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Report/Tuensang 1

ACWADAM

Hydrogeology based Catchment Area Planning for Spring Water Management in Tuensang District, Nagaland

"Hydrogeology based Catchment Area Planning for Spring Water Management in Tuensang district, Nagaland under the North East Initiative (NEI)"

- *submitted to NEIDA, Guwahati, Assam*

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Background

Springs are the only reliable and sustained source of freshwater for the people residing in the Himalaya. Experience from the Himalayan region reveals the depletion and deterioration of natural resources, especially that of groundwater resources. ACWADAM"s own experience from working in the Himalaya portrays an acute state of affairs. Pressures from a growing population, changing aspirations of people and an increasingly urban lifestyle has meant that demand on water resources will continue to grow at a rapid pace, making conservation of groundwater resources extremely vital.

In mountain areas like the Himalaya, the high relief of the ground and the complex geological structure in the sub-surface clearly play a role in the geometry and behaviour of mountain aquifers. The hydrogeological complexities resulting from highly variable rainfall and geological factors are seldom considered while assessing recharge to groundwater, especially in work on watershed development. Thus, a shift from the classical ridge-to-valley to a valley - to - (the next contiguous) valley approach is desired in policies dealing with spring water, in many parts of this landscape, although not necessarily as a rule. Having said that, a good understanding of the science of groundwater becomes important in identifying typologies of problems and developing processes to address these problems. The subject of hydrogeology helps understand problems and develop solutions / processes to address these problems, depending upon situations at different scales. Hydrogeological mapping of springs often reveals that the recharge area and the area of protection of the springs show quite a site - specific relationship.

Noksen block in Tuensang district of Nagaland, where this study was undertaken, portrays acute water crises in many parts, despite dense vegetation (a common assumption, otherwise, is that dense vegetation ensures water). An earlier reconnaissance visit by ACWADAM - in Mokokchung and Tuensang districts (Observation Summary appended as annexure to this report) revealed that Noksen is underlain by a different geological setting, land use patterns and spring hydrology as compared to the other Himalayan areas. Aquifers with low transmissivities, may have been affected by major changes in recharge / recharge areas are quite typical.

A typical chaotic setup of pipelines used for distributing water tapped from springs in the hills, Mokokchung, Nagaland

The proposed rapid action-research study was undertaken in Noksen block and facilitate site specific inputs to Water and Sanitation (WATSAN) programmes in such project villages of Noksen block with clearly defined objectives:

Objectives

- Identification of springs surrounding the villages and mapping based on the base line data
  (*Based on NEIDA's input*)
- Developing a monitoring setup for continuous data collection on springs
  (*Mainly weather and spring discharge data*)
- Identifying natural ground water recharge areas of the springs
  (*Based on the local hydrogeology and geological structure*)
- Developing conceptual hydrogeological layouts of springsheds
  (*Based on secondary data and field data*)
- Developing a model-pilot springshed
  (*Action-research based implementation in a selected springshed*)
- Capacity buildings of the NEIDA as well as the villagers on spring recharge activities, catchment protection and groundwater management
  (*An integral part of the fieldwork*)
- Providing a plan for further work on groundwater resources and their management in the area
  (*A strategy suggesting a way forward for NEIDA's work on groundwater resources*)

Methodology

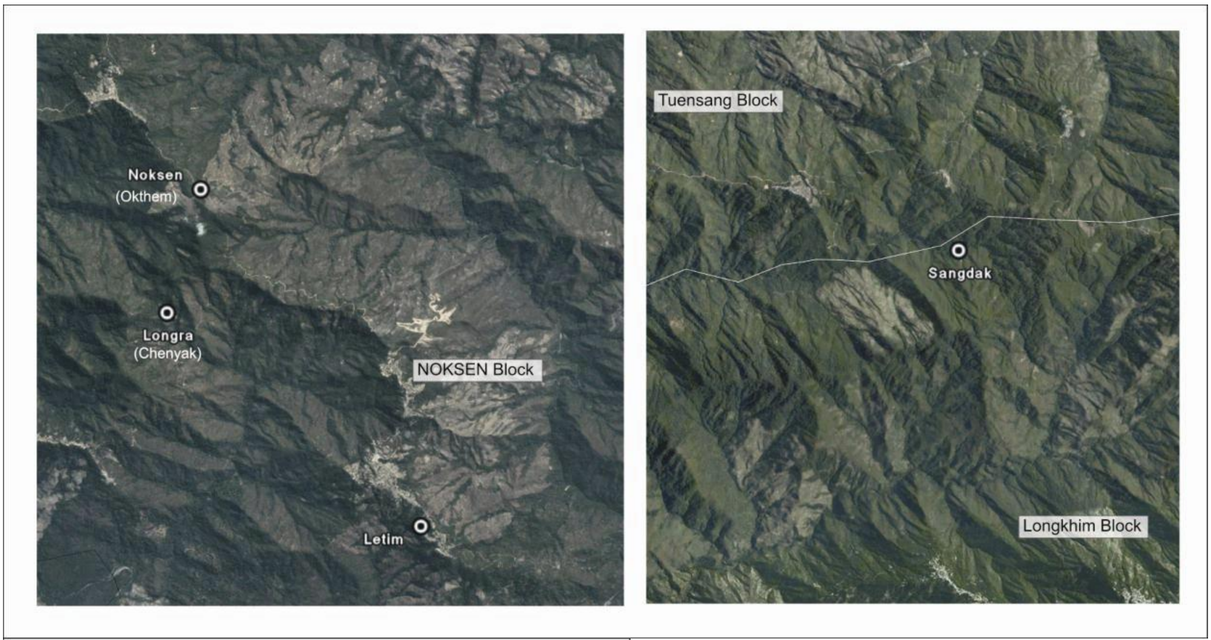
The methodology in order to achieve the above-mentioned objectives included three major components namely

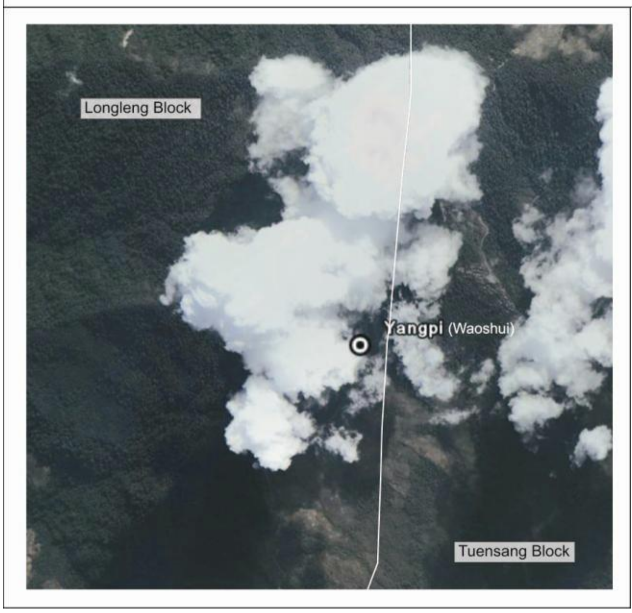
1. Fieldwork: ACWADAM undertook two field visits to the study areas (springsheds) to map out various lithologies and study certain hydrogeological aspects of underlying aquifers, including the study of geological structures, natural drainage and springs. A monitoring network will be setup in the area(s) for continuous collection of data regarding spring discharges, weather, water quality etc. The partner organisation will be engaged in collection of this data. On-field capacity building of villagers and other facilitating members involved in the project would be an integral part of these field visits.

2. Analysis: This component involved deskwork, mainly at ACWADAM"s office in Pune. It has included study of information available with the partner organizations and ACWADAM in the form of secondary data. This complimented primary information collected through field work and was thought to provide key inputs to the interpretative components of the project. Based on the information collected, conceptual layouts of springsheds have been prepared. These layouts help describe, in a very general sense, the hydrogeology of these areas, including the aquifers or groundwater systems and areas for recharge/treatment.

3. Reporting: Some of the obvious results were explained to NEIDA"s staff and partners in the field. Each visit was followed by a brief report. A detailed report that synthesizes field observations, measurements and analysis (through the deskwork) will be furnished at the end of the study. The report includes hydrogeology of the spring system, salient observations, some synthesis and a set of recommendations for the Noksen block, not just about the treatment in connection with the springs, but also in terms of its protection and upkeep. The report has the potential to be used as a decision-support tool in terms of up-scaling of WATSAN activities.

Location





Google images depicting spring locations under study

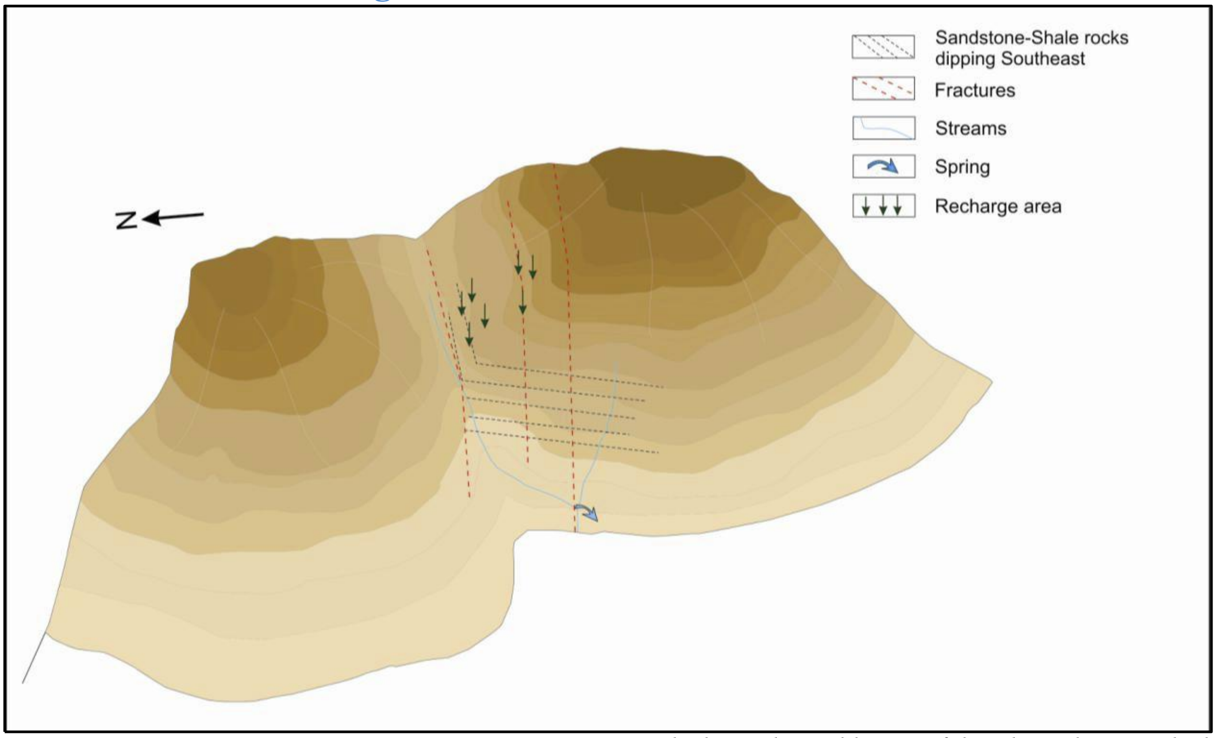
Framed between the Assam plains to the west and Myanmar to the east, Nagaland is located in the northern extension of the Arakan-Yoma ranges. The state is bound between the parallels of 25°15' and 27°00' N latitudes and 93°20' and 95°15' E longitudes. Almost the entire state is hilly, except along the foothills flanking the Assam plains. The general elevation increases towards the east, the highest peak Saramati (3826.15 metres) belongs to the easternmost hill ranges of the state. Barail and Japvo ranges and their extensions in Mokokchung and Tuensang mark a prominent water divide separating Brahmaputra and the Chindwin River systems

Out of 16,527 sq. kms of total land area, about 14,360 sq. kms is under forests. The forests under government control are reported to be about 28.5% of the total forest area. The average rainfall is between 175cm and 250 cm. Most of the heavy rainfall is during the 4 months from June to September.

Hydrogeologically, the area is underlain by unconsolidated and semi-consolidated formations ranging in age from Upper Cretaceous to Recent. Disang Formation comprises shale and sandstone and Barail Formation comprises bedded fine to medium grained compact sandstone.

Spring: **Chenyak**

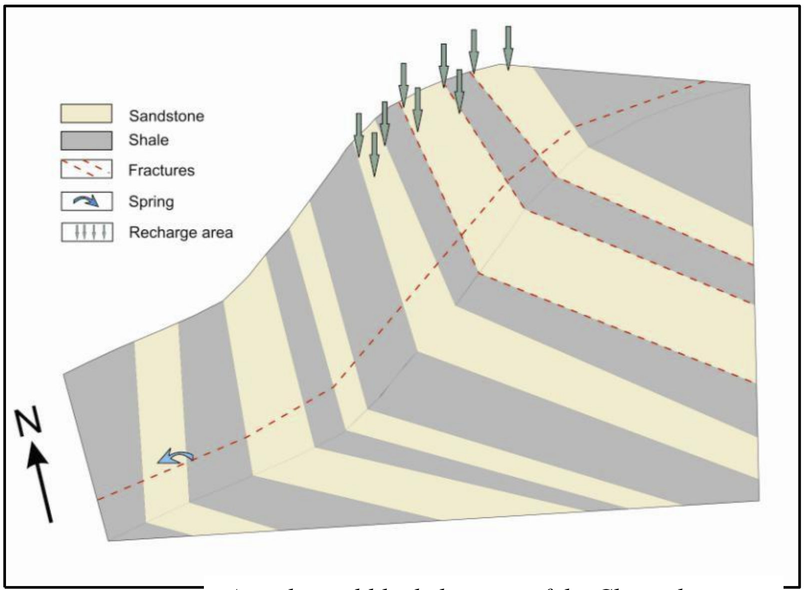
Water to be sourced to: **Longra**



A hydrogeological layout of the Chenyak springshed

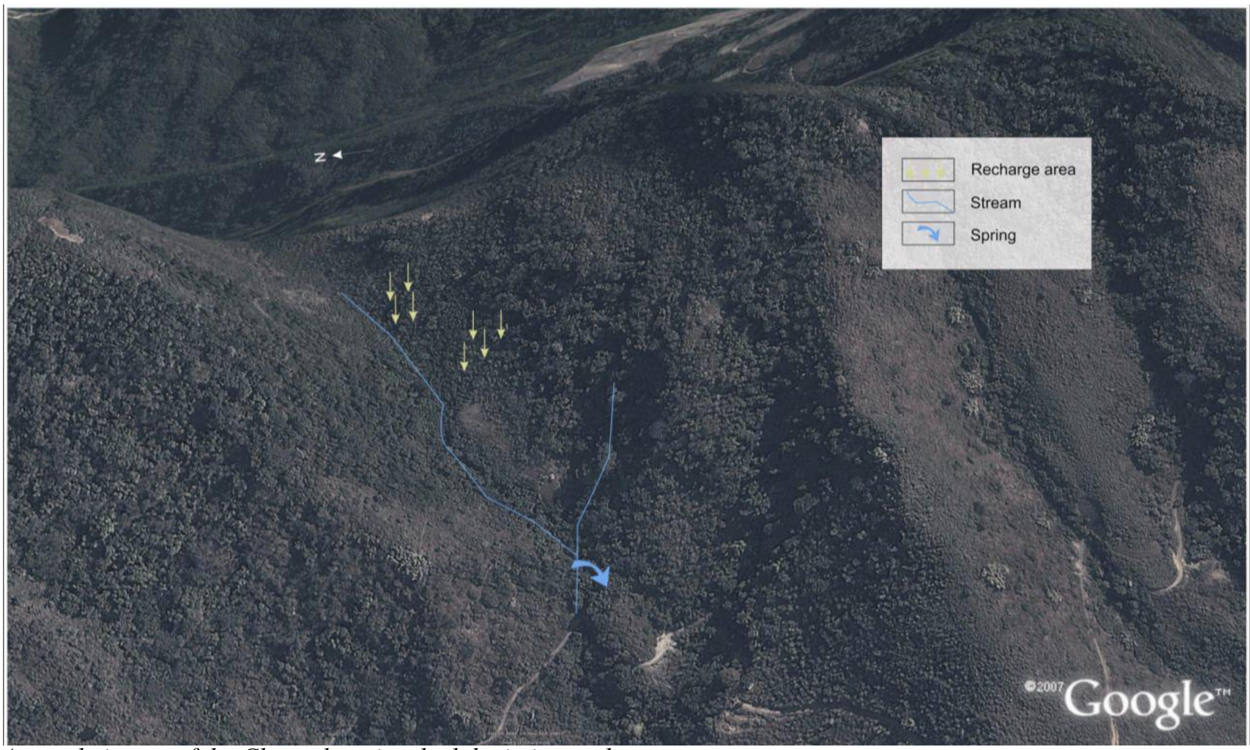
Chenyak Spring located in Noksen block of Tuensang district emerges at an elevation of 1181m. The spring discharge measured in March"13 was 23 liters per minute. The spring emerges on the western slope of the hill the upper reaches of which are thickly forested.

The entire springshed is made-up of layers of sedimentary rocks and is dominated by a sequences of sandstone and shale. The entire sequence of sedimentary rocks dips by an angle of 35-40° towards southeast. Similar trends are observed all across the hill as well as in the adjacent hills to the north, indicating that the strike and dip of this sedimentary sequence is quite regional. The rocks show prominent fractures trending E-W. The spring Chenyak emerges along one such fracture and is thus classified as a fracture spring, with a major proportion of the groundwater storage expected to be held by the weathered-fractured sequence of sandstone-shales exposed along the slope. A major part of this storage is expected to move towards the south-east, along the dip direction of the sediments. The fracture that transects this sequence is the only mechanism that draws water from aquifers above to discharge to Chenyak spring. The shales, highly weathered as compared to the sandstones, have contributed to forming a



A geological block diagram of the Chenyak spring considerable soil cover.

The recharge area to the spring is located towards the northeast of the spring as shown in the above diagram. The recharge area accounts to be ~2 hectares. Given the thick vegetation, thick but loose soil and a relatively steep surface slope - the spring is located on the escarpment slope - staggered trenches are recommended in the recharge area. Chains of staggered trenches should be made along successive contour lines so that water left by one line of trenches is captured by the lower line. The gaps in the contour line should fall below the trenches in the higher contour line.



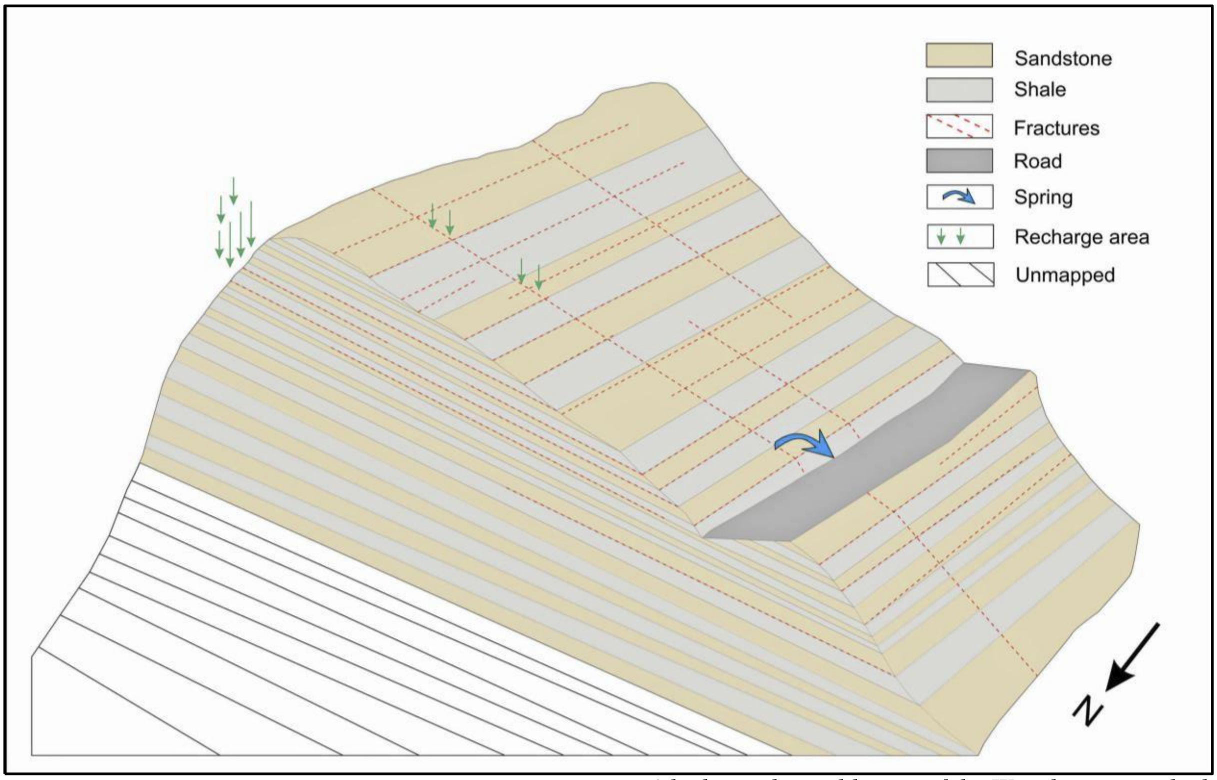
A google image of the Chenyak springshed depicting recharge areas

Chenyak spring

Massive Jhum near to the spring

Jhum cultivation - has in all probability obliterated exposures of the major fractures and permeable contact zones between sandstones and shales in and around the recharge area. Controlling the Jhum at least in and around the two-hectare recharge site will enable soil erosion and facilitate further recharge. Alternatively, staggered trenches along the relatively gentler portions of the Jhum field can also be undertaken as part of the recharge-augmentation process.

Spring: **Waoshui**
Water to be sourced to: **Yangpi**

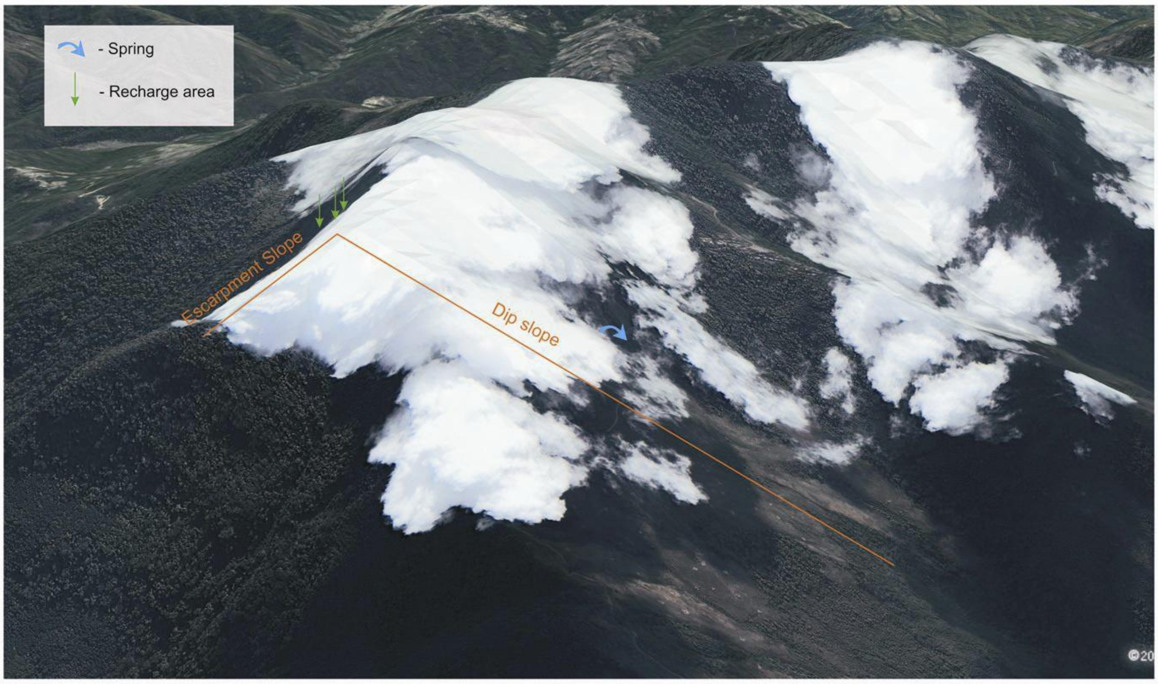


A hydrogeological layout of the Waoshui springshed

Waoshui spring located in Shakshi block of Longleng district emerges at an elevation of 1714 m. The spring discharge measured in March"13 was 10 liters per minute. The spring emerges on the western slope of the hill the upper reaches of which are thickly forested. The entire springshed is made-up of Sandstone-shale rocks. The sandstone is thick and quite indurated (hard) as compared to the thin and weathered shale layers. The rocks dip by an angle of 30-35° towards the west. Two sets of fractures are observed in the rocks, one along the bedding planes of the rock along the dip direction and the second vertical trending E-W. The spring emerges clearly along an E-W trending fracture and is thus classified as a fracture spring. The spring emerges on the dip slope while the recharge area to the spring is located on the escarpment slope towards the east. Fracture traces on the surface, particularly those evident as clear partings parallel to the bedding in close association with the vertical fractures should be targeted to construct trenches for recharge in the recharge area demarcated on the escarpment side of the ridge. Relatively deeper recharge pits to be made in recharge area demarcated on the dip slope along the vertical fractures.

The spring collection chamber at Waoshui spring

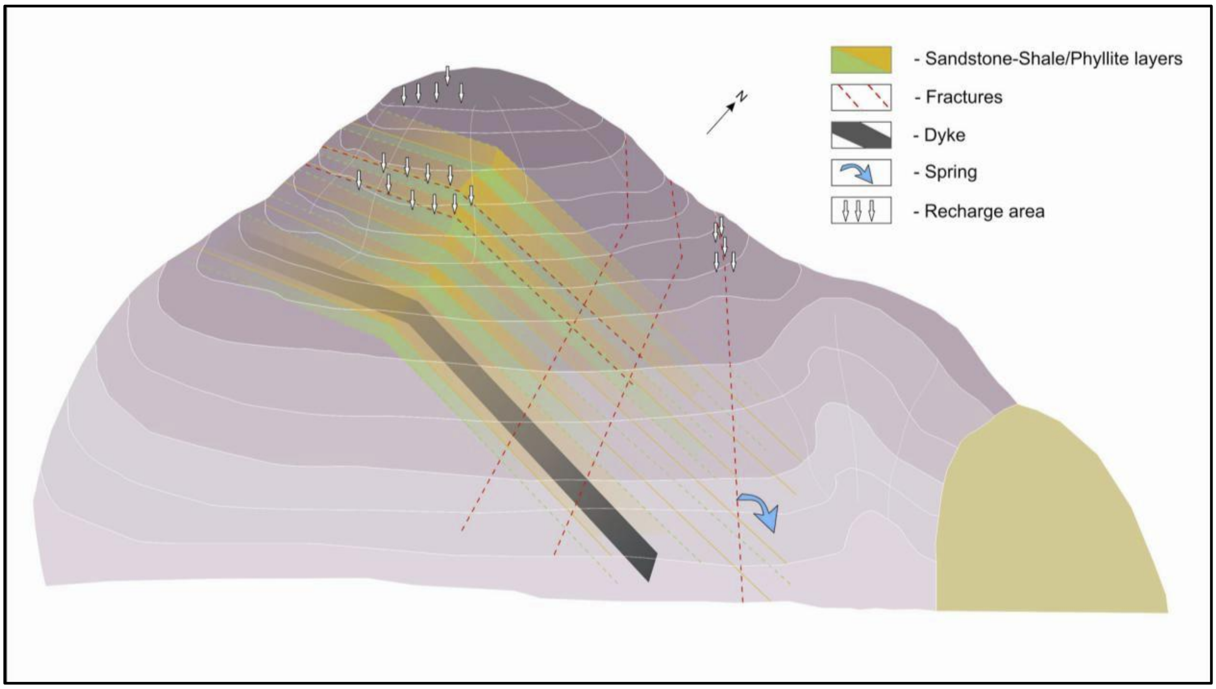
The recharge area along the dip slope



A google image of the Waoshui springshed depicting recharge areas

Sandstone-shale rocks dipping west

Spring: **Okthem**
Water to be sourced to: **Noksen**

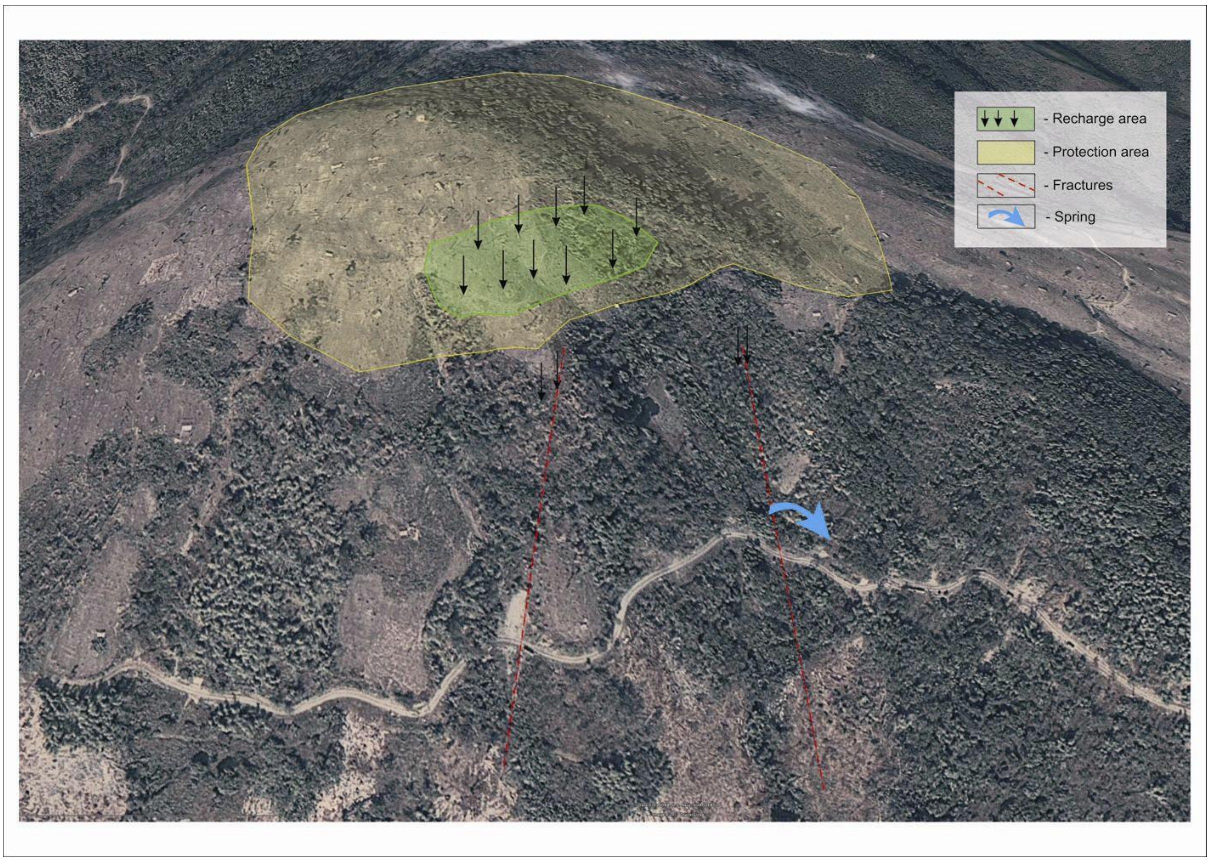


A hydrogeological layout of the Okthem springshed

Okthem spring located in Noksen block of Tuensang district emerges at an elevation of 1446 m. The spring discharge could not be measured at the source but, it was observed to be in the range of 3-5 lpm. Sandstones-shale layers make-up the entire springshed. The rocks are well exposed along the road cutting just below the spring. The rocks dip towards the north by an angle of 35-40°. A mafic (igneous intrusion) - possibly emplaced along the bedding plane during uplift - possibly forms an impermeable base to the vertical movement of groundwater through fractures in the sandstone-shale-phyllite sequence. The sequence upslope, therefore, makes up a complex aquifer system feeding springs along the contact of the sediments and the intrusive body. This intrusion is exposed just southwest to the spring. Two fracture trends are observed one vertical and the second dipping towards southwest. Okthem spring emerges along the vertical fracture, although the spring itself could be classified as a combination of a contact and fracture spring. Shales are highly weathered as compared to the sandstones and could possibly form the relatively low-permeability, but some storage-bearing units of the aquifer system.

The spring is fed by recharge from two areas - from the escarpment slope towards the west and through one major fracture zone that extends upslope in the northwesterly direction. Staggered trenches have been suggested in the recharge area where relatively flatter land is available. Saturation of land in the relatively plain stretches in both these areas by such trenches is recommended. Jhum cultivation in the demarcated recharge should be completely banned.

Spring tank at Okthem



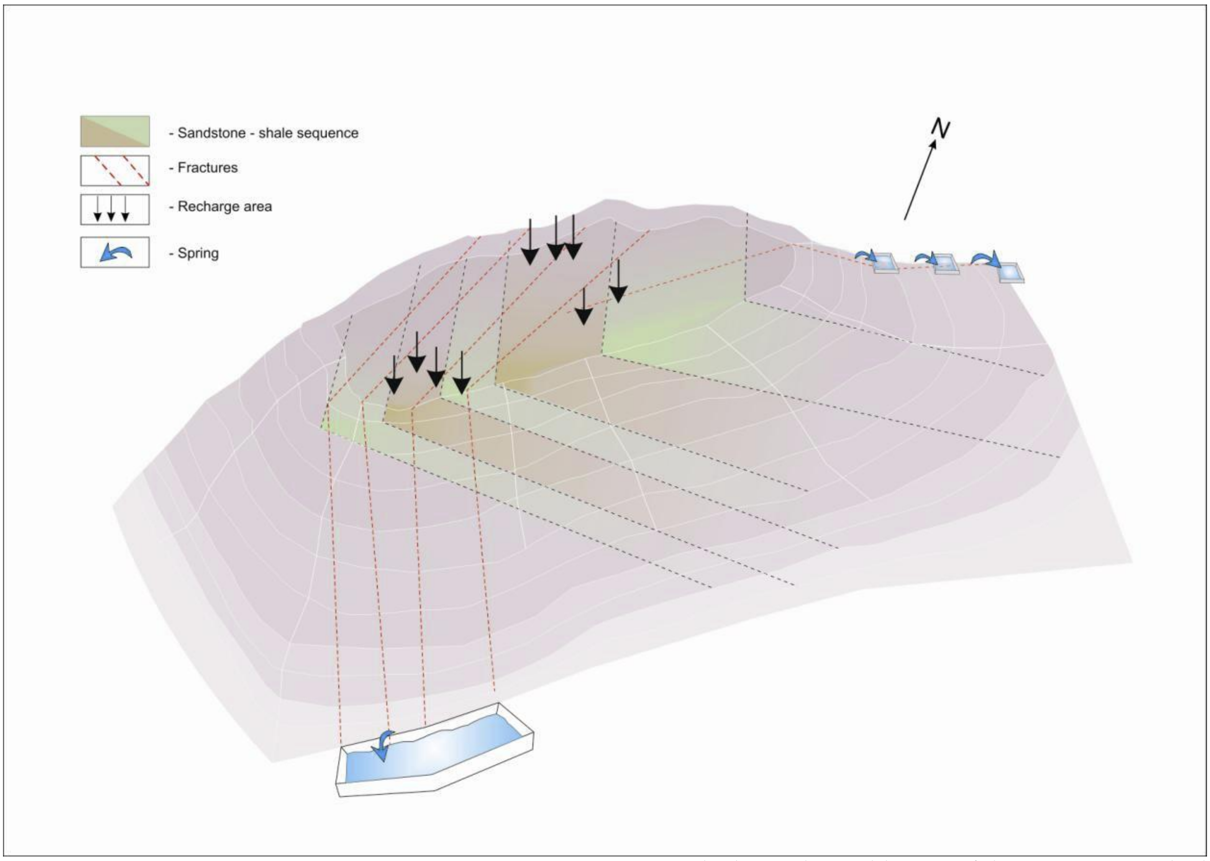
A google image of the Okthem springshed depicting recharge areas

Rocks exposed in the Okthem springshed

A trench being dug in a recharge area at Okthem

Spring: **Litem**

Water to be sourced to: **Litem**

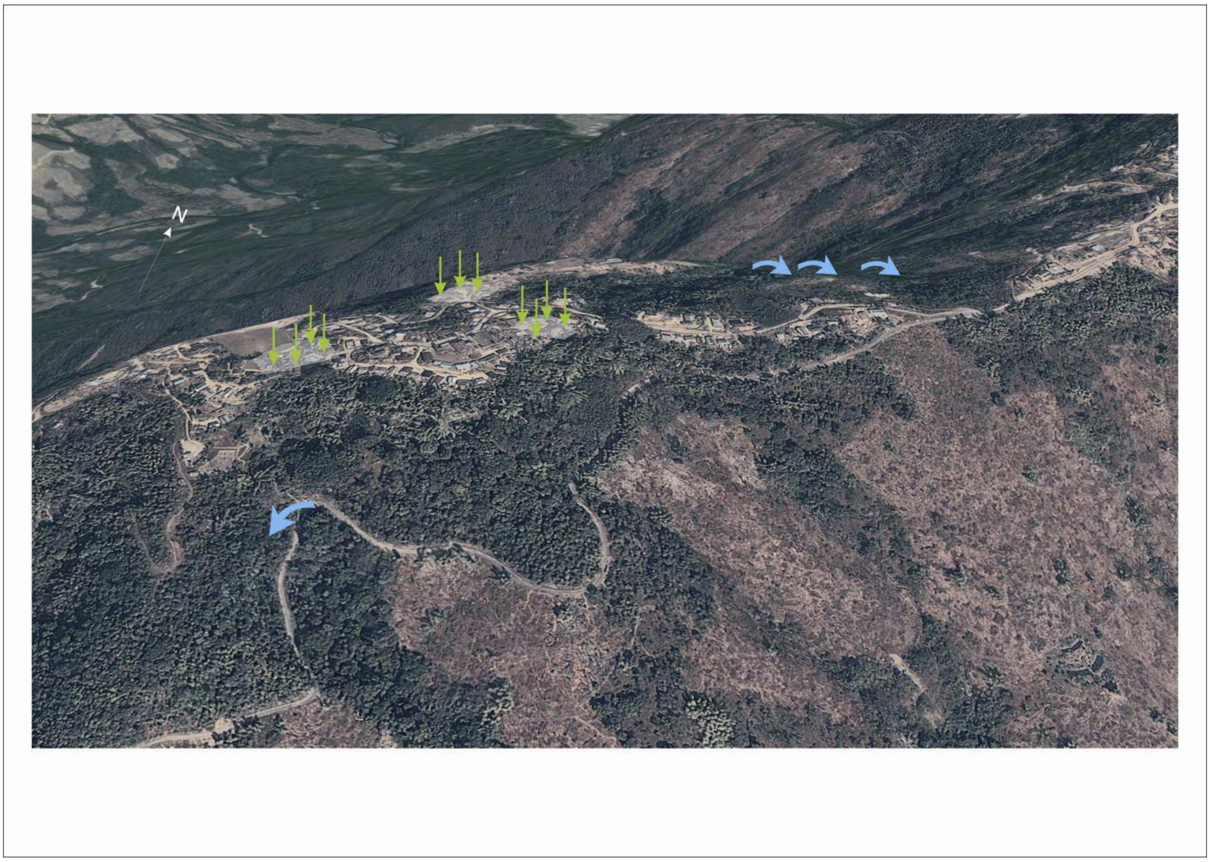


A hydrogeological layout of the Letim springshed

Litem village rests on top of an elongated ridge trending NE-SW at an elevation of 1252 m. A series of springs is observed on the northeastern as well as the southern slope of the ridge. On the northeastern slope three springs are observed along a stream. The springs are actually shallow ponds/wells 3-4 feet deep. On the southern slope a high discharge spring is observed, the water from which is collected in a big tank constructed just below. The ridge or the springshed is made-up of sandstones and shales. Only a few exposures are observed indicating that the rocks dip east. A set of vertical fractures trending N-S are also observed in the rocks. The spring system on the northeastern slope represents „depression springs", while the spring on the southern slope is a fracture spring.

The recharge area for the springs is located on the top in and around the village. One area for recharge lies exactly above the spring on where the surface of the ground shows vertical fractures. Settlements make it difficult for land to be available for recharge. Hence, recharge through rainwater harvesting forms a feasible alternative. The rainwater harvested on roof tops to be channelized through pipes and diverted in the small but relatively deep recharge pits. The recharge pits should be well spaced from any sanitation facility nearby.

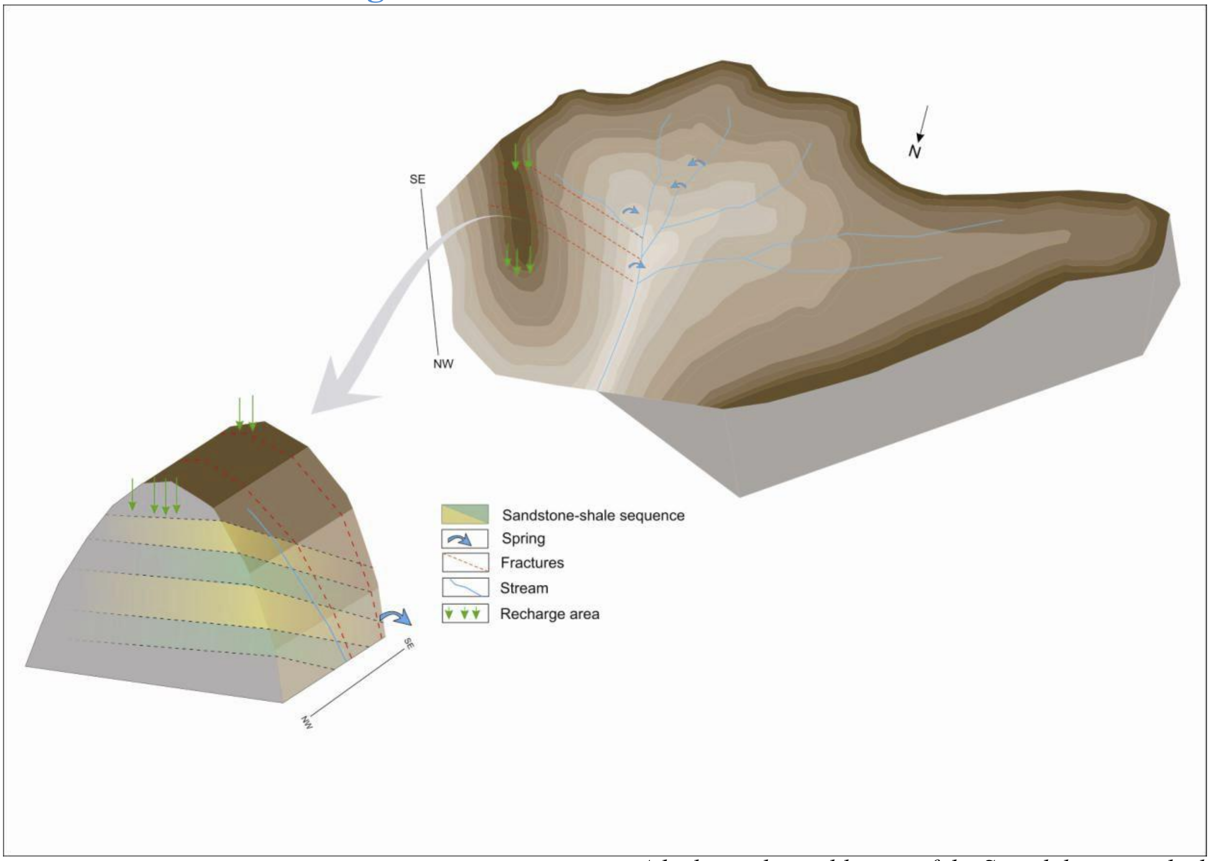
Spring tank at Litem



A google image of the Litem springshed depicting recharge areas

Spring tank at Litem

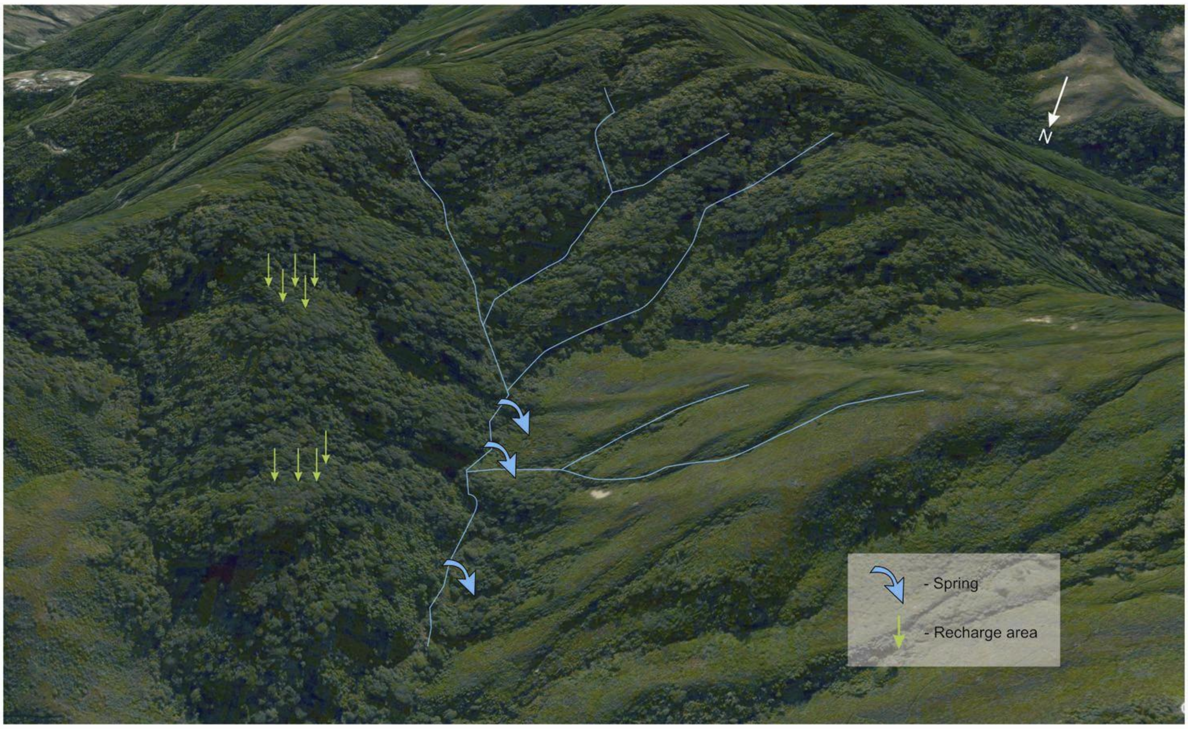
Spring: **Sangdak**
Water to be sourced to: **Sangdak**



A hydrogeological layout of the Sangdak springshed

The Sangdak catchment spreads over an area of about 250 hectares and is part of the Chemyak river system. The entire catchment is thickly forested, with no settlements. Numerous springs emerge in the catchment which then flow on the surface to form larger streams. The thick vegetation makes it difficult to spot rock exposures. Sandstones and shales make-up the entire catchment. The rocks dip southeast by dip angles varying in the range of 45 to 65°. Hence, the streams draining the catchment are located dominantly on the escarpment slope. Sandstones and shales are relatively more weathered along the valley portions; as one moves upslope, sandstones appear hard and indurated, with limited partings to allow movement of water. On the other hand, shales are consistently weathered throughout, although they yield somewhat clayey material in the lower portions of the Sangdak catchment. The springs, however, emerge along NE-SW trending vertical fractures, which carry water from the aquifer systems formed by the sandstone-shale sequence on either sides. The stream derives its discharge from both, direct runoff from heavy showers and also from spring discharges from numerous small and large fracture springs along the NE-SW trending fracture system. The proposed tapping point of the stream (spring fed) is at an elevation of 1785m. The recharge area to the spring system is located in the northeastern part of the catchment. The stream discharge measured at the proposed tapping point was 250-300 liters per minute, although this is likely to vary during the course of the year. The lean discharge may drop to as less as 50 lpm after the rains stop and the only contribution to the stream is from the fracture springs. The pristine forest and relatively undisturbed conditions in the catchment will ensure sufficient natural recharge from rainfall and therefore no artificial recharge measures have been proposed in this area - carrying out such measures is also likely to prove difficult.

The key to ensuring minimum discharges and sustainable discharge from the system is to "protect and conserve" the catchment. The demarcated recharge area, particularly, should be protected from any developmental activities or jhum cultivation. Part of the stream flow should also be maintained to ensure sufficient environmental flows and water for other systems downstream.



A google image of the Sangdak catchment depicting recharge areas

Measuring stream discharge at Sangdak

Rocks exposed in the Sangdak catchment

Summary of proposed catchment treatment plan

Village	Spring	Area for recharge(ha)	Area for protection(ha)	Treatment measures suggested
Longra	Chenyak	1.2	6.5	Recharge pits, Staggered trenches
Yangpi	Waoshui	15	60	Contour trenches
Noksen	Okthem	1.5	10	Staggered trenches
Litem	Litem	0.8	17	Recharge pits
Sangdak	Chenyak	5.2	35	Contour/Staggered trenches

A way forward

Hydrogeological science forms the basis for any work related to watershed, springshed or any other intervention with connection to groundwater and aquifers. The science helps better understand springs scientifically and classify them into types based on the nature of their properties.

The complex geology, spring discharge locations and site specific recharge areas imparts a shift from the classical ridge to valley to a valley to (the next contiguous) valley approach in studies dealing with spring water.

This study involved a rapid hydrogeological assessment of the spring catchment to demarcate recharge areas of five springs located in Mokokchung and Tuensang districts. Based on the recommendations implementation measures would be carried out in the demarcated recharge areas. However, in order to gain some insights on how the implementation has affected the spring continuous monitoring of spring discharge in conjunction with basic water quality monitoring and rainfall are fundamental necessities. This would also help in managing and distributing spring-water, sustainably and equitably and taking certain informed decisions down-the-line, if need be.

Although a spring point source may emerge in a private land, its ownership should be community managed, considering the entire hydrogeological system and its recharge areas a larger system that may encompass not just land in one village, but the whole of part of land in an adjoining village. Similarly, the tapping point for water supply for a set of villages and/or a town may be located in land within the purview of a far-flung village. The location an extent of recharge areas, especially, are purely governed by the local hydrogeology and not by administrative or socio-economic boundaries. Thus, community involvement and awareness regarding role of geology in governing recharge areas, importance of data collection etc. becomes almost a non-negotiable aspect in any groundwater related work, particularly in work such as the one that NEIDA is undertaking in Nagaland in particular, and the northeast, in general.

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Annexure

ACWADAM

Visit Summary: Springs in Tuensang District, Nagaland

Key observations from Nagaland visit |HIMANSHU KULKARNI

LITEM

Hydrogeological features

- Fine grained sandstones, mudstones and shales - some places with low degree of metamorphism (?phyllites)
- Rocks show strike of NE-SW, with dips in the SE direction, consistently throughout the village
- Fractures coherent with the dips of rocks
- Gentle folding along slopes that exhibit strike
- Fractures (major set) along 191 degrees - NNE-SSW direction

Aquifers & Discharge

- Multiple aquifer system, with discharge points at different elevations, e.g. spring tanks[1]
- Low discharge spring tanks, but numerous, all close to the village
- Wetland kind of discharge zone at the top also indicates aquifers with some storage capacity, but low hydraulic conductivity

Suggestions

- Catchment area treatment, after proper identification of recharge zones, which are likely to be in the upper portion and on the NNWestern slopes.
- Along fractures on the SSEastern slopes.
- Rainwater harvesting, with appropriately linked recharge mechanisms across different neighbourhoods in the village.

[1] Spring tanks are commonly referred to as *dugwells* in the area. Most are open chambers for spring "collection", open on the upslope side and concreted / walled on the downstream side, with inflow above the water level in the tank. A few are actually wells, where inflows are below the water table, indicating the saturation in the aquifer that these tap.

NOKSEN

Hydrogeological features

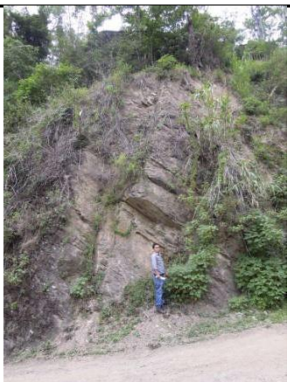
- Indurated sandstones; dominance of shales, carbonaceous at places; some carbonates (?need to be confirmed); phyllites and schists also
- Regional dips in the ESE direction, with steepening at many places, indicating the presence of isoclinal folding
- Fractures are generally aligned along the axial planes of folds, generally NNE-SSW, with another set perpendicular to this one
- Fractures (major set) along 191 degrees - NNE-SSW direction

Discharge characteristics

- 11 spring tanks, 5 seasonal, 6 perennial (reported)
- *Langla* - place of stone - source with very poor discharge now; on SE slope, dominated by arenites - sandstones; quartzites at some places
- One perennial source on eastern slope, where rock is softer, weathered shales and mudstone

Suggestions

- Multiple catchment areas in and around the village
- Recharge work to be undertaken along major fractures on SE slopes and at appropriate locations on NWestern slopes

YANGPI

Hydrogeological features

- Presence of carbonates - mostly impure limestones, with sandstones and shales that show low-grade metamorphism
- Regional dips in the ESE direction, with folding at a few locations
- Fractures are generally aligned along the NNE-SSW, with another set perpendicular to this one; fractures may or may not be aligned with the axial planes of folding
- Fractures (major set) along 191 degrees - NNE-SSW direction

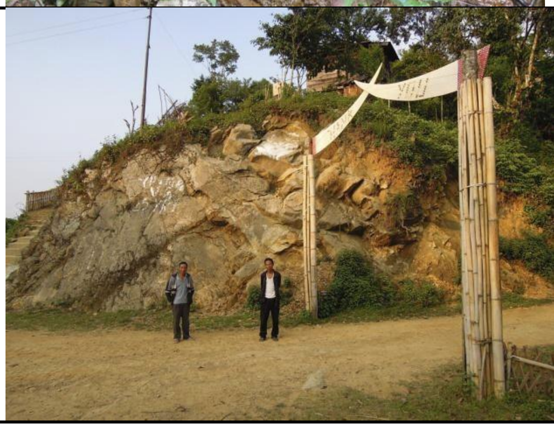
Discharge characteristics

- 10-15 spring tanks, mostly seasonal or with highly depleted spring discharge
- Seasonal discharge high, with leanest period between March and May each year
- One perennial source on SWestern (?) slope, connected to a pipeline

Suggestions

- Multiple catchment areas in and around the village
- Recharge work to be undertaken along major fractures on SE slopes and at appropriate locations on NWestern slopes



SANGDAK

Hydrogeological features

- Part of River Chemyak system - flows from South to North
- Mixed and highly diverse geology - southern part of river (where sources for Noksen town and proposed source for Sangdak are located) with sandstones, quartzites, carbonaceous shales and impure (hard, indurated) limestone; northern part of river basin where Sangdak is located, shows more ferruginous sandstones, shales and impure limestones
- Regional dips in the ESE direction, with steepening at many places, particularly along drainage lines, indicating the presence of isoclinal folding (?)
- Several sets of fractures aligned along the axial planes of folds, generally NNE-SSW, with another set perpendicular to this one; faulting along regional thrust planes
- Fractures (major set) along 191 degrees - NNE-SSW direction

Discharge characteristics

- Proposed source in Chemyak river is along the NWestern slope and is probably a system of fracture springs - perennial with a lean discharge of about 50-100 lpm - needs to be confirmed with a V-notch; the delivery length is estimated to be about 17km, with a net head difference of about 10-20m. This source is in dense forest
- Local sources are equally important, although these are low discharge, contact (?) springs, mostly on SEastern slopes, at approximately the same elevation from msl - base is impermeable, with and exposed aquifer. The aquifer material, in all probability, is exposed at slightly higher elevations on the NWestern slopes, which would be a good area for recharging the local water sources
- All these sources are perennial, but low-discharge (2-3lpm)

Suggestions

- Multiple catchment areas in and around the village for treatment of local spring water aquifers
- Detailed geological and engineering investigations for the regional source and supply scheme that is proposed




Overall observations

- Different setting - geological, land-cover/land-use, spring hydrology and user profiles - from other parts of the Himalayan - Sub-himalayan hydrology.
- Acute water crises in many parts, despite dense vegetation.
- Aquifer systems within sediments / metasediments that are structurally deformed and uplifted into mountain chains.
- Low-transmissivity aquifers which may have been affected by major changes in recharge / recharge areas.
- Scope for improvements in decentralised WATSAN, even in addition to more centralised plans.
- Hydrogeological investigations at the scale of spring-sheds possible and likely to provide key inputs to WATSAN Planning.
- Possibility of extrapolation to states like Mizoram and Arunachal Pradesh plus some parts of Assam.
- Integration of capacity building, action research and WATSAN Planning likely to lead to comprehensive benefits.