Spring Hydrogeology: Science based Approach for Springshed Management

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Why Springs?

- A **spring** is a place where water from beneath the ground naturally flows out to the surface. The word originates from the German word 'springer,' which means 'to leap from the ground.'
- Spring are lifeline for communities in mountains.
- Diversity in Springs (Typologies).
- Springs discharges are decreasing & urgent need to revival.
- Common pool resource.
- Scientific management through community participation.
- Need to look at both **augmentation** as well as demand **regulation**.
- Need for a cadre of last mile workers.
- Need for increased public awareness in springs rejuvenation.
Emerging trend: Water Security to Scarcity

Perennial Spring → Seasonal Spring → Dried Spring

Water Security in Changing Climatic and Socio-Economic Scenarios

Springs are drying
There is increasing evidence that springs are drying up or their discharge is reducing and started emerging as a common theme across the mountain regions.

Why are springs drying?
- Climate change, especially rainfall
- Land cover and land use changes
- Socioeconomic and demographic changes
- Change in cropping pattern

Impacts
- Drinking and domestic water shortage in rural and urban areas.
- Irrigation water insecurity in the hills
- Poor ecosystem services – e.g., low base flow and human-wildlife conflicts
Different Scenarios of Water Security

Springs: supply & demand

Springs: managing supply

Springs: managing demand

Springs: Resource sustainability only through demand management

Supply and demand...SPRINGS

Springs: Resource sustainability - resource augmentation and demand management

Source: ACWADAM
Hydrogeological Diversity

Mountain Systems – rock structure plays a significant role in groundwater occurrence and movement.
Alluvial (Unconsolidated) Systems - water in sand and silt lenses, with clays separating aquifers.
Sedimentary (Soft Rock) Systems - coarse sandstone, grit, coal, fossil-bearing rocks - usually contain many openings and water travels through them quickly.
Sedimentary (Hard Rock) Systems - sandstones, limestones, siltstones; contain bedding, fractures and joints may play a significant role in groundwater storage and movement.
Volcanic Systems - mostly basalt – some dykes - water stored in vesicles and weathered zones - movement mostly through joints.
Crystalline (Basement) Systems - granites, schists, gneisses - groundwater accumulates and moves through weathered zone, joints and fractures.
Vulnerability Assessment

Major rock system in Uttarakhand

Figure: Distribution of aquifers in the state
At a larger national scale, a gross estimate of nearly 200 million Indians depending upon spring water across the Himalayas, Western Ghats, Eastern Ghats, Aravallis and other such mountain ranges - implies that more than 15% of India’s population depends on spring water. (Niti Ayog)
Change in Rainfall in Dabka Watershed (1985-90 to 2005-10)

<table>
<thead>
<tr>
<th></th>
<th>Annual Average Rainfall</th>
<th>Moonson Rainfall</th>
<th>Non-Moonson Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Change in Rainfall</td>
<td>-7.08</td>
<td>-30.19</td>
<td></td>
</tr>
</tbody>
</table>

Source: Rawat et al.

Status of Springs in Dabka Watershed

<table>
<thead>
<tr>
<th>Percentage of Springs</th>
<th>Perennial</th>
<th>Seasonal</th>
<th>Dried</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>94.12</td>
<td>47.06</td>
<td>25</td>
</tr>
<tr>
<td>2008</td>
<td>5.88</td>
<td>27.94</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Rawat et al.
Methods for Springshed Management

1. Base line survey
2. Spring Inventory
3. Hydrogeological Survey
4. Village water security plan preparation
5. Capacity building
6. Institutional Framework & Governance structure
7. Catchment Area Treatment (recharge works) through UWSC
8. Operation and Maintenance
9. Data & MIS
The science of groundwater known as ‘hydrogeology’ can lead us to a better understanding of aquifers, thus providing ways and means for its proper sustainable management. In the mountain areas like the Himalayas, high relief and the complex geological structure plays a vital role in formation of these mountain aquifers. Hydrogeological mapping of the springs often reveals that the recharge area and the area of protection of the springs show a very site-specific relationship.
• Layers of sediment consolidate to form a bed of rock.
• Many beds or layers lie one below the other in a simple sequence of sediments.
• The beds may be horizontal or dipping

Sometimes beds dip, i.e. they become inclined with respect to the horizontal.
The dip is an angle of the bed with the horizontal plane.
The line of intersection of a dipping bed, with the ground surface is called strike. Strike has a direction.
Types of porosity

- Primary Porosity

Secondary Porosity

Relations Between Texture and Porosity:
A. Well-Sorted Sand Having High Porosity;
B. Poorly-Sorted Sand Having Low Porosity;
C. Fractured Crystalline Rocks (Granite);
D. Soluble Rock-Forming Material (Limestone).
Hydrogeological Cross Section

Index
- Quartzite
- Phyllite
- Fracture

Legends
- Recharge area
- Topography
- Aquifer
- Quartzite
- Phyllite
- Fracture
- Spring

Geological Cross section of Luhali village

Legends
- Quartzite
- Sandstone
- Phyllite
- Fracture
- Major Fracture
- Fault
- Recharge Area

Hydrogeological layout of Kunjajari

INDEX
- Spring
- Recharge area
- Calcarious Phyllite
- Slate
- Limestone
- joint Set/ fracture
- Unconsolidated Debris
Types of Springs: Spring Classification

- Depression spring
- Contact spring
- Fracture spring
- Fault spring
- Karst spring
Fracture springs

- Fracture springs occur as a result of permeable fracture zones appearing in low permeability rocks. Movement of groundwater is mainly through the fractures which tap both shallow and deep aquifers. Springs are formed where these fractures intersect the land surface.
Contact springs

- Contact springs emerge at places where relatively permeable rocks overlie rocks of low permeability.
- A lithological contact is usually marked by a line of springs.
- Such springs are usually associated with perched aquifers in mountains.
Depression Spring

- Formed at topographic lows.
- Formed when water table reaches the surface due to topographic undulations.
- A local flow system is created and a spring is formed at the local Discharge zone.
Fault Spring

Faulting may also give rise to conditions favorable for spring formation as groundwater (at depth) under hydrostatic pressure (such as in confined aquifers) can move up along such faults. An impermeable rock unit may be brought in contact with an unconfined aquifer due to faulting.
Karst Spring

- Limestones host many springs.
- Springs in limestone terrains can be interconnected to topographic depressions caused by sinkholes – depressions in the ground surface cause due to the dissolving of limestones below.
- Large quantities of water move through the cavities, channels, conduits and other openings developed in limestones.
Hydrogeological Approach
Springs and its recharged areas marked on a Google image
Activities Proposed in Recharge Area of Bowri-1 & Bowri-2 in Luhali Village
Recharge Works through UWSCs
Springshed Recharge work was completed in February, 2016.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Dimension</th>
<th>Volume in Cubic Meters</th>
</tr>
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<tbody>
<tr>
<td>Staggered Contour Trenches</td>
<td>2mx0.45mx0.45m</td>
<td>203</td>
</tr>
<tr>
<td>Recharge Pond</td>
<td>2mx1mx0.45m</td>
<td>22</td>
</tr>
<tr>
<td>Recharge Pits</td>
<td>0.6mx0.6mx0.45m</td>
<td>57</td>
</tr>
</tbody>
</table>

- **Plantation:** Fodder Plants: 500 Plants, Napier Grasses: 10,000 Saplings
- **Impact:** Spring discharge increases 3.5 times from base line (August 2015)
Spring discharge behaviour with Groundwater recharge (2002-2019), Chureddhar village of Tehri district of Uttarakhand

Projected Spring Discharge

Recharge Interventions (2009)
Recharge Interventions /Desilting (2012)
Desilting (2018)
Recharge Interventions (2019)

Groundwater Recharge in Cubic Meters

Water Demand Vs Availability in Chureddhar Village (2002-2018)

- Water Demand
- Water Availability

Recharge Interventions (2009)
Springshed Management: Steps for Preparation of Hydrogeological Technical Report

- Geotagging of Springs
- Spring Inventory
- Hydrogeological Survey
- Hydrogeological mapping of springshed
- Classification of the spring
- Secondary data collection and interpretation
- Identification of recharge area based on local geology and structure
- Setting up a monitoring system for periodic spring discharge, rainfall and water quality data collection
- Delineation of the mountain aquifer
- Conceptual layout of spring
- Sharing with UWSC/ community in local language
- Planning of treatment measures in the recharge area with the help of community participation
Thanks