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Chapter 6

Community based Springshed Development in Response to Drying Springs in Nagaland

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INTRODUCTION

As per the climate change trends, the period from 2021-2050 is likely to be most vulnerable for Nagaland (Ravindranath 2011). During this period Nagaland will observe heavier precipitation during the monsoon and increase in frequency of extreme events. The annual average temperature is likely to by warmer as compared to the present and there would be increase in number of drought weeks by 20-25 percent (PSI 2016-17).

Groundwater is the predominant source of water for drinking and agricultural purposes. In mountainous and hilly regions, springs become most common surface expression of groundwater. Springs are point sources of groundwater that are fed by aquifers formed by systematic arrangement of rocks. This system of rocks is capable of storing and transmitting sufficient quantities of water (to the springs).

Having established springs as groundwater, it is important to note that groundwater is a common pool resource and the effects of augmentation by a few are enjoyed by many, while on the other hand, the effects of over extraction of the same aquifer by a few–through wells or springs-can also harm a larger population dependent on them. Such disturbance also severely impact ecological flows in a stream or river, as springs are the base flows that contribute to the river system. Depending on the severity of impact the rivers can turn seasonal from perennial.

Mountainous regions are characterised by complex geological systems, with a diverse set of rocks bearing various structural features. Above the surface, water follows the principle of 'path of least resistance and hence conforms to the concept of watershed. Even when the water follows the same principle in subsurface, the arrangement of rocks inside the earth are of different set-up. Difference in elevation and arrangement of obstruction indicates that the boundary of watershed will differ from that of springshed. Thus, augmentation programmes need to be modified to factor this and change the 'ridge-to-valley' approach of watersheds into a 'valley-to-valley' approach. The above-explained concept defines springshed.

Adding further to the concept, majority of the programs focus solely on management of springs and seldom pay attention to the aquifers. Very often, the aquifer feeding a spring in one watershed may have its recharge area in another watershed. In such a case, the management activities in the watershed where spring emerges may not have desired impact given the aquifer feeding that spring has its recharge area in another watershed. Thus, there is dire need to shift the focus from source (spring) to resource (aquifer) to develop a sustainable model for springshed management.

BACKGROUND

Nagaland is the youngest Himalayan mountain ranges in the world. It is situated in the extreme North East of India. It is a tectonically active area (Seismic Zone-V) due to which diverse kinds of rock formations exist here. Geologically, Nagaland is mostly a sedimentary terrain. Metamorphic and Igneous rocks are found in some south-eastern parts apart from sedimentary rocks. These are the areas of Saramati formation. It has rich deposits of heavy metals like chromite and megnatite.

After the formation of the state of Nagaland, the water resource development has not received much deserved attention and priority. According to the Nagaland Water Policy (2016) under Department of Soil and Water Conservation, Government of Nagaland, submitted by Indian Environment Law Offices One of the main reasons for not being able to effectively conserve natural resources in Nagaland has been the fragmented institutional management. The overlap in mandates have resulted in water resource related concerns and challenges.

Community-led springshed development program aims to deal with the institutional and climate change induced water insecurity. This program is based on the principles of participatory groundwater management (PGWM). Through this program the target has been to achieve SDG 6 that is aimed at 'ensuring availability and sustainable management of water and sanitation for all. By training the community in trained and made aware of the natural resource disasters that loom over and is climate change induced. Involvement of community in this program enables resilience preparedness.

METHODOLOGY

Land Resources Department (LRD), Nagaland initiated pilot project on Springshed development in the year 2016 for 11 springs in Nagaland. LRD along with People's Science Institute (PSI), Dehradun developed an intervention plan to carry out spring recharge in these critical springs. The site selection was carried out based on the unstructured

Table 1: List of Selected Villages & Springs

S. N	District	Block	Village	Spring	Co-ordinates	Household Dependency	Beneficiaries (Approx.)
1	Zunheboto	Tokiye	Lukikhe	Kili Ghoki	N26°01'23.7'' E94° 38'29.0''	86	565
2	Wokha	Sanis	Chudi	Ratchu	N26°07'58.3'' E94° 08'47.2''	35	180
3	Tuensang	Chare	Longkhitpeh	Amungru Khikha	N26°16'59.9" E94°38'40.9"	87	532
4	Phek	Pfutsero	Gidemi	Ruzaru	N25°37'29.94'' E94°22'51.05''	20	100
5	Peren	Athibung	Pielhang	Canaan	N25°33'43.1'' E93°33'48.7''	60	300
6	Mon	Tizit	Old Jaboka	Khoatnu	N26°56'03.3" E95°10'43.0"	15	90
7	Mokokchung	Ongpangkong	Kinunger	*Sebtsu*	N26°22'27.1''	40	200
8	Longleng	Longleng	Dungkhao	*Johjong yung*	N26°30'59.1" E94°50'18.4"	45	230
9	Kohima	Chiephobozou	Thizama	*Peso Dzukhou*	N25°44'37.3'' E94°6'27.05''	207	1035
10	Kiphire	Sitimi	Tethuyo	*Aseriite*	N25°49'29.2" N94° 46'29.8"	72	300
11	Dimapur	Nuiland	Ghokuto	*Aphu Ghoki*	N25°51'52.7'' E93°56'43.3''	40	190
Total						**707**	**3722**

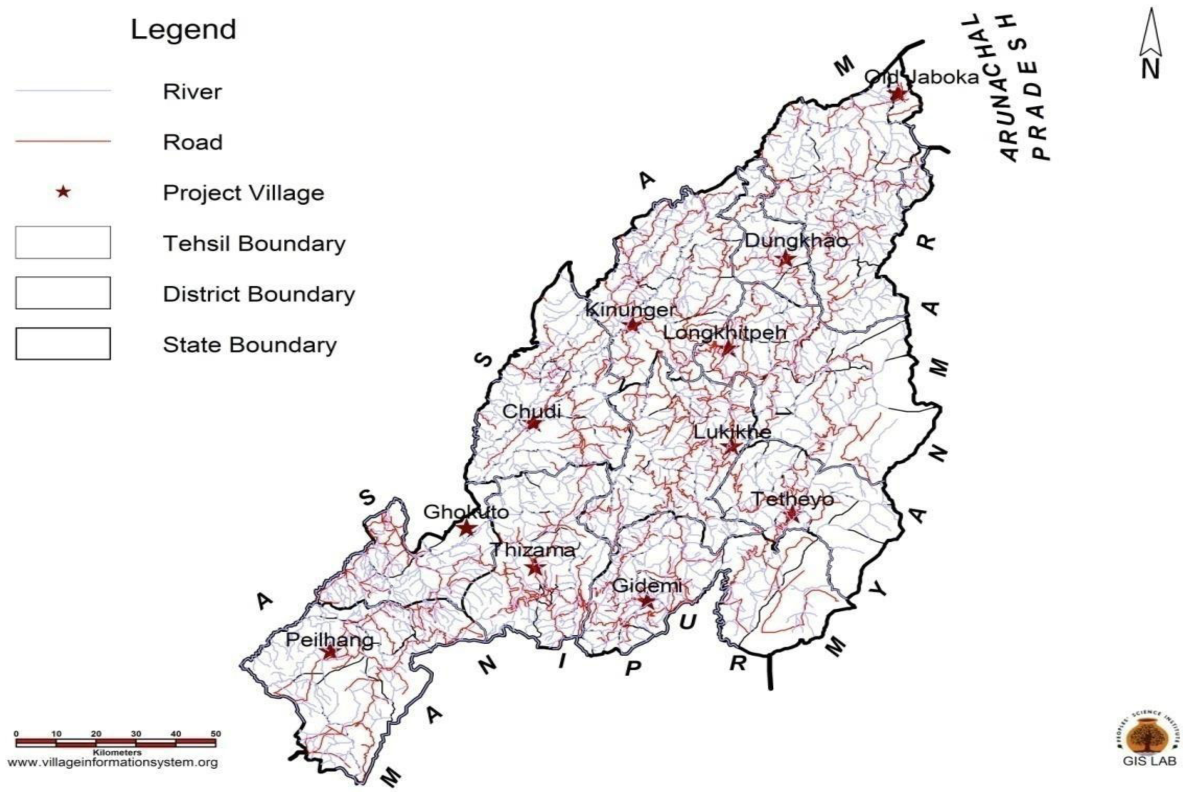


Fig. 1: Location of Pilot Villages

interviews conducted with the community to know about the spring discharge decline over a period of time in these areas. Table 2 provides a list of villages that were selected villages. Following are the factors that were considered during the selection of springs:

- Dependency of the village community on the springs.
- Decline in spring water discharge over the years.
- Water demand and supply gap.
- Willingness of community to participate in spring recharge program.
- Geological feasibility pertaining to the recharge potential of springs.
- Medium sized village (50-150 households)
- Economical backwardness.
- Minimum reach of government programmes.
- Willingness of the village community to participate in the program.

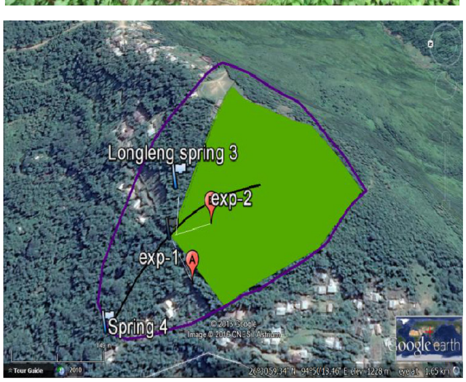
Training

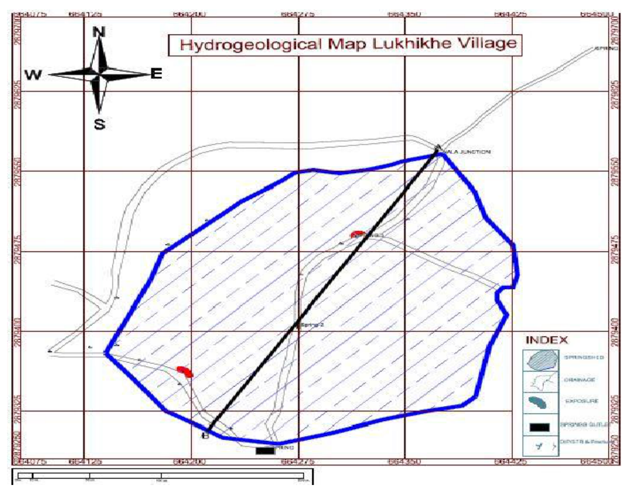
Our training follows a trickle down principles. Both the department official and community members are given training where they are explained fundamental concepts of water cycle, groundwater occurrence in aquifers, hydro-geology, rock types and so on. Thereafter officials and the community work together Classroom training Field training towards achieving water security. Hand-holding is also provided by the official who are provided assistance by geologist in PSI on need basis. The aim of the workshop was to prepare a cadre Engineering Measures Discharge Measurement of local para-hydrogeologists by providing them training in regeneration of springs and involvement of the local training workshop communities. The training measurements, estimation of water demand and supply gaps, hydro-geological studies for recharge area demarcation, measures (engineering, vegetative & social) for spring recharge and issues related to water quality, equity and sustainability of groundwater resources.

Fig. 2: Classroom and Field Sessions during the Training Workshop

Data Collection and the Process of Hand-holding

During the training workshop the community is trained to also collect relevant data on a regular basis. The data includes spring discharge, quality of its water and rainfall measurements. The hydro-geological mapping also includes the participation of officials and community members. After their thorough training in geological mapping the community is given the charge to conduct mapping while the geologists of PSI assist them. The aim of this exercise is to map the underlying aquifer and understand the drainage pattern of the sites, identification of rock and spring typologies, demarcation of recharge zones. The community also does a water supply and demand estimation of their village, which helps them in understanding their water consumption, patterns and make suitable changes if required.





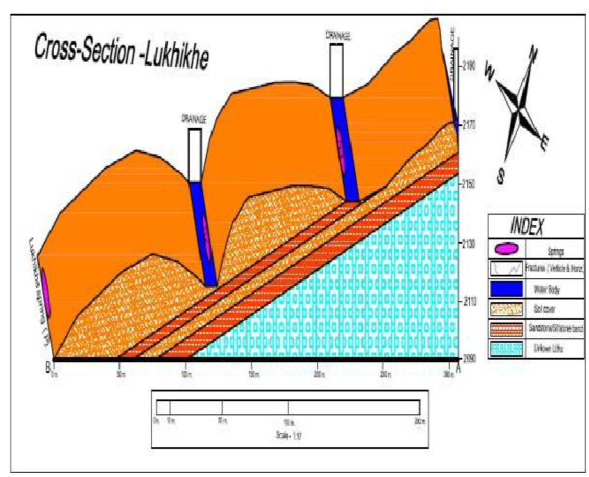


Fig. 3

The following table provides a snippet of treatment measures

Table 2: Spring Treatment Measures

District	Zunheboto	Wokha	Tuensang	Phek	Peren	Mon
Village	Lukikhe	Chudi	Longkhitpeh	Gidemi	Pielhang	Old Jaboka
Spring Name	Kili Ghoki	Ratchu	Amungru Khikha	Ruzaru	Canaan	Khoatnu
Spring type	Depression	Depression	Depression & Contact	Fracture & Contact	Depression	Fracture & Contact
Seasonality	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial
Specific recharge area (hectares)	0.9	0.6	0.6	0.9	0.9	0.9
Land Use (recharge area)	Mixed forest & shifting cultivation	Partly habitation and kitchen gardening (slash& burn)	Mixed cultivation (trees/vegetables) & partly habitation	Mixed forest	Mixed cultivation (trees/vegetables) & partly habitation	Mixed forest
Land ownership	Community & Individual	Clan	Individual	Community & individual	Community	Individual
Size of Trenches (SCT)	2 × 0.6 × 0.45 m (40-50% slope)	2 × 0.45 × 0.45 m (30-50% slope)	2 × 0.45 × 0.45 m (30-40% slope)	2 × 0.45 × 0.45 m (30-40% slope)	`2 × 0.6 × 45 m (30-50% slope)	2 × 0.6 × 0.45 m (40-50% slope)
No. of trenches	200	60	35	160	150	4
Vertical interval (contour)	8-10 m	8-10 m	8-10m	8-10 m	8-10 m	8-10 m
Proposed no. of saplings/tree plantation	700	55	270	600		

Table 3: Spring Treatment Measures (contd.)

District	Longleng		Kohima	Kiphire	Dimapur	Mokokchung
Village	Dungkhao		Thizama	Tethuyo	Ghokuto	Kinunger
Spring Name	Johjong yung		Peso Dzukhou	Aseriite	Aphu Ghoki	Sebtsu tsubu
Spring type	Depression		Depression & Contact	Fracture & Contact	Fracture & Contact	Depression & Contact
Seasonality	Seasonal		Perennial	Perennial	Perennial	Perennial
Specific recharge area (hectares)	0.9		0.6	0.9	0.9	0.6
Land Use (recharge area)	Mixed cultivation (trees/vegetables) & partly habitation		Mixed forest & partly habitation	Mixed forest & shifting cultivation	Mixed forest & partly habitation	Mixed forest & partly habitation
Land ownership	Individual		Individual & community	Individual	Individual & community	Individual
Size of Trenches (SCT)	2.5 X 0.6 X 0.6	20% - 30% (slope)	2 × 0.45 × 0.45 m (30-50% slope)	2 × 0.45 × 0.45 m (30-40% slope)	2 × 0.45 × 0.45 m (30-50% slope)	`2 × 0.6 × 45 m (30 - 50% slope)
	2 X 0.6 X 0.45	30% - 40% (slope)	(2 percolation tanks		60	
	2 × 0.45 × 0.45	40% - 50% (slope)	-5x3x0.6 m)		8-10 m	

Field Facilitation and Capacity Building

Post hand-holding, the trainees were given some time to complete the information collected by them, interact with the communities, design the interventions required and work on their own in their respective areas. A second phase of the training was then organized from 16–28 October, 2016. In this training, the trainees of the previous training workshop who had been guided through hand-holding exercises were the resource persons under the supervision of PSI team. The participants were other WDT members and community representatives who would be involved in springshed development work. There were a few APOs and AIs as well. The focus of this training workshop was presentation of the information gathered by the trainees after the hand-holding, revision of the concept of PGWM/springshed development, dissemination of the knowledge to other participants in the workshop and preparation of plans for spring recharge works.

Fig. 4

RESULTS AND DISCUSSION

Hydrographs were developed for selected spring. In every spring shed rain gauge has been installed. The precipitation data from rain gauges was incorporated into the spring hydrographs in order to analyze the response from recharge events particularly post and pre implementation phase. Available data shows increased discharge after implementation all across the seasons and it helped to reduce the water demand and supply gap during lean season.After performing a careful analysis of these hydrographs, it appears that most of the springs are more responsive to recharge events during post implementation phase.

Increased Discharge in Lean Season

Based on monthly collected data of discharge of springs increased discharge during lean season is clearly visible.

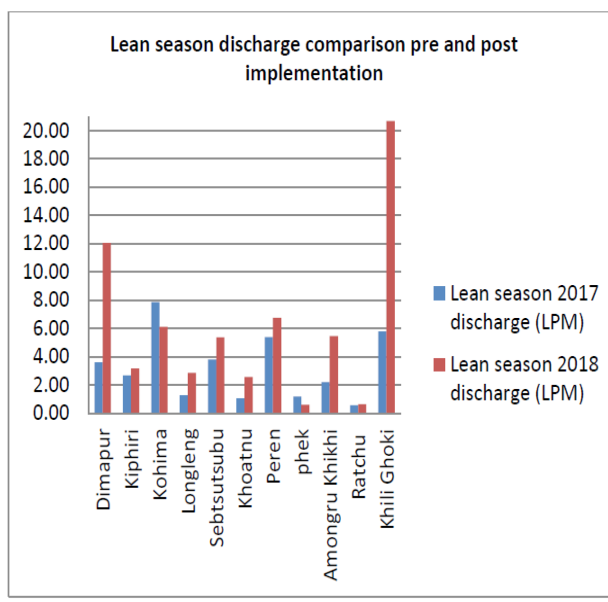


Fig. 5: Lean Season Discharge Comparison Pre and Post Implementation

In North eastern region of India December, January and February are the months which are normally considered as lean period because this time of year we receive less amount of rainfall in comparison of whole year. From March onwards the region start getting pre monsoon rain. We took the average of lean season discharge in pre and post implementation phase. The results suggest that the average lean season discharge has increased in 10 springs. In most of the cases the increase is significant.

Most of the implementation was done during February-march 2017. During implementation slope is considered as an important factor. Being a hilly terrain we could not utilize whole the recharge area. Basically our intervention were restricted upto slope of 50 percent beyond that only vegetative measures were considered. Size of trenches was also based on slope. As slope increases size of trench decreases gradually.

Reduced Demand and Supply Gap

To ensure, that every rural person has enough safe water for drinking, cooking and other domestic needs as well as livestock,NRDWP has fix some norms which is following:

Table 4: NRDWP Norms in Rural Areas

Purpose	Quantity (lpcd)
Drinking	3
Cooking	5
Bathing	15
Washing utensils and house	10
Ablution/Toilets	10
Washing of Clothes and other uses	12
Total	**55**

Our demand side is considered based on the same norms as 55 litre/capita daily and supply side was discharge of the springs. It is observed that during monsoon in most of the cases that demand is fulfilled due to access amount of water but during the lean season gap between demand and supply is wide. So if there is increased in discharge during lean season this gap can be filled.

Sebtsutsubu Spring (Mokokchung)

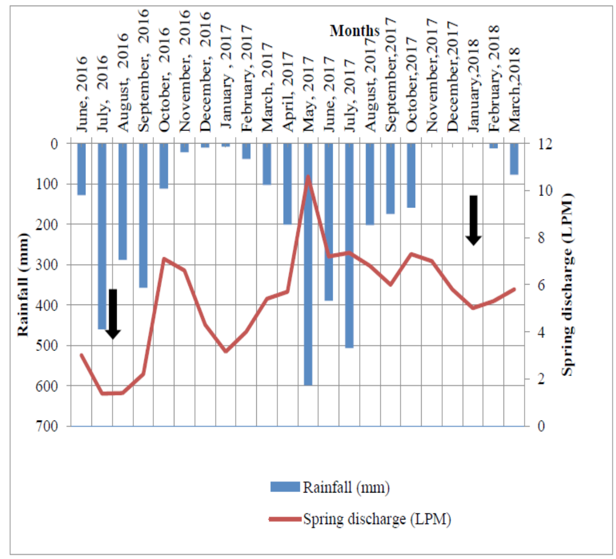


Fig. 6: Hydrograph of Sebtsu Tsubu

The impact of recharge interventions are clearly visible the spring is yielding more water even in lean season of 2018 than monsoon 2016 which is marked with bold indicator.

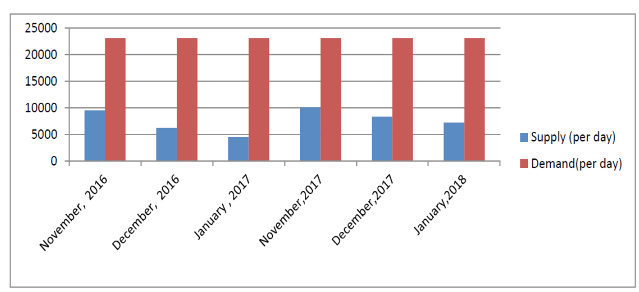


Fig. 7: Demand Supply Gap of Sebtsutsubu Spring during Lean Season (Pre and Post Implementation Phase)

The spring discharge increased from 3.1 LPM in January 2017 to 5 LPM in June 2018 after the spring recharge interventions. It compensated around 80000 ltr. Water in January 2018 month only (refer calculation below)

Spring discharge in January, 2017 (Pre-treatment)		
Discharge of spring =3.1 lit/min Supply of spring per month = 3.1*60*24*30 **= 1,33,920 lit/month**	Demand/month = 40*6*55*30 **= 3,96,000 lit**	Gap in Supply per month = **2,62,080 lit**
Spring discharge in January, 2018 (Post-treatment)		
Discharge of spring = 5 lit/min Supply of spring per day= 5*60*24*30 **= 2,16,000 lit/month**	Demand/month = 40*6*55*30 **= 3,96,000 lit**	Gap in Supply per month = 1,**80,000 lit**

Khoatnu Spring (Mon)

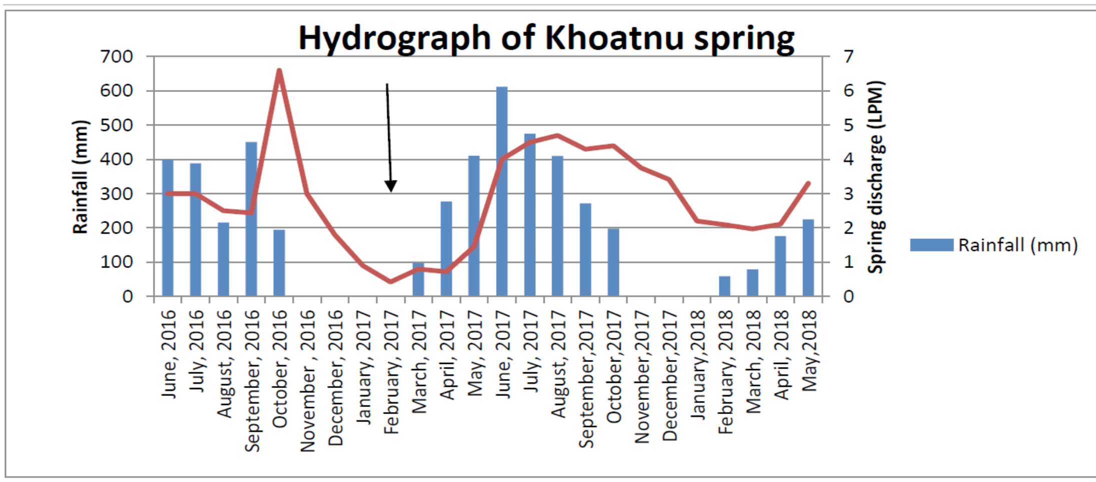


Fig. 9: Hydrograph of Khoatnu Spring

Spring discharge in January 2017, (Pre-treatment)		
Discharge of spring =.9 lit/min Supply of spring = .9*60*24 **= 1296 lit/day**	Demand/day= 15*6*55* **= 4950 lit**	Gap in Supply per day = 3654 **lit/day**
Spring discharge in january, 2017 (Post-treatment)		
Discharge of spring = 2.2 lit/min Supply of spring per day= 2.2*60*24 **= 3168 lit/day**	Demand/day= 15*6*55 **= 4950 lit**	Gap supply per day = **1782lit/day**

Spring shows increased discharge during lean season and it sustained water during the lean season. The intervention was done during February 2017. After that it has shown some good results as per discharge as well as quality.

The spring discharge increased from 0.9 LPM in January 2017 to 2.2 LPM in June 2018 after the spring recharge interventions and when we talk about lean season its really crucial because of the distance of alternate sources in old jaboka village. It compensated around 1872 ltr. Water daily in January 2018 month only (refer calculation above)

Demand, and Supply Gap of Khoatnu Spring (Pre/Post) Intervention Results

Amongru Khikha (Tuensang)

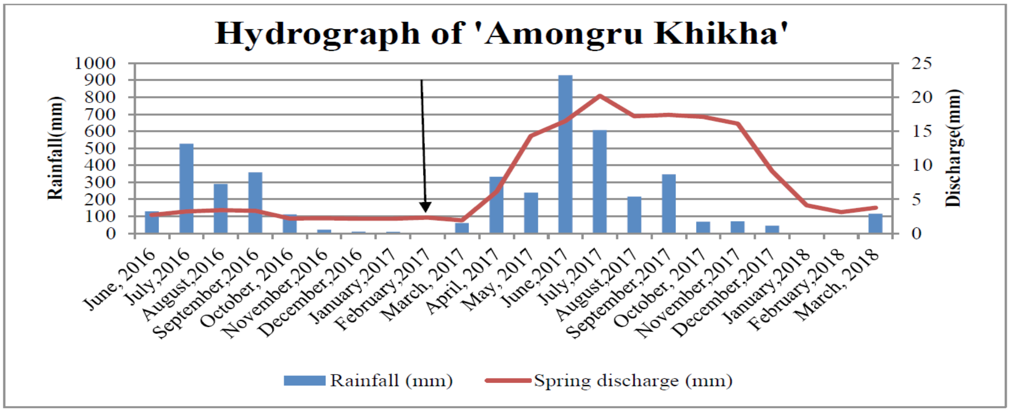


Fig. 11: Hydrograph of Amongra Khikhi (Pre/Post Intervention)

The intervention was done during January and February 2017 after comparison we can clearly see that spring retains good amount of water during the lean season also and gives good response to rainfall pattern. After intervention rainfall is impacting to discharge at a higher rate.

Ratchu Spring (Wokha)

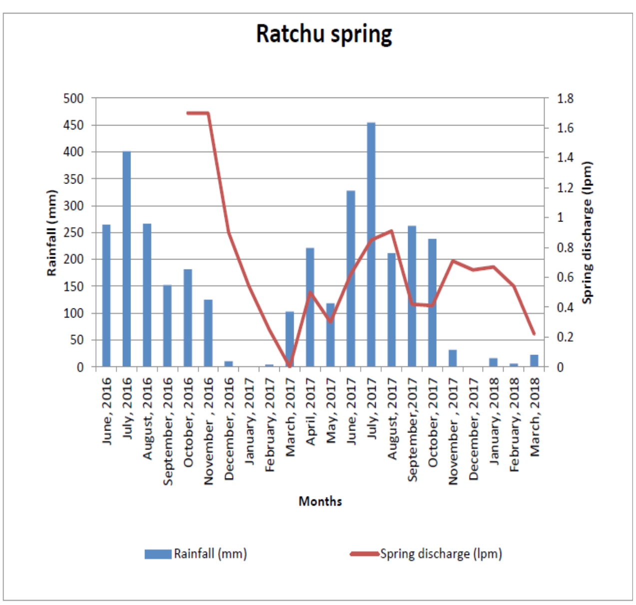


Fig. 12 Hydrograph of Ratchu spring

Based on Hydrograph we can clearly state that the spring used to go dry during lean season but after implementation it sustain water in it and did not show any type of erratic pattern which is used to show before the implementation. Here we must have to mention that the recharge area of ratchu spring was already small half of the recharge area has slope more than 50 percent.So very limited no. of recharge activities are being done there.

Canaan Spring (Peren)

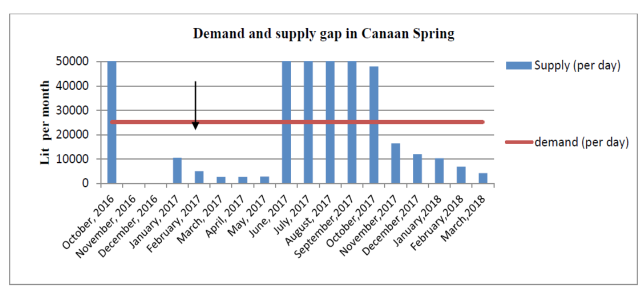


Fig. 13: Water Demand and Supply Comparison of Pre-and Post-treatment in Canaan Spring

Canaan spring shows drastic change in the discharge pattern. Despite of that supply side during the lean season has increased in post implementation phase.

Response to Rainfall

The springs has shown some different trend as per discharge. After intervention phase we can see some rapid increase in discharge of spring which is directly proportional to rainfall. When comparing two springs (Figs.7 & 8), the results suggest that both the springs are responsive to rain events after implementation phase while discharge shows marginal impact of rainfall before the implementation.

Kili Ghoki (Zunheboto)

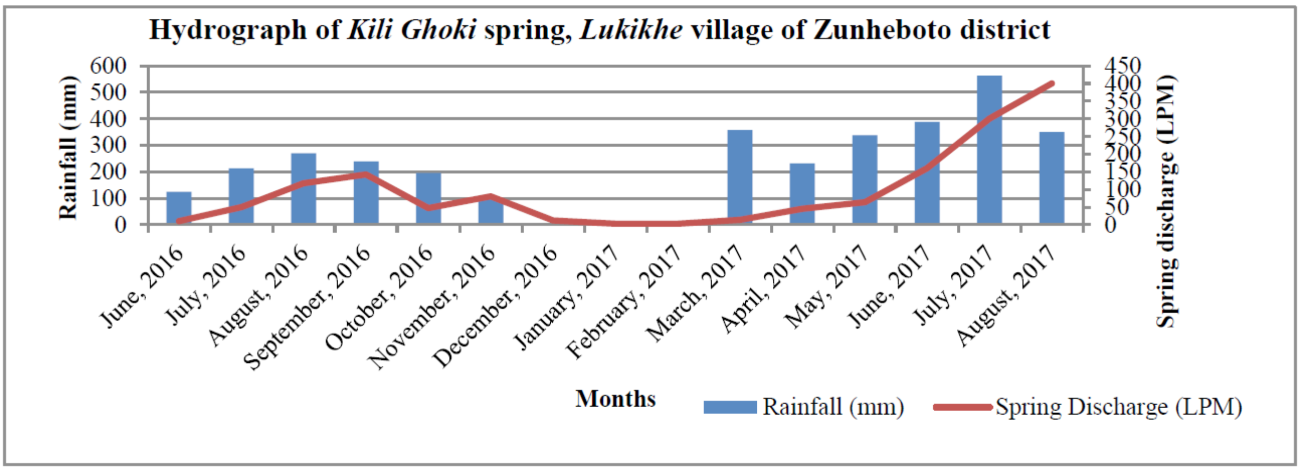


Fig. 14: Hydrograph of 'Kili Ghoki' Spring

Apu Ghoki (Dimapur)

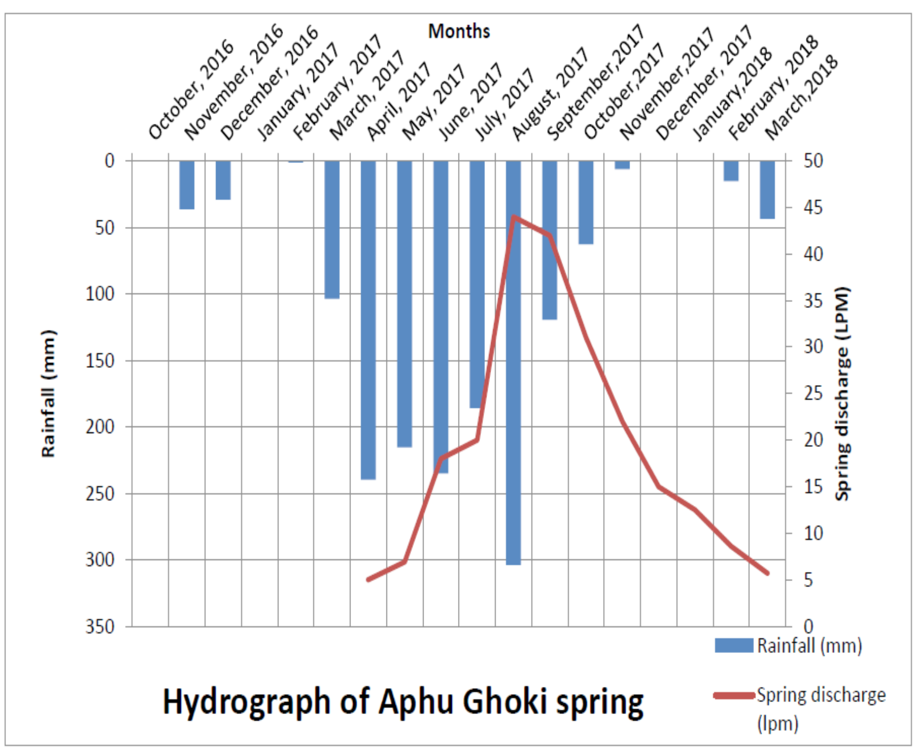


Fig. 15: Hydrograph of 'Apu Ghoki' Spring

In Kili Ghoki springshed from June 2016 to march 2017 it rained 1494 mm. while during this period average discharge of the spring was 51.79 lpm.After implementation it rained 1948 mm. from June 2017 to march 2018 in this period average discharge of the spring was measured 146 lpm. Here we can see that spring discharge was 3 time more during post implementation period with response to marginally increased rainfall.

In Aphu Ghoki springshed from November 2016 to March 2017 which is mostly lean season it rained 169.9 mm maximum rainfall was 103 mm. during March 2017. while during this period average discharge of the spring was9.3 lpm with maximum value of 15 lpm in November 2017.After implementation it rained 64.5 mm. from November 2017 to march 2018 maximum rainfall was in march 2018 with the value of 43.5 mm within the seasom,in this period average discharge of the spring was measured 12.76 lpm. The spring which used to give 22 lpm discharge during july gave even 15 lpm in December which is considered as lean season due to impact of implementation.

Local Water Governance for Management of Water Resources

Based on detailed study some protocol and management system was developed with community to get the results and sustain the model which are-

Reserving springs for drinking water and protecting the recharge areas of these springs from contamination (and therefore planning safe sanitation systems in the recharge areas).

All the springs in the region should be monitored regularly (at least once a month) in a participatory mode. Spring discharge, its quality and the rainfall in the region should be monitored in order to plan management of the water resources in the region. At the same time, monitoring pre and post the interventions will help in evaluating the impact and efficiency of the structures. Monitoring of the discharge will provide insights into the aquifer characteristics which will in turn aid in developing management protocols.

Identifying springs for irrigation, allocations and distribution of the water in an equitable mode while considering the actual year-long availability based on quantifications from the monitoring. Participatory monitoring will enable the community to quantify their resources and therefore create an atmosphere for equitable and sustainable use of the resource.

An understanding of the aquifer response to rainfall will help in developing a system for climate adaptation. Post a few cycles of monitoring, the community will be able to understand the relationship between rainfall and spring discharge and thus plan the winter and summer water accordingly

To protect and conserve the recharge area unnecessary construction and disturbance must be restricted. Prohibition of deforestation, open grazing for animals, Jhum cultivation and construction of house in the recharge area

Watershed Committee to be the mediator between the village and LRD

OUTPUTS OF THE PROGRAMME

Regeneration of 11 springs (1 spring each in 11 districts) based on the spring shed management concept. In which hydrogeology, engineering and water quality had been major component. Various methods and structures are used for recharging groundwater. But the choice and effectiveness of any particular method & structure is governed by the local hydro geological conditions. Besides this delineation of the recharge area of pilot springs based on hydro geological mapping which further led to spring recharge interventions at all the 11 sites (one in each of the 11 districts).

During this process a cadre of trained personnel developed for spring shed development in LRD (Nagaland) during the training workshop. Trainees were trained to gather the hydro geological information, to do the recharge activities, engineering measures and water quality analysis of the springs after the hand-holding. This will be helpful to understand the concept of PGWM/springshed development, dissemination of the knowledge to community and preparation of plans for spring recharge works in future.Regular monitoring network for rainfall measurement, spring discharge and water quality is established by the community under the supervision of trained WDT members.

OUTCOMES OF THE PROGRAM

The major outcomes include Increase in spring discharge due to which more availability of water during lean season is restored. Seasonal water quality data and hydro-geological data of the region is generated which will be more useful for further researches. Scientific capacity building of institutions for the integrated water resource management which will be important in local water governance for management of water resources and this is the model-to be replicated in other villages also.

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2. Priyanka Negi, Research Assistant (People's Science Institute, Dehradun)
3. Sana Anjum, Research Assistant (People's Science Institute, Dehradun)

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