REPORT OF COMMITTEE TO COLLECT/COMPILE METADATA OF ALL SPRINGS IN HILLY STATES PAN-INDIA

February, 2019

Composition of Committee to collect/compile metadata of all springs in hilly states pan-India

1. Sh S. K. Sinha, Director, Survey of India — Chairman
2. Sh G. C. Pati , Member(HQ), CGWB, Delhi — Member Secretary
3. Representative of NRSC — Member
4. Representative of Deptt. of Science & Technology — Member
5. Representative of NATMO — Member
6. Representative of India Meteorological Department — Member
7. Representative of each Hilly State — Member

Monitoring Group of the Committee

1. Sh. S K Sinha, Director, International Boundaries Directorate, SOI & Chairman of the Committee
2. Sh G C Pati, Member (HQ), CGWB & Member Secretary of the Committee
3. Sh. D.N. Pathak, Director, DSA, Survey of India
4. Dr Sudhir Kumar, Scientist-E, NIH, Roorkee
5. Sh. V. M. Chowdary, Sci / Engg. 'SG', NRSC, Delhi
6. Dr. Poonam Sharma, Sr. Hydrogeologist, CGWB
7. Sh. S. K. Sinha, Suptdg. Hydrologist, CGWB
8. Sh S N Dwivedi, Scientist C , CGWB, Faridabad

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Cover Photo : Spring in Barail Sandstone, Tuensang District, Nagaland (Source-CGWB)

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PREFACE

The completion of the Committee's report 'collect/compile metadata of all springs in hilly sates pan-India' has been possible because of the active participation and wholehearted support from members of the committee, especially from Central Ground Water Board, Survey of India, National Remote Sensing Centre, Geological Survey of India & National Institute of Hydrology. I take the opportunity to thank the Committee members for their valuable input in making available information on spring and I am grateful to Sh. Akhil Kumar, Joint Secretary (IC & GW), Ministry of Water Resources, RD & GR for entrusting the Committee with the responsibility. My special thanks to Lt. Gen Girish Kumar (VSM) for his valuable suggestions and support in making the resources of Survey of India, available to the Task Group.

The Monitoring Group and Task Group of the Committee met four times during this period and had discussions on information received from various State / Central agencies on springs, and integrating them to a common platform as Spring-GIS. The task would not have been possible without the valuable contributions of all the Committee members, the guidance of the Monitoring Group and sincere efforts made by every member of the Task group.

Springs like ground water are important source of fresh water for local people, especially in hilly difficult terrains where other sources of water are not easily available. Himalayas are source of many springs and waterfalls. Traditionally, local inhabitants are using springs for their domestic, drinking and irrigation needs. However, as observed by the Committee, there is not much records available on information/attributes of springs in hilly states. On the other hand, NGOs and Research Institutes are doing work at local level in participatory mode. Chiraag & Himmothan (NGOs) have also shared their information on springs for Uttarkhand State. Water has a key role in nation building and availability of water in hilly areas to people not only decreases their drudgery but also will support them to progress in other sectors.

This report is a sincere attempt to compile the heterogeneous information on Springs, available with various Central/State agencies, on a GIS-system. It is an endeavour which will act as base data for further facilitating various central, states, NGOs & research institutes to add information, filling the data gaps, planning, monitoring and taking up works for rejuvenation of vulnerable springs.

Feb., 2019

(S. K. Sinha)
Chairman of the Committee

Acknowledgements

The committee "Collect / compile metadata of all springs in Hilly States, pan-India" constituted by the Ministry of Water Resources, RD & GR thanks all central &state agencies, research institutes & NGOs who participated / shared their valuable views & information on springs. The committee is extremely indebted to Sh S K Sinha, Director, International Boundaries, Survey of India for his invaluable guidance and continuous monitoring of work assigned to the committee. The committee is extremely thankful to Lt. Gen Girish Kumar (VSM), Director General, Survey of India for providing full support not only in making available various thematic layers but also giving support in compilation of information on springs in the form of Spring-GIS. The Committee thanks to Sh K. C. Naik, Chairman, CGWB for providing full support & guidance from time to time.

The committee thanks to NRSC, IIRS, CGWB regional offices of hilly Himalayan states and NIH for providing support in taking up the initiative of Spring-GIS, which is perhaps the first compilation attempt taken under the guidance of Ministry of Water Resources, RD & GR. The committee thanks to Forest Deptt., J& K, Jammu University, Wadia Institute, NESAC, Dhara Vikas, Sikkim; Chiraag- NGO, Himmotthaan Society, Dehradun, NGO; PHED, Mizoram; Institute of Natural Resource Management, Meghalaya Basin Development Authority, Maghalaya for sharing their spring data. The committee gives special thanks to Geological Survey of India for generously providing data of geothermal springs in Himalayas. The committee is thankful to Dr Poonam Sharma, Senior Hydrogeologist, CGWB and Lt. Col. P K Panday, Survey of India, Dehradun for writing chapters of the report and editing done by Sh. V. M. Chowdary, Sci / Engg. 'SG', NRSC,Delhi. The Committee thanks to members of Task Group from IIRS, NIH, NRSC, SOI & CGWB for compilation of information and brining in the form of Spring-GIS. Special thanks to Regional Directors of NWHR, Jammu; NHR, Dharmshala; NER,Guwahati & ER, Kolkatta and especially to Dr Sudhir Kumar, Scientist-D, Sh Vipin Malik, Scientist-B, Sh Biplab Roy, Scientist-D, Dr Bagchi, AHg & Ms Ankita Bhattacharya, Scientist-B for providing their valuable support. The committee also thanks to Sh S. N. Dwivedi, Scientist-C & Ms Madhumanti Ray, Scientist-B from CGWB for arranging meetings of the committee & compiling data of springs.

(G C Pati)
Member Secretary of the Committee

EXECUTIVE SUMMARY

1. The Committee to Collect / Compile Metadata of all Springs in Hilly States pan-India was constituted on 31st August, 2018 by the Ministry of Water Resources, River Development & Ganga Rejuvenation to collect / compile metadata of springs, finalise atlas & recommendations for better management & development of springs (Appendix 1).
2. Members of the Committee are from Central Orgainsations such as Survey of India, NRSC, Dept. of Science & Technology, NATMO, IMD including CGWB and representative of Hilly States (Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Sikkim & 7 North Eastern States i.e. Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland & Tripura).
3. The Committee under the Chairmanship of Sh S K Sinha, Director, International Boundaries Directorate, Survey of India constituted Monitoring and Task Groups for overall guidance & monitoring of the work assigned and Task Group for collection& compilation of spatial distribution of springs data on GIS platform.
4. Water resource availability, its development & sustainable management are key components of social & economic growth of an area. Although, ample water & snow resources are available in difficult mountainous terrains of Himalayas,, but access of water at doorstep is difficult. Villages / habitations are scattered on valleys & hilly slopes, and water supply if available is through lift system only. Under such conditions, millions of habitants are depending on springs for their drinking, domestic as well as irrigation water needs. Springs traditionally remained preferred source of water at local level for catering water demands in mountainous regions of Himalayas. However, management of springs is difficult and lacking in this region in the absence of information on springs location, annual water resource availability and spring water quality. In the era of rapid technological advances, some Non-Government Organizations (NGOs) taken initiatives on spring rejuvenation at few locations in Hilly States in association with local people.

Further, they are conducting capacity building programs for inhabitants of this region in the sustainable management of springs..

5. In the year 2018, NITI Aayog submitted Report of Working Group I on 'Inventory & Revival of springs in the Himalayas for Water Security' with specific objectives namely (i) to take stock of the magnitude of the problem (drying of springs, spring water quality) and (ii) to review related policies across Indian Himalayan Region (IHR). This study ascertained adequacy and gaps and reviewed existing initiatives and best practices that included inventorization and spring revival by different agencies across IHR. Further, report highlighted to what extent learning from all the best practices and methodologies can be integrated to strengthen the work on springs.. The report suggested several general and specific recommendations such as i)Systematic mapping of springs across the IHR States, ii) Creation of a web-enabled database/web portal on which the springs can be mapped/tagged. All State government departments, Research and Development (R&D) institutions and NGOs working on springs and spring-shed management will upload data on the web-portal iii) Capacity building activities, focusing on creation of a cadre of para-hydrogeologists, iv) Organising a national level workshop for policymakers and decision-makers in order to sensitize them on the issue of drying-up of springs and the crucial role of spring-shed management, v) Mainstreaming and convergence of spring-shed management with other developmental programmes, will be required to facilitate greater synergies with government schemes etc. The most important recommendation of the group is to launch a National Programme on Regeneration of Springs in the Himalayan Region.
6. Efforts are made by the committee to collect the limited springs information available with few research organizations, NGOs and academic institutes. These stakeholders are working independently and are willing to share the data. Further, the Committee found that some of the hilly States / research institutes / universities have showed their interest in monitoring of springs (J&K, Meghalaya) if funds are made available to them. In this regard, the committee suggests that the Ministry of Water Resources, RD & GR may consider funding for systematic mapping and collection of attribute data of springs in Himalayan states. Use of latest technologies, web enabled platforms for data sharing and collaborative mapping with community participation and adherence to standards should be central to the systematic mapping exercise.

7. As Himalayan hilly states are now well-poised to tap into several developmental sectors, driven by factors such as urbanization & education; availability of water at local level is of vital concern for drinking, health and agricultural / horticultural needs. The committee is of opinion that there is urgent need to strengthen knowledge, awareness and financial support for spring management& revival of dying springs.
8. The committee realized that spring renovation and management are being done under the Ministry of Rural Development in watershed programme in different watersheds and also by some NGOs and State agencies. However there is no umbrella scheme under which short term, long term objectives can be set, and financial support can be made available for spring inventory, monitoring, rejuvenation. Capacity building of locals through training and outreach programmes in Himalayan States is the need of hour.
9. The Committee has completed the assigned task and a brief report on Spring-GIS with its key recommendations is being submitted. The Committee convey sincere thanks to the Ministry of Water Resources, RD & GR,Government of India for the privilege of serving.

INTRODUCTION

The Himalayas pass through India, Pakistan, Afghanistan, China, Bhutan and Nepal. The Himalayan Mountains stretch across the north to north-eastern portion of India. The Himalayas include three parallel mountain ranges often referred to as the Greater Himalayas, the Lesser Himalayas and the Outer Himalayas. The Indian Himalayan Region (IHR) is spread across 10 States (Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Meghalaya, Arunachal Pradesh, Tripura, Nagaland, Mizoram& Manipur) and some hill districts of Assam &West Bengal, stretching across a length of 2,500 km and width of 250 to 300 km. Mount Everest at 8,848m is not only the highest peak in the Himalayas, but also the highest peak on the Earth. The geographical areas of respective Indian states situated in Himalayan region is presented in the Table 1.

Table 1. Geographical areas of states in the Indian Himalayan Region(%)

S.No	State/Region	Geographical area (%)
1	Jammu & Kashmir	41.65
2	Himachal Pradesh	10.43
3	Uttarakhand	10.02
4	Sikkim	1.33
5	West Bengal hills	0.59
6	Meghalaya	4.20
7	Assam hills	2.87
8	Tripura	1.97
9	Mizoram	3.95
10	Manipur	4.18
11	Nagaland	3.11
12	Arunachal Pradesh	15.69

Besides the physical bearing of these mighty mountains, the Himalayas are of great social, cultural and economic significance for the people of India. The IHR is home to over 50 million people. Most of northern India's river systems originate in the Himalayan region, fed either by glacial melt or the many springs that dot the mountainous landscape. The

Himalayas known as ‘the water tower of the earth’, is a major source of fresh water for perennial rivers such as the Indus, the Ganga and the Brahmaputra (NITI Aayog, 2018).

Fig 1: 3D view of physiography at Hot water Spring -Tapovan ,Chamoli, Uttarkahnd (Google Earth pic)

Glaciers are the primary source of recharge to groundwater in the Himalayas particularly in the high mountainous regions. Due to the steep topography and rocky surfaces, most of rainfall based runoff flows out and does not infiltrate substantially to the subsurface as the aquifers’ thickness is so thin that it can’t store enormous amount. Villages generally have shallow depth dugwells for exploitation of the groundwater as unconsolidated sediments thickness overlying the rocks is thin in high hilly terrains. Most of the groundwater in these areas comes out as springs wherever it cuts the ground slope or along the contact with hard rocks and fracture / shear zones (Fig.1). Therefore, springs are the major source of groundwater in Himalayas. It seeps / oozes as springs at various places along valleys, slope & faults in Himalayan mountainous terrain (Fig 2 &3).

Fig 2. Spring in Chhimluang village, Aizwal, Mizoram State (CGWB)

Fig3. Ground water seepage in Kohima District, Nagaland (CGWB)

Spring water has been used by the mountain people since ancient times to meet their basic needs. Traditionally springs are worshiped and many temples are located along them. Springs always remained the main source for drinking/domestic water & irrigation for habitations located at higher relief. However, population growth, adoption of modern drilling techniques for withdrawal of water & changes in rainfall pattern have affected the spring discharge and groundwater conditions in Himalayan valley regions. Further, in the foothills of Himalayas, rainfall is the major contributor to groundwater recharge and as a result many springs appear below the foothill zone in alluvial along the entire Himalayas.

In the present day context, groundwater storage and spring management are important issues for water management in Himalayan catchments.. At higher Himalayas, groundwater storage in aquifers in valley areas and sustainability of springs discharge not only depends on snow melt runoff but also on the availability of favourable topography / terrain for natural recharge to take place. However, variations in summer monsoon precipitation as well as surface water flow in many parts of the Himalayas also impact groundwater recharge &discharge rates of springs.

CLASSIFICATION OF SPRINGS

A spring is a place where water oozes out from the ground surface and continually gets replenished from the source to flow in the form of stream / waterfall (Fig.4). A series of springs when occur along a line is called a spring line. Springs can be divided into thermal and non-thermal springs (Hot &Cold water springs) as per temperature gradient. Most non-thermal / cold springs have temperatures that are approximately the same as the mean annual air temperature of the region in which they are found. Geysers are hot springs that emit a stream of mingled steam and hot water at regular or irregular intervals. Springs can also be classified on the basis of the continuity of flow as perennial or permanent springs that flow throughout the year. Intermittent or temporary springs flow only during or after rainy season.

Fig4. Spring at Mamley, South Sikkim (source -CGWB)

i) Types of Springs

Springs can also be classified according to flow rates, seasonality of flows, water temperature, water quality and the presence of dissolved gases. Fetter (1994) classified springs into six dominant types based on their geology as given below:

1. Depression / Valley spring – when undulating topography intersects the water table to form depression / Valley spring.
2. Contact spring – When permeable rocks or sediments overlie less permeable units, infiltrated water flows laterally (due to higher hydraulic conductivity) rather than vertically due to gravity. Thus, preferential flow paths are created at the contact of different lithological units with variable hydraulic conductivity. Water flowing through these flow paths emerges at the surface to form contact spring.
3. Fault spring – When faults have higher hydraulic conductivity than the material in which they are embedded in due to stress, movement or weathering, the faults can act as a regional boundary for groundwater movement and provide a preferential flow path for water. When water moves along fault lines and discharges at the surface, fault springs are formed.
4. Artesian Spring – Because of pervious formation between the impervious formations, pressure forms in water due to rain infiltration and comes out as spring along the contact of two formations or along some fault or major fracture in overlying impervious hard rock.
5. Sinkhole or karst springs – Limestone bedrock can have large conduits, cavities and channels (termed karst), which act as preferential flow paths for groundwater. When water in these flow paths is under artesian pressure, sinkhole or karst springs are formed.
6. Joint / Fracture spring – Many joints with high hydraulic conductivity may be present in low permeability rocks. When water flows in these joints, joint springs are formed (Fig.5). Because fractures have a higher hydraulic conductivity than adjoining rocks, water preferentially flows in these fractures, thus forming fractured springs.

Fig.5: Spring / groundwater seepage along the fractures along crenulations in phyllites

ii) Monitoring of Springs

Scientific studies to assess the impacts of climatic change, water demands & landuse changes on sustainability springs are presently available in disaggregated form in published literature. Further, knowledge on springsheds is limited due to sporadic studies / pilots as well as no single platform available for compilation of database, case histories & success stories pertaining to springs which can be referred by experts, planners & local implementers.

Spring discharge is influenced by spatial variation in topography and geology as well as temporal variation in hydrology and climate. Direct measurements include monitoring spatial and temporal variations in groundwater levels and pump tests. Continuous water level monitoring in areas with limited areal recharge can assist in identifying preferential flow paths within an aquifer. Regional geological maps / mapping can aid in understanding the rock type, their structure and texture, which will in turn increase understanding of the hydrogeology. Thus, topography and geology can aid in spring mapping exercises in the Himalayan region.

Monitoring of spring discharge is an important activity that must be undertaken for any study on spring or for planning any strategy for its rejuvenation. Monitoring of the discharge must be undertaken at least twice a year (i.e during the pre-monsoon and post-monsoon seasons), though ideally a monthly measurement of the spring discharge would always be preferable. Discharge monitoring of the springs are guided by the flow conditions at the monitoring site which may change with change in the season. The following are some of the general monitoring methods adopted for measurement of spring discharge

a) Making use of a Container and a Stopwatch

In this method, the flow (*Q*) from the spring can be captured into a container of known volume (*V*). Using the time taken (t) to fill the container of the known volume (V), the discharge can be determined using the discharge equation:

$Q=V/t$

This method is commonly employed at sites where flow can be captured into a container. This method is generally suitable for springs with low to moderate discharge rates.

b) Filling Time Method

This method is applicable where spring flow enters a tank that has an outflow valve that can be closed in order to allow the tank to fill. In this method, the discharge can be determined by measuring the volume of water accumulated in a tank over a certain amount of time. The initial water level must be noted before closing the outflow valve, and the final water level noted before re-opening the outflow valve. The dimensions of the inside of the tank must also be measured in order to obtain the volume of fill over the given time. Discharge is calculated using the equation (V/t).

At sites/places where direct volumetric measurement is difficult or would give unreliable measurement, the spring discharge should be monitored under the supervision of a qualified technical personnels by making use of various hydraulic relationships like the area-velocity-discharge relationship, Manning's equation, and the Darcy-Weisbach equation depending on channel geometry and flow characteristics.

The Central Ground Water Board, Ministry of Water Resources, RD & GR has identified number of springs during its regular hydrogeological studies in Himalayas and measured discharge for some of the springs (Fig.6).

Fig 6.: Gauri Kund Spring discharge measurements by scientists of CGWB.

Spatial heterogeneity and anisotropy in geologic parameters require intensive field observations to understand spring hydrology. Establishing and maintaining field networks on springsheds in mountainous areas difficult to monitor & maintain. In this regard, analysis of spring water chemistry can provide insights into the occurrence and interactions of water with aquifer materials, thereby providing insights into the residence time of groundwater . The quality of the spring water should be monitored for the major parameters (Ca, Mg, Na K, HCO_3, Cl, NO_3, SO_4) during the pre-monsoon season. The parameters like the EC, pH and temperature should be recorded in the field itself. The use of naturally occurring isotopes – 18O, 2H and 3H – as spring discharge markers are as ideal water tracers & can be used to determine the age and the source of groundwater. Chemical analysis of pre- and post-monsoon spring discharges can also be useful for taking watershed interventions, especially subsurface dikes, check bunds and contour trenches.

Spring hydrograph separation technique can also used to separate baseflow to determine any reduction in spring flow. Further, Conceptual Models are also useful for the study of springshed which can be regularly updated with new data and information as & when available in management of springshed for sustainability of spring discharge. Conceptualization of springshed & springflow need identifying and describing the processes that control or influence the movement and storage of groundwater and provide information on how spring flow utilization is expected to impact on the groundwater and surface water bodies that depend on groundwater in any specific area. Such studies need to be taken for selected springs by experts & research institutes in participatory made with local stakeholders.

In summary, the prerequisites for preparing plan for the management of can be (a) hydrogeologic and hydrologic characterization of the spring type, drainage (discharge) and recharge area, and recharge and discharge parameters, such as water quantity and quality; and (b) reliable and predictive modelling of spring discharge and water quality, which can be achieved by collecting discharge and quality data of springs. The conceptual model can be prepared by using the available geology maps, field observations, borehole (lithologs) data and spring locations. The model can be supported by thematic maps produced from remote sensing images, which were ground-truth by field visits. An analysis of historical rainfall, spring discharge, water quality and temperature data are mandatory for the springshed region. Data on water chemistry (e.g., calcium, nitrate, etc.) and physical properties (temperature, pH, TDS, electrical conductivity, etc.) could also aid in understanding water sources. Rainfall and streams should be gauged to understand the status of the local hydrologic regime. Further, spring discharge monitoring plans need to be formulated with the community, so that they are also included in spring protection measures and can sustain the development projects for longer periods. The above understanding on spring hydrology and estimation of aquifer properties can be useful for future studies on spring hydrology.

iii) Issues of Spring Revival in Hilly States of Himalayas

The Himalayan mountainous region feeds several perennial rivers and springs that are important sources for meeting drinking and irrigation purposes of local inhabitants. However, the Himalayan eco-system is fragile and water sources are sensitive to rainfall and snow melt runoff under changing climate as well as also due to anthropogenic activities. Limited water supply schemes in mountain areas is a serious problem for fetching water for domestic needs, as it needs to be fetched up-hills by the locals, especially by women & girls. Though, groundwater is a *in-situ* water source in valley areas, but it oozes out at many places in mountain areas in the form of seepage, spring or as base flow. In higher Himalayan region, majority population is dependant entirely on springs as the sole source for drinking and domestic needs. Villages that are located on higher relief in scattered hamlets generally do not have access to fresh water during winter due to freezing conditions.

Further, a large percentage of Himalayan population also depends upon spring water for their livelihood. Agriculture, horticulture, kitchen gardens and local industry etc are entirely dependent on seasonal streams and springs. Nearly, 166000 habitations agglomerated in about 57000 revenue villages in mountain regions of the Himalayan states are directly or indirectly dependent on spring water. However, with time due to intense human interference with Himalayan eco-system, deforestation, land use changes and low winter rainfall during recent years in Himalayan regions have reduced the discharge of springs & accelerated the drying of springs at many places.

Revival of springs and underground flows are crucial components of water management in mountainous areas to ensure sustainable water availability to local inhabitants and tourists in Himalayan states. Changes in the rainfall pattern due to climate change, urbanisation as town clusters increase in tourism and over exploitation of groundwater in valley areas have impacted springs flow. This led to need for urgent attention for taking up remedial actions for their revival & protection from twin problems of drying up and contamination. The quantity and quality of water for majority springs have declined rapidly in recent years. Several Non Government Organisations' and few State governments have taken initiatives in revival of springs through watershed and springshed development in Himalayas.

COLLECTION / COMPILATION OF SPRING DATA OF HILLY STATES

The Committee during its first meeting requested the representatives from the nodal agency of states as committee members to co-ordinate with other Departments/Agencies/ NGOs in their respective state to make available meta-data information & data on various types of information (location / discharge / water quality/ temperature/ water use etc) of the springs. Two templates were also designed for receiving attribute information & meta-data information on the springs (Table 3 & 4). As there was slow response from the states and central agencies in providing metadata information, the committee for a quick head start agreed to focus on data (layers & attribute information), & attributes of springs provided by Central Ground Water Board, Geological Survey of India and few State agencies for creation of Spring-GIS/Spring-Atlas with the view that as and when the data / information would be received, these can be further supplemented as a continuous process in the future.

Central Ground Water Board, Ministry of Water Resources made available spring attributes collected during its various previous studies and Survey of India provided foundation data-sets comprising Hydrography (including springs), Settlements, Hypsography, Administrative/Forest Boundaries, Toponymy etc. in digital form and undertook the work of GIS plotting of spring information. National Remote Sensing Centre (NRSC) has provided thematic layers of LU/LC, Geomorphology and lineament for Himalayan states through BHUVAN WMS services. In this connection, Monitoring Group and Task Group were constituted by the Committee, wherein the Task Group had members from CGWB, SOI, NIH, NRSC & IIRS to work on Spring-GIS atlas at SOI, Dehradun, & Monitoring Group comprised members from SOI, CGWB & NRSC under the Chairmanship of the Committee on springs.

Information on springs from states in general (except from few) was not received; which could be either due to the records not being available with single department or not much activities have been taken up in respect of spring management / inventory in those states. Whatsoever information received from some States, universities, research institutes, CGWB, GSI & few NGOs was tabulated in a format for about 8700 springs at CGWB (Table 5) and provided to Task Group at SOI, Dehradun. In the first instance, the Task Group plotted spring locations of data available with Survey of India itself on GIS platform and subsequently spring data provided by CGWB & other organisations was plotted for ten hilly states. Further, an exercise was carried out to find spring locations falling with in 100m, 200m, & 500m distance proximity from the road. This helps us to know the number of springs that can be considered for ground truthing and selection of stations for monitoring the springs etc. with view point of accessibility. An attempt was also made to find quantum of springs that have easy proximity to village locations. In future, such GIS based queries can provide information on the springs of various interests and also helps in the selection of the springs, which need continuous monitoring and rejuvenation based on the dependency of local population on them for water needs.

Spring being part of groundwater is common resource and support for poor and marginal people living in rough & rugged terrains in difficult climatic conditions. Information on metadata of springs have not been received from any State / organization, which indicates that spring data is not being systematically recorded and stored, and there may not be much concern at present on spring management. Basically no record on metadata information of springs reflects that efforts in spring management are not prevailing at state government level.

Further, out of various attributes indicated in template in Table 2 for spring information, only the geographic locations of springs are available for data received. Other attributes such as discharge, temperature & water quality are available in spring records provided by Central Ground Water Board only. Hence, the committee could not carry out GIS analysis on spring type based on its discharge or temperature.

Geothermal springs information has been received from Geological Survey of India & plotted as separate layer. Though, water in geothermal springs is groundwater, except their flow paths are from greater depth and sometimes near to magmatic hotspot / activated contact zone in Himalayas. These springs are famous due to their hot water with some therapeutically properties, hence traditionally popular amongst locals and tourists all over the Himalayas.

Spring discharge is one of the vital attributes for long term monitoring as continuous availability of water from spring is of paramount importance. Spring discharge generally varies seasonally (pre to post monsoon), however it also gets affected due to landusechanges in springshed and disasters such as landslide / earthquake / fracturing etc. In such cases, either the discharge of the spring slowly declines and recedes to almost nil or spring changes flow path & oozes out from some other place. Discharge measurements of some of the springs carried out by the Central Ground Water Board were made available to committee indicated that general fluctuations in discharge of the springs do exist during from pre to post-monsoon period. This could be attributed to variations in natural recharge taking place during the monsoon period. CGWB carried out spring rejuvenation studies of Guarikund area, Uttarkhand, where springs got buried during disaster in the area. The recommendations of CGWB were adopted by the State Govt Department to rejuvenate the springs. Presently, CGWB is providing technical guidance to State department in the monitoring and management of the lost springs that have been revived..

The springs being utilized by the locals as the water source for drinking, domestic or agricultural purposes, need to be monitored regularly on biannual basis for their water quality and discharge. Similarly, those springs which have high discharge and large number of habitations dependent on them for water are to be taken up for mapping of their springshed and identification of the sites for recharge in springshed for their sustainability. Spring modelling on such springs can also be attempted to understand spring flow dynamics & its relation with climatic changes.

Organisations / institutes such as NIH, Wadia Institute & Universities can be knowledge partners for mapping and modelling for identified springsheds. However, the committee did not get such type of information / records from any state / central organizations on springs. Further, the Committee also analyzed Census 2011 data, in which under village amenities category information on spring availability, seasonality and spring-use attributes etc have been given. Such details can also be plotted in GIS environment on having geographic locations of these villages. Spring data collected by CGWB scientists corresponds to the survey period 1980, ground-truthing is necessary for verifying the existence of these springs at present. Similarly, information / data provided by Survey of India, other organizations and NGOs need ground-truthing for inventory-level survey. The preceding chapter elaborates plotting of spring information on GIS platform by Task Group at Survey of India, Dehradun and preparation of web enabled Spring-GIS.

Table -3

META-DATA INFORMATION FOR SPRINGS

(To be Filled up by various Agencies holding the data)

Name of State to which Data Relates:

Name of Department/Organization/Agency Holding the data:

Contact Details of Nodal-Person from the Department / Organization /Agency:

District-wise Meta-data Information for Location Information of Springs

SNo	Name of District	Whether data available for Part/Whole of District	No. of Springs for which data available	Form in which Location Information Available for Springs				Scale on which Information Available	Projection in which Spatial Information Available	Datum in which Spatial information Available	Whether Height Information available (Y/N)	Vertical datum of Height Information
				GIS form (Y/N)	CAD Form (Y/N)	Hard Copy Map (Y/N)	In Tabular form as X,Y co-ordinate (Y/N)					

Table -4

FORMAT FOR PROVIDING THE AVAILABLE DATA ON SPRINGS

Sl. No	ID	Village name	Spring name	Location Details	Coordinates		Elevation (a msl)	State	District	Block	Geology/ Rock Type	Geomorphology	Spring Type *	Discharge (lpm)		Perennial (Yes/ No)	Quality				Use			Dependent population (approx)
					Lat	Long								Pre-Monsoon	Post-Monsoon		EC	pH	Temp	NO3/F/ Fe	Domestic	Pipe Supply/ Community Water Supply	Other	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25

* Spring type: Contact spring, depression spring, fracture spring, tubular spring etc.

Note: Kindly provide the available information as per the given format either in soft/ hard copy by post.Column may be left blank if required information is not available.

Data / Attributes received for Springs from Various Central & State Agencies TABLE-3

Sl. No	State	Source of Information	Spring No	Spring name	Coordinates: Latitude	Coordinates: Longitude	Elevation (amsl)	District	Block	Geology/Rock Type	Geomorphology	Spring Type*	Discharge (lpm): Pre-Monsoon	Discharge (lpm): Post-Monsoon	Perenniality	Quality: EC	Quality: pH	Quality: Temp	Quality: NO3/F/Fe	Use: Domestic	Use: Pipe Supply/Community Water Supply	Use: Other	Dependent population (approx)
1	Jammu & Kashmir	CGWB	650	N.A	N.A	N.A	N.A	Available	N.A	N.A	N.A	N.A	District wise range		District wise	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A
		University of Jammu	1296	Available	Available	Available	N.A	Available	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A
2	Himachal Pradesh	CGWB	178	Available (47)	Available	Available	N.A	Available	Available (131)	N.A	N.A	Available (47)	Available (47)	Available (47)	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A
3	Uttarakhand	CGWB	294	Available	Available	Available	Available (60)	Available	N.A	N.A	N.A	Available (37)	Available	Available	Available (234)	Available (10)	Available(10)	Available(60)	Available(10)	N.A	Available(18)	N.A	N.A

		Uttarakhand Spring Atlas by Chirag, NGO	948	Available	Available	Available	Available	Available	G.P available	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A
4	West Bengal	West Bengal State Govt.	611	Available	Available (188)	Available (188)	N.A	Available	Available	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A
5	Sikkim	Dhara Vikas,RMDD	704	Available	Available	Available	Available	Available	Available	N.A	N.A	N.A	Avg discharge		N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	Available
		CGWB	57	Available	Available	Available	Available	Available	N.A	Available (45)	N.A	N.A	Available	N.A	Available(20)	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A
		CGWB old report (different source)	540	Available	N.A	N.A	Available	Available	Available	N.A	N.A	N.A	Available	N.A	Available	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A
6	Arunachal Pradesh	CGWB	141	Available (30)	Available (117)	Available (117)	Available (26)	Available	N.A	N.A	N.A	N.A	Avg discharge(16)		N.A	Available (18)	N.A	N.A	N.A	N.A	N.A	N.A	N.A
7	Nagaland	CGWB	26	N.A.	Available	Available	N.A	Available	N.A	N.A	N.A	N.A	Available	Available	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A

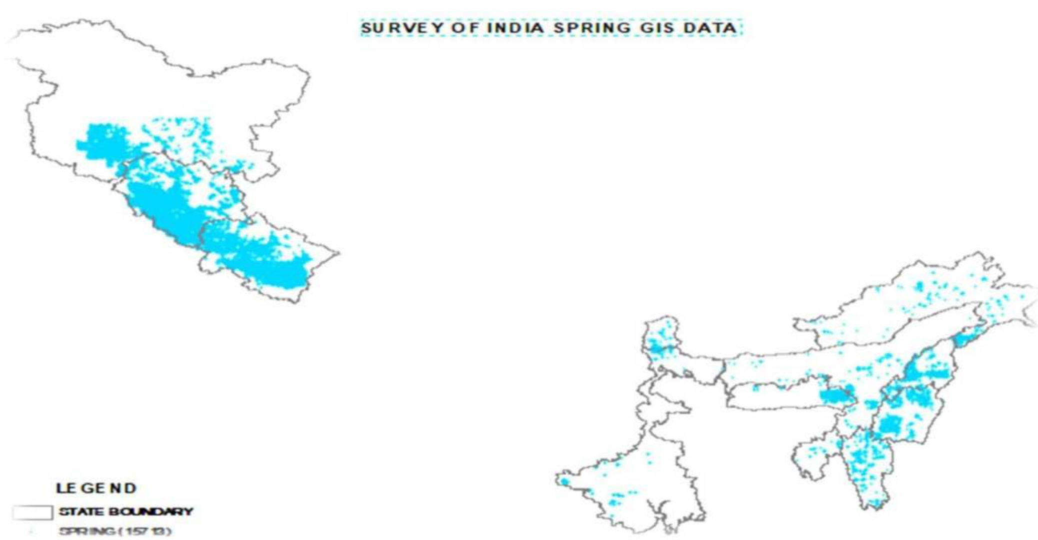
8	Mizoram	PHED Mizoram	2037	Available	Available	Available	Available	Available	Available	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A
9	Meghalaya	CGWB	101	Available	Available	Available	Available	Available	Available	Available (90)	Available	Available	Available (63)	Available	Available	Available (35)	N.A	N.A	N.A	Available (47)	N.A	N.A	N.A
		Institute of Natural Resource Management, Meghalaya Basin Development Authority	1148	Available	Available	Available	Available	Available	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A
10	Manipur	GSI (district resource map)	7	N.A	Available	Available	N.A	Available	N.A	N.A	N.A	Available	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A
11	Geological Survey of India	Geothermal springs																					

COMPILATION OF AVAILABLE DATA OF SPRINGS IN GIS READY FORM

A task group was constituted to create a database of springs existing in mountainous regions of India, especially in Indian Himalayan region (total 12 states) by compiling all information already available with Survey of India, CGWB, State govts, NGO's and other organizations. Members from SoI, CGWB, NIH and NRSC were nominated to help the task group in incorporating additional spring data available with their respective organizations and further analyse the compiled database for value addition.

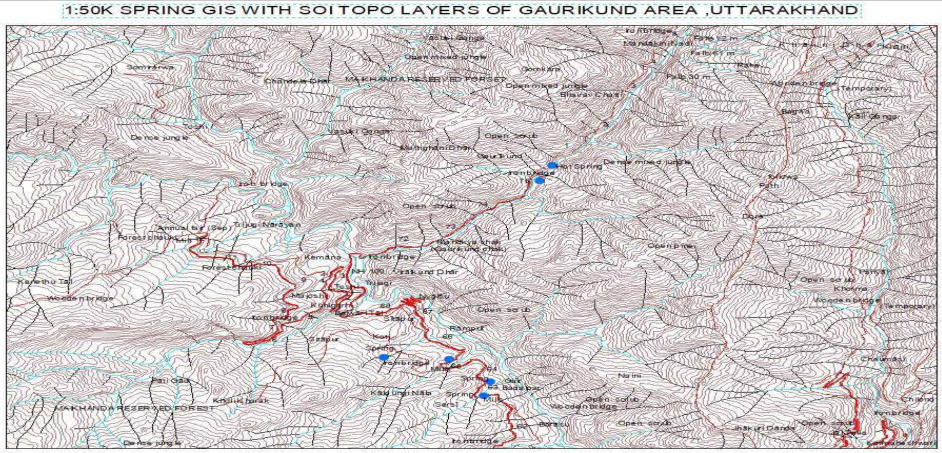
Pursuing the terms of reference, the task group proceeded to compile the basic GIS database of springs of Indian Himalayan region. The detailed methodology adopted in creation of spring GIS is elaborated in ensuing paragraphs:-

(a) All the spring location information, available with 1:50K foundation database of Survey of India was incorporated to create a basic GIS database in a standardised format. This GIS database consisted of a modified schema, which was based on the spatial database model structure (Spring_Name, Spring_Type, Pre_Monsoon_Discharge(in lpm), Post_Monsoon_Discharge (in lpm), Perennial (Yes/No), EC, pH, Temp, Nitrate, Fluoride, Iron, Dependent_Population, Rock_Type, Village_Name, Location_Details) as recommended by monitoring committee.

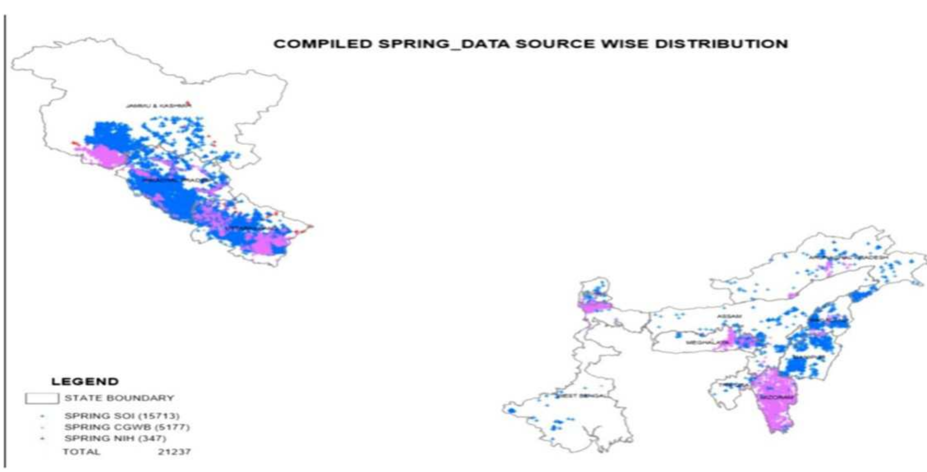


(b) Basic topographical datasets of relevance as recommended by monitoring committee viz. Hydrography, Settlements, Communication, Hypsography, Administrative/Forest Boundary, Toponomy etc in respect of all 12 hilly states included in phase 1 (Himachal Pradesh, Sikkim, Uttarakhand, Jammu and Kashmir, Arunachal Pradesh, Meghalaya, Nagaland, Mizoram, Assam, Manipur, Tripura and West Bengal) were included in the spring GIS database. The latest Survey of India spatial data model structure was incorporated in these topographical datasets, a pictorial depiction of the same is as follows :-

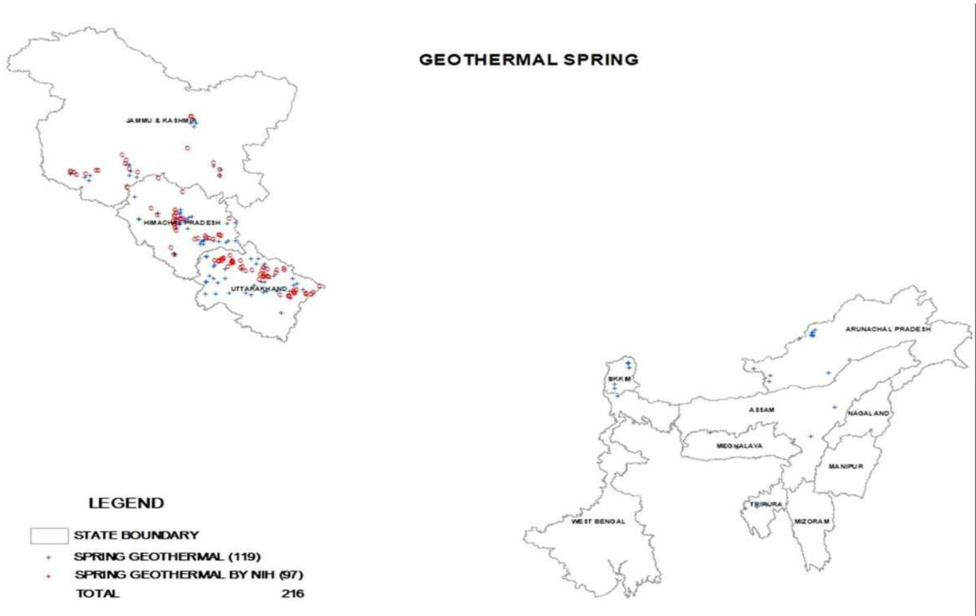
1:50K SPRING GIS WITH SOI TOPO LAYERS OF GAURIKUND AREA ,UTTARAKHAND



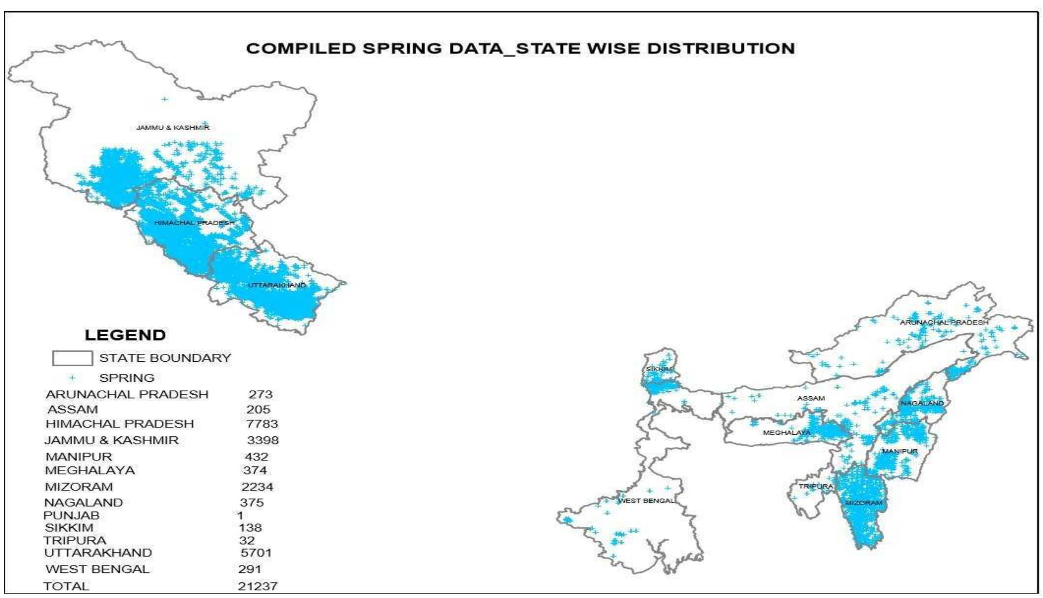
(c)All additional data/information supplied by members of task group was integrated with the basic spring GIS for further value addition. The congruity and consistency of the data was checked with reference to the natural features like contours, drainage and watershed. The schema of this additional information was made compatible with the standard spatial data model structure of basic spring GIS data. A detailed depiction of complete spring data as per the source as follows.



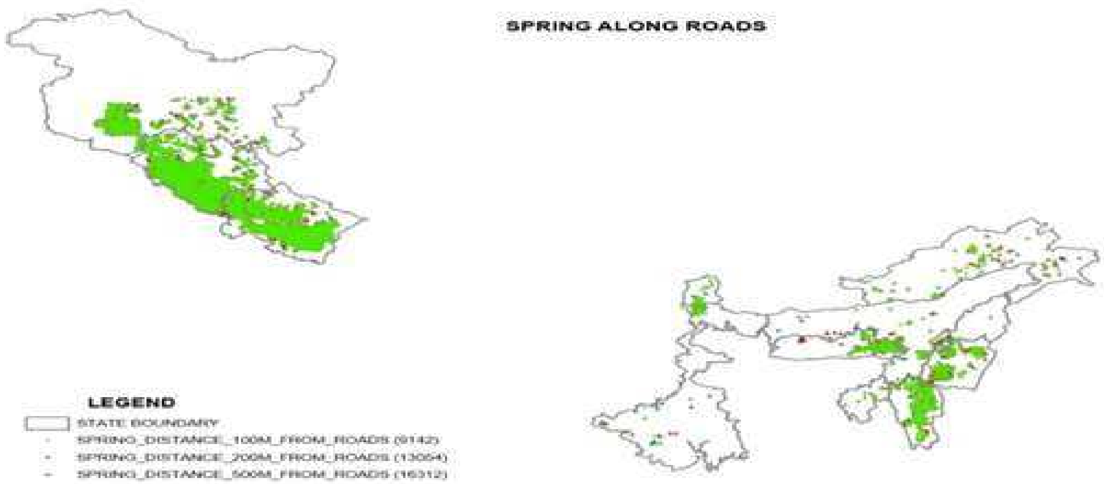
(d) The members of CGWB and NIH provided details (latitude, longitude) of geo thermal springs of 12 Hill states. A separate geo database of the same was created and plotted on GIS platform.



(e) Once the comprehensive fingerprinting of springs in mountain region was completed, analysis was carried out on the spring GIS database, where it was further stratifed into administrative blocks of State, District, Tehsil and up to village level. The detail of above information is as follows.



(f) Further, as per the direction of monitoring committee, spatial analysis on basic spring GIS database was done in order to find accessible springs for monitoring purpose. For this a multilayer buffer of 100, 200 and 500m were created on the road layer provided by SoI and all the spring within the respective buffer zone were plotted as below.



<u>Outcome and Use of Spring GIS Data</u>:-

a) The efforts of task group yielded into fingerprinting of springs in the mountains region of India, especially in Indian Himalayan region (total 12 states) and compilation of spring database in GIS format. The GIS layers are available in shape(.SHP) file format, which can be utilized by various stakeholders with help of commonly used open source or COTS software. Also, process has been initiated by SoI to make this spring GIS ready database available as web based service through recently launched <u>SOI G2G portal</u>, for promoting data sharing amongst Government agencies and facilitating geospatial- enablement of their existing systems. This data will further enable/facilitate the stakeholders who are involved in spring rejuvenation upload newly acquired data and provide/authenticate attribute information collected from the field. A subset of above data/service can be also made available through the public portal of SoI.

b) Survey of India has also developed a mobile application named "Sahyog" for its user viz Government(national/state)departments, Non-Profit Organisations, Institutions, students, PSUs and citizens of India to voluntarily support and contribute in the preparation , updation and enriching National Topographical Database(NTDB). Considering the specific requirement of spring GIS database, SoI has modified the application to meet specific requirements of Spring GIS to facilitate collection of spatial/attribute data from the field to a central server. The data collected through Sahyog application, will be subjected to Quality Control & Security Vetting and rolled back to the stakeholders through G2G/Public Portal of SoI. This would lead to maturing of Spring Information system with the involvement of all the stake holders in a collaborative manner.

Need for High Quality Data for Spring GIS

The geospatial data and related topographical features compiled by the task group are mostly based on 1:50K scale maps of SoI. These data are burdened with positional errors associated with scale, datum transformation and limitations of technology adopted in yesteryears. Also, much of the data regarding springs, contained in this map date back to 20 to 30 years ago. The location data provided by various national/state agencies are mostly based on non survey grade GPS instruments. The attribute information related to springs are available for less than 25% of total numbers of springs compiled by the Task Group.

Thus, while the GIS ready data compiled by the Task Group is good enough for initial level of conceptual planning, there is a need for high quality geospatial datasets, which could serve as base for field data collection and act as foundation data set for creation/development of a comprehensive Spring GIS springshed development.

Road Map for Acquisition of Quality Data for Springshed Development

Leveraging the advantages of latest technologies, providing platform/framework for data sharing and data-acquisition with collaboration of all stakeholders, adherence to standards, tight integration of survey/mapping with other activities of phasewise Springshed Development/Monitoring Programmes should be central to the strategy for systematic survey/mapping of Himalayan States.

Various Technologies like LiDAR, Digital Photogrammetry (with large scale aerial photographs) are already a proven option which have been adopted in Projects like Integrated Coastal Zone Management(ICZM), National Hydrology Project(NHP) and National Mission for Clean Ganga (NMCG) Project for systematic mapping of large areas under an MoU between SOI and various ministries (MoEF&CC, MoWR G&R). The economics of these technologies work out well if survey/mapping is to be carried for large contiguous areas. These technologies, which make use of aerial platform are reasonably mature and offer great degree of control over processes . However, at implementation level there is real challenge of synchronizing the flying approvals with flying schedule within the seasonal windows available for flying.

Systematic Mapping with use of UAV/Drone Platform is getting more and more popular because of high quality data that can be required with faster turn-around time and flexibility in scheduling the flight plans as per Project requirements. There is a greater scope of tightly integrating the survey/mapping activity with other Spring Rejuvenation activities and involvement of community in the plans for Systematic Survey/Mapping. Use of UAV/Drone platform based technologies also suitable acquisition of high quality geospatial data in specific areas for change detection analysis.

Technologies involving use of imageries from satellite platform, though not suitable for foundation datasets, are useful for acquiring time series of data for regular monitoring and change detection.

The selection of technology, finalization of standards & design, and estimation of costs involved in systematic survey/mapping can be worked out at the DPR stage in accordance with the manner in which the project for springshed development/spring rejuvenation is designed for phase wise implementation.

SPRINGS IN HILLY STATES, HIMALAYAS, INDIA

Springs are the fundamental sources for meeting the demands of drinking water, domestics and irrigation water in the difficult terrains of Himalayan States. The tribal people since ancient times used to collect water from the mountain springs located at much higher or lower elevations. Further, with their innovative minds transported the water under gravity through indigenous bamboo pipes or collected water as head load in containers in parts of the Himalayas especially in north-eastern states. As springs are important manifestations of ground water as well as important sources of water for the communities residing in mountainous difficult areas, studies carried by the Central Ground Water Board, Ministry of Water Resources, RD & GR on springs in its various hydrogeological studies in hilly Himalayan states are mentioned below.

ARUNACHAL PRADESH

A large number and variety of springs are present in the State. They are generally of gravitational and non-gravitational types. Thermal springs of West Kameng (Dirang valley), Tawang and other districts of higher altitudes belong to non-gravitational type of springs. Contact or fracture springs are common in foothill districts, viz., PapumPare, East Kameng, West Siang, Lower Dibang Valley, Lohit, Changlang and Tirap; and depression springs located in East Siang district are of gravitational type(fig 7,8 &9)

Fig7. Springs in West Siang District, Arunachal Pradesh (Source CGWB)

Fig8: Traditional Practice to collect spring water at Banskata, Pasighat, East Siang District. The spring line develops all along the base of the Pasighat Terrace.(Photo CGWB)

Fig.9 : Depression spring at Mottum village, Mebo Block, East Siang District. Discharge of the Motum spring is 6.25LPS (December 2017).(Photo CGWB)

The yield of the springs is mostly noted during the lean period. The spring discharge generally varied from 0.01 litres per second (lps) in East Kemeng district to 28 lpsin East Siang district. The spring water belong to Ca-Mg-HCO_3-CO_3 type indicating natural recharge from rainfall. The spring water is fairly fresh having low electrical conductivity (EC) and total dissolved solids (TDS) and flow distance within the aquifer may not be very long.

ASSAM

There are many thermal springs in Garam Pani area of KarbiAnglong and Lumding area of Hojai district. The springs of Lumding area seep from sandstone and shale of Tertiary age and in Garampani the spring water oozes out from unconsolidated rocks of Quaternary age. The spring water of Lumding area is slightly acidic to neutral while Garmapani spring water is alkaline.Locals use spring water for domestic purposes.

MEGHALAYA

Most of the villages are highly dependent on the springs for their drinking and domestic purposes in the state. Springs are depression (topographic) and fractured types. The discharge of springs generally increases during monsoon season and gradually decreases with the cessation of rainfall.

The discharge of springs in Ri Bhoi district ranged from 0.57 to 81 litres per minute (lpm) during pre-monsoon and 0.6 to 102 lpm during post-monsoon season (Fig 10). Except Iron, other chemical parameters were within the permissible limit set by BIS. In East Jaintia Hills District, during the year 2017-18, the discharge of 9 springs monitored ranged from 0.6 to 12 lpm during pre-monsoon and 1 to 27 lpm during post-monsoon season. All the chemical parameters were within the permissible limit set by BIS.The EC value ranged from 42 to 323 µS /cm at 25^0C.

Fig10: Water from Contact spring being collected by constructing spring tap chamber at Ri-Bhoi District. CGWB

In West Jaintia Hills District, during the year 2017-18, 25 springs were established and monitored by CGWB. It was observed that the discharge of springs in this district ranged from 0.6 to 30 lpm during pre-monsoon and 1 to 40 lpm during post-monsoon season during that year. All the chemical parameters were within the permissible limit set by BIS. The EC value ranged from 13 to 238 µS /cm at 25^0C.

In East Khasi Hills District in year 2017-18, 54 springs were established and monitored periodically by the Board. Discharge of springs, in general, varied from 0.6 to 120 lpm during pre-monsoon and from 3 to 180 lpm during post-monsoon season. Some springs had high discharge even in pre-monsoon season viz., springs at Mawlai, Mawsynram and Mawryngkneng (240 litres/minute) while some went dry during pre-monsoon season viz., spring at Umtynagar. It was observed that the discharge of springs generally increases during post monsoon. Most of the springs showed drastic increase in discharge during post monsoon season. While, few springs have a gradual impact of rainfall on their discharge. Most of the springs fall under 5^{th} and 6^{th} order as per Meinzer's classification. It is observed that all the chemical parameters are well within the permissible limit as prescribed by BIS.

Fig.11: Depression spring in West Khasi District in Agriculture field is irrigated by channelling water from spring source (source CGWB).

Traditionally, the tribal population of Shillong have been using spring water to meet their needs. It is reported that earlier there were many big springs, which were thronged by people to collect water for drinking and domestic purposes. These springs were located at Demthring, Umkdait and Mawlai Mawdatbaki area. With mushrooming of tubewells in Shillong, many such springs are reported to be dying, which has impacted the economically weaker section of society dependent on springs. People generally correlate dying of spring phenomena with increase of bore wells in Shillong. Dying of springs is not only due to bore well drilling activities, but also due to changes in rainfall & land use pattern in urban areas, which has also affected the spring sheds.

Spring water of Meghalaya is slightly acidic to alkaline (pH ranges from 6.6 to 8.2). Total hardness ranges between 18 to 83 mg/lit while carbonate content was not detected in any of the samples. Iron content ranges from 0.05 to 1.00 mg/lit except at Sakwing village, Mawkirwat block, East Khasi Hills district where it is 2.00 mg/lit. The other constituents were well within the permissible limit for drinking as well as for agricultural purpose.

NAGALAND

Studies conducted by CGWB in Kohima district during the year 2017-18 indicated , the discharge of springs ranged from 0.019 to 0.043 lps during pre-monsoon and 0.021 to 0.07 lps during post-monsoon season.. Except iron, other chemical parameters were within the permissible limit set by BIS. In PhekDistrict, CGWB monitored 10 springs periodically and reported that the discharge of springs ranged from 0.014 to 0.143 lps during pre-monsoon and 0.005 to 0.168 lps during post-monsoon season in that year. Except iron, other chemical parameters were within the permissible limit set by BIS. Analysis of two samples collected from Kezo town and Pfusachodumi village indicated concentration of fluoride in spring water was found to be 2.9 and 2.6 mg/l respectively, higher than the permissible limit.

In Tuensang District, the discharge of springs ranged from 0.003 to 0.035 lps during pre-monsoon and 0.002 to 0.072 lps during post-monsoon season in year 2017-18. Most of the springs were noted as dry during the pre monsoon period (Fig 12). All chemical parameters were within the permissible limit set by BIS. The EC value was up to 275.8 μS/cm at 25^0C. In Wokha District, discharge of few springs ranged from 0.01 to 0.042 lps during pre-monsoon and 0.6 to 102 lps during post-monsoon season during the year 2017-18. All chemical parameters were within the permissible limit set by BIS. The EC value was up to 119.2µS/cm at 25^0C.

Fig.12: Spring in Barail Sandstone, Tuensang District (Photo CGWB)

CGWB established and monitored 6 springs in Zuhenboto District during the year2017-18. Discharge of springs ranged from 0.072 to 0.078 lps during pre-monsoon and 0.024 to 0.124 lps during post-monsoon season. Most of the springs were dry during the pre-monsoon period. Except Iron, other chemical parameters were within the permissible limit set by BIS. The EC value was up to 140.3 µS/cm at 25^0C. In Mokokchung District, most of the springs were dry during the pre-monsoon period. Except iron, other chemical parameters were within the permissible limit set by BIS. The EC value was up to 42.1 µS/cm at 25^0C.

MANIPUR

Kalhang is one of the villages that used to make indigenous salt from natural salt springs. Salt is manufactured largely in the northern part of the Tangkhul settlements. The major salt production areas among the Tangkhul villages are Marem, Challou, Namrei, Marengphung, Peh, Kharasom and Razai. Salt is prepared from the brine spring water. The brine springs that are found in Ukhrul region are about 20 to 30 feet deep. Salt is one of the main sources of income for the people of the surrounding villages which have brine spring.

MIZORAM

The topography of Mizoram has complex geo-tectonic settings with hilly terrains. Almost the entire area comprises North-South trending anticlinal strike ridges with steep slopes and narrow intervening synclinal valleys with series of parallel hummocks or topographic highs. Springs ('Tuikhur' in Mizo) are the most important sources of water supply in Mizoram since time immemorial. The age old method of fetching water from natural springs is still prevalent in many parts of the state. Spring is one of the main sources of water supply both for domestic and agricultural purposes in Mizoram.

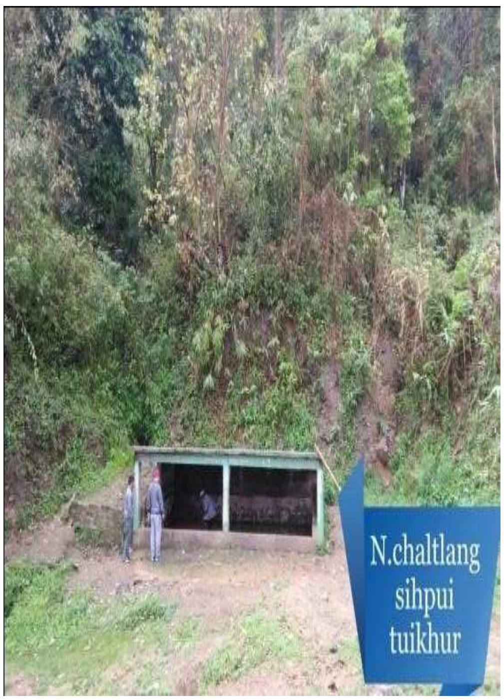


Fig.13 : Springs in N Chaltlang & Chhimluang in Mizoram (Photo CGWB)

HIMACHAL PRADESH

Springs are widely distributed along the favourable geological and geo-morphological zones in the state. The fracture and joint types of spring exist in the low topographic areas either along the structurally weak zones or at the contact of geological formations where seepage type springs are formed on the slopes of hills covered with loose material such as talus and scree or other granular materials. Springs are both perennial and ephemeral getting recharged from rainfall and snowfall. Discharge of these springs generally increases during the summer (Fig 14). Most of the springs in

Himachal Pradesh are located in Satluj and Beas valleys. Vast numbers of ordinary springs are also present. Majority of the population in the state is dependent on these springs for drinking as well as irrigation purposes. Details of 179 springs from Kangra, Kinnaur, Lahaul & Spiti, Nalagarh, Mandi, Bilaspur, and Hamirpur districts have been collected by CGWB.

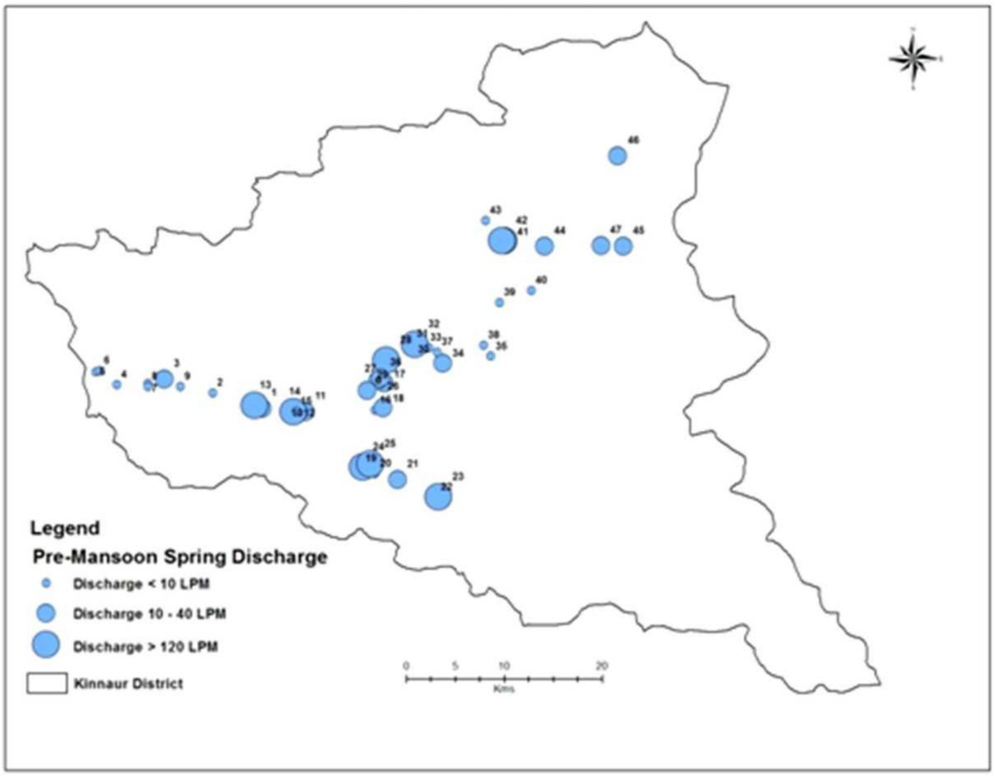


Fig. 14: Map showing spring discharge measured during Pre-monsoon Period by CGWB

Hot water springs are quite popular in the state for their therapeutic properties. The origin of hot spring can be by seeping of water at deeper depth in the earth, having path of water movement is close to some magma plume. The heated water then emerge as hot spring. They are either alkaline or acidic in nature and rich in minerals like calcium, silica and sulphur.

SIKKIM

Sikkim, the tectonically active State has lithology consisting a variety of rock formations, complex structural set up, undulations, hill slopes and profuse rainfall in Himalayas and as a result both perennial and non-perennial springs are formed at various topographic levels in the state. The presence of innumerable perennial springs with varied discharge in various rock formations and weathered zones in phyllite, schist, gneisses and quartzite rocks is common.

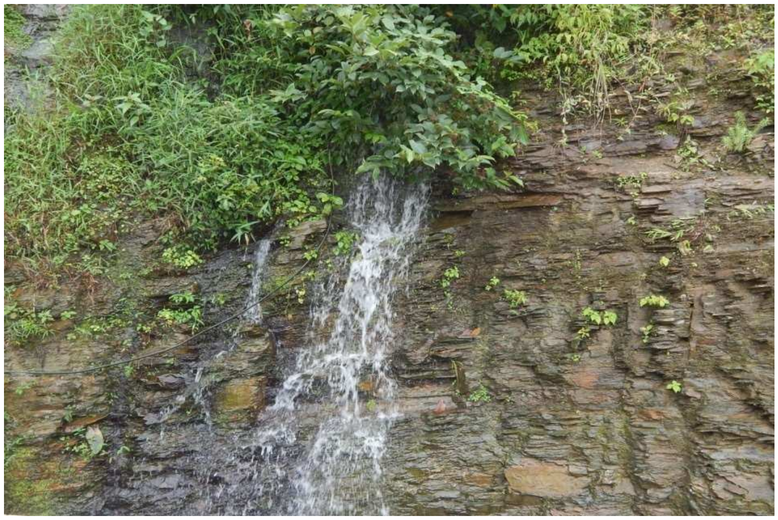


Fig.15. High discharge spring located at Namchi, South Sikkim (CGWB)

Akin to other Himalayan States, springs form the main source of water supplyboth in rural and urban areas of Sikkim. In lean period, water scarcity exists throughout the state and maximum occurs in the rain shadow areas of the state.

Jammu & Kashmir

The Himalayan region confined between the Shiwalik in the south and the Zanskar range in the North representing hilly and rugged terrain consisting of a variety of rock formations and are continuously undergoing disintegration through glacio-fluvial actions. Large part of this region remains under snow throughout the year. The Great Himalayas are the gathering grounds of a multitude of glaciers, some of which are among the largest in the world outside the polar circles (Wadia 1990). The Inter granular pore spaces, openings, fissures, fractures, joints and bedding planes developed in rocks and loose sediments promote the infiltration of rainwater and glacial melt flow, which reappear down slope as springs and seepages. Groundwater occurs under secondary porosity of the formation and in unconfined aquifers in higher Himalayas.

Fig.16. 3D view of physiography at Tatopani, hot water spring in Rajouri,Jammu& Kashmir

The sub-Himalayan region in the state lies to the south of the Himalayan zone and is occupied by the Shiwalikr anges.The foothills of Himalayas is characterized by coarse materials (principally boulder-gravel) forming the piedmont terrain. It is referred as Kandi in Jammu & Kashmir. Groundwater occurs in unconfined aquifers and water table is very deep (30 m or more bgl). Downstream of Kandi is Terai belt which has stratified bands of dominantly coarse sediments with clay. It has an upper unconfined aquifer and lower interconnected system of confined aquifers. Herein recharge is facilitated by high rainfall and hilly streams. This is a narrow belt and its contact with Kandi is marked by a spring line. Natural springs in the state not only provide water for drinking and washing purposes, but also represent cultural and religious ethos of people of this region. There are many springs near Nagri Parolein Kathua district. Springs are also located some 9-10 Kms from Nagri Parole. On the outskirts of Jammu city, many springs existed earlier which now stand depleted except at "BhairDevasthan" around 15 kms from Jammu towards Udhampur. KhoonSpring is 50 kms far from Udhampur, along Dhar road.

Uttarkhand

Starting from the foot hills in the south, the state extends up to the snow-clad peaks of the *Himadri*. The region, being situated centrally in the long sweep of the Himalaya, forms a transitional zone between the per-humid eastern and the dry to sub-humid western Himalaya. With an altitudinal variation ranging from 200m to more than

8,000m above mean sea level, the state comprises of five lithotectonically and physiographically distinct subdivisions namely, the outer Himalaya comprising Tarai and Bhabhar, sub-Himalayan belt of the Siwaliks, the lesser Himalaya, the great Himalaya, and the trans-Himalaya or the Tethys.

Springs are the primary source of water supply in the mountainous terrain occupying ~85% of the total geographical area of Uttarakhand state. The springs are gravitational fracture springs and are perennial or seasonal in nature. The highly weathered and immensely fractured geological rock units allow a rapid transit of water through the aquifer. These springs dry up in early summer in present days as the soil which has water retaining capacity are being degraded due to deforestation and thinning of forest cover in the state.

The Central Himalayan zone lies to the north of Main Central Thrust(MCT) with an elevation ranging from 5000 to 8000 m above mean sea level. Both cold water and hot water (thermal) springs are present in this zone. So far a total of 25 thermal springs have been investigated by the Board with temperatures ranging from 32°C to 70°C and discharge varying between 60 to 600 lpm, corresponding to 5^{th} order and 4^{th} order as per Meinzer's Classification of spring discharge. In these snow - covered areas, due to high inaccessibility and steep hydraulic gradient, the possibility of ground water development is almost negligible in this area, and springs are preferred.

Central Ground Water Board (CGWB) is monitoring about 37 perennial springs in parts of Dehradun, Nainital, Almora and Uttarkashi districts four times in a year viz. in January, May, August and November. Out of the 37 springs, 3 springs are located in Dehradun district, 7 in Nainital district, 23 in Almora district and 4 in Uttarkashi district. Apart from these springs (as Ground Water Monitoring Stations), some cold-water and thermal springs were also inventoried during District Ground Water Management Studies and Aquifer Mapping Studies in the National Aquifer Mapping Program by the Board.

In Uttarkashi District, 57 springs (both cold and thermal springs) inventoried by CGWB on the basis of regional hydrogeology. Long-term discharge data of three springs at Dharasu, Nagal and Ratodisar vary in pre-monsoon from 5.71 lpm at Dharasu to 7.50 lpm at Nagal& in post-monsoon from 0.83 lpm at Dharasu to 11.29 lpm at Ratodisar. In Tehri Garhwal District, 53 cold-water springs were inventoried and discharge data indicates that during pre-monsoon, the maximum & minimum recorded discharge was 54.5lpm near Silasu Bridge (Jaunpur block) & 0.19 lpm at Muneth, Devprayag block respectively. During post-monsoon, the maximum and the minimum discharge of springs were ~100 lpmnearPhakot and 0.41 lpm at Aindi (Jaunpur block), respectively. In Pithoragarh District, 47 springs were inventoried and discharge was 0.09 lpm at Thala (Bin block) and the highest discharge was 40.20 lpm at Nainipatal in Kanalichhina block in pre-monsoon; & minimum discharge was 0.13 lpm at Thala & maximum was ~60 lpm at Balmara (Dharchula block) in post-monsoon period.

Fig17: Contact spring between massive quartzite and jointed quartzite of Nagthat Formation (Jaunsar Group), near Nainbag, Jaunpur block, Tehri Garhwal district(CGWB)

In Bageshwar District, based on the available data of ground water management studies of CGWB and compilation of data obtained from NGOs, discharge of 33 springs is available for the district. Some springs have negligible discharge (<0.06 LPM) and are known as naulas now. Recorded pre-monsoon discharge of springs varied from minimum 1.20 lpm at Baijnath (Garur block) to maximum of 13.20 LPM at Chirabagar in Kapkot block.

In Nainital District,spring discharge during pre-monsoon was found varying from 0.68 lpm at DansiNaula (Losgyani) to a maximum of 119.37 lpm at SipahiDhara. During post-monsoon, the discharge was found to be varying from 11.51 lpm at KudaGhat to

240.60 lpm at SipahiDhara. In Champawat District, 13 springs were inventoried by CGWB in Siwalik Group, Almora Group and Ramgarh Group rocks in the district. Minimum pre-monsoon discharge 2.0 lpm& maximum 12.0 lpm recorded. During post-monsoon, the discharge variations were from 3.0 lpm to 15.0 lpm. In Almora District, 110 springs/gadheras (group of springs) were inventoried by CGWB in year 2009-2010. The highest pre-monsoon discharge of 90 lpm was recorded at village Birkhanmua, Chaukhutia block whereas the lowest discharge was 0.2 lpm at BridhaJageshwar. During post-monsoon, the highest discharge was 129lpm, again at Birkhanmua whereas the lowest discharge was 0.5 lpm at Nakuta.

In RudraprayagDistrict, 35 springs and gadheras, including a hot spring at Tapt Kund/Gauri Kund were inventoried by CGWB during Ground Water Management Studies. Discharge data of the springs during pre-monsoon recorded minimum discharge 1 lpm at Khankra, followed by 2 lpm at Dhungar whereas the maximum discharge was ~1200 lpmGavani Gad Gadhera. In post-monsoon, discharge was found to be varying from 2 lpm (at Khankra) and 3 lpm (at Dhungar) to a maximum of ~80 lpm at Narayan KotiGadhera.

In Pauri Garhwal district, 155 springs and gadheras/srots were inventoried by the CGWB. Discharge of springs, srots and gadheras recorded during pre-monsoon, the minimum was 0.5 lpm at places like Chui Sot, Rathwadab and Dibadanda, followed by 1 lpm at Khirsu, Chorkhandi and Golikhet. In post-monsoon, the maximum recorded discharge was ~600 lpm at Dhanna Sot, followed by ~500 lpm at PatisainGadhera and Rikhad and ~300 lpm at Rikhri Khal.

In Dehradun District, about 23 springs were inventoried as Key Observation Stations (KOS) during groundwater management studies by CGWB. Long-term discharge data of these springs indicate that in pre-monsoon, the minimum mean discharge is 5.80 lpm at Bhatta while the maximum discharge is 18.20 lpm at Kandoli. Among the KOS, the minimum discharge was 0.84 lpm at Mashakgad whereas the maximum discharge was 122.0 lpm at Nalapani. In Chamoli District, about 31 springs were inventoried &discharge recorded minimum at pre-monsoon was of 2 lpmat locations like Sunali, Saregwar and Khenti whereas the maximum discharge was 54.55 lpmat Kokrai and in post-monsoon, minimum recorded discharge was 1 lpm at Nagarachukhal while the maximum was 85.71 lpmat Kokrai spring.

Fig.18: Spring source tapped through channels for water supply at Khalari village, Purola block, Uttarkashi district (Photo CGWB)

The spring discharge in the state was observed lowest in pre-monsoon (May) whereas significant increaseof spring discharge is observed during post-monsoon (August), which indicated rainfall is the principal contributing factor for variation in spring discharge. Minimum discharge of the cold-water springs during the period 2014- 2015 varied from 0.52 lpm at Someshwar to 420 lpm at Sipahidhara out of 33 springs measured in Dehradun, Uttarkashi, Chapmawati, Nainital &Almora districts in the state. Discharge of these springs varied within wide range during the intervening period. In Dehradun district, spring discharge varied between 2.92 lpm at Bhatta in May 2014 and 42.85 lpm at Khandoli in August 2014. In Nainital district, spring discharge varied from a minimum of 2.87 lpm at Kudaghat (May 2014) to a maximum of 420 lpm at Sipahidhara (August 2014). In Almora district, the spring discharge was found to be varying from a minimum of 0.52 lpm at Someshwar in January 2015 to a maximum of 150.0 lpm at Dhansari in January 2015. In Uttarkashi district, spring discharge was varying from 2.74 lpm at Dharasau in November 2014 to a maximum of lpm in Dharasau in January 2015.

RECOMMENDATIONS

1. The committee recommends for inventory of springs in Himalayan States. It is suggested to have separate central program for proper inventory & ground truthing of springs for selection of representative springs for regular monitoring of various attributes of springs such as temperature, Discharge, Water quality & their use; so that vital springs can be intensively studied by springshed mapping and spring modelling for taking necessary measures on their health and rejuvenation.
2. Understanding of lithology and geological structures forming together the underground aquifers need to be mapped in springshed areas with hydrogeological expertise to take up measures on spring water management, recharge in springsheds, rejuvenation and their sustainability. Efforts are also required for hydrogeological knowledge transfer in simple terms to local agencies / persons involved in spring management.
3. There shall be provision under the central program/ scheme for funding to the state governments for proper inventory, mapping spring sheds, monitoring and rehabilitation of those springs which are vital source of water to habitations / those vulnerable to anthropogenic activities or climate changes in Himalayan environment.
4. Web enabled Spring Information System as repository of information of mountain springs of Himalayas is suggested to be on govt e-portal. Various Central, State, NGOs, local agencies can be encouraged to add information on Springs that can be used for various kinds of research studies on springs. The information shall also be accessible to NGOs, research and academic institutes as web map service. In this connection, a prototype of Spring-GIS is being submitted by the committee along the report to the Ministry. Further, if web feature service (WFS) of lithology, Geological structures, habitation information are integrated with spring information, Spring-GIS can act as guide not only understanding relation of springs with various lithologies / geological structures / local aquifer characteristics but also in deciding measures for their rejuvenation and sustainability by local NGOs, state agencies etc.
5. Survey of India has developed a Mobile App ‘Sayahog’ on point of interest, which can geotag any information of ground. The App can be useful in

geotagging springs and their some of the attributes along with photographs. Such Apps can be made available to organizations / persons who can register themselves for filling information related to spring.

6. Public interaction programs on sensitisation /awareness and capacity building in mapping springshed, rejuvenation of springs and sustainable management of springs to be organised at district-level in hilly States for technical guidance to local NGOs and self-help groups.
7. Research institutes / universities shall also be encouraged under R& D programs of the governments for funding studies on impact of urbanisation / climate changes on vulnerable spring sheds. States shall also consider to notify springshed area of vulnerable springs as springshed sanctuaries, on water of which a large population is dependent. Spring sanctuary can be type area which can be used for capacity building and on- field demonstrations on methods/ measures for spring protection.
8. Water harvesting, augmentation of recharge through area specific feasible recharge structures shall be encouraged under ongoing programs of Central and State governments in participatory approach with local organizations / self-help groups who can later take up spring management for maintenance / protection of springshed.

File No.T-13012/100/2018-GW

Dr P. Sharma, Sci D
GWS
12.9.18

F. No. T-13012/100/2018-GW
Government of India
Ministry of Water Resources, River Development and
Ganga Rejuvenation

Shram Shakti Bhawan,Rafi Marg,
New Delhi,Dated 31st August, 2018.

ORDER

Subject: Constitution of Committee to Collect/compile metadata of all springs in hilly states pan-India.

A meeting was held under the chairmanship of Joint Secretary (IC&GW), Ministry of Water Resources, River Development & Ganga Rejuvenation on 21/08/2018 regarding rejuvenation of Springs through spring shed development for sustenance of water supply in hilly areas of the country and to constitutue a Committee to prepare an "Atlas/document in similar form" which may cover all springs with their detailed maps and other related data. Copy of minutes of the meeting is enclosed. In accordance with the decision taken in the meeting, a Committee with the following composition is constituted:

1.	Representative of Survey of India	Chairman
2.	Representative of NRSC	Member
3.	Representative of Deptt. Of Science & Technology	Member
4.	Representative of NATMO	Member
5.	Representative of India Meteorological Department	Member
6.	Representative of each hilly State *	Member
7.	Shri G.C. Pati, Member, CGWB, Delhi.	Member Secretary

- Hilly States – Himachal Pradesh, Sikkim, Uttarakhand, Jammu & Kashmir, Seven Northeastern States - Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura.

2. The Committee will work on the following:

i Collect/compile metadata of all springs in hilly states pan-India.

ii Finalise "Atlas/any document in similar form" for effective utilization of springs.

iii Further attributes to be added in future (by using latest technology) to make the compiled data more meaningful.

iv Any other relevant suggestion/recommendation for better management/ development of springs.

Sh S.N. Dwivedi
Scty pl
PS
12/9/18

3. The Committee will submit its report/suggestions/recommendations within a period of two months from its constitution.

4. TA/DA to the Official/non-official Members of the Committee will be paid as per GoI provisions.

This issues with the approval of competent Authority.

Signature valid
Digitally signed by ASHISH KUMAR
Date: 2018.0 .34:51 IST
Reason: Approved

(Ashish Kumar)
Director
Tele No. 23716928
e-mail: gwdesk-mowr@nic.in

To

1. Secretary, Department of Science & Technology, New Delhi.*
2. Chief Secretaries of: Himachal Pradesh, Sikkim, Uttarakhand, Jammu & Kashmir, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura.*
3. Director General, Indian Meterological Department, New Delhi*
4. Director General, Survey of India*
5. The Director, Survey (Air) & Delhi Geo-spatial Data Centre, Survey of India, West Block No.4, R.K. Puram, New Delhi - 110 066.
6. The Director, National Remote Sensing Centre, New Delhi
7. Shri G.C. Pati, Member, CGWB, Faridabad.

*With the request to nominate suitable officers for the Committee.

Copy to:

1. PPS to Secretary (MoWR, RD & GR)
2. PPS to JS(IC&GW)