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SPRINGSHED MANAGEMENT FOR REVIVING MOUNTAIN SPRINGS: A NATURE-BASED PATHWAY TO WATER SECURITY

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Springs constitute the most critical and dependable freshwater sources in India's mountainous and hill regions. In the Himalayas, Western Ghats, Eastern Ghats and associated hill systems, springs serve as the primary source of drinking water, support subsistence agriculture, sustain livestock, and maintain ecological flows in rivers during the lean season. Recognising their strategic importance, the Ministry of Jal Shakti has identified spring revival as a national priority, noting that nearly half of India's perennial springs have either dried up or become seasonal due to a combination of climatic, geological, and anthropogenic factors. The Ministry's document *"Springshed Management in the Mountainous Regions of India"* marks a paradigm shift in water management by formally recognising that springs are not isolated discharge points but manifestations of complex groundwater systems governed by recharge areas, subsurface geology, land use, and ecological health. Springshed management, therefore, focuses on restoring the natural processes that sustain spring flow rather than relying on extraction-based or outlet-centric interventions.

***Fig. 3**: Different components of Spring System*

Concept of Springshed: A Shift from Surface Watershed Thinking

A spring is the visible expression of groundwater emerging at the surface when subsurface flow paths intersect the land surface. The area that contributes recharge to this groundwater system is referred to as the springshed. Unlike surface watersheds, which are defined by topographic divides, springsheds are governed by subsurface geological controls such as fractures, faults, lithological contacts, and weathered zones.

Springsheds often extend across multiple surface watersheds and administrative boundaries. As a result, conventional watershed development programmes frequently fail to revive springs because they do not adequately address the actual recharge zones. Springshed management therefore requires a hydrogeology-driven approach that integrates geology, geomorphology, land use, vegetation, and community institutions.

Free-flowing Springs and Seep Springs

Springs in mountainous regions commonly occur as either free-flowing springs or seep springs, each reflecting distinct hydrogeological condition. Free-flowing springs discharge water at a well-defined point, often with a continuous and visible flow. These springs are typically controlled by fractures, joints, or contacts between permeable and impermeable rock formations. Because of their concentrated discharge, free-flowing springs are frequently developed for piped water supply systems but are also more vulnerable to disruption if recharge pathways are disturbed. In contrast, seep springs emerge diffusely over slopes as slow oozing or damp zones rather than a single outlet. They are associated with shallow aquifers, weathered rock layers, and soil–rock interfaces. Although individual discharge rates are low, seep springs play a crucial role in maintaining soil moisture, supporting vegetation, stabilising slopes, and sustaining baseflow to streams. The Ministry's framework recognises that seep springs are often overlooked but are hydrologically and ecologically significant, particularly in forested and grassland landscapes.

Fig. 2: (A) Free Flow Spring & (B) Seep Spring

Classification of Springs Based on Geo-hydrological Conditions

Springs in mountainous regions can be classified according to the geological and hydrological mechanisms controlling groundwater movement and also correct identification of spring type and aquifer conditions is fundamental for designing effective rejuvenation strategies, as recharge mechanisms and response times vary significantly among different spring classes.

1. **Depression springs:** These springs discharge where the ground surface intersects the water table, representing the upper surface of the aquifer (Fig. 3). Such springs are generally found in undulating topography where slopes change abruptly and the water table tends to intersect the topography in depressions.

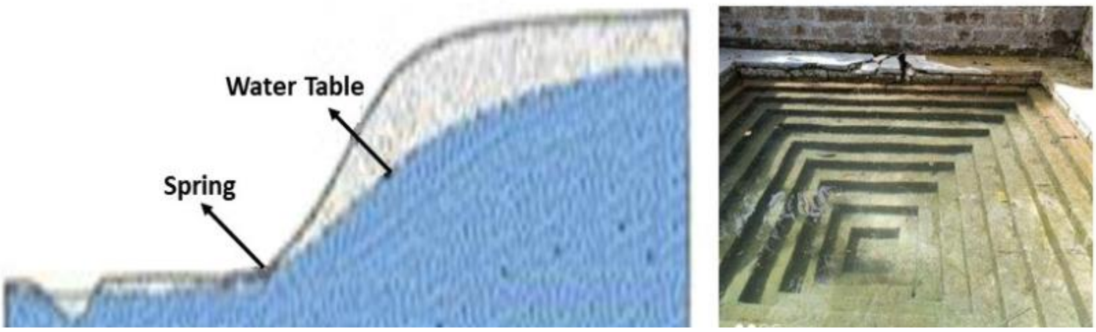

Fig. 3: Conceptual diagram of Depression Spring

2. **Contact springs:** These springs where a permeable water bearing formation overlies a less permeable or impermeable formation intersects the ground surface (Fig. 4). Occurrence of a number of springs in a horizontal line pattern indicate the existence of contact springs in the area.

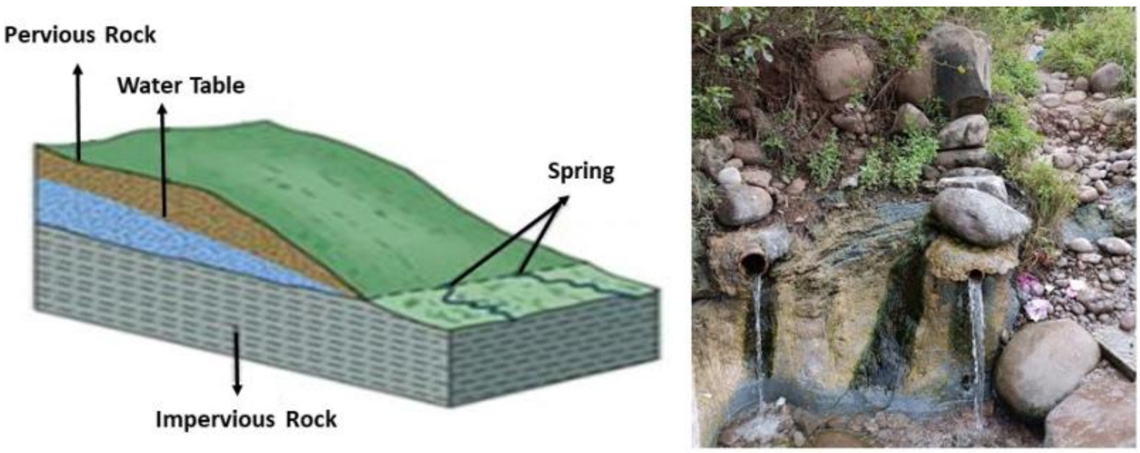

Fig. 4: Conceptual diagram of Contact Spring

3. **Fracture/fault spring**: These springs originate from water-bearing fractures or faults in the Earth's crust that intersect the topography along specific areas. In these springs, water seeps into the ground, navigating through geological fractures or faults, and eventually emerges as a spring on the Earth's surface (Fig. 5). Genesis of number of springs along a vertical line pattern are the indication of fracture or fault springs in the area.

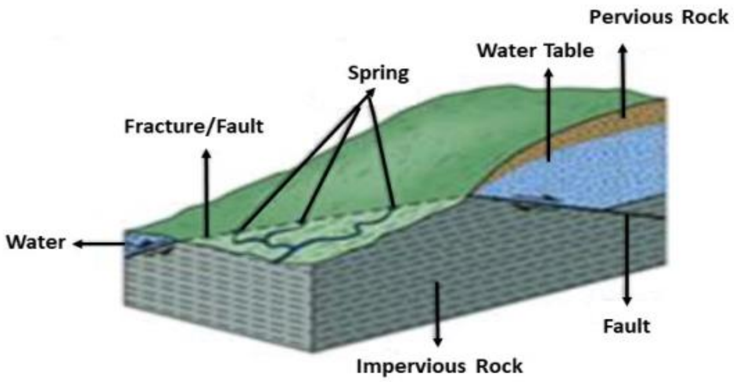

Fig.e 5: Conceptual diagram of Fracture/fault Spring

4. **Karst springs:** These springs are the typical example of springs originating from limestone or dolomite lithology. In Karst springs, water flow within sinkholes or cavities formed in carbonate rocks due to the dissolution of rock material by chemical action (Fig. 6). Over time, these cavities get enlarged due to continuous dissolution, forming caves from which groundwater emerges.

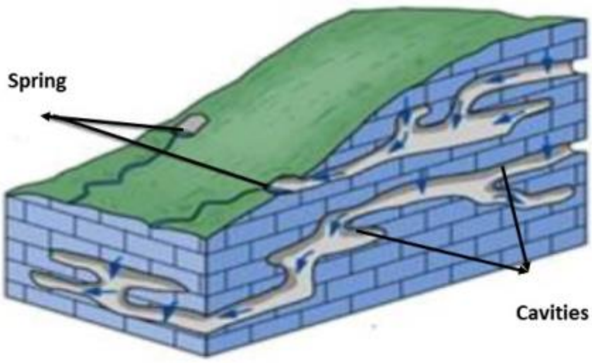

Fig. 6: Conceptual diagram of Karst Spring

Causes of Spring Degradation in Mountainous Regions

Spring discharge decline is primarily attributed to changes in recharge dynamics rather than reduced rainfall alone. Increasing rainfall intensity combined with shorter duration leads to higher surface runoff and reduced infiltration. Deforestation, loss of forest litter, road cutting, construction activities, and unregulated tourism disrupt natural recharge pathways. Climate change further compounds these issues by altering precipitation patterns, reducing winter snowfall, and increasing evapotranspiration. Springs act as early indicators of groundwater stress, and their drying reflects broader degradation of mountain aquifers. Addressing spring decline therefore contributes not only to drinking water security but also to long-term groundwater sustainability.

Springshed management is conceptualised as a phased and systematic process. It begins with spring inventory and mapping, followed by hydrogeological assessment to delineate recharge zones. Treatment measures are then implemented primarily in recharge areas rather than at the spring outlet. These measures aim to enhance infiltration, increase subsurface storage, and protect recharge pathways. Structural interventions such as contour trenches, staggered trenches, percolation pits, recharge shafts, and small check dams are combined with eco-hydrological measures including afforestation with native species, grass bunding, mulching, and protection of forest litter layers. The emphasis is on low-cost, decentralised, and nature-based solutions that work with the terrain rather than against it.

Spring outlets are protected through spring chambers, fencing, and diversion drains to prevent contamination. The Ministry also underscores the importance of water quality protection by regulating sanitation, waste disposal, and land-use practices within recharge zones.

Institutional Framework and Community Participation

Springshed management, as articulated by the Ministry of Jal Shakti, is inherently community-centric. Since recharge areas often extend beyond village or administrative boundaries, collective governance mechanisms are essential. Village water committees, Panchayati Raj Institutions, and local user groups are encouraged to take ownership of monitoring, maintenance, and regulation of spring use. The framework also promotes convergence with national programmes such as the Jal Jeevan Mission, MGNREGA, and watershed development projects like PMKSY to ensure financial sustainability and institutional support. Continuous monitoring of discharge, rainfall, and water quality is integral to adaptive management and long-term success.

Outcomes and Significance for Water Security

Evidence documented by the Ministry shows that scientifically planned springshed interventions can significantly enhance spring discharge, improve dry-season water availability, and reduce dependence on tanker water and deep borewells. Beyond drinking water security, revived springs contribute to improved agricultural productivity, enhanced ecosystem services, and sustained baseflows in rivers.

Springshed management thus represents a transition from extraction-driven water supply models to recharge-oriented, ecosystem-based groundwater governance, aligning with climate adaptation and sustainable development goals.

Conclusion

Springshed management framework provides a robust scientific and institutional foundation for reviving India's drying springs. By recognising springs as integral components of groundwater systems and addressing their recharge areas through hydrogeological understanding, ecological restoration, and community stewardship, springshed management offers a resilient pathway to water security in mountainous regions.

As climate variability intensifies and groundwater stress deepens, the revival of free-flowing and seep springs through springshed management will be indispensable for sustaining rural livelihoods, protecting fragile ecosystems, and securing India's water future.

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