SINDHUPALCHOK SPRING HYDROGEOLOGY, NEPAL

ACWADAM

Advanced Center for Water Resources Development And Management

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Based on fieldwork for WLE project in partnership with ICIMOD

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BACKGROUND

Sindhupalchok District is a part of Bagmati Zone and one of the seventy-five districts of Nepal, with an area of 2,542 sq. kms. Elevations as high as ~6500m is observed in the northern-most part of the district while those as low as ~700m is observed at the southernmost part of the district. Across the entire district ridges trending North-South are observed. The valleys are V-shaped but are narrow and deeper as compared to Dailekh. Large scale agriculture is observed only in the lower elevations. The regional flow of surface drainage is towards the South. ACWADAM's Hydrogeological studies included 6 springs out of 20 identified by ICIMOD. HELVETAS, a partner on WLE project is being functional here for Earthquake relief work and are intending to develop water supply schemes. A monitoring system is setup to collect discharge data for springs identified. The presence of unconsolidated debris on the slopes and in the valley bottoms make depression springs (***Fig.2***) more prevalent in the area. Discharge in many springs indicated a change in behavior post-earthquake. Few springs which were perennial have dried up in early summer this year. Landslides have occurred in many places ***(Fig.1***) due to earthquake washing out loose deposits from the slopes affecting many springs. Vegetation cover is quite well preserved in all the four VDC's.

Figure 1: Landslides witnessed post-earthquake

Figure 2: Depression spring

The study comprised of detailed hydrogeological assessment based on which potential recharge area for selected springs was identified. This report provides details regarding recharge area demarcation along with maps and conceptual layouts.

Figure 3: Locations of the springs in Mahankal VDC

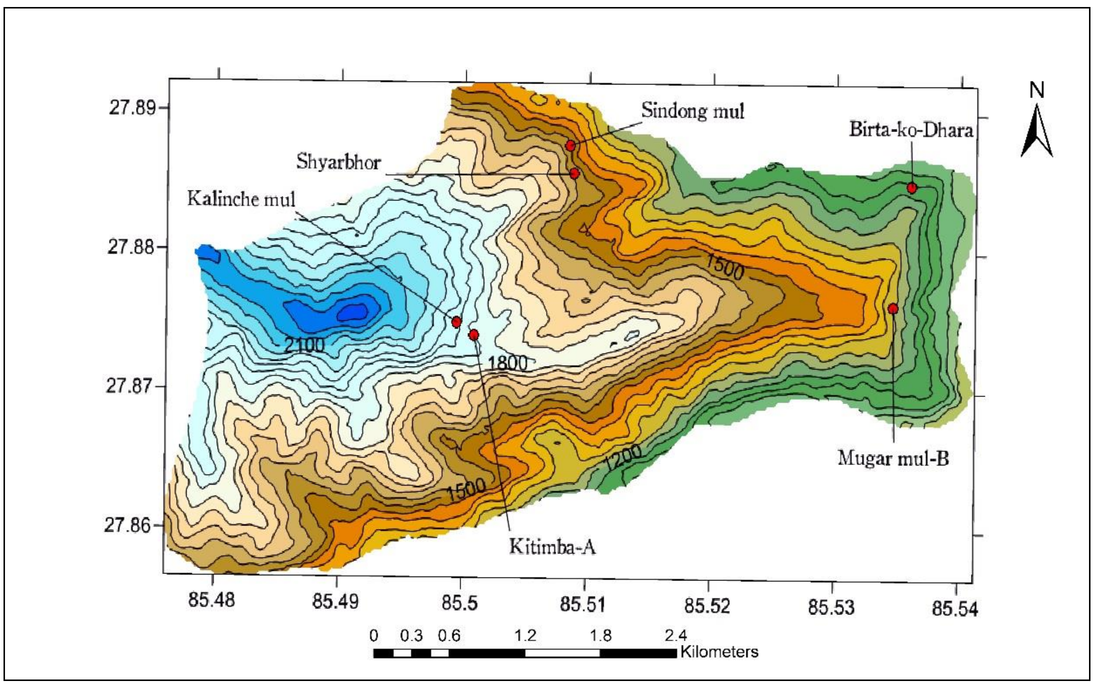

Figure 4: Contour map of Mahankal VDC

GEOLOGICAL SETUP

Schists and Gneisses with Schist having regional dips in the west (Fig.5) prominently dominate study area**.** Ridges trend mostly North-south and few East-west. Weathering and fracturing is present across the whole area. Two sets of fractures are prominent with one dipping in ESE (100°) and traversing NNE-SSW with gentler dips while other one dipping SSE (160°) traversing ENE-WSW with steep dips. Foliation dips of the Schist are in the southwest. Gneisses are found at the higher elevations. The gneisses show a general dip towards NW/W at a varying amount of 20º-40º.

Figure 5: Foliated Schists bearing dips in the west to south-west

HYDROGEOLOGY OF THE STUDY AREA

Study area in Sindhupalchok consists of 4 VDCs spread over mountain ranges of various shapes and heights. These 4 VDCs have more North-South extent than East-West extent. Major valleys are south flowing valleys. Melamchi River marks the VDC boundary between Ichok and Keiwl which flows south along major valley.

The m along valleys, one can see gneisses covered with sediments (debris) and soil. Gneisses are mostly seen at base of the mountains and on top of lower elevation mountains. The gneisses show a general dip towards NW/W at a varying amount of 20º-40º.2-3 major sets of fractures and joints are seen in the region. N-S trending set of joints dipping towards East at 40 º. NW-SE trending vertical fractures observed at many places.

Mostly the type of springs found in this region are fracture springs. Gneiss and Schist are crystalline rocks and are hard and compact therefore possess very low porosity and permeability, thus major water stored and transmitted is through the fractures and joints. Also along the valleys where there are thick layers of sediments, depression springs are found. Layer of sediments stabilized over the slopes is a potential area for groundwater storage.

Earthquake has disturbed this system affecting many springs. A spring (Birta-ko-Dhara) which used to be perennial with high discharge has dried up in lean summer season. Fractured Schist forms the major aquifer in this area and thus fracture springs are quite prevalent in this area. ***Fig.6*** shows a model discharge graph for a particular spring and its behavior reflecting effect of earthquake.

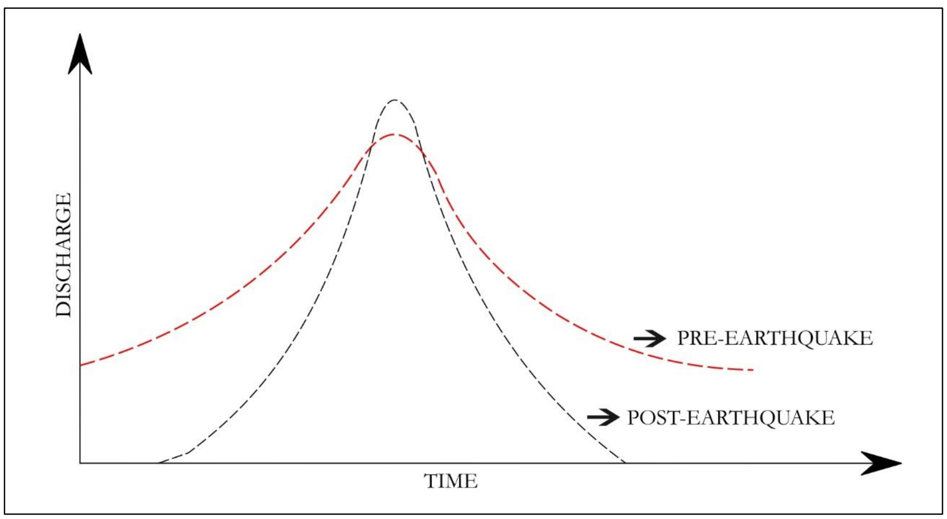

Figure 6: Discharge graph for a spring and its behavior post-earthquake

The graph shows discharge plot of a spring for one hydrological cycle. Pre-earthquake spring was perennial through all three seasons but post-earthquake discharge was at peak after the initiation of monsoon and dried up in the early summer. This indicates that earthquake has disturbed the geological setting and in turn affecting the aquifer system.

Fracture set dipping towards East forms the major set feeding springs emerging out from them as fracture springs. Many of these fracture springs are emerging out on the escarpment slopes. Fractured Schist accounts for storage and transmission of groundwater through it (***Fig.7).*** Depression springs on the other hand develop though a thick pile of unconsolidated material, which stabilizes over the slopes ***(Fig.7).***

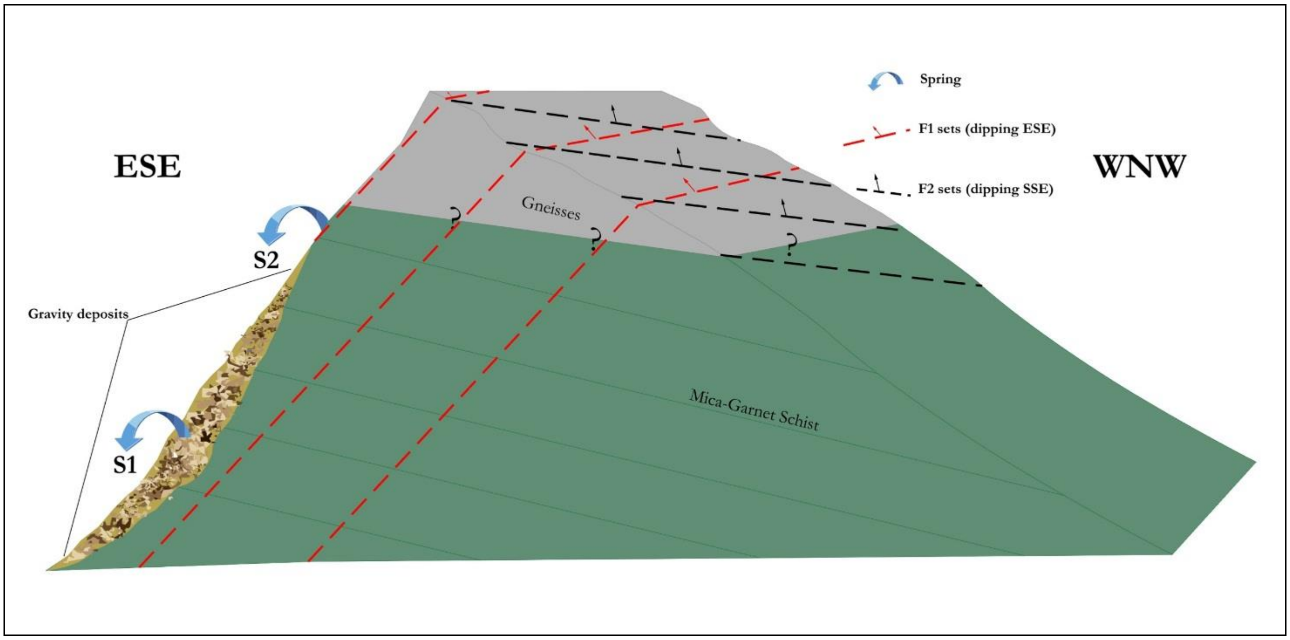

Figure 7: Conceptual model for springs found in Sindhupalchok

BIRTA KO DHARA

Latitude	Longitude	Elevation
27.884913°	85.536549°	1121m

The springshed is comprised of westerly dipping Foliated Schist with dips ranging from 25° to 30°. Spring emerges on the NE facing escarpment slope. Springshed is also traversed by two set of fractures viz. one set dipping in the ENE while the other dipping in the SE. Fracture set dipping towards ENE; trending NE-SW clearly controls the spring emergence and thus becomes fracture spring. Fracture system in Schist controls the storage and transmission of groundwater. Continuity of fractures is clearly seen in the field. Another interesting fact about this spring is that it was perennial for all these years until the earthquake, which took place last year, but this year it is running dry. Large amount of loose material was seen scattered near the base of the spring and outcrop on the top of the spring was found exposed which indicated that the earthquake brought all the loose material down which was actually a local aquifer system feeding the spring. This unconsolidated material was the primary storage for groundwater, which was helping this spring to remain perennial. Thus spring was earlier a depression spring which is now a fracture spring due its emergence through a fracture and storage also being within the fracture system ***(Fig.8).***

Figure 8: Google image depicting hydrogeological observations

Based on hydrogeological conditions prevailing in the springshed, potential recharge area was identified. The prominent fracture set dipping ENE is the primary pathway for the recharge to the fractured aquifer system. The recharge lies on the same escarpment slope along with major portion of the ridge on the left with respect to the spring location (***Fig.9 & 10).*** The desired impact in discharge may not go much high on treating the recharge area, but chances of achieving sustainability in terms of seasonality are most likely to occur.

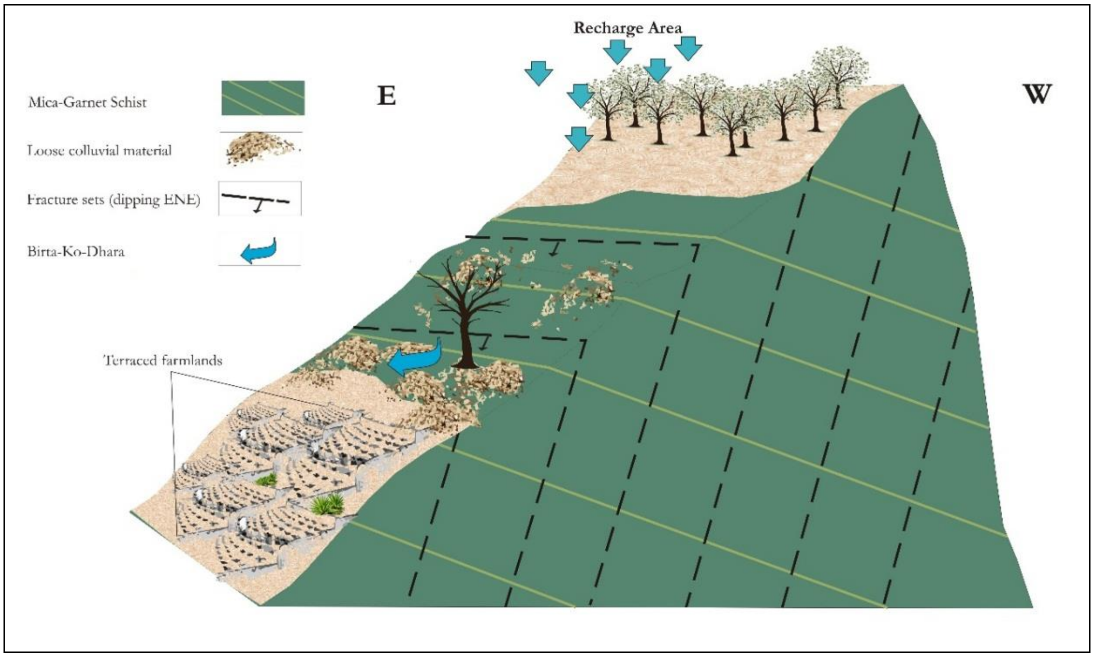

Figure 9: Hydrogeological conceptual layout of the springshed

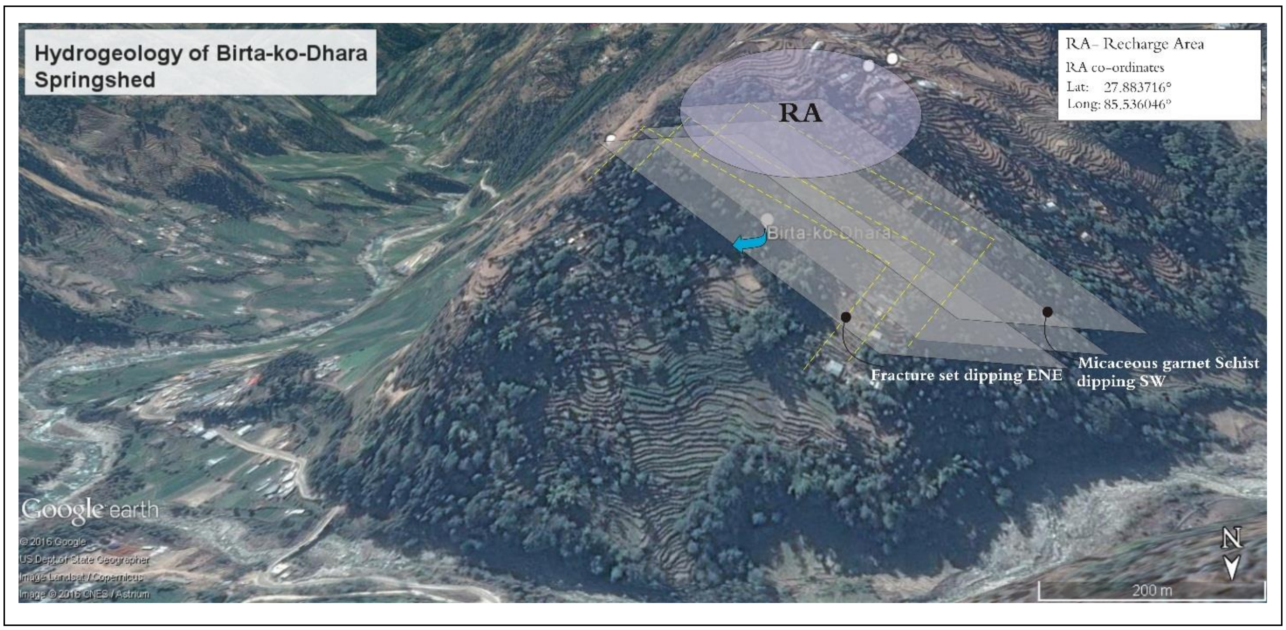

Figure 10: Google image of the sprinshed depicting potential recharge area; RA coordinate: (Lat: 27.883716° Long: 85.536046°)

RECHARGE AREA RECOMMENDATIONS

The identified recharge area falls under village land, which is primarily used for agricultural practices ***(Fig.10).*** Some portion of the slope where there are no agricultural field terraces, staggered contour trenching can be planned. Terraced should be made with slopes facing inwards to facilitate recharge while agricultural practices are taking place. Small dimension deep trenches in each of the terrace can be structured to facilitate recharge to the underlying aquifer system without damaging the agricultural land. Plantation activity along with physical measures would be the best way towards achieving good recharge.

MUGAR MUL

Latitude	Longitude	Elevation
27.8762°	85.53461°	1246m

The springshed is comprised of north westerly dipping micaceous banded Gneisses with dips ranging from 15-30°. The spring is found emerging on the slope facing east which is an escarpment slope. Springshed is also traversed by two set of fractures viz. one set dipping in the SW traversing NW-SE while the other dipping in the NE traversing WNW-ESE. The emergence of the spring through this fracture system is very evident. This fracture system imparts porosity to the hard gneisses, thus making it a potential aquifer feeding the spring.

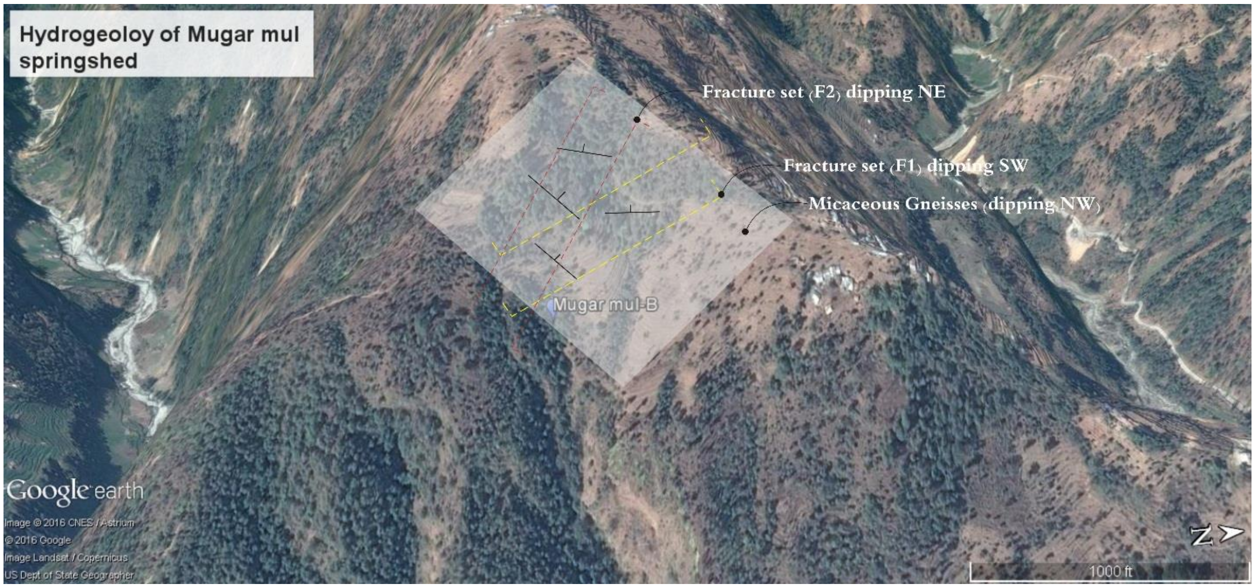

Figure 11: Google image depicting hydrogeological observations

Taking into account the above hydrogeological conditions, it becomes important to consider the fracture trends in planning potential recharge area. On the basis of the fracture trends, two potential recharge areas were identified and demarcated. RA-1 (on the left with respect to spring location) targets fracture sets dipping NE while RA-2 (on the right with respect to spring location) targets fracture sets dipping SW ***(Fig. 12 & 13).***

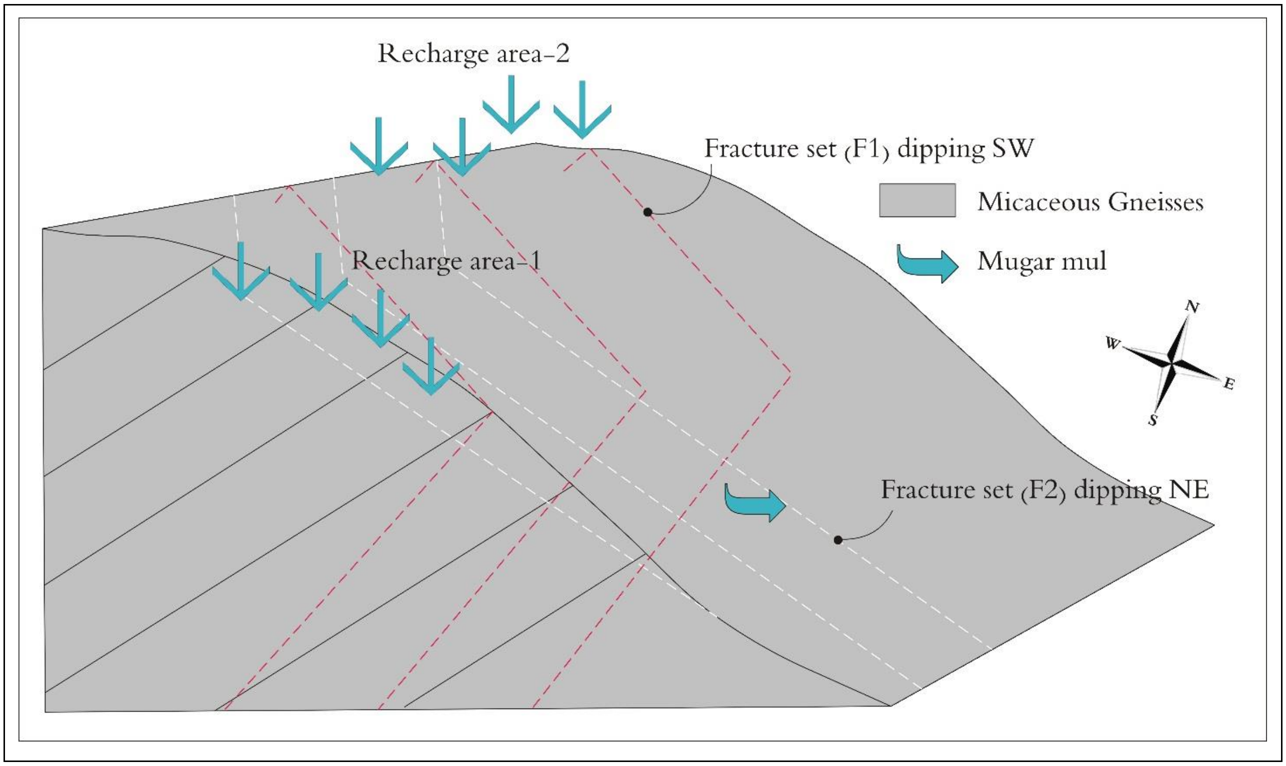

Figure 12: Hydrogeological conceptual layout of the springshed depicting potential recharge area

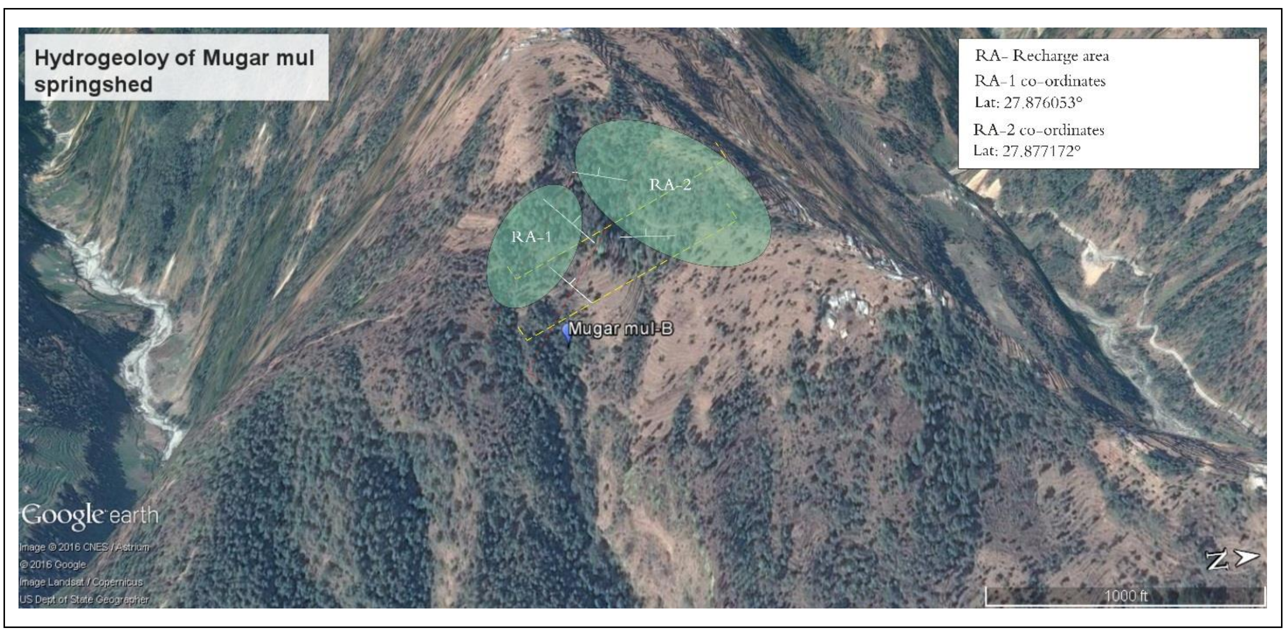

Figure 13: Google image depicting hydrogeological observations depicting potential Recharge area

RECHARGE AREA RECOMMENDATIONS

The identified potential recharge areas comprises of two locations ***(Fig.13).*** RA-2 lies on the escarpment slope which seems to be quite barren in terms of land use which can be treated with staggered contour trenching depending on slope percentage (*Dhara Vikas manual, Sikkim*). RA-1 lies on the dip slope which can also be treated with staggered contour trenching. Some portion of the recharge area is cultivated, where trenching won't be possible. In such cases, randomly spaced small dimension deep trenching can be planned. Plantation should accompany while carrying out physical interventions.

SINDONG MUL

Latitude	Longitude	Elevation
27.88766°	85.50848°	1536m

The springshed is comprised of north westerly dipping banded Gneisses with gentler dips. The spring is found emerging on the dip slope. This spring is a classic example of fracture spring. Two fracture sets are found traversing the springshed, one dipping NE traversing NW-SE while the other one dipping ESE traversing NNE-SSW ***(Fig. 14).*** The spring emerges out through one of these fracture sets. Gneisses being hard and compact do not possess any primary porosity but the fracture network provides it a secondary porosity making it a potential aquifer feeding the spring.

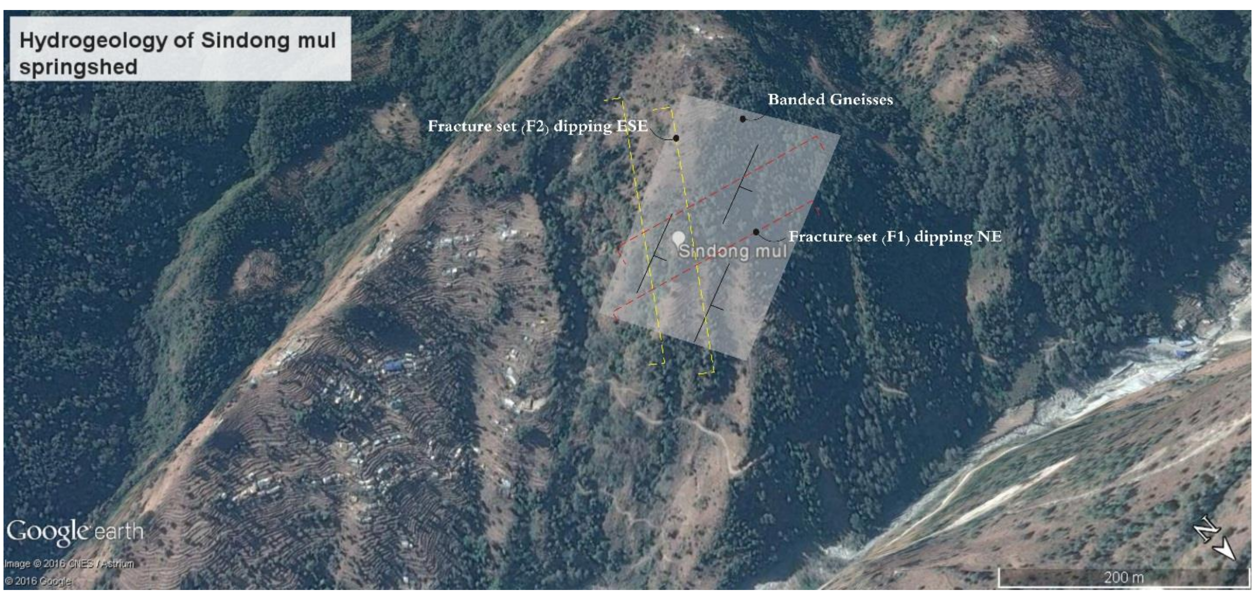

Figure 14: Google image depicting hydrogeological observations

On the basis of hydrogeological assessment, potential recharge area was ascertained. Spring being located on the dip slope, it is important to treat the escarpment slope. The bedding planes and fracture sets providing pathways to the fractured aquifer systems should be targeted. The potential recharge area thus identified was on the slopes facing SE ***(Fig. 15)*** taking into account bedding planes and fracture trends.

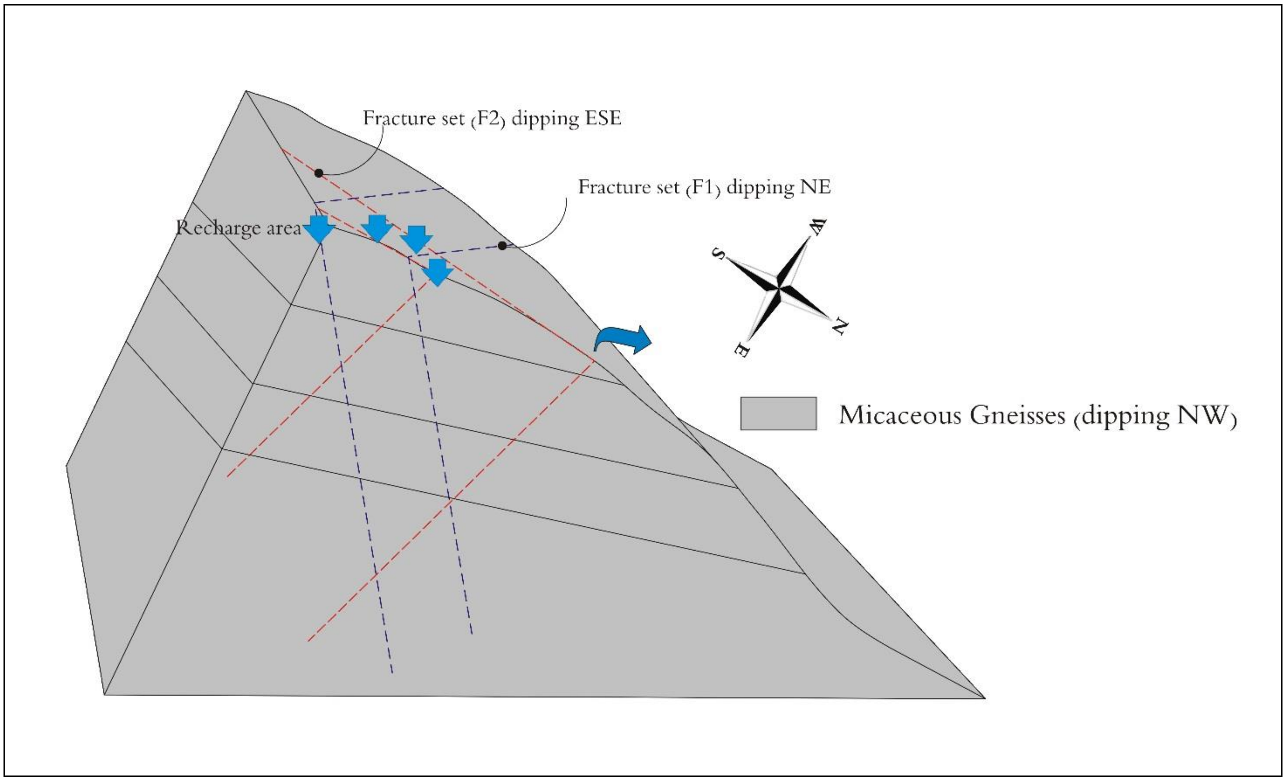

Figure 15: Hydrogeological conceptual layout of the springshed depicting potential recharge area

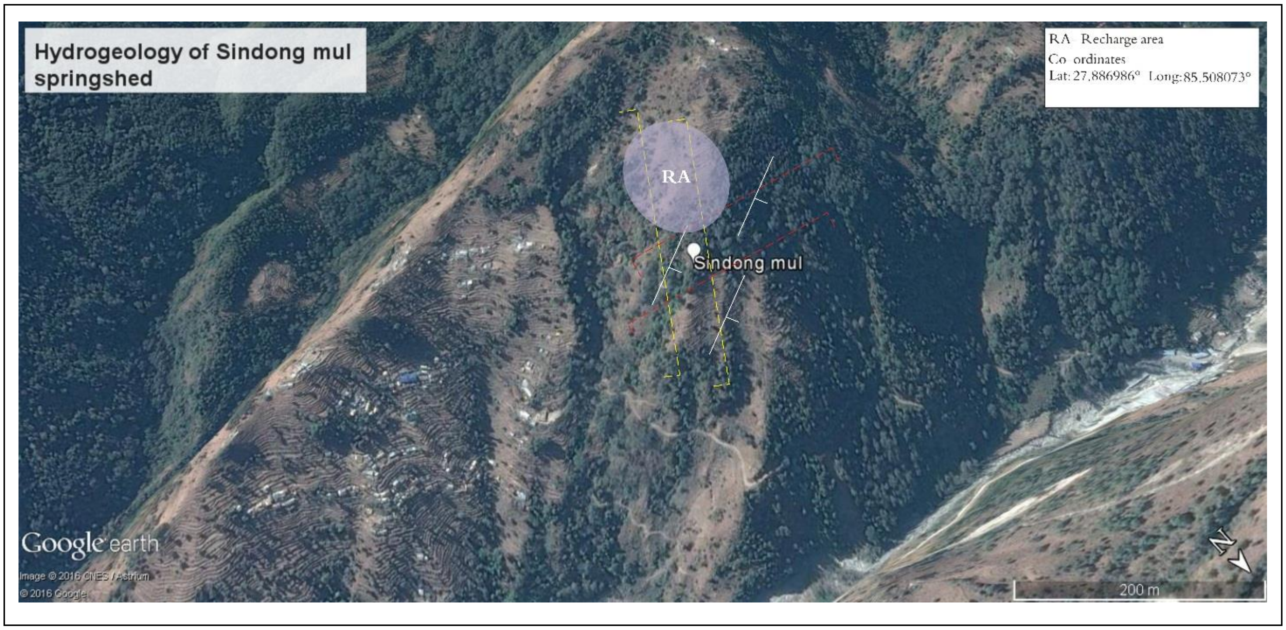

Figure 16: Google image depicting hydrogeological observations depicting potential recharge area

RECHARGE AREA RECOMMENDATIONS

The identified recharge area lies on the slope facing SE direction with slopes ranging from 50-60%. Depending on the land cover/use, activities can be planned. Staggered contour trenching can be designed in case of barren lands which are not used for any other activities. Agricultural field terraces can be raised with inward sloping faces. Plantation activity would be very important to arrest soil erosion because of steeper slopes.

SHYARBHOR MUL

Latitude	Longitude	Elevation
27.88561°	85.50875°	1531m

The Shayarbhor mul springshed is mainly composed of loose unconsolidated debri material. There are multiple discharge points through which the spring emerges making it a classic example of depression spring. This system of debri material is found in narrow valley with gneisses underlying it. A small outcrop on one side of the valley was found where measurements were carried out. Gneisses are banded and dips in the south-west direction with amounts ranging from 20-30°. They are traversed by two major set of fractures, one dipping NW trending NE-SW while the other one dipping ENE trending NNW-SSE ***(Fig.17).*** Spring emerging out through the thick pile of loose unconsolidated debri becomes a potential aquifer feeding it. The fracture system also adds to some amount of contribution to the existing aquifer.

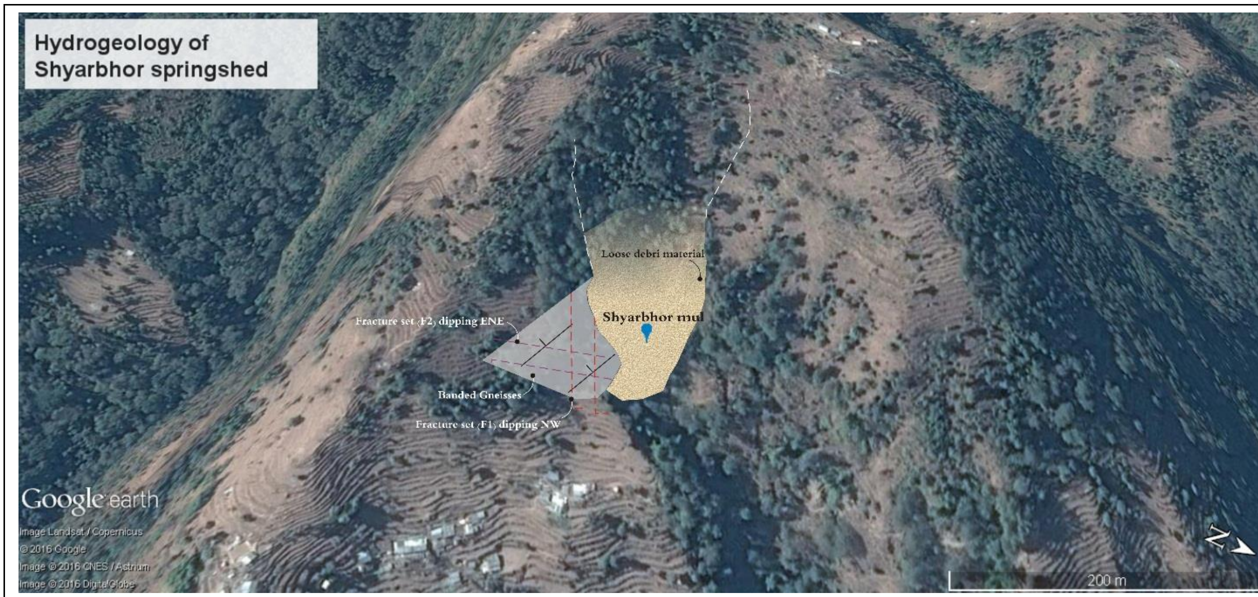

Figure 17: Google image depicting hydrogeological observations

Based on hydrogeological regime present in the springshed area, the potential recharge area lies on the same slope over the ridge area. The focus is targeting the underlying fractured gneisses along with the overlying debri material. The potential recharge area identified targets both the elements ***(Fig.18).***

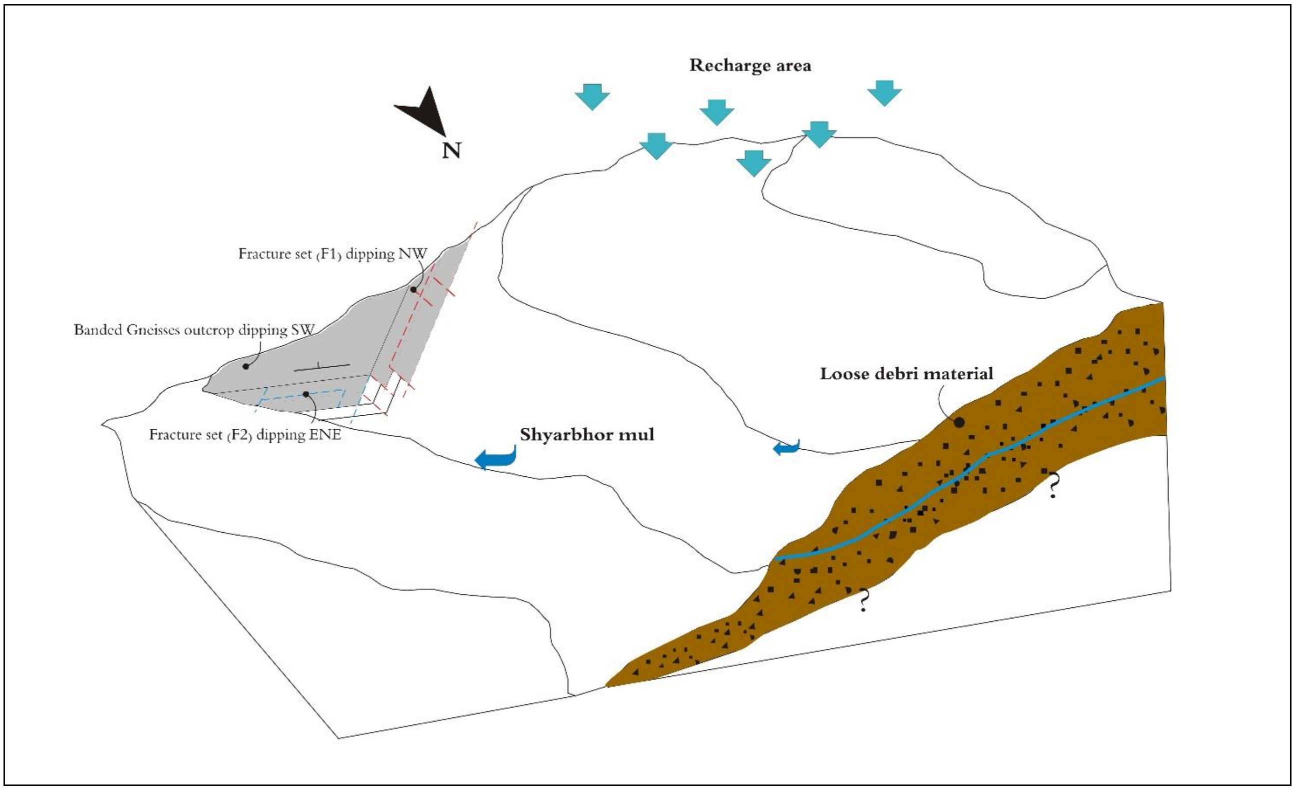

Figure 18: Hydrogeological conceptual layout of the springshed depicting potential recharge area

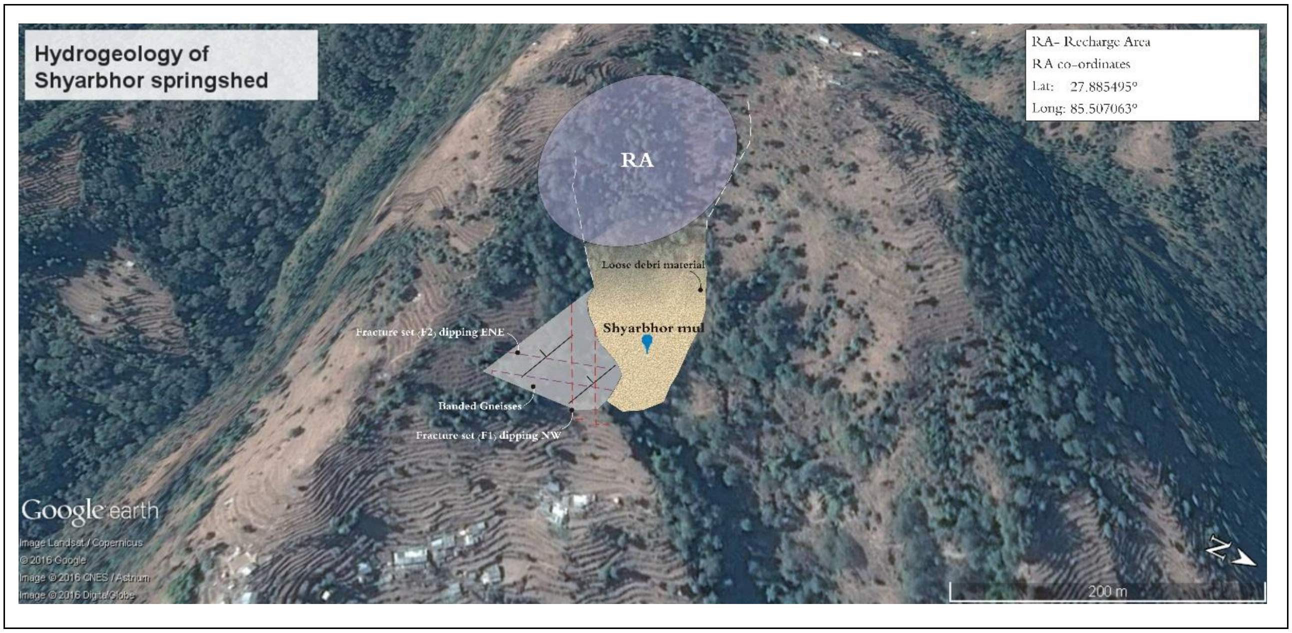

Figure 19: Google image depicting hydrogeological observations depicting potential recharge area

RECHARGE AREA RECOMMENDATIONS

Identified recharge area lies on same slope as that of the spring. Most of the area that falls in the recharge area is covered with agricultural field terraces. In such a case, contour trenching would be bit difficult. Vegetation cover seems to be quite good which needs to be preserved along with some additional plantation. Small dimension continuous trenching towards inner side of the field terraces will be beneficial to facilitate recharge to the underlying aquifer system.

SUMMARY

- The other two-spring Kitimba mul and Kalinche mul belong to the system, which is still pristine in nature. There is no single point discharge for these two springs. Both of them occur in the form of multiple discharge points, a classic example of depression springs and share almost common catchment area, which is covered with quite dense and pristine forest. Thus, it is important to protect the existing conditions to ensure natural healthy recharge to the system.

- Sindhupalchok as a whole is quite groundwater surplus. The only thing that is required is proper management and awareness regarding the same.

- Earthquake has caused certain disturbances to the geological setup prevalent and thus also to the hydrogeological regimes. Understanding these disturbances and changes in the landscapes will involve substantial amount of work in field. For now, few interventions can be carried out to see if it shows impact to some extent.