5 yrs.)	~1,600	hubnetwork.in, 2025
State/Partner Investment (Reported)	₹4,000 to ₹8,000 crore	The Meghalayan Express, 2025
ADB Water-Harvesting Project	US$62.5 million (~₹516 crore)	The Times of India, 2025

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Physical and Human Drivers

The crisis is driven by a confluence of physical and anthropogenic factors, as detailed in Table 2.

Table 2: Key Drivers of the Water Crisis in Meghalaya

Driver	Mechanism	Evidence
Seasonal, Intense Rainfall	High intensity causes rapid surface runoff; limited baseflow in dry months.	MBDA, 2025
Deforestation	Reduces interception & infiltration; increases erosion and siltation.	INRM, 2025
Soil Compaction &Infrastructure	Increases imperviousness, reduces percolation, leads to flashier flows.	CGSpace, 2025
Mining (Coal, Limestone)	Subsurface disturbance, acid drainage, contamination, disrupts flowpaths.	ResearchGate, 2025
Over-extraction	Rising demand from households and irrigation pressures limited flows.	NABARD, 2025
Climate Variability	Shifted monsoon timing and longer dry spells weaken recharge.	agu.confex.com, 2025

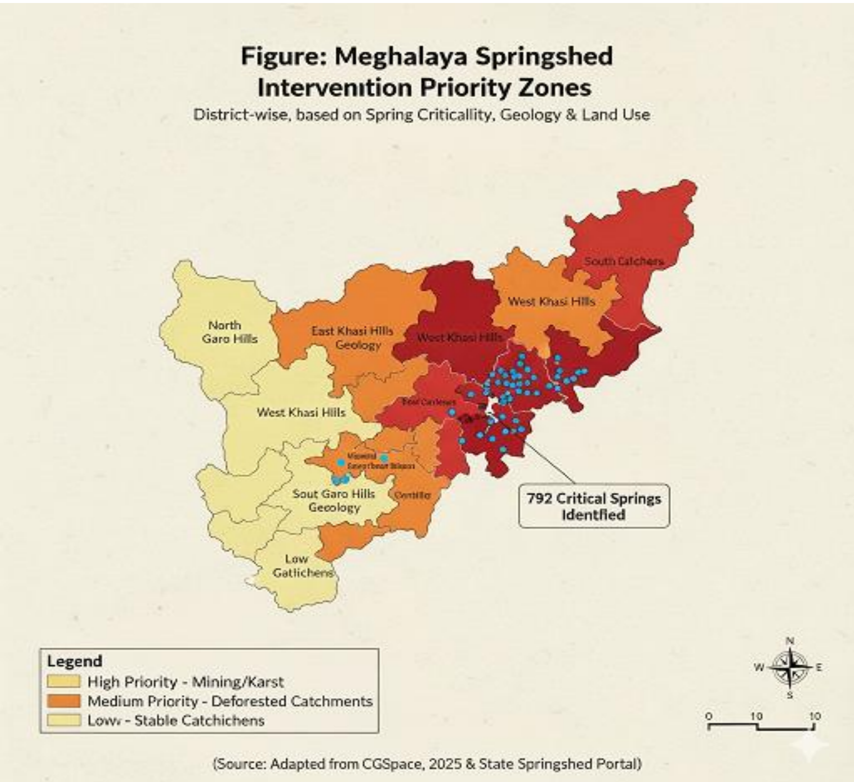
Spatial Prioritization and Interventions

Spatial analysis, as suggested by the ongoing mapping of 55,000 springs, is crucial for targeting interventions. Priority areas include:

1. High-Dependency Rural Landscapes: West Khasi, East Khasi, and Garo Hills districts.
2. Karst & Mining Hotspots: East Jaintia Hills for pollution remediation.
3. Steep, Deforested Catchments: Areas with the highest runoff potential for soil conservation.

A GIS map would illustrate this spatial prioritization, overlaying district boundaries, critical springshed locations, geological zones (especially karst), and mining-affected areas, based on data from sources like CGSpace (2025) and the state's springshed portal.

Figure 1: GIS Map of Meghalaya showing district-wise priority zones for springshed intervention, based on spring criticality, geology, and land use. (Source: Adapted from CGSpace, 2025 & State Springshed Portal).



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A range of interventions are being implemented. Engineering measures like spring chambers, percolation pits, and check dams are widely used to enhance infiltration (megsoil.gov.in, 2025). Afforestation with native species and community-led land-use management have shown promise in improving seasonal resilience. Institutionally, significant funds are being mobilized through schemes like MGNREGS, NABARD, and the ADB project, alongside policy efforts like the Meghalaya State Water Policy (2019) and the formation of a state climate council.

DISCUSSION

The findings confirm that Meghalaya's water crisis is a classic example of a "scarcity in abundance," where physical geography sets the stage for vulnerability, and human actions exacerbate the problem. The high number of critical springsheds (792) and the sample showing over 54% degradation are alarming indicators of systemic stress. The juxtaposition of high rainfall with inadequate recharge underscores the limitations of viewing water availability through a purely climatic lens; the critical factors are geological and ecological. The case studies of Mawphanlur and Wah Shari spring demonstrate that technical solutions, when combined with community participation, can significantly improve water security. These successes align with global best practices in integrated water resource management for mountainous regions (NITI Aayog, 2019). Conversely, the situation in Jaintia Hills serves as a stark warning of how extractive industries can disrupt hydrological systems and poison water sources, necessitating strict regulatory enforcement and remediation. The massive financial investments (₹4,000-₹8,000 crore) highlight the political recognition of the crisis. However, the effectiveness of these investments will depend on their strategic allocation based on spatial priorities (Figure 1) and the integration of technical, governance, and community dimensions. The recommendations put forward—such as formalizing springshed protection zones, blending finance, and empowering women in water committees—provide a holistic pathway forward. The emphasis on community monitoring and low-cost sensors is crucial for building a robust evidence base to guide future action and ensure accountability. A significant limitation of this study is its reliance on evolving and sometimes unverified secondary data. The numbers related to springsheds are dynamic, and project reports may contain optimistic assessments. Future research must focus on establishing a standardized, long-term monitoring network to generate reliable time-series data on spring discharge and water quality.

CONCLUSION

The water crisis in Meghalaya is a complex, geographically-conditioned challenge that cannot be solved by isolated interventions. This paper has demonstrated that a deep understanding of the physical geography—the climate, geology, and slopes—is non-negotiable for crafting effective solutions. While significant financial and technical resources are being deployed, their long-term success hinges on strong governance, including the legal protection of recharge zones, stringent regulation of mining, and the meaningful inclusion of local communities, particularly women. By adopting a spatially-explicit, integrated springshed management approach that respects the state's unique physical landscape, Meghalaya can transition from a paradigm of water scarcity to one of water security and resilience.

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