JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Water Resource Management in Mountain Villages of Arunachal Pradesh

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Abstract

Water resource management in mountain regions involves unique challenges arising from complex topography, fragile ecosystems, climatic variability, and dispersed human settlements. Arunachal Pradesh, located in the Eastern Himalayan region of India, is commonly perceived as a water-rich state due to its high rainfall and extensive river systems. However, many mountain villages across the state increasingly experience seasonal and localized water scarcity, particularly during dry months. This paper examines the nature and dynamics of water resource management in the mountain villages of Arunachal Pradesh, with particular emphasis on the role of springs as primary sources of drinking water, community-based management practices, and institutional interventions. Based on secondary data drawn from academic literature, government reports, policy documents, and credible media sources, the study argues that water insecurity in mountain villages is less a consequence of physical water scarcity and more the result of ecological degradation, changing land-use patterns, climate variability, and governance approaches that inadequately reflect mountain hydrology. The paper highlights how declining spring discharge, weakening traditional institutions, and infrastructure-centric policy responses have contributed to growing vulnerability at the village level. It emphasizes the importance of springshed conservation, integration of indigenous knowledge with scientific planning, and community participation in water governance. The study concludes that context-sensitive, ecosystem-based, and decentralized management approaches are essential for ensuring long-term water security in the fragile mountain landscapes of Arunachal Pradesh.

Keywords: Water resource management, mountain villages, springs, Arunachal Pradesh, Himalayan hydrology, community governance

Introduction

Water is central to the survival, health, and socio-economic stability of mountain communities, yet its management in highland regions is among the most complex governance challenges. Mountain ecosystems function as critical water towers, feeding rivers, sustaining biodiversity, and supporting downstream populations. However, for communities residing within these landscapes, access to safe and reliable water is often uncertain and seasonally constrained. In Arunachal Pradesh, a predominantly mountainous state in Northeast India, water resource management has emerged as a critical issue despite the region's reputation for hydrological abundance. Arunachal Pradesh receives high annual rainfall and hosts several major river systems originating from the Eastern Himalayas. Traditionally, mountain villages relied on natural springs, streams, and small rivulets to meet domestic and livelihood needs. These water sources were embedded within local ecological systems and governed through customary norms and collective practices. For generations, such arrangements ensured relatively stable water access despite the challenges posed by steep

terrain and dispersed settlements. However, in recent decades, these traditional systems have come under increasing stress due to ecological degradation, demographic change, and climatic variability. One of the defining features of mountain villages in Arunachal Pradesh is their dependence on springs as primary drinking water sources. Springs are highly sensitive to changes in rainfall patterns, vegetation cover, and land use within their recharge zones. Deforestation, road construction, urban expansion of rural settlements, and shifting cultivation practices have altered catchment hydrology, leading to declining spring discharge in many areas. Consequently, villages that once enjoyed perennial water supply now face seasonal shortages, compelling residents—particularly women and children—to travel long distances to fetch water. Climate change has further intensified these vulnerabilities. Altered rainfall patterns, prolonged dry spells, and increased frequency of extreme weather events disrupt natural recharge processes. The hydrological uncertainty introduced by climate change undermines both traditional knowledge systems and modern infrastructure-based solutions. At the same time, state-led interventions such as piped water supply schemes and flagship programs like the Jal Jeevan Mission have expanded physical infrastructure but often without adequate consideration of local hydrological realities and long-term sustainability. Against this backdrop, the management of water resources in mountain villages of Arunachal Pradesh must be understood as a complex interaction between natural systems, community institutions, and state policies. This paper seeks to analyze these interactions by examining how water is sourced, governed, and distributed in mountain villages, the challenges that undermine sustainability, and the pathways for strengthening water security in a fragile Himalayan context.

Research Methodology

The study adopts a qualitative research design based entirely on secondary sources of data. Relevant literature was collected from peer-reviewed academic journals focusing on Himalayan hydrology, rural water governance, and environmental management, along with government reports and policy documents related to rural drinking water supply in Arunachal Pradesh. Reports published by research institutions, environmental organizations, and development agencies were also consulted to capture practical insights into spring management and community-based water initiatives. In addition, credible newspaper articles and digital media sources were used to document recent trends and emerging challenges related to water scarcity in mountain villages. The collected data were analyzed using a thematic and interpretive approach. Key themes such as spring dependency, community governance, institutional interventions, ecological degradation, and climate variability were identified and systematically examined. By synthesizing perspectives from geography, environmental studies, public administration, and development studies, the methodology treats water resource management as a socio-ecological system rather than a purely technical issue. This approach enables a contextual understanding of how environmental processes, policy frameworks, and local practices interact to shape water security in the mountain villages of Arunachal Pradesh.

Conceptual Review of Literature

The literature on water resource management in mountain regions emphasizes the distinctiveness of highland hydrological systems and the socio-cultural dimensions of water use. Scholars have argued that mountains function as “water towers” for downstream regions, yet local communities within these regions often face water scarcity due to uneven distribution and limited storage capacity. In the context of the Himalayas, studies highlight the importance of springs and small catchments as primary sources of drinking water, particularly in rural and tribal areas. Conceptual approaches to mountain water management increasingly stress the need for integrated and ecosystem-based frameworks. Traditional engineering-centric models, focused on large-scale infrastructure, are often inadequate for mountain terrains where geological instability and dispersed settlements pose significant constraints. Instead, scholars advocate decentralized, community-managed systems that align with local ecological conditions. This perspective resonates strongly with Arunachal Pradesh, where indigenous communities have historically developed localized water management practices suited to their environments. A significant body of literature documents indigenous knowledge systems related to water conservation in Arunachal Pradesh and other northeastern states. Practices such as bamboo piping systems, community-protected forest catchments, and customary rules governing water sharing reflect a deep ecological understanding. These systems are embedded within social norms and institutions, ensuring collective responsibility and sustainability. However, recent studies also note the

gradual erosion of such practices due to external interventions, market integration, and generational shifts in values. Climate change has emerged as a critical theme in contemporary literature. Researchers point to changing rainfall patterns, rising temperatures, and increased incidence of landslides as factors disrupting traditional water sources. In Arunachal Pradesh, where meteorological data are sparse, local observations of spring depletion and seasonal variability provide important insights. The literature underscores the vulnerability of mountain water systems to climate-induced stress, particularly in regions with limited adaptive capacity. Policy-oriented studies examine the role of state institutions and development programs in water provisioning. While schemes such as the Jal Jeevan Mission aim to ensure universal access to drinking water, their implementation in mountain villages faces challenges related to terrain, logistics, and long-term sustainability. Scholars argue that top-down approaches often overlook local contexts, resulting in infrastructure that is difficult to maintain and poorly integrated with community needs.

Critical Analysis and Discussion

The water crisis experienced by many mountain villages in Arunachal Pradesh illustrates a fundamental mismatch between hydrological realities and governance approaches. Although the state is endowed with abundant rainfall, the spatial and temporal distribution of water is highly uneven. The steep terrain causes most rainfall to flow rapidly as surface runoff, limiting groundwater recharge. Springs, which depend on slow subsurface flows, are therefore particularly sensitive to environmental disturbance. This hydrological characteristic explains why water scarcity emerges even in regions with high precipitation. Institutional responses to water scarcity have largely focused on infrastructure expansion rather than ecological restoration. Piped water schemes and storage tanks provide short-term relief but remain dependent on declining spring sources. Without systematic springshed management, such infrastructure risks becoming unsustainable. The absence of integrated watershed planning reflects a broader governance gap, where sectoral approaches fail to address interconnected socio-ecological systems. Community-based initiatives offer important lessons in adaptive water management. Villages that have invested in protecting spring catchments through afforestation, recharge trenches, and collective monitoring often report improved water availability. These efforts demonstrate that water security in mountain regions is as much a social and institutional challenge as a technical one. However, community capacity varies significantly, influenced by factors such as social cohesion, leadership, and access to external support. Where such capacity is weak, reliance on state intervention increases, often without commensurate improvement in outcomes. Climate change introduces an additional layer of uncertainty. Shifting rainfall patterns undermine both traditional seasonal calendars and modern planning assumptions. Springs that were once reliable throughout the year now exhibit fluctuating discharge, complicating supply planning. Adaptive governance requires integrating climate projections into water management strategies, yet such integration remains limited in policy practice. The result is a reactive rather than anticipatory approach to water security. A critical concern emerging from the analysis is the sustainability of current governance models. The emphasis on infrastructure without adequate maintenance frameworks, ecological safeguards, and community ownership risks long-term failure. Effective water resource management in mountain villages requires a shift from supply-centric to systems-based approaches that recognize the interdependence of ecology, institutions, and livelihoods.

Research Gaps and Future Directions

Despite growing attention to water issues in Arunachal Pradesh, significant research gaps remain. There is a lack of long-term empirical data on spring discharge trends and their relationship with land-use change and climate variability. Village-level studies examining gendered dimensions of water access and decision-making are also limited, despite women bearing a disproportionate burden of water collection. Furthermore, the interaction between formal state institutions and customary governance systems remains under-theorized. Future research should prioritize interdisciplinary approaches combining hydrology, social science, and policy analysis. Comparative studies across Himalayan regions could help identify scalable best practices. Greater emphasis on participatory research would also ensure that policy recommendations are grounded in local realities.

Conclusion

Water resource management in the mountain villages of Arunachal Pradesh highlights a critical disconnect between natural water availability and effective access at the local level. Despite high rainfall and dense river systems, many villages experience increasing water insecurity due to the fragile nature of mountain hydrology, declining spring sources, and growing ecological stress. This study shows that water scarcity in these areas is shaped more by environmental degradation, land-use change, and weak institutional adaptation than by absolute shortages of water. Springs remain the backbone of rural water supply in mountain villages, yet they are highly sensitive to changes in vegetation cover, rainfall patterns, and human interventions. The decline of spring discharge, combined with climate-induced variability, has disrupted traditional water systems and increased the burden on rural households, particularly women. While government programs such as the Jal Jeevan Mission have improved physical access to water through infrastructure expansion, their effectiveness is often limited by inadequate attention to springshed conservation, local hydrological conditions, and long-term maintenance. The findings suggest that sustainable water security in Arunachal Pradesh requires moving beyond infrastructure-focused approaches toward integrated and community-oriented management models. Protecting catchment areas, strengthening local institutions, and aligning state policies with mountain-specific ecological realities are essential steps in this direction. Recognizing water as a socio-ecological resource and incorporating both traditional knowledge and scientific planning can contribute to more resilient and equitable water management in the mountain villages of the state.

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