Regional hydrogeology of the Tendong hills and a Rapid hydrogeological assessment for Kitam

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Introduction

The complex interplay of rock types and rock structure in the Himalaya not only give rise to diverse hydrogeological environments, but such environments lie in close proximity to each other. The hydrogeological setting in mountain areas is a result of variation in the rock type and structure of the aquifers. Overlap and inter-fingering of different litho-units or rock strata lead to the development of composite aquifers (aquifers formed by a grouping of different rock types). Such overlaps are facilitated by structural deformation such as folding, faulting and development of fracture zones. Loss of aquifer continuity at mountain slopes or along faults and fractures, leads to the formation of springs. Spring discharges vary considerably depending on various factors, the foremost being the variations in pore-space and hydraulic conductivity of the aquifers (rock type and rock openings). Moreover, change in the quantity of precipitation on account of altitudinal differences is responsible for varying degrees of temporal variation in the discharge of springs. Aquifers in Himalaya, due to the discontinuity of the rock formations by conditions imposed by the terrain and the structural setting, are often only of local extent. Even within a small area, many separate aquifers may be encountered; these aquifers may be composed of a single lithology or may be composite in nature.

Despite such an intricate and complex geological setup, a vast majority of the watershed development programmes and spring development strategies implemented in Himalayan villages give no regard to the geology of the catchment. Even in geologically less complex areas, the success of watershed development programmes depends highly upon a sound geologic input.

In the Himalayan mountain belts, therefore, many projects with watershed or spring development agenda run the risk of limited scope, sometimes leading to the failure of achieving the full objective of the project. These projects are important because of various risks posed to springs, whether through fluxes imposed by a changing climate or by anthropogenic factors ranging from deforestation to hydropower infrastructure, much of these fluxes weighing hydrologically or structurally on the aquifers and watersheds hosting important spring systems.

ACWADAM, in partnership with other organizations, is attempting the development and implementation of scientifically motivated, hydrogeologically driven spring development programmes in the Indian Himalayan Region. The hydrogeological input provided by ACWADAM is intended to identify and "treat" the recharge area of the aquifer / spring. This is important because the diverse hydrogeological setting in the Himalaya means the size and location of a recharge area of a spring can be highly variable.

ACWADAM is also attempting to help partner organisations monitor spring discharge and spring water quality in a bid to understand spring behaviour and to help capacity building of partner organizations and the community through a knowledge and information driven process.

The Dhara Vikas project the State of Sikkim is a Government of Sikkim initiative, involving partners such as Rural Management and Development Department (RMDD henceforth) and State Institute of Rural Development (SIRD henceforth) and various other partners. The Dhara Vikas was constituted with the hope to arrest the disappearance of springs and develop strategies for the conservation of springs through an approach appropriately labeled “Springshed” development. The technical input for these strategies was provided various entities, with ACWADAM undertaking detailed hydrogeological investigation of the spring catchments and study of factors like spring discharge and spring water quality.

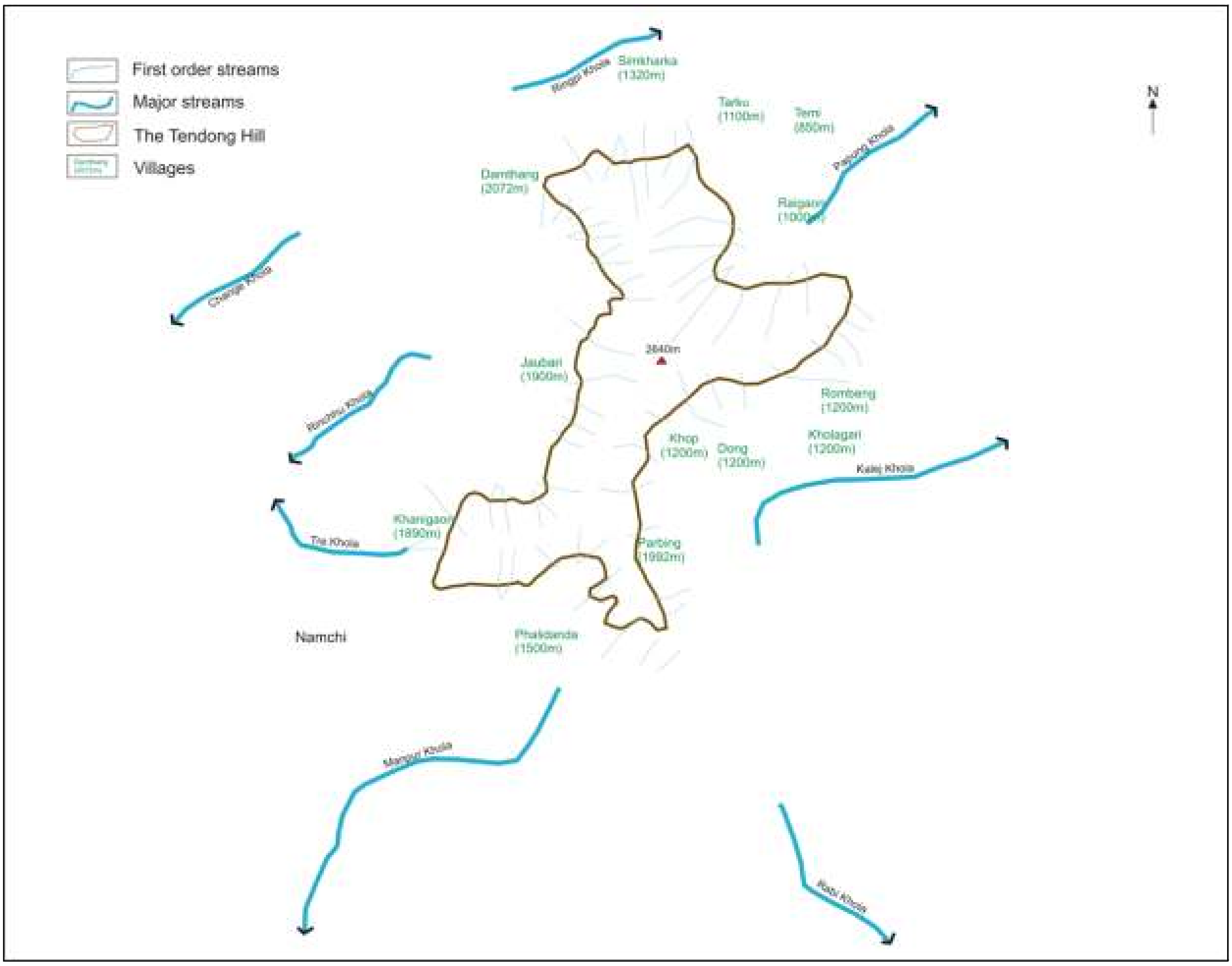
ACWADAM’s involvement in the project at the beginning of 2010 commenced with selection of springs for collection of data and group exercises for improving the understanding of hydrogeological principles among the participants. Field facilitation was coupled with capacity building exercises and providing back-stopping support to organizations involved in the project, a process in keeping with ACWADAM's modus operandi. In order to develop a first-cut understanding of the science of hydrogeology, 15 members from partner organizations were invited to participate in the July, 2010 training session in Pune. The comprehensive training session was followed by field exercises in the spring-shed area (aimed at the identification of spring recharge area and planning of recharge measures for different springs on the basis of hydrogeological investigations conducted). Refresher workshops, to revisit the skills and knowledge acquired during intensive training sessions and for the development of future strategies in the treatment of individual springs, have been planned from time to time. Subsequent to these, RMDD has been deputing some of its staff for the 15-day foundation training on hydrogeology and groundwater management conducted by ACWADAM in Pune.

Subsequently, ACWADAM undertook a rapid participatory hydrogeological study of 30 springs and 3 hill top lakes in Sikkim under a project funded by GIZ (formerly GTZ). The project outputs were used in springshed development around these 30 springs, many of which were mapped through the efforts of field facilitators of RMDD. The actual implementation of measures was undertaken by RMDD through MGNREGS funds.

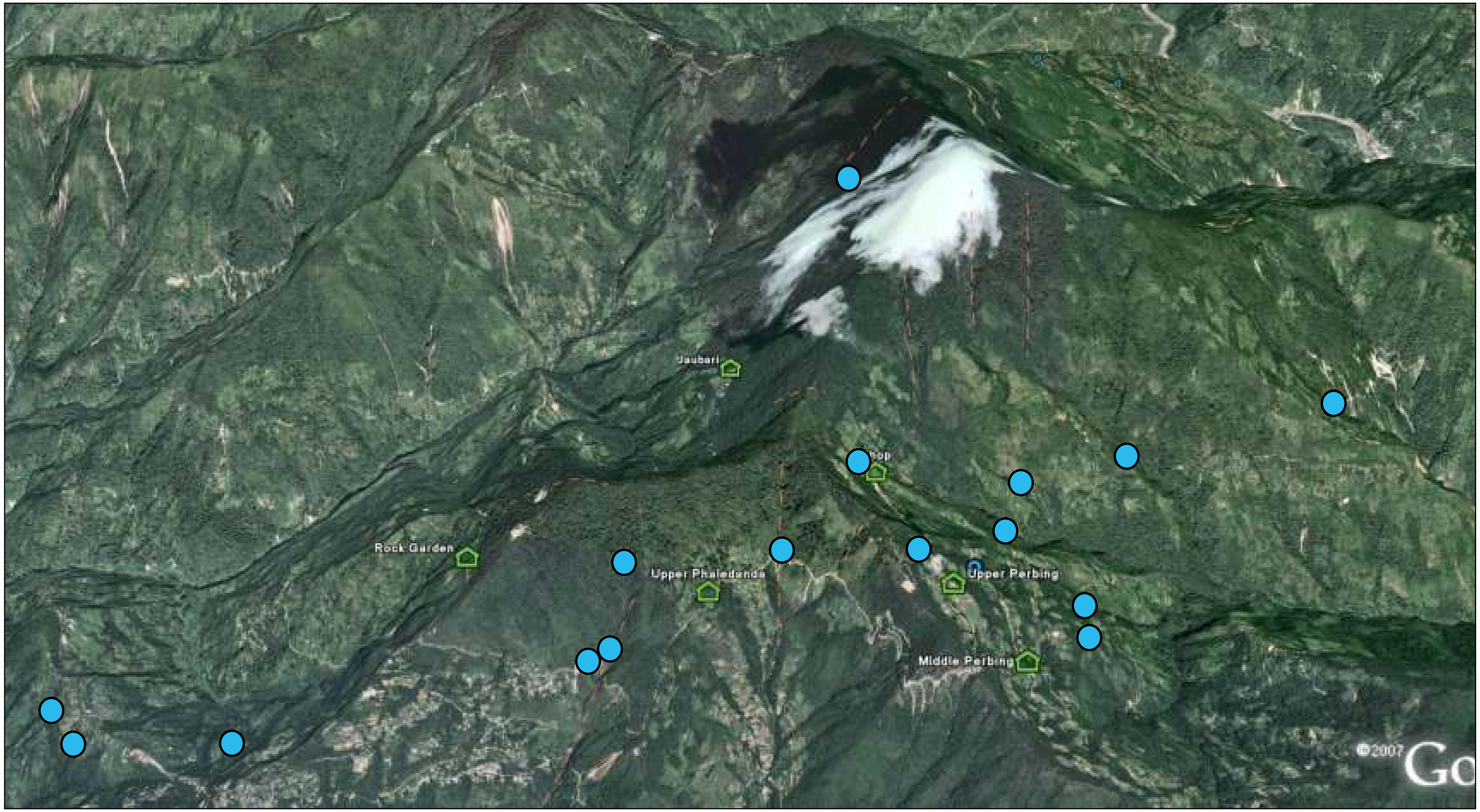
The current study comprised of developing a Regional Springshed development plan for the Tendong hills and a rapid hydrogeological assessment for Kitam.

Location

The Tendong Hill, located in South district of Sikkim rises to a highest elevation of around 2640 m (8545 feet) above mean sea level. The hill is devoid of human settlements on top and is a popular trekking destination for tourists. The Tendong hill is an abode to several natural springs that support almost all the settlements surrounding it, mainly on its flanks and in the adjoining valley portions. A popular tourist destination, Tendong Hills is also a part of a high rainfall zone. South District, of which Namche is the headquarters and is located quite close to the Tendong Hills, receives an average annual rainfall of more than 1600 mm. CGWB, in its groundwater district profile of South Sikkim (http://sikkimsprings.org/dv/Educational%20research/South_sikkim.pdf) pegs the annual rainfall for the region as close to 3500 mm, a more realistic range for Tendong Hills.



Tendong Hill region with various streams emerging from the region; Namchi lies to its southwest

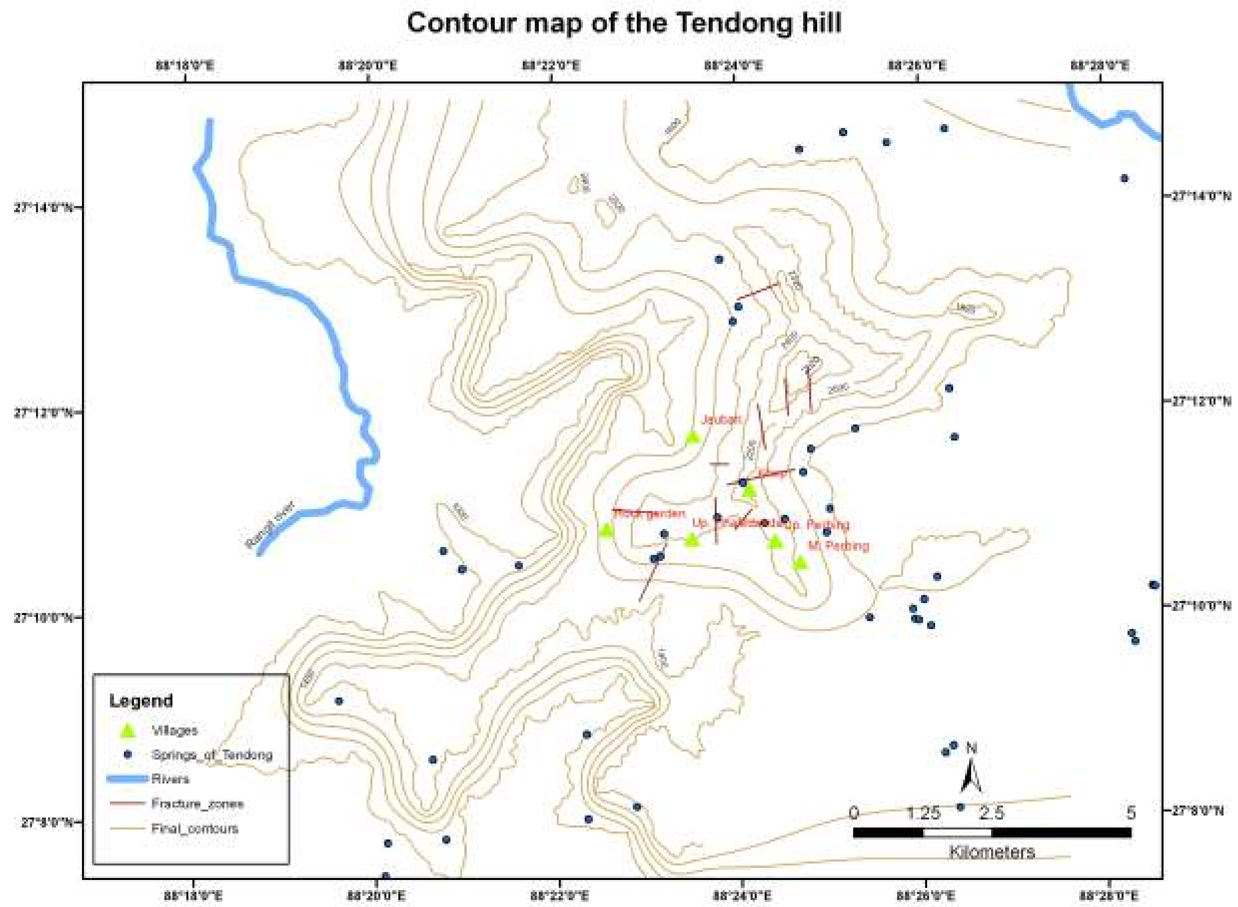


A google earth view of the villages and springs surrounding the Tendong hill

Tendong Hill
water resource system

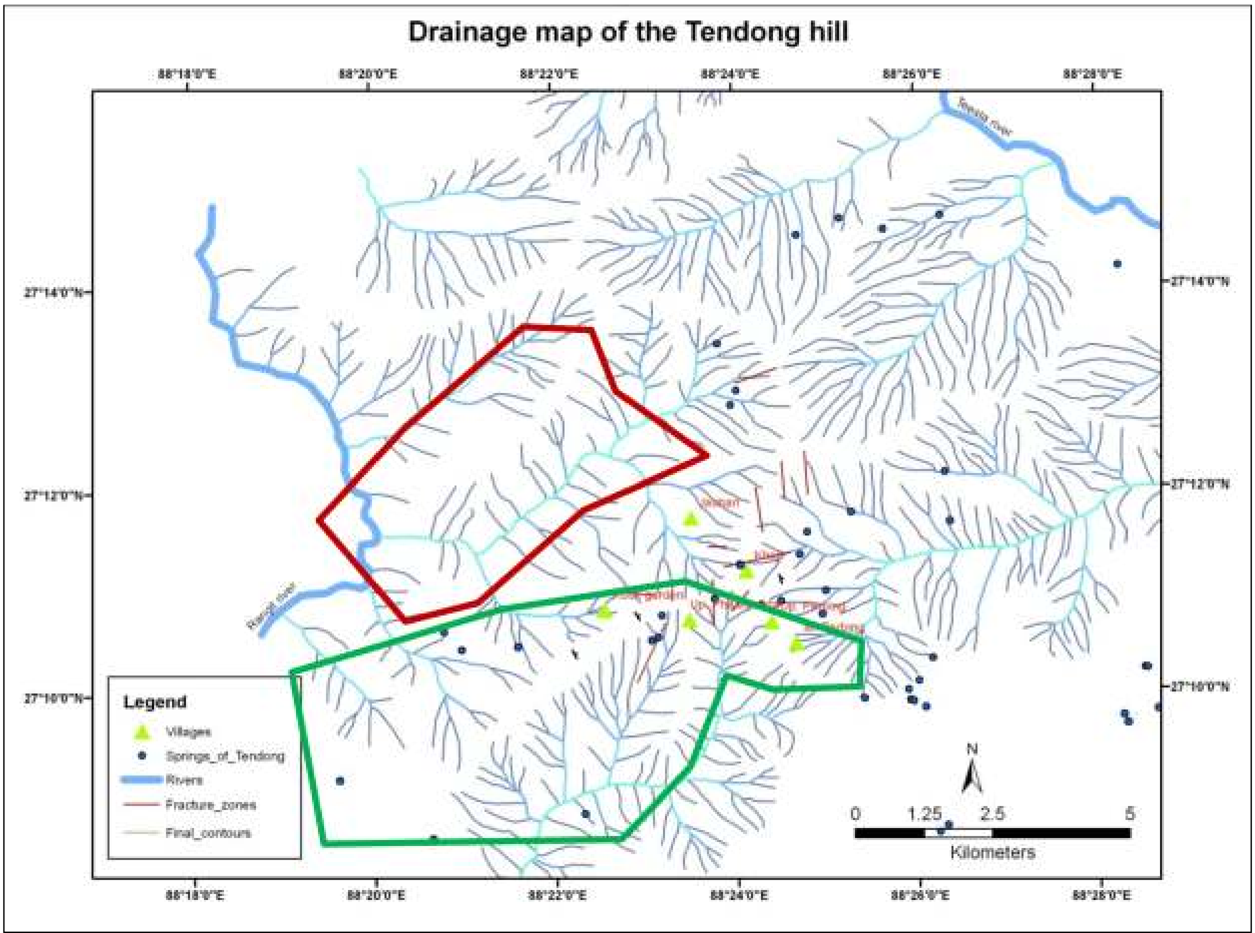
Topography and Drainage

Tendong hill region occupies a trans-river region that is part of the divide between Rangit and Teesta River Basins . The contour map of the region shows how the hill slopes more gently towards the northeast, i.e. towards Teesta as compared to the west and southwest, i.e. towards the Rangit. The slopes are generally indicative of the underlying structure and formed the first-cut in exploring the underlying geology. However, before doing so, it was felt necessary to understand the imprint of the drainage network given the slope configuration of the region.



Tendong Hills – Contour map, with villages, springs and position with regard to the two major rivers of Sikkim –Rangeet in the west and Teesta in the northeast

It becomes important to understand the drainage in the region, given that the vegetation cover, particularly forest, is quite dense and it is difficult to visualize the drainage, even on Google Images. Survey of India toposheets – on the scale of 1: 50000 - for the region, provided by RMDD, were used to digitize drainage in order to understand drainage patterns and relate it, if possible to other aspects such as slope and the underlying geology. The drainage in Tendong Hill region is part of the two major river basins of Sikkim. The drainage map clearly shows that despite the slopes, the only drainage that shows a sub-dentritic pattern is in the southwest (green polygon). All the other drainage is dominated by parallel to sub-parallel drainage patterns, except in the western part where some of the drainage shows a trellis pattern (red polygon).



Tendong Hills – detailed drainage map with a few villages and springs

The drainage types in the area are indicative of the following factors:

Drainage type	Tendong Hills region – as indicated on map	Indicative geo-morphological features
Dendritic	Green polygon – in the southwest portion of Tendong Hills	Drainage pattern is represented by a large number of branching streams that do not necessarily follow any set pattern. Such drainage is representative of impermeable surfaces, often crystalline rocks; the impermeable nature of rocks is also reflected in steep slopes along which such 'branching' of streams is apparent.
Trellis	Red polygon – one major watershed in the western part of Tendong Hills	Tributaries are aligned perpendicular to the main stream. Such drainage is usually developed in sedimentary rocks that are dipping and fractured.
Parallel	Most other drainage is of this type in Tendong Hills region	Tributaries are parallel to each other and often to their main streams, indicating flow along linear (often water bearing features) such as faults and fractures.

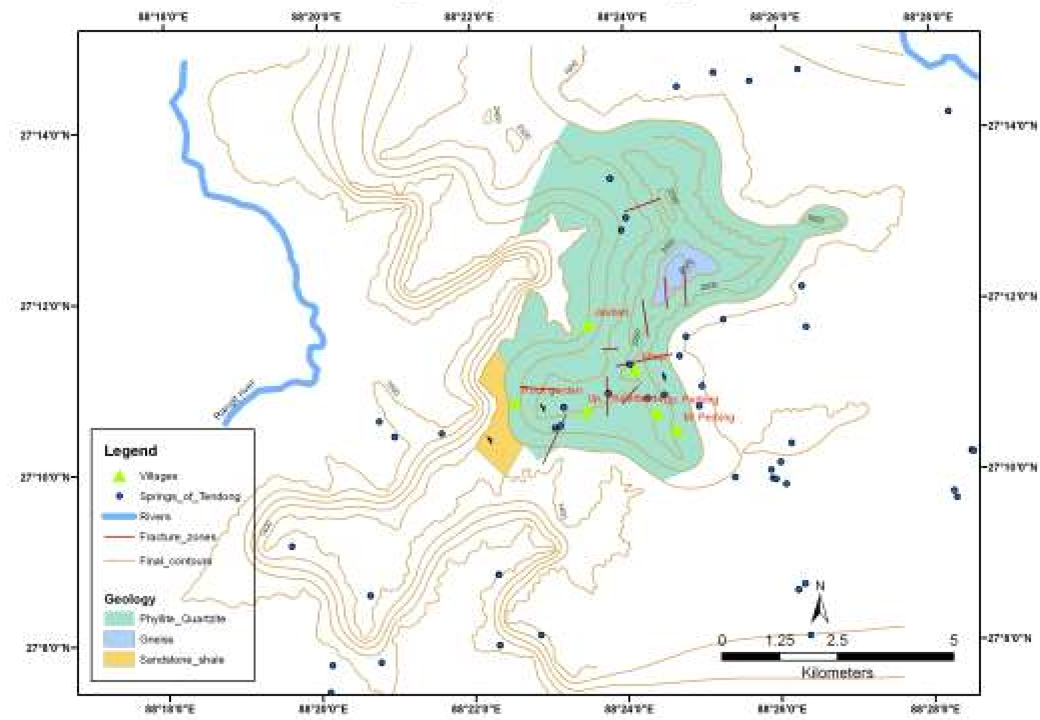
Tendong Hills drain into the Teesta through four major watersheds, all flowing along the eastern and northeastern portions of the Hills. Another four major watersheds, along with at least 4 smaller ones drain the western portions of the hills into Rangit river. Incidentally, the major villages that were first identified as part of the larger set for VWSPs, are situated close to the divide between watersheds draining into Teesta and Rangit. This could be one of the reasons that these villages face an acute water scarcity during certain periods. However, this is a question that needs further exploration as we move forward into adding another layer to contours and drainage – the layer of information on the geology, which determines the nature and extent of aquifers and the amounts of groundwater that an aquifer discharges to springs located in its groundwater discharge zones.

Hydrogeology

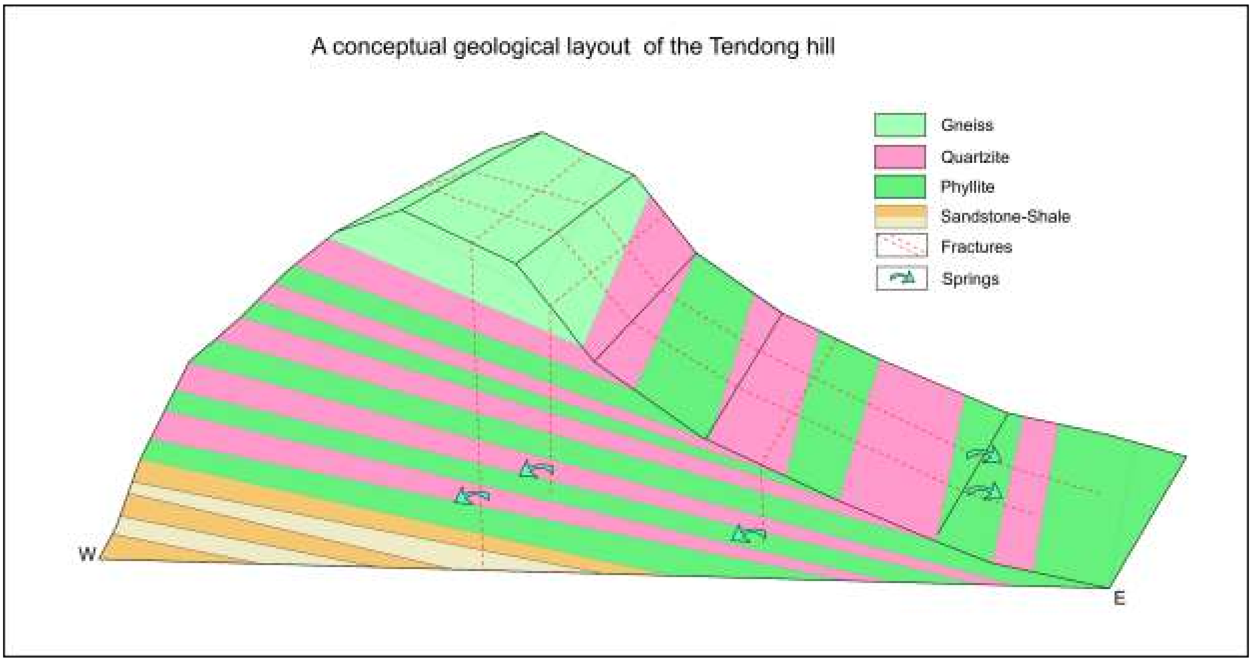
Extensive hydrogeological mapping was carried out in the Tendong area with an aim of developing a regional implementation plan for the area was first conducted. This was, in fact, the first part of the exercise that ACWADAM carried out. Critical factors such as geology, location of springs, structure of rocks and fractures were considered for demarcation of recharge areas for the implementation plan. Geology was thought to be particularly important because available geological maps indicate a large part of this region to be under unclassified rocks (map made available by RMDD labeled after CISMHE). However, other literature indicates rocks belonging to the Daling Group (phyllites, quartzites and slates) and Gondwana Group (shales and sandstones along with coal-bearing horizons and a few quartzites) to be dominating in the regions around Tendong Hills.

The geological study by ACWADAM indicated that the lithological setting of Tendong hill is largely constituted of three different suites of rocks. The lowermost in the sequence is a shale-sandstone sequence of rocks, exposed from the base of the Tendong Hill to an approximate elevation of 1700 m on the southern flank. Some parts of the shales are coal-bearing, clearly indicating that these rocks belong to the Gondwana Group. This sequence of rocks is comparatively softer than those found further upslope or even those at the top of the hill. These rocks are also quite weathered as compared to the sequence of rocks further upslope. At elevations higher than 1700 m, the sequence changes to alternate layers of quartzite and phyllites. Phyllite layers are thicker than the quartzite layers and show some degree of folding. Quartzites dominate this sequence with rise in elevation and are more fractured than weathered. Local exposures of gneisses are observed on top of the hill at an elevation of around 2500m, where a small plateau represents the top portions of the hill.

Geological map of the Tendong hill



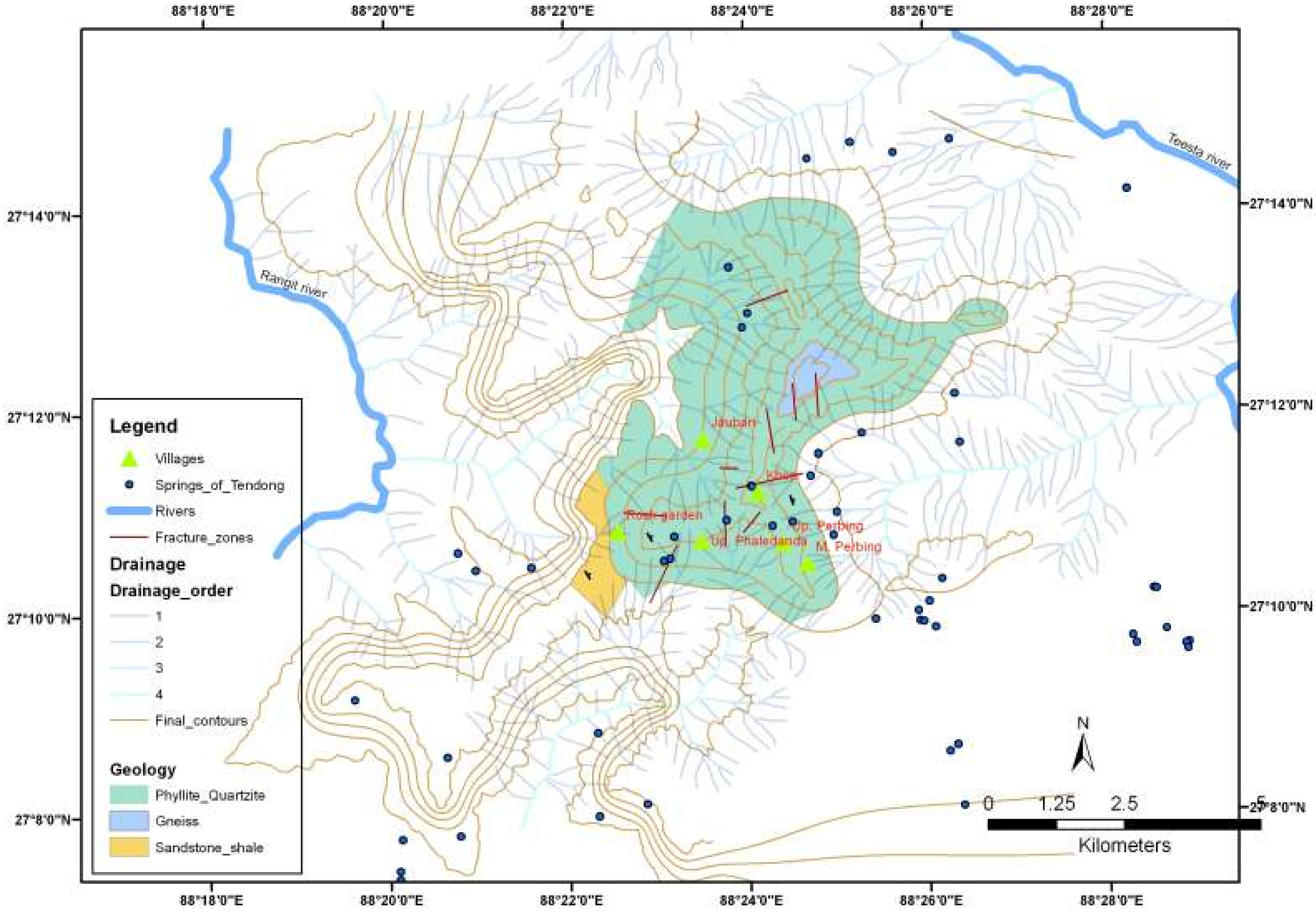
The shale-sandstone sequence and the phyllite-quartzite rocks, both dip towards northeast by an amount 30-40 degrees. This implies that the western and south western slopes from the escarpment slopes of Tendong Hill, while the northeastern and eastern slopes form the dip slopes. All the three rock suites are traversed by regional fracture zones, with two fracture trends being persistently observed across the hill. One of the fracture trends is NNE-SSW and the other is ENE-WSW, with a majority of fractures in both trends being vertical to sub-vertical. Much of the major drainage – the second and third order streams of the larger watersheds mentioned earlier – is closely aligned closely to these two fracture trends.



Conceptual geological layout of Tendong Hills – also indicating the discharge locations for the major spring systems in the region

The genesis of most of the springs emerging in the Tendong hills is related to these two fracture trends, although the storage of groundwater discharged to these springs is either on account of the porosity attributed to the aquifer by the weathering and fracturing of the sandstone-shale and the phyllite-quartzite sequence. Most springs are controlled by fractures in these two suites of rocks, with weathering of shales and phyllites accounting for groundwater storages close to the southwestern or western slopes, i.e. the dip slopes. Although a few depression springs are observed as a result of local isolated unconsolidated deposits – mostly gravity-moved debris – most of the other springs are largely controlled by the two sets of fracture systems that traverse the Tendong Hill Region.

Hydrogeological map of the Tendong hill



A regional implementation plan for the Tendong Hills

Rural Management and Development Department (RMDD) requested hydrogeological inputs for preparing a regional springshed implementation plan for the Tendong Hills, which was based largely on field visit carried out in Jan?   13. This visit was expected to pave the way for taking the water security pilot for the Tendong Hill area further and form a platform for a more focused field visit to the selected project village and focused capacity building in conjunction with the localized field visit. This input was also based on certain hydrogeological information analysed through the mapping and GIS layers generated – as described in the foregoing sections.

Clearly, the approach emerging from the hydrogeological study of Tendong Hill region is related to the following key aspects:

1. The escarpment slopes of Tendong Hill – western and southwestern slopes of the hill – form the major recharge zones for springs on the dip slopes towards the northeast and east.
2. The two major fracture zones also contribute to recharge depending upon their relationship with the dipping strata.
3. The discharge points – springs – are either aligned at along the major fractures if they are not on the main dip slope or they emerge at the fractured contacts of phyllites and quartzites on the dip slope.
4. Most of the springs in the immediate vicinity of the Tendong Hill are restricted to the phyllitic-quartzitic sections of the local geology.
5. Most of these springs are a mix of contact and fracture types, although fracture springs dominate.
6. Given this situation, the regional implementation of recharge through MGNREGS is likely to have an overall significant impact on the discharge of many springs in this region.

Based on the structure (dips) of rocks, their weathering and fracturing patterns and the regional trends of the two major fracture zones, the recharge areas for the spring systems have been identified. The recharge areas fall in three parts of the Tendong hill, one in the north and the others towards southwest and south. They are depicted in the sections below, with overlays on Google Images.

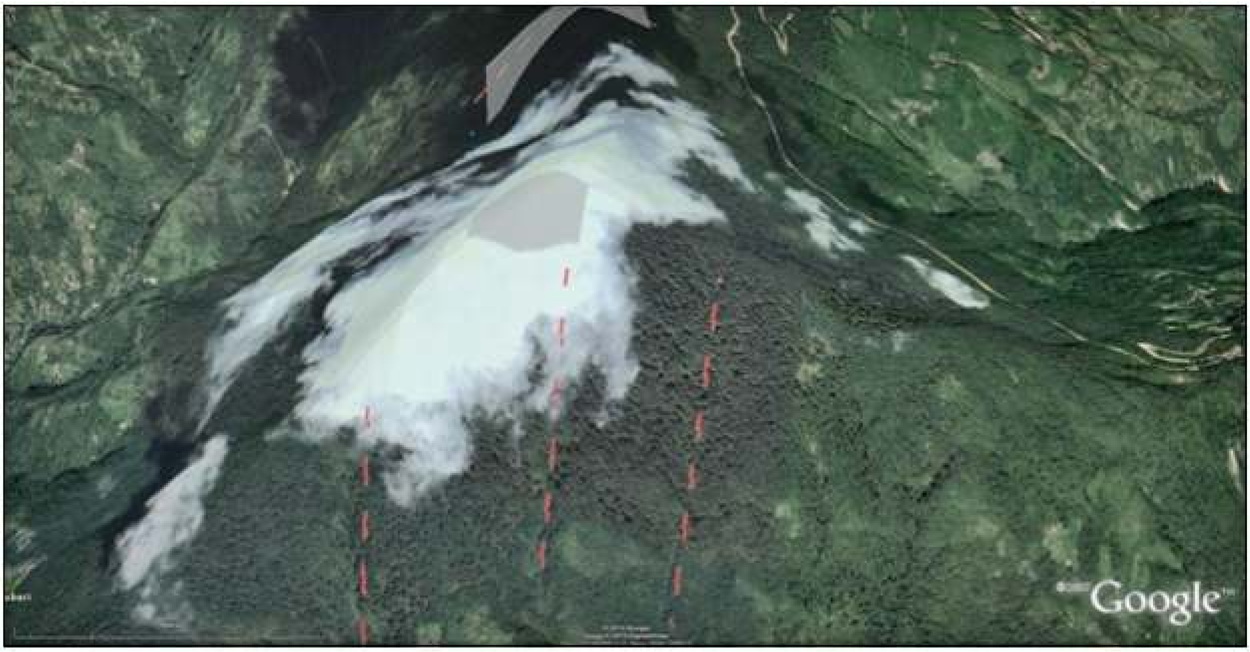
Catchment area 1 – for Damthang, Temi and Tarku villages

Recharge areas towards the north of the Tendong hill

Springs emerging in the areas of Damthang, Temi and Tarku villages have their recharge areas to the north. The total area for recharge is about 27.42 hectares. A part of the recharge area is along the ENE-WSW trending fracture while the one northernmost is on the escarpment slope as the rocks dip north east.

Thick forest is observed on the dip slopes of Temi region in the northeastern part of the Tendong hill. This zone should act as the area for protection where any deforestation activities should be banned. In the recent developments it has been observed that a four lane wide tar road is being constructed under some tourism activity which has resulted in clearingoff a lot of forest ground.

Catchment area 2 – Plateau of Tendong Hilltop



The top of the Tendong hill is a relatively small and flat area. A Gompa at the very top has a simple rainwater harvesting system which fills up a small tank nearby. During the rains, the overflow from this tank could be used to carry out point recharge by constructing small but fairly deep recharge pits. The area on top, for recharge is about 7 hectares, a considerable area given that the slopes here have a relatively gentler gradient as compared to other parts of the hill.

The top of the Tendog hill, a relatively flat area hosts a few gompas. Point recharge through roof top rainwater harvesting should be carried out around this area, where the rooftop rainwater harvesting can be connected to recharge pits at various location on the plateau.

Catchment area 3 – Khop and Parbing villages

Clay layer observed in the area close to the football ground west of Parbing

The NW-SE trending ridge towards the south of the Tendong hill is a critical recharge area for springs emerging towards Parbing and Khop villages. The ridge has a flat top and is dominantly made-up of phyllites dipping northeast. The recharge areas fall on the escarpment side of the ridge i.e. towards the southwest. The phyllites on top are quite intensely weathered, forming thick clay zones at some places. Such areas should be avoided as they act as impermeable zones restricting water to percolate downwards. The total area for recharge is about 4-5 hectares.

Catchment area 4 – Phalidanda village

The NE-SW trending ridge towards the south of the Tendong hill hosts a critical recharge area for springs emerging towards Phalidanda village. Treatment measures are to be carried out on the escarpment as well as the dip slope as depicted in the google image above. The spring systems around this village are local and are a combination of fracture and depression type. The total area for recharge accounts to be around 9-10 hectares.

Areas suitable for treatment just NE of Samdruptse; the break in slope leading to a relatively flatter area is suitable for recharge to springs in Phalidanda village area.

A regional implementation plan for the Tendong hills. The total catchment area for the regional implementation plan accounts to be around 50 hectares.

(Springs as blue dots, Fractures as red dashed lines, Recharge areas as grey polygons and villages in green symbols)

A rapid hydrogeological assessment of Kitam

Kitam-Manpur GPU is located at 27°07''21.38''N - 27°07'28.14 and 88°21'35.90''E - 88°20'38.86E. The GPU is spread over elevations ranging from 500m to 1000m. It shares its boundary with Lower Goam in the North, Sorak in the East, Kitam Bird Santuary to the West and Manpur Khola and Mickkhola in the South. The Greater Rangeet River and Manpur Khola flows along the southern flank, forming a major drainage system of the area. An adjacent part of the Kitam GPU was declared as the Kitam Bird Sanctuary in the year 2006, which houses more than 100 species of birds, more than 20 species of wild animals and more than 40 species of Non-timber forest products.

The village Kitam is divided into three subdivisions: Upper Kitam(UK), Middle Kitam(MK) and Lower Kitam(LK). Kitam is spread across an area of about 180-200 hectares.

Elevation ranges in Kitam

Subdivision	Elevation
U. Kitam	1050m to 850m
M. Kitam	850m to 740m
L. Kitam	740m to 450m

Demography of Kitam-Manpur GPU
(source: VAC, Kitam)

Name of ward	Total Households	Population
U. Kitam	39	203
M. Kitam	65	311
L. Kitam	60	303
Belbotay	53	240
Manpur	51	258
Total	268	1315

A majority of the population works as labour, some at government departments and very few are into agriculture, restricted only to L. Kitam.

Fields in L. Kitam

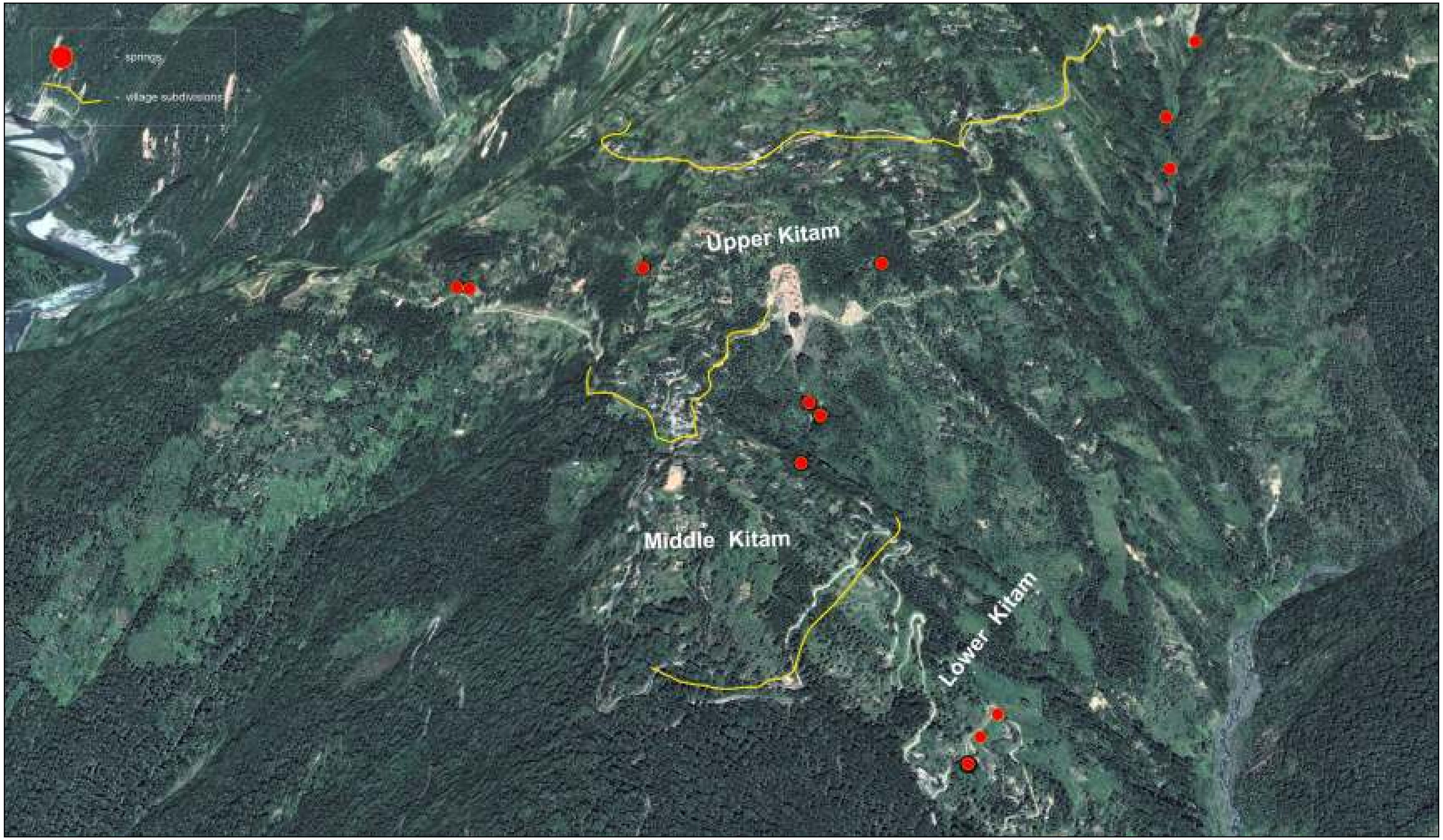
Hydrogeology

Kitam is located at the southwestern end of the Tendong Hill range. The geology in and around Kitam is also similar to that of the Tendong hill. Almost the entire area under Kitam is made up of phyllitic rocks. The phyllites are quite weathered, with fracturing along their dips (towards the southeast). The degree of weathering of the phyllites is also a major consideration in the separation of aquifer systems. Although detailed investigations would be needed to verify the hypothesis, we believe that there are two disctinct aquifer systems in Kitam, one being tapped through the springs in upper and Middle Kitam and one being tapped by spring in Lower Kitam (lower discharges). Hydraulic conductivities are likely to be higher in the upper aquifer system.

The entire population of Kitam is dependant on groundwater sourced from springs emerging within and outside the administrative limits of the GPU.

The details of springs sourcing water to Kitam are mentioned below:

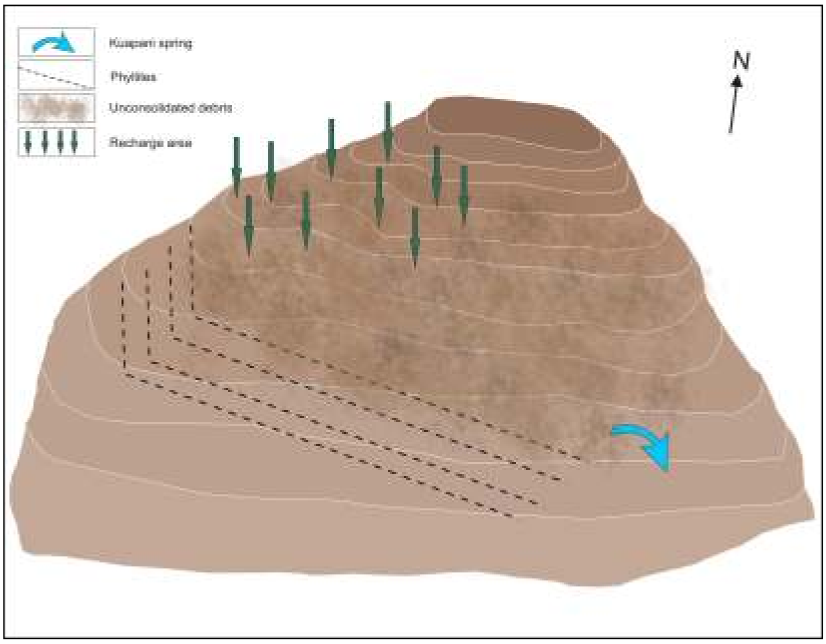
Name	Elevation	Discharge	Type	Sourced to
Kuapani (A)	950m	1.5 lpm	Depression	U. Kitam
Museypani	945m	4 lpm	Depression	U. Kitam
Dhara Kholcha	825m	>30 lpm	Depression	L. Kitam
Lampatey	815m	30-35 lpm	Contact/Depression	L. Kitam
Kuapani (B)	814m	5 lpm	Depression	M. Kitam
Lampatey (A)	865m	25 lpm	Depression	Belbotay
Lampatey (B)	866m		Depression	Belbotay
Mickkhola (A)	1034m	>100 lpm	Fracture	U. Kitam
Mickkhola (B)	956m	>80 lpm	Fracture	M. Kitam
Buddhay Kholsa	899m	> 80 lpm	Fracture	M. Kitam
5-6 Local springs	620-650m	3-4 lpm/spring	Depression	L. Kitam



Springs and sub-divisions of Kitam

Kuapani (A) Spring

27° 7'24.06" N | pH 6.6, TDS 50mg/l,
88°20'38.39" E | S 30ppm, EC 74μs, T 73°F
950m



Hydrogeological layout of Kuapani springs

The Kuapani spring is a depression spring with a relatively low discharge. The discharge measured in Nov'13 was ~ 1.5 lpm. The entire springshed is made-up of unconsolidated material with phyllites at the base. The spring is currently devoid of any distribution system although a tank is present nearby the spring. People from U. Kitam fetch water directly from the spring through buckets. A small pipe is seen privately tapped from the spring. Spring water is primarily used for drinking. The source dries up by the month of April.

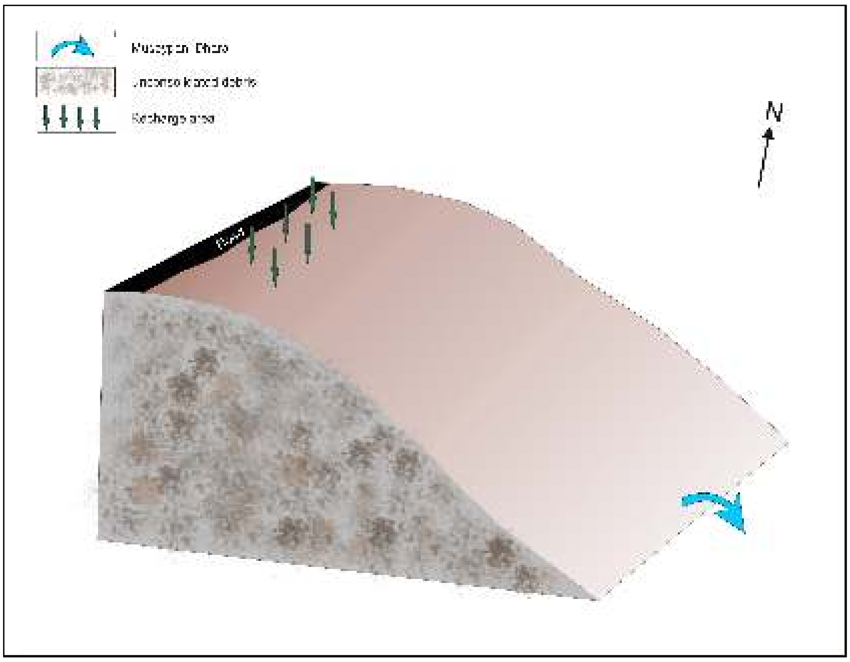
Based on hydrogeology the recharge area to the spring lies towards NW of the spring and accounts to about 5 ha.

A google image depicting the Kuapani spring and its recharge area

Museypani Spring

27° 7'35.62" N
88°20'49.89" E
945m

pH 7.4, TDS 140mg/l,
S 100ppm, EC 211µs, T 71°F



Hydrogeological layout of Museypani springs

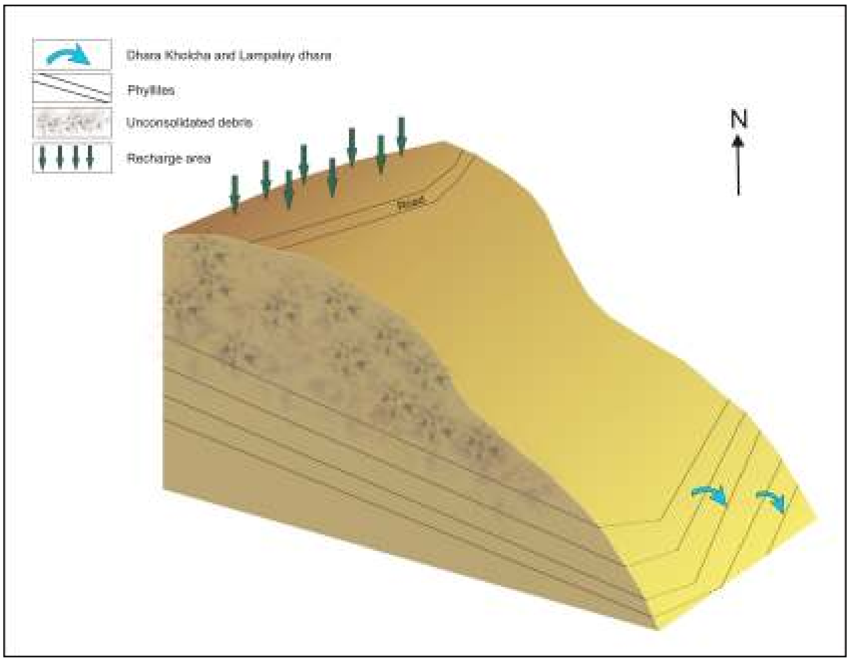
The Museypani spring is also a depression spring. The entire springshed is made-up of loose unconsolidated material which accounts a storage larger than that of the Kuapani spring. The spring is said to be owned privately by a person from Manpur. The spring supplies water to 4-5 households in U. Kitam. The users collectively pay a monthly installment of Rs. 300 to the owner. The spring also supplies water to a household in Manpur. A collection tank is present nearby spring which distributes the springwater.

The recharge area of the spring lies on the top towards the East of the spring. The recharge area accounts to be about 1.5 ha.

A google image depicting the Museypani spring and its recharge area

Dhara Kholcha and Lampatey dhara

27° 7'26.32" N 88°20'52.76" E 825m	27° 7'26.31" N 88°20'53.87" E 815m	pH 7.5, TDS 40mg/l, S 60, EC 133µs, T 71°F



Hydrogeological layout of Dhara kholcha and Lampatey springs

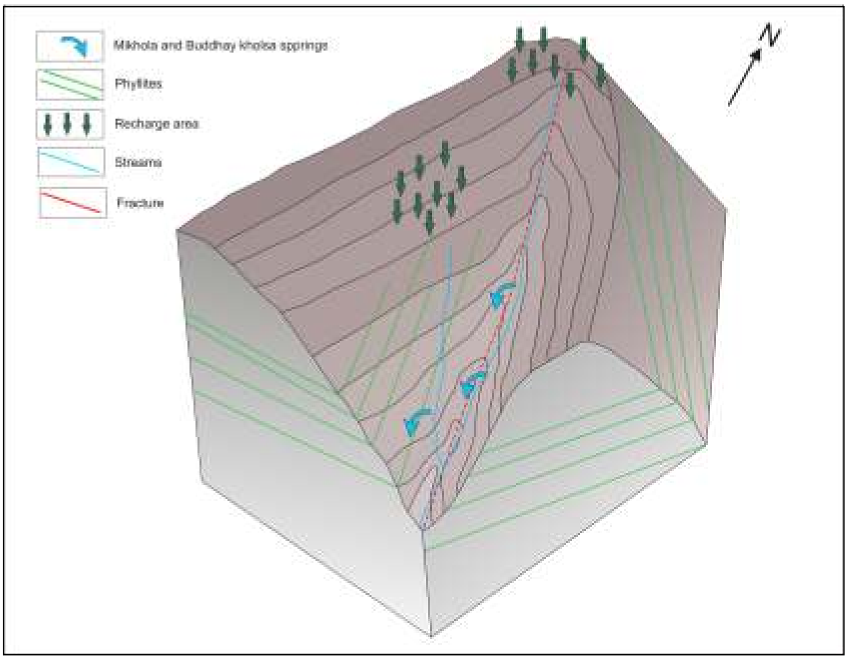
The springs are a combination of depression and contact type. The springshed is made-up unconsolidated material with phyllites at the base. The Phyllites exhibit a dip towards the SE. Both are high discharge perennial springs sourcing water to L. Kitam. Dhara Kholcha supplies water to about 15 households in L. Kitam. A new water supply scheme has been recently sanctioned by the RMDD for L. Kitam.

The spring also gains some of its recharge from the Museypani aquifer. The recharge area to the spring lies towards the NW of the spring. A small part of the recharge area (0.5ha) lies just above the road and a larger recharge area is shared by those of Kuapani and Museypani springs.

A google image depicting the Dhara kholcha andLampatey spring and its recharge area

Mickkhola Springs (A &B) and Buddhay Kholsa

27° 8'16.13" N	27° 8'9.74" N
88°20'44.82" E	88°20'47.40" E
1034m	956m



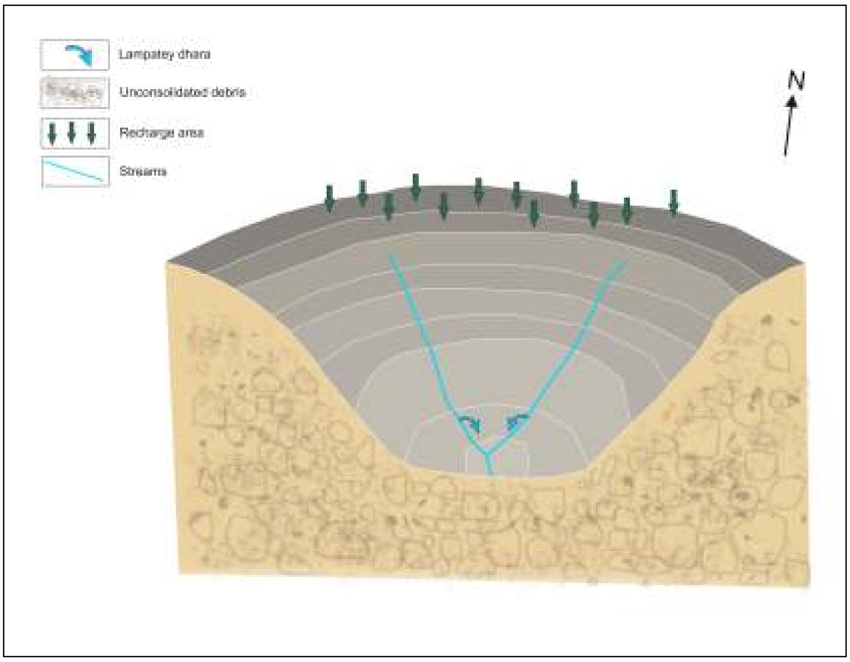
Hydrogeological layout of Mickkhola and Buddhay springs

The Mickkhola and Buddhay springs are of fracture type. The entire springshed is made-up of phyllite rocks that dip towards the SE. The rocks dip by an angle of 40-50º. A N-S trending regional fracture cuts across the phyllites. The Mickkhola stream flows along this fracture. Both the Mickkhola springs emerge along this fracture. The Buddhay kolsa is also a part of the Mickkhola system and emerges along a fracture paralle to the Mickkhola valley just downstream of the Mickkhola springs. All three are high discharge springs with discharges ranging to 60-80lpm. The Mickkhola spring (A) is tapped to supply U. Kitam and the Mickkhola spring (B) supplies to M. Kitam. A canal draws water from the Buddhay kholsa which is primarily used for horticulture in M. Kitam. The entire valley along the fracture is thickly forested.

A google image depicting the Mickkhola, Buddhay springs and their recharge area

Lampatey springs

27° 7'18.91" N 88°20'22.83" E 865m	27° 7'19.29" N 88°20'23.78" E 866m	pH 7.5, TDS 160mg/l, S 110ppm, EC 234µs, T 74°F



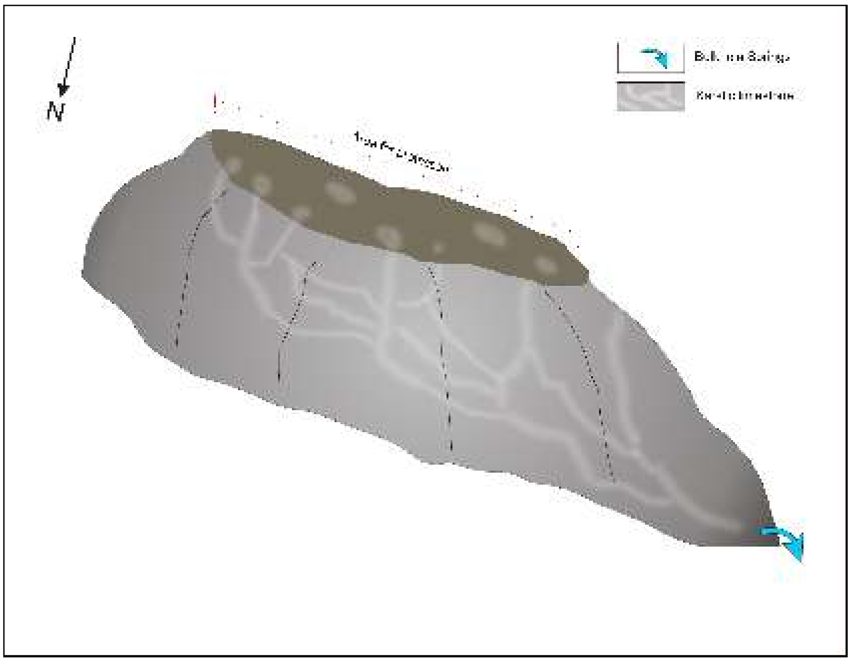
Hydrogeological layout of Lampatey springs

The Lampatey springs emerge along two streams which eventually converge into a single stream and flow down the slope. The entire springshed is made-up of loose unconsolidated debris that accounts to a relatively large storage. The combined discharge of the springs is about 30 lpm. Both the springs are classified as depression springs. The springs supply water to Belbotay village under the Kitam-Manpur GPU to about 40 households. The recharge area to the springs is towards the North of the springs and accounts to be around 1.5-2 ha.

A google image depicting the Lampatey springs and their recharge area

Bulkhola springs

27° 9'15.18" N | pH 8.3, TDS 260mg/l,
88°23'23.49" E | S 180ppm, EC 385µs, T 66.2°F
1228m



Hydrogeological layout of the Bulkhola springs

The Bulkhola springs are a set of Karst springs. The springs emerge at the base of the E-W trending elongated hillock. The entire hillock is made-up of limestone that has weathered over time giving rise to a karstic terrain. The karstic limestone hosts huge amounts of groundwater and the discharge through multiple spring outlets ranges to the tune of >1000lpm. It is important that the top of the hill which acts as the recharge area remains protected.

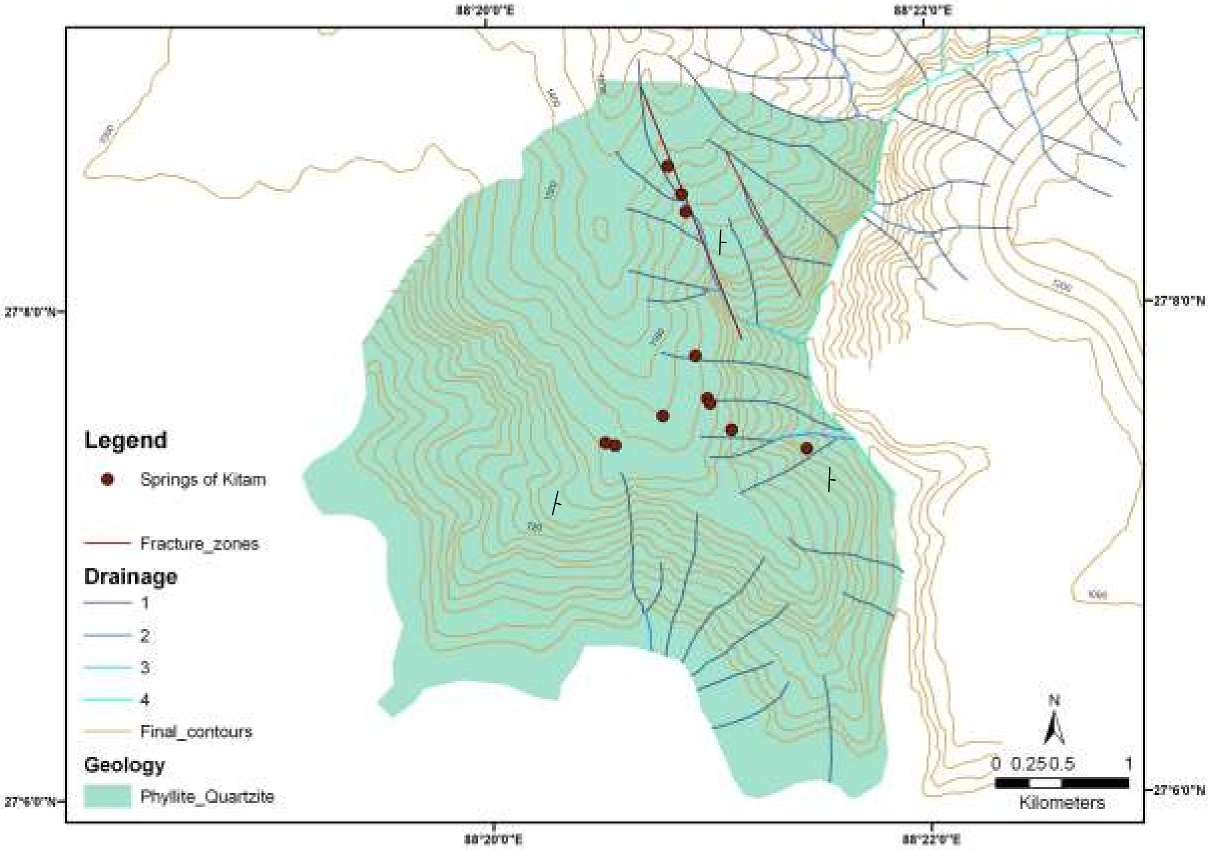
The Bulkhola springs have been recently bought by the Water user committee of U. and M. Kitam.

A google image depicting the Bulkhola springs and their recharge area

Springwater management in Kitam: a way forward

A total of 11 main springs and an additional 5-6 local springs currently supply water to Kitam. Two more big water supply schemes from Lampatey dhara and Bulkhola springs have been recently planned.

Hydrogeological map of Kitam



A barefoot engineer operates the daily water distribution system for U. and M. Kitam. A distribution tank under the central system is under construction for L. Kitam. Water sourced from the Mickkhola springs is only under the central distribution system, rest all the springs are a 24/7 supply. Water is supplied to households at two time slots through a day: 6-8am and 4-6pm. A fee of Rs. 20/household/month is collected by the water user committee. Almost all the households in U. Kitam are covered under the central distribution system. 45 households from M. Kitam are covered by the central water distribution system. The new tank under construction plans to cover ~35 households from L. Kitam.

The Bulkhola springs was purchased by the Water User Committee of the U. and L. Kitam at Rs. 41,000 for a period of 35 years. A water supply scheme from these springs is being planned.

A spring outlet of the Bulkhola springs

Springs and distribution tanks for Kitam

Activities	Rainy Season		Lean Season		Water Requirement	
	No of Buckets/Gagri/Jar	*Volume (in ltrs)*	*No of Buckets/Gagri/Jar*	*Volume (in ltrs)*	*Rainy Season (in ltrs)*	*Lean Season (in ltrs)*
Drinking per day	4	12	6	12	48	72
Bathing per day	8	12	8	12	96	96
Washing dishes and cleaning home	5	12	5	12	60	60
Washing clothes per day	200ltrs		200ltrs		200	200
For cattle per day	50 liters		70 ltrs		50	70
Watering in Kitchen garden, green house per day	50 ltrs/day		70ltrs/day		50	70
Total					504	518

Source: Draft Village Water Security Plan, GIZ - totals in last two columns are per household (all other figures being per capita)

Sub-division	No. of springs	Discharge Jul-Dec (lpm)	Discharge Dec-Jul (lpm)	Groundwater availability as spring discharge Jul-Dec (m^3)	Groundwater availability as spring discharge Dec-Jul (m^3)	No. of HH	Demand (m^3) (6 months)
U. Kitam	3	105.5	21	27216	5443	39	3510
M. Kitam	3	165	35	42768	9072	65	5850
L. Kitam	3 +(3)	70	14	18144	3629	60	5400

The table above summarizes water requirement per household which is about 500 liters. During the Nov'13 visit, spring discharge, wherever possible were measured. The following calculation takes into consideration, the discharges measured in Nov for a period between Jul-Dec and 20% of those have been considered as the amount available for the period Dec-Jul. There is surplus water availability (as the difference between availability and demand) for U. and M. Kitam even in the lean season. L. Kitam, however shows a deficit for the lean season, with a significant reduction in discharge. Based on this analysis it is inferred that the scarcity is really a reflection of the 'inequity' in water availability across the three sub-divisions rather than an absolute scarcity. The perception of scarcity itself is related to the inequitous availability of water from springs in L. Kitam, putting pressure on water demand of springs in the middle division. The deficit observed for L. Kitam specifically is embedded into the larger question of inequity but is can also be projected to be linked to the question of sustainability. Tackling the issue must also therefore be viewed in the light of driving the surplus discharges from the upper divisions to L. Kitam with a combination of recharge activities and springshed development.

Recommendations (summary)

- Source development at almost all the springs feeding Kitam is a must to ensure appropriate tapping of springwater on lines developed through similar work by RMDD.

- A monitoring setup to measure periodic discharges of springs (through RMDD or VAC or VWC)

- A proper arrangement to measure spring discharge at source or at the collection chambers

- Periodic weather and spring data in order to generate a comphrensive springwater management plan

- The priority in terms of supply must ensure bringing water down into L. Kitam, particularly during the drier season, given the skewed equation between demand and availability.

- Springshed development on a blanket scale at Sorak as this area acts as a common recharge area to multiple springs sourcing Kitam.

- Recharge activities that form the menu of RMDD's *Dhara Vikas Programme* must form the focal interventions in the Sorak area; this is expected to lead to improved spring discharges in springs present in all the three divisions of Kitam, i.e. Kuapani (2), Lampatey (2), Dhara kholcha (1), Museypani (1).

- Recharge locations and activities, as indicated in the foregoing sections, are particularly relevant to Buddhay (1), Mickkhola (2) given that the Sorak area is less likely to play a role in their recharge augmentation.

- All the potential recharge areas indicated in this report, in various sections must include two clear protocols of groundwater management:

1. Protecting and securing recharge areas from uses outside forestry and including activities of soil and water conservation and nothing else.
2. Securing these areas, particularly against potential contamination, whether from any form of sanitation - open access or otherwise - and activities such as littering and waste-disposal.

A google image depicting the recharge area around Sorak

People from U. Kitam
fetch water through buckets

The low discharge Kuapani spring

Dipping phyllites (weathered)
exposed near the spring

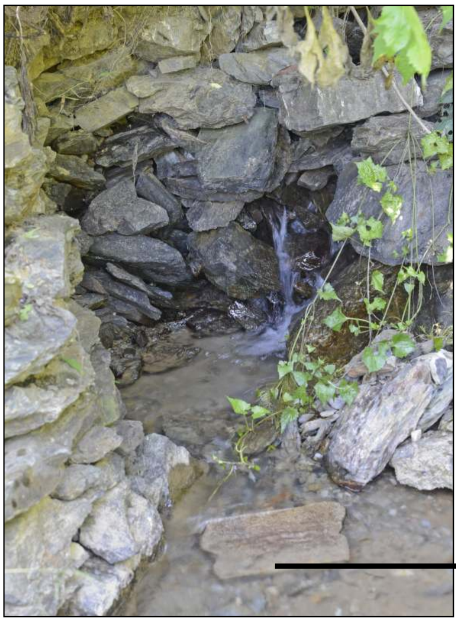
A low discharge spring in U. Kitam

Measuring spring discharge

The low discharge Museypani source

Spring distribution tank
for Museypani source

Measuring water quality
at the Lampatey spring



One of the outlets of
Mickkhola spring

The distribution tank for
the Mickkhola source

A barefoot engineer operates the valves at a distribution tank

Dense forest along the Mickkhola valley

Collection tank for the Mickkhola spring

Distribution tank for M. Kitam

Buddhay Kholsa

Karstic features observed at the Bulkhola springs

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