National Mission on Himalayan Studies (NMHS)

PERFORMA FOR THE HALF YEARLY PROGRESS REPORT
(Reporting Period *from* **July 2018** *to* **December 2018**)

1. Project Information

Project ID	NMHS/2015-16/LG02/02
Project Title	**Rejuvenation of Springs and Spring-fed Streams in Mid-Himalayan Basins using Spring Sanctuary Concept**
PI and Affiliation(Institution):	**Er. Soukhin Tarafdar**, Scientist D & PI, GBPNIHESD, Srinagar, Uttarakhand
BTA	Water Resource Management
Project Partners	1. State Government Forest Department 2. IIT Guwahati 3. National Institute of Hydrology, Roorkee

2. Project Objectives

1. To quantify hydrological processes and establish functional relationship of land use changes and hydrological responses in social and climate change scenario.
2. Model development for ground water augmentation through participatory approach in Kumaon, Garhwal.
3. Development and demonstration of functional land use model using optimised hydrological response (water allocations) at sub-watershed level
4. Disseminations of an Aadaptive land use policy and integrated decision support system for water resource management at watershed level.
5. To recommend policies and practices of land use (forest and non-forest land), land transformation (one land use category to other) and related water use.

3. Half Yearly Progress

Quantifiable Deliverables	Monitoring Indicators	Progress made against deliverables in terms of monitoring indicators
1	2	3
Inventory and mapping of village-wise springs/seeps and spring fed streams using handheld GPS and high resolution satellite data of all three watersheds	• Monitoring in comparison to the baseline information to be provided by proponent	• Physico-chemical properties of 88 springs for summer season have been analysed to quantify seasonal changes in the Kosi watershed. • Using the rating curve equation with the help of continuous stage measured data, amount of discharge obtained between July –Sep was obtained. Along with this discharge, Flow duration curve was also graphed. • Soil moisture data was also analyzed (*refer Annexure-1*).

Functional Land use plan for sub-watersheds	• No. of HRU/ spring sanctuary treated/ demonstrated **(Nos. 05)**	
DSS for Efficient Water allocation strategies for competing land uses	• No. of beneficiaries **(Nos.)**	
Document on the best management practices	• Digital maps for different sites (map data) showing the interventions **(Nos. 05)**	
Land Use Policy guidelines with efficient water allocation	• Alternative land use models studied **(Nos. 1)**	
Tool for complementary water budgeting at watershed level	No. of documents prepared and published **(Nos.)**	
Performance indicators for monitoring & evaluation of land use plan	• No. of databases/models developed**(Nos. 01)**	
	• No of performance indicators developed after testing**(Nos.)**	

Submitted to:
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Annexure-1

Water Quality Assessment in Upper Kosi Basin:

1: Physico-chemical properties of spring's water: Water sample for 88 monitoring springs was collected for analysis of physico-chemical parameters of spring's water and to quantify seasonal changes. Results obtained after analysis indicated that from pre-monsoon to post monsoon, there is increase in EC (µS/cm), pH, TH (mg/L) and Alkalinity (mg/L) and concentration of other parameters declined. From the results it can be concluded that pH, EC, Turbidity, Chloride, Alkalinity, sodium and potassium showed change in the concentration with seasonal variation (Figure 1).

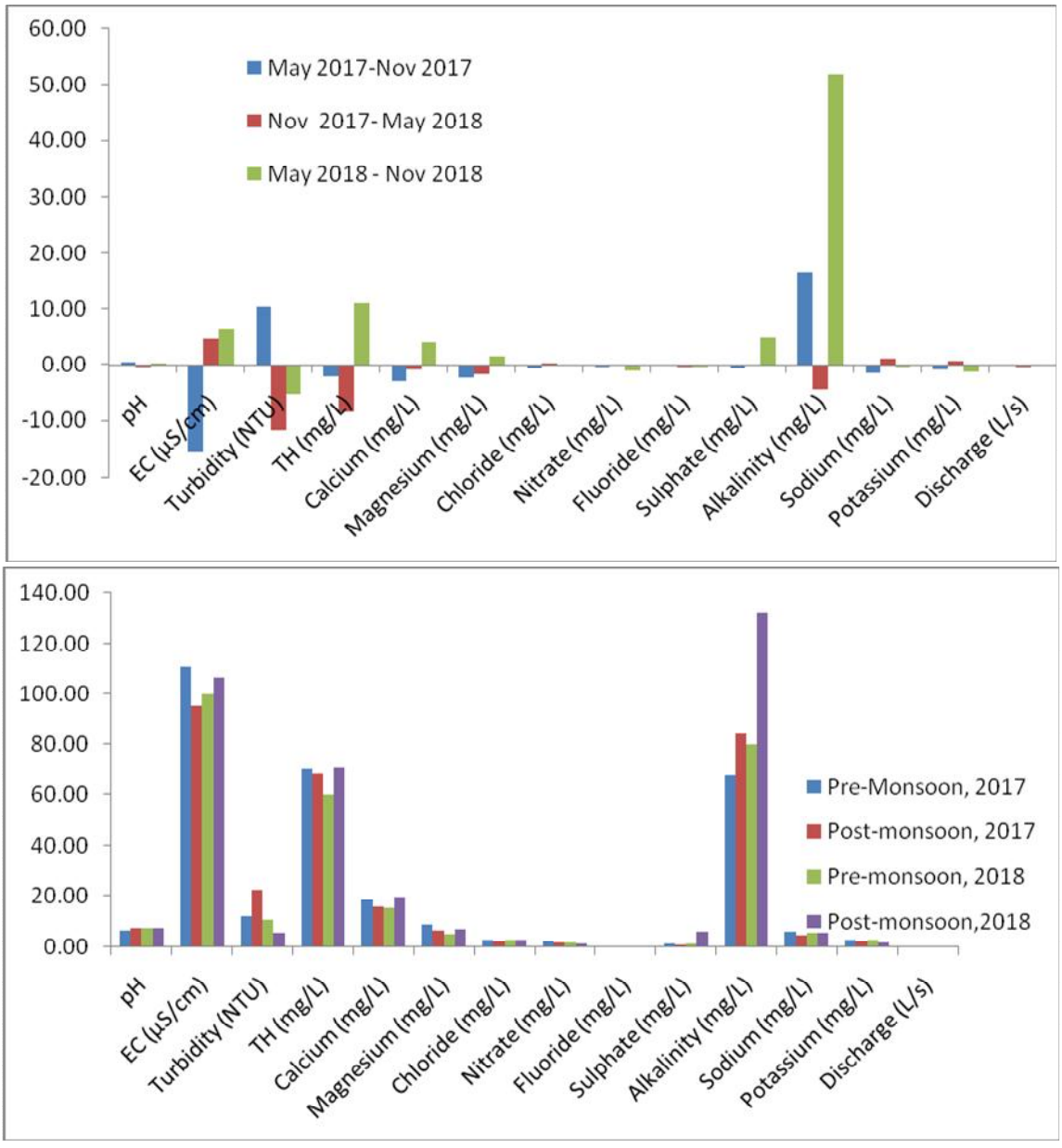


Figure 1: Changes in physico-chemical parameters with different seasons

Table 1 : Descriptive statistics of springs water physico-chemical parameters for May-18

18-May								
Physico-chemical parameters	**Min**	**Max**	**Mean**	**SD**	**SE**	**Skewness**	**Kurtosis**	**CV**
pH	5.93	9.78	7.40	0.73	0.08	0.32	0.08	9.86
EC (µS/cm)	20.30	679.00	100.16	106.02	11.24	3.66	15.20	105.85
Turbidity (NTU)	0.00	327.00	11.02	38.69	4.10	7.69	62.38	351.19
TH (mg/L)	14.00	202.00	60.05	36.73	3.89	1.80	3.57	61.15
Calcium (mg/L)	4.10	62.00	15.47	9.99	1.06	2.17	6.37	64.60
Magnesium (mg/L)	0.05	29.31	5.25	4.96	0.53	2.80	9.57	94.40
Chloride (mg/L)	1.42	5.68	2.86	0.95	0.10	0.26	0.17	33.16
Nitrate (mg/L)	0.09	9.85	2.09	1.87	0.20	2.57	7.28	89.48
Fluoride (mg/L)	0.02	0.11	0.05	0.02	0.00	0.73	1.08	36.05
Sulphate (mg/L)	0.11	3.92	1.34	0.82	0.09	1.00	0.89	61.43
Alkalinity (mg/L)	25.00	150.00	80.00	29.35	3.11	0.42	-0.22	36.69
Sodium (mg/L)	0.28	15.62	5.88	4.06	0.43	0.61	-0.48	69.02
Potassium (mg/L)	0.00	12.48	3.10	2.18	0.23	1.46	4.08	70.19
Discharge (L/s)	0.01	0.79	0.07	0.12	0.01	3.88	17.10	179.93

Table 2 : Descriptive statistics of springs water physico-chemical parameters for Nov-18

18-Nov								
Physico-chemical parameters	**Min**	**Max**	**Mean**	**SD**	**SE**	**Skewness**	**Kurtosis**	**CV**
pH	6.5	9.6	7.8	0.7	0.1	0.0	-0.1	8.6
EC (µS/cm)	16.3	698.0	106.7	118.8	12.6	3.5	12.8	111.4
Turbidity (NTU)	0.0	60.2	5.8	8.9	0.9	3.5	17.6	153.2
TSS (mg/L)	0.0	0.1	0.0	0.0	0.0	5.5	36.4	250.3
TH (mg/L)	24.0	332.0	71.2	50.0	5.3	2.7	10.0	70.3
Calcium Hardness (mg/L)	8.4	147.0	42.6	27.6	2.9	1.4	2.3	64.9
Calcium (mg/L)	3.4	132.6	19.7	19.0	2.0	3.3	15.6	96.4
Magnesium (mg/L)	1.2	50.1	6.9	7.1	0.8	3.8	18.5	102.7
Chloride (mg/L)	1.4	5.7	2.9	0.8	0.1	0.5	2.0	26.2
Nitrate (mg/L)	0.1	8.8	1.2	1.6	0.2	2.8	8.5	132.2
Fluoride (mg/L)	0.0	0.1	0.0	0.0	0.0	1.0	1.2	33.4
Sulphate (mg/L)	2.3	32.5	6.3	4.9	0.5	3.4	13.4	76.7
Alkalinity (mg/L)	50.0	275.0	131.9	50.5	5.3	0.5	-0.3	38.3
Sodium (mg/L)	0.2	14.6	5.7	3.8	0.4	0.5	-0.8	65.6
Potassium (mg/L)	0.0	12.2	1.9	2.1	0.2	2.7	9.7	110.1
Discharge (L/s)	0.0	0.4	0.1	0.1	0.0	1.5	3.0	95.3

Descriptive analysis of sample indicated that spring water is highly variable except in case of pH. Very high Coefficient of variation, ranging from 33% to 351% in pre-monsoon for the entire sample except pH (10%) and 26% to 250% in post-monsoon except pH (8.5%) was recorded. The pH value of spring water samples in the study area varies from 5.93 to 9.78 during pre-monsoon and 6.52 to 9.6 in post-

monsoon season. 32% springs in pre-monsoon indicated slightly acidic nature of water while 19% spring indicated acidic nature in post-monsoon season. Standard deviation of some of the parameters (turbidity, EC, magnesium, nitrate and sulphate) is higher than the mean value (Table 2). The results of physico-chemical analysis indicated that turbidity ranged from 0.05-327 NTU with mean value of 11.02 NTU in pre-monsoon sample while the same was ranged from 0.04-60.2 NTU with Mean value of 5.82 NTU. Similarly, large variation in EC was observed which lies between 20.3-679µS/cm with mean value 100.16µS/cm (CV=105.85) in pre-monsoon and 16.3-698 µS/cm with mean value 106.65 µS/cm (CV=111.35) in post monsoon season. Overall, 75 sample of spring water has EC<500µS/cm (fresh water) in the watershed while 01 springs have EC higher than specified limit in pre-monsoon and considered as spring with marginal water (>500µS/cm) whereas number of this types of spring with marginal water increased upto 04 in post-monsoon. 35 springs indicated decrement in EC value in winters (post-monsoon) as compared to summers (post-monsoon). The EC of water is directly related to recharge of aquifer through precipitation.

2: Water Quality and Human Health

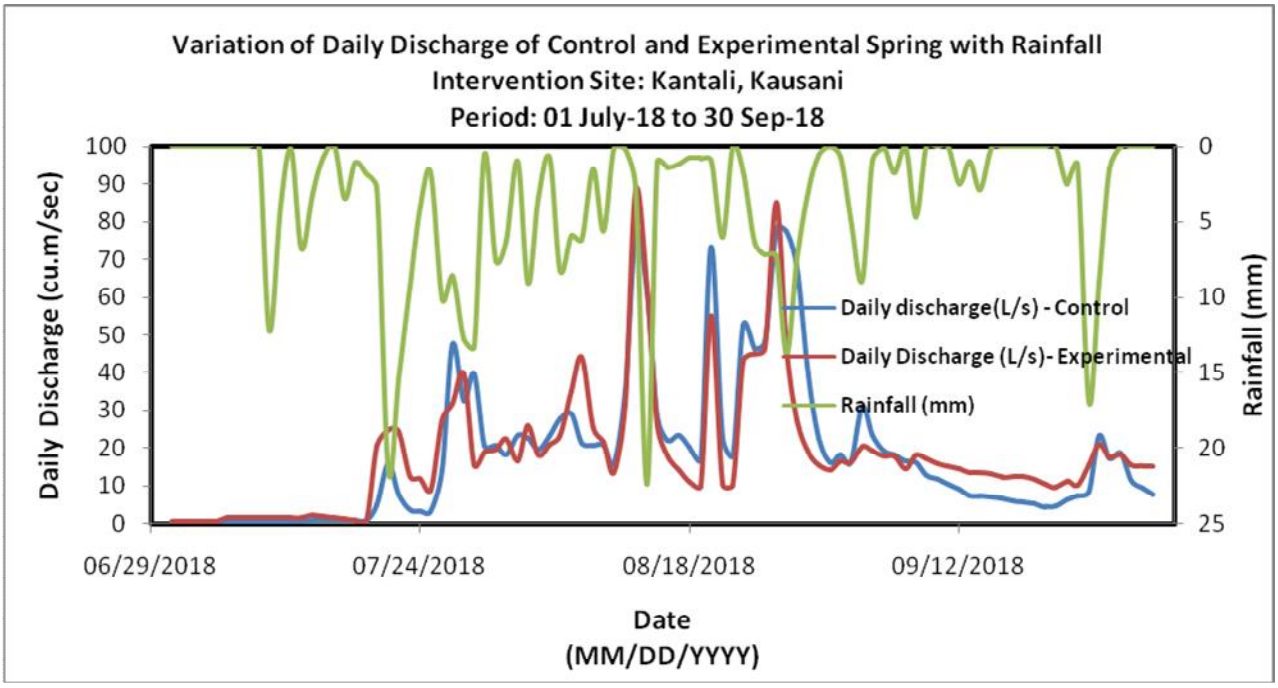
The conclusion inferred from chemical analyses indicate that the water of 95.1% spring is chemically potable in the study area and found suitable for domestic uses, since the various ionic concentration and parameters are generally within the maximum acceptable limits of the drinking water specification (ISO 10500:2012). Some spring (4.9%) have higher than permissible range of EC (300µS) as per drinking water standards and considered as nonpotable. Although pH of some springs are also lower than 6.5 but it was temporary (season specific). Drinking water [quality] Guidelines limit of 1 NTU as desirable and 5 NTU as permissible for turbidity showed that water of some spring (33% in pre-monsoon and 24% in post-monsoon) have higher turbidity and should not used directly for drinking. Higher turbidity in drinking water may not cause adverse health effects for human. The most important and interesting thing came into knowledge through chemical analysis about spring water in this area is Magnesium-bicarbonate type of water, which has been proven to be very healthy and good for digestion and healthy water for drinking throughout year with insignificant seasonal changes. The hydro-geochemical studies of spring's water in upper Kosi river basin revealed that the water samples were neutral to slightly basic (6.52-9.6) in winters (i.e. post-monsoon) and slightly acidic to slightly basic (5.93-9.78) in summers, soft and moderately hard (10.5-117.60 mg/L in summer, 8.4-147 mg/L in winters). Hydro-chemical analysis of the spring water samples exhibit that Ca2+ (19.69mg/l) was the prominent cation followed by $Mg2^{+}$(6.94mg/l). Among anions, HCO3- is the most dominant anion followed by SO4 .The electric conductance of water (EC), pH, TH, cations (Ca2+, Mg2+, Na+, K+) as well as anions (NO3-, Cl-, HCO3-) are well below the BIS drinking water standards except some springs (lower pH) temporarily and particularly in summers. Chemical parameters indicated that the springs are chemically potable in the study area and found suitable for domestic uses after treatment of turbidity which was high in most cases. Apart from that, the mountain water in upper Kosi basin have magic qualities and have great potential to attract mineral water industries.

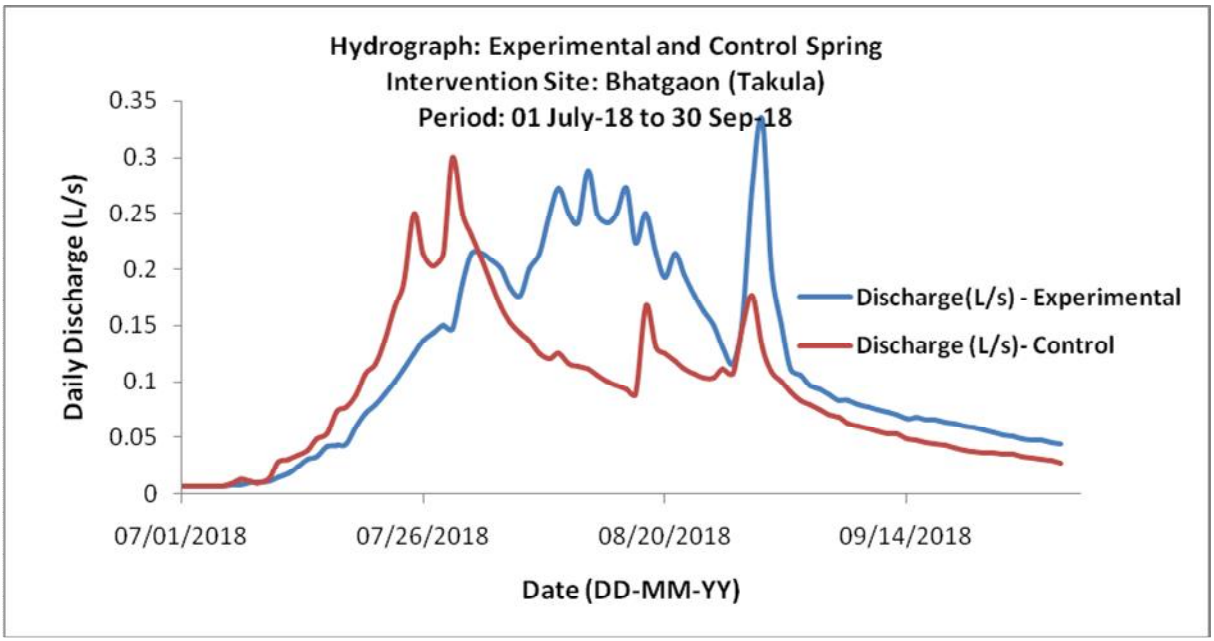
Table 3: Drinking water specification as per Bureau of Indian Standard (BIS) for water quality.

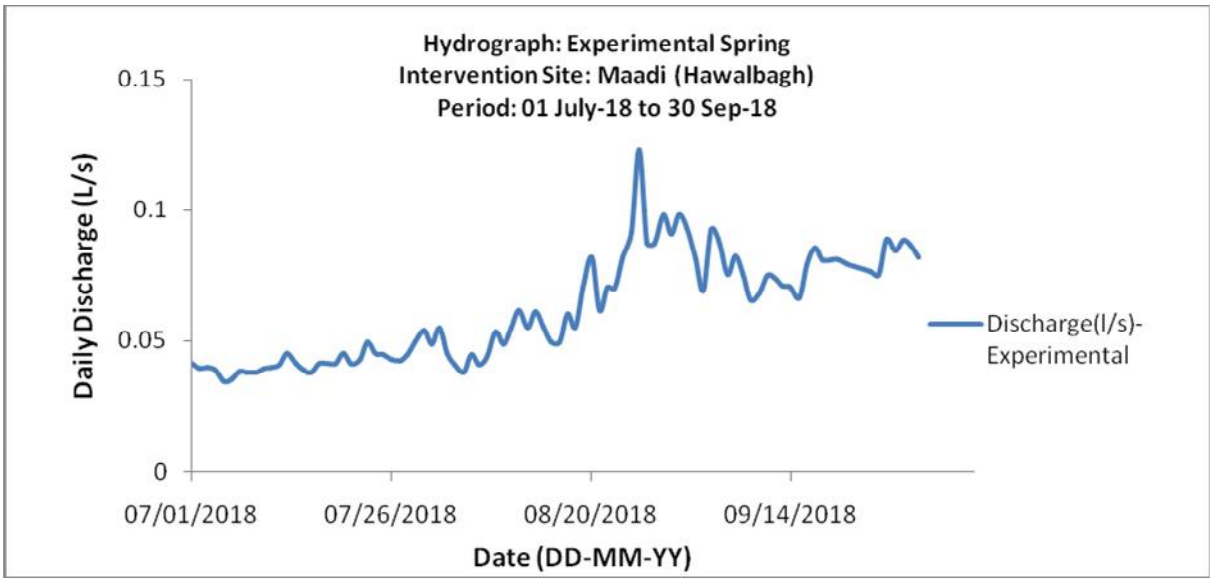
Drinking water specification(n=88)						
Parameters	***Acceptible limit***	***Permissible limit***	**18-Nov**			**Comment**
			Min	**Max**	**Mean**	
Turbidity (NTU)	1	5	0	60.2	5.826329114	**High in 24% springs**
TH	200	600	24	332	71.15	all acceptable
Calcium (mg/L)	75	200	3.36	132.6	19.698625	all acceptable
Magnesium (mg/L)	30	100	1.17	50.06	6.942875	all acceptable
Chloride (mg/L)	250	1000	1.42	5.68	2.919875	all acceptable
Sulphate (mg/L)	200	400	2.27	32.45	6.3355	all acceptable
Nitrate (mg/L)	45	None	0.1	8.81	1.2355	all acceptable
Fluoride (mg/L)	1	1.5	0.018	0.0987	0.047187342	all acceptable
Alkalinity (mg/L)	200	600	50	275	131.875	all acceptable
EC	300	None	16.3	698	106.65125	All acceptable except 4 springs
pH	6.5-8.5	None	6.52	9.6	7.774	All acceptable except 8 springs

Discharge Measurement in Upper Kosi Basin:

Observation at intervention sites: Observed data from different intervention sites has been compiled. Figure 2 indicated the variation in discharge of experimental and control springs at different intervention sites. Discharge data at various intervention site indicated increase in discharge at experimental spring as compare to control one. Figure 2 indicated discharge of control and experimental springs at various intervention sites.


Variation of Daily Discharge of Control and Experimental Spring with Rainfall
Intervention Site: Kantali, Kausani
Period: 01 July-18 to 30 Sep-18
Daily Discharge (cu.m/sec)
Rainfall (mm)
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
06/29/2018
07/24/2018
08/18/2018
09/12/2018
Date
(MM/DD/YYYY)
Daily discharge(L/s) - Control
Daily Discharge (L/s)- Experimental
Rainfall (mm)


Hydrograph: Experimental and Control Spring
Intervention Site: Bhatgaon (Takula)
Period: 01 July-18 to 30 Sep-18
Daily Discharge (L/s)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
07/01/2018
07/26/2018
08/20/2018
09/14/2018
Date (DD-MM-YY)
Discharge(L/s) - Experimental
Discharge (L/s)- Control



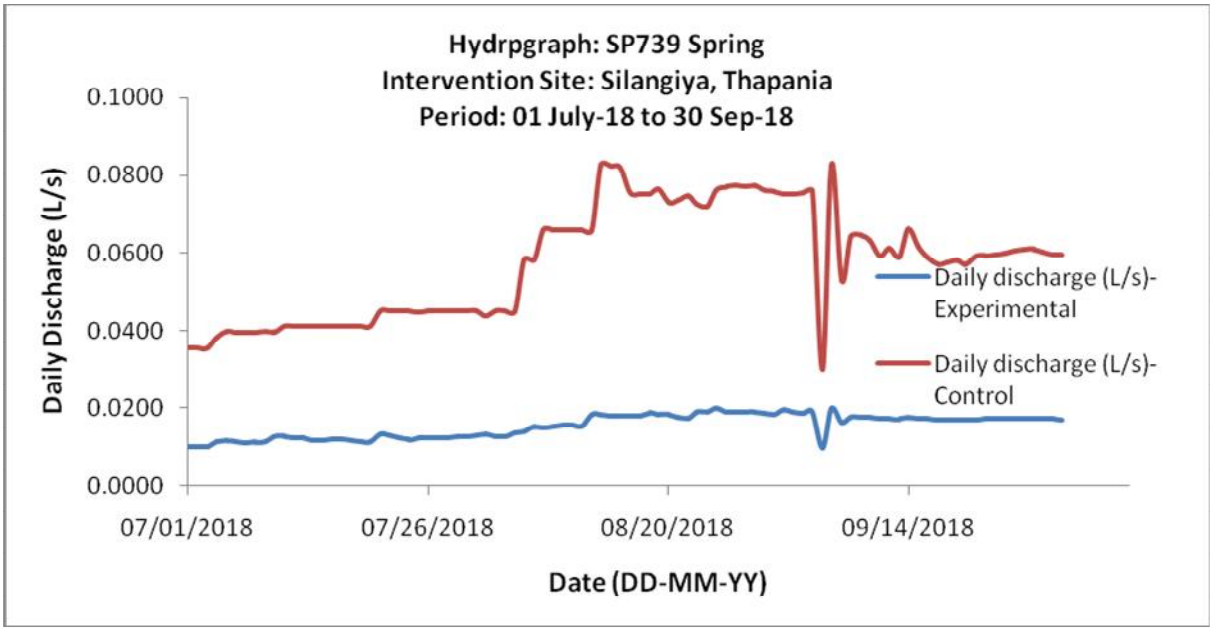


Figure 2: Discharge (L/s) of control and experimental springs at different intervention sites

Rainfall and discharge: Among all 09 rains gauging stations highest total rainfall was recorded at Panchayat Ghar, Bholgaon (368.28 mm) while lowest total rainfall was recorded at Primary School, Maave (223.33 mm) during reporting period (July-September). Discharge recorded at three stream gauging stations has been given in Table 1. Lowest discharge was recorded in May at Kantali and Kosi bridge while lowest discharge was recorded in April month at Ranman stream gauging station.

Table 4: Discharge (cu.m/s) at stream gauging stations

Month	Discharge (cu.m/s)			Monthly Volume (Ha.m)
	Minimum	Maximum	Ave. Monthly	
	Kantali			
July-18	0.0124	3.2994	0.3638	72.3125
Aug-18	0.6454	4.0342	1.2485	248.1146
Sep-18	0.2380	1.0294	0.5286	105.0498
	Ranman			
July-18	0.3219	26.4900	6.3055	1688.871
Aug-18	8.8510	33.3629	20.8332	5579.853
Sep-18	1.2231	55.6186	17.3783	4654.606
	Kosi bridge			
July-18	1.0860	7.4919	3.3053	856.7360
Aug-18	NA	NA	NA	NA
Sep-18	NA	NA	NA	NA

Soil moisture and temperature: In order to see the impacts of groundwater augmentation structures on volumetric moisture content of soil and its temperature as well as variation in these parameters with elevation along experimental streams catchment before and after the treatment. Data compiled from three soil moisture and temperature sensors installed along the gauging site Kantali, Kausani shows that with increasing altitude, soil temperature (at 20cm depth) decreases from 20.96 °C at 1747 m amsl to 18.92 °C at 1796 m amsl. The average difference of soil temperature between top and bottom most measuring site is 1.03 °C. Though the volumetric moisture content (VMC) of soil mass decreases with altitude (at 20 cm depth). The average difference of VMC between top most and bottom most sensor is 0.1266 cu.m/cu.m (July-18 to Sep-18).

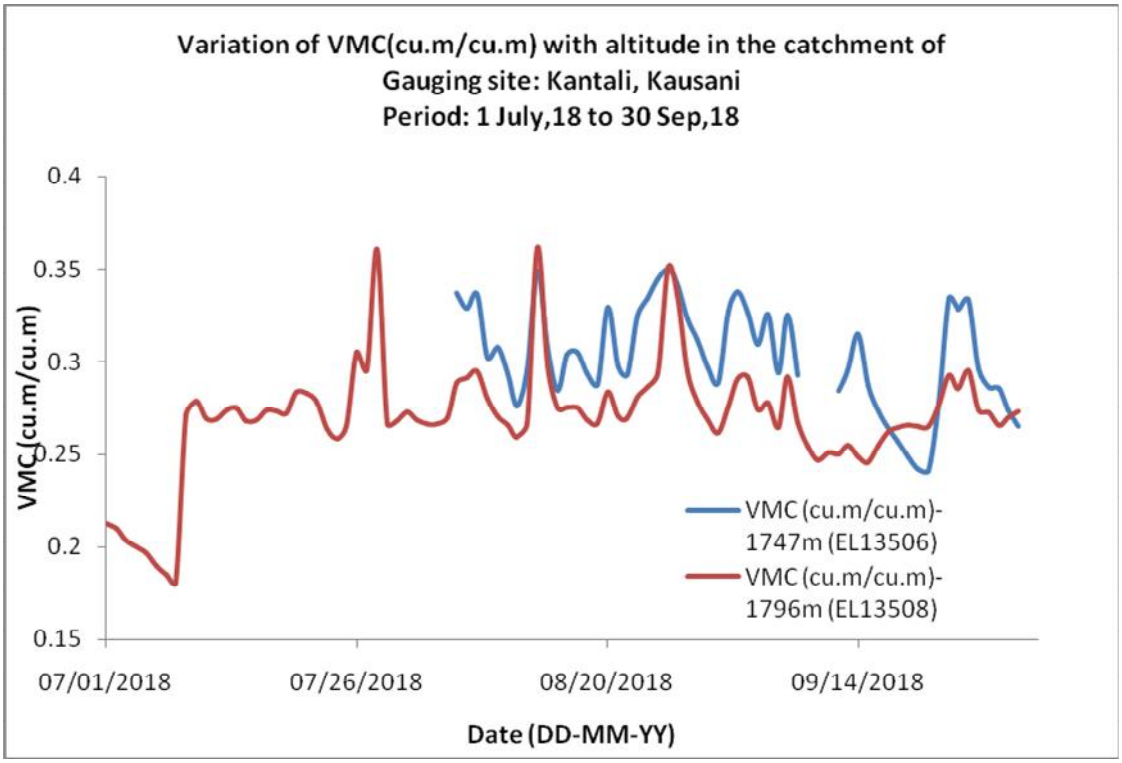


Figure 3: Variation of VMC for Gauging site: Kantali, Kausani

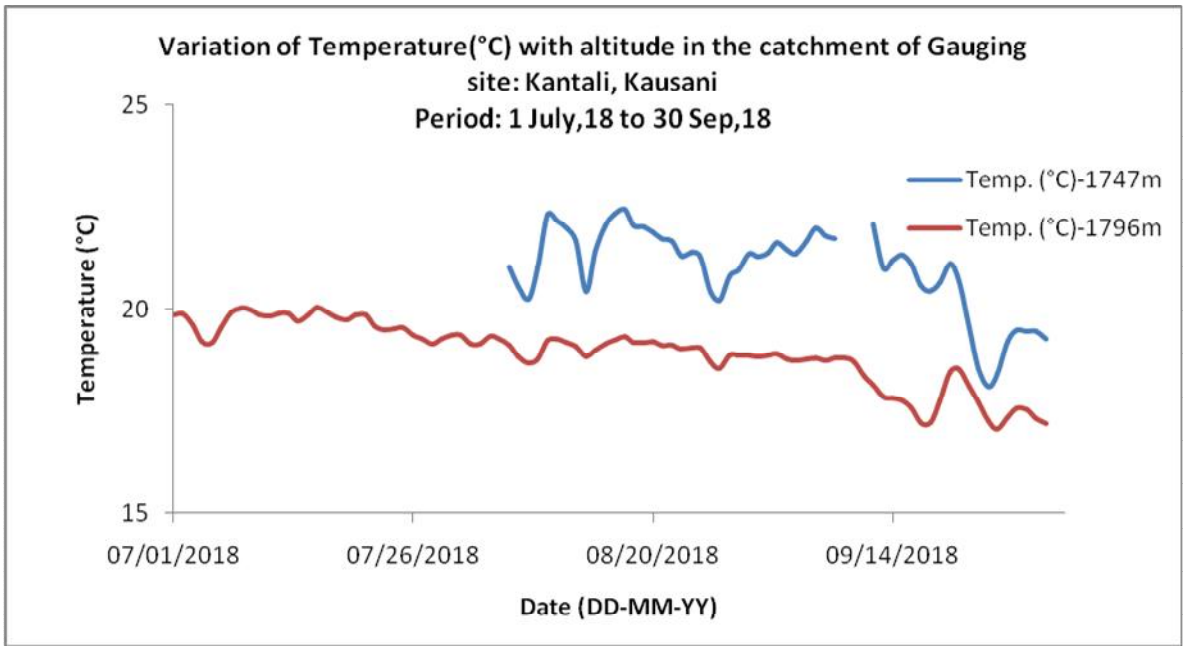


Figure 4: Variation of Temperature (°C) with altitude for Gauging site: Kantali, Kausani

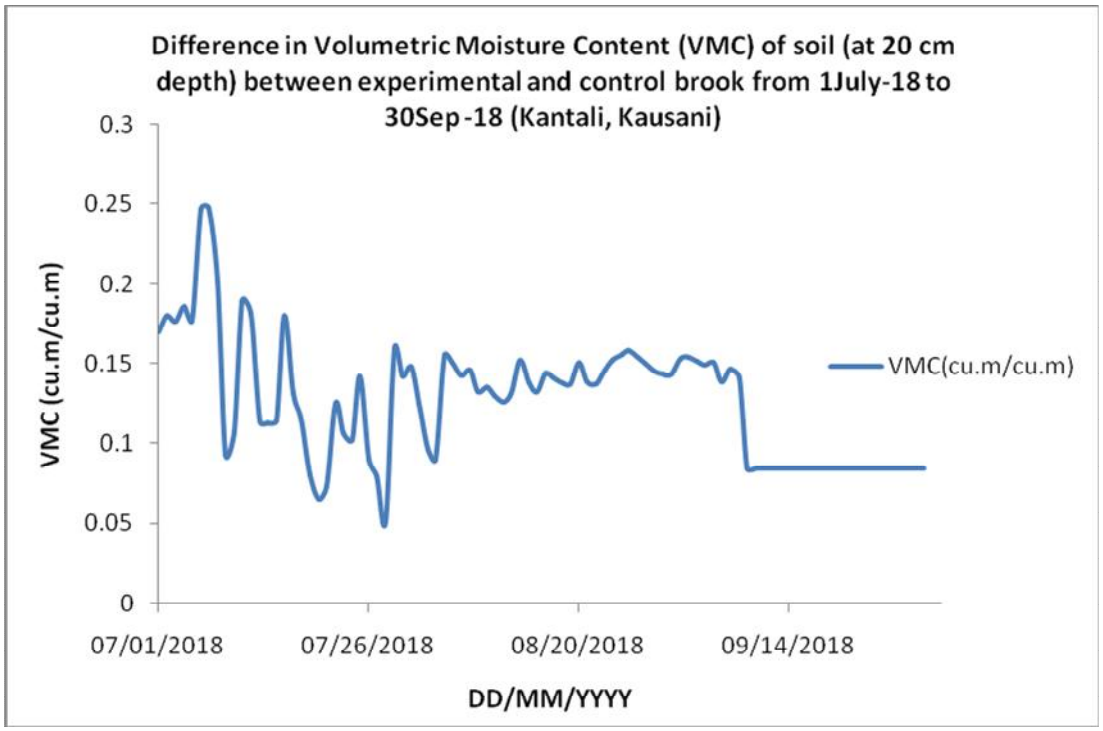


Figure 5: Difference in Volumetric Moisture Content (VMC) of soil (at 20cm depth) between experimental and control brook

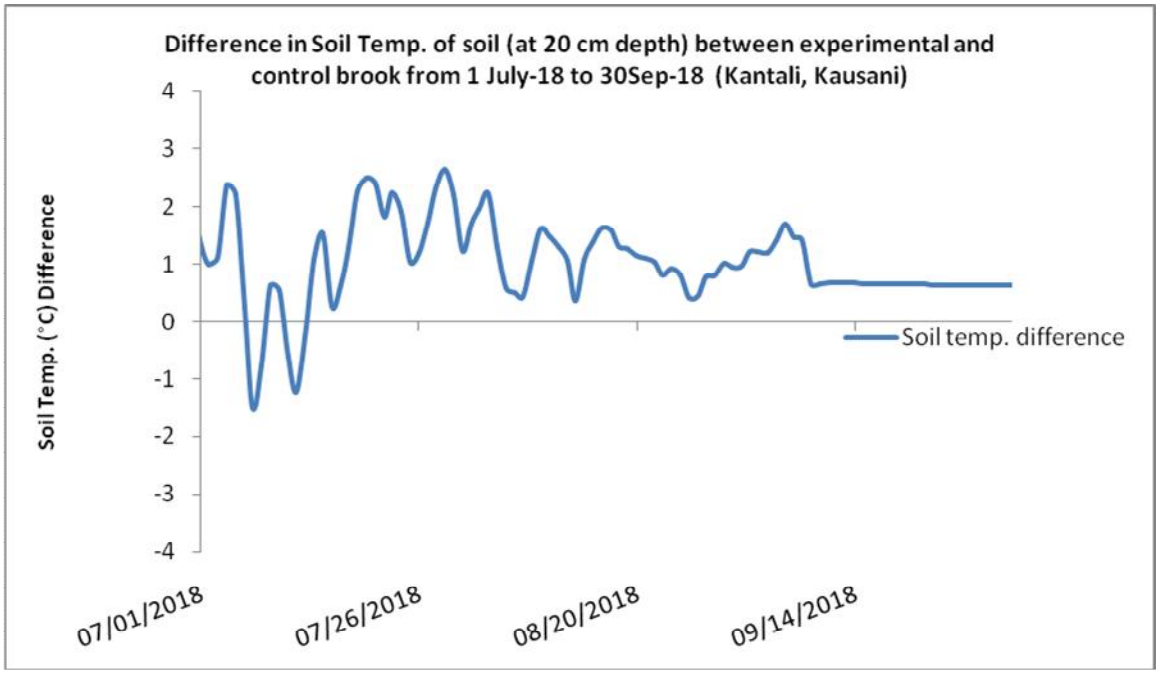


Figure 6: Difference in Soil Temp. of soil (at 20 cm depth) between experimental and control brook