Template/Pro forma for Submission

NMHS-Himalayan Institutional Project Grant

NMHS-FINAL TECHNICAL REPORT (FTR)

Demand-Driven Action Research and Demonstrations

NMHS Reference No.:	NMHS/2017-18/MG19/03

Date of Submission:								
	d	d	m	m	y	y	y	y

PROJECT TITLE (IN CAPITAL)

WATER SECURITY THROUGH COMMUNITY-BASED SPRINGSHED DEVELOPMENT IN THE IHR

Project Duration: *from* (22-12-2017 to 21-09-2021).

***Submitted to*:**
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GENERAL INSTRUCTIONS:

1. The Final Technical Report (FTR) has to commence from the date of start of the Project (as per the Sanction Order issued at the start of the project) till its completion. Each detail has to comply with the NMHS Sanction Order.
2. The FTR should be neatly typed (in Arial with font size 11 with 1.5 spacing between the lines) with all details as per the enclosed format for direct reproduction by photo-offset process. Colored Photographs (4-5 good action photographs), tables and graphs should be accommodated within the report or should be annexed with captions. Sketches and diagrammatic illustrations may also be given giving step-by-step details about the methodology followed in technology development/modulation, transfer and training. Any correction or rewriting should be avoided. Please give information under each head in serial order.
3. Training/ Capacity Building Manuals (with details contents of training programme technical details and techniques involved) or any such display material related to project activities along with slides, charts, photographs should be brought at the venue of the Annual Monitoring & Evaluation (M&E) Workshop and sent at the NMHS-PMU, GBP NIHE HQs, Kosi-Katarmal, Almora 263643, Uttarakhand. In all Knowledge Products, the Grant/ Fund support of the NMHS should be duly acknowledged.
4. The FTR Format is in sync with many other essential requirements and norms desired by the Govt. of India time to time, so each section of the NMHS-FTR needs to duly filled by the proponent and verified by the Head of the Lead Implementing Organization/ Institution/ University.
5. Five (5) bound hard copies of the Project Final Technical Report (FTR) and a soft copy should be submitted to the **Nodal Officer, NMHS-PMU, GBP NIHE HQs, Kosi-Katarmal, Almora, Uttarakhand**.

The FTR is to be submitted into following two parts:

Part A – Project Summary Report

Part B – Project Detailed Report

Following Financial and other necessary documents/certificates need to be submitted along with Final Technical Report (FTR):

Annexure I	**Consolidated and Audited Utilization Certificate (UC) & Statement of Expenditure (SE)**, including interest earned for the last Fiscal year including the duly filled GFR-19A (with year-wise break-up)
Annexure II	**Consolidated Interest Earned Certificate**
Annexure III	**Consolidated Assets Certificate** showing the cost of the equipment in Foreign and Indian currency, Date of Purchase, etc. (with break-up as per the NMHS Sanction Order and year wise).
Annexure IV	**List of all the equipment, assets and peripherals** purchased through the NMHS grant with current status of use including location of deployment.
Annexure V	Letter of Head of Institution/Department confirming Transfer of Equipment Purchased under the Project to the Institution/Department
Annexure VI	**Details, Declaration and Refund of any Unspent Balance transferred through Real-Time Gross System (RTGS) in favor of NMHS GIA General**

NMHS-Final Technical Report (FTR) *template*

Demand-Driven Action Research Project

DSL: Date of Sanction Letter

2	2	1	2	**2**	**0**	**1**	**7**
d	d	m	m	y	y	y	y

DPC: Date of Project Completion

2	1	0	9	**2**	**0**	**2**	**1**
d	d	m	m	y	y	y	y

Part A: Project Summary Report

1. Project Description

i.	Project Reference No.	NMHS/2017-18/MG19/03					
ii.	Type of Project	Small Grant		Medium Grant	✓	Large Grant	
iii.	Project Title	Water security through community-based springshed development in the IHR					
iv.	State under which Project is Sanctioned	Uttarakhand					
v.	Project Sites (IHR States covered) (Maps to be attached)	Uttarakhand, Nagaland, Arunachal Pradesh					
vi.	Scale of Project Operation	Local		Regional	✓	Pan-Himalayan	
vii.	Total Budget/ Outlay of the Project	Rs.1.95 (in Cr)					
viii.	Lead Agency	People's Science Institute, Dehradun					
	Principal Investigator (PI)	Dr. Debashish Sen					
	Co-Principal Investigator (Co-PI)	Dr. Sumit Sen					
ix.	Project Implementing Partners	IIT-Roorkee; Department of Land Resources, Nagaland; WWF-India, Arunachal Pradesh, and Arghyam, Bengaluru.					

	Key Persons / Point of Contacts with Contact Details, Ph. No, E-mail	Dr Sumit Sen, Associate Professor, Department of Hydrology, IIT Roorkee, sensumit2@gmail.com Mr. Albert Ngullie, LRD-Nagaland (8119018449) albertngullie@gmail.com Mr. Suresh Babu S.V. – WWF India Director Rivers, Wetlands & Water Policy suresh@wwfindia.net (9818997999) Ms. Jayamala V. Subramaniam CEO – Arghyam info@arghyam.org (080-41698941)

2. Project Outcomes

2.1. Abstract (not more than 500 words) [it should include the background of the study, aim, objectives, methodology, approach, results, conclusion and recommendations).

Background: The Indian Himalayan Region (IHR) is generally viewed as having abundant water resources. However, most of these perennial springs and streams are becoming seasonal or have dried up primarily due to the impacts of climate change, growing water demands, changes in land use patterns, deforestation, urbanization, etc. A specific way forward to this is to work more directly with natural processes to secure the regeneration of groundwater sources at the local level. The hypothesis for this project is that working at a watershed scale will result in a holistic approach to managing water resources as each of these hydrologically-defined geographic areas are unique in physiography, ecology, climate, water bodies, and land use.

Objectives/ Aim: The aim is to plan for water security in the Himalayan region. The approach used was community-based springshed management.

Methodology: The 6 headwater watersheds selected are in the most water-scarce zones of districts - Phek & Zunheboto in Nagaland; Almora & Pauri in Uttarakhand and Tawang & West Kameng in Arunachal Pradesh. The focus of our actions was on increasing spring discharge and promoting sustainable and equitable use of the augmented groundwater for maintaining water security. The major activities included inventorization of springs in 3 states – Uttarakhand, Nagaland, and Arunachal Pradesh **(Annexure XIII)**, hydrological modelling by collecting continuous data through instruments **(Annexure IX)**, community involvement, spring recharge pilots in Uttarakhand **(Annexure VII & VIII),** knowledge dissemination, and advocacy.

Approach: The approach used was participatory groundwater management. Cluster-based approach was used for spring revival. This approach along with treatment measures carried out in the micro-watershed helped to improve the flow in the first-order streams **(Annexure X).**

Results: The interventions have resulted in the preparation of an inventory of 300 springs **(Annexure XIII)**, and the delineation of critical springs and first-order streams in the selected watersheds. Spring recharge areas were demarcated in the demonstration sites in Almora and Pauri Garhwal based on hydrogeological studies. Hydrological modelling at these sites helped to derive protocols for best water management practices **(Annexure IX & XI).** The inception data generated suggested a high lag in spring response compared to stream **(Annexure XIV a,b,c).**

Conclusion: Community involvement helped in decentralized water governance. The cumulative data helped to understand the contribution of surface runoff from the hydrological catchment and base flow from the spring catchments. In addition, the stream flow data helped to understand the effect of land use/land cover on stream flow in the watershed. Assessing and understanding the underlying geology and hydrological processes of Himalayan springs is important to scientifically plan for their rejuvenation for addressing growing water security concerns.

Recommendations: Community participation should be encouraged for attaining water security. A combination of hydrologic time series analysis and geological characterization used in this study could be a valuable approach for assessing spring revival in the IHR and has a potential for implementation across other parts of the Himalayas. However, there is a need to understand the aquifer characteristics and water quality aspects for sustainable springshed management. Extensive demystification of hydro-geological knowledge for community awareness and participation would also be effective.

2.2. Objective-wise Major Achievements

Objectives	Major achievements (in bullets points)
Inventorization of 300 springs - 50 springs/district x 6 districts	Inventory of 300 springs prepared **(Annexure XIII).**

Objectives	Major achievements (in bullets points)
Piloting community-based regeneration of 12 springs in the selected watersheds in Uttarakhand	1. Springs and first-order streams delineated for hydrological monitoring in Almora & Pauri Garhwal **(Annexure VII).** 2. Installation of instruments (AWS, water level recorder, flumes, flow probe, EC meter, rain gauges) for hydrological monitoring. 3. 6 critical springs in Almora and 7 critical springs in Pauri Garhwal districts have been treated **(Annexure VIII).** 4. Groundwater recharge measures initiated at the micro-watershed level in Almora and Pauri Garhwal **(Annexure X).**
Evolving state level policy recommendations for conservation and sustainable use of groundwater resources	1. Best management practices implemented for micro-watershed in Almora and Pauri Garhwal, Uttarakhand. 2. DPRs for the rejuvenation of critical springs prepared for the Forest Department of Uttarakhand. 3. Extension of springshed management program initiated in Nagaland through The Department of Land Resources and the Rural Development Department. 4. Officials of the PHED Department, Arunachal Pradesh were trained in participatory springshed management. 5. Discussions were held with FD, SWCD & NABARD for SSD in the Papum-Poma River of Arunachal Pradesh. 6. PSI shared its experiences on SSD in the IHR the for preparation of the National Water Policy document and NMSHE. 7. State-level consultation workshops were organized for Uttarakhand, Nagaland, and Arunachal Pradesh to share the experiences and challenges of SSM and also to discuss the ongoing research, policy recommendations, and way forward.

Objectives	Major achievements (in bullets points)
Knowledge dissemination and communication	1. Capacity building of forest rangers and Van Panchayat members for springshed development initiated in Uttarakhand. 2. Training of WWF-India (AP) & LRD (Nagaland) in preparation of spring inventory by PSI. 3. Training of PSI staff and communities in hydrological monitoring by IITR. 4. Training of 89 program staff under the Meghalaya Basin Development Authority's (MBMA) Community-Led Landscape Management Program (CLLMP) supported by the World bank. 5. Research papers published: ***(i) Hydrological process monitoring for springshed management in the Indian Himalayan region: field observatory and reference database****,* Current Science, Vol.,120, NO. 5, 10 March 2021. ***(ii) Assessment of spring flows in Indian Himalayan micro-watersheds – A hydro-geological approach*****,** Journal of Hydrology, Vol. 598, July 2021, 126354.
	6. Case studies published: (i) case study on community initiatives taken to revive a spring in one of the project sites in Western Arunachal Pradesh. https://www.rediffmail.com/cgi-bin/red.cgi?red=https%3A%2F%2Fwww%2Eindiawaterportal%2Eorg%2Farticle%2Frejuvenating%2Dsprings%2Dwestern%2Darunachal%2Dpradesh%2D0&rediffng=0&rogue=4f25d5dc5e9e7fe16b4abb757049486f521c8faa&rdf=VHJRMgZvXzMBKAQxAGIFYQ== (ii) case study on the solar lift scheme in Pali village, Pauri Garhwal. https://hindi.indiawaterportal.org/content/pali-solar-lifting-yojana-ek-sajha-anubhav/content-type-page/1319336314
	7. Digital training content on water quality and treatment measures developed for para-workers.
	8. A handbook on springshed management that explains social measures, hydrogeology, water quality, and treatment measures.

2.3. Outputs in term of Quantifiable Deliverables*:

S. No.	Quantifiable Deliverables*	Monitoring Indicators*	Quantified Output/ Outcome achieved	Deviations made, if any, & Reason thereof:
1	Maps and action plan of spring revival in 6 districts of Nagaland, Arunachal, and Uttarakhand delivered to state agencies for implementation	Publication and/ or Knowledge Products developed on the Best Practices of Water Resource Management **(Nos.)**	The land use maps were prepared and the pattern was studied for the pilot watersheds *Haraita* in Pauri Garhwal and *Shiv Gadera* in Almora, Uttarakhand. GIS-based maps were prepared for drainage, spring location, and geology of the 6 watersheds delineated. Landuse maps were prepared by WWF India for Rimleng Kang Sumba Chu micro-watershed in Tawang district and Shamshing SachiRi micro-watershed in West Kameng district Arunachal Pradesh. Maps of L B Diyung and Laniye Tizu micro-watersheds in Nagaland were prepared by DoLR, Nagaland.	No deviations were made.
		No. of Policy Guidelines and Legislative Mechanisms: Prepared and/ or Communicated **(Nos.)**	PSI presented its experiences on springshed management at the national workshop on “Springshed Management in the Himalayas – Integrating Practice, Research, and Policy” on 11 September 2019 in New Delhi. The workshop was organized by ACWADAM under the National Mission for Sustaining the Himalayan Ecosystem (NMSHE) with technical and knowledge	

S. No.	Quantifiable Deliverables*	Monitoring Indicators*	Quantified Output/ Outcome achieved	Deviations made, if any, & Reason thereof:
			support from the Indian Himalayas Climate Adaptation Programme (IHCAP) of the Swiss Agency for Development and Cooperation (SDC). PSI shared its experiences on spring rejuvenation and management and presented its recommendations for the National Water Policy on December 23, 2019 in New Delhi. The workshop was organized under the Spring Initiative Network. Preparation of a policy document is in process. A national webinar on springshed management in the IHR based on experiences from Himachal Pradesh was jointly organized by PSI and Revitalising Rainfed Agriculture Network (RRAN) on 8th October 2020. PSI conducted a virtual training and capacity building programme for the Meghalaya Basin Development Authority's Community Led Landscape Management Program (CLLMP) supported by the World Bank and technically supported by Arghyam – a Bengaluru based charitable foundation working on water and sanitation, and Sattva consultancy group working on	

S. No.	Quantifiable Deliverables*	Monitoring Indicators*	Quantified Output/ Outcome achieved	Deviations made, if any, & Reason thereof:
			scalable solutions for social impact. This training was spread over a period of 4 months from April – July 2020. It was attended by over 80 representatives of the State Programme Management Unit (SPMU), District Programme Management Unit (DPMU) and the Village Community Facilitators (VCFs) under CLLMP for preparation and implementation of village-level water security plans. The expected outcomes of the program were implementation of the methodology of springshed management across the entire state of Meghalaya; training through a Training of Trainers (ToT) approach and development of 100 professionals to function as 'master trainers' for the state. The master trainers were then supposed to train the VCFs into para-professionals and also supervise the development of springshed management plans by them. A virtual training program on springshed management was also organized for the PHED officials in Arunachal Pradesh from 18 September 2020 to 6 November	

S. No.	Quantifiable Deliverables*	Monitoring Indicators*	Quantified Output/ Outcome achieved	Deviations made, if any, & Reason thereof:
			2020. The topics covered were the concept of springshed management, community mobilization and institution building, hydrogeology and aquifers, spring inventory & recharge area demarcation, treatment measures, water quality monitoring, and water budgeting. PSI developed practitioner-oriented digital content on springshed management for the village community, para-workers, and personnel from community-based organizations, government departments, and policymakers. The content will be accessible to the practitioners beyond training to refresh their knowledge and will be easy to view and share through mobile phones.	
	Spring revival models for 2 micro-watersheds covering 12 springs in Uttarakhand;	No. of Spring Revival Models Developed and Implemented **(Nos.)**	The plan for revival of selected springs in the pilot sites - 6 in Almora and 7 in Pauri Garhwal watersheds **(Annexure VII & VIII)** was discussed with the village communities. Implementation work was carried out for spring revival the details of which are mentioned below: **Uttarakhand:** In Nag kaurali village, Someshwar, Almora, 611 trenches and 409 small pits were dug. In Salauj, 260	No deviations made.

S. No.	Quantifiable Deliverables*	Monitoring Indicators*	Quantified Output/ Outcome achieved	Deviations made, if any, & Reason thereof:
			trenches and 175 pits were dug. At the watershed level, 1120 trenches and 3 gabions were constructed for soil and water conservation. Plantation of 900 plants and 5600 grass saplings was done. In Pauri Garhwal, 306 trenches were dug in pali village, 220 in Bamoli, and 557 trenches in Dashmeri village were dug. At the watershed level, 967 trenches were dug and four gabion check dams were also constructed for soil and water conservation. Plantation of 1470 plants and 23,800 grass saplings was done. Estimates were worked out for a solar lift pump and water supply system in Pali village. Construction work was completed during the extension period. A case study on the solar lift scheme in Pali village, Pauri Garhwal got published on India Water Portal. (Link provided). The entire work was carried out involving the local communities. They voluntarily contributed 25 percent of the total expenses incurred for physical works and also gave consent for use of community/private land for	

S. No.	Quantifiable Deliverables*	Monitoring Indicators*	Quantified Output/ Outcome achieved	Deviations made, if any, & Reason thereof:
			recharge works. In the extension period of the project desiltation of trenches/pits and plantation work in the pilot sites of Uttarakhand was carried out. **Arunachal Pradesh:** In Arunachal Pradesh, 950 trenches were dug in Thembang watershed, West Kameng under the guidance of the PSI team and supervision of the WWF team. Construction of poly houses and nurseries for plantation work were also carried out. In the Zemithang watershed, the existing water tanks were repaired and a community stand post was constructed for drinking water supply. **Nagaland:** Two critical springs were identified in L B Diyung watershed, Zunheboto district for rejuvenation and treatment measures, were carried out for their revival. Members of the village council were trained in different activities.	https://hindi.indiawaterportal.org/content/pali-solar-lifting-yojana-ek-sajha-anubhav/content-type-page/1319336314
	Documentation of best practices of water management;	Reports supporting and depicting the envisaged outcomes	All the quarterly and annual reports along with the financial statements and supporting documents were submitted and uploaded on the NMHS portal.	

S. No.	Quantifiable Deliverables*	Monitoring Indicators*	Quantified Output/ Outcome achieved	Deviations made, if any, & Reason thereof:
		(nos.)	Data obtained from the hydrological instruments installed by IIT-R in Almora and Pauri Garhwal micro watersheds were analyzed for documentation and for preparing the research papers. The potential recharge area was demarcated based on hydrogeological studies and it was used to design treatment measures for spring recharge. Watershed level water security plans for all the 6 watersheds in the 3 states were prepared **(Annexure X).** The work done was compiled and presented in the 4th Monitoring & Evaluation workshop organized by NMHS-PMU on 3rd November 2020.	
	Spring inventory of 300 springs.	No. of Springs Inventory/ Springs Revived with respect to each IHR State targeted **(Nos.)**	An inventory of 300 springs (50 springs in each of the 6 districts) was prepared **(Annexure XIII).**	

(*) As stated in the Sanction Letter issued by the NMHS-PMU.

2.4. Strategic Steps with respect to Outcomes (in bullets)

S. No.	Particulars	Number/ Brief Details	Remarks/ Attachment
1.	New Methodology developed	The cluster-based approach was used for spring revival. This approach along with treatment measures carried out in the micro-watershed helped to improve the flow in the first-order streams.	Maps of micro watersheds; The potential of reviving the monitored springs in the water-scarce pilots prior to decisions on site-specific interventions was assessed. The methodology involved high-resolution spring, stream, and hydro-meteorological monitoring in two headwater micro-watersheds. Underlying hydro-geological processes were understood and a high-resolution spring and stream database was created.
2.	New Models/ Process/ Strategy developed	An integrated springshed management strategy for rural water security in the Indian Himalayas was formulated. A conceptual framework for conducting springshed research was developed. An ecosystem modeling approach was employed to quantify springshed fluxes.	Translation of the concept into a methodological approach, site-specific problems were identified post inventory, identification, and community accord based on a four-point criterion for planning future scientific activities. A two-part research approach was employed for assessment and finally adaptation and coping. Also simulations of water yield, supply, and consumptions using an ecohydrological model -InVEST were applied. The outputs aid in formulating a set of indices for decision-making and assessing changes in local and regional water security.
3.	New Species identified	None	

S. No.	Particulars	Number/ Brief Details	Remarks/ Attachment
4.	New Database established	GIS-based MIS prepared for 300 springs inventorized across 6 districts of 3 states. High-resolution data for spring and stream flow along with rainfall. Water quality data for 17 parameters tested for 300 springs across the 6 selected districts in 3 states.	GIS-based MIS of 300 springs.
5.	New Patent, if any	None	-
	I. Filed (Indian/ International)		
	II. Granted (Indian/ International)		
	III. Technology Transfer (if any)	Demystification of technical knowledge for springshed management to para-workers and local communities.	Digital content prepared on water quality, treatment measures, PRA tools, and village-level institutions for the para-workers.
6.	Others (if any)	None	-

3. Technological Intervention

S. No.	Type of Intervention	Brief Narration on the interventions	Unit Details (No. of villagers benefited / Area Developed)

S. No.	Type of Intervention	Brief Narration on the interventions	Unit Details (No. of villagers benefited / Area Developed)
1.	Development and deployment of indigenous technology	Contour trenches and runoff collection pits have been scientifically designed. These techniques have been employed in the demarcated recharge area. Also, indigenous vegetation which is beneficial for sustainability has been planted. All these have been planned and executed by locals with assistance from the technical team. Besides this, farmer-friendly, socially accepted, economic, environmentally sound indigenous practices were deployed which were suitable for the specific local needs and environmental conditions. These included vegetative measures to help in groundwater recharge, soil conservation, and increase in biomass. Measures like social fencing were used for recharge area protection and improving the drinking water quality.	Around 32.3 Ha (Shiv gadera, Akmora)) and 33.7 Ha (Haraita, Pauri) springshed area has been developed. This forms a part of the larger beneficiary watershed having 421.48 Ha and 2202.12 Ha Agricultural cover respectively.
2.	Diffusion of High-end Technology in the region	An automatic weather station and hydrological instruments were installed at the pilot sites in Uttarakhand.	1 no. AWS system in each pilot. state-of-the-art spring and stream discharge gauge (flumes integrated with high-resolution water level recorders) 225 villagers (Shiv gadera) in 63 households and 284 villagers (Haraita) in 74 households are the beneficiaries.

S. No.	Type of Intervention	Brief Narration on the interventions	Unit Details (No. of villagers benefited / Area Developed)
3.	Induction of New Technology in the region	Automated High-resolution spring and stream discharge measurement using pre-fabricated hydraulic structures for open flows complemented with state of the art (imported) capacitance-based stage sensors (on-site calibration required).	1. One perennial spring and one stream in Shiv gadera, Almora. 2. One perennial spring, two intermittent springs in Haraita, Pauri. 3. One stream in Haraita, Pauri.
4.	Publication of Technological / Process Manuals	A manual on springshed management was prepared and shared with other organisations.	-
5.	Others (if any)	An integrated hydrogeological methodological framework was published in the Journal of Hydrology (598) in 2021 for the Himalayan Mountain Region.	Beneficial to various stakeholders, the pilot villages, civil society members, and central and state decision-making authorities.

4. New Data Generated over the Baseline Data:

S. No.	New Data Details	Status of Existing Baseline	Additionality and Utilisation New data
1	Hydrometric data (Precipitation, Wind, Humidity, Temperature) for two pilot sites in Almora and Pauri districts of Uttarakhand	IMD data for select stations across Uttarakhand state.	High-resolution site-specific data, utilized for generating water budgets

2	Spring discharge data (total of four springs in two pilot sites in Almora and Pauri districts of Uttarakhand)	Manual discrete and scattered spring data records.	Fine resolution spring discharge data was utilized to assess flow regimes, the potential of target spring revival/ rejuvenation, and employed in statistical analysis.
3	Stream discharge data (high-frequency stream data for two mountain streams in Almora and Pauri district)	Scarce records of 1st and 2nd order streams.	Stream discharge data was utilized for the assessment of water budgets, flow duration characteristics, and recession hydrographs.
4	Geotagged inventory of 300 springs	Details fed into the spring inventory format	MIS prepared using the new GIS coordinates; other organizations in the region are using the information generated data. Academic and research institutions like Amity University, ICIMOD, ACWADAM, Srinagar University, and others are using the inventory to scale up the work.
5	Water quality of 300 springs	The existing baseline had 3 parameters – pH, TDS, and qualitative Fecal Coliform.	15 additional parameters (TSS, EC, Turbidity, TA, TH, Ca Hardness, Chloride, Calcium, Magnesium, Fluoride, Sodium, Potassium, Nitrate, Sulphate, Iron, and quantitative assessment of FC) helped to identify the geological contamination and to understand the hydrochemistry of springs.
6	Discharge and rainfall data collected through instruments	The existing baseline had manually collected rainfall and discharge data.	High-resolution data collected through instruments were utilized for hydrological assessment and research purposes.

5. Demonstrative Skill Development and Capacity Building/ Manpower Trained:

S. No.	Type of Activities	Details with number	Activity Intended for	Participants/Trained			
				SC	ST	Woman	Total

S. No.	Type of Activities	Details with number	Activity Intended for	Participants/Trained			
				SC	ST	Woman	Total
1.	Workshops	315 participants participated (UK, Nagaland, Arunachal)	Experience of different stakeholders on spring shed management, the water quality of springs, digital training content on spring discharge measurement & water quality testing, strategies for springs revival				315
2.	On-Field Training	30 capacity-building trainings in 5 implementation villages in UKD. These trainings were on spring recharge measures, discharge and rainfall measurement, VLIs, O&M	Discharge and water quality monitoring, rainfall measurement, PRA training, handling the meetings with the community,	12	18	77	107
3.	Skill Development	A cadre of para-workers trained in water quality monitoring, rainfall and discharge measurement, and data analysis.	Discharge and water quality monitoring, rainfall measurement, involving the community in PRA activity, Layout of trenches, implementation work, measurement of implementation work,	35	42	33	110

S. No.	Type of Activities	Details with number	Activity Intended for	Participants/Trained			
				SC	ST	Woman	Total
4.	Academic Supports (PHD students)	**No. of PhD students – 1** Training in hydrological monitoring carried out by IITR for PSI in UKD (no. of participants-5); for DoLR in Nagaland (no. of participants-5); for WWF in Arunachal (15). Training by IITR on the installation of AWS (no. of participants-5). Review meetings with POs (6), Training of POs in preparation of spring inventory, recharge estimates, engineering measures, water budgeting, and preparation of water security plans (4)					**15**
	Others (if any)						

6. Linkages with Regional & National Priorities (SDGs, INDC, etc)/ Collaborations:

S. No.	Linkages /collaborations	Details	No. of Publications/ Events Held	Beneficiaries
1.	Sustainable Development Goal (SDG)	SDG (3): Healthy life and well-being for all. SDG (5): Reduced drudgery; gender empowerment. SDG (6): Improved water quality; decentralized water and sanitation management. SDG (13): Improved education, awareness-raising, and human and institutional capacity building on climate change adaptation. SDG (15): Increased water availability for domestic and agricultural needs, soil conservation, enhanced biomass.		

S. No.	Linkages /collaborations	Details	No. of Publications/ Events Held	Beneficiaries
2.	Climate Change/INDC targets- Intended Nationally Determined Contributions (sustainable agricultural practices); promoting renewable sources of energy (Pali solar lift scheme); Plantation/increase in biomass; adaptation to climate change by initiating drinking water security measures; capacity building; knowledge dissemination.			

S. No.	Linkages /collaborations	Details	No. of Publications/ Events Held	Beneficiaries
3.	International Commitments	1. Sharing experiences in international conferences: a) Webinar on reimagining groundwater governance with a special emphasis on India, organized by ACWADAM from 20th July to 10th August, 2021. b) Webinar on water resources management organized by Water for People and IRC on June 9, 2021. c) UNESCO Groundwater Conference held on 19th May 2022. 2. International Project Partner under a) SDC initiative on springs titled "Development and Implementation of science-based Springshed Management in the Indian Himalayan Region" funded by ICIMOD, Nepal (1st April 2021 to 30th June 2023) b) Water Security through Integrated Water Management, based on scientific data and evidence-based decision support system" (July 2021 to June 20024) with support of Wheel Global Foundation, US c) Spring Rejuvenation in Chamoli district of Uttarakhand, funded by Frank Water UK (1st January 2022 to 31st December 2022)	-	-

S. No.	Linkages /collaborations	Details	No. of Publications/ Events Held	Beneficiaries
4.	Bilateral engagements	Forest Department and Watershed Management Directorate, Uttarakhand. State Jal Jeevan Mission, Arunachal Pradesh. Rural Development Department, Jal Shakti Vibhag, and Forest Department, Himachal Pradesh Meghalaya Basin Development Authority (MBDA), and Soil and Water Conservation Department, Meghalaya	-	-
5.	National Policies	Made contributions at 1) National Workshop on Springshed Management, 10th and 11th September 2019, New Delhi 2) Water Solutions: Leveraging Impact through Smart Philanthropy, September 21, 2019, Mumbai 3) Water Future Conference, 25-27 September 2019, Bengaluru 4) Meeting with Niti Aayog, December 23, 2019, New Delhi 5) Meet on National Policy Advocacy Workshop on Springshed Management, 28th October 2021 6) National Workshop on Role of Civil Society Organizations in Water Security for Sustainable Development – Learning & Development, 23rd-24th November, 2022		

S. No.	Linkages /collaborations	Details	No. of Publications/ Events Held	Beneficiaries
6.	Others collaborations	Initiated dialogues through meetings and workshops for state-level springshed management programs in Uttarakhand, Himachal Pradesh, Arunachal Pradesh, and Nagaland. Sector Partner for National Jal Jeevan Mission		

7. Project Stakeholders/ Beneficiaries and Impacts:

S. No.	Stakeholders	Support Activities	Impacts
1.	Gram Panchayats	Water quality monitoring of springs	Now they are aware of maintaining sanitation and cleanliness around the springs.
2.	Govt Departments (Agriculture/ Forest)	The Forest Dept. UKD. North-East Initiative Development Agency (NEIDA), Department of Rural Development and the Department of Land Resources, Nagaland Centre for Micro-Finance and Livelihoods (CML) NABARD	Detailed Technical Report for 30 springs (10 springs each in Rudraprayag, Pauri Garhwal, and Dehradun district) Pilot programme on the revival of 13 springs in Nagaland across 9 villages was carried out. The programme was to be scaled up to 100 villages by RD and DoLR, Nagaland. A pilot programme on the revival of 6 springs in Arunachal Pradesh, 7 springs in Mizoram, and 4 springs in Tripura was planned and DPRs were prepared.
3.	Villagers	Water quality testing, implementation activity	Villagers understood about the quality of water, took care of cleanliness around their springs, fixed time and rules for filling water, and collected monthly contributions so that it could later be used for the maintenance of their springs.

S. No.	Stakeholders	Support Activities	Impacts
4.	SC Community	Along with involvement in spring recharge work, this community got some temporary employment.	People did the work of implementation during the COVID pandemic, which also helped them financially.
5.	ST Community		
6.	Women Group	Women stopped cutting of branches from trees.	People used to cut branches from the trees for fuel. The trained group of women in the villages stopped this practice.
	Others (if any)	CSR funding ICIMOD	Initiation of springshed management activities in Chamoli district of Uttarakhand with the support of Frank Water, UK, and CGM-CMA CSR. Pilot projects in Himachal Pradesh and Uttarakhand with the support of ICIMOD in partnership with IIT-R and ACWADAM.

8. Financial Summary (Cumulative):

S. No.	Financial Position/Budget Head	Funds Received	Expenditure/ Utilized	% of Total cost
I.	Salaries/Manpower cost	61,61,648	63,73,432	34
II.	Travel	22,36,449	19,28,421	10
III.	Expendables &Consumables	3,56,962	2,97,369	2
IV.	Contingencies	-	-	-
V.	Activities & Other Project cost	76,66,892	78,23,479	42
VI.	Institutional Charges	4,50,000	5,00,027	3
VII.	Equipments	19,04,000	18,77,348	10
	Total	1,87,75,951	188,00,076	
	Interest earned	1,57,774		
	Grand Total	1,89,33,725		

* Please attach the consolidated and audited Utilization Certificate (UC) and Year wise Statement of Expenditure (SE) separately, *ref*. **Annexure I.**

9. Major Equipment/ Peripherals Procured under the Project (if any)**

S. No.	Name of Equipment	Cost (INR)	Utilisation of the Equipment after project
1.	Automatic Weather station	2,94,115	Meteriological Monitoring
2.	Solar Power Automatic station	1,88,977	
3.	Global Water flow probe	2,72,344	Real time discharge measurement
4.	Hobo conductivity Logger	2,36,000	Real Time Water Quality Tester
5.	Water level recorder	2,82,610	Water Level measurement
6	Work Station (IIT Roorkee)	1,00,000	Data monitoring & reports generation.

Details should be provided in details **(*ref* **Annexure III &IV).**

10. Quantification of Overall Project Progress:

S. No.	Parameters	Total (Numeric)	Remarks/ Attachments/ Soft copies of documents
1.	IHR States Covered	3	Uttarakhand, Nagaland and Arunachal Pradesh
2.	Project Site/ Field Stations Developed	6	6 field stations (2 in each district) have been developed.
3.	New Methods/ Modeling Developed	3	1. GIS-based MIS has been prepared for 100 springs in Uttarakhand using the spring inventory. 2. Linking of hydrogeological characterization with the subsurface flow and delineation of recharge area was studied. It helped to recommend practices for water security through community-based actions and lay the groundwork for policy recommendations. 3. Best water management practices as per hydrological modeling for climate change adaptation were worked out by IITR. These were based on the **InVEST** (Integrated Valuation of Ecosystem Services and Tradeoffs). It helped to explore how changes in watershed/land use and rainfall lead to

S. No.	Parameters	Total (Numeric)	Remarks/ Attachments/ Soft copies of documents
			changes in the flows of many different benefits to people.
4.	No. of Trainings arranged	30	30 capacity-building training were organized in the villages. A total of 107 people were trained through these training.
5.	No of beneficiaries attended trainings	1,2,3	These training benefitted more than 350 households in the selected watersheds in Uttarakhand. These watersheds cover 2 villages in Almora and 3 villages in Pauri Garhwal.
6.	Scientific Manpower Developed (Phd/M.Sc./JRF/SRF/ RA):	1 PhD	
7.	SC stakeholders benefited		
8.	ST stakeholders benefited		
9.	Women Empowered		
10.	No of workshops arranged along with level of participation	15	1. An inception workshop was organized on 30th January 2018 at WWF, New Delhi. 2. The first review meeting was organized on 14th August 2018 at WWF, New Delhi. 3. Workshop on hydrological monitoring was organized from 17-20 December 2018 in Almora 4. The second review meeting was organized on 25th February 2019 in Guwahati. 5. A consultative meeting on springshed management was organized on 25th February, 2019 in Guwahati. 6. The second hydrological monitoring workshop for partner organizations was organized on 3rd and 4th May, 2019 in Arunachal Pradesh. 7. The 3rd review meeting was held on October 3, 2019 in Guwahati.

S. No.	Parameters	Total (Numeric)	Remarks/ Attachments/ Soft copies of documents
			8. The 4th review meeting was held virtually in April-May 2020 due to COVID 19 outbreak. 9. A training workshop was organized for 22 para-workers from 18 to 20th February 2021 in Dehradun to discuss the collected discharge and water quality data, issues regarding community mobilization and work attitude, and initiatives taken up by them for undertaking new work in the area, etc. They were given hands-on training in PRA, water quality testing and analysis, and spring discharge measurement. They were also made aware of the discrepancies in their collected data so that they could be rectified by them in the future. 10. Stakeholders state-level consultation workshop for Arunachal Pradesh organized on 6th May, 2021 and attended by 38 participants. 11. Nagaland workshop - 25th May, 2021, 113 participants. 12. Kumaon workshop - 29th June, 2021, 69 participants. 13. Garhwal workshop – 29th July, 2021, 103 participants. 14. UKD state level workshop – 2nd September, 2021, 46 participants. 15. National workshop – 28 October, 2021, 133 participants.
11.	On field Demonstration Models initiated	Maps/photos attached.	The demonstration sites are in Almora and Pauri Garhwal districts in Uttarakhand. The headwater watersheds selected are *Shiv Gadera* under Sahigad watershed in Someshwar, Almora, and *Haraita* under Pundoli watershed in Dwarikhal,

S. No.	Parameters	Total (Numeric)	Remarks/ Attachments/ Soft copies of documents
			Pauri Garhwal **(Annexure VII).**
12.	Livelihood Options promoted		Spring recharge through catchment area treatment will directly impact their flows and extension of the availability of water further into the drier seasons. It would also mean the opportunity to cultivate more crops which may increase the income of the people. Regeneration of springs will improve water and biomass availability for domestic use and livelihoods (irrigation). Higher biomass will be available in the form of fodder and firewood. The communities will develop resilience to climate change.
13.	Technical/ Training Manuals prepared	*1*	Training manual developed on social measures, recharge area treatment, and water quality monitoring.
14.	Processing Units established	NA	NA
15.	No of Species Collected	NA	NA
16.	New Species identified	NA	NA
17.	New Database generated (Types):	Images/GIS-based based maps for 2 watersheds in each of the 3 states *Inventory of 300 springs.* *Water quality data of 300 springs.* *High-resolution discharge,*	Watershed, LULC, Spring location, Geological maps etc have been prepared. GIS-based MIS has also been prepared using the spring inventory.

S. No.	Parameters	Total (Numeric)	Remarks/ Attachments/ Soft copies of documents
		rainfall, and streamflow data.	
	Others (if any)		

11. Knowledge Products and Publications:

S. No.	Publication/ Knowledge Products	*Number*		*Total Impact Factor*	***Remarks/* Enclosures**
		National	**International**		
1.	Journal Research Articles/ Special Issue: Manuscript	*1 (Current Science)*	*1 (Journal of Hydrology)*	*CS – 1.102* *JoH – 5.722*	*Hydrological process monitoring for springshed management in the Indian Himalayan region: field observatory and reference database,* Current Science, Vol.,120, NO. 5, 10 March 2021. *Assessment of spring flows in Indian Himalayan micro-watersheds – A hydro-geological approach*, Journal of Hydrology, Vol. 598, July 2021, 126354. Hydrological Process Monitoring for Springshed Development in the IHR : Field Observatory and Reference Database
2.	Book Chapter(s)/ Books:	1			
3.	Technical Reports				
4.	Training Manual (Skill Development/ Capacity Building)				
5.	Papers presented in Conferences/ Seminars-	1	1		1) “Reviving Springsheds in Himachal Pradesh: Experiences from Thanakasoga GP” at IWMI-Tata Partners’

S. No.	Publication/ Knowledge Products	*Number*		***Total Impact Factor***	***Remarks/*** **Enclosures**
		National	**International**		
					Meet, December 4-6, 2018, Anand (Gujarat) 2) "Mapping of Vulnerable Springsheds and Preparing Restoration Plan in Uttarakhand" at UKFD-UNDP springshed activities, February 13, 2019 3) "Springshed Development: Experiences from the North-East" at Springshed Management in the North-Eastern States of the Indian Himalayan Region, Kohima, May 29, 2019 4) Community-based Springshed development for Water security in Himalayan Region: Experiences from Thanakasoga GP – Paper presented at the Water Future Conference, 25th September 2019 5) Community-based groundwater governance in the Himalayan and central plateau landscapes of India – Paper presented at the UNESCO Groundwater Conference held on 19th May 2022. 6) "Springshed Development in Watershed Management: Concept & Approach" at

S. No.	Publication/ Knowledge Products	*Number*		*Total Impact Factor*	***Remarks/*** **Enclosures**
		National	International		
					Orientation Workshop on PMKSY-Watershed Development Component, July 8, 2022, Dehradun
6.	Policy Drafts/Papers	1			1) Section on Springs for National Water Policy, December 2019 2) Drinking Water Policy for Himalayan States, June 2020
7.	Others: case studies	2			(i) case study on community initiatives taken to revive a spring in one of the project sites in Western Arunachal Pradesh. https://www.rediffmail.com/cgi-bin/re%2F%2Fwww%2Eindiawaterportal%2Eorg%2Farticle%2Frejuvenating%2Dsprings%2Dwestern%2Darunachal%2Dpradesh%2D0&rediffng=0&rogue=4f25d5dc5e9e7fe16b4abb757049486f521c8faa&rdf=VHJRMgZvXzMBKAQxAGIFYQ== (ii) case study on the solar lift scheme in Pali village, Pauri Garhwal.

* Please append the list of KPs/ publications (with impact factor and further details) with due Acknowledgement to NMHS.

12. Recommendation on Utility of Project Findings, Replicability and Exit Strategy

Particulars	Recommendations
Utility of the Project Findings	1. Situational assessment of springs for site/ spring/ aquifer specific management options 2. High-resolution spring dataset in the Indian Himalayas and continued operability 3. Elaborate methodology for pioneering spring instrumentation hydrology in IHR 4. Methodological research framework for integrated hydrological and hydro-meteorological approach 5. Assessment of spring aquifer potential in storage and transmission, regimes of hydrogeological flows, and characterization of spring behaviour over the years. 6. Improved water and food security will help in improving the quality of life, agriculture-based livelihoods and instill resilience to global climate change.
Replicability of Project	1. A participatory management and intervention approach has been established where the local communities are involved right from the beginning of the project. This approach has integrated traditional knowledge with modern science. 2. Spring and stream instrumentation, setting up of weather stations, and regular maintenance and operability have been conducted with the involvement of local people. 3. The water user groups are at the forefront of spring source quality maintenance, equitable resources allocation and workshops and knowledge sharing sessions. 4. A system where women, local communities, and commoners have a stake in informed decision-making has been established. 5. An improvement in sustainability of water resources and ecosystem services and development of springshed management infrastructure was achieved by a combination of traditional knowledge of the mountain communities and scientific knowledge garnered from the project. 6. The project was implemented at a pilot scale in two districts of Uttarakhand, India with a detailed description of methods and strategies, which can be replicated across the IHR.

Particulars	Recommendations
Exit Strategy	Please describe the Exit Strategy of the project, self-sustaining and benefitting the stakeholders and local community: 1. Strengthening and capacity building – By means of workshops, street plays, awareness drives and involving locals from inception stage, infrastructure setup to intervention stage. The VLIs and the stakeholder communities have been trained for supervision of spring instrumentation functioning and assistance during maintenance and operability crises. 2. Monitoring – Para-hydrogeologists have been trained for effective monitoring of instrumentation and sites may be sustained easily before it is tapered out after ample data has been collected. 3. Knowledge dissemination – The project outputs have been published to provide hands-on learning, evidence for assessment of potential, selection of spring source for rejuvenation while considering optimal usage of resources, detailed methodologies, strategies of instrumentation, and framework for research methodology. The publications highlight recommendation for policy and decision-making. The project is discussed in detail to ease its replicability across the IHR. In addition, the project has built capacity in the region across a range of stakeholders, and elevated awareness of springs in general.

(**PROJECT PROPONENT/ COORDINATOR**)

(Signed and Stamped)

(**HEAD OF THE INSTITUTION**)

(Signed and Stamped)

Place: Dehradun.
Date: …../……/……

PART B: PROJECT DETAILED REPORT

The Detailed report should include an Executive Summary and it should have separate chapters on (i) Introduction (ii) Methodologies, Strategy and Approach (iii) Key Findings and Results (iv) Overall Achievements (v) Project's Impacts in IHR (vi) Exit Strategy and Sustainability (vii) References and (viii) Acknowledgement (It should have a mention of financial grant from the NMHS, MoEF&CC)

Further, description of Technical Activities, List of Trainings/ Workshops/ Seminars with details of trained resources, list of New Products developed under the project, Manual of Standard Operating Procedures (SOPs) developed, Technology developed/Transferred etc should be enclosed as Appendix.

1 EXECUTIVE SUMMARY

The Executive Summary of the project should not be more than 3–5 pages, covering all essential features in precise and concise manner as stated in Part A (Project Summary Report) and Part B (Comprehensive Report).

This project was initiated in January 2018 under the National Mission for Himalayan Studies (NMHS) supported by MoEF & CC. It was led by PSI with IIT-Roorkee; Department of Land Resources (DoLR), Nagaland; WWF-India; and Arghyam as its partners. The project primarily focused on demonstrating a model based on a hydrological approach and community involvement for increasing spring discharge and promoting sustainable and equitable use of the augmented groundwater for maintaining water security in the IHR. The work was carried out in 6 headwater watersheds which are in the most water-scarce zones of districts – Phek and Zunheboto in Nagaland; Almora and Pauri Garhwal in Uttarakhand, and Tawang and West Kameng in Arunachal Pradesh.

The hypothesis is that working at a watershed level will result in a holistic approach to managing water resources as each of these hydrologically-defined geographic areas are unique in physiography, ecology, climate, water bodies, and land use. The approach used was the inventorization of 50 springs in each of the 6 selected districts, hydrological modeling, building up village-level institutions, community involvement, spring recharge pilots, knowledge dissemination, and advocacy. The focus of our actions was on the identification of critical springs, working towards their rejuvenation, and promoting sustainable and equitable use of the augmented groundwater for maintaining water security through a participatory approach.

In the Uttarakhand pilot micro-watersheds – *Haraita* in Pauri Garhwal and *Shiv Gadera* in Almora, automatic weather stations, Parshall flumes, water level sensors, pan-evaporimeters, etc. were installed for continuous collection of high-resolution hydrological data for spring discharge, streamflow, rainfall, and the rate of evaporation **(Annexure IX).**

The findings indicate a high dependency of the spring discharge and streamflow on rainfall. The discharge data obtained from *Shiv Gadera* springs indicate uniform underlying geology as compared to *Haraita* which has a fractured bedding plane hence variable spring flow dynamics. This indicates that intense planning for spring rejuvenation is needed for complex geological areas like Haraita. In other words, assessing and understanding the underlying geology and hydrological processes of Himalayan springs is of paramount significance to scientifically plan for the rejuvenation of springs. In addition, streamflow data collected from the selected sites will help to understand the effect of land use/land cover on streamflow in the watershed.

In this way, working at a micro watershed level with high resolution data will help to develop an integrated approach to resolve water scarcity issues by involving the communities. Spring water will have to be used wisely and monitored on a regular basis for its discharge and quality by the local people. Therefore, village level institutions have been formed and para-workers have been trained in water quality, discharge, rainfall and spring treatment measures to create local governance. InVEST (Integrated Valuation Services and Tradeoffs) model was used to explore how changes in watershed/land use and rainfall can lead to changes in the flow and availability of water. It helped to suggest best water management practices for ensuring water security at the watershed level.

2 INTRODUCTION

2.1 Background of the Project (max. 500 words) –

The Indian Himalayan Region (IHR) is generally viewed as having abundant water resources. This region is known as the water tower of Asia. While this is true at the regional scale, there are problems of scarcity emerging amidst plenty. More than 75 million people live here and the lives and livelihoods of these people are mostly dependent on groundwater in the form of springs and streams rather than on big rivers. However, most of these perennial springs and streams are becoming seasonal or have dried up primarily due to the impacts of climate change, growing water demands, changes in land-use patterns, deforestation, urbanization etc. As a result, dry spell during summers has become an annual phenomenon. The decline in glaciers due to global warming is causing mountain streams and rivers to dwindle — increasing both drought and fire risk. Several districts in the Himalayan states like Uttarakhand, Himachal Pradesh, Nagaland, Assam among others have been declared drought-hit during the last decade. Drinking water availability issues in the region are rapidly assuming alarming proportions. The major burden falls on women who have to fetch water by walking several kilometers every day. Scarcity of water along with poverty and limited options for alternative livelihoods will further reduce the resilience and vulnerability of the people to cope with extreme climatic events.

A specific way forward to this is to work more directly with natural processes to secure the regeneration of groundwater sources at the local level. The basis was that working at a watershed scale will result in a holistic approach to managing water resources as each of these hydrologically-defined geographic areas are unique in physiography, ecology, climate, water bodies, water quality, and land use. The approach would facilitate identifying and solving problems in a better way. The project partners implemented community-based springshed development projects based on hydrogeological studies involving the local communities in the IHR. This has substantially enhanced water availability and quality in the selected villages.

The proposed study has laid the groundwork for state and central programs for the regeneration and protection of springs based on the existing geohydrological conditions in the selected headwater watersheds of Nagaland, Uttarakhand, and Arunachal Pradesh states. It has recommended practices for sustained and safe water supply through community-based actions to withstand climate variability. Spring recharge will result in water and food security, more biomass production, better livelihoods, and improved quality of life. Involvement and capacity building of communities especially women in the maintenance of springs will make them more resilient to climate change. The project addressed the Broad Thematic Areas of Water Resources Management. The major thrust area "Water security through rejuvenation of springs and catchments" included the inventorization of 300 springs in the selected districts of Nagaland, Uttarakhand, and Arunachal Pradesh. This was followed by preparing springshed development plans for the springs in the watersheds demarcated in each selected district. As a pilot, hydrological modeling was carried out at two selected watersheds in Uttarakhand to design best management practices. The initiative was led by People's Science Institute (PSI) Dehradun, in partnership with the Land Resources Department, Government of Nagaland, IIT Roorkee, WWF-India and Arghyam, Bengaluru.

2.2 Overview of the Major Issues to be Addressed (max. 1000 words)

In Uttarakhand, ninety percent of the drinking water supply is spring based. However, most of these perennial springs and streams are becoming seasonal or have dried up. Around 37 percent of natural springs in Uttarakhand, which directly contribute to the Ganga river system, are drying[1]. Nearly 40 percent of the 5257 sources monitored by Jal Sansthan in 2005-06 had recorded a decrease of more than 50 percent of their original discharge. The 2016 droughts in our country affected nearly 256 districts including 9 districts in Uttarakhand. The drought assessment report by the Uttarakhand State Agriculture Department mentions that more than 50 percent of farmland in these 9 districts as drought-hit. According to a report by Uttarakhand State Agriculture Department, post-monsoon rainfall in these districts had gone down by 50 percent in 2015-16 which triggered drought-like conditions. The worst affected districts are Almora and Pauri with 57 percent of affected farmland. The state's fragile water resources are stressed and depleting, while sectoral demands (including drinking water, industry, agriculture, and others) are growing rapidly in line with urbanization, population increases, rising incomes, and industrial growth. All this has resulted in declining per capita water availability and deteriorating quality.

[1] Down to Earth: October 2015

The state of Nagaland is most vulnerable to climate change risks. The rapid changes in topography result in climatic changes within short distances. Warmer summers, irregular but high-intensity rainfall, and unpredictable snowfall in some areas point towards changing climate in Nagaland. The state has been badly hit by the scourge of water scarcity. The people of Nagaland are dependent on natural springs and sub-surface flows for domestic and irrigation purposes (*NSAPCC 2012*). The predominant sources of water in Nagaland are surface water in rivers, streams, natural springs, and subsurface water occurring as groundwater. The water in these is mainly sustained by the heavy rainfall received in the state which is of the order of 2000-2500 mm, one of the highest amongst all states in India. However, the sources of water are either drying up or becoming seasonal. This could be because physio-graphically, the state consists of a narrow strip of hills with the result that a major part of the rainfall is lost in the form of surface runoff. The other reasons which are decreasing the availability of water across the state are deforestation due to shorter *jhum* cycles, urbanization, and developmental activities. On the other hand, there is high dependence of livelihoods on natural resources like water and forest. Consequently, the demand and need for freshwater resources in all sectors are increasing. The groundwater especially in the form of springs and traditional wells plays a key role in meeting the water needs of the people. But the impacts of rainfall variability caused by climate change and multifarious developmental activities have jeopardized the perennial flow of springs.

In Arunachal Pradesh, the serious challenge is related to the frequency and magnitude of extreme weather events like drought and floods due to climate change. A large knowledge gap exists in the present scenario regarding the climate change implications on water resources and related hazards in the Himalayas and their downstream river basins. Primary data generation and its utilization in developing scenarios taking into account water demand and socio-economic development as a whole are required. The establishment of a monitoring system for surface and groundwater and the use of the latest hydrological model are the keys. Climate change may have a detrimental effect on the present socio-economic structure in the region also. Society will also have to adapt to the stresses of climate change on their livelihood. Participation of people in their general welfare backed by institutional support and an updated knowledge base will be important in developing their resilience to climate change.

With scarce water and groundwater tables falling, and temperature rising, the soil conditions will become drier. Low productivity, loss of working days and its impact on annual earnings will lead to more migration from Himalayan villages. Several micro-studies also indicate problems of groundwater quality in the IHR. Groundwater samples from the Indian Himalayan states routinely show the presence of coliform bacteria.

As mentioned earlier, the Himalayan region is characterized by steep slopes which do not allow water retention resulting in quick runoff, and climate change and anthropogenic activities further lead to drying up of springs and small rainfed streams. However, if kept recharged, springs can turn into the sources of perennial water in these remote areas and help in preventing severe water scarcities. Recharging springs and base flows in a mountain topography is possible as there is a wide scope to utilize the available rainfall in the region.

2.3 Baseline Data and Project Scope (max. 1000 words):

The project baseline is important as it works as a reference point to compare and measure the progress of the project against the plan. It helps in measuring the performance of the project during the execution period. Since the aim of the project is to achieve water security through community-based springshed development in the IHR, the most important deliverable of this project are increased spring discharge, improved water availability, and water quality.

For this purpose, spring discharge, rainfall, and water quality of the critical springs identified for rejuvenation were measured pre-implementation, during implementation, and post-implementation to record comparative results and to measure the impact of the interventions carried out.

At the intersection of groundwater and surface water, natural springs are a significant source of water for people. Where springs are available, they are often one of the most cost-effective ways to provide relatively pure water for consumption, hygiene, and irrigation.

As household and agricultural water demands increase over time, a well-informed water resource management is all the more pressing. Therefore, measuring spring discharge under a variety of flow conditions is important. One of the key questions for water resource management is how discharge will vary over time, and discharge monitoring is fundamental for understanding that variability. While variability is ultimately the result of changes in recharge or aquifer structure, recharge and aquifer structure are challenging to observe directly. In contrast, spring discharge itself is usually accessible plainly on the surface. Therefore, variation in discharge can be used to understand variations in recharge and aquifer characteristics, even when recharge and the aquifer cannot be observed directly (Bredehoeft 2007, Kormaz 1990, Manga 2001). A record of discharge is important for identifying long-term trends, understanding general seasonal water availability, and interventions required for spring rejuvenation. Therefore, spring discharge was monitored on a weekly basis for all the springs. The rainfall was measured on a daily basis. Analysis of spring discharge data provided important insight into the way the aquifer stores and transmits water. Recession analysis was used with discharge time series (spring hydrographs) to determine the rate at which heavy flow during precipitation returns to base levels when there is no precipitation. Such a type of analysis facilitates the forecasting of water availability. Long-term discharge data is also necessary for the construction and validation of water balance models.

Since there are also concerns about the quality of spring water, all the basic drinking water quality parameters were assessed on a seasonal basis. The data helped to formulate social and sanitary protocols for maintaining spring water quality. The collected data helped to quantify the impact of all the interventions carried out for spring rejuvenation and protection of their recharge areas.

2.4 Project Objectives and Target Deliverables (as per the NMHS Sanction Order)

S.No	Project Objective	Target Deliverables
1	Inventorization of 300 springs - 50 springs/district x 6 districts	Maps and action plan of spring revival in 6 districts of Nagaland, Arunachal, and Uttarakhand delivered to state agencies for implementation
2	Piloting community-based regeneration of 12 springs in the selected watersheds in Uttarakhand	Spring revival models for 2 micro-watersheds covering 12 springs in Uttarakhand
3	Evolving state-level policy recommendations for conservation and sustainable use of groundwater resources	Documentation of best practices of water management. State-level policy recommendations.
4	Knowledge dissemination and communication	Dissemination of knowledge to POs in other states. Research Papers.

3 METHODOLOGIES, STRATEGY AND APPROACH

3.1 Methodologies used for the study (max. 1000 words)

(i) Inception Workshop: This was organized to familiarize the partner organizations with the objectives of the project and also with the selected project locations /villages. This helped in setting up clear goals and objectives to achieve desirable outcomes.

(ii) Literature review & site visit: Collection of secondary information, recce visits, and baseline surveys of water-scarce regions in selected districts.

(iii) Preparation of spring inventory: An inventory of 300 springs (50 springs in 6 districts of Nagaland, Uttarakhand, and Arunachal Pradesh) was prepared.

(iv) Selection of Watersheds: One watershed in each of the 6 districts (Phek & Zunheboto districts in Nagaland, Almora & Pauri districts in Uttarakhand, and Tawang & West Tameng districts in Arunachal Pradesh) was selected. Some groundwork for this was carried out by the proponent and its partners by conducting recce visits and collecting necessary information.

(v) Awareness Campaigns and community empowerment: *Sandesh Yatras* were carried out to create awareness about springs and for community participation in the programme. This was followed by PRA exercises, resource mapping, formation of village-level institutions for operation and maintenance.

(vi) Hydrogeological Studies: Different types of rocks in the area, the openings present between them, and their altitude govern the accumulation and movement of groundwater. Hydrogeological studies were undertaken to map the underlying geology, to understand the distribution and movement of groundwater in the soil and rocks of the area, and to demarcate the spring recharge area.

(vii) **Estimation of Water Demand & Supply Gap:** Estimation of water demand and supply (springs and streamflow) gap in drinking, domestic, and irrigation water requirements was carried out for the selected villages.

(viii) **Springshed Treatment Plans:** Based on the above estimates, springshed treatment plans were prepared. In the future, these plans will help the stakeholders to increase water availability through spring recharge works and to replicate the interventions at other sites.

(ix) **Hydrological Studies:** Two pilot micro-watersheds, were selected in Uttarakhand state, India. Primarily, in a two-part research approach, weather stations were set up for hydro-meteorological data collection and monitoring at sub-hourly scales. Secondly, a parallel hydro-geological field assessment to lay out conceptual springshed maps and understand the geological influence on the hydrological outputs was piloted. Detailed geological mapping of the study area, including the determination of the lithological and structural framework of the area, as well as measuring the dominant orientation of bedrock fractures and foliation present in the rocks, was done. A combination of topographical information and site investigations was used. Parshall flumes and HS flumes gauged the stream and spring flows, respectively, in both the micro-watersheds. Regional geology and stratigraphy were studied on the ground, and literature regarding the study area has been referred to. Toposheets (Survey of India) of the study area were collected for plotting the geological data and locating the springs. Outcrops were studied to gather information about the various rock types and trends of openings, the direction and attitude of rock beds and geological structures were measured using a Brunton, spring locations were marked and discharge rate was measured. The dip and strike of the rocks and slopes of the given region were measured; the lithological and structural (folds, faults, and fractures) characteristics of the rocks were marked, and oriented photographs and samples were taken. The foliation types, based on schistosity, were specified in the pilot study, and the rock type identification was followed by the specification of the lithology by image petrology. All the lithologs were recorded and later fed into a spreadsheet program. The study sites are instrumented with Automatic Weather Stations (AWS), HS- and Parshall- flumes, and other hydrological instruments. Various environmental sensors installed at AWS enabled real-time measurement of weather parameters, including precipitation, relative humidity, atmospheric pressure, solar radiation flux, wind- speed, and direction. Continuous water depth data are converted into discharge values using the Flume discharge equation. Upon identification of the pilot sites and establishing community agreement, the site-specific problem is identified based on a four-point criterional i.e. 1) Water security 2) Spring flow continuum 3) Demography and Migration 4) Ecosystem services. Activities were then planned for an extensive scientific assessment. In a two-part research approach, hydrometeorological observatories were set up for data collection and monitoring while parallel hydro-geological field assessment to layout conceptual springshed maps and understand the geological influence on the hydrological outputs is conducted. Water security was appraised considering the problem-specific issue, in our case its spring water decline, and if an integrated management approach can solve the issue. The security assessment was done through the springshed paradigms and adaptation and coping measures were then designed based on it.

(x) **Interventions for Spring Recharge:** The hydrological modeling as described above helped to study the impacts of climate variability. The study brought out the best water management practices for the two selected watersheds. Based on the outcomes of this study, spring recharge interventions were piloted using engineering, vegetative and social measures. Engineering measures like CCTs, SCTs, etc., helped in harvesting rainwater. Nurseries were established for plantation work. Native plants and fodder grass were grown in the recharge area to reduce surface runoff, and soil erosion and to increase infiltration of water. Village-level institutions were formed and the existing institutions were strengthened to manage the local water resources. Social protocols were developed to sanitary protect the recharge areas and water sources. Regular measurements of spring discharge, rainfall, and water quality were planned and carried out by trained local people.

(xi) **Monitoring & Evaluation: Monitoring** was done on a regular basis with the various layers of the project staff: The project staff will have clear-cut roles and responsibilities as well as reporting framework, timelines, and patterns. Quarterly review meetings were organized. The VLIs formed organized monthly meetings and monitoring of springs discharge and water quality on monthly basis in the villages where spring revival pilots were implemented. Social protocols were supervised for recharge area protection. Subject specialists carried out monitoring and evaluated the program.

(xii) **Knowledge Management & Communication:** Knowledge resources were prepared in the form of research papers, reports, case studies, manuals, watersheds, hydrogeological maps etc. Sample surveys were conducted for impact assessment studies.

(xiii) **Advocacy:** State and National level workshops were organized for policy advocacy and to suggest state-level spring revival programs.

3.2 Preparatory Actions and Agencies Involved (max. 1000 words): FD, IPH (AP); Jal sansthan, SMC, NEIDA, RD (Nag) –

	Organization	**Brief Description**
1.	The Forest Department, Uttarakhand	In the first phase, PSI prepared the Detailed Technical Report for 30 springs (10 springs each in Rudraprayag, Pauri Garhwal Dehradun district).

2.	North-East Initiative Development Agency (NEIDA), Department of Rural Development, and the Department of Land Resources, Nagaland	A pilot programme on the revival of 13 springs in Nagaland across 9 villages was carried out. The programme was then scaled up to 100 villages by RD and DoLR, Nagaland.
3.	Centre for Micro-Finance and Livelihoods (CML)	A pilot programme on the revival of 6 springs in Arunachal Pradesh, 7 springs in Mizoram, and 4 springs in Tripura was planned and DPRs were prepared.
4.	NABARD	Discussions were held with NABARD for springshed development work in the Northeast.

3.3 Details of Scientific data collected and Equipments Used (max 500 words):

Spring and Stream Discharge data - For gauging the stage and discharge, the springs and first-order streams were instrumented with HS-flumes and Parshall flumes complemented with Odyssey® capacitance water level probes (Dataflow Systems Limited, New Zealand). The spring sites were installed with a 0.6 ft HS flume and the selected locations for the stream gauges were installed with 12 inches

Parshall flumes using local masonry were installed for water level sensing. A stilling well with a small opening at the base was fitted adjacent to the designed flow channel of the flumes. The water level sensor element was dropped into the stilling well, and the logger encased in a cylindrical water-resistant casing was secured in a metal box to protect it from extreme weather, wild animals, and extremities. These gauges were configured to sense discharge data every 15 minutes and have been collected since July 2018.

Hydrometeorological data – In order to collect hydrometeorological data representative of the selected watersheds, the sites were equipped with an automatic weather station (AWS). These systems can measure precipitation, wind speed and direction, solar radiation, atmospheric pressure, and relative humidity. The AWS installation sites were selected such that they were free from any canopy, electricity distribution lines and were in an open space to not obstruct wind, rainfall and, sunlight. Precipitation was measured by a tipping bucket raingauge called ECRN50, the wind was measured using a Davis cup anemometer, ATMOS 14 measured the ambient temperature, vapour pressure, and humidity, while the solar radiation flux was measured using a pyranometer. The preconfigured set of sensors was mounted on a cross arm and attached to a standard pole mast. The mountings were leveled, and the stands are grouted in concrete to firmly secure them to the base. The data logger was also mounted on the pole mast and secured in a metal safety box. All the sensors were connected to respective ports in the data logger which can parse the raw data and store it in usable data formats for analysis. Two AWS systems have been running since August, 2018.

3.4 Primary Data Collected (max 500 words):

Hydro-meteorological Data – Precipitation, humidity, ambient temperature, wind speed and direction, and solar radiation data for the whole project duration has been collected using Automatic Weather Station installed in both pilot locations.

Discharge Data – Spring and streamflow rate/discharge data have been measured using flumes complimented with in-situ water level sensors at sub-hourly frequency. A time-series record has been generated.

Landcover Data – Landcover and land-use pattern for both selected watersheds (Haraita and Shiv gadera).

Seasonal Water consumption pattern – Domestic water consumption data were collected for winter, summer, and monsoon season by household surveys.

Geological Data – Geological Outcrop logs, rock lineaments, dip and strike, and geologic typology was collected using field surveys.

3.5 Details of Field Survey arranged (max 500 words):

Field surveys were conducted initially to inventorize the springs in the selected pilot project districts in Uttarakhand. The selection of sites for instrumentation of both springs and streams was done after a reconnaissance survey. Several factors were considered, such as the criticality of springs in terms of declining discharge and water quality, local community dependence and support, flatter gradients not susceptible to changes, bedrock, sediment deposition, ease of accessibility and installation, and instrument safety. Then a baseline survey was conducted to ascertain the situation and extremity of the situation and then community accord was established for a participatory research approach. The problems were identified based on set of criteria and scientific activities were planned accordingly. The selection of sites representing different land usage and coverage was also taken into account as the data's diversity would aid in proper assessment of the Himalayan hydrology and increase the relevance of the pilot studies. Field hydrogeological surveys were conducted too. Regional geology and stratigraphy were studied on the ground and Toposheets (Survey of India) of the study area were used for plotting the geological data and locating the springs. Field outcrops were studied to gather information about the various rock types and trends of openings which may be in the form of bedding planes, foliation planes, fractures, and faults. The direction and attitude of rock beds and geological structures were measured using a Brunton, which further helped in determining the recharge area of the concerned spring. To identify the underlying geological conditions and to interpret the type of spring or aquifer, spring locations were marked and discharge rate was measured manually. The dip and strike of the rocks and slopes of the given region were measured, the lithological and structural (folds, faults, and fractures) characteristics of the rocks were marked, and oriented photographs and samples were taken. In the pilot study, the rock type identification was followed by the specification of the lithology by image petrology. The rock types were identified by visual methods.

3.6 Strategic Planning for each Activities (max. 1000 words)

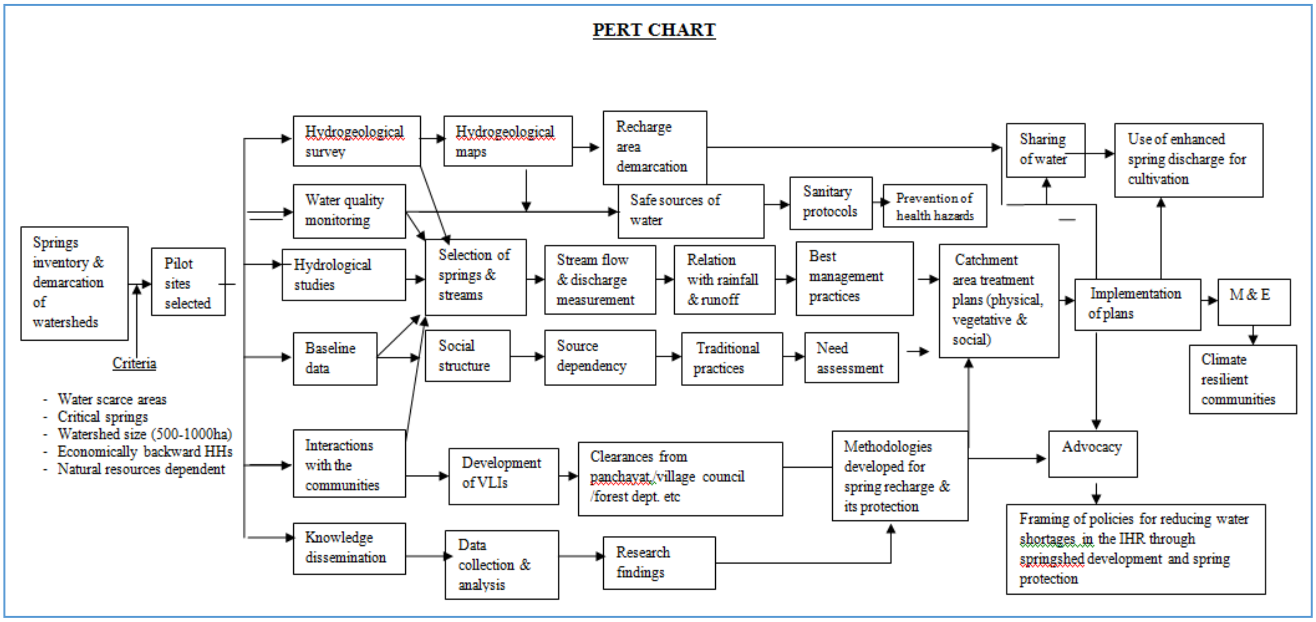
For Hydrological Studies weather parameters recorded by AWS were used for Water Balance (WB) analysis of both selected micro-watersheds. The WB components have been calculated on a daily basis with no irrigation, the water balance equation was realized in the form; $\Delta S = P - ET_{ref} - R$, where ΔS is the change in the soil water storage, P, and R represent precipitation, and runoff, and, ET_{ref} is the reference evapotranspiration for grass surface during the computation period. The WB components were represented as equivalent water depth per unit time. Statistical analysis of the time series was conducted using autocorrelation which is a univariate analysis, performed to assess the linear dependency of spring and stream discharge values on its preceding time series and to have a characterization of the system's memory. The autocorrelation function is obtained by normalizing the covariance of the univariate series. Such an analysis provides insights into the short and long-term influences of an event, as the correlograms describe the response of a system to an event. To analyze the magnitude and time lag of the system's response to a given input, rainfall was cross-correlated with discharge observations, as it would determine the degree of linear interdependence of the rainfall and spring and stream discharge series as a time function. The cross-correlation function is obtained by normalizing the covariance of the bivariate series. Univariate and bivariate analysis (autocorrelation and cross-correlation, respectively) of the discharge- and rainfall- time series is a complementary analytical technique to study the functioning and hydrodynamic behaviour of spring systems. To quantify the effects of individual recession events to indicate the nature of sub-surface processes Master recession curves analysis was conducted, as discrete recession segments of a hydrograph do not provide much information on aquifer systems due to high variability in storage and recharge fluxes. Information on the hydro-geological properties and dynamics of the underlying aquifer systems help in recharge area management. Also, flow duration curves were generated to understand the relationship between the magnitude and frequency of spring and stream flows during our monitoring period. These curves quantify the flow characteristics without considering the sequence of its occurrence and give a frequency distribution of outflows both in time and magnitude. It also provides a feasible platform to compare the flow characteristics of two or more springsheds. A comprehensive graphical view of discharge variability at a particular site can be obtained.

Geological study- post-field work, lithological, and hydro-geological cross-section maps were prepared for better understanding and visualization. Laying out the springshed with its underground structural makeup as conceptual diagrams facilitates a better process understanding of the aquifer mechanisms. Simplified geological maps of the study area were prepared that show the strike and dip direction of dominant lithological strata and the geological cross-section showing rock exposure, potential recharge area, dominant dip direction of bedrock, and set of fractures, and the location of spring outflow point.

Community participation- Local communities were also involved in participatory exercises for assessing the usage of spring water and its recharge area. The historical transect of the concerned springs further helped in understanding the anthropogenic and natural factors leading to the depletion of spring discharge. Resource mapping exercise helped in understanding the land usage and ownership of the recharge area. Awareness campaigns were organized in each village of the concerned micro-watersheds in the form of street plays, puppet shows, and village meetings to generate public interest and support for spring revival. This was followed by the formation of village-level institutions (spring water user groups) and their capacity building for operation and maintenance. The planning for spring treatment was done considering the topography, soil type, land use, and land ownership of the identified recharge area along with the water and biomass needs, in consultation with the local communities. The feasibility of such springshed treatment plans was based on hydro-geological assessments. Household surveys were conducted to understand the seasonal consumption pattern from the springs for the concerned villages and further to compare it with the prescribed norms.

Community participation resulted in their involvement and contribution to spring recharge work, plantation, and also to the solar lift water supply system in Pali village, Pauri Garhwal. The villagers volunteered to become members of the water user groups for the maintenance of springs and their recharge areas.

3.7 Activity wise Time frame followed [using Gantt/ PERT Chart (max. 1000 words)]



4 KEY FINDINGS AND RESULTS

4.1 Major Research Findings (max. 1000 words)-

Geological assessment of pilot sites - The geology of Almora springshed is quartzite, with a strike along N 60˚- 240˚ and towards N 150˚and a dip amount of 20˚. Two major sets of fractures were also reported in the area; trending NE-SW and NW-SE. In the central portion, three other sets of fractures dipping towards NE, SW, and NW with moderate dip amounts ranging from 45˚- 55˚ were observed. The NW trending fracture is observed throughout the mapped area. While for Haraita, the geology analysis concludes that the springs in the Haraita are fractured types. The major fracture sets supporting the groundwater are trending 292/45˚-N22˚E, 050/75˚-N40˚W, and 130/60˚-S40˚W respectively, in hard lithology zones. Hydro-geologically, the region hosts two main aquifer systems. Alluvium aquifer system hosts springs at the base towards west separated by thick Schist and a weathered quartzite intercalated layer while a highly fractured but closely spaced flaky rock system forms the second aquifer system. The area is dominated by Schist of low-grade metamorphism and possesses characteristics such as fine-grained with shiny luster, moderately compact yet highly cleaved in nature. The strike shows undulating nature along NE-SW, and therefore the direction also varies from NW, SW, and W. Towards the north, intercalated quartzite beds trend N70˚-N250˚towards N340˚.

Water Balance - Monthly water balance assessments of both the study sites were conducted and compared. Both micro-watersheds under study exhibited a seasonal monsoon climate with positive water storage mainly during the monsoon season, i.e., from July- September even though the number of rainy days for Shiv gadera was similar to Haraita micro-watersheds (i.e., 156 days and 145 days, respectively), the total rainfall is almost twice, 999879 m^3 in Haraita compared to 583984 m^3 in Shiv gadera. Less rainfall combined with the higher vegetation cover in Shiv gadera micro-watershed also resulted in about a two-times increase in the reference evapotranspiration with an average of 6.28 mm d^{-1} as compared to 2.99 mm d^{-1} in Haraita micro-watershed during the study period. This trend of ET_{ref} has a negative impact on aquifers. Despite receiving ample rainfall compared to the country's average annual rainfall (i.e., 1200 mm), both the micro-watersheds were unable to carry on the above-average water storage conditions. This behavior is due to the prevailing steep terrain, degree of fractures in the underlying aquifer systems, and highly heterogeneous rainfall, more than 60% and more than 70% of which occurred during the three months of monsoon season only. A continuous reduction in storage was also observed for the non-monsoon months in both the experimental sites.

<u>Springflow characterization</u> - Spring discharges from Shiv Dhara are perennial with and an average flow of ≈ 50 lpm, while the spring flows in Haraita micro-watershed show intermittent flow behavior, thus characterizing the primary hydro-geological features of the underlying aquifers. The hydrograph responses indicated that both the springshed systems are highly controlled by precipitation input and the permeability matrix of the aquifer. Shiv gadera has better storage capacity and homogeneity as the hydrograph responses show a persistent and gradual increase and decrease as compared to the hydrograph of Haraita springs. Gradual terrain slope and homogenous underlying geology play a key role in maintaining a perennial continuum of Shiv Dhara spring. While it was observed in the case of Nauli Dhara spring (Haraita) that pressure propagation through large fractures and conduits triggers an initial response to the increase in discharge and it is not the outflow of the newly infiltrated water after the rain events. Such reactions are characteristic of transmissive fracture rock. After the flow rate stabilizes the discharge then starts rising gradually as a response to the rainfall events. But analysis of spring discharge of Bichola pani (Haraita) shows that the spring is drained through a well-developed network of fractures and conduits and hence it takes a longer time to dissipate the initial response, and it stabilizes after 40 days of Nauli Dhara attaining stability, responding to the same rainfall events. A sharply peaked hydrograph is observed for Haraita spring indicating high fractures and impermeable strata as such hydrograph signatures are characteristic of small storage and rapid discharge, whereas the Shiv Dhara spring exhibits a comparatively flatter, wider, and delayed response.

<u>Statistical analysis of flows</u> –Univariate and bivariate analysis were employed (autocorrelation and cross-correlation, respectively) of the discharge- and rainfall- time series to find out the linear dependency of spring and stream discharge values on its preceding time series and to characterize the system's memory. It serves as a complementary analytical technique to study the functioning and hydrodynamic behavior of spring systems. The auto-correlation for the discharge of both Shiv Dhara and Shiv gadera diminishes very slowly (damped with prolonged memory effect) during the entire 120 days of time lag. This damped response is potentially explained by a larger storage capacity within the Shiv gadera micro-watershed. The aquifer has stored water and contributes to stream and spring continually for a prolonged

period. In contrast, for Haraita springs, there is a sharp decline in the auto-correlogram during the initial 50 to 70 lag days, thus showing less memory effect as compared to Shiv gadera. A shorter memory effect in the Haraita micro-watershed is an indication that the discharge is an independent variable exhibiting quasi-randomness. The ACF declines slowly with a higher memory effect for Shiv gadera, indicating a larger storage capacity of the underlying aquifer than Haraita. A gradually decreasing trend in auto-correlogram indicates the presence of small fissures through which water flows at much lower velocities, as exhibited by Shiv gadera, Almora. In contrast, a well-developed fracture system has little memory and the response decreases steeply and quickly, as shown by Haraita, Pauri Garhwal. An asymmetrical cross-correlation function indicates a high dependency of the springshed systems' output (i.e., discharge) on system input (i.e., rainfall) for both the study sites. A gradual decrease in cross-correlation function for Shiv gadera as compared to Haraita represents a slower emptying rate of the aquifer and hence a large storage capacity regulating the input flow and propounds the idea that the aquifer storage of Haraita is unable to attenuate the flood pulse of the storm event to the same extent as in Shiv gadera. Shiv gadera, amplification in signals can be seen when there is a delay in spring flow due to the release of stored water It also indicates the large. storage capacity of the aquifer and this high storage potential can be explained by the presence of minute fissures that store water and release gradually post-peak flows when highly transmissive channels are de-saturated.

Spring water quality - During the study period, seasonal water quality monitoring was conducted. Samples were collected in pre-washed plastic bottles from selected springs of Pauri and Almora districts. Physical parameters such as pH and TDS and chemical analysis like alkalinity were analyzed at the sampling site. Biological parameters - total coliform and fecal coliform were also analyzed. The rest of the Physico-chemical parameters - turbidity, total hardness, calcium, magnesium, sulphate, nitrate, Iron, sodium, and potassium were analyzed in PSI's Laboratory as per the APHA standard methods (APHA AWWA WEF-2012). The Bureau of Indian Standards (BIS 10500:2012) was followed for assessing the water quality. The observed results of the complete study reveal that most of the spring sources of Pauri and Almora are contaminated by fecal coliform bacteria. The possible reasons for contamination could be human and animal excreta which come through human habitation in the recharge area and by penetration or leaching through the soil to the water sources. Iron concentration was higher than the prescribed standard limit of 0.3 mg/l in most of the springs of Almora and some of the springs of Pauri. The rest of the parameters such as turbidity, total hardness, calcium, magnesium, iron, nitrate, fluoride, sulphate, sodium, potassium, chloride, and fluoride were well within the standard limits (BIS 10500:2012) in all seasons.

4.2 Key Results (max 1000 words in bullets covering all activities)

- In both the micro-watersheds – Shiv gadera and Haraita, the intensity and duration of rainfall have a strong influence on spring discharge. However, the variations in spring response can be attributed to differences in the type of springs, geology, terrain slope, and land-use patterns. A continuum of rainfall-runoff responses was observed at both sites.

- Shiv gadera is characteristic of predictable flow responses, homogeneous geology and indicates a distinctive feed from the recharge area. In contrast, Haraita exhibits variable flow dynamics and a complex spatial extent of recharge area feed, thus highlighting the need for the adaptation of the site-specific springshed management practices.
- The presence of intricate flow networks and low flow velocities aid in aquifer storage in Shiv gadera, and strong peaks in the hydrograph in Haraita indicate the presence of a well-developed fracture system. So, treatment measures must consider the geology and terrain characteristics.
- Gradual FDC of spring and stream flows for Shiv gadera indicates perennial flow, whereas Haraita springshed exhibits intermittent to ephemeral flows. These variable behaviors indicate how local water management and user groups can formulate management plans and regulatory protocols.
- The FDC results suggest more groundwater contribution to springs discharge in Shiv gadera compared to Haraita. Hence, we infer that better and sustained spring discharge can be achieved by employing the recharge intervention measures in Shiv gadera.
- Slow emptying of the aquifer can be inferred from gradual and prolonged damping of lag responses in Shiv gadera. In contrast, an asymmetrical cross-correlation indicates variability in flow responses and complex spring dynamics. Hence springshed treatment should be based on the storage potential and transmissive nature of the springshed.
- Community participation can play a crucial role in the equitable and sustainable use of water as well as in recharge area protection by planning and implementing sanitary protocols.

4.3 Conclusion of the study (maximum 500 words in bullets)

- Our focus was to assess the potential of reviving drying springs with the help of hydro-geological studies in water-scarce villages. The project findings so far highlight that assessing and understanding the underlying geology and hydrological processes of Himalayan springs is of paramount significance to scientifically plan for their rejuvenation for addressing growing water security concerns.
- The methodology involved high-resolution data monitoring of springs and first-order streams in two headwater micro-watersheds, namely, Shiv gadera and Haraita, in the rural Himalayas of Uttarakhand, India, with unalike topography and geology.
- To understand the hydro-geological processes and assess the flow regimes and aquifer storage dynamics, water balance, correlation, flow duration, master recession curves analysis, and geological studies were used.

- The univariate and bivariate analysis showed that Shiv gadera has a better system memory, indicating a larger storage capacity than Haraita.
- The spring hydrograph responses suggested Shiv gadera to have a better storage and a homogenous aquifer feed.
- The water balance, however, was found to have positive storage only during the rainy months in both the sites.
- The hydro-geological characterization from hydrograph analysis, recession analysis, and field surveys showed that Shiv gadera has intricate flow networks and slow flow velocities while Haraita is characteristic of transmissive fractured rocks.
- The spring flows in Shiv gadera were observed to be perennial and that more groundwater contributes to spring discharges while Haraita exhibits intermittent to ephemeral nature.
- The recession curves also indicated uniform geology, a distinctive feed from recharge area, and slow emptying of the aquifer, while Haraita exhibited shallow storage and quick responses to storms.
- Spring flows in Shiv gadera showed better stability than Haraita, as indicated by Q_{10}/Q_{90} and Q_{50}/Q_{90} measurements.
- These inferences qualify Shiv gadera as having a better chance of responding to management and treatments, thus a better potential for revival.
- The combination of hydrologic time series analysis and geological characterization used in this study could be a valuable approach for assessing spring revival in the IHR and has a potential for implementation across other parts of the Himalayas.

4.4 Conclusion of the study (maximum 500 words in bullets)

- Community participation is a must for attaining water security and for decentralized governance.
- Preparing the inventory of springs helped to identify critical springs for rejuvenation on a priority basis.

The project work also indicated some critical aspects of spring rejuvenation:

- Spring type identification and potential recharge area mapping, based on hydro-geological studies
- Understanding of aquifer characteristics and water quality aspects for sustainable springshed management
- Need for the extensive demystification of hydro-geological knowledge for community awareness and participation.
- The necessity of policy reforms and institutional support.
- Experiences in springshed management to be shared on state and national level platforms for policy dialogue towards enhanced uptake, upscale,, and replication purposes.

- A successful methodology that can guide replication and upscale of the springshed development model to other areas, also by studying the lessons from the pilot projects in Almora and Pauri Garhwal districts of Uttarakhand.
- Participatory approach should be mainstreamed for long-term sustainability. The local communities were involved in planning, implementation of recharge measures, monitoring, and management of the facilities developed.

5 OVERALL ACHIEVEMENTS

5.1 Achievement on Project Objectives [Defining contribution of deliverables in overall Mission (max. 1000 words)]

Objective	Overall Achievement
Inventorization of 300 springs - 50 springs/district x 6 districts	1. Watersheds delineated in all the 6 districts. 2. Inventory of 300 springs. 3. Geological mapping completed for all the 6 sites. 4. PRA exercise completed in all the 6 sites. 5. *Sandesh yatra*, community mobilization, and formation of VLIs completed for the pilot site (Uttarakhand). 6. Planning process, trainings, field facilitation completed with the POs in Nagaland & Arunachal Pradesh.
Piloting community based regeneration of 12 springs in the selected watersheds in Uttarakhand	1. Springs and first order streams delineated for hydrological monitoring in Almora & Pauri Garhwal. 2. Installation of instruments (AWS, water level recorder, flumes, flow probe, EC meter, rain gauges) for hydrological monitoring. 3. 6 critical springs in Almora and 7 critical springs in Pauri Garhwal districts have been treated. 4. Estimation of water demand and supply gap completed. Watershed level WSPs were prepared for one watershed each in Uttarakhand, Arunachal Pradesh, and Nagaland.
Evolving state level policy recommendations for conservation and sustainable use of groundwater resources	1. Design and estimates prepared for water management practices for micro-watersheds of Almora and Pauri Garhwal, Uttarakhand. 2. Best management practices implemented for micro-watershed of Pauri Garhwal, Uttarakhand 1. SSD program ongoing with Forest Department of Uttarakhand, Rural Development Department of Nagaland, and PHED Department of Arunachal Pradesh

	2. Discussions with FD, SWCD & NABARD for SSD in Papum-Poma river of Arunachal Pradesh. 3. Shared experiences on SSD for the National Water Policy and NMSHE.
Knowledge dissemination and communication	1. Capacity building of forest rangers and Van Panchayat members for springshed development initiated in Uttarakhand. 2. Training of WWF-India (AP) & LRD (Nagaland) in preparation of spring inventory by PSI. 3. Training of PSI staff and communities in hydrological monitoring by IITR. 4. Training of program staff under MBMA's CLLMP program for Meghalaya supported by the World bank. Virtual training was provided to 89 MTs in July-August, 2020. 5. Research papers and case studies as mentioned on pages 6-7.

5.2 Establishing New Database/Appending new data over the Baseline Data

- High-frequency spring discharge data (15-minute resolution)
- High-frequency stream discharge data (15-minute resolution)
- Weather Station dataset (Precipitation, Humidity, Ambient temperature, Wind speed and direction, solar radiation at 30-minute resolution)
- Daily Potential Evapotranspiration data for two micro-watersheds (Almora and Pauri districts)
- Database of Master recession hydrographs for spring and streams of two micro-watersheds (2 streams and 4 springs)
- Frequency distributed dataset for flows in both the micro-watersheds.

S. No.	New Data Details	Status of Existing Baseline	Additionality and Utilisation New data
	Geotagged inventory of 300 springs	Details fed into the spring inventory format	MIS prepared using the new GIS coordinates; other organizations in the region are using the information generated data. Academic and research institutions like Amity University, ICIMOD, ACWADAM, Srinagar University, and others are using the inventory to scale up the work.

	Water quality of 300 springs	The existing baseline had 3 parameters – PH, TDS and qualitative Fecal Coliform.	15 additional parameters (TSS, EC, Turbidity, TA, TH, Ca Hardness, Chloride, Calcium, Magnesium, Fluoride, Sodium, Potassium, Nitrate, Sulphate, Iron and quantitative assessment of FC) helped to identify the geological contamination and to understand the hydrochemistry of springs.
	Discharge and rainfall data collected through instruments	The existing baseline had manually collected rainfall and discharge data.	High-resolution data collected through instruments were utilized for hydrological assessment and research purposes.
	Spring treatment plans prepared for the revival of critical springs in the pilot sites Almora and Pauri Garhwal in Uttarakhand.		

5.3 Generating Model Predictions for different variables (if any) (max 1000 words in bullets points

- Predictions of the underlying aquifer storage potential, wherein the Shiv gadera (Almora) pilot site exhibited higher capacity than Haraita (Pauri) experimental site.
- Predictions of the flow regimes in Shiv gadera which was found to be more influenced by the underlying geology and slow flow pathways in the rock matrix.
- An increased memory effect in Shiv gadera, was predicted, which indicates that the underlying aquifer system is influenced by an event for a longer duration implying that the system has more storativity.
- The Haraita micro-watershed was predicted to have more developed fractures and a widespread network of flow paths and conduits that indicated a poorly drained network of conduits.
- Recession modelling predicted shallow storage that quickly responds to storm events
- Model predictions suggest that Haraita springs aquifer feeding mechanism is complex and induced by a combination of pores, micro-fractures, and conduits.
- Predictions from the shape of the MRC indicate conditions of short residence time in the aquifer of Haraita.

5.4 Technological Intervention (max 1000 words)

In this project a combination of high-resolution hydrologic and hydro-meteorological time series analysis complemented with geological characterization was employed to assess the spring flows and characterize the spring aquifers in the rural Himalayas of India. This situational analysis was done prior to physical interventions to ascertain the potential of revival or rejuvenation of the springs. This approach helped design treatment protocols specific to the site. Two pilot sites were instrumented for the experimental study and geological investigations to understand the underlain hydro-geological process. Both these sites were instrumented with automatic weather stations to monitor the hydrometer parameters at a finer scale. The springs were instrumented with HS flumes which are designed flow channels that help calculate the discharge flowing through it. To aid spring discharge monitoring, capacitance-based water level sensors were attached along with the flume. These water level sensors are capable of sensing stage levels every 15 minutes. They are easy to use, handle and maintain, while calibration is required on-site periodically. Similarly, streams were instrumented with Parshall flumes and water level sensors.

5.5 On field Demonstration and Value-addition of Products (max. 1000 words, in bullet points);

A value-added activity is any action taken that increases the benefit of an activity carried out. In this project, springs were revived which increased the availability of water. As a soil and water conservation measure, trenches and recharge pits were dug and plantation was carried out in the spring recharge area. Most of these were fodder and fruit varieties of plants. Their real value will emerge when these trees will start bearing fruits. A few households are using the surplus water for minor irrigation. Physical measures (digging and desiltation of trenches) created temporary employment opportunities for the villagers. Besides, the increased water availability saved the time of women to collect water. As per the impact assessment survey of 60 women conducted by PSI in Almora and Pauri project sites, 46% of surveyed women are involved in reproductive work, 4% in productive work, and 50% in both kinds of activities.

5.6 Promoting Entrepreneurship in IHR

Entrepreneurship was not developed as such but a cadre of trained para-workers skilled in measuring spring discharge, rainfall, and water quality has been developed. With these skills, they would be able to work on their own for village development or even work for some other organization.

5.7 Developing Green Skills in IHR

Sustainable management and the use of ecosystem services from IHR presents huge opportunities for creating employment and supporting entrepreneurship. The soft green skills would help to understand these changes and develop an economically and environmentally sound mountain ecosystem, which would improve the living standards of mountain populations as well as sustain the flow of vital ecosystem services. Green skills are the knowledge, abilities, values, and attitudes needed to live in, develop and support a sustainable and resource-efficient society.

Through this project we have been able to develop the following activities that are especially important for green occupations:

- **Technical skills:** These are hard skills encompassing competencies involved with the layout, design, and construction of trenches, gabions, and water tanks.
- **Science skills:** Demystification of the science of hydrogeology, recharge area, groundwater aquifer, spring recharge, and water quality to the communities. These skills are in high demand in the IHR owing to the need for replication of this work for water security.
- **Operation management skills:** Know-how related to managing the water user Samiti's work, collecting monthly contributions, managing the bank account, and implementing sanitary protocols. These skills help to build up local governance.
- **Monitoring skills:** These skills are required to measure the spring discharge, rainfall, and water quality on a regular basis and take timely necessary actions.
- In addition to these skills, a range of soft skills like adaptability to the changing climate, community mobilization, work presentation, organizing meetings, and handling disputes have also been developed.

5.8 Addressing Cross-cutting Issues (max. 500 words, in bullet points)

The cross-cutting issues being considered are climate change, gender equity and communication. The programme especially focused upon pilots on community-based springshed development as a way of climate change adaptation. The predominant sources of water in the selected headwater watersheds are natural springs and streams. However, the sources of water are either drying up or becoming seasonal.

- Springshed development through rainwater harvesting structures in the recharge area, plantation and surface runoff barriers can help enhance rainfall infiltration into the ground, recharge springs and enhance base flows in the streams and rivers. As mentioned earlier, springshed treatment plans will be prepared for the selected watersheds in 6 districts (2 each in Nagaland, Uttarakhnad, and Arunachal Pradesh).
- The targets will be achieved by involving the communities from the planning stage itself in understanding the water issues, the importance of springs, and in developing and implementing the plans, followed by equitable and sustainable use of the enhanced spring discharge for obtaining

water security. Since women are the principal carriers of water from the springs and their further usage, they would be involved in the programme right from the planning stage. It will be ensured that they actively participate in drafting the local water rights and establishing benefit-sharing mechanisms. The springshed development activities are thus likely to empower the women as well as reduce their time fetching water. Improved drinking water quality will ensure the better health of the people.

- Communication and participation can serve as multipliers across groups and through time it can increase the efficacy and impact of the programme. Communication is a critical tool for reducing vulnerability and enhancing stakeholders' involvement and public participation. Having access to information about climate impacts on springs, vulnerability, and best management practices is a prerequisite to improving the existing conditions. These issues will be taken care of by regular field visits to increase our interaction with the communities, involvement of local community workers who can understand and speak the local languages, and use of IEC material. Relevant information would be made available in the public domain. A workshop at the end of the programme period is proposed to advocate state-level programme on springshed development.

6 PROJECT'S IMPACTS IN IHR

6.1 Socio-Economic Development – There has been a positive impact on socio-economic development, particularly among women. As per a survey conducted by PSI to understand the impact of spring rejuvenation work on women in five districts - Nainital, Pauri, Dehradun, Pithoragarh, Almora, of Uttrakhand across 24 villages, spring rejuvenation work has brought a huge impact on the self-esteem of the women. Overall, 34% have stated an increase in self-esteem in the form of an increase in self-confidence at both family and community levels and overall, 60% of women are now involved in community mobilisation activities due to an increase in confidence.

Similarly, 46% of surveyed women are involved in reproductive work (stitching, pickle making), 4% in productive work (increase in family time, focus on children), and 50% in both activities.

6.2 **Scientific Management of Natural Resources In IHR -** Hydrogeology-based revival of springs; and plantation work in the spring recharge area, particularly native varieties and fodder plants; sustainable agriculture practices; community involvement for its management; interventions based on topography and needs of the community; cluster approach for spring rejuvenation will lead to better management of the natural resources.

6.3 **Conservation of Biodiversity in IHR -** Riparian vegetation is known to be particularly valuable for native biota. Plantation work carried out in the spring recharge areas not only helps in soil and water conservation but also provides habitat to wildlife, birds, and insects thus increasing biodiversity.

6.4 **Protection of Environment–** Soil and water conservation measures help in preventing soil erosion, enhancing groundwater, and increasing soil moisture. Regular monitoring of water quality and implementation of sanitary protocols further help in the overall protection of the environment.

6.5 Developing Mountain Infrastructures– Solar water lift scheme and supply system (constructed in Pali village, Pauri Garhwal), construction of water tanks, gabions in Uttarakhand and Arunachal Pradesh, installation of automatic weather stations in Uttarakhand and Nagaland are the infrastructure developed under this project which is an asset to the villages where they have been constructed.

6.6 Strengthening Networking in IHR: A number of regional, state level and national workshops were organized (details on p.). Training and orientation workshops were organized for the project partners and government officials from various departments. The findings were shared in different workshops/platforms. This helped in strengthening networking in the IHR.

7. EXIT STRATEGY AND SUSTAINABILITY –

A gradual withdrawal strategy was planned. Strengthening and capacity building proved to be an effective strategy. Therefore, the exit strategy included building the capacities of the POs, VLIs, and the communities, supervising their functioning, and assisting them wherever there are any shortfalls.

7.2 How effectively the project findings could be utilized for the sustainable development of IHR (max. 1000 words)

The project findings are crucial for managing and sustainably developing the Indian Himalayan region by means of the conceptual framework established. Integrating spring instrumentation hydrology and hydro-geological studies, the conceptual idea can be scaled to a methodological approach. After establishing a community accord, the problems are to be identified. After which future scientific activities can be planned. The idea is an assessment of the springshed before we rope in the interventions and treatment. The various components for the springshed assessment culminate into its situational analysis and site-specific adaptations. Ultimately translating focus into key areas like water security, socio-hydrology, and even policy and decision making. From the project, it can be ascertained that a high-resolution scientific dataset aids in discerning a lot about the flow processes and the complex interactions that occur in the watershed. This analysis helped us decipher site-specific issues and bottlenecks that help plan the development of the region efficiently rather than implementing an umbrella approach to the whole of IHR. This approach could be useful for assessing the spring revival potential in the IHR and making informed springshed management decisions. The approach can also be implemented across other parts of the Himalayas.

7.3 Efficient ways to replicate the outcomes of the project in other parts of IHR (Max 1000 words)

To replicate the outcomes of the project in other parts of the IHR, firstly a comprehensive inventory and problem identification must be completed. For the particular region or project site, community participation is a must hence efforts must be laid to establish community support prior to the implementation. Once that phase is successfully completed a meticulous spring/ stream or watershed instrumentation must be carried out based on the specific problems encountered/ identified. The instrumentation be it for monitoring quality or quantity must be able to collect a high-frequency dataset. These high-frequency datasets upon cleaning and processing may reveal innate and complex response patterns that shall provide in-depth knowledge of the processes underlain. These instrumentation systems must be monitored and maintained regularly for efficient data collection. Regular field visits shall enable stakeholders to monitor and ascertain any problems related to instrumentation and resolve it quickly. Regular data collection and processing is the key to replicating the outcomes efficiently.

7.4 Identify other important areas not covered under this study needs further attention (max 1000 words)

- This study can be further complemented with isotopic studies to understand the origin and residence of groundwater, electromagnetic sounding like Ground Penetrating Radar (GPR), and Electrical resistivity imaging to determine the thickness and lithologic horizons of geologic media.
- Study of aquifer property characterization and aquifer mapping for the springs.
- Hydro metrological data-based water budgeting for the watersheds of Arunachal Pradesh and Nagaland to achieve water security.
- Long-term monitoring and hydro metrological data collection in the watersheds of Uttarakhand, Arunachal Pradesh, and Nagaland.
- Carrying capacity of springs for sustaining water supply and ecosystem services.
- Study of climate vulnerability of springs.
- Detailed study of bacteriological contamination of springs.

7.5 Major recommendations for sustaining the outcome of the projects in future (500 words in bullets)

- Identification and inventorization of spring typology and potential recharge area mapping, based on hydro-geological studies and high–resolution time series analysis.
- Demystification of hydro-geological knowledge for community awareness and to garner community participation for bolstering the sustainability of the program design.

- Achieve active participation of the community at all stages to enhance the long-term efficacy of treatment measures.
- Assessment of socio-cultural capabilities of the communities and leverage science as well as local knowledge in program design.
- Train and empower groups/individuals in data collection, monitoring, and local governance of the spring systems.

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9. ACKNOWLEDGEMENT

The People's Science Institute (PSI), Dehradun would like to sincerely thank the Ministry of Environment, Forest & Climate Change (MoEF&CC) for proving us an opportunity to work under the National Mission on Himalayan Studies for the project titled "Water Security through Community Based Springshed Development in the IHR". We would like to express our deep gratitude to Er Kireet Kumar, Scientist-G, Nodal Officer, and staff of NMHS-PMU, G.B. Pant National Institute of Himalayan Environment (NIHE), Almora for their constant support and for providing proper guidelines throughout the study period. We also place on record our sincere thanks to external quality teams/ peer-reviewed members without whose active support, an output of this quality would not have been possible.

The contribution of Dr. Sumit Sen Associate Professor, Department of Hydrology Head, Centre of Excellence in Disaster Mitigation and Management Indian Institute of Technology Roorkee, and his team for carrying out the hydrological studies under this project is thankfully acknowledged.

Our sincere thanks to Mr. Albert Ngullie, LRD-Nagaland, Mr. Suresh Babu S.V. – WWF India Director Rivers, Wetlands & Water Policy, and their teams for working in Nagaland and Arunachal Pradesh under this project. Our thanks to Ms. Jayamala V. Subramaniam, CEO – Arghyam for being a part of this project.

This project's success totally depends on the local communities and authorities in the project villages. We also extend our gratitude to the women participants from these villages who enthusiastically participated in all the activities.

APPENDICES

Annexure I – Consolidated and Audited Utilization Certificate (UC) and Statement of Expenditure (SE)

Appendix II – Consolidated Interest Earned Certificate

Appendix III – Consolidated Assets Certificate

Appendix IV – List or Inventory of Assets/ Equipment/ Peripherals

Appendix V –Transfer of Permanent Equipment purchased under Research Project titled "Water security through community-based springshed development in the IHR" funded under the NMHS Scheme of MoEF&CC – reg.

Appendix VI – Declaration

Appendix VII – Site location Maps and Photos

Appendix VIII – List of 13 Springs

Appendix IX – Details of springs with instrumentation

Appendix X– Water Security Plans (6) – attached as **zip folder**.

Appendix XI– Hydrological modelling

Appendix XII– Seasonal domestic water consumption pattern in the selected villages of Almora and Pauri Garhwal

Appendix XIII– An inventory of 300 springs for six districts - Almora, Pauri-Uttarakhand, Phek, Zunheboto-Nagaland, and Tawang, West Kameng-Arunachal Pradesh is attached as a **zip folder**. (Annexure-7). KML file has also been provided for GIS based MIS of springs.

Appendix XIVa - Spring Hydrographs - Pre & Post Treatment (Almora)

Appendix XIVb - Spring Hydrographs - Pre & Post Treatment (Pauri Garhwal)

Appendix XIVc - Spring Hydrographs based on data collected through instruments

Appendix XV - All the knowledge products and publications mentioned under Section 11 in the report are mentioned on Page 94 and attached as a **zip folder**.

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Consolidated and Audited
Utilization Certificate (UC) and Statement of Expenditure (SE)

For the Period: 01st Jan 2018 to 30th Sep 2021

1	Title of the project/Scheme/Programme:	Water Security through community Based Spring shed Development in the IHR
2	Name of the Principle Investigator & Organization:	Dr.Debashish Sen, People's Science Institute
3	NMHS-PMU, G.B. Pant National Institute of Himalayan Environment, Kosi-Katarmal, Almora, Uttarakhand Letter No. and Sanction Date of the Project:	Letter No. NMHS-2017/MG-03/479 Dated-22.12.2017
4	Amount received from NMHS-PMU, G.B. Pant National Institute of Himalayan Environment, Kosi-Katarmal, Almora, Uttarakhand during the project period (Please give number and dates of Sanction Letter showing the amount paid):	Rs.187,75,951.00 Ist Installment -10.01.2018-Rs.77,45,800.00 IInd Installment-23.09.2019-Rs. 52,04,713.00 & Accrued interest-Rs.2,20,087.00 IIIrd Installment-29.09.2019-Rs.56,05,351.00
5	Total amount that was available for expenditure (Including commitments) incurred during the project period:	Rs.187,75,951.00
6	Actual expenditure (excluding commitments) incurred during the project period:	Rs.188,00,076.00
7	Unspent Balance amount refunded, if any (Please give details of Cheque no. etc.):	Rs.133,649.00 (UTR NO-UTGBH22088368526)-dtd.28.03.2022
8	Balance amount available at the end of the project:	(-Rs.24,125.00)
9	Balance Amount:Inculding accured bank interest (-)	Rs.1,33,649.00
10	Accrued bank Interest:	Rs.1,57,774.00

Certified that the expenditure of Rs.1,88,00,076/- (Rupees. One Crore Eighty Eight Lakh Seventy Six Only) mentioned against Sr. No. 6 was actually incurred on the project/scheme for the purpose it was sanctioned.

For Peoples Science Instiute

[Stamp: PEOPLE'S SCIENCE INSTITUTE, ITBP ROAD, P.O. KANWALI, DEHRADUN]

Dr.Debashish Sen
Director
Date: Thursday, 14 April, 2022
Places: Dehradun

For Sachin Rastogi & Co

[Stamp: SACHIN RASTOGI & Co. CHARTERED ACCOUNTANTS, CA, 402915, DEHRADUN]

CA.Sachin Rastogi
M.No. 402915
FRN No.012311C

UDIN: 22402915AHBFGA2319

Statement of Consolidated Expenditure-

EXPENDITURE STATEMENT
NATIONAL MISSION ON HIMALAYAN STUDIES

Statement showing the expenditure of the period from 01st Jan 2018 to 30th Sep 2021

Sanction No.NMHS-2017/MG-03/479 & Date: 02 Jan 2018

1. Total outlay of the project	Rs.1,95,24,480.00 (Including additional amount of Rs.4,30,560/- approved vide letter dated.28.09.2021)
2. Date of Start of the Project	01st Jan 2018
3. Duration	45 Months (Including extendion of 9 months by letter dated.23.12.2020).
4. Date of Completion	30th Sep 2021
a) Amount received during Jan 18 to Sep 21 (Including bank interest)	Rs. 1,89,33,725.00
b) Unspent amount carried forward from pervious : Quarter	Rs.00
c) Total amount available for Expenditure (a+b)	Rs. 1,89,33,725.00

S.No.	Budget head	Amount Received	Expenditure	Amount balance/ excess expenditure
1	Salary	61,61,648	63,73,432	-2,11,784
2	Travel	22,36,449	19,28,421	3,08,028
3	Expendables /Consumables	3,56,962	2,97,369	59,593
4	Activities & other project cost	76,66,892	78,23,479	-1,56,587
5	Institutional Charges	4,50,000	5,00,027	-50,027
6	Equipments	19,04,000	18,77,348	26,652
		-		
7	**Total**	**1,87,75,951**	**1,88,00,076**	**-24,125**
8	Accrued Bank Interest	1,57,774		1,57,774
9	**Total (7+8)**	**1,89,33,725**	**1,88,00,076**	**1,33,649**
10	Amount allowed to be carried forward to the next quarter	-		

Note: An additional amount of Rs.4,30,560/- was approved under the salary head vide letter dated 28.09.2021

Certified that the expenditure of Rs.1,88,00,076/-(Rupees: One Crore Eighty Eight Lakh Seventy Six Only) mentioned against Sr, no.7 was actually incurred on the project/ scheme for the purpose it was sanctioned.

For Peoples Science Institute

[Stamp: PEOPLE'S SCIENCE INSTITUTE, ITBP ROAD P.O. KANWALI, DEHRADUN]

Dr.Debashish Sen
(Director)
Date **Thursday, 14 April, 2022**
Place **Dehradun**

For Sachin Rastogi & Co

[Stamp: SACHIN RASTOGI & Co., CHARTERED ACCOUNTANTS, 402915, DEHRADUN]

CA.Sachin Rastogi
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PEOPLE'S SCIENCE INSTITUTE
PSI

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Annexure-II

Consolidated Interest Earned Certificate

This is to confirm that interest of Rs.3,77,861/-has been earned in the project titled "**Water security through community-based Springshed development in the IHR".** Year wise details of bank interest received are:-

(All amount are in Rupees)

FY	PSI	LRD	WWF	IIT Roorkee	Total interest
2017-2018	53,491.00	-	-	-	53,491.00
2018-2019	1,64,674.00	-	-	1,922.00	1,66,596.00
2019-2020	99,352.00	19,037.00	4,052.00	-	1,22,441.00
2020-2021	30,372.00	457.00	-	2,927.00	33,756.00
2021-2022 (Till Sep 21)	1577.00	-	-	-	1577.00
Total	**3,49,466.00**	**19,494.00**	**4,052.00**	**4,849.00**	**3,77,861.00**

Land Resource Department Nagaland (LRD), WWF India, IIT Roorkee are project partners.

For Peoples Science Institute

Dr. Debashish Sen
Director
Date: 13th April 2022
Place: Dehradun

PEOPLE'S SCIENCE INSTITUTE ITBP ROAD P.O. KANWALI DEHRADUN

Annexure-III

Consolidated Assets Certificate

Assets Acquired Wholly/ Substantially out of Government Grants

(Register to be maintained by Grantee Institution)

Name of the Sanctioning Authority: G.B.Pant National Institute of Himalayan Environment and Sustainable Development (GBPNIHESD), Kosi - katarmal ,Almora Uttarkhand.

Consolidated Asset Certificate

Sl.No	Name of Grantee Institution	No. & Date of sanction order	Amount of the Sanctioned Grant	Brief Purpose of the Grant	Whether any condition regarding the right of ownership of Govt. in the property or other assets acquired out of the grant was incorporated in the grant-in-aid Sanction Order	Particulars of assets actually credited or acquired	Value of Assets as on	Purpose for which utilized at present	Encumbered or not	Reasons, if encumbered	Disposed of or not	Reasons and authority, if any, for disposal	Amount realised on disposal	Any Other Remarks
1	Peoples Science Institute	NMHS-2017/MG-03/479 dated 22-12-2017	19,04,000	For project acitivities Water Security through Community Based Springshed Development in the IHR	No	Brunton Compass	3068	Geological Mapping (Dip & Strike measurement)	No	-	-	-	-	-
2	Peoples Science Institute				No	Geological hammer -Small	4720	Geological Mapping	No	-	-	-	-	-
3	Peoples Science Institute				No	Geological hammer-Big	4956	Geological Mapping	No	-	-	-	-	-
4	Peoples Science Institute				No	Garmin GPS		GPS Co-rdinates (Latitude & Longitude)	No	-	-	-	-	-
5	Peoples Science Institute				No	Sony DSC Camera-		Photographic Documentation	No	-	-	-	-	-
6	Peoples Science Institute				No	Parshal Flumes		Real Time Spring Discharge Measurement	No	-	-	-	-	-
7	Peoples Science Institute				No	HS Flumes		Real Time Spring Discharge Measurement	No	-	-	-	-	-
8	Peoples Science Institute				No	Rain Gauge	4720	Rainfall Measurement	No	-	-	-	-	-

9	Peoples Science Institute				No	Water Level Recorder		Water Level measurement	No	-	-	-	-	-
10	Peoples Science Institute				No	Evaporation PAN		Evaporation Measurement Pan	No	-	-	-	-	-
11	Peoples Science Institute				No	Automatic Weather Station		Meteriological Monitoring	No	-	-	-	-	-
12	Peoples Science Institute				No	Data Logger		Meteriological Monitoring	No	-	-	-	-	-
13	Peoples Science Institute				No	Brunton Compass	1711	Geological Mapping (Dip & Strike measurement)	No	-	-	-	-	-
14	Peoples Science Institute				No	Brunton Compass	1888	Geological Mapping (Dip & Strike measurement)	No	-	-	-	-	-
15	Peoples Science Institute				No	Asus Vivobook laptop		admin work	No	-	-	-	-	-
16	Peoples Science Institute				No	Dell Inspiration Notebook Laptop		admin work	No	-	-	-	-	-
17	Peoples Science Institute				No	Software - Automatic weather station		Meteriological Monitoring	No	-	-	-	-	-
18	Peoples Science Institute				No				No	-	-	-	-	-
19	Peoples Science Institute				No	Solar power Automatic weather		Meteriological Monitoring	No	-	-	-	-	-
20	Peoples Science Institute				No	Global Water Flow probe		Real time discharge measurement	No	-	-	-	-	-
21	Peoples Science Institute				No	Portable EC and temp meter		Water quality tester (pocket)	No	-	-	-	-	-
22	Peoples Science Institute				No	Hobo Conductivity Logger		Real Time Water Quality Tester	No	-	-	-	-	-
23	Peoples Science Institute				No	Hobo Optic base station			No	-	-	-	-	-
24	Peoples Science Institute				No	Hobo proware software			No	-	-	-	-	-
25	Peoples Science Institute				No	Rain Gauge with logger		Real time rainfall measurement	No	-	-	-	-	-
26	Peoples Science Institute				No	Ordinary rain gauge	5192	Rainfall Measurement	No	-	-	-	-	-
27	Peoples Science Institute				No	Ordinary rain gauge	5192	Rainfall Measurement	No	-	-	-	-	-
28	Peoples Science Institute				No	Ordinary rain gauge		Rainfall Measurement	No	-	-	-	-	-
29	IIT Roorkee				No	Workstation	1,		No					

Annexure-IV

List or Inventory of Assets/ Equipment/ Peripherals

S. No.	Name of Equipment	Quantity	Sanctioned Cost	Actual Purchased Cost	Purchase Details
	Brunton Compass	2	19,04,000/-	3,068.00	Roorkee industries Bill.no.62, dated 07.03.2018
	Geological hammer -Small	1		4,720.00	
	Geological hammer- Big	1		4,956.00	
	Garmin GPS	1		25,886.00	
	Sony DSC Camera-	1		20,700.00	Cinema Art Studio- Model no. S010406817C
	Parshal Flumes	2		23,634.00	KMV Agrotech & Engineering Works Bill no. 006, dtd.23.05.2018
	HS Flumes	6		34,692.00	
	Rain Gauge	2		4,720.00	
	Water Level Recorder	10		2,82,610.00	
	Evaporation PAN	2		33,040.00	
	Automatic Weather Station	1		2,94,115.00	
	Data Logger	2		42,480.00	Cellcomm Solutions Limited Invoice No.907068, dtd.10.08.2018
	Brunton Compass			3,599.00	
	Asus Laptop	1		50,530.00	
	Dell inspiration laptop	1		37,878.00	
	Solar power Automatic weather station	1		2,47,977.00	Solar Power Automatic weather Station & web server.
	Global Water Flow probe	2		2,72,344.00	Roorkee Industries Inv. No-78,

	Portable EC and temp meter	4		36,580.00	dtd.28.03.2019
	Hobo Conductivity Logger	2		2,36,000.00	
	Hobo optic base station	1		17,700.00	
	Hobo ware pro software	1		14,160.00	
	Rain Gauge with logger	1		29,500	
	Ordinary Rain Gauge	9		25,134.00	KMV Aggrotech & Engineering work Invoice NO-GST-027
	Workstation	1		1,00,000.00	With IIT Roorkee.

(PROJECT INVESTIGATOR)
(Signed and Stamped)

(FINANCE OFFICER)
(Signed and Stamped)

PEOPLE'S SCIENCE INSTITUTE DIRECTOR DEHRADUN

(HEAD OF THE INSTITUTION)
(Signed and Stamped)

Annexure-V

To,

The Convener, Mountain Division
Ministry of Environment, Forest & Climate Change (MoEF&CC)
Indira Paryavaran Bhawan
Jor Bagh, New Delhi-110003

Sub.: Transfer of Permanent Equipment purchased under Research Project titled "**Water security through community-based springshed development in the IHR"** funded under the NMHS Scheme of MoEF&CC – reg.

Sir/ Madam,

This is hereby certified that the following permanent equipment purchased under the aforesaid project have been transferred to the Implementing Organization after completion of the project. Details of Assets enclosed as list -fixed assets.

Head of Implementing Organization: Dr. Debashish Sen

Name of the Implementing Organization: Peoples Science Institute

PEOPLE'S SCIENCE INSTITUTE DIRECTOR DEHRADUN

Date:13/04/2022

Copy to:

1. The Nodal Officer, NMHS-PMU, National Mission on Himalayan Studies (NMHS), G.B. Pant National Institute of Himalayan Environment (NIHE), Kosi-Katarmal, Almora, Uttarakhand-263643

Research Headquarters
ITBP Road, Niranjanpur
Near Hotel Sun Park Inn
P.O. Kanwali, Dehra Doon-248001 (UK)

PEOPLE'S SCIENCE INSTITUTE
PSI

Tel: 0135-2971954, 2971955,
2971956, 2971957
E-mail: psiddoon@gmail.com

Annexure VI

Declaration

Certified that out of Rs.56,06,928/- grants-in-aid sanctioned during the year 2020-2021 & bank interest earned of Rs.1,577/- received under the project title "Water security through Community-based Springshed development in the IHR" under this Letter No.NMHS-2017/MG 03/479/227/286/370/142 dated 28.09.2021, a sum of Rs.40,11,119/-only has been utilised for which it was sanctioned and that the balance of Rs.1,33,649/-remaining unutilized as on 30.09.2021.Further declare that unutilised balance of Rs.1,33,649/- refunded to NMHS GIA General Account No-3530505520 through RTGS as on 29.03.2022 having UTR No-.UTGBH22088368526.

For Peoples Science Institute

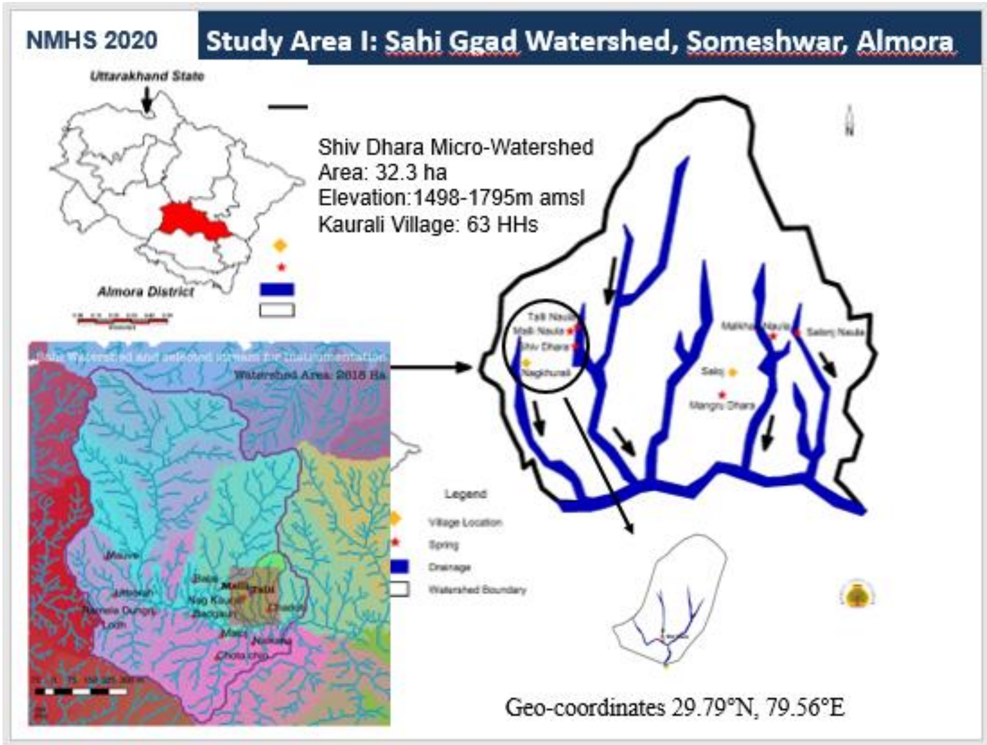
Dr. Debashish Sen
Director

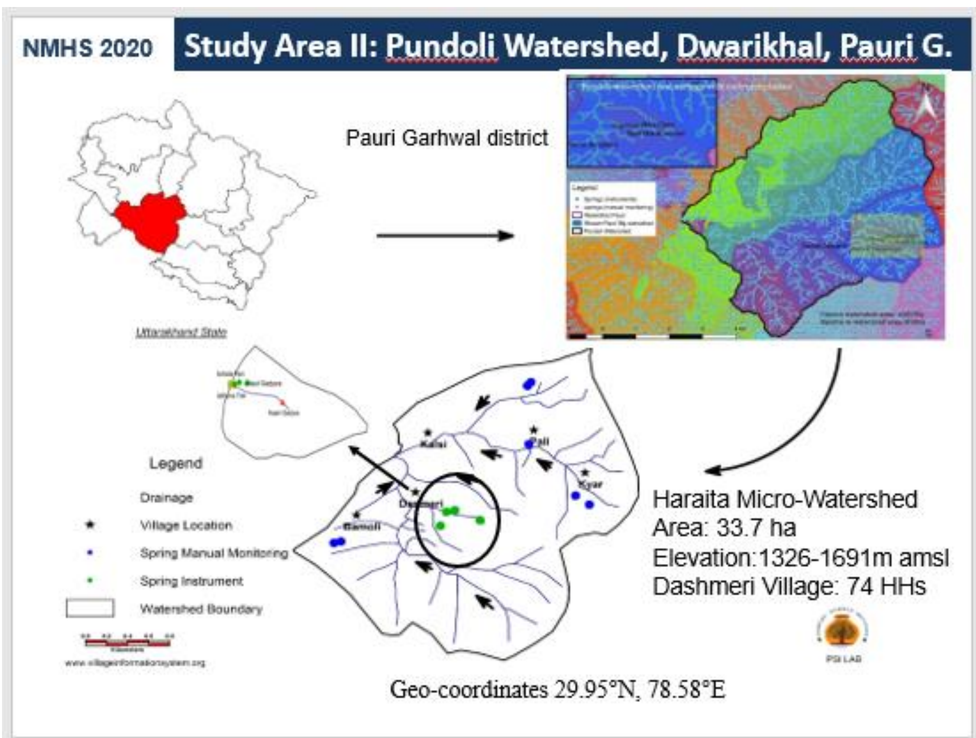
PEOPLE'S SCIENCE INSTITUTE DIRECTOR DEHRADUN

Date: 13/04/2022
Place : Dehradun

Annexure-VI1

Site Location Maps





Site Photos (Almora)

Site Photos (Pauri Garhwal)

Annexure-VIII

List of 13 Springs

S.N	District	Watershed	Village	Name of Spring	Latitude (N)	Longitude (E)	Elevation (m)	Slope (%)	Geology (Rock Type)	Date of Visit	Discharge (lpm)	Water Quality		Dependent HHs	Spring Catchment	
												pH	TDS (ppm)		Land Use	Land Ownership
1	Almora	Nag Kaurali	Saloj	Mungru Dhara	29˚47'14.4"	79°33'59.2"	1512	20-30	Quartzite	15-Aug-18	5	7.1	55	50	Individual	Private
			Saloj	Malkhau Naula	29˚47'20.5"	79°34'06.6"	1539	20-30	Quartzite	15-Aug-18	8	7.2	19	50	Individual	Private
2			Saloj	Salonj Naula	29˚47'21.5"	79°34'09.9"	1534	20-30	Quartzite	15-Aug-18	6.5	6.3	79	30	Individual	Private
3			Nag Kaurali	Malli Naula	29.75556	79.55733	1560	20-30	Quartzite	23-Mar-18	6.4	7.3	86	50	Settelment	Private
4			Nag Kaurali	Shiv Dhara	29.78894	79.55956	1553	20-30	Quartzite	17-Apr-18	15	6.8	22		Settlement & Forest	Van Panchayat

S.N	District	Watershed	Village	Name of Spring	Latitude (N)	Longitude (E)	Elevation (m)	Slope (%)	Geology (Rock Type)	Date of Visit	Discharge (lpm)	Water Quality		Dependent HHs	Spring Catchment	
												pH	TDS (ppm)		Land Use	Land Ownership
5			Nag Kaurali	Talli Naula	29.78933	79.55958	1565	20-30	Quartzite	23-Mar-18	6.3	7.4	82		Settelment & Forest	Van Panchayat
														180		
1	Pauri Garhwal	Dashmeri	Pali	Pali Dhara	29.95877	78.58883	1353	30-40	Phyllite	13-Jan-18	30	7.4	32	18	Agriculture & Forest	Private
2			Bamoli	Dangdyar	29.9493	78.56955	1433	40-50	Phyllite		3	7.4	27	50	Agriculture Land	Private
3			Bamoli	Dangdyar Talla	29.94944	78.57025	1376	40-50			2	7.8	25	35		
4			Dashmeri	Kasti Gadera Malla	29.95169	78.58419	1530	40-50	Quartzite & Phyllite	14-Jan-18	6	7.8	20	20	Barren Agriculture Land	Private
5			Dashmeri	Nauli Gadera	29.9525	78.58155	1448	40-50			15	7.6	17	10		

S.N	District	Watershed	Village	Name of Spring	Latitude (N)	Longitude (E)	Elevation (m)	Slope (%)	Geology (Rock Type)	Date of Visit	Discharge (lpm)	Water Quality		Dependent HHs	Spring Catchment	
												pH	TDS (ppm)		Land Use	Land Ownership
6			Dashmeri	Bichola Pani	29.95252	78.58094	1423	40-50			1	7.8	17	20		
7			Dashmeri	Jethuna Tok	29.95247	78.58069	1412	40-50			3	7.7	19	20		
														173		

Annexure-IX

Details of springs with instrumentation

Table 1. Spring location in Haraita watershed, Pauri Garhwal, Uttarakhand, India

Spring	Latitude	Longitude	Elevation (m)	Slope (%)	Land use
Kasti Gadera Malla	29°57′06″N	78°35′03″E	1530	20–30	Barren agricultural land
Nauli Dhara	29°57′09″N	78°34′53″E	1448	20–30	Barren agricultural land
Bichola Pani	29°57′09″N	78°34′51″E	1423	20–30	Barren agricultural land
Jethuna Tok	29°57′08″N	78°34′50″E	1412	20–30	Barren agricultural land

Table 2. Spring location in Shiv Gadera watershed, Almora, Uttarakhand

Spring	Latitude	Longitude	Elevation (m)	Slope (%)	Land use
Malli Naula	29°45′20″N	79°33′26″E	1560	20–30	Settlement
Shiv Dhara	29°47′20″N	79°33′34″E	1553	20–30	Settlement and forest
Talli Naula	29°47′21″N	79°33′34″E	1565	20–30	Settlement and forest

Images of Instruments Installed in Sahigad Watershed, Almora

a) Water level sensors

b) Hilly terrain of Almora watershed

c) Auto Weather Station

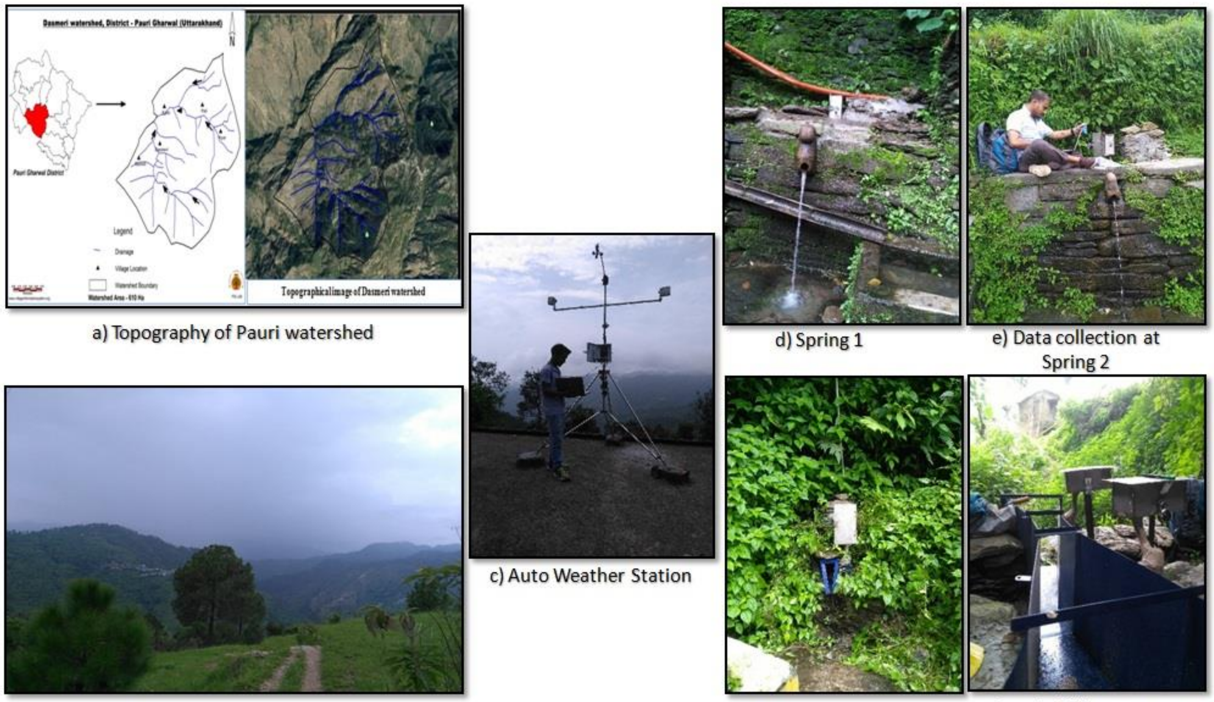
d) Spring location

e) Parshall flume at stream

f) Lean flow in stream

g) Non-recording rain gauge

Images of Instruments Installed in Pundoliraul Watershed, Pauri



a) Topography of Pauri watershed

b) Mountainous terrain of Pauri watershed

c) Auto Weather Station

d) Spring 1

e) Data collection at Spring 2

f) HS flume at Spring 3

g) Parshall flume at Stream

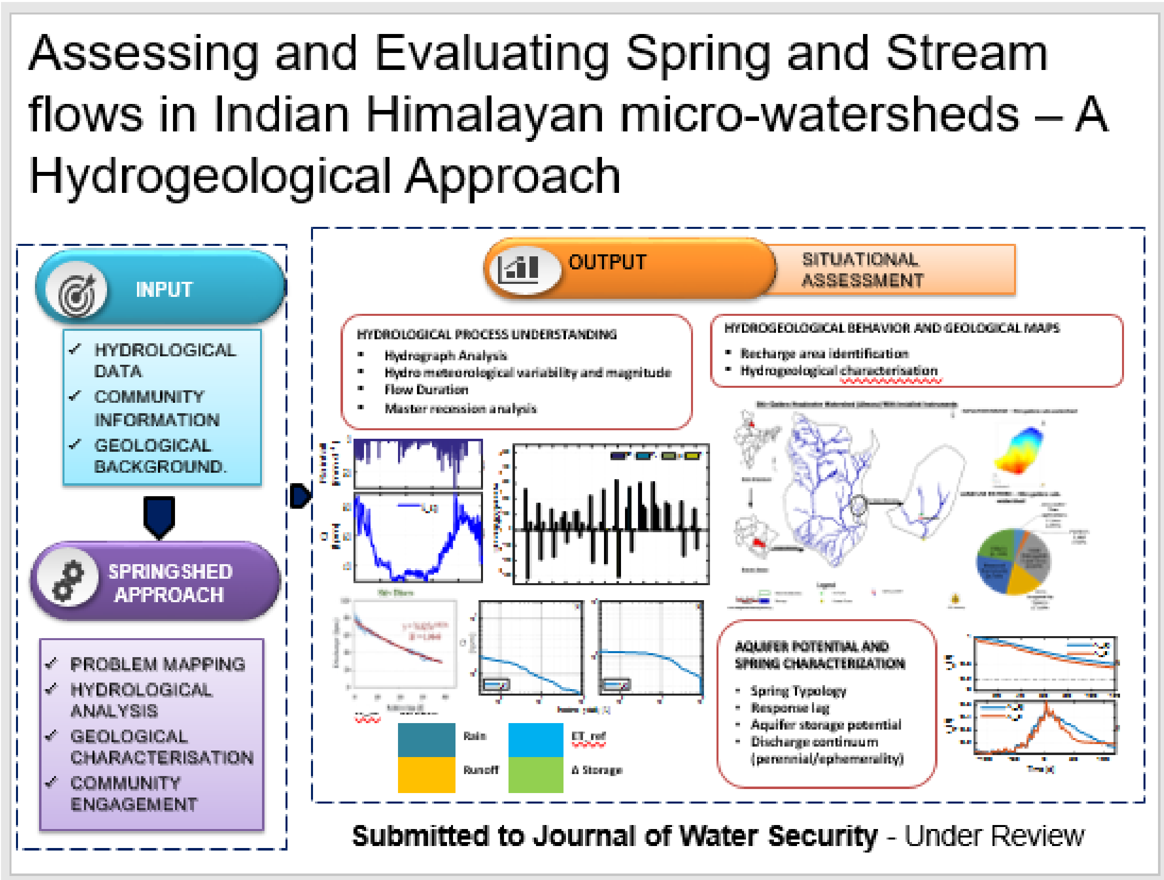
Annexure-X

Water Security Plans

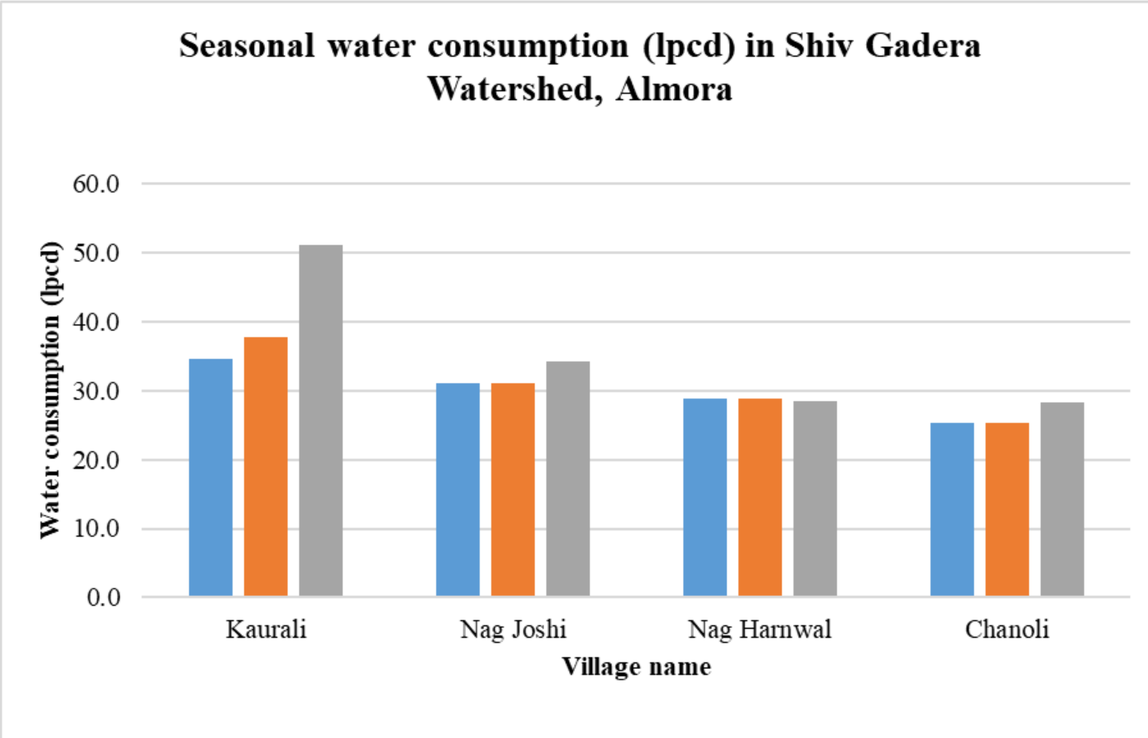
The watershed level water security plans for all the six selected watersheds in Almora, Pauri-Uttarakhand, Phek, Zunheboto-Nagaland, and Tawang, West Kameng-Arunachal Pradesh are attached as a zip folder (Annexure-4)

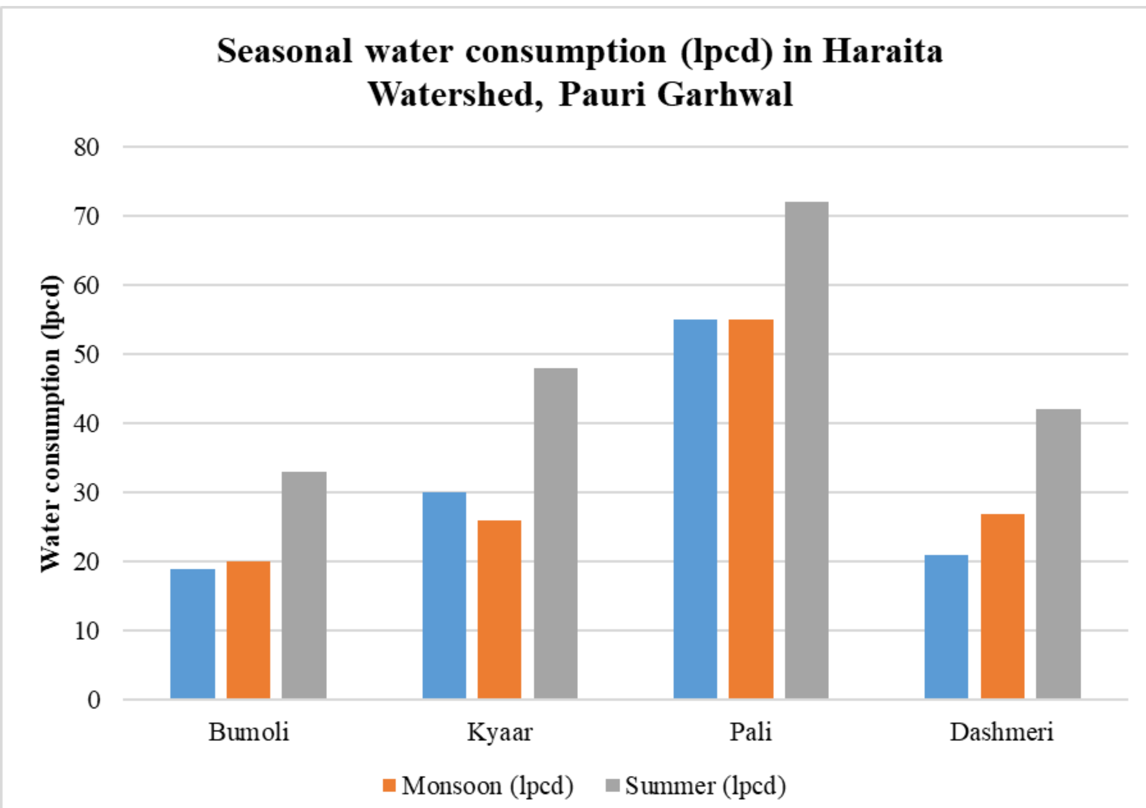
Annexure-XI

Hydrological modelling



Seasonal domestic water consumption pattern in the selected villages of Almora and Pauri Garhwal





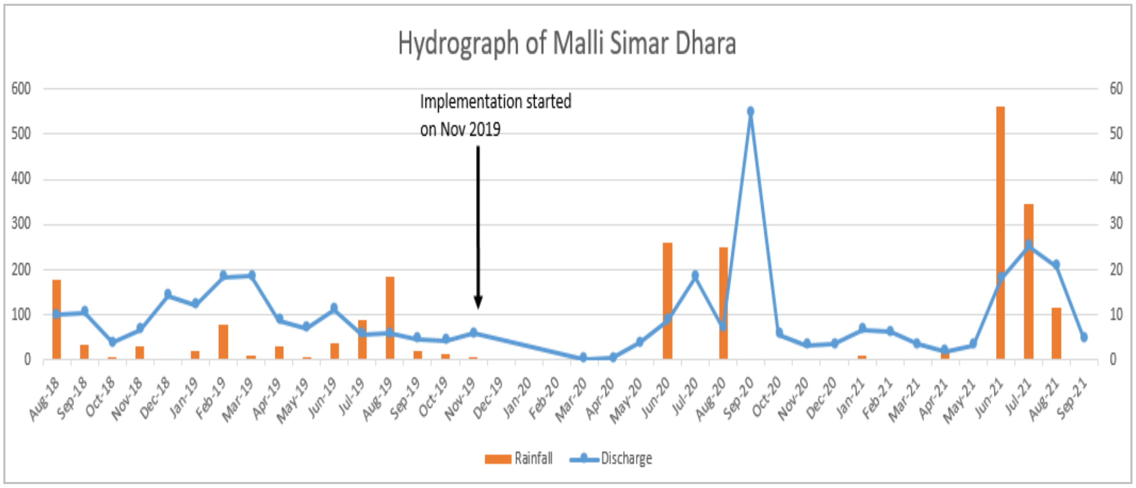
Annexure-XIII

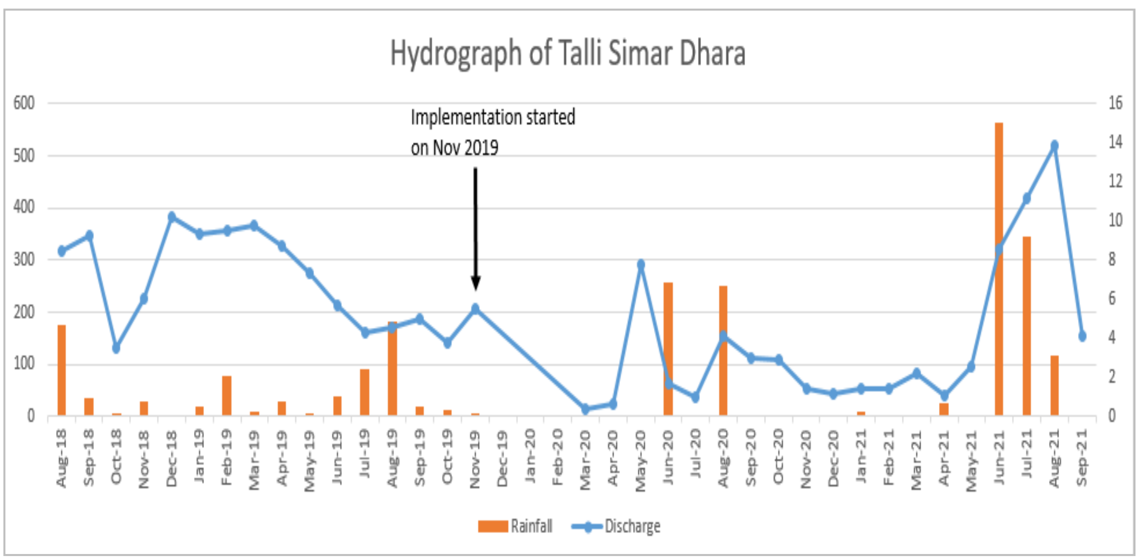
An inventory of 300 springs for six districts - Almora, Pauri-Uttarakhand, Phek, Zunheboto-Nagaland, and Tawang, West Kameng-Arunachal Pradesh is attached as a zip folder. (Annexure-7)

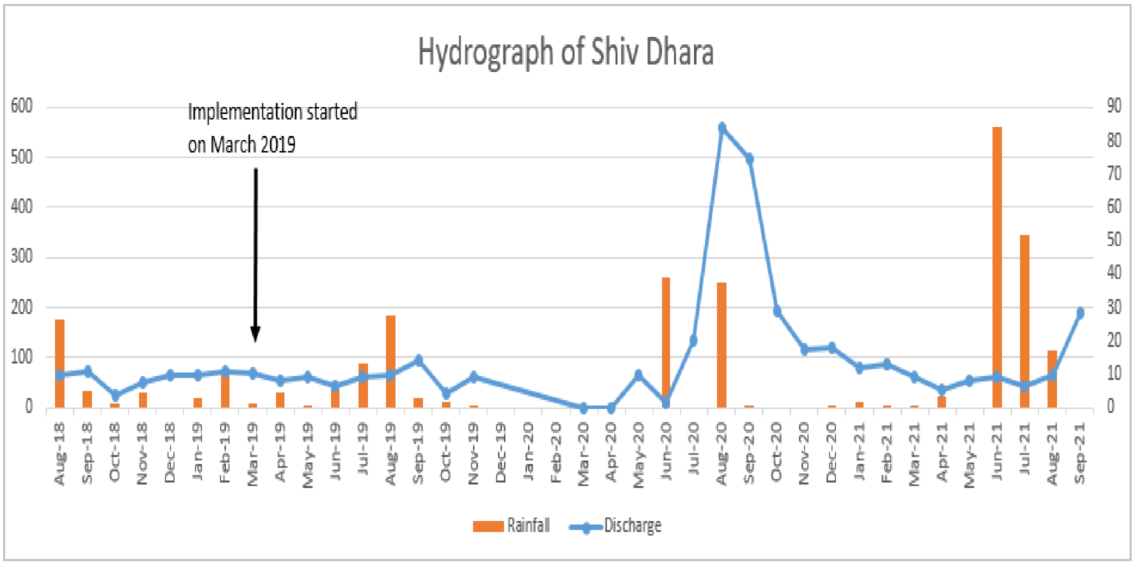
Kml file has also been provided in Annexure -7.

Annexure-XIVa

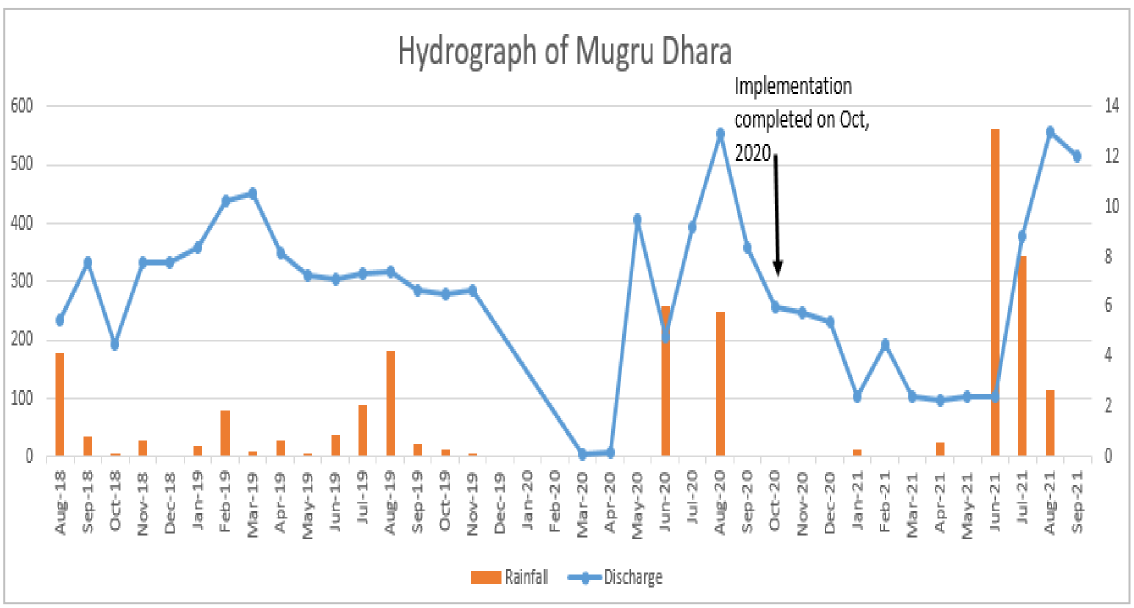
Spring Hydrographs - Pre & Post Treatment (Almora)



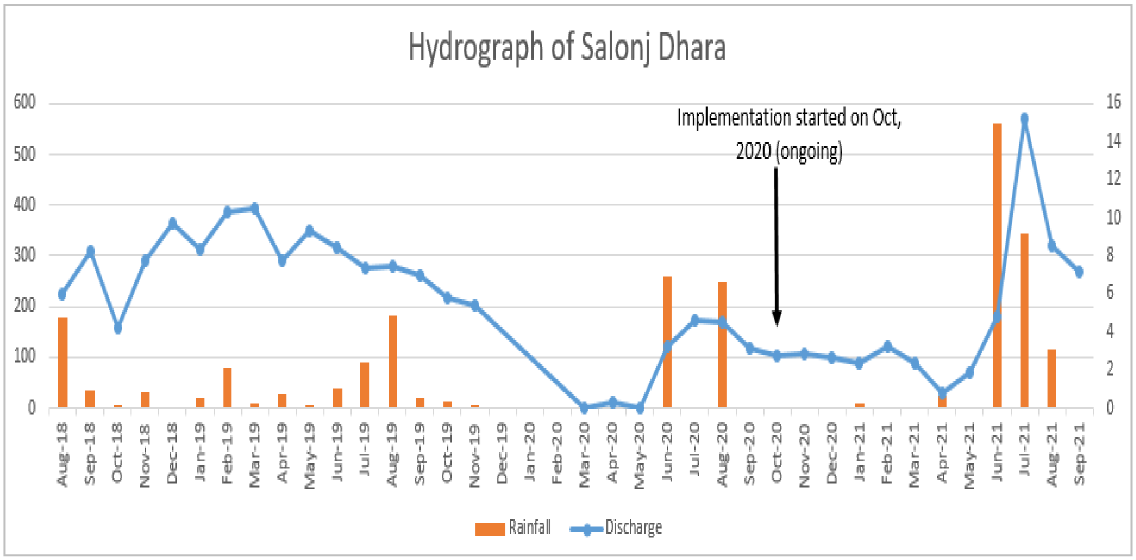




Hydrograph of Shiv Dhara
Implementation started on March 2019
600
500
400
300
200
100
0
90
80
70
60
50
40
30
20
10
0
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Feb-19
Mar-19
Apr-19
May-19
Jun-19
Jul-19
Aug-19
Sep-19
Oct-19
Nov-19
Dec-19
Jan-20
Feb-20
Mar-20
Apr-20
May-20
Jun-20
Jul-20
Aug-20
Sep-20
Oct-20
Nov-20
Dec-20
Jan-21
Feb-21
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Rainfall
Discharge



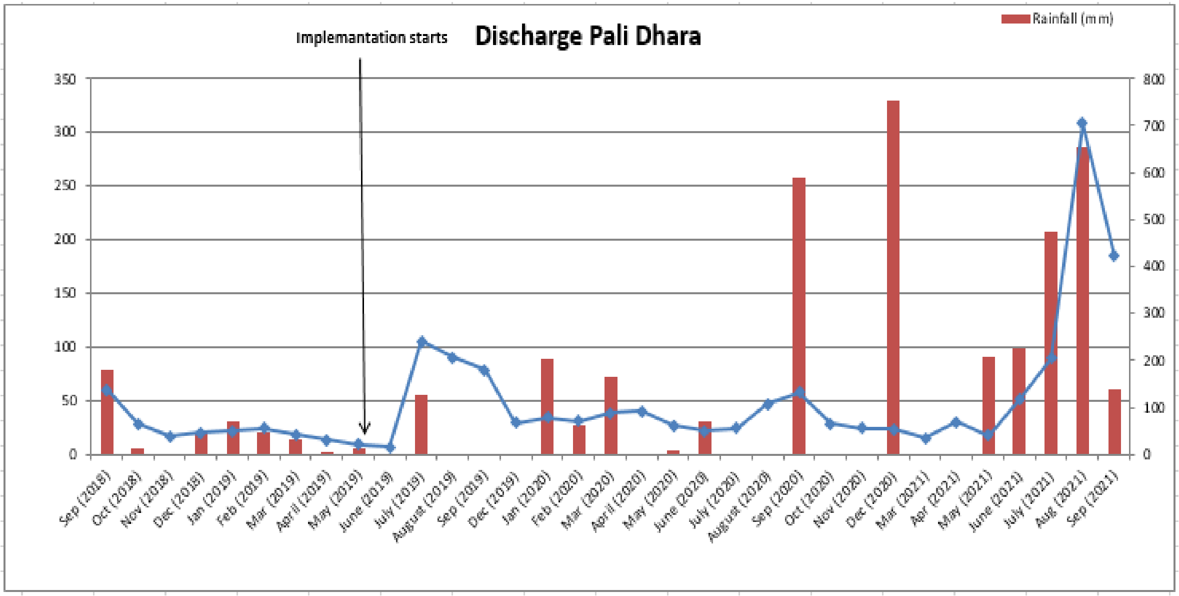
Hydrograph of Mugru Dhara
Implementation completed on Oct, 2020
600
500
400
300
200
100
0
14
12
10
8
6
4
2
0
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Feb-19
Mar-19
Apr-19
May-19
Jun-19
Jul-19
Aug-19
Sep-19
Oct-19
Nov-19
Dec-19
Jan-20
Feb-20
Mar-20
Apr-20
May-20
Jun-20
Jul-20
Aug-20
Sep-20
Oct-20
Nov-20
Dec-20
Jan-21
Feb-21
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Rainfall
Discharge

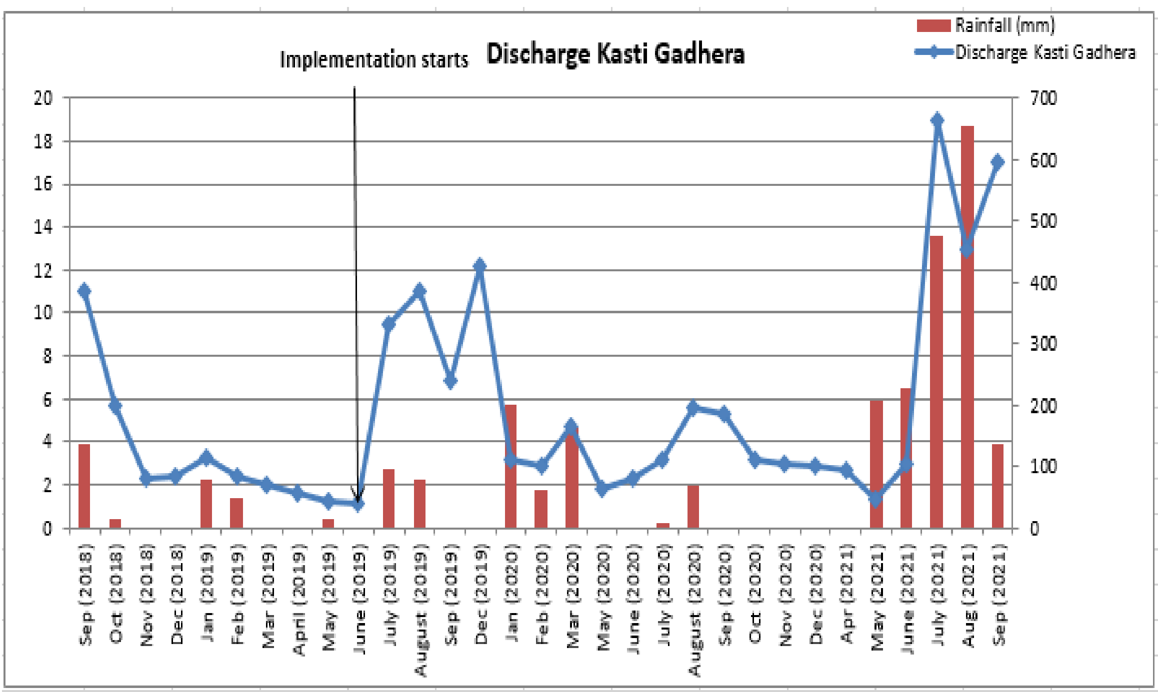


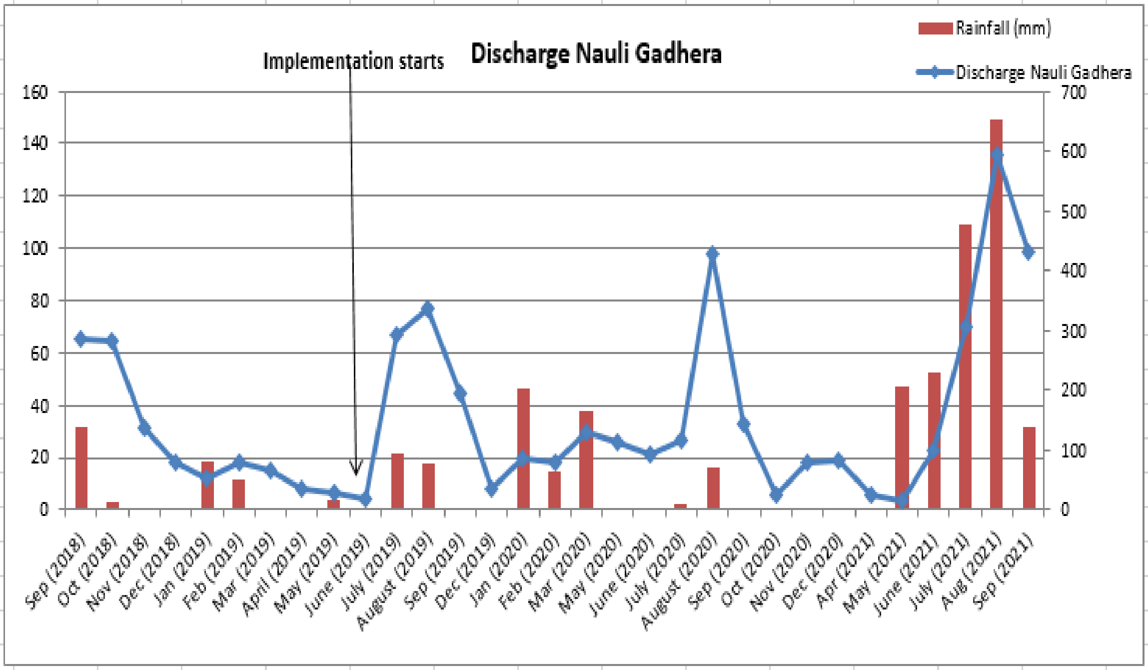
Hydrograph of Salonj Dhara
Implementation started on Oct, 2020 (ongoing)
600
500
400
300
200
100
0
16
14
12
10
8
6
4
2
0
Aug-18
Sep-18
Oct-18
Nov-18
Dec-18
Jan-19
Feb-19
Mar-19
Apr-19
May-19
Jun-19
Jul-19
Aug-19
Sep-19
Oct-19
Nov-19
Dec-19
Jan-20
Feb-20
Mar-20
Apr-20
May-20
Jun-20
Jul-20
Aug-20
Sep-20
Oct-20
Nov-20
Dec-20
Jan-21
Feb-21
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Rainfall
Discharge

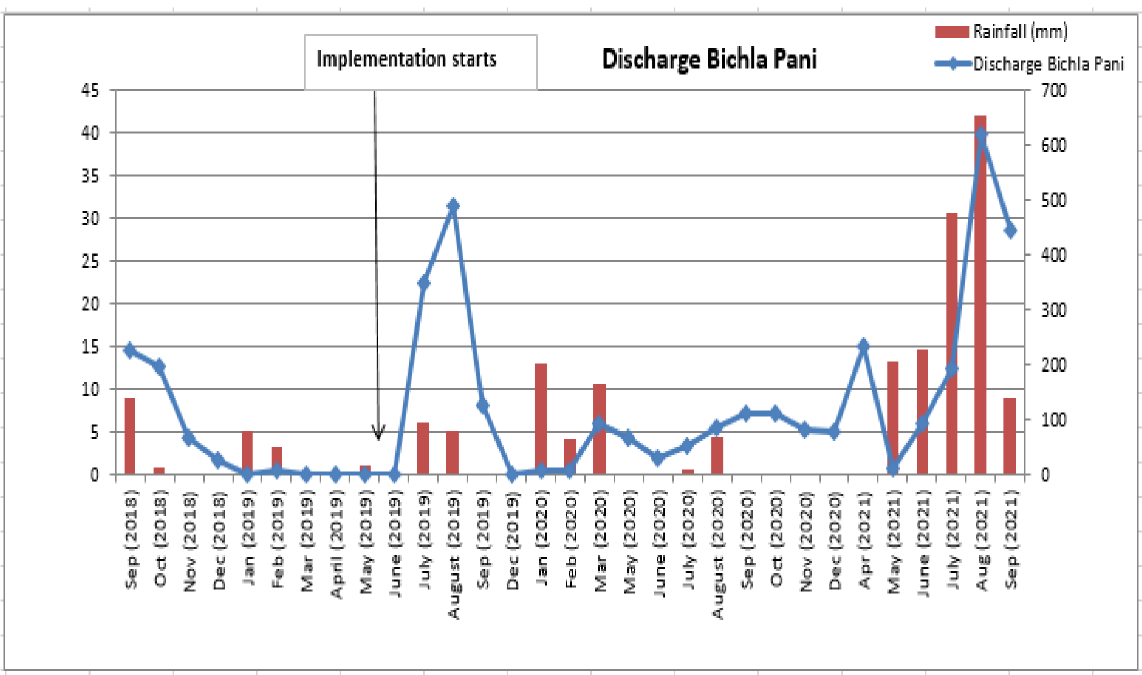
Annexure-XIVb

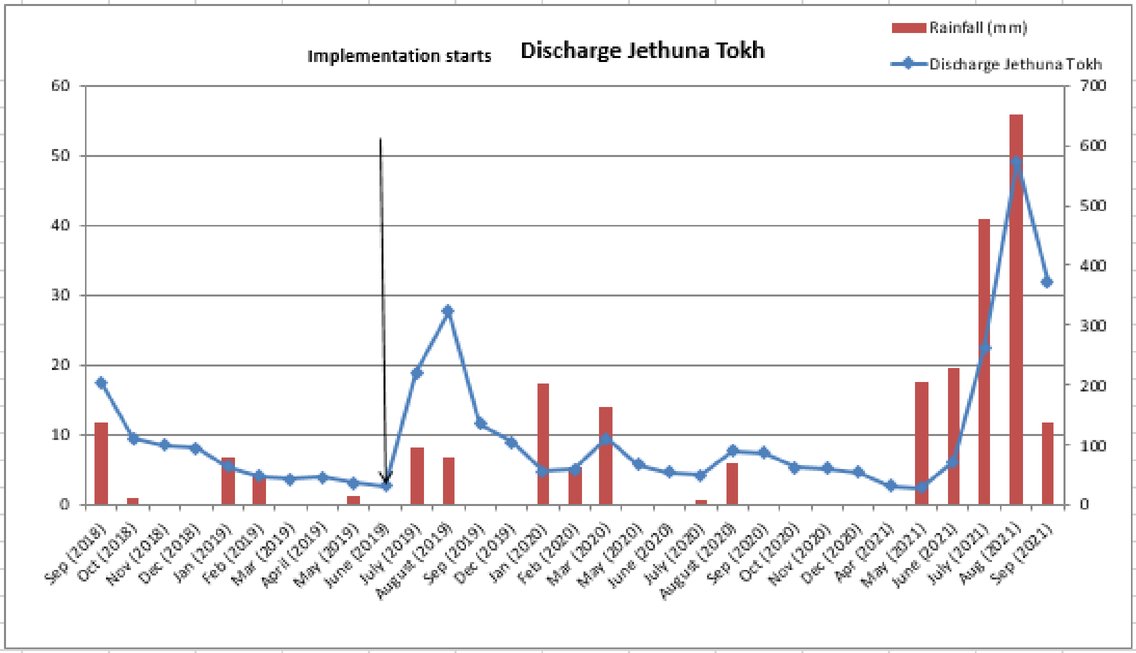
Spring Hydrographs - Pre & Post Treatment (Pauri Garhwal)



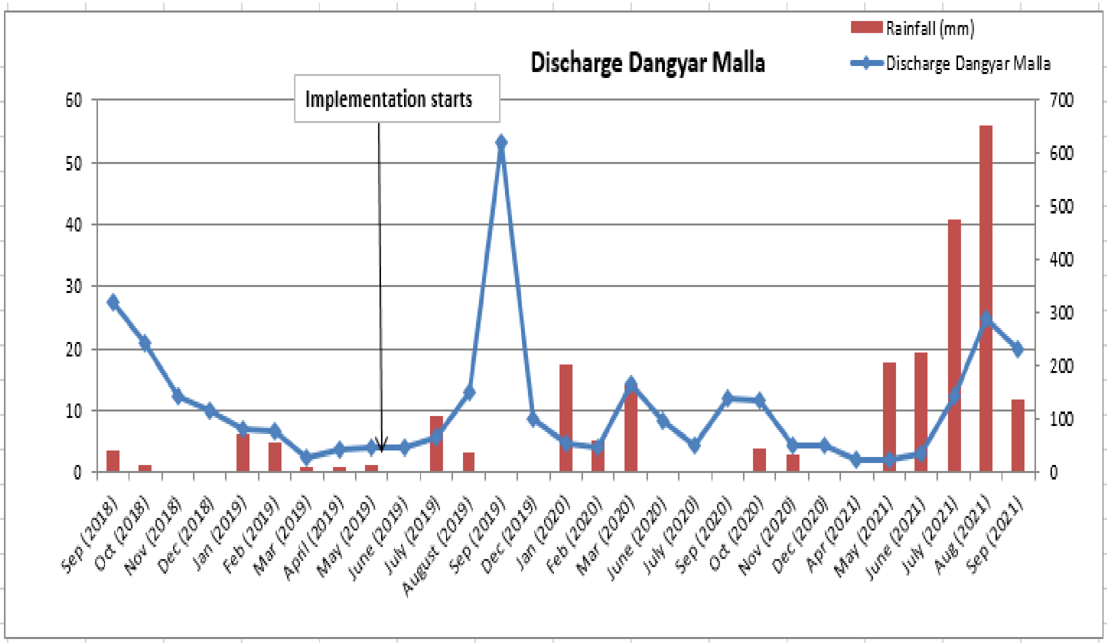



Discharge Nauli Gadhera
Implementation starts
Rainfall (mm)
Discharge Nauli Gadhera
0
20
40
60
80
100
120
140
160
0
100
200
300
400
500
600
700
Sep (2018)
Oct (2018)
Nov (2018)
Dec (2018)
Jan (2019)
Feb (2019)
Mar (2019)
April (2019)
May (2019)
June (2019)
July (2019)
August (2019)
Sep (2019)
Dec (2019)
Jan (2020)
Feb (2020)
Mar (2020)
May (2020)
June (2020)
July (2020)
August (2020)
Sep (2020)
Oct (2020)
Nov (2020)
Dec (2020)
Apr (2021)
May (2021)
June (2021)
July (2021)
Aug (2021)
Sep (2021)

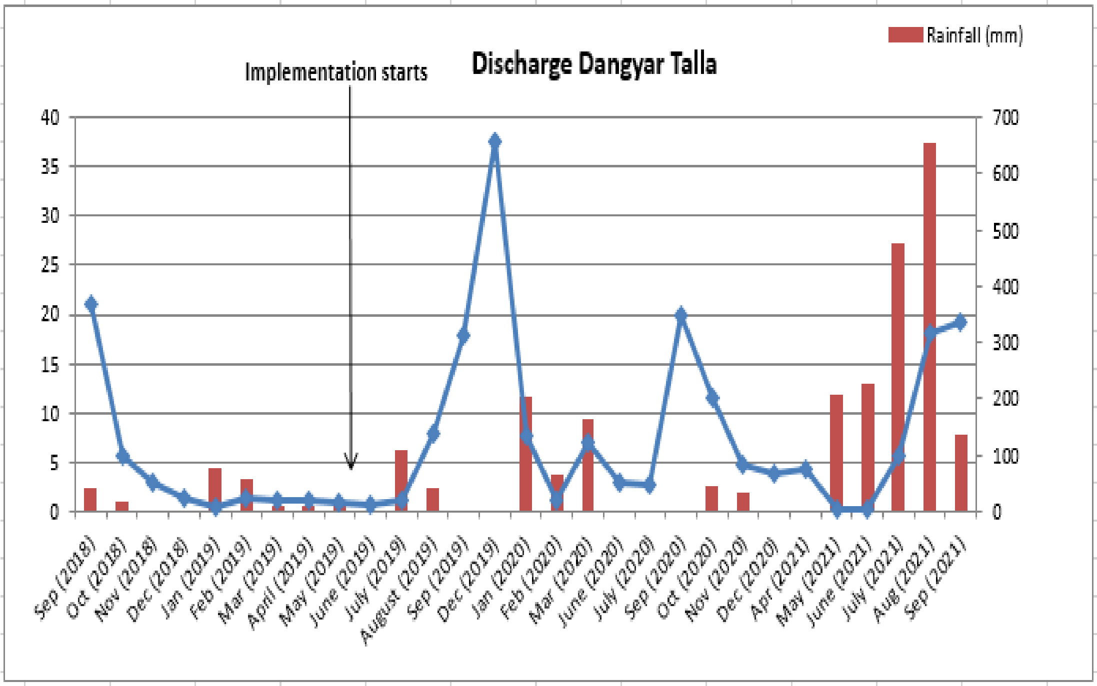

Implementation starts
Discharge Bichla Pani
Rainfall (mm)
Discharge Bichla Pani
0
5
10
15
20
25
30
35
40
45
0
100
200
300
400
500
600
700
Sep (2018)
Oct (2018)
Nov (2018)
Dec (2018)
Jan (2019)
Feb (2019)
Mar (2019)
April (2019)
May (2019)
June (2019)
July (2019)
August (2019)
Sep (2019)
Dec (2019)
Jan (2020)
Feb (2020)
Mar (2020)
May (2020)
June (2020)
July (2020)
August (2020)
Sep (2020)
Oct (2020)
Nov (2020)
Dec (2020)
Apr (2021)
May (2021)
June (2021)
July (2021)
Aug (2021)
Sep (2021)



Discharge Jethuna Tokh
Implementation starts
Rainfall (mm)
Discharge Jethuna Tokh



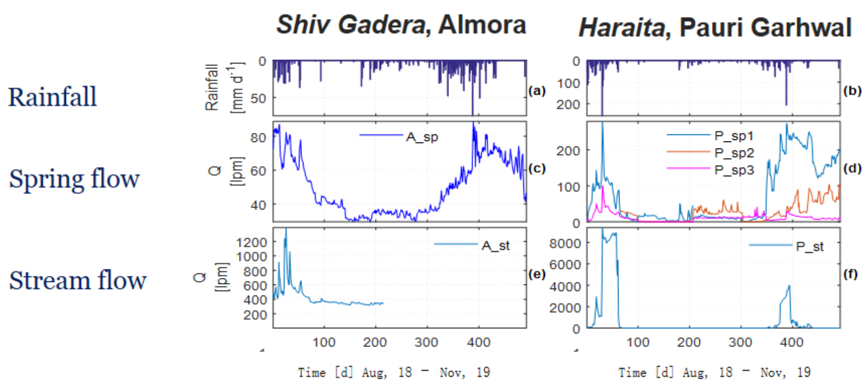
Discharge Dangyar Malla
Implementation starts
Rainfall (mm)
Discharge Dangyar Malla



Rainfall (mm)
Discharge Dangyar Talla
Implementation starts
40
35
30
25
20
15
10
5
0
700
600
500
400
300
200
100
0
Sep (2018)
Oct (2018)
Nov (2018)
Dec (2018)
Jan (2019)
Feb (2019)
Mar (2019)
April (2019)
May (2019)
June (2019)
July (2019)
August (2019)
Sep (2019)
Dec (2019)
Jan (2020)
Feb (2020)
Mar (2020)
June (2020)
July (2020)
Sep (2020)
Oct (2020)
Nov (2020)
Dec (2020)
Apr (2021)
May (2021)
June (2021)
July (2021)
Aug (2021)
Sep (2021)

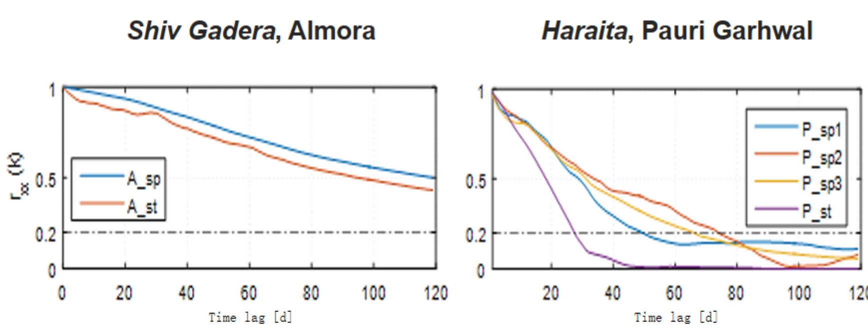
Spring Hydrographs based on data collected through instruments

NMHS 2020 | **Spring and Stream Flows**



- Spring discharge from Shiv Dhara is perennial with average flow of ≈ 50 lpm.
- The springs of Haraita sub-watershed, Nauli dhara (sp1), Bichola pani (sp2) and Jethuna tok (sp3) show significant differences in their average flow rates (13 lpm to 71 lpm) and decrease across the transect.
- Hydrograph responses indicate that both the springshed systems are highly controlled by interactions between precipitation and aquifer characteristics.
- Impact of treatment measures (initiated between May and August 2019) on spring discharge can be seen in terms of increase in base flows.

Auto-Correlation Analysis



- The analysis shows effects of slope and geological characteristics on spring discharge.
- Autocorrelation in *Shiv Gadera* shows damped responses with prolonged memory effect. It signifies aquifer storage and feed into springs.
- Autocorrelation in *Haraita* exhibit sharp decline and minimized memory effect i.e. low aquifer storage and quick outflow of rain water.
- A gradual trend in *Shiv Gadera* implies presence of minute fissures, moderate slope and weathered rocks leading to GW flows at lower velocities.
- A steep decrease and a lesser memory effect indicates a well developed fracture system, low weathering and steep slopes in Haraita.

Annexure-XV

All the knowledge products and publications mentioned under Section 11 in the report are attached as a zip folder (Annexure-9)

List of products and publications:

1a. **Journal Research Paper** - Hydrological process monitoring for springshed management in the Indian Himalayan region: field observatory and reference database, Current Science, Vol.,120, NO. 5, 10 March 2021.

1b. **Journal Research Paper** - Assessment of spring flows in Indian Himalayan micro-watersheds – A hydro-geological approach, Journal of Hydrology, Vol. 598, July 2021, 126354.

1c. **Manuscript** - NMHS conference IITR PSI

5. **Papers presented in Conferences/ Seminars –**

7) "Reviving Springsheds in Himachal Pradesh: Experiences from Thanakasoga GP" at IWMI-Tata Partners' Meet, December 4-6, 2018, Anand (Gujarat)
8) "Mapping of Vulnerable Springsheds and Preparing Restoration Plan in Uttarakhand" at UKFD-UNDP springshed activities, February 13, 2019
9) "Springshed Development: Experiences from the North-East" at Springshed Management in the North-Eastern States of the Indian Himalayan Region, Kohima, May 29, 2019
10) Community-based Springshed development for Water security in Himalayan Region: Experiences from Thanakasoga GP – Paper presented at the Water Future Conference, 25th September 2019
11) Community-based groundwater governance in the Himalayan and central plateau landscapes of India – Paper presented at the UNESCO Groundwater Conference held on 19th May 2022.
12) "Springshed Development in Watershed Management: Concept & Approach" at Orientation Workshop on PMKSY-Watershed Development Component, July 8, 2022, Dehradun

6a. **Policy Drafts/Paper** - National Water Policy – IHR

6b. **Policy Drafts/Paper** - Critical issues related to drinking water policy for Himalayan states

7. **Others**

(i) case study on community initiatives taken to revive a spring in one of the project sites in Western Arunachal Pradesh

(ii) case study on the solar lift scheme in Pali village, Pauri Garhwal.

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