HYDROGEOLOGY BASED SPRINGSHED MANAGEMENT PLAN IN KHAR, DARCHULA DISTRICT, NEPAL

ACWADAM

Advanced Center for Water Resources Development and Management

HYDROGEOLOGY BASED SPRINGSHED MANAGEMENT PLAN IN KHAR, DARCHULA DISTRICT, NEPAL

Based on fieldwork and analysis of results: For KSL project, in partnership with ICIMOD

INCLUDES CONCEPTUAL MODELS AND SUGGESTIONS FOR GROUNDWATER RECHARGE

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ACWADAM

Advanced Center for Water Resources Development and Management

www.acwadam.org

acwadam@vsnl.net

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INTRODUCTION

Khar Village Development Committee (VDC) is one amongst the twenty VDCs of Api Nampa conservation Area (ANCA) which is an administrative unit in Darchula district, Mahakali zone, in the Far Western region of Nepal. The Kali River which marks the border for India and Nepal flows on the west of Khar VDC. The VDC consists of 9 villages namely, Dallekh, Chaurigau, Godhani, Kakanadi, Chaud, Saalimaad, Khupuligau, Jaamir and Sundamunda. Dallekh and Sundamunda villages have been selected for piloting the springshed management approach under the KSLCDI project being implemented by ICIMOD and partners.

The study area is located between N29°50'- N29° 45' and E80° 35'- E80° 40' grid of the toposheet number 2980 03 and 3080 15, issued by Survey Department, Govt. of Nepal. Altitudinal range of the study area falls from 2819m at its highest point to 1400m at the lowest point where the Nau Khola stream flows. Dallekh and Sundamunda villages are located on the either sides of a ridge trending NW-SE with steeper slopes on the south-west flank which are mostly barren, while comparatively gentler slopes on the north-east flank with ample vegetation. However dense vegetation patches are found in the vicinity of the springs.

The major streamlets in the Dallekh Watershed are Khar Khola and Gundharu Khola while a 40m high Spring Fall and Ghalle Khola are found in the Sundamunda Watershed. Both the watersheds are adjacent to each other, with Sundamunda on the north-eastern flank of the ridge separating the two watersheds (Fig.3). Streams from both the watersheds drain into Nau-Gad, which flows from North to south in the west. Interestingly in combination they form a springshed, which can be referred to as 'Dallekh-Sundamunda Springshed' from here onward and the details of which are discussed later in the report.

Geologically, Khar VDC lies in the Lesser Himalayan Zone consisting of mountains with highly undulating topography. Dendritic and trellis drainage patterns are observed with trellis pattern being the predominant one over the springshed region. This is attributed to the steeply sloping hills evident in the region in combination with the underlying geology. The significance of this observation has not been studied in great detail.

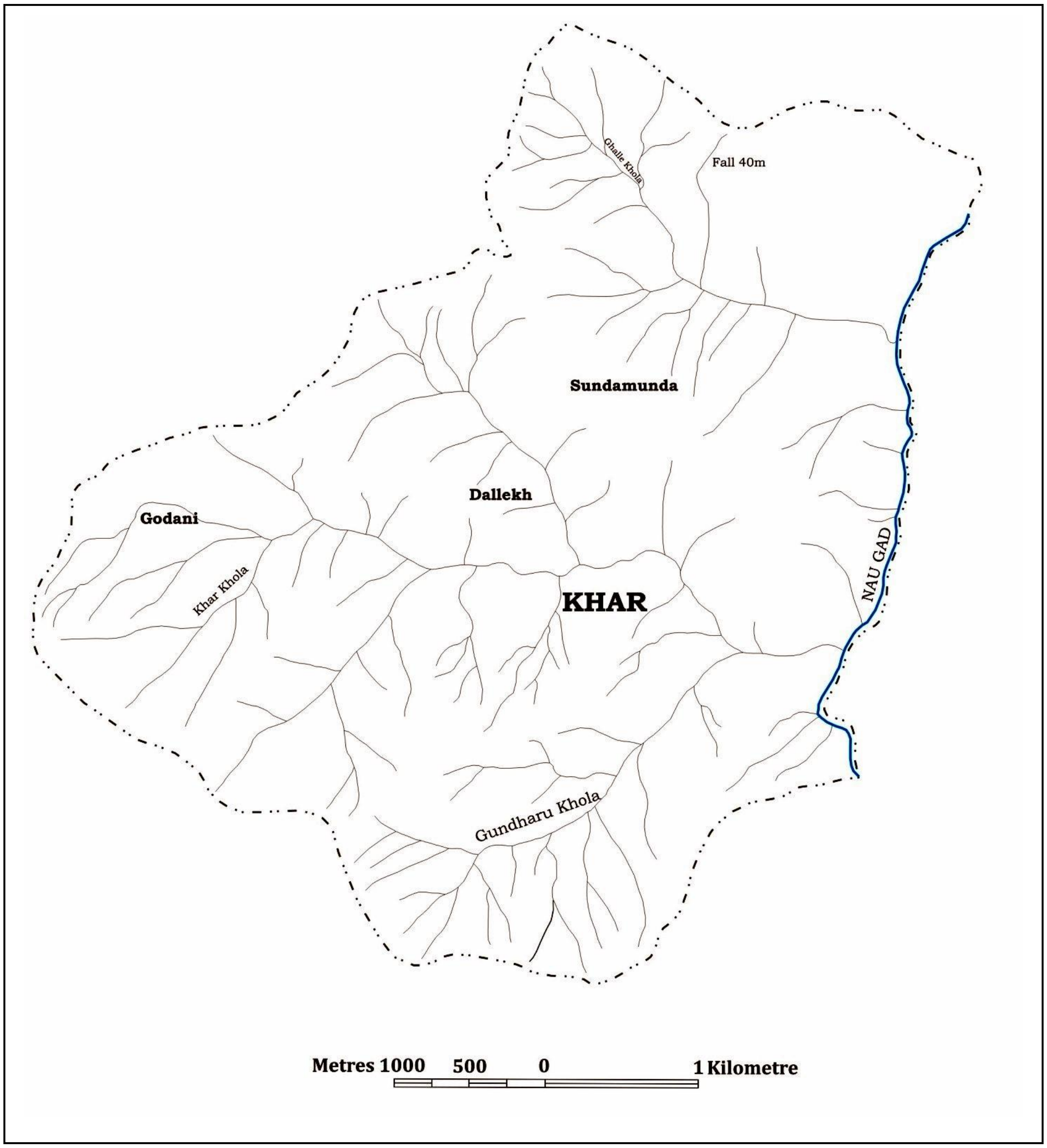

Figure 1: Drainage pattern in Khar VDC

GEOLOGICAL SETUP

The watersheds comprise sedimentary layers with the entire springshed dominated by slates, with some interbedded limestone and outcrops of phyllite, at a few places. The limestone country is dominant in the south-western part and also in the upper reaches of the springshed. Calcareous deposits are even found intercalated within phyllite and slate beds. The bedding planes exhibit variation in the directions of dip and strike. Stratigraphically, the slates rest above the massive limestone and dolostone beds. The rocks are subjected to metamorphism owing to tectonics involved in the Himalayan orogeny. Weathering and erosion is common with a majority of limestones being weathered and the slate generally being eroded forming gullies and causing landslides along their joint planes, at places especially in the eastern part of the springshed.

The regional structural setting of the study area is controlled by tectonics. At places, the limestones are metamorphosed to dolostones and slates exhibit phyllitic character due to metamorphism. Owing to the competency fractures in limestone beds are sparsely developed with sharp edges while slates are highly crushed and appear ‘crumbly’. According to the present study, shear zones (Fig.2) are observed at three different places accompanied by joints and fractures across the VDC. The rocks observed along shear zone are highly fractured than the rocks seen in the nearby region. This may be a reflection of a continuous shear zone trending ENE-WSW. The rocks are also subjected to folding as it is evident by rotation of the strike direction in the region.

Figure 2: Massive Slates (left) and sheared Slates (right) observed in the field area

HYDROGEOLOGY OF KHAR

Springs are mostly found in the valley parts. A total of 48 springs were identified previously in the area which includes both perennial and seasonal springs. Most of the springs shown in the map below are perennial springs forming main source of drinking water in this region. Few springs are tapped by constructing a collection tank from where water is supplied to village through pipeline.

Slates possess low primary porosity, and poor permeability. Thus, in this case, the secondary porosity, developed due to fractures and joints, is very important in the accumulation and movement of groundwater. The shear zone observed may also be an important factor with respect to the movement of groundwater because of the anomalous porosities and permeabilities developed in the rocks along this zone. Also, the weathering and erosion of limestone, observed near the top of the mountains, play an important role in constituting an aquifer for a few springs in the region.

Figure 3: Google Earth Imagery showing locations of Identified Springs in Dallekh-Sundamunda Springshed.

A total of 48 springs were discovered in both the watersheds. Out of 48 springs, 4 springs, viz. Chaharakhola, Mulpanyar, Nalakhola and Ram ko Khane Pani located in the Sundamunda Village and 3 springs viz. Thallan pani, Jugaipani and Panyar in Dallekh Village (Table 1) have been identified by ICIMOD Team for carrying out Springshed Management activities on the basis of Focus Group Discussions (FGD) and other such surveys conducted in the villages falling in the springshed. Presently, Chaharakhola, Mulpanyar, Nalakhola, Thallanpani and Jugaipani springs are studied and discussed in detail in the later part of this section.

Spring Name	**Spring Code**	**Latitude**	**Longitude**	**Elevation (meters)**	**Village**	**Occurrence**	**Seasonality**	**Spring type**
Chaharakhola	SP1	N29°48'36.1"	E80°38'20.6"	2241	Sundamunda	Fracture/ Depression	Perennial	Dhara
Jugaipani	ST3	N29°47'1.1"	E80°37'41.3"	2088	Dallekh	Fracture/ Depression	Perennial	Dhara
Mul Panyar	SP36	N29°47'41.6"	E80°38'47"	1972	Sundamunda	Fracture/ Depression	Perennial	Dhara
Nalakhola	SP47	N29°47'48.4"	E80°38'33.7"	1998	Dallekh	Fracture	Seasonal	Dhara
Panyar	SP37	N29°47'47.1"	E80°37'41"	1955	Dallekh	Fracture/ Depression	Perennial	Dhara
Ram Ko Khane Pani	ST15	N29°48'34.3"	E80°38'10.5"	2173	Sundamunda			
Thallan Pani	SP49	N29°47'53.8"	E80°37'41.3"	2232	Sundamunda	Fracture	Perennial	Dhara

Table no. 1: Spring inventory sheet

Nalakhola Spring

Location	Latitude N29°47'48.4"	Longitude E80°38'33.7"	Elevation 1998 m
Discharge	0.4 lpm		
Water quality	pH- 8.03	E.C.- 276 µs	Temperature- 17 ºC
Spring Type	Fracture		

The dominant lithology comprises slates dipping in the NW direction towards which their thickness further reduces. The variation in the thickness of the beds is observed due to the presence of shear zones in the region. The beds are gently folded dipping in northwest and southeast directions and are highly fractured. Two major set of fractures, one trending N-S while other one trending NW-SE traverse the springshed area and are closely spaced. Strike of the slates slightly rotates indicating folding but no clear evidences were observed in field in the form of a folded structure in the rocks. The spring emerges on the dip slope through these two sets of fracture zone and thus becomes a fracture spring. (Refer to Fig. 4a and 4b). Highly fractured slate forms the aquifer feeding this spring. It has a relatively low storage capacity due to which discharge reduces to a marginal extent in lean summer months.

As the emergence of spring is on the dip slope, recharge area lies on the same slope. The fracture zone should be targeted more to increase storage in the fractured system. N-S trending fracture zone is evident by the linear vegetation developed along it.

Recharge Measures

Taking into consideration the dip of the beds and the fracture zone, recharge structures viz. staggered contour trenches can be constructed below the ridge line on the dip slopes. Targeting the fracture set trending N-S for recharge measures will help optimize the effort at recharging the slaty aquifer and in turn, improving the spring discharge. Slopes in the east of the spring where there are agricultural fields, deep trenches will be beneficial in recharging the fractured slate which forms the only aquifer in the springshed (Refer to Fig. 4c and 4d). Targeting larger area for recharge beyond the fracture zone trace will also contribute to some extent. Construction of check-dams and gabion structures in the stream near the spring will facilitate additional recharge. (Refer to Fig. 4a and 4b).

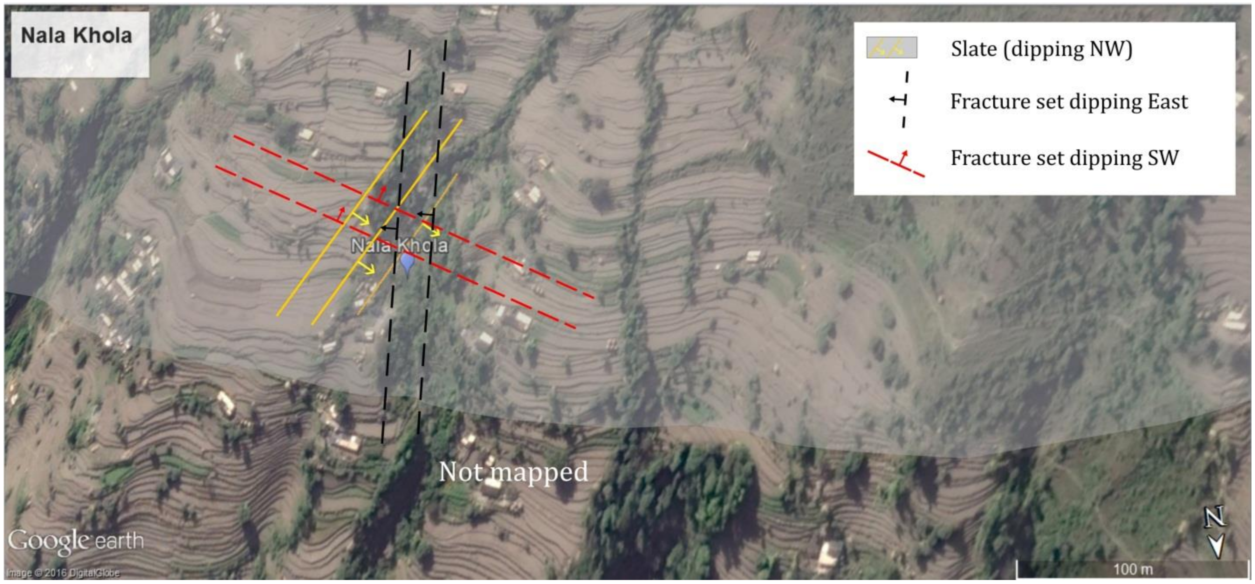

Figure 4a: Overlay of geological setup for Nalakhola spring on Google Image

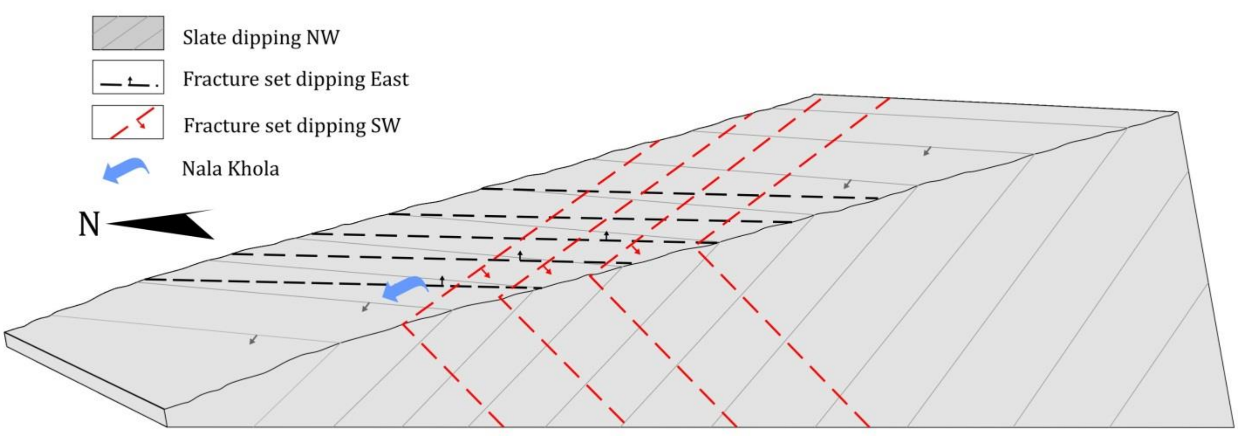

Figure 4b: Conceptual layout of Nalakhola springshed

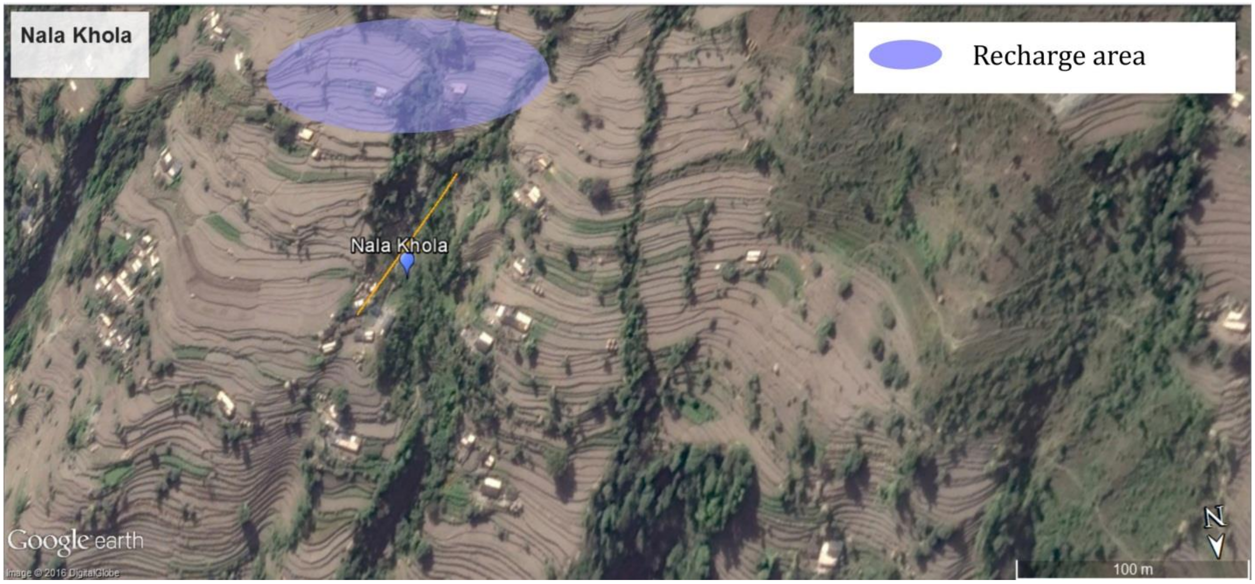

Figure 4c: Overlay of recharge zone on Google Image (Nalakhola springshed)

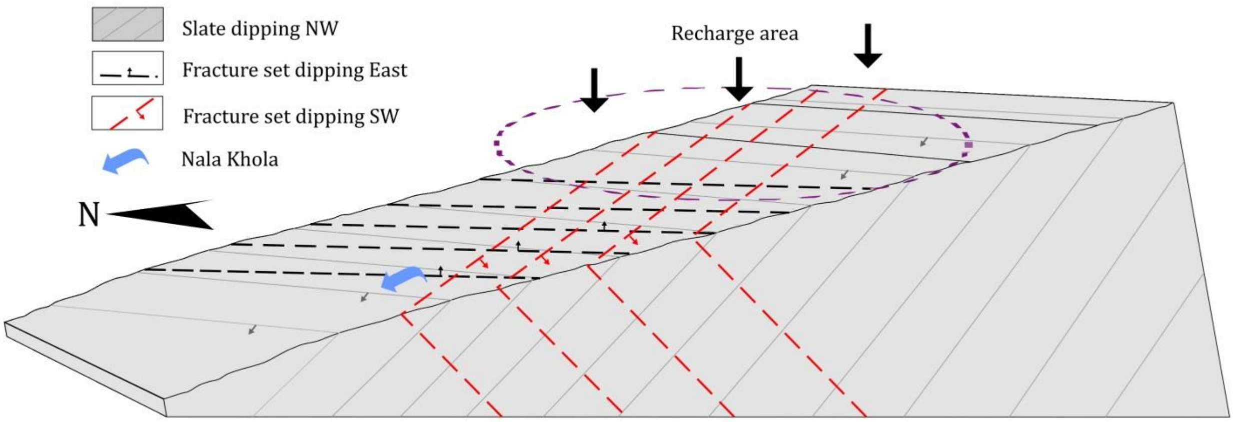

Figure 4d: Conceptual layout of Nalakhola springshed including demarcated recharge zone

Mulpanyar Spring

Location	Latitude N29°47'41.6"	Longitude E80°38'47"	Elevation 1972
Discharge	6.43 lpm		
Water quality	pH- 8.07	E.C.- 349 µs	Temperature- 16.9 ºC
Spring Type	Fracture-Depression		

The massive and sheared slates are observed in the vicinity of the springs exhibiting phyllitic characteristics. The dip amount ranges from 25º-40º while their dip direction is generally towards NW. Two sets of joints are measured, trending NE-SW and NNE-SSW directions and dipping steeply (60º -70º) in the SE and WNW direction respectively The rocks above the springs are highly crushed and have formed loose debris, predominantly slaty in nature through which the spring emerges. This spring shows similar characteristics as that of the Nalakhola spring except for its emergence through loose unconsolidated debris making it a combination of Fracture-Depression spring and it is clearly indicated by the discharge data obtained in the month of April mentioned in the table above. Interesting feature of this spring is that it is fed by three aquifers viz. Phyllitic slates dipping towards spring, fracture sets traversing across the springshed and loose unconsolidated debris. Loose debris bears large storage for groundwater as compared to that of phyllitic and fractured slates. A deep valley formed by a stream along the existing NNE-SSW trend is evident even in the Google image. Upper reaches of the ridge above the spring is covered by pristine forest (Refer to Fig. 5a and 5b).

Recharge Measures

As mentioned above, the existing forest cover should be kept virgin and demarcated as protection zone. Deforestation, waste disposal and open defecation should be strictly prevented in this zone to ensure good quality water emerging in the spring. Further below the forest cover where loose debris is found, recharge interventions should be implemented. Field observations show that this area is covered by farm lands and thus it will get difficult to implement traditional recharge structures like contour trenches etc. In such cases, deep trenches of smaller dimensions in the farms can be useful in recharging the aquifer system. Taking into consideration the dips of the beds recharge should be focused on the ridge in the east of the spring. Availability of land type will be important in deciding on structures that need to be implemented. The valley created by stream besides the spring can be treated by constructing small check-dams and gabion structure to facilitate recharge in the fractured slates. (Refer to Fig. 5c and 5d).

Figure 5a: Overlay of geological setup for Mulpanyar spring on Google Image

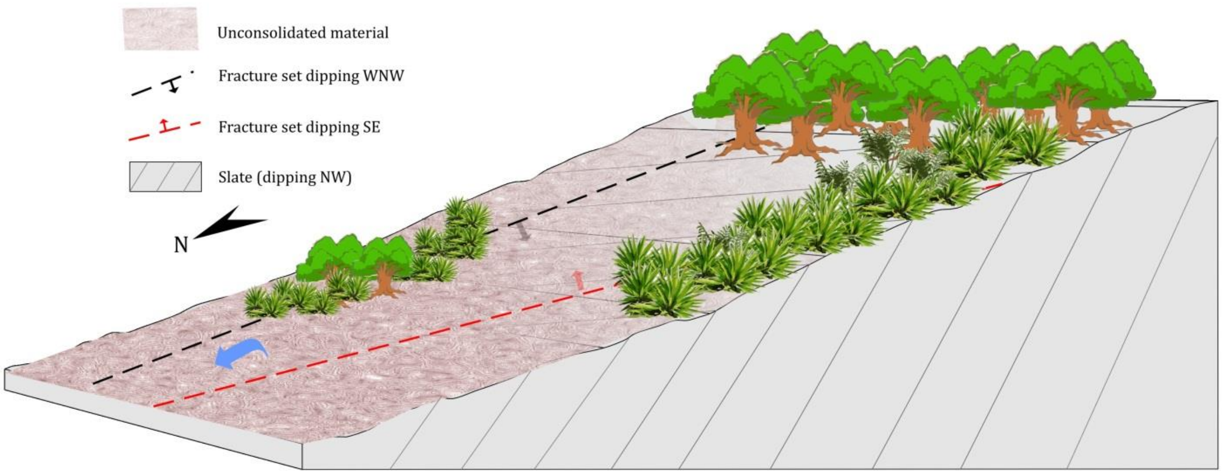

Figure 5b: Conceptual layout of Mulpanyar springshed

Figure 5c: Overlay of recharge zone on Google Image (Mulpanyar springshed)

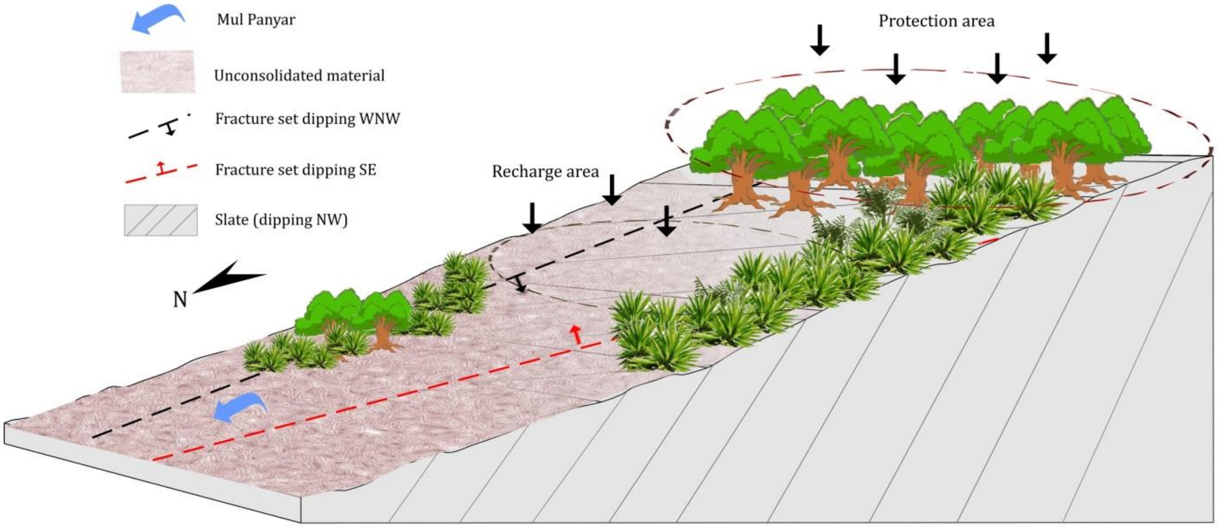

Figure 5d: Conceptual layout of Mulpanyar springshed including demarcated recharge zone

Chaharakhola Spring

Location	Latitude N29°48'36.1"	Longitude E80°38'20.6"	Elevation 2241
Discharge	31.56 lpm		
Water quality	pH- 8.17	E.C.- 409 µs	Temperature- 15.4 ºC
Spring Type	Fracture		

The springshed for Chaharakhola spring encompasses North-westerly dipping rocks. Massive and fractured slate is again a predominant rock-type in the springshed. Spring emerges besides a gadhera through a thick pile of unconsolidated sediments. Outcrops just above the spring exhibits two major fracture sets, one set trending N-S with dips in the East with amounts ranging between 20-25º while the other set trending NE-SW with dips in the SE with amounts ranging between 25-30º. Spring emerges within a small valley. Slopes on the south of the spring exhibit dense vegetation while on the slopes on the north of the spring shows prevalence of grass cover (Refer to Fig. 6a and 6b). This small valley holds a thick pile of unconsolidated sediments which becomes an aquifer feeding the spring. Discharge rate in the month of April mentioned in the table above indicates fairly good groundwater storage. Field observations indicate that fractured slates also contribute in accumulation and movement of groundwater and thus spring becomes a combination of Depression and Fracture spring. Spring emerges on the escarpment slope, but the recharge area remains on the same slope. Recharge area for the Chaharakhola lies close to it in the upper reaches of the valley slopes enclosing it.

Recharge measures

Recharge area demarcation becomes crucial while taking into account the varied conditions present in the springshed. The slopes in the south of the spring bearing dense vegetal cover should be demarcated as protection zone. On the other hand the slopes in the north bearing grass cover and further barren land on the top will be suitable location for implementing recharge measures. Staggered contour trenches can be implemented as per details included in *Dhara Vikas Handbook (Govt. of Sikkim, GIZ publication).* Gadhera can be treated with gully plugs for additional recharge in the springshed (Refer to Fig. 6c and 6d).

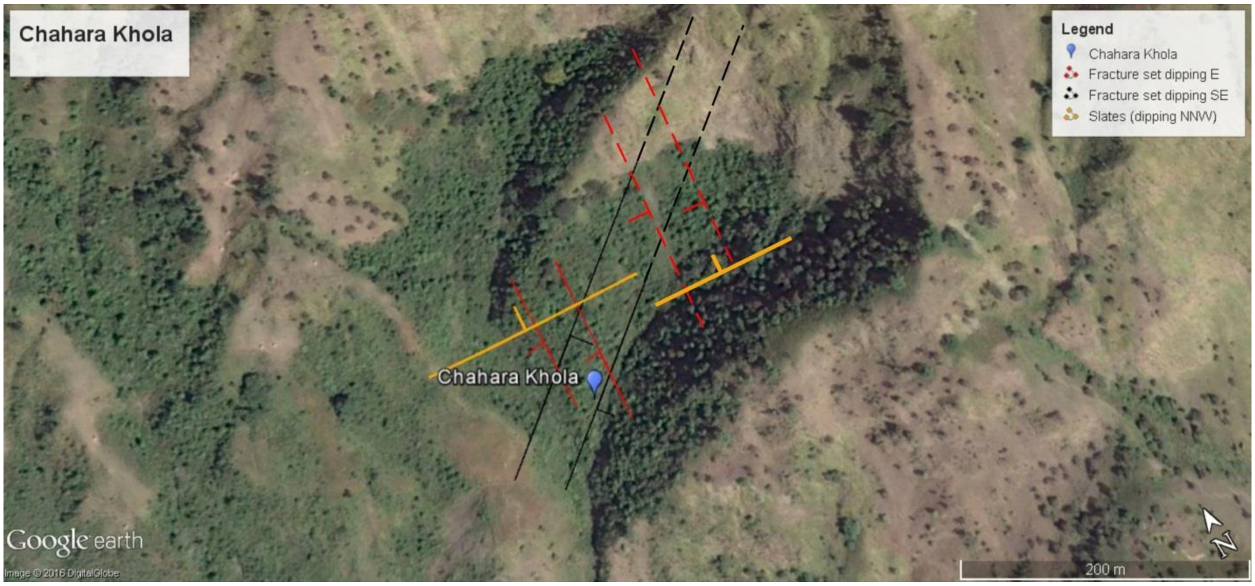

Figure 6a: Overlay of geological setup of Chaharakhola spring on Google Image

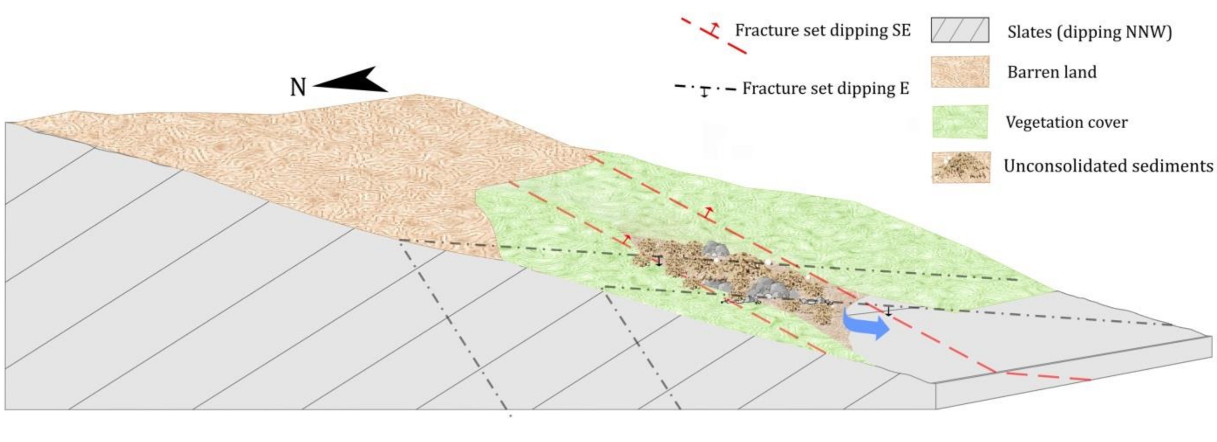

Figure 6b: Conceptual layout of Chaharakhola springshed

Figure 6c: Overlay of recharge zone on Google Image (Chaharakhola springshed)

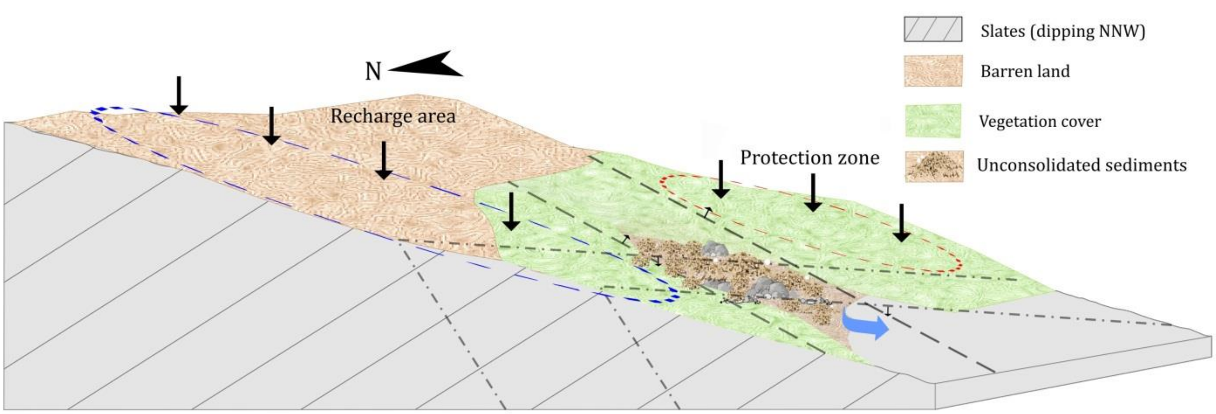

Figure 6d: Conceptual layout of Chaharakhola springshed including demarcated recharge zone

Thallanpani Spring

Location	Latitude N29°48'36.1"	Longitude E80°38'20.6"	Elevation 2232
Discharge			
Water quality	pH- 8.09	E.C.- 247 μs	Temperature- 13.1°c
Spring Type	Fracture		

Jugaipani Spring

Location	Latitude N29°47'1.1''	Longitude E80°37'41.3"	Elevation 2088
Discharge	3.53 lpm		
Water quality	pH- 8	E.C.- 337 μs	Temperature- 14.2°c
Spring Type	Fracture-Depression		

The springshed is slate dominant with dips in the NE. Two major set of fractures traverse the springshed with one trending NNE-SSW with dips in ESE while the other set trending WNW-ESE with dips in SSW which play a major role in the accumulation and movement of groundwater.

Thallanpani spring is exposed along a road cut emerging through a fracture system while Jugaipani emerges through a cone of debris deposited below the Thallanpani spring on the same escarpment slope. Both the springs do not follow the same spring line but they are fed by same aquifer (*fractured slate*) having two different emergence points. This is evident by continuity of same set of fractures and lithology shared by both the springs. Emergence of Jugaipani through debris makes it a combination of Fracture-Depression spring. Thus Jugaipani spring is fed by two aquifer systems viz. loose debris and fractured slates (Refer to Fig. 7a and 7b).

Land is not under agricultural practice as it forms the escarpment slope and is thus mostly barren except for less dense vegetation patches at few places. Both the springs lie on the same discharge area on the escarpment slope.

Recharge measures

The area above the both the springs can be implemented with recharge structures. Contour trenches with reference to *Dhara Vikas Handbook (Govt. of Sikkim, GIZ publication)* will prove beneficial in the recharge to the fractured aquifer system. Top of the ridge seems to have fairly flat area where small recharge ponds can help in recharging the fracture network in slates. Ridge slope on the west of the spring should be focused more taking into consideration dip slope of the slates. The vegetation patch above the Jugaipani spring should be protected which is holding the loose debris cover which is also groundwater storage system feeding Jugaipani spring. Small stream above it can be treated with small gully plugs to facilitate additional recharge into the springshed for Jugaipani (Refer to Fig. 7c and 7d).

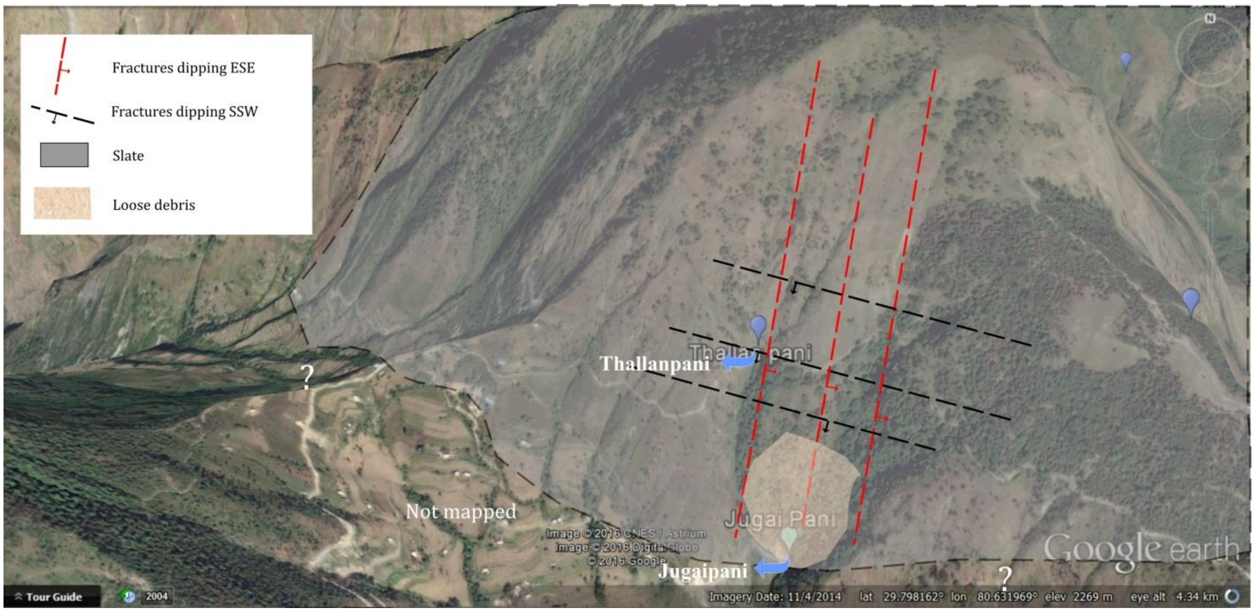

Figure 7a: Overlay of geological setup for Thallanpani spring and Jugaipani spring on Google Image

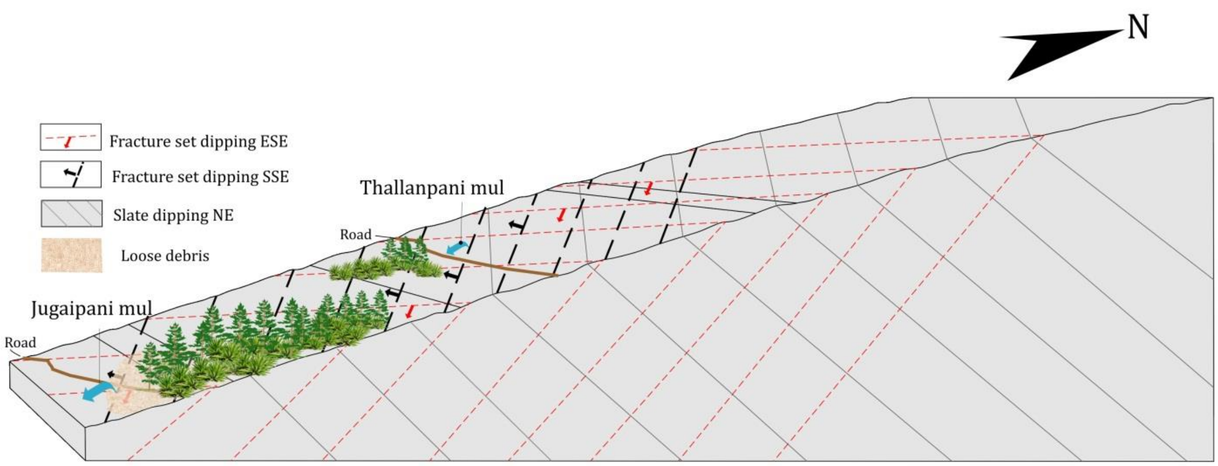

Figure 7b: Conceptual layout of Thallanpani and Jugaipani springshed

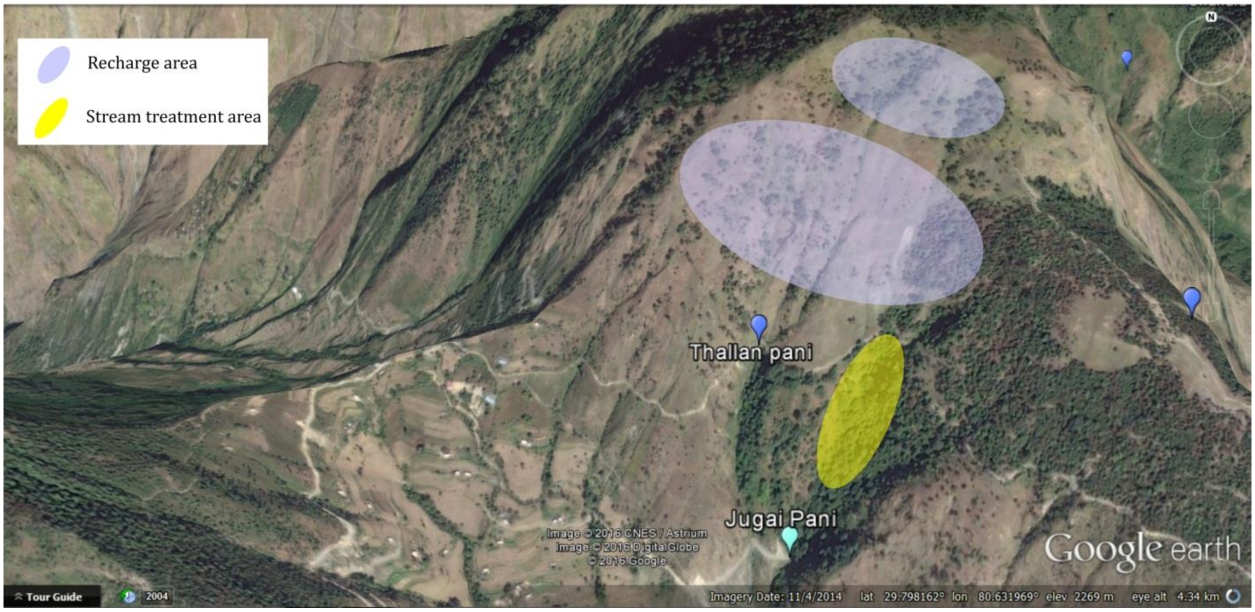

Figure 7c: Overlay of recharge zone on Google Image (Thallanpani and Jugaipani springshed)

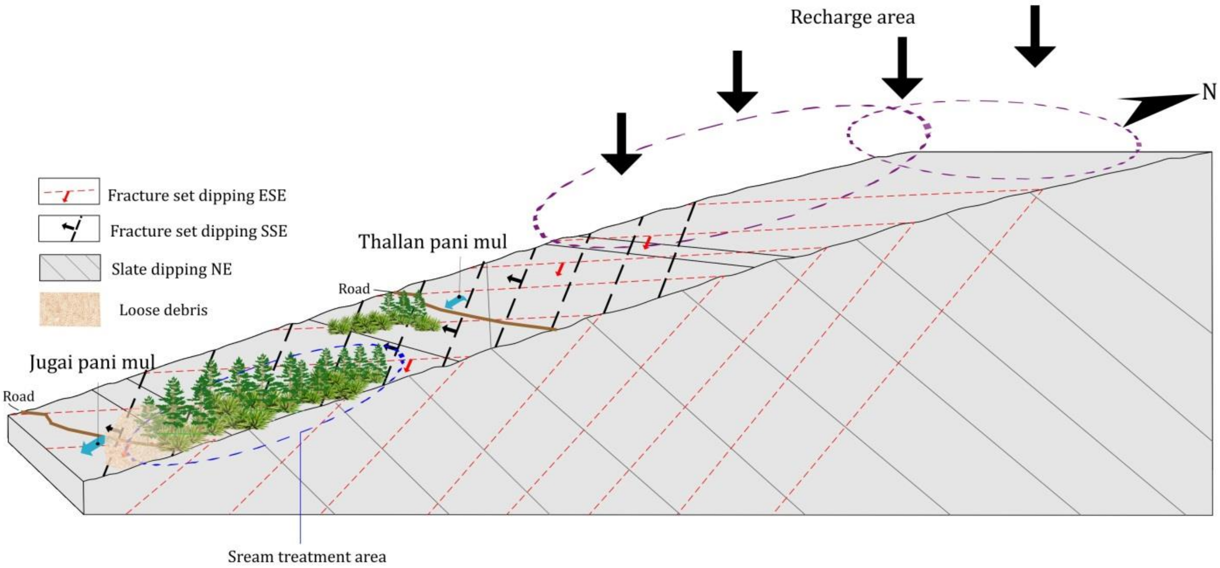

Figure 7d: Conceptual layout of Thallanpani and Jugaipani springshed including demarcated recharge zone

WAY FORWARD

1. Discharge data collected need to be exhibited in a uniform format with regards to date and month of collection (*specifying it*) for constructing authentic hydrographs.

2. The process of collecting discharge data needs to be revised again with key resource persons.

3. Detailed Geological and Hydrogeological assessment is required for Gudgude and Khadkhade springs which lie outside the Dallekh-Sundamunda springshed owing to their importance in the generation of hydroelectricity for the region.

4. Hydrogeological assessment to be done for Panyar spring which lies within the springshed in Dallekh village.

5. Conducting Barefoot Hydrogeologist training for the local people in Dallekh and Sundamunda village.

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