Temperature and Relative Humidity at Sandakphu
(As Observed during the Survey Periods from April, 1995 to April 2017)

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daily Temp (in°C)	-17 to - 6	-15 to -3	-8 to +4	-3 to +5	0 to +10	+2 to +12	+2 to +11	+1 to +9	0 to +8	-2 to +7	- 4 to +4	-12 to +2
Rel. Hum (in %)	51 to 65	47 to 62	43 to 58	41 to 56	38 to 63	54 to 76	58 to 79	59 to 77	55 to 72	54 to 67	48 to 63	49 to 66

10.5. Micro-geomorphic Characteristics

As stated in the previous table the annual distributions of temperature and relative humidity on Sandakphu indicate the prevailance of cool temperate climate over the area. Hence the geomorphic processes acting here differ enormously from the lowlying belts of the Southern Singalila Range. Weathering by freeze-thaw action is the most prominent feature found in the surfacial strata, especially in the gneissic crags standing over the peak. Consequently boulders and pebbles of irregular shape are the resultant materials which ultimately slide slowly along the slopes of the mountain. Cool but moist climate allows a special type of chemical weathering (described in chapter-6) by which silicates are produced along the free faces of the summit. These loose materials are transported quickly downslope – by mass wasting in drier periods, and both by mass wasting and fluvial erosion during the monsoon months.

Structurally the northern face of Sandakphu is more resistant to erosion as the headstreams of the Sandakphu khola, the stream draining that part, follow the dip of the strata. Whereas the southern face is very much fragile as it exposes the thrust-end. The headward erosion of the rivulets originating here which make the Kankaimai khola at the base of the 'klip' Sandakphu, is a conspicuous feature on this slope. Most of their channels are anti-dip in nature showing severe attack on highly jointed rock masses by all types of corrasive activity. Thus the slope of this face is retreating rapidly diminishing all the terraces as well as natural breaks of slope of the mountain. The rocky terrace encircling the summit top, lying about 15m below the summit, is also shrinking day by

day by gradual process of slope retreat. The old shorter trekpath connecting the summit with a meadow lying mid-way from Bikhebhanjyang does not exist today. A wide and vigorous gully has wiped out the path completely which is converting itself into an important headstream of the Kankaimai khola.

Due to the differentiation in amount of effective solar energy only silicification is dominant on the eastern slope of Sandakphu. While the southern slope shows the combined processes of silicification and ironization. Soil produced in the latter case, though immature in nature, shows reddish horizons only for this reason. Soil creep and debris avalanche are common phenomena on this side throughout the year.

10.6. Local Environment and related Problems

The environment of Sandakphu peak area is quite different than that exists along the lower altitudinal belt encircling it. The difference can easily be recognized by gazing at the plants grown over there. Dwarf rhododendrons (less than 4m in height) are the only trees naturally thriving here. Thick undergrowth of aconites are unique feature of this area for which the peak has got its name – 'Sandak' meaning poison, 'phu' meaning mountain (in Tibetan). Profusion of fir trees, which are very tall and the most striking vegetation type found over the top, were actually planted by afforestation programme in late 1980's and early 1990's. Original extension of fir forest could not ascend the last scarp face of the summit till then.

The environment of the summit is very much dynamic and often shows its harsh characters. Heavy snowfall in winter, incessant rainfall in monsoon months, and high velocity gales in late winter and spring time make plights not only for humans but also for the local topography. These environmental conditions push the geomorphic agents to accelerate their activities. Landslide and other types of mass wasting are visible effects followed by any hazardous event.

High altitude and very 'keen' (simultaneous low temperature and relative humidity) climate occasionally lead to health problems for newcomers on the summit such as acute mountain sickness caused by body's inability to adapt in low air pressure as well as low amount of oxygen. Mild symptoms like headache and loss of apetite are noticed among many tourists, especially who arrive here by vehicle. Care must be taken by the newcomers for acclimatization (i.e. physical adjustment to local environment). They should not hike in quick pace; ought to drink plenty of water and follow the rule of 'climbing high-sleeping low' during their time of rest.

Due to climate change and alteration in stratigraphic constituents beneath the surface of the summit water tables are fluctuating tremendously. The spring issueing from temple site is also exhibiting its flow waning in recent time. Rainwater harvesting is, therefore, essential very much for human consumption over the peak area. Use of forest woods as fuel is harmful for local environment as it affects the thin sensitive atmosphere much more than the airmass with normal density at low altitudes. Since the growth rate of local trees is very low regular downcutting of woods is fatal to the mountain forest. Hence modern sources of energy including supply of electricity (from nearby Rammam Hydel power station), the conventional source of energy, are to be immediately introduced here. These can help to mitigate the acute shortage of energy for livelihood of Sandakphu people.

With the increased number of tourists in recent years the environment over Sandakphu is degraded alarmingly. Large amount of waste materials produced daily by man are the main problem being found at this place. Proper method of disposal of these materials should be implemented at the earliest. On the other hand, low density airmass over the peak is affected badly by heavy molecules of green house gases which are emitted in dangerous quantum by the vehicles plying over and also by the portable power generators used in private lodges. This is very much harmful to local vegetation, and might pollute the spring waters too.

10.7. Recommendation for Sustenance of Sandakphu

Over number of tourists along with increasing number of private hotels are compelling the famous view site to be dying in coming days. For maintaining the delicate environment of Sandakphu area authorities of both countries (Nepal and India) should take a proper planning. It would be best if an alternate site (at or slightly above Bikhebhanjyang) of tourists' accommodation having arranged with all their primary requirements may be set up in near future.

Chapter 11 | Basin Morphology of the Siri Khola

11.1. Introduction

Basin of a river is an area where the particular river originates, grows and takes its ultimate shape through the normal geomorphic activities (the degradation and aggradational processes) being enclosed by water-divides and characterized by a particular set of terrainic sculptures. Thus the basin acts as the zone of accumulation of total discharge flowing through that river. Due to the action of geomorphic processes which are supplied energy both from endogenetic as well as exogenetic sources the shape and size of the basin can never be static and the watershed changes with time.

11.2. Location, Shape And Extent

The basin of the Siri Khola is one of the most important units of the Southern Singalila Range. The name of the river has been derived from 'shir', meaning head in Nepali – thus indicating the source of the fluvial system at very high altitude. The river is one of the main tributaries of the Rammam drainage system providing maximum discharge throughout the year. The valleys of the basin are set in a very rugged terrain having at least four well marked streams acting as its headstreams. All of them are perennial due to the presence of saturated water tables at their head areas and prevailance of humid climate over the tract.

The basin of the Siri khola is triangular in shape the base of which lies on the highest summit-line of the Range extending from Sabarkum peak to Bikhebhanjyang, while its apex touches the confluence point of the Siri khola on the Rammam river (27° 07.5' N, 88° 06' E, 1600m) – just below the village Rajavir. The northern end of the base is located on Sabarkum peak (27° 10' N, 88° 01' E); thus the rivulets originating beneath the peak

(at or above 3500m) feed the first headstream of the basin. None but this stream has got the name of the main river Siri which flows on and along the southern fault-line of the Sabarkum ridge. The ridge stands as the northern boundary of the basin.

The second important headstream of the Siri khola basin, the Sandakphu khola, emanates from the horse-shoe shaped hollow (27°01.5' N, 87° 59.5' E) at 3550m lying close to Sandakphu peak and joins the first one little north of Gurdum village (27°07.5' N, 88° 02.5' E) at an altitude of 2465m. The third one, the Partham khola, receives its discharge from the gullies situated in the north of Bikhebhanjyang (27°0.5' N, 88° 01' E), while the fourth headstream, the Gurdum khola descends from the northern slope of the Rimbik danra (27°0.5' N, 88°02' E). This Rimbick ridge confines the south-eastern limit of the basin.The altitude of source areas of the latter two streams ranges from 3100 to 3260m.They merge together little south of Gurdum village at 2300m (27° 02' N, 88° 03.5' E). Ultimately the two vigorous channels are united in a single river below Gurdum (27° 02.5' N, 88° 04' E, altitude 2060m). From here the valley represents a full-discharged drainage system flowing through a formidable gorge stretching upto the Rammam valley. All the four major headstreams with their innumerable rivulets and gullies give rise to a well-established dendritic pattern of drainage system which drains the largest part (57.5sq.km) of the entire mountain.

11.3. Local Geology

The tectonic wave of the Southern Singalila Range has changed its direction below Sandakphu (as stated earlier) – from north-south to NW-SE. This results in the closing ends of the bounding ridges of the Siri khola basin. Thus the basin itself has not only been shaped in a triangular form but also become fragile in its inner parts. The spur connecting Sandakphu and Gurdum has been highly crumpled and segmented by several high-angled reverse faults throughout its length.

The micro-level survey of lithology found in the basin area is explained through the following table:

Lithological characteristics	Associated geomorphological features found in micro-level survey
Residual soils (Holocene) covering the ridge-tops; deposition of sands and gravels	Rills and gullies over ridge-tops; patterned ground just below the summit-line (the

Lithological characteristics	Associated geomorphological features found in micro-level survey
in the lower valley section of the river.	zones having gradients less than 5°, in the effect of periglacial processes of recent past); immatured and discontinuous terraces along the lower valley sections
Interglacial alluvia (Late Pleistocene) on the western rim (showing sets of horizons due to periglacian action of recent past); Boulder-drifts in the rivulets and in the extended gullies.	Wide terrace-like features composed of the interglacial alluvia; graded profile of the headstreams is broken by knick points at the upper ends due to neo-tectonic movements.
Conglomerate, shale, etc (Upper Tertiary) found on the valley-walls (exposed in the lower valley section, especially near Sepi).	Narrow, deep gorges with cascades of different volumes at their bottoms; ravine-like jhoras at their upper sections.
Granite and pegmatite (Lower Tertiary) - being intruded through older rock-beds.	Round-headed rock pinnacles along the summit-line of the main Range; giant rocky outcrops along the upper section of the ridges.
Quartzite and slate (Permian-Carboniferous) roofed by a prominent unconformity; beds are highly faulted and jointed (found in the valley walls along the altitudinal belts lying between 1800m and 2200m).	Vertical cliffs and overhangs along the valley walls sometimes marked by shallow caverns.
Gneiss and milonite (Archaean) forming the upper parts of the Range and ridges. These are highly foliated and often thrusted with directional changes.	Bold summit line of the main Range as well as of the bounding ridges - all acting as the local watersheds and showing steeper slopes towards south in accordance with the thrust waves; the slopes are covered with screes; gullies and rivulets are clogged with taluvial deposits.

11.4. Evolution of the Siri Khola

The Siri khola is one of the youngest rivers of the region under study. The basin of the river has evolved very recently – in Holocene epoch. During the glacial ages of Pleistocene time the region under study was fully covered with thick ice sheets which hindered any type of erosional work over the surface. Thus the present landscape of the terrain is the result of geomorphic processes acting solely in later age. The preceding course of the Siri khola, however, established its channel in some time of an inter-glacial age (most probably the last one) along the fault extended from Gurdum to Rammam valley. The deep non-serpentine lineament of the valley in this stretch proves such paleo-channel of the river. After the obliteration of ice-sheets, around five to seven thousand years ago, the present Siri khola set its headstreams over the mountain slopes. Series of cascades in the deep glens above Gurdum village provide a strong evidence for recognizing their very young ages. The altitude (2350m) of that village (the land of which showing very gentle gradient) also coincides the average height of common planation surfaces found elsewhere in the Rammam valley. These surfaces exhibit glacial tills and were formed by the action of the last glaciers retreating from the region.

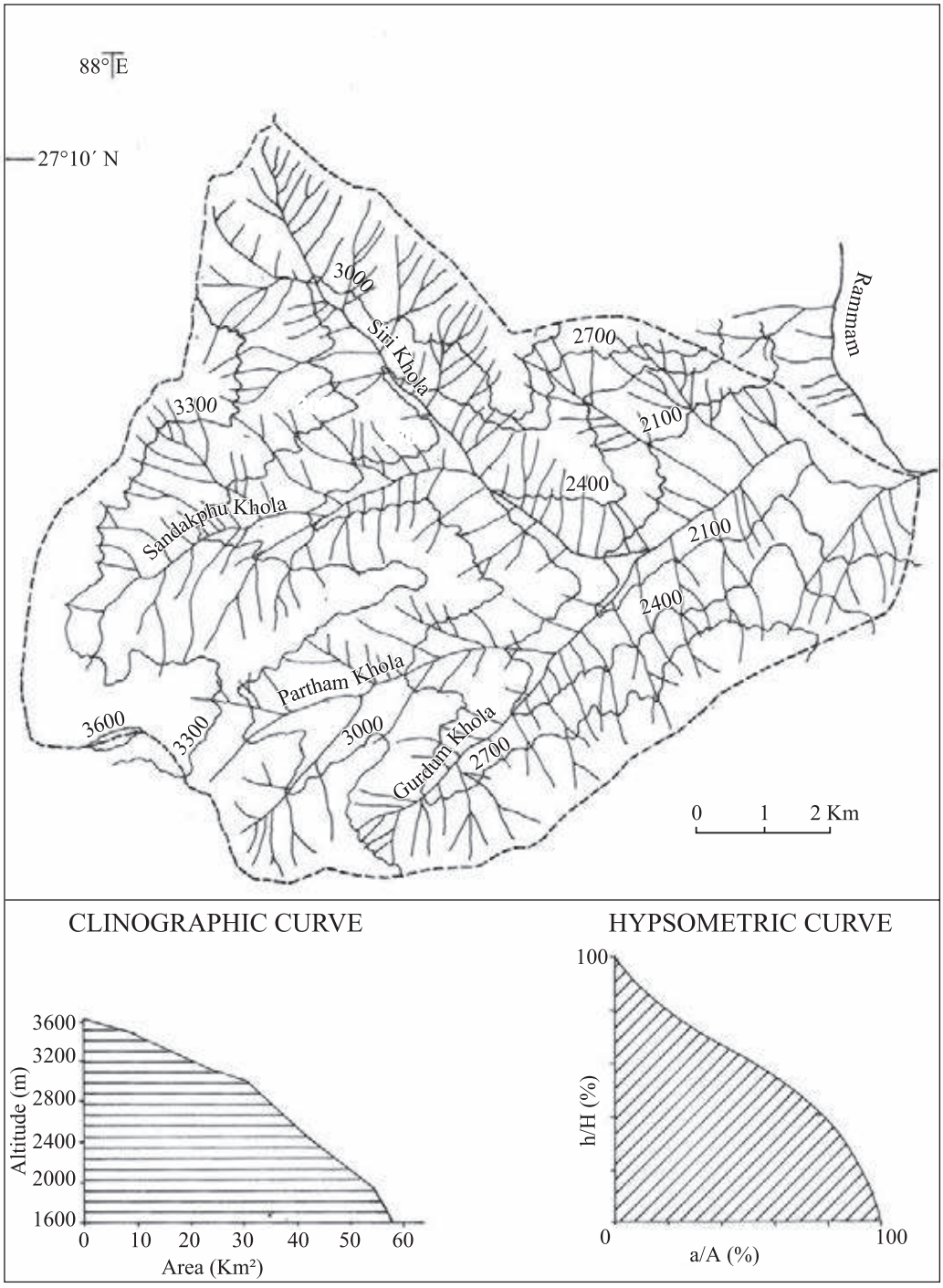
Since the disappearence of the last glaciers the area has undergone through combined processes of periglacial and fluvial action showing a delicate interaction between them. The effect of global warming has almost ceased the periglacial conditions previously prevailed along the summit section of the basin. Moreover, the present humid climate accelerates headward erosion of the headstreams of Siri khola. This has been shifting the position of the water-divide toward west and north-west, and breaking the crest-line at some places (for instance, the shallow gaps in between Thakum and Sabarkum).

11.5. Fluvial Features found in the Basin Area

In general the basin area experiences cool moist temperate climate – relatively higher temperatures being found below 2800m. During the winter months snowfall is a common phenomenon with occassional blizards along the crest line. The zones lying below 2400m go through the effects of winter snows rarely and the soil moisture never freezes. Fluvial processes thus dominate almost all over the basin area where every types of erosional features related to running water can be identified extensively.

The rim of the basin i.e. the water-divide is remarkably broken by rills and gullies. This is due to high rate of precipitation as well as the fragile rock structures along this belt. Innumerable springs make the section wet throughout the year. Soil creeping and rockflow are common features at the gully-heads while landslip at their bases.

Topography of Siri Khola Basin



The lengths of the gullies vary widely - from some metre to tens of metre showing their depths ranging from few centimetre to more than five metre. Merger of several rills and gullies forms a rivulet which may be longer than one kilometre along with its depth varying from ten to twenty metres. The gradient of a rill, gully or of a rivulet can be found very high - often 90o at the scarplets and at the points of crossing the bedding planes. The marginal section of the basin thus drops sharply and the surface-altitude decreases rapidly – 250m within a distance of one kilometre at the head of Gurdum khola!

High gradients are also found in the upper stretches of the main headstreams – more than 40o. These result in rapid downcutting at their bases with insignificant lateral corrasion. The conspicuous features, consequently, are glen-type valleys of the streams, and many rapids and cascades along their flows. The latters, however, indicate clearly the neo-tectonic upliftments of the area. The incised serpentine segment of the Siri khola (about 2km in length) above its confluence point with the Rammam also depicts the same.

The valley-walls of the last stretch of the Siri khola, from Siri khola village to Rajavir, are well-prone to rockslips and landslides during the monsoon period. These are caused by the presence of unconformity as well as highly jointed and partly metamorphosed sedimentary strata of the Permian origin lying below it. Accumulation of debris in huge amount often clogs the flow of the river (and also of its tributaries) which results in flash floods for many times.

11.6. Morphometric Characteristics: A Micro - Level Study

In the Siri khola basin the most dominant geomorphic processes are of degradational types – mainly mechanical and bio-chemical weatherings, mass movements and erosion caused primarily by fluvial actions; aggradation is insignificant except the colluvial deposits at the breaks of slope. The morphometry thus produced is characterized by intricate network of deep valleys with sharp interfluves. The latters are the resultant features of degration on granite-gneissic structure having greatly influenced by local morpho-climatic indices. To apprehend the present state of the terrain some common morphometric analyses are presented here.

i) Clinographic Curve:

This curve is generally used for understanding the gradient condition of a basin as a whole. Following the computation method of R. De Smet the average inclines

of the area have been graphed – from 1600m to 3650m altitudinal zones at 100m contour interval. The maximum gradients of more than 30° are found between 2500m and 2900m and again between 3100 and 3600m. An uplifted planation surface with a lower gradient of 18°, being modified by sub-aerial erosion, can thus be marked along the zone lying between 2900m and 3100m contour interval. The section enclosed by the contours of 1900m and 2100m reveals another planation surface: younger than the former with lower gradient values – averaging 19°. Maximum cultivated fields are situated along this belt.

ii) Hypsometric Curve:

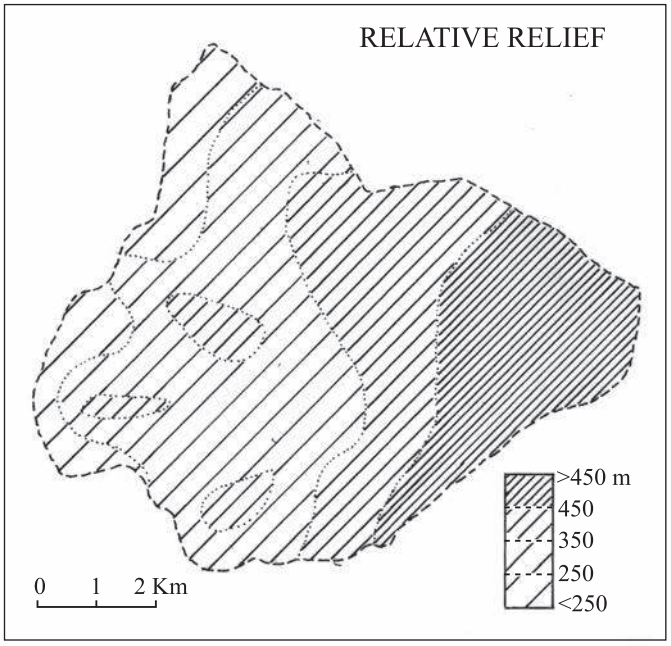
This curve is obtained by plotting the proportional values (in cumulative) of area and elevation along the abscissa and ordinate respectively. The merit of this diagram is to find out the 'Hypsometric integral' which is nothing but the graphed area bounded by the curve. For Siri khola basin the numerical value of the integral is 58.3%, thereby expressing the dominance of highly elevated lands all over the terrain.

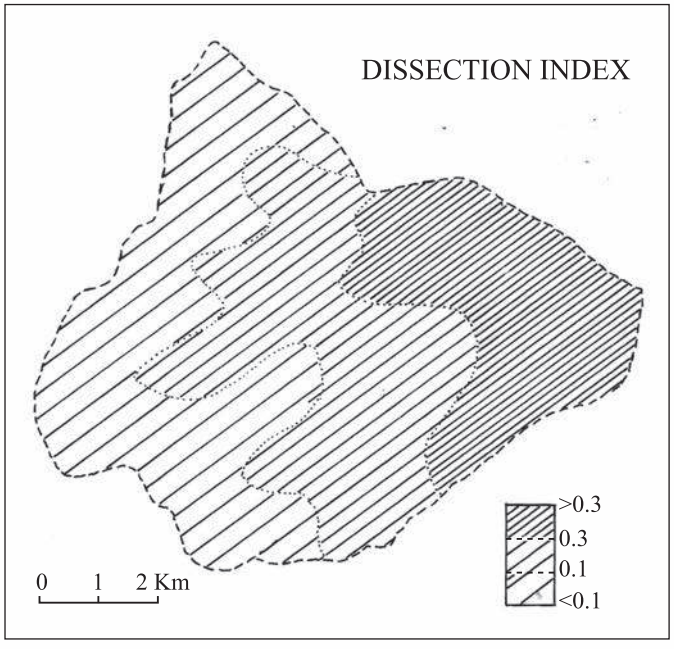
iii) Relative Relief and Dissection Index:

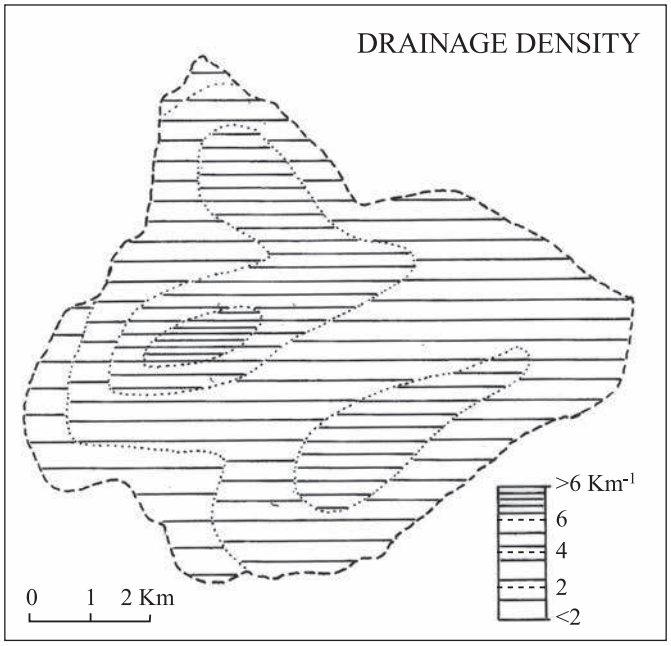
The basin area shows a varying relative relief from 150m to 550m. Owing to the presence of deep glens and chasms the section lying in between Gurdum and Siri khola villages, is set with the highest figures – more than 450m. Whereas low relative relief values, less than 250m, are found in the western fringe. Recent initiation of rilling and gullying in this part is not capable to eke up the vertical readings. The values of dissection index, less than 0.1, also indicate the initial stage of that segment. The central parts exhibit their youthful stage (from 0.1 to 0.3); while the easternmost section shows the passage of landscape to its mature stage having the numerals of more than 0.3.

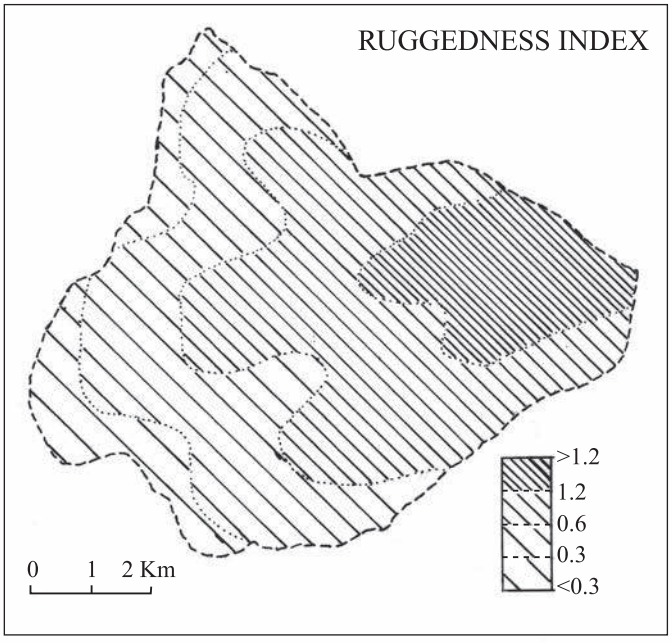
iv) Drainage Density and Ruggedness Index:

Since the area has steep gradients across its entire stretch, sinusity indices of the streams are very low. But the location of innumerable rivulets on the escarpment of the ridges increase the values of drainage density – as high as 4.0km-1 or more in some places like the both sides of the Gurdum ridge and the northern slope of the Rimbik ridge. Since ruggedness index is nothing but the numerical product of relative relief and drainage density, the index value also becomes high at the north-eastern part of the basin, especially below the village of Gurdum – more than 1.2 at the cuscading zones of the main two tributaries. While the


RELATIVE RELIEF
>450 m
450
350
250
<250
0 1 2 Km


DISSECTION INDEX
>0.3
0.3
0.1
<0.1
0 1 2 Km


DRAINAGE DENSITY
>6 Km-1
6
4
2
<2
0 1 2 Km


RUGGEDNESS INDEX
>1.2
1.2
0.6
0.3
<0.3
0 1 2 Km

summit section joining Sandakphu and Sabarkum exhibits very low ruggedness – less than 0.3.

V) Discharge and Velocity:

Among the four main headstreams of the Siri khola basin the Sandakphu khola is the longest – having length of 8.8km (from Sandakphu to Gurdum). But, on account of havier rainfall along the narrow but deep valley of the Partham khola lying between the Sandakphu and Rimbik ridges, the latter shows maximum amount of discharge in the whole basin area. The varying velocity of the Siri khola near the Siri khola suspended bridge is as follows:

During winter: less than 1km/hour.
Spring : 1 to 3km/hour.
Rainy season: 3 to 8 km/hour (much more during flash floods).

11.7. Geomorphic Hazards within the Basin Area

The main hazard (with disastrous effects) in the Siri khola basin, as mentioned in the previous sentence, is Flash floods which occur generally at the interval of several years. The last fearsome flash of immense volume came down through the channels of the river after the heavy downpours in September, 1999. Landslide, rock slide, gully erosion, debris avalanche, etc are other types of geomorphic hazard found in the area regularly, especially during the monsoon period.

11.8. Role of the River in Local Development

Although the major part of the Siri khola basin lies within the territory of the Singalila National Park, last 7.5km of the valley runs through well inhabited villages. The first two of them – Gurdum and upper Siri khola have been grown on the planation surface originated in late Pleistocene time (as stated earlier). The altitude of these levelled but inclined surfaces varies from 2350m to 2425m; the width ranging from 50m to 80m.Thick coverage of Holocene deposits including deep solum enriched with organic matters lead to produce crops, both food and cash types. Contour- stripping for agricultural work has been well-arranged over the said planes with a great effort of the local farmers (in small patches of forest clearing). Maize is the main food crop produced here followed by potato, peas, carrot and different types of vegetable. Among the cash crops cardamom is the most important which is raised mainly along the low altitudinal belt.

Excellent beauty of the river valley invites a large number of travellers each year. Besides the Trekkers' hut of Siri khola (Government owned) several lodges and homestays have been set up along the lowermost terrace stretching from Siri khola village to Sepi. The macadam road has recently been extended from Rimbick to Siri khola suspended bridge and the trek-path is being widened upto Siri khola village for the use of vehicles. This will help to enhance the number of tourists in future.

Chapter 12 | The Village Gorkhey: An Example of Deterministic Land Use and other Anthropogenic Attributes

12.1. Introduction

The most beautiful village Gorkhey, as ever seen by the author over the entire Himalayan Mountain system, lies in the north- eastern part of the Southern Singalila National Park. It is accessible only by trekking paths and mule tracks. The settlement is marked on the district map as one of the halting points on the famous trekking route starting from Manebhanjyang and running over Sandakphu and Phalut which terminates at Rimbick. Thus it is well-known to adventuresome people since the mid-19th century and is loved by them very much for its extreme serenity. It was a very little, semi-compact settlement inhabited then by some families whose livelihood depended mainly on pastoralism. With the passage of time population of the village have increased largely and their occupational structure have also changed: primarily being the agricultural activities.

As the settlement is situated in a physiographically unfavourable terrain and is almost detached from other parts of the district so it has retained many of the cultural characteristics of its own since its early stage of growth. These are reflected in its demography, house types, farming method and other economic activities of the inhabitants. They are still dependent on the local environment directly for their livelihood. Though there are changes taking place in various cultural aspects of the village today but the pace is very slow.

12.2. Location, Shape and Size

Gorkhey, the village under study is located at the east-end slope of the Kingsa danra, or Kingsa ridge. It is the northernmost village of the district Darjiling lying just above the confluence point of the river Rammam (or Rangbong) and Rato khola. The latitude and longitude of the village are 27° 11' N and 88° 04' E respectively. Total area of this

tiny habitation is only 0.2sq.km with altitudes varying from 2255m (near the Trekkers' Hut) to 2360m (at the top of the village). Though the settlement is located on a high mountainous tract, it is accessible by permanent mule roads running on the both sides of the river Rammam. It is situated at a distance of 9km from Daragaon, the Headquarter of the local Gram Panchayet; and 21km from Rimbick, the main market of the area. After crossing a narrow wooden culvert across the river Rammam the mule track extends south-eastward from the village Gorkhey for 5km which connects Bhareng, relatively a larger village lying in the district of West Sikkim. A trek-path descends to the village from Phalut peak traversing all along the Kingsa danra for about 10km. For administrative purposes the village is enlisted in Daragaon Gram Panchayet of the Darjiling-Pulbazar C. D. Block (Police station - Lodhoma).

12.3. Physical Attributes

i) Litho-stratigraphy:

The river Rammam passing by the village Gorkhey entirely follows one of the weakest belts of the Himalayan mountain system - the Main Central Thrust. The zone obviously represents complicated litho-structural characteristics along with high grade of metamorphism. Besides the main composition of Darjiling gneiss, migmatite, mylonite and diorite are other type of rocks generally found in this belt. Garnetiferous granites and pegmatite can also be noticed abudantly which depict the intrusive activities along the deep-seated Fault plane as well as melting and re-consolidation of ancient rocks (the process of granitization). Violent crushing and crumpling activities of the orogenic movement make the structural features much more complicated with sporadic nature of dipping in and around the area. The angle of dips varies from as low as 10° (along the M.C.T.) to more than 45° (on the southern flank of the Kingsa danra or the northern bank of the Rato khola). The topography of the area clearly reveals the effect of underlying structure though the zone has been affected many times by the orogenic movements occurring in later ages.

ii) Geomorphology:

Due to prolonged sub-aerial erosion done by the trunk river Rammam (in the process of slope retreat) the topographic gradient of the eastern end of the Kingsa danra is very high – from 50° to 65°. The village under study has grown over the nose of

it - just above the confluence point of the said river and one of its righthand tributaries, the Rato Khola. Chemical weathering of Darjiling gneiss in periglacial condition lying at the head of the latter creates reddish regolith as well as clays resulting in reddish tint in the water of the stream. It is a very young stream originated in Late Holocene epoch and shows a single terrace along its dale – about 4m above its present bed.

The valley of the Rammam is, as stated earlier, one of the oldest valleys in the Himalayan chain (Oligocene-Miocene). The uppermost segment of the river stretching from Phalut peak to Rammam village (5km south of Gorkhey), however, resulted due to the processes of headward erosion most probably in Late Tertiary-Quaternary periods. Consequently the glen of it is marked by terraces of unequal heights and widths – each of them indicating a major upheaval of the region. Thus the lowermost terrace found in the south corner of Gorkhey is the youngest of them. Its irregular surface composed of Holocene deposits starts here at 2255m - showing a slight fall towards the downstream and diminishing near lower Daragaon village. It is wide enough for setting up cultural landscape over it – more than 50m just south of the confluence point of the Rato khola - river Rammam. Here lie the most extensive cropping fields along with a large Government-owned Trekkers' Hut (established in 1986) amidst them.

The second terrace lying at the altitude of 2265m shows a paired formation with varying widths – from 5m to 15m. It was formed after the upheaval of the region in Late Pleistocene time though Holocene deposits mostly clothe its top layers. Obviously the terrace is extensively used for agricultural activities. The Eden lodge (established in 2001), Paradise Lodge (established in 2010) and Hotel Denver's gallery (established in 2016) are located onto it. The terrace is much wider on the opposite bank of the village Gorkhey, but its landscape is yet to be changed by human activities.

The third terrace runs along the mid-slope of the ridge almost following the 2295m contour. It constitutes some important cultural features of the village including a well-maintained nursery, a Hindu temple, and a small lodge (Santi Homestay, established in 1999). This terrace was formed by any movement occurring either in Late Pliocene or in Early Pleistocene. It is very difficult to determine its exact age due to its narrow ledge-like feature affected badly by gully erosion and downslope mass-wastings. The terrace is used for cultivation too but in very small holdings. The houses grown over it are also scattered and are often shifted with the shifting nature of the gullies.

The actual forest area starts above the village at an altitude of 2360m. Due to the bulging figure of the eastern end of the Kingsa danra towards the Rammam valley, the overall projection of Gorkhey village is in plunging appearance and triangular in shape – the base lying along the main river bed.

Velocity of flow of the river Rammam:

Place of measurement: 20m downstream from the wooden culvert.
Velocities:
During winter: 1.5 km/hour.
During spring: 1.5 to 4.5 km/hour.
During rainy season: 4.5 to 15km/hour.

iii) Weather Conditions:

On account of high altitudinal location the village experiences cool temperate climate: 'Dwb', according to Koppen's scheme (1940). As a result it shows a mild summer (from June to September) and severe winter (from mid- October to March) associated with two transitional periods, the pleasant spring (April and May) and autumn (first half of October), lying in between them. Maximum rainfall (more than 80%) occurs in summer on account of the inflow of south west monsoon. The winter months receive little amount of rainfall (about 15%). Snowfall occurs sometimes though the amount has been decreasing for the last hundred years due to global warming (last snowfall observed in January, 2009). Rest of the precipitation occurs in spring time (with occasional gales); while the short autumn remains almost unaffected by any weather disturbances. Incidence of inversion of temperature is a common phenomenon at Gorkhey due to its inner valley location. In early morning the air temperature at the base of the valley lowers more than 2° Celsius than that of its upper portions. Katabatic winds are also found stronger with chill effects during the same time.

iv) Natural Vegetation:

Depending upon the cool temperate climate the village of Gorkhey and its surrounding mountain slopes are covered with dense coniferous forest dominated primarily by pines. Oak, maple, alder and chestnut are also found abundantly in that vegetative zone. Most of the natural vegetations are grown in the deep narrow gorges and above the ridge tops. Terraces along the valleys with thick and fertile hill soils (pH – less

than 5.5) are used for agricultural work as well as pasturing dzoes and cows. The village and its surrounding forests are situated in the territory of Singalila National Park (officially declared in 1986).

12.4. Evolutionary History

The picturesque village Gorkhey began to grow inside the dense highland forest of the Southern Singalila Range. In the early 19th century some Gorkha families arrived here with the invading groups of Gorkha warriors inside the then Sikhim state. The early settlers were used to pasture dzoes and cows along the grass covered terraces of that place. The pastoralism is still found as one of the occupations of some members of the village. But most of them started to set agriculture around mid-20th century along these terraces, especially over the first and second strips of land on the right bank of the river Rammam. The farming method was very primitive and the production of buck-wheat and vegetables was merely on subsistence basis. The population of the village grew enough in the latter half of 20th century; influx of trekkers also enhanced after the construction of Trekkers' Huts at Phalut and Gorkhey. At present (April, 2017) the village is well inhabited by 34 families with their own households: each possessing approximately one acre of land.

12.5. Cultural Attributes

i) The Inhabitants :

The name of the village 'Gorkhey' might have been derived from the word 'Gorkha' which constitutes the majority of the local inhabitants. The word 'Gorkha' is a canopy term which brings many ethnic groups of people (once coming from Nepal) under its shade such as Rai, Gurung, Chhetri, Tamang, etc. The village Gorkhey is settled by 11 families belonging to Rai, 8 families to Chhetri, 2 families to Gurung, 10 families to Sherpa and 3 families to Tamang. The Sherpas do not belong to 'Gorkha' but are directly the descendents of a folk who lives in south-central Tibet and in the Nepalese villages lying at the base of Mount Everest. From the latter region they came to the village after following the Gorkha newcomers and immediately settled here. Each community has a language for its own but Nepali is used as a common one for general communication amongst the villagers. Besides this language

many of the people can speak Hindi and understand Bengali and English due to regular contact with trekking groups.

The Rais, Chhetris and Gurungs follow Hinduism whereas the Sherpas and the Tamangs follow Buddhism. People of both religions show their respects to the religious performers and also to the sorcerer who takes their care for minor illness. For serious treatment they depend on the hospitals located either at Darjiling or at Siliguri. Neither a health centre nor a medical shop is found in the village.

ii) Land Use along with Ekistics:

The site of Gorkhey is unique as it stands on the right bank of the river Rammam where the gradient of the river is the lowest in its upper course (1 in 20) and the width of the terraces is enough to set up arable lands. The channel width of the river here is minimum- only 8m where the construction of a wooden culvert across it has been possible. Thus, the village gains also a 'situational' facility – becoming a nodal point of the village paths. The 5m long culvert across the Rato khola has been replaced by a concrete structure. Thus the village can now communicate easily with its neighbouring village Samanden (1.5km), though by the mule track said above, even in the flashing time of the stream (in the peak-times of the monsoon rains).

It is obvious from the very first glance of the village Gorkhey that the shape of the settlement is fully dependent on two factors: (a) Physiography of the place, and (b) Local weather conditions. All the households have been grown over smooth slope of the spur - the projected part of the Kingsa danra. In spite of high gradients, the slope is covered with thick soil layers including thicker regoliths beneath them. The breaks of slopes are used for the setting up of arable lands as well as the large houses. The quality of crops raised here is much satisfactorily though there is no use of fertilizers except only home-made manures.

The horizontal rows of the houses along the terraces and rock-ledges represent a typical linear pattern. The line of houses including the Trekkers' hut and the other private lodges shows a marvelous panorama along the western bank of the river Rammam. Majority of houses in the village is concentrated along the lower and middle terraces. All the households including the arable lands are situated on the adret side of any rib of the spur – front doors and verandah of all houses facing sunnyside. It is essential very much because the village lies at an altitude of cool temperate climate. Upper limit of the households is confined by the line of frequent snowfalls and dense mists in winter months. The lowermost terrace is sometimes affected by inundation during excessive downpours in the upper catchment areas

of the river Rammam as well as its second hand the Rato khola. But this is a very rare occurrence and, hence, the terrace is widely utilized for human activities.

iii) Field Landscape:

The distribution of fields as well as their size and shape are predominantly controlled by the contours of the land. The maximum cropping fields are located along the contour-strips lying in between the first and third river terraces though some plots have been extended further up - over the forest cleared slopes of the ridge (upto 2360m altitude). The strips show a remarkable feature - the decline in width and length of each of them upward. The strips of fields are generally elongated in shape. The cropping fields are located in front of the houses and it is almost attached to the house. This is done to keep eyes on the cropping field as the invasion of bear, wild boar and other wild animals is a common phenomenon.

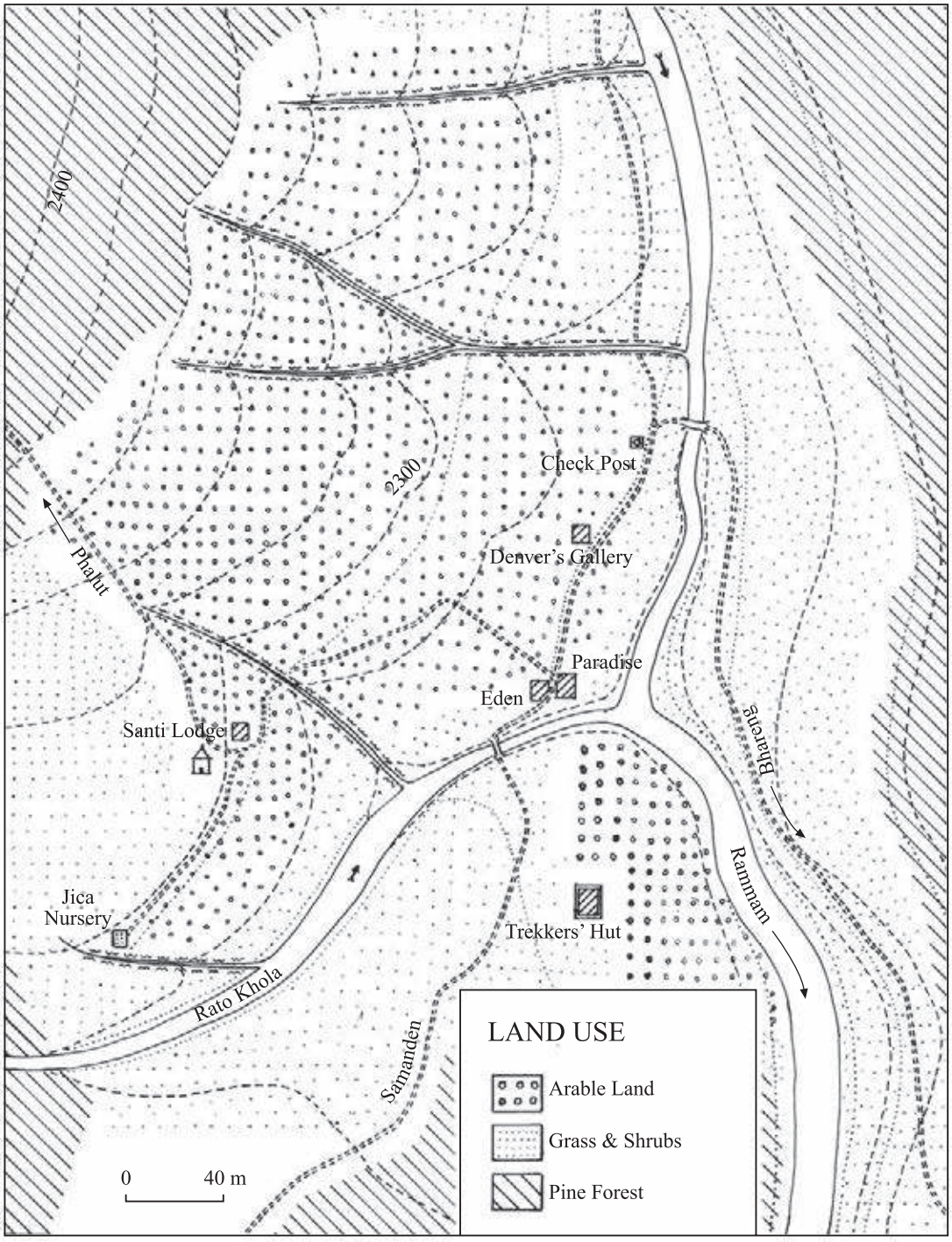
Usually same types of crops are grown in all the fields of this little village in a same growing period. Main crops grown here are hill potato, green pea, bean, carrot, cabbage and maize. There are two cropping seasons found at Gorkhey- one from December/Jan to July/ August and another from May/June to October/November. The copping periods are lengthy (almost eight months) due to low temperature of this tract. Farming is done on subsistence level and mixed cropping is generally practised. At a time three or more crops are shown in alternate rows. The combination of crops are like potato, bean and green pea occupying the land from Jan to July and cabbage, carrot and Maize occupying the land for the period of June to November. Seeding of crops for the latter combination may start before the harvesting of crops of the previous one. All the crops are consumed by the owners although the surplus production especially of hill potato is sold to the nearby markets. The production of Maize is also high and its surplus production is kept as fodder for pigs. There is no provision of irrigation; natural precipitation is the only source of water at the fields.

Farming of Buck wheat and barley has been ceased in recent years, while the production of green pea has been increased manifold. Farming of mushrooms is yet to be practised. It is collected from nearby forests. Bamboo shoots are also collected from bamboo-forests lying over ridge-tops.

iv) Architecture of the houses:

The architecture of the houses is also controlled by local litho-physiography as well as weather and climatic conditions. Except the Trekkers' Hut and the Denver's

Land Use Map : Gorkhey



Surveyed in May, 2016

gallery all the buildings of the village are single storied and light weighed. The first two have reinforced concrete structure below their ground floor (to prevent any type of damages caused by earthquake), brick or stone walls upto the mid-height of the same floor, and wooden walls upto the roof. The roof is made of corrugated iron sheets as in the case of other well built houses. A new building near Denver's gallery, under construction, is going to follow the same architectural characteristics. This type of architectures is well suited and much approriate for the site of Gorkhey where three types of litho-physiographic unstability prevail conspicuously: i) The village stands on a slope which is retreating by natural process of slope retreat; ii) The place is situated on the belt of M.C.T., i.e. one of the most vulnerable seismic zones over the Earth's Surface; and, iii) The solum beneath the buildings are thick enough (50 to 80 cm) but are very immature, incohesive and are unable to sustain the load of a heavy structure.

Apart from litho-physiographic constraints weather and climate are also found influencing factors for contruction of a house. The roofs of the houses in the village Gorkhey are always inclined outwards as this place experiences heavy rainfall during the monsoonal times. The roofs made of corrugated iron sheets are divided into two parts- one part projecting over another keeping a vertical gap in between to avoid sapping of rainwater as well as to make ventilation along their hinge-portion.

v) Economic Activities of the People:

In early days, till the mid-20th century, local people were only engaged in pasturing which damaged a lot of the forest- trees. But whenever they started to cultivate lands and began to raise crops pressure on forest decreased. The shift in the occupational structure was due to the increase in population as well as the newcoming people who are expert in tilling the highland terraces. At present the main occupational activity of the villagers is agriculture, each possessing one acre or little more arable land (allotted by the authority of Singalila National Park, on the basis of lease for 60 years). The farmers now grow maize, hill potato and different types of vegetables for their own consumption as well as for export (surplus production) to the nearby markets like Rimbick in Darjiling district and Sombarey in West Sikkim.

Pasturing is the second important occupation of the local inhabitants still today. Herds of cows are generally pastured in the forest area above the village daytime, while the pigs and horses are kept inside the village territory to avoid the attack of wild carnivores on them. No organized poultry has set up till now though the rearing of hens is also a common feature here.

Besides pasturing and farming, five families of the village have now been engaged in tourism for earning more. Due to verdure scenic beauty with serenity of the village it is to be growing rapidly as a tourist centre for nature and peace loving tourists.

Vi) Salient Features Highlighting the Food and Drinks of the local Inhabitants:

- Consumption of forest animals such as ghoral, tahr, ibex, kakar, etc. has been ceased especially after the declaration of the region as the national park (1992). The number of these animals has been lowered considerably in recent years.
- Breeding of dzoe is not practised now in this village because male yaks cannot survive here (in warmer climate, relatively to the summit section of the Singalila Range).
- The villagers engaged in pasturing today are neither experienced nor interested in rearing yaks and dzoes.
- Beverage made of rhododendron flowers (Gurans), popularly known as local Roxy is consumed by local villagers widely as well as by the tourists interested in drinks. These flowers are collected from local forests (from 2000m to 3000m).
- Pah, a type of frog living in the fissures of rockmass, is occasionally consumed by the villagers.
- Sacrificed Yak is consumed generally by the Buddhists.
- Beef is also consumed by the Buddhists.
- Fowl and pigs are consumed by all.

12.6. Future Prospects as Projected

In spite of the physiographical constraints the cultural landscape of the village is slowly developing. The main path connecting Rammam through Samanden village has been metalled (by boulders) recently. The culvert over the Rato khola has been reinforced after its disappearance by the flash flood in September 1999.The cropping fields have been well established along the entire lengths of the terraces since 1990's. Older houses (entirely made of thatched roofs and walls) are being replaced by newer ones (semi concrete buildings). During the last two decades the use of toilet has been introduced

almost in every house of this village. But the plans of houses have remained the same as before i.e. one part is used for human habitation and the rest is for fuel-stock and the rearing of domestic animals. The surface configuration of Gorkhey may change further with time if the communication system increases, and if the relation of the villagers with 'nature' changes with time.

Glossary of Local Terms

Batasi (Bengali): Windy, a place with non-stop breezes; the name was given by the Bengalee trekkers.

Bhanjyang (Nepali/Limbu): A gap or low lying area between a pair of hills.

Bikhebhanjyang (Nepali): The hill-gap with poisonous (bikhe) plants, denoting the luxuriant growth of aconites across it.

Bong (Tibetan): A human settlement or village.

Bungalow (Anglo-Indian): A hut resembling the thatched houses in the plains of Bengal.

Champ (Nepali): Michelia and other flowers of the same family, sometimes extended to magnolias also, derived from 'Champak' –a word used in Pre-Aryan India.

Chandupokhri (Nepali): The crescent-shaped (chandu or chandra) lake (pokhri).

Chiabhanjyang (Nepali/Limbu): The hill-gap of mushroom; i.e. where mushrooms are grown plentifully.

Chitrey (Nepali /Tibetan): The site of a frescoed Gumpha –a Buddhist monastery.

Chomolahri (Tibetan): Derived from the pristine word 'Chumulhari' meaning the mountain (ri) of goddess.

Chomolungma (Tibetan): The Mountain of the Goddess mother. The Nepali term for the peak 'Sagarmatha' was given in 1950's.

Chorbato (Nepali): A shortened (chor) foot-track (bato).

Daling (Tibetan): The place of arrow, indicating an arrow-shaped conical hill located in Kalimpong sub-division.

Danra (Nepali): A ridge projected from a mountain.

Daragaon or Danragaon (Nepali): The village (gaon) located on a ridge (danra)

Darjiling : Frequently spelt as Darjeeling (Tibetan): The place (ling) of mystic Thunder-bolt (Dorje).

Dhotrey (Nepali): A place having been torn or deformed with landslides.

Dhupi (Nepali/Limbu): The trees which can be ignited, like fir and other conifers with soft and resinous timber.

Gahribas (Nepali): Originated from 'Gahiro-bas' meaning the place lying at a deep portion (gahiro, derived from Sanskrit word 'gahwar' meaning a depression or hollow) in a mountainous section.

Goth (Nepali): The place for pusturing yaks and cows.

Ghum (Nepali): A bend, depicting the bending path across the ridge-top.

Gurans (Nepali): The flower of rhododendron.

Gurdum (Nepali): The village located at a nook of the mountain.

Gorkhey (Nepali): The settlement inhabited by the Gorkhas (the people originated in central Nepal).

Jannu (Tibetan): Abridged and distorted form of 'Jao Pungri', meaning the mountain of condensed rainbows. The Limbu name of it is 'Phoktanglungma' and the official name given by the Nepal Government is 'Kumbhakarna'.

Jaubari (Nepali): The house (bari) of oat/buck wheat (jau).

Jhora (Nepali): A mountain torrent, derived from the Sanskrit word 'Nirjhar'.

Jorethang (Tibetan + Nepali) : A pair of Meadows, indicating the pair of flat fertile lands on the both sides of Bari Rangit river.

Kabru (Tibetan): Distorted form of 'Kyabru', meaning the Horns of protection; the term vividly describes the shape of the mountain having a pair of crests.

Kalipokhri (Nepali): A lake (pokhri) with black (kali) water.

Kali khola (Nepali): The stream (khola) with black (kali) water.

Kalimpong (Tibetan): A Fortress (pong) of the King's minister (kalon); the King refers to the ruler of Bhutan as the area was occupied by the Bhutanese in early 18th century.

Kaiyakatta (Lepcha+ Hindi): A lair of bear-cat (kiya); the Hindi word has been added most probably by the tourists due to its resemblance with civet (katta).

Kang la (Tibetan): The mountain pass covered with snow (kang).

Kangchendzonga (or, khangchendzonga,Tibetan) : Variant spelling of the name 'Kangchenjunga' or 'Kinchinjunga' is generally used by the foreign authors, 'Kanchanjangha' by the Bengalees; meaning of the original term is 'the five Treasure-houses covered with big snows'. According to the version of a letter written by Lobzang Chhoden, then Private secretary of the Sikkim Rajah, on 01.07.1931 to the Editor of Himalayan journal (published in April 1932): Kang –snow, chen –big, zod –Treasury and nga –five; thus the combined word indicates the five lofty snow-clad summits of the great mountain. The five Treasures are salt, gold & turquoise, holy books, arms and crops & medicines. The Lepcha name for the mountain is 'Kongchen Kongchlo', meaning 'The Great Rockmass'; while in Limbu it is called 'Sewalungma' expressing the mountain that we offer greetings to.

Khola (Nepali): River.

Karsiyang /Kurseong (Lepcha): The site of stick (sheang)-like cane (kar).

Lamedhura (Tibetan): The mountain track (dhura) sacred by a Lama, the monk in Buddhism.

Lhotse (Tibetan): The south (lho) peak (tse), indicating its location in the south of the main peak 'Chomolungma'.

Makalu (Limbu): The Great (Maha) black (kala), depicting the blackish top of the mountain composed of gneisses.

Manebhanjyang (Tibetan+ Nepali): The hill-gap (bhanjyang) adorned with Mane or Mani.

Manegaon (Tibetan+Nepali): A village (gaon) having a Mane (religious structure made by the Buddhists).

Meghma (Nepali): The site of accumulated Clouds (Megh); the word has directly been borrowed from the Sanskrit word 'Megh'.

Mirik (Lepcha): The old name 'Mir-yok', meaning a burnt place, memorizing a great forest-fire once broke out here.

Narsing (Tibetan): Derived from 'Narseng', meaning the uplifted nose –the typical profile of the mountain viewed from the adjacent valleys.

Pandim (Lepcha): The King's minister, Kangchendzonga being the obvious King of the entire mountainous tract.

Phalut (Lepcha): Combined form of Phak (bare) and lut (hill), a genuine description of the rocky crag completely devoid of forests.

Rajah (Nepali): The King or the Ruler of a place; the original Sanskrit word is 'Rajan'.

Rajavir (Nepali): The great slope (vir), indicating the high, steep ridge-slope lying at that place due to vigorous hydraulic actions of the river Rammam.

Rammam (Lepcha): Probably derived in abridged form from 'Rang-Mong', where Rang – rivulet or ravine; and Mong – Demon lake (the source of the river).

Rangit (Nepali): Borrowed from the Lepcha word 'Rangnyit ung', meaning any of the two perennial rivulets; thus the word indicates the two main channels of the region: Bari (Great) Rangit and Chhota (Little) Rangit.

Rato khola (Nepali): The Red (Rato) river, indicating the reddish colour of water at its source area.

Rimbick (Lepcha): Derived from the word 'Rum-vik' which means warrior (vik) of the God (Rum).

Sabarkum (Lepcha): Sometimes spelt as 'Sabargum'; meaning of the word is the cliff of muntjak or musk deer (savar or sayar); the slopes of the ridge indeed abounded with this type of deer till 19th century.

Sadar (Hindi): The principal centre or the headquarters of a district.

Samanden (Lepcha): A place of levelled (saman) land (den).

Sandakphu (Tibetan): The mountain (phu) of poisonous (sandak) plants i.e. aconites which grow here abundantly.

Sepi (Nepali): The place lying at the shadowed zone of the mountain or ridge.

Sikkim (Nepali/Limbu): Derived from sui (new) –khyim (house), i.e. the new habitation for the Nepali and Limbu people especially in late 19th century when they were allowed to reside in the river valleys and to start their agricultural work there.

Siliguri (Northern Bengali dialect): Older name 'Silaguri', meaning the place (guri) strewn with pebbles and boulders (sila).

Singalila (Tibetan): Derived from Singley-la, meaning the mountain pass (la) with alder (singley) trees. The Lepcha word for alder is kowal.

Siri khola (Nepali): Shir khola, signifies the location of its head (shir) or source area on the elevated portion, i.e. near Sabarkum peak, at an altitude of 3500m.

Sukna (Nepali): A dry place; the dryness on the surface of the area is due to the deposition of coarse materials carried down from the upper hill section which conceals all seepages.

Tarai/Terai (Nepali-southern dialect): Low-lying wet lands, especially along the southern foothill region of the Himalaya.

Teesta/Tista (Northern Bengali dialect): Derived either from 'Deestang' (local tribal name); or from the old Bengali word 'Trisrota', originally derived from two Sanskrit words 'Tri'-Three and 'Srota' –torrents, indicating the three main distributaries of the river across its floodplain, viz. the Punarbhaba, Atreyee and Karotoya. The Tibetan name of the river for its mountainous course is 'Tsang chhu', meaning the stream (chhu) with Holy (Tsang) water.

Tonglu/Tanglu (Lepcha): Derived from Tang (conifer) –lut (hill), i.e. the hill covered with coniferous trees.

Tumling (Tibetan): Most probably derived from 'Tamling', where Tam –flat land, and ling –place, indicating the flattish land on the mountain top of that place.

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[Besides own collection many photographs have been borrowed from Sumit K. Das, Rahul Majumdar, Debabrata Lahiri and Suchitra Ray. I express my heart-felt thanks to all of them.]

Appendix | Geomorphic Units of the Darjiling Himalaya

Introduction : The Darjiling Himalaya is a small but unique segment of the entire Himalayan Mountain system. The ridges and spurs lying in this region mostly belong to the Lesser Himalaya (except the Siwaliks in the south) and remain open from permanent snow-covers. The rugged topography along with irregular slopes of the ranges shows a clear imprint of complex sub-aerial erosional processes; while the tortuous and terraced valleys reveal a structural instability of the terrain as a whole. The neo-tectonic movements have made the tract more intricate as responding the humid monsoonal climate prevailing at present. The following article is, thus, looking for an attempt to divide the total mountain segment into different geomorphic units each of which posseses some distinctive morpho-structural characteristics of its own.

Location, Area and Nature of Landscape

The mountain ranges of the Darjiling Himalaya cover the northern part of the Darjiling district which constitutes three sub-divisions – Darjiling, Mirik and Kurseong (or, Karsiyang). It shapes almost a trapezoid, slightly pulled out in the north-western part. The Rammam-Rangit valley makes its northern boundary, Southern Singalila Range along with the Mechi valley in its western boundary, and the great strath of the mighty river Tista in its eastern boundary. The southern rim of the mountains are sometimes ambiguous because of the extentions of large alluvial deposits, but the contour of 300m running along the piedmont belt of the Siwalik hills may be considered as the demarcation line with least controversy.

The latitudinal and longitudinal extensions of the Darjiling Himalaya are 26°15' N to 27°13' N and 87°59' E to 88°28' E respectively. Total area of the tract is 1371.4 sq. km. the altitude of which rises rapidly from 300m along the southern piedmont belt to

3000m over the Southern Singalila Range lying in its north-western part – within some tens of kilometre distances! The panoramic view of the entire region exhibits an attractive imagery containing lofty ridges and deep valleys. The colours of the landscape vary from deep to light sheds of green due to the covers of tropical to temperate forests as well as tea estates over the tract. The district headquarters Darjiling and other hill stations, however, can be visualised clearly on the map of the terrain by the sprawling homesteads amidst the green.

Lithology of the Region

The mountains of the Darjiling Himalaya are mainly composed of folded rockmasses piled over one another by a series of compressional forces occurring successively from Early Eocene to Pliocene epochs of Tertiary period. The protruding hillocks of the Siwaliks came over the narrow belt of the diminishing Tethys sea in the last epoch of that upheaving processes. The overthrusts of the mountain bodies caused by the wave-forms of the orogeny led the strata to be situated in an inverted sequence. Thus the Archaean rocks (gneiss and migmatite with high grade of metamorphism with granitic intrusions) are found in the topmost layers of the mountains concealing younger rocks (partly metamorphosed sedimentary formations) beneath them. The latter rock groups extend up to the Boundary Thrust and often cover the northern fringe of the Siwaliks which are mostly composed of Rudaceous and Arenacious rocks of sedimentary group. The succession of the entire terrane is briefly stated here:

Rock group	Age	Lithological characteristics
i)Sands, gravels and other colluvial deposits.	Quaternary	Loose, badly weathered, easily susceptible to mass-wasting.
ii) Mudstone, greywacke, limestone and conglomerate confined in the Siwalik formation.	Tertiary	Weathered but relatively resistant to mass-wasting.
iii) Shale, sandstone, etc of Gondwana group.	Late Palaeozoic	Partly metamorphosed, coal seams occur in sporadic manner.
iv) Quartzite, dolomite and grey slate of Buxa series.	Late Proterozoic	Compressed and laminated under the thrusts.

Rock group	Age	Lithological characteristics
v) Phyllite, schist and green slate of Daling formation.	Early Proterozoic	Foliated, grade of metamorphism increases from lower to high elevations.
vi) Darjiling gneiss, mylonite and migmatite.	Archaean	Very hard and resistant, often intruded by igneous bodies of later ages.

Evolution of the Topography

The evolution of the topography in the Darjiling Himalaya is fully dependent on the orogenic movements as well as the past and present climates prevailing over the tract. The neo-tectonic upliftments have made the ridges much more rugged than the topography existed in early Pleistocene age. The imprints of the Pleistocene glacial actions, especially of the Wurm glacial age, along the high altitudinal zone of the Southern Singalila Range are very much detectable (as depicted in Part-I, Chapter-3). Now this belt experiences cool temperate climate.

The maximum portions of the Darjiling Himalaya lying above 1000m are under humid and warm temperate climate, while the lower areas of the Siwalik hills, in the Mechi valley and along the Tista valley show the influence of per humid tropical climate. The varied climatic conditions over the tract are the main factors for differential denudation processes which ultimately result in varied range in reliefs along with wide varieties of topographic features.

Since the retreat of the last glacial age the region has been going through the sculpturing processes of the two major river systems – the Rammam-Rangit-Tista and the Mechi-Balason-Mahananda. Large lakes and plains are significantly absent in the entire terrain. The springs and rivulets are, however, abundant all over the hills and mountains. They play very active role in developing the surface configuration which is changing rapidly in present climate.

Regional Differences in Landforms

Variation of landforms with distinctive relief and slope characteristics within a very short distance is a conspicuous feature of the Darjiling Himalaya. The Southern Singalila Range stretches along the north-western boundary of the region for about 50km. The physiographical analyses of the Range have been discussed in details in the main part of this book. The eastern flank of this Range is confined by the Boundary Thrust of the Chhota Rangit valley which originates in the south-eastern slope of the Tonglu peak and joins the Bari Rangit valley near Jorethang, 6km north-west of the district headquarters Darjiling. The gradient of upper section of the valley is very steep (abrupt fall from the height of 2500m to 800m in a length of only 12km), whereas that of lower section is faint. A large alluvial fan has been formed at the mouth of the Chhota Rangit which exceeds one sq. km. in area.

To the south-east of the Chhota Rangit valley lies the bow shaped Sukhiapokhri-Ghum-Tukdah ridge and the arrow shaped Darjiling-Kurseong spur which intersect each other at Ghum (2250m). Both of the lineaments are composed of synclinoriums with the top layers of hard resistant gneissic stratum. The Senchal hill (2715m) and Tiger hill (2585m), lying two km south-east of Ghum, are nothing but the projections of that synclinoriums. The world famous hill station Darjiling (2100m) has been grown on the northern slope of the Darjiling spur which plunges towards the Main Central Thrust running below the Bari Rangit valley (average inclination 13° degrees, slopes of the sides often exceed 50°). Another hill station Kurseong (or, Karsiyang,1400m) is situated on the southern extension of the Kurseong spur. It acts as the water-divide between the rivers Balason and Mahananda. The slopes of the spur vary from 15° near southern piedmont belt to 55° in the northern part.

The northern flank of the Tukdah ridge (towards the Bari Rangit valley) shows very steep gradients – more than 60°, but its southern parts are gentler. The former part is drained by numerous short streams and rivulets – all arranged in parallel drainage pattern and plunging to the river Bari Rangit almost at right angle. On the other hand the latter part is drained by the subsequent streams of the mighty river Tista. These streams exhibit relatively longer courses with dominant dendritic patterns. The Giel khola possesses the largest basin area amongst them. Maximum height of the Tukdah ridge has been measured as 2056m at a place lying 3 km south-west of Lamahatta.

The northern slopes of the ridge extending from Sukhiapokhri to Ghum show moderate slopes – varying between 20° and 35°. Whereas the southern slopes are steep enough –

from 40° to 45°. The crest line of the ridge is little undulating: ranging from 2150m to 2250m. The headstreams of the river Balason have carved out the southern part of the ridge and given its wide arcuate shape which is distinctive very much for the whole tract.

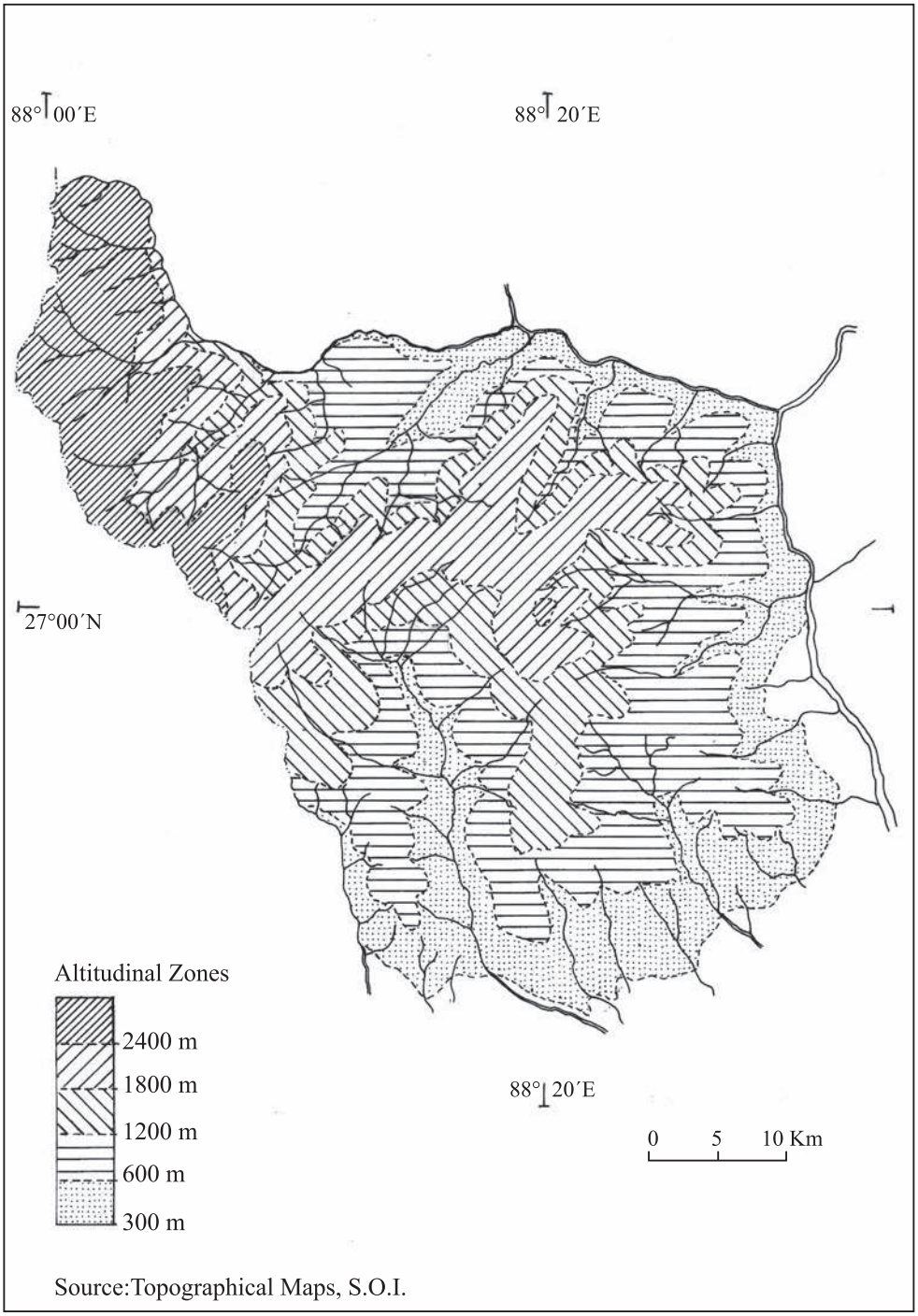
The Mirik ridge lies south of the Sukhiapokhri ridge. It extends almost due south through the wide gap (6km) of the Mechi and Balason valleys and terminates at the belt of Siwaliks. The altitude of this ridge nowhere exceeds 1800m. The hillocks constituting the ridge are round headed with slopes of moderate to low gradients: from 5° to 35°. The popular lake of Mirik, 'Sumendu Lake', is a dammed waterbody which lies on an old lowland 'Sumendu Dhap' – a structural basin located at the head of the Kali khola. Along with this stream many other streams and rivulets with very short lengths drain the western slopes of the Mirik ridge. Whereas the eastern slopes of the ridge are drained merely by the tributaries of the river Balason.

The hillocks of the Siwaliks are conspicuous in the narrow but elongated segment extended from the river Mechi to Mahananda (following the tectonic belt in between the Himalayan Boundary Thrust and the Himalayan Frontal Fault). The altitude of them is very low – never exceeding 400m (except the height of the Lohargarh top – 403m). The segment is differentiated from the main ridges of the Lesser Himalaya by narrow gaps (following the Himalayan Boundary Thrust). These gaps are generally occupied by many gullies and short streams. The Sevok khola is the longest amongst them which rises on the south-eastern end of the Kurseong ridge and merges into the river Tista after making a large sand-bar at its mouth.

Highly elevated river terraces are prominent features along all the large rivers of the Darjiling Himalaya. These are the results of neo-tectonic movements related to the entire Himalayan orogeny. Each terrace marks the relic of the valley floor existed in the past. Thus the lowermost setting of the terraces indicates the last upliftment of the region, i.e. in the Pleistocene epoch. Height of the terraces caused by that movement is more or less same – about 30m (slight variations are found in different valleys depending upon the rate of erosion on varied rock strata). Immatured terraces can also be noticed in the sides of the main thalwegs which are composed of recent deposits.

The terraces are paired along the river Rammam and wide enough – more than 200m at Rimbick and Goke villages. Whereas unpaired and narrow terraces are found along the other rivers because of the differential erosion in different rock strata arranged in their valley sides. In the last stretches of the rivers Balason and Tista the left bank terraces have either been shrunk or obliterated due to the shifting nature (eastward) of these rivers.

Altitudinal Zones : Darjiling Himalaya



Height of some Places in the Darjiling Himalaya

Name of the place	Height (m)	Latitude (N)	Longitude (E)
Darjiling mall	2178	27°02.5'	88°16'
Ghum	2250	27°0.5'	88°16'
Bijanbari	960	27°04'	88°11.5'
Singla Bazaar	380	27°07.5'	88°17.5'
Rimbick Bazaar	2080	27°07'	88°06'
Sukhiapokhri	2200	27°00'	88°11.5'
Jorepokhri	2280	26°59.5'	88°09.5'
Manebhanjyang	2100	26°59'	88°07.5'
Chitre danda	2572	27°00'	88°06'
Tonglu	3063	27°02'	88°05'
Sandakphu	3631	27°06'	88°00'
Phalut	3596	27°13'	88°01'
Simana Busti	2350	26°59'	88°08.5'
Mirik Lake	1590	26°53.5'	88°11'
Kurseong (or Karsiyang)	1440	26°52.5'	88°17'
Sonada	1840	26°58'	88°17'
Tiger Hill	2585	27°00'	88°17.5'
Senchal peak	2715	27°59'	88°17.5'
Lamahata	1680	27°03'	88°21'
Tista Bazaar	260	27°04'	88°25.5'
Mongpu Rock	1000	26°58'	88°23.5'
Sittong	1700	26°56.5'	88°23.5'
Latpanchar	1100	26°55'	88°25'
Ghoramara	800	26°52'	88°25'
Sukna	160	26°47'	88°22'

Accuracy of latitudes & longitudes – upto 0.5'
Source: Topographical maps, Survey of India

Length of the Major Streams and Rivers in the Region under Study

Name of the stream/ river	Length (km)	Source/Entry point	Mouth/Exit point
Rammam	41	Phalut	Jorethang
Lodhoma	14	Garhibas	Salingdang
Chhota Rangit	13.5	Tonglu	Singla Bazaar
Jhepi khola	12	Phubsering	Kankibong
Bari Rangit	19.5	Jorethang	Melli
Ragnu khola	17	Jorebunglow	Batamtam
Tista	28	Melli	Sevok
Giel khola	9.5	Tukdah	Giel
Rayeng (Riyang) khola	18	Upper Mamring	Rayeng
Kali khola	8	Latpanchar	Kalijhora
Sevok khola	8	Ghoramara	Sevok
Mahanadi	16	Mahaldiram	Golaghat
Balason	25.5	Lepchagaon	Panighata
Rangbong	15.5	Simana Busti	Mirik Busti
Mechi	19	Pashupati	Lohargarh

Geomorphic Units

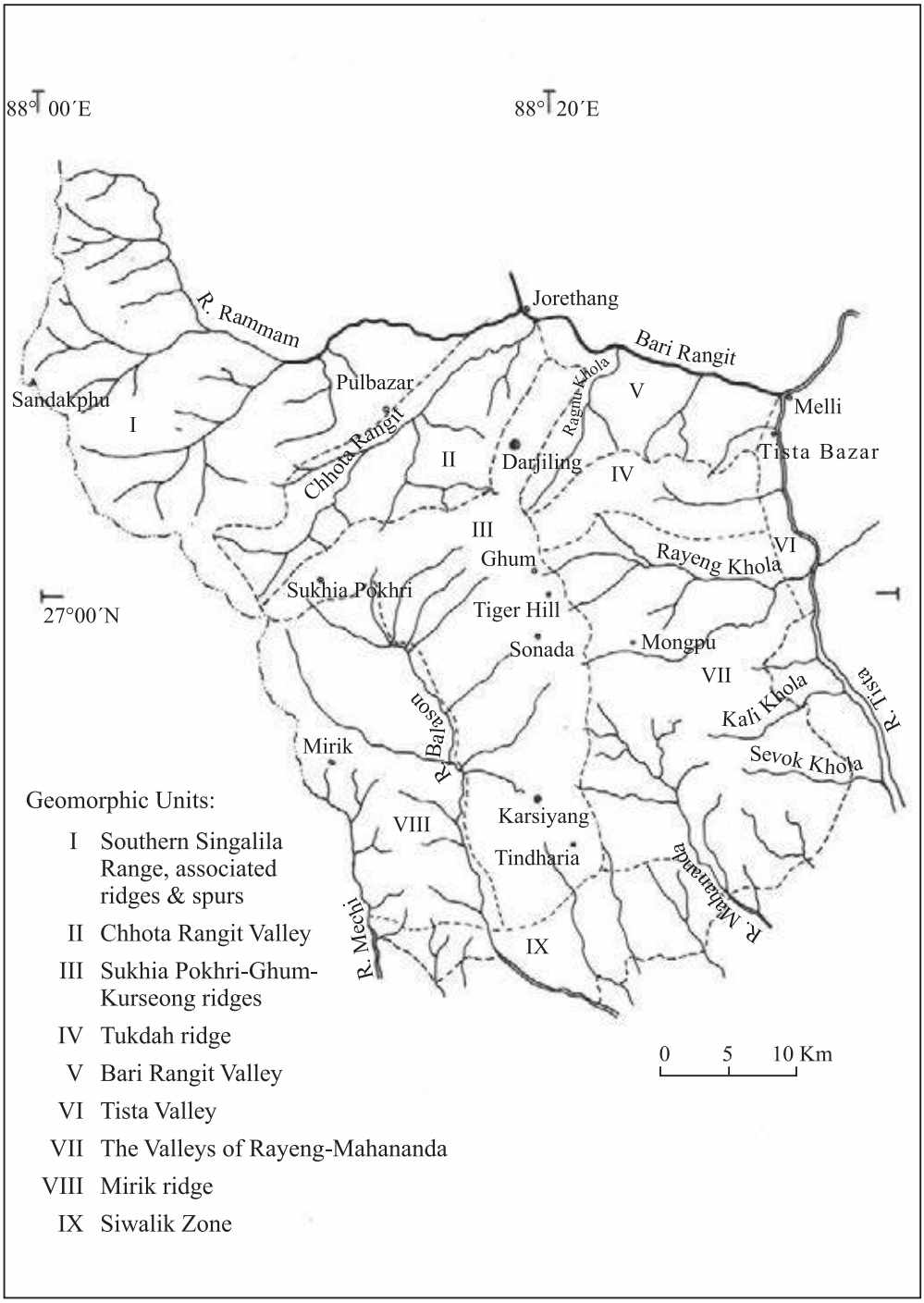
According to landform characteristics along with their structural bases the terrain of the Darjiling Himalaya can be divided into several Geomorphic units. These are described briefly in the following table:

Geomorphic unit	Structural base	Landform characteristics
i)Southern Singalila Range, associated ridges & spurs	i)Huge nappe – pushed by the M.C.T.; Pliocene & Quaternary faults are marked by stream-heads & their scarplets by mineralization; upper stratum is composed mainly	i)Jagged summit section represents a klippen-type mountain; southern slopes of the summits are formidably steeper than their opposite slopes; stream profiles show high

Geomorphic unit	Structural base	Landform characteristics
	of Archaean gneiss often intruded by granite, pegmatite,etc of later age.	gradients & are broken at short distances by recent faults & ruptures; minor periglacial features are found from Thakum to Phalut at Ubac sides of the summit crags.
ii) Chhota Rangit valley	ii) Guided by deep-seated fault; underlying rock srata are exposed along the valley walls of the main river &its tributary – the Rilling Khola.	ii) Except the Fan-area entire valley is characterized by boulder deposition; steep sides are susceptible to landslides & debris avalanches; terraces are prominent but narrow.
iii) Sukhiapokhri-Ghum-Kurseong ridges	iii) Complex synclinorium of a medium-height nappe pushed by the M.C.T.; top portion is composed of Archaean gneiss.	iii) Rolling topography; crest-lines are gentle, but the ridge-flanks are steep due to headward erosion of the rivers like Balason &Mahananda; hanging walls above the valleys are heavily slide-prone.
iv) Tukdah ridge	iv) Upwarped mass in front of the M.C.T., surprisingly gentler slope on the southern slope; crest line composed of Archaean gneiss.	iv) Sharp crest, innumerable springs & gullies on the both sides; deep glens found in the headstreams of the Giel khola.

Geomorphic unit	Structural base	Landform characteristics
v) Bari Rangit valley	v) Wide strath, very old valley following the M.C.T. zone; valley walls exhibit the rock strata of different ages.	v) Terraces are prominent on the both sides but are segmented frequently by deep gorges of the tributary-streams; alluvial cones and colluvial deposits are common on the valley sides; various types of sand bars present on the valley floor; thawleg is branched in some places.
vi) Tista valley	vi) Wide gorge, running in north-south direction following a deep seated Transverse Fault; reveals all strata on the valley sides; probably age –anterior to the Darjiling Himalaya	vi) Western bank is well-terraced; series of alluvial cones & colluvial deposits on the both sides of the valley; sand bars & shoals along the river bed (submerged recently due to the construction of dam –just below the confluence point of the Tista & Kali khola).
vii) The valleys of Rayeng-Mahananda.	vii) Young valleys with typical consequent nature; depth of the gorges increases on lower strata composed of softer rocks.	vii) Rapids and pools are common on the valley floors, cascades are present at or near the unconformity planes; obsequent valley-segment found in the last 5 km of the Rayeng khola

Geomorphic Units : Darjiling Himalaya



Geomorphic Units:

- I Southern Singalila Range, associated ridges & spurs
- II Chhota Rangit Valley
- III Sukhia Pokhri-Ghum-Kurseong ridges
- IV Tukdah ridge
- V Bari Rangit Valley
- VI Tista Valley
- VII The Valleys of Rayeng-Mahananda
- VIII Mirik ridge
- IX Siwalik Zone

Remarking Notes

Because of the humid climate prevailing at present fluvial processes are very much active over the region. The evolution of landforms is, however, interrupted frequently by neo-tectonic movements. Creation or omission of caves, springs and cascades, reconstruction of hill slopes and terraces, sharpening of water divides, seasonal landslides, regular process of colluvial deposition and widening of alluvial fans, etc are common phenomena almost in every parts of the terrain. With the warming nature of the atmosphere periglacial features are diminishing rapidly from the high mountainous area. In short, the Darjiling Himalaya is an ideal example showing all tectonic and geomorphic settings for the whole segment of the Lesser Himalaya.

Appendix : Geomorphic Units of the Darjiling Himalaya

Geomorphic unit	Structural base	Landform characteristics
		(width of the divide between the R. khola and its trunk river- the Tista is only 1.5 km).
viii) Mirik ridge	viii) Squeezed and thrusted hills bounded in all 4 sides by deep faults; top layers are composed of Archaean gneiss; lower strata reveal younger formations – from Early Proterozoic to Lower Tertiary.	viii) Subdued topography, highly dissected by the headstreams of the Mechi & Balason – erosional activities are stronger for the latter group due to more orograhic rainfall in the Balason valley.
ix) Siwalik zone	ix) Narrow belt of Pliocene formation lying in between the H.B.T. & H.F.F.	ix) Erosional effects are vigorous on the soft & porous sedimentary rocks which result in a series of detached blocks of hillock in the zone; heavy mass-wastings are common phenomena during the rainy season.

17a. Rupture in gneissic strata
by freeze-thaw action

17c. Broken rock stratum after exfoliation

17d. Spectacular soil horizons formed under
periglacial process in recent past

17b. Exfoliation after removal
of upper strata

17e. Silicification of rock strata

18a. Silted bed of Chandupokhri-2012

18b. Pebble-tops partly protecting soil erosion

18c. Hydraulic action on the valley wall of Upper Rammam

18d. Formation of pot-holes at the bed of Upper Rammam

19a. Gully erosion: at the head of Rithu Khola

19b. Slump of soil: South face of Sabarkum danra

19c. landslide at Kaiyakatta-2012

19d. Bamboo fences for protection from masswasting – an old practice

20a. Subsidence of rockmass over the cave of Kalipokhri 2012

20b. Debris avalanche:
below Daragaon 2013

20c. Landslide at Jawleygaon 2013

20d. Relics after Flash flood in Devi khola,
a tributary of Siri khola 1999

21a. Top of Sandakphu 1960
by : D. Mordecai

21b. Sandakphu- 2001

21c. The highest crag on Sandakphu

21d. The reservoir below a spring: main source of drinking water at Sandakphu

22a. Head area of Siri khola

22b. The Siri khola: north of Gurdum village

22c. A culvert across Siri khola gorge:
east of Gurdum village

22d. Wide valley of Siri khola: near Sepi.

23a. Siri khola Trekkers' hut and the suspended bridge

23b. Length-wise viewof the suspended bridge 2012

23c. Terrace cultivation on the left bank of Siri khola

24a. The picturesque village Gorkhey

24b. Settlements along the lowermost terrace of Rammam valley

24c. Valley of the Rato Khola