CHAPTER II

PHYSICAL SETUP OF THE STUDY AREA

2.0 Geomorphology of the study area

Geomorphology is the study of landforms. Three key elements of geomorphology are land form, geomorphic process, and land-surface history. Form is described by morphological maps or more in recent times, by geomorphometry. Geomorphologists usually use a systems approach to their subject. Form systems, flow or cascading systems, and process–form or process–response systems are all acknowledged. Negative feedback and positive feedback relationships are significant features in the dynamics of geomorphic systems. The great achievements of process geomorphology include notions of stability, instability, and thresholds in landscapes, the last two of which contradict simplistic ideas on cause and effect in landscape evolution. Uncertainty surrounds the issue of geomorphic process rates (Fundamentals of Geomorphology, Richard John Huggett, 2007).

Assessment of geomorphic river condition measures whether the processes that shape river morphology are appropriate for the given setting, such that deviations from an expected set of attributes can be appraised (Larson, 1991). Key consideration must be given to whether changes to the boundary conditions under which the river operates have brought about irreversible changes to river structure and function (Fryirs, 2003).

Rayeng Basin is a mountainous basin of Darjeeling Himalaya. The elevation of the basin ranges between 180m to 2400m. The elevation of the basin stridently rises from northeast to northern and south eastern part. The basin has highly jagged topography with very steep to moderate slope. Many deep 'V'-shaped valleys have been developed in this basin area. High gradient of the basin encourages the streams to carry large pebbles of crystalline rocks swiftly. The streams are mainly engaged in vigorous vertical erosion and headward erosion which encourage valley deepening and stream lengthening. Consequently steep walled narrow and deep channels are produced. The close examination of contours depicts that the basin is characterized by many spurs, cliffs, rocky slopes, narrow river valleys etc. The valleys although relatively straight when viewed from a high level plane or space satellite, are fairly sinuous in detail marked by interlocking spurs. Many ridges of the basin are covered by dense vegetation. River terraces are also found in this basin. According to A. Gansser, 1964, structurally the Himalayas are regarded as intermediate between the Alpine and Jura type of fold mountains. Indeed the basin is situated in Lesser

Himalayan zone which is generally composed of unfossiliferous sediments or metamorphosed crystalline rocks.

To portray the accurate graphic representation of the landforms of the basin geomorphological map has been prepared. Geomorphological map provides an integrated and comprehensive statement of landforms and drainage. For the preparation of the geomorphological map following methodologies have been followed:

1. A contour map has been prepared from the topographical sheets bearing the number 78A/8 and 78B/5 at the scale 1:50000.
2. Topographic configurations of the basin have been indentified from the thorough study of the alignment of the contours on the contour map. These relief features have been displayed on the map by symbols.

Geomorphic features of the basin

The precise study of the geomorphology of the basin the entire basin may be divided into following physiographic units (Figure 2.0, 2.1, 2.2 & 2.3):

Hilly tract of the north-western and southwestern part

About 90% area of the basin has the characteristics of hill. The elevation of tract ranged between 300m to 2500m. This unit is covering the villages of Pubang Khasmahal, Pubong Teagarden, Mongpu Cinchona Plantation, Reshop Bazer, Sanchal Forest, Lada Khasmahal and Rongchong Khasmahal of Rangli Rongliot Block, Chattokpur Forest, Upper Mamring Khasmahal, Lower Mamring Khasmahal, Toryak Khasmahal, Sittong Khasmahal, Selpu Khasmahal, Rolak Khasmahal, Barasitong Khasmahal, Rolak khasmahal, Lonku Khashmahal of Kurseong Blok. Slope of this unit varies from 16° to 30° and above. Thus this physiographic has moderately steep to very steep slope. Statigraphy of this unit displays the Darjeeling gneiss, Paro-subgroup, lingtse granite, gneiss, feldspathic greywacke marble, Reyang formation and Gorubathan formation. Structurally this unit displays foliation, schistosity, mega fold, micro and mesofold, fault, cleavage, fracture, pucker lineaments etc. Moderate to high drainage density is found in this physiographic unit. In this physiographic unit following features are found:

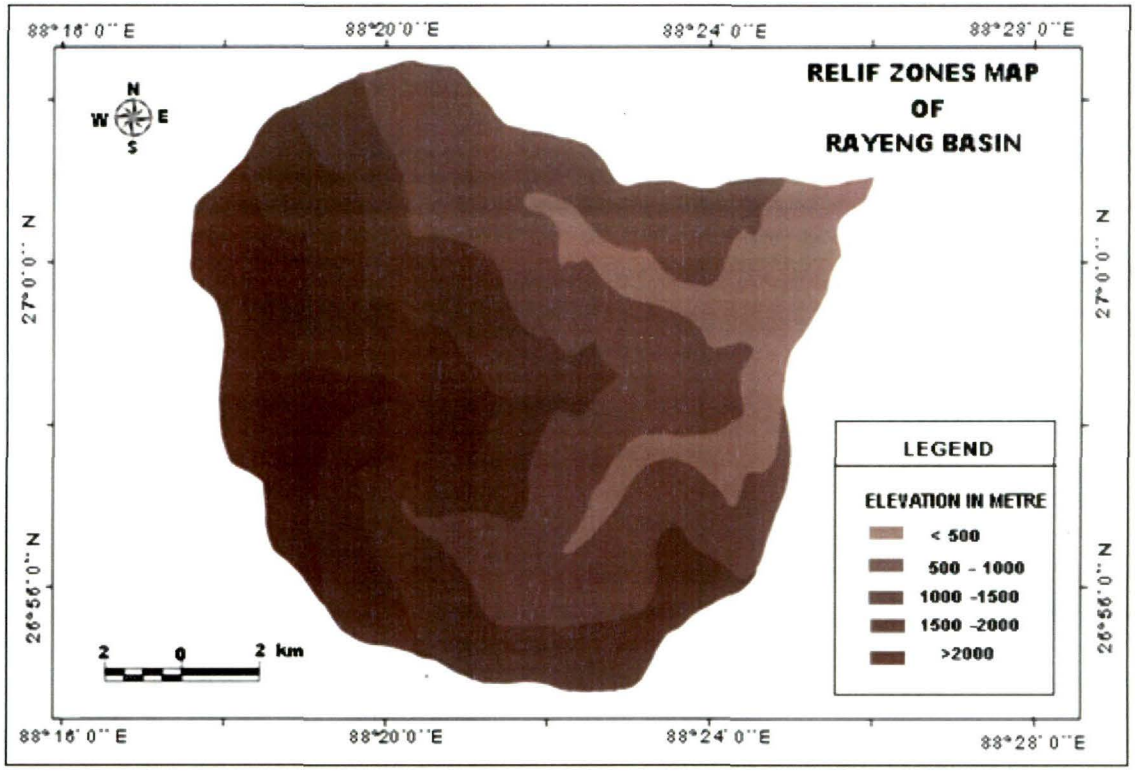


Figure 2.0 Different relief zones of the basin.

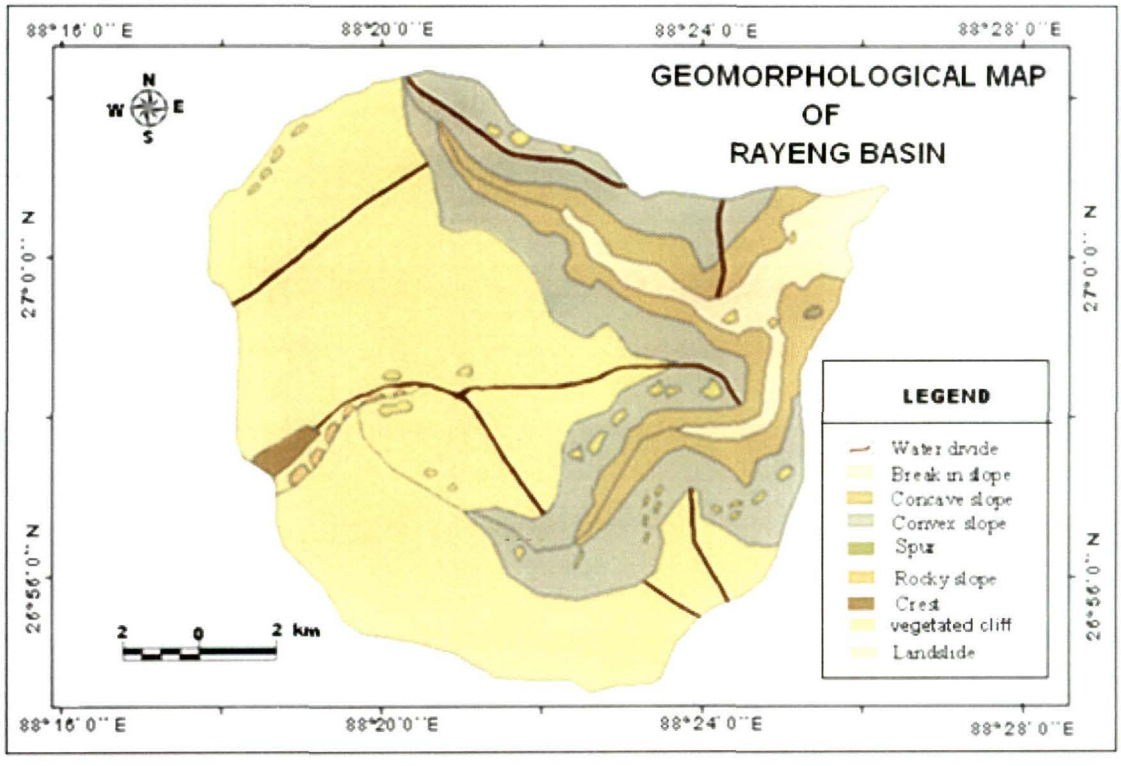


Figure 2.1 Geomorphic features of the basin.

TERRAIN CONDITION OF THE RAYENG BASIN

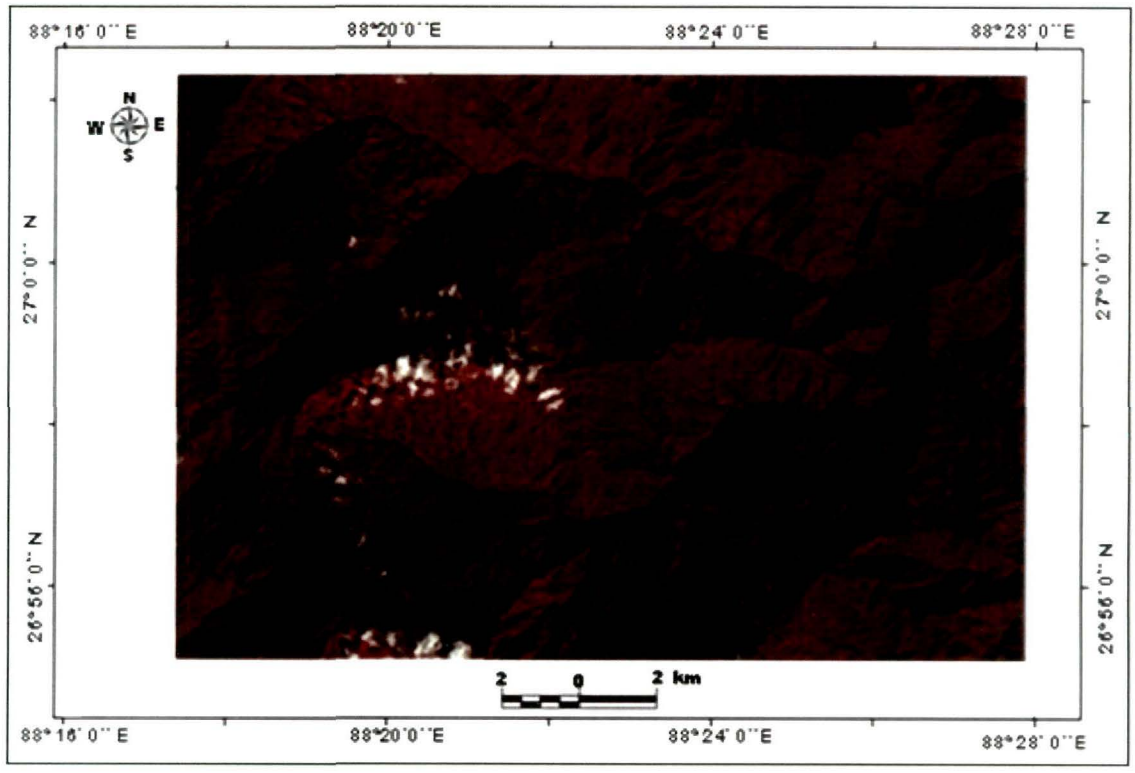


Figure 2.2 False colour composite (Band 2, 3 and 4).

PHYSICAL FEATURES OF THE RAYENG BASIN

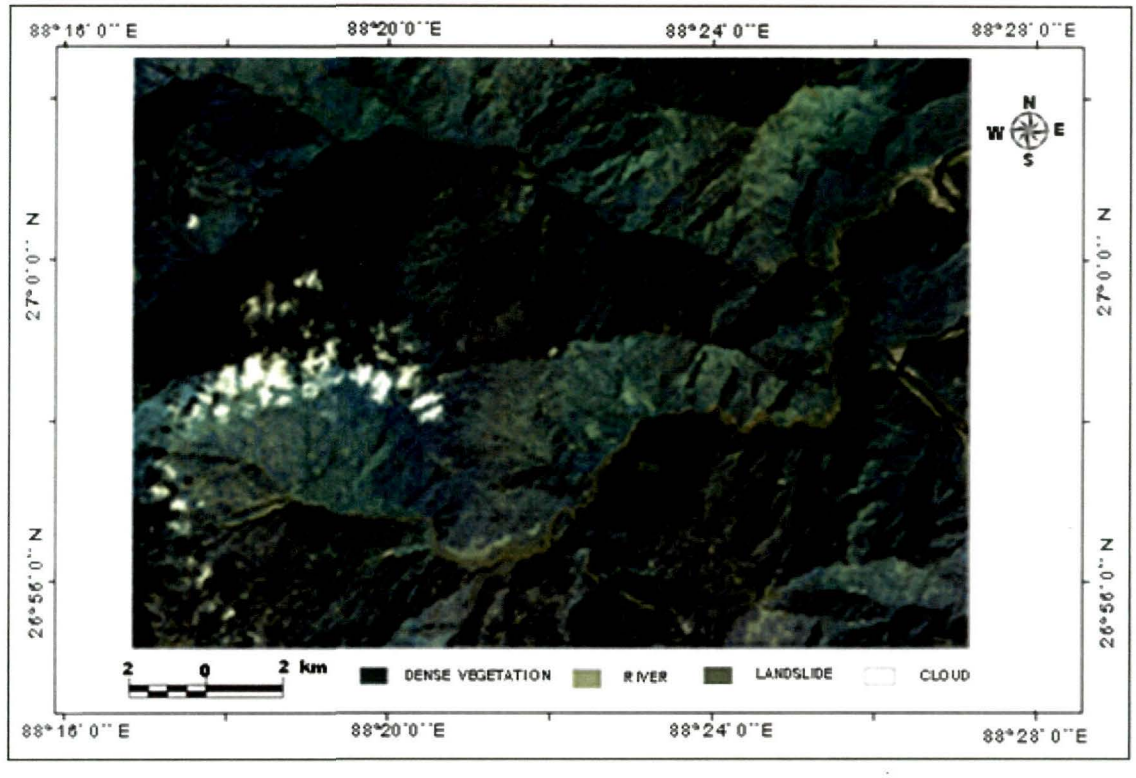


Figure 2.3 Different physical features of the basin.

Spurs

One spurs is situated almost in the central part through Sanchal forest and Mongpu cinchona plantation and functioned as water divide between Rayeng and Rambi River. This spur is sharply sloping down from western part to southeastern part. Many small streams have been developed on both sides of this water divide. Another spur has been developed in the northwestern part (Pubong Khasmahal) and functioned as small water divide (plate 2.0). The third spur is situated in the south western part (Sittong and Selpu Khasmahal) and sloping down from west to northeast.

Vegetal cliffs

There are spectaculars bedrock cliffs which have been developed in this physiographic unit. These cliffs are situated in the Pubong Khasmahal, Mongpu Cinchona Plantation, and Resop Bazar respectively.

Rocky cliff

Rocky cliffs are also found at Pubong Bazar Khasmahal, Resop Bazer having slope >40°.

Slope convexity

This physiographic unit has convex slope within the elevation zone between 600m to 2100m. And Comprises Pubong Khasmahal, upper part of Mangpu plantation, upper part of Resop Bazar and Labda Khashmahal.

Slope concavity

Adjacent to lower valley area within the elevation of 300m to 600m having concave slope property comprising lower part of Pubong Teagarden, Mongpu Cinchona Plantation, Resop Bazar and Rongchong Khasmahal.

Rocky slope

Rocky slope has been developed near the Senchal Forest.

Hill summit

The hill summit is located above the height of 2300m in the Senchel Forest.

Narrow 'V' shaped river valley

Several narrow and deep valleys have been produced by Rayeng and its tributaries. The significant steep sided river valleys are situated in the north eastern and southeastern parts respectively.

Plate 2.0 A spectacular view of vegetated spur at Rambi Bazar.

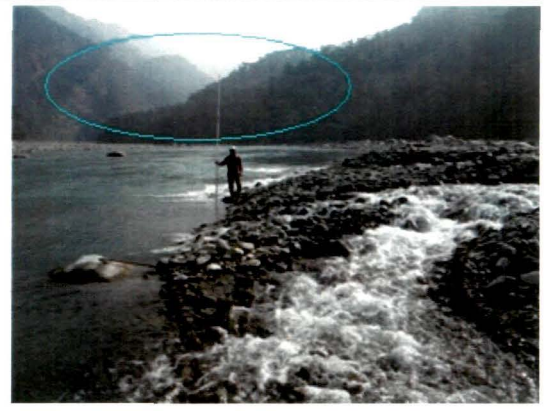


Plate 2.1 Panoramic view of ridges and 'V' Shaped river valley of Rayeng Basin.

Plate 2.2 Phyllite, one of the significant rocks of Rayeng Basin.

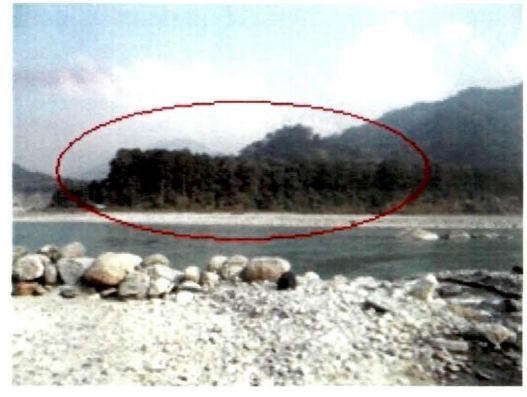


Plate 2.3 Vegetal cover beside the bank of Rayeng at the confluence.

Break in slope

Sharp break of slope is found at the conjunction point of the hilly tract and lower valley area.

Landslides

On the steep slopes of the cliffs slopes failures are occurred due to landslides. Sites of landslide are situated haphazardly in the entire basin.

Lower valley region

This tract covering the area below 300m of the basin is situated near the Rambi Bazar of Kalimpong Block-1. In this tract fluvially induced depositional landforms have been developed. Sands and boulders have been deposited by the rivers Rayeng and Rambi. Point and mid channel bars are found along the lower course of Rayeng River. Due to lateral erosion of Rayeng and Rambi Rivers bank erosion is caused along the lower course

of Rayeng River. Statigraphy of this unit is displaying Reyang and Gorubathan formation. This unit has moderate slope and drainage density.

The above discussions conclude that physiographic landscape of the basin is the latest phase of the tectonic uplift. The basin is influenced also by subaerial denudation. The evolution and the recent characteristics of the landforms of the basin are highly dominated by the geologic structure and resistances of rocks to their erosion. The hills, ridges and scarps are generally associated with hard and resistant rocks.

2.1 Geology of the study area

In geomorphology structure has also stratigraphic implication that habitually implies an appreciation of rock succession and the regional relationships of rock strata. As a general principle, the structural features of rocks are much older than the landform development upon them, and in most cases rock structure control the development of landform characteristics. Commonly the relationship between the structure and the landforms development upon them are quite obvious and result in striking topographic features. The striking difference in topography may simply indicate marked variation in rock structures, where as the homogeneity of structure or lack of structural control may simply result in homogeneity of topography. The synoptic view of the terrain on the aerial photographs and satellite images could be better used as a tool to understand this principle of mutual response between the underlying structures and the resultant topographic expression in a perceptible way. Variations in geological structures and lithology or composition of materials may exert varying degrees of influences under different climatic conditions towards development and genesis of landscapes in a region. Contemporary geomorphologists namely, J.T Hack, 1960; R.J Chorley, 1978; S.A. Schumm, 1956 and D.E. Sugden argued strongly about the influence of active and passive structure on landform development.

For the better description of geomorphic features of a region, sufficient attention on geology of the concerned region is essential. Indeed the study of geology helps in understanding the composition and structure of rocks, which further determine the nature of soils. For the comprehension of geomorphology of river basin detail study of underlying structure is necessary. W.D Thornbury (1954) stated, "Geologic structure is a control factor in the evolution of landforms and reflected in them". The structure, process, and stage are the three major control-factors considered by W.M Davis (1899) in the evolution of landforms resulting in the historical development of landscape. Thornbury mentioned that the term structure must be used in wider sense. The term is not only

confined to rock features like folds, faults, unconformities, but also includes the physical and chemical attributes of the materials out of which the landforms are carved.

Rayeng Basin displays complex geological layout. The study area is basically composed of landforms induced by the river Rayeng and its tributaries flowing through the narrow, deep and more or less straight channels. Due to successive vertical erosion performed by the streams, presence of different tectonic units has been exposed. According to Mallet (1875), Audent (1935), the tectonic units of Darjeeling Himalaya are found to be in reverse order of superimposition and represented by Siwalik and Gondowana formation. A widespread stratigraphic framework along a south-north traverse from the foothills of Darjeeling-Himalaya to the northernmost part of the Sikkim Himalaya is established by Ray in 1989 (Table 2.0).This stratigraphic framework give detail information about the geology of Rayeng basin.

Table 2.0 Tectonostratigraphic Succession along South-North Darjeeling-Sikkim Himalayan Section (after Ray, 1989; GSI, 2000).

NORTH

TETHYAN GROUP

4. Chho Lhamo Formation

3. Lachi Formation

2. Mt. Everest Limestone

1. Mt. Everest Pelitic Formation

_____ *TRANS AXIAL THRUST* _____

SIKKIM GROUP

Darjeeling Gneiss, Khangchendzonga Gneiss and

Chhungthang (=Paro) Subgroup with Lachen

Leucogranite (and its Equivalents)

_____*SIKKIM (MAIN CENTRAL?) THRUST*_____

DALING GROUP

Gorubathan Sub-group (with Lingtse Granite Sheets at different Structural

Levels) (Syngenetic Fe-Cu-Pb-Zn Mineralisation)

_____ *KALET CHHU-LEGSHIP THRUST* _____

DALING GROUP

Reyang Sub-group

Buxa Subgroup Gondwana Group

Gorubathan Subgroup

PAJOK THRUST

A Zone of pile of thin scales of Daling Group (Gorubathan-Reyang-Buxa Subgroups) and Gondwana Group (Rangit Pebble Slate - Damuda Formations)

NORTH TATAPANI THRUST

GONDWANA GROUP

2. Damuda Formation

1. Rangit Pebble Slate

DALING GROUP

3. Buxa Subgroup

2. Reyang Subgroup

1. Gorubathan Subgroup

NAYA BAZAR THRUST

A Zone of Pile of thin Scales of Daling Group (Gorubathan-Reyang-Buxa Subgroups) and Gondwana Group (Rangit Pebble Slate -Damuda Formations)

KITAM-MANPUR KHOLA THRUST

DALING GROUP

2. Reyang Sub-group

1. Gorubathan Subgroup

SIM JHORA THRUST

DALING GROUP

Gorubathan Sub-group (With Lingtse Granite Sheets)

NORTH DARJEELING (BARNESBERG-BADAMTAM) THRUST

SIKKIM GROUP

Chhungthang Sub-group, Darjeeling Gneiss, Khangchendzonga Gneiss

(? Middle CenozoicPegmatite Aplite Formation and small Granite Bodies)

SOUTH DARJEELING THRUST

DALING GROUP

Gorubathan Sub-group (Intruded, Metasomatically Replaced and Technically Emplaced Lingtse Granite) (Syngenetic Fe-Cu-Pb-Zn Mineralisation)

DEORALI-RONGCHONGTHRUST

DALING GROUP

2. Reyang Sub-group (with slices of Gorubathan Subgroup)

1. Gorubathan Sub-group (with slices of Rangit Pebble Slate and Damuda Formation in Basal Portion)

_____ *DALING THRUST* _____

GONDWANA GROUP

2. Damuda Formation

1. Rangit Pebble Slate (Slices of Daling Group)

_____ *TINDHARIA THRUST*_____

GONDWANA GROUP

Damuda Formation

_____ *MAIN BOUNDARY THRUST (SOLE OF NAPPE)*_____

SIWALIK GROUP

2. Geabdat Formation

1. Chhunabhatti Formation (Intermixed with Damuda Slices in Rangtong Thrust)

_____ *RANGTONG (IMBRICATE) THRUST* _____

SIWALIK GROUP

3. Murti Boulder Bed

2. Parbu Grit

1. Geabdat Formation

_____ *UNCONFORMITY/FAULT* _____

QUATERNARY GROUP

Alluvium Terrace Boulder Beds

SOUTH

For the study of geological layout of the Rayeng Basin a geological map of Darjeeling – Sikkim Himalaya has been collected from the geological survey of India, Gangtok, Sikkim. The map was compiled by Dr. S.K. Acharyya & K.K. Ray (1989). The sources of compiled map are map of M.B. Pawde, V.K. Raima, Pushkar Singh, Dr. Acharyya, Dr.S.Sinha Roy, K.K.Ray, S.S.Saha, U.Bhattacharya and B.S.C. Pathak (1989). Based on the above mentioned geological map the geological layout (Figure 2.4) of the Rayeng basin has been described as follows (Table 2.1):

Straticgraphic aspects

Darjeeling gneiss

According to Acharyya and Ray (1989), Darjeeling group primarily consists of gneiss. In the source area of Rayeng River i.e., Chattakpur Forest, Upper Mamring Khasmahal of

Kurseong C.D block mainly Darjeeling Gneiss is found. Darjeeling Gneiss is mainly found in the higher reaches of the Darjeeling hill areas. The Darjeeling gneiss is gradually grade into more metamorphism and highly foliated. The Darjeeling gneiss in general is a magmatic banded gneiss containing enclaves of high grade schist. The schist erodes relatively easily.

Kanchenjungha augen gneiss

This rock is belonging to gneiss group. It is also highly foliated due to metamorphism. In the source area of Rambi River i.e., in Senegal forest area of Rangli Rangliot C.D Block, Kanchenjungha Augen Gneiss is found. Orthogranitic Khangchendzonga gneisses (part of the Darjeeling series) are structurally in contact with limestones.

Damuda formation

In Damuda formation coarse-grained hard Sandstone, quartzite, Carbonaceous Shale and Slates are basically found. In the Rayeng Basin this formation is found at the source area of Rayeng River, Pubong Khasmahal of Rangli-Rangliot C.D Block.

Paro sub-group

This sub-group is belonging to Sikkim group. According to Acharyya and Ray (1989) rocks of the paro sub-group have characteristics similar to the Darjeeling group. A large portion of the basin is underlain by Paro subgroup formation. In the Pubang Khasmahal, Rangli Rangliot Tea Garden, Resop Bazar and Labda Khasmahal of Rangli Rangliot C.D Block and Lower Mamring Khasmahal and Toryak Khasmahal villages of Kurseong C.D Block this formation is found. There is a narrow sinuous strip of quartzite key beds in this group.

Lingtse granite gneiss

A narrow sinuous strip of lignite granite gneiss is found just below the paro sub-group formation.

Feldspathic greywacke marble

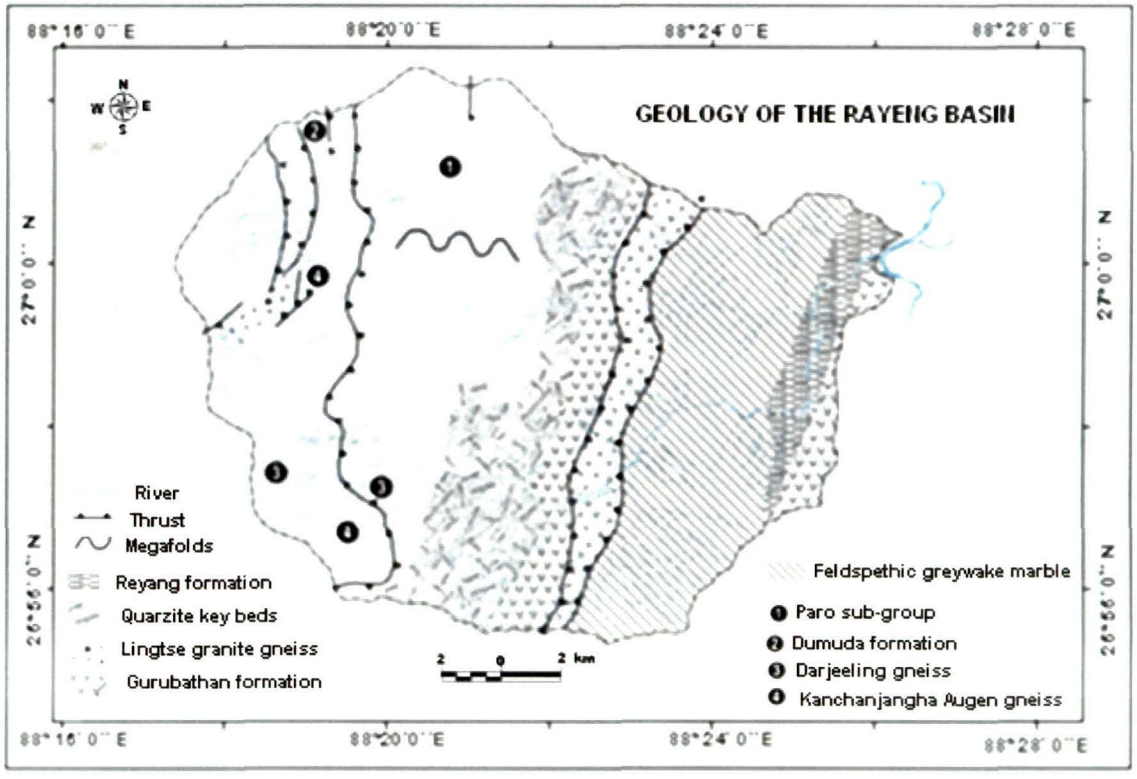
In the downstream area of Raying Basin a significant portion is composed of feldspathic greywacke marble. This is found in some villages of Rangli Rangliot and Kurseong C.D blocks. Feldspathic greywacke marble is belonging to Daling group of formation. Felds pathic Greywacke marble is low grade metamorphosed rock.

Reyang formation

It is belonging to Daling sub-group of formation. In the downstream of Rayeng River just below the feldspathic greywacke marble Reyang formation is found. It is found mainly at the northeastern part of Kurseong C.D Block.

Gorubathan formation

This is also belonging to Daling group of formation. Gorubathan formation is found near the confluence of Rayeng River with Tista River. It is found in some villages of Kurseong sub-division.



Source: GSI, Gangtok.

Figure 2.4 Geological Map of the basin.

Greywacke

It is immature, poorly stored, coarse-grained sandstone in which fairly angular particles of lithic fragments are embedded in matrix of finer material, generally argillaceous. They are typically marine, deposited in an environment in which erosion, transportation, deposition and burial were rapid to preclude complete weathering.Greywackes are remarkable for a large of sedimentary structure which they display.

Stratigraphic aspects

Foliation and schistocity

Foliation is one of the important attributes of some metamorphic rocks in their tendency to split into thin laminae or sheets caused by parallel arrangement of platy, layered or planar minerals. Schistosity is a well defined foliation caused by platy or elongated particles, usually micas, arranged in a parallel to subparallel manner, along which a coarse grained crystalline rock tends to cleave. This structure is caused by stresses due to regional

metamorphism. Layering or bending in metamorphosed rocks is a succession of parallel tabular units, like layer and strips, differing in mineralogy or texture. It is sometimes depictive as it may resemble bending in sedimentary rocks. Gneissic foliation is a widely-spaced, less marked and generally irregular and discontinuous foliation or layering of coarse- grained metamorphic rocks into alternating silica of small aggregates of platy or elongated minerals. In the Darjeeling gneiss and Kanchenjangha Augen gneiss formation many foliation and schistosity are occurred. Lineament and striping are also found in the feldspathic greywacke marble formation.

Cleavage

This is a feature of metamorphic rocks whereby it breaks or fractures into very closely spaced, often parallel, planes at right angles to the direction of compression. It should not be confused with bedding whose vestige is sometimes retained by low-grade sedimentary rocks. Cleavage plane is the surface of fracture along which it splits preferentially. Slaty cleavage develops by parallel arrangement of partially recrystallised platy minerals in fine grained rocks due to intense formation; it does not destroy all traces of bedding. Axial plane cleavage is slaty cleavage that is parallel to the axial plane of a fold, generally a minor one. Fan cleavage is a type of axial plane cleavage in which cleavage plane are not parallel but fan out at different angles on each side of the axial plane of a fold. Flow cleavage results from solid state flowage accompanied by regrowth of minerals in which traces of bedding are almost destroyed. Further recrystallisation may result. Slip or shear cleavage occurs closely but finely spaced sub parallel cleavage supposed on slaty cleavage or schistosity along which slip has taken place. Fractured cleavage is a series of cleavage fractures or joints along which no slip has taken place in very slightly metamorphosed deformed rocks. It affects incompetent layers occurring in a succession of beds of varying degrees of competency. Strain-slip or crenulations cleavage is a later cleavage superimposed on a previous salty cleavage by further deformation. Cleavage is also found in this basin.

Mega fold and warp

Mega folds and warps of third and fourth generation are found in Kanchenjangha gneiss formation.

Fault

In the Feldspathic Greywacke formation on left bank Rayeng a fault line is found denoting the occurrence of faulting process.

Table 2.1 Geology of the Rayeng Basin at a glance.

Location	Rock type	Structural factors
(A) C.D Block Rangli-Rangliot:		
1. Pubong Khasmahal	Damuda group, Rangit Pebble slate	Foliation, schistosity
2. Rangli Rangliot Tea garden.	Paro sub-group	Mega fold, warps of forth & fifth generation
3. Mongpu Tea garden.	Rangit Pebble, Slate	Cleavage, fracture
4. Reshop Bazer	Paro sub-group	
5. Labda Khasmahal	Paro sub-group	Lineaments, puccer
6. Mangpu Cinchona plantation	Graphite, schist, gneiss	Striping
7. Rong Chong khasmahal	Gorubathan formation , feldspathic greywacke marble	Cleavage, fracture
(B) C.D Block Kurseong:		
1. Chattakpur Forest	Darjeeling gneiss	Lineaments, puccer
2. Upper Mamring Khasmahal	Darjeeling gneiss	Stripping
3. Lower Mamring Khasmahal	Paro sub-group	Lineaments, puccer
4. Toryak Khasmahal	Paro sub-group	Lineaments, puccer
5. Sittong Khasmahal	Lingtse granite, gneiss	Cleavage, fracture
6. Barasit Tong Khasmahal	Gorubathan formation, feldspathic greywacke marble	Cleavage, fracture, striping
7. Mangpu Cinchona plantation	Graphite schist, gneiss	Cleavage, fracture
8. Selpu Khasmahal	Lingtse granite, gneiss	Cleavage, fracture
9. Rolak Khasmahal	Gorubathan formation, feldspathic greywacke marble	Cleavage, fracture
10. Lonku Khasmahal	Gorubathan formation feldspathic greywacke marble	Cleavage, fracture
C.D Block Kalimpong		
1. Riyong Forest	Reyang formation, Quartz key beds	Cleavage, fracture
2. Turzam Forest	Gorubathan formation Feldspathic greywacke marble	Cleavage, fracture
3. Rambi Bazar	Reyang formation, Quartz key beds	Foliation, schistosity

4. D.I.F. Riayang Railway Station	Reyang formation ;quartz key beds	Lineaments, puccer
5. Birik Forest	Reyang formation ;quartz key beds	Faulting
6. Suntalay Khasmahal	Reyang formation ;quartz key beds	Faulting

Source: Geological map of Darjeeling-Sikkim Himalaya- by Dr. S.K, Acharyya & K.K. Ray (1989).

Discussion

Discussion on geology of the Rayeng Basin concludes that the basin is formed of rocks of different formations and geological ages. Due to various geological formations the morphological features in the basin area vary in magnitude and dimension. Bare rocky steep scaps, rugged topography, deep river valleys have produced by the stream of this basin on account of Stratigraphic variation. This basin has been affected by Himalayan orogeny.

2.2 Soil of the study area

The underlying geological structure is one of the most dominating factors for the development of soil of the study area. Moreover, it has been developed by both fluvial action and lithological disintegration. Due to the existence of phyllite and schist in the source region of the Rayeng and Rambi River occasional dark soils are found. Soil of the lower reaches of the basin is composed of alluvium. In this portion sandy loam is most common. There are also considerable tracts of sandy and gravelly soils. While in the hilly tract the soil are white, red and black. In the greater portion of the basin soils are reddish loam due to excessive leaching. Interfluvial areas of the basin are mainly composed of mixed sandy loam soil. Sandy loam soils are found in the east of the River Tista. All the soils of the basin are basically acidic in nature with the tendency to increase slightly with depth. In most cases they leach from surface and accumulation in the lower horizons. Soils of the basin suffer from deficiency of lime. The soils near the river at the confluence are sandy and gradually turn to deep loam to the interior part. Different thickness of the regolith and soils depend on the rate of weathering along the longitudinal slope profiles and intensity of mass movements.

Reddish soils have been developed on gneiss while brownish on schist and shale. Clayey dark soils are developed on Daling series. The character of bed rock is reflected only in the grain size composition of the soil. On Darjeeling gneiss, very fine particles (50% - 80%) are found. In Damuda and Daling series percentage of sandy and coarse particles are higher. The soil over the Darjeeling gneiss is characterized by high potassium derived

from feldspar and muscovite mica. The soils of the entire basin are poor in lime, magnesium, iron oxides, phosphorous. Therefore lime is used in soil for tea cultivation. The soils of the basin are not suitable for food crops but different dry crops and fodders are cultivated.

2.3 Climate of the study area

W.D Thornbury (1954) stated that "an appreciation of world climates is necessary for a proper understanding of the varying importance of the different geomorphic processes". Geomorphic processes are influenced by climate of the concerned region. Specially the two elements of climate i.e., temperature and rainfall influence the operation of geomorphic processes. In the study area high rainfall in the monsoon season provides energy for streams and rivers to operate their geomorphic processes. The erosional activities of the river and streams of this basin are vigorous in the rainy season. Characteristics and the distribution of vegetation of the area are highly controlled by the temperature and rainfall of the basin. One of significant natural causes of landslides and soil erosion of the basin area is heavy downpour in monsoon season. The Rayeng Basin situated in Darjeeling hill area characterized by temperate climate. The climate of the mountain basin is highly dominated by altitudinal factor of relief. This basin enjoys heavy seasonal rainfall mainly the orographic rainfall. The temperature of the basin declines with increasing elevation. Thus, significant variation in temperature is found between the foot hill area and the hill tops. Annual temperature fluctuates from 24° C in foot hill area and drops to12° C on the ridges. During the summer month the temperature reaches 16°-17° C on the ridges and during winter it drops to 5°-6°C.The average annual rainfall is about 300cm with an average of 126 rainydays in a year. The highest rainfall generally occurs in the month of July. This basin experiences the following seasons:

Summer (April to June): This is the hot season with an average temperature at the foot hill area is 27° C. While temperature decreases with increasing altitude. In this season weather is generally hot and dry. High temperature and low humidity are the chief characteristics of this season Thus it is also known as hot weather season hot and dry summer season. This season is also referred as premonsoon season.

Monsoons (July to August): This is the season of heavy rainfall. Significant amount of rainfall is recorded in this season. In this season temperature slightly decreases than the dry and hot summer due heavy rainfall. Average monthly rainfall in this season exceeds 600mm.The Rivers and streams of the Rayeng Basin reach the nearby bankfull stage. The amount of discharge of the streams and rivers increases drastically. The river banks are

flooded and huge sediments are carried by streams. Erosional activates of the streams are vigorous in this season. Landslides frequently occur in this season.

Autumn (September to November): This is accompanied with intermittent showers and temperature starts declining. In the month of September average rainfall is more than 200mm. From the month of September both temperature and rainfall starts decreasing. In the month of November temperature is sharply declined.

Winter (December to January): This the cool season with low temperature and low relative humidity. In this season occurrence of rainfall is very low. In the higher altitude temperature ranges between 5° C to 7° C. Mists and fogs frequently occur in this season. In this season, discharge of the streams gets drastically reduce and depositional environment is produced.

Spring (February to March): In this season temperature increases but the relative humidity is low. Thus, it is the dry season with mild temperature. In this season streams suffer from paucity of water. The records of rainfalls of the darjjeling district are given below(Table 2.2 & 2.3). The meteorological data particularly for the basin is not avaiable. Thus, data of the Darjeeling district is given.

Table 2.2 Year-wise average monthly rainfall in mm.

Year & Month	Jan.	Feb.	Mar.	Apr.	May.	Ju.	Jul.	Au.	Sep.	Oct.	Nov.	Dec.
2008	19.5	2.9	48.9	66.9	191.8	915.0	738.5	875.4	292.2	137.8	175	00
2009	00	00	12.9	147	398.4	350.4	765.2	759.8	265.8	307.3	.5	1.8
2010	00	3.4	6.8	73.3	304.3	635.4	981.4	913.7	468.7	136.3	15.20	00

Source: Hydrometric Division of India, Meteorological Department.

Table 2.3 Mean monthly temperature, monthly average rainfall & potential evapotranspiration of the Rayeng basin 2009.

Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Au	Sep	Oct	Nov	Dec
Temperature.	°C	9.40	10.40	14.40	17.40	18.50	19.30	19.40	19.60	19.20	18.00	14.70	11.5
	°F	48.90	50.70	57.90	63.30	65.30	66.70	66.90	67.30	66.60	64.00	58.50	60.77
Rainfall (mm)		00	00	12.90	147.00	398.40	350.40	765.20	759.80	265.80	307.30	0.500	1.80
Potential Evapotranspiration (mm)		177.89	196.84	272.63	347.77	370.00	387.77	384.44	395.55	384.44	355.00	294.44	319.66

Source: Hydrometric Division of India, Meteorological Department.

Chacteristics of temperature

There is significant variation (Figure 2.5) in seasonal temperature in the basin area. There is a remarkable variation in temperature of lower valley area and the higher altitudinal area of the basin.

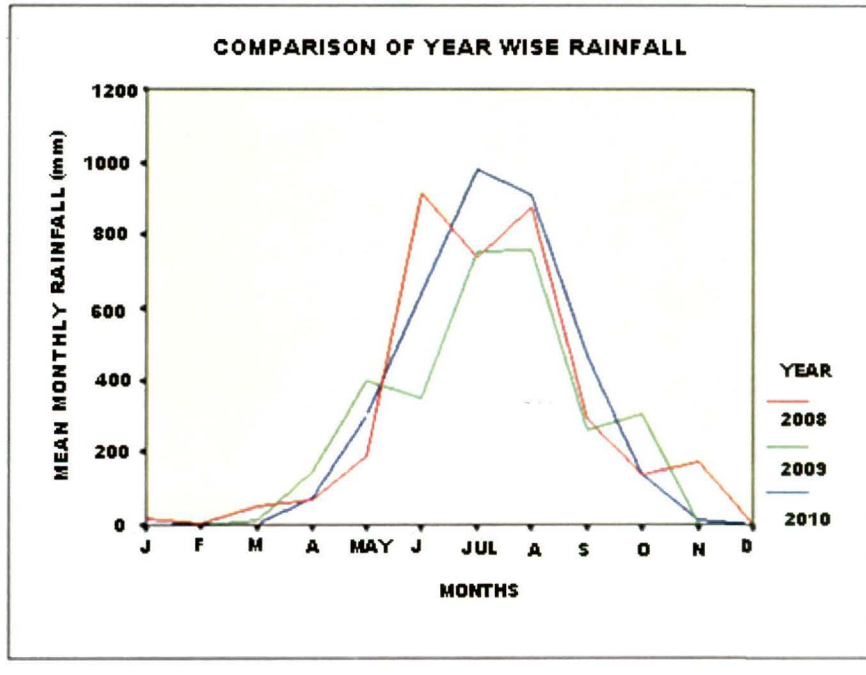
Characteristicss of rainfall

Rainfall of the Darjeeling districts including the Rayeng Basin is highly concentrated in the month of May to August. The amount of rainfall slightly variers from year to year (Figure 2.6). Huge amount of orographic rainfall by the southeast monsoon is received by this basin. From the month of November to April, the hilly area including the Rayeng Basin of the Darjeeling district gets very low amount of rainfall.

Water Budget

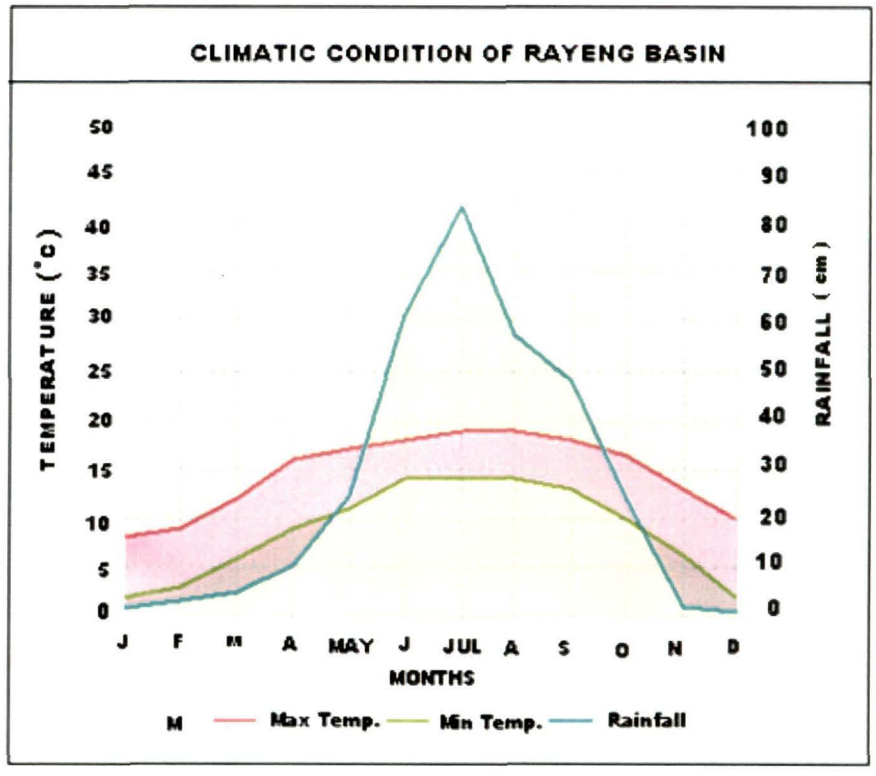
Water budget of the basin area denotes that from the month of July to September soil water is surplus as the amount of rainfall excedes the amount of evapotranspiration (Figure 2.7). On the other hand deficiency of soil water is found from the month of November to April as the amount of evapotranspiration excedes the amount of rainnfall.

From the overall study of climatic condition of the study area it is revealed that in the basin area erosive activity of the streams are vigorous in the monsoon season as huge amount of water received by the basin. On the other hand in non-monsoon season due to lack of water discharge is reduced. Thus transporting capacity of the streams is reduced.



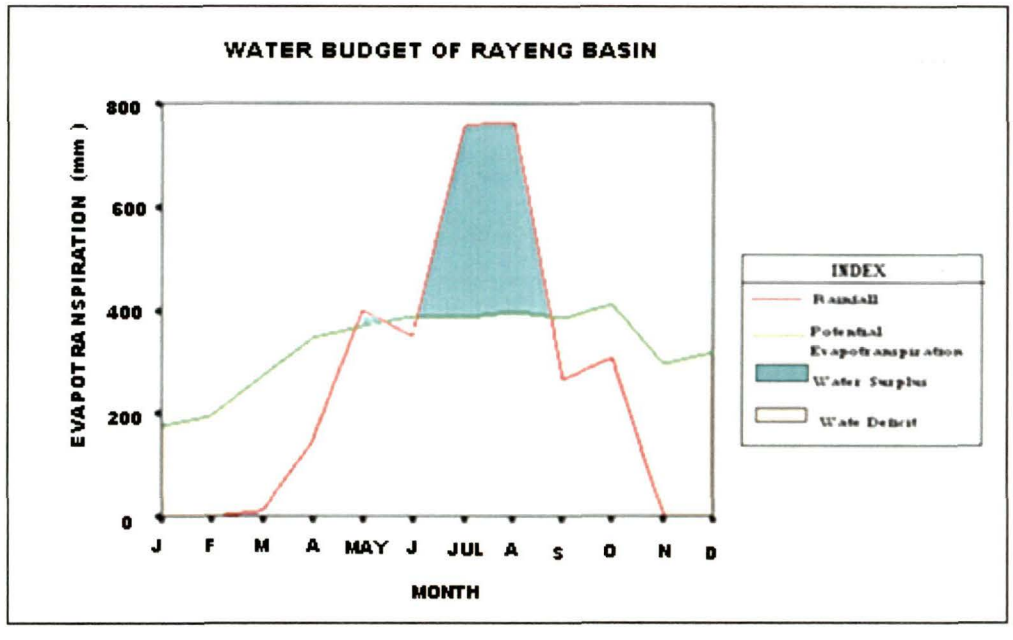
Based on meteorological data of Darjeeling District.

Figrue 2.5 Comparison of year-wise rainfall of the study area.



Based on meteorological data of Darjeeling District (2009).

Figrue 2.6 Comparison of month-wise temperature & Rainfall of the study area.



Based on meteorological data of Darjeeling District(2009).

Figrue 2.7 Water budget of the study area.

2.4 Vegetation of the study area

Vegetation means the assemblage of plant species living in association with each other in a given environmental frame often termed ecological frame. The term flora refers to plants of a particular region or period listed by species and considered as a group. The term forest is generally used to denote a large tract of land covered by trees and shrubs. In the Rayeng basin plant species variety is influenced both by climatic condition and altitude. The study area experiences hot and humid summer and dry and cool winter season. High rainfall and high temperature of the study area is favorable for luxuriant growth of tropical semi evergreen vegetation (Figure 2.8 & plate 2.3). Three major forest types according to altitudinal variation found in the Rayeng basin, viz:

1. Tropical moist deciduous forest below (1000m).
2. Temperate evergreen lower montane vegetation (1000m – 2000m).
3. Temperate evergreen upper montane vegetation (above 2000m).

1. Tropical moist deciduous forest below (1000m)

In the Rayeng Basin this variety is found mainly at the altitudinal zone of elevation less than 1000m. Heavy monsoon rainfall (> 150 cm) and high temperature (> 27°C) in summer and dry winter have encouraged the growth of moist deciduous variety. Such variety attaining average height between 30m to 40m and shedding leaves during spring and early summer (March to April). This vegetation is found in the Selpu Khashmahal, Sittong Khashmahal, and Barasitong Khashmahal of Kurseong C.D Block and Rongchong Khashmahal of Rangli Rangliot C.D Block. The notable trees of this variety are Shisham (Dalbergia Sissoo), Adinacordifolia, Callicarpa arborea, Schima Wallichii, Gmelia Arborea, Duabanga grandiflora, Alangium chinensis, Terminalia alata etc. A vast area of this vegetation has been cleared owing to interference of human activities.

2. Tropical evergreen lower montane vegetation (1000 m – 2000 m)

At the altitudinal zone of 1000m to 2000m of the Rayeng Basin, tropical evergreen vegetation is found. In this altitudinal zone average annual rainfall ranges between 200cm and 250 cm and mean annual temperature lies between 24°C and 27°C and humidity of 80%. This vegetation is characterized by evergreen trees mixed with deciduous having typical features like less dense canopy, Gregariousness, frequent buttressed trunks, thicker and rougher barks and heavy climbers. Although bamboos are less abundant but epiphytes are present in large number. Notable plant varieties include Aini, Semul, Gutel, Mundane, Hupea, Benteak, Irul, Laurel, Bomsum etc. This variety found at Labda Khasmahal, Reshop Bazar, and Dubong Khasmahal of Rangli Rangliot C.D Block.

VEGETATION SCENARIO OF THE RAYENG BASIN

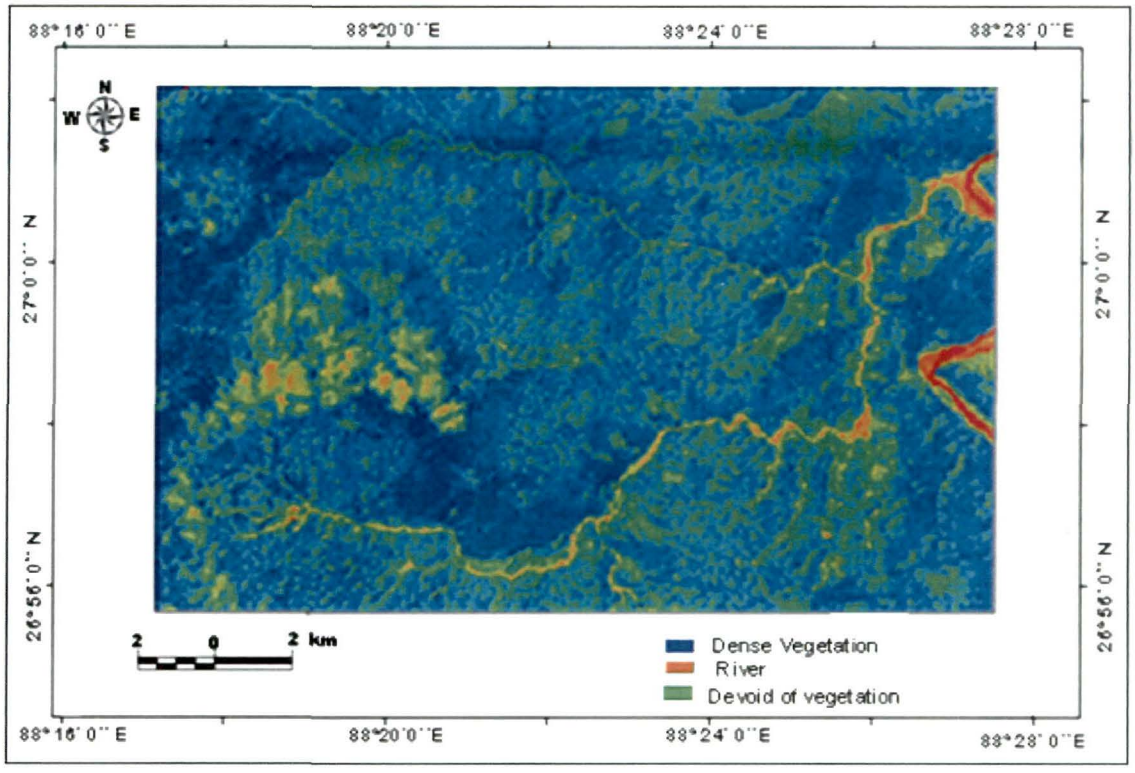


Figure 2.8 Normalized differentiated Vegetation Index (band 4-3).

2. Temperate evergreen upper montane vegetation (above 2000m)

At the source region of Rayeng and Rambi River where the elevation is above 200m, mainly temperate evergreen upper montane forest is found. In this part average annual rainfall is more than 200cm and mean annual temperature below 20°C. Height of the tree ranges between 15 to 18m having much undergrowth and many epiphytes, mosses and ferns. Magnolia, Iaurel, Rhododendron, Elm (ulmus) etc are common trees, Cinchona has been introduced from outside.

Status of the forests

In the Raying Basin many forests are situated namely, Takdah Reserve forest, Senchel forest, Chattakpur forest, Bhalukhop forest, Birik forest and Riyong forest (plate 2.4).

Takdah Reserve forest

Takdah Reserve forest chiefly comprises Dubong Kashmahal of Rangli Rangliot C.D block. In this forest mostly temperate evergreen variety of plants are found.

VEGETATION COVERS OF THE RAYENG BASIN

Figure 2.9 Satellite view of vegetal cover of Rayeng Basin.

Status of the forests

In the Raying Basin many forests are situated namely, Takdah Reserve forest, Senchel forest, Chattakpur forest, Bhalukhop forest, Birik forest and Riyong forest.

Takdah Reserve forest

Takdah Reserve forest chiefly comprises Dubong Kashmahal of Rangli Rangliot C.D block. In this forest mostly temperate evergreen variety of plants are found.

Senchel forest

This forest comprises northern part of Reshop Bazar, Labda Khasmahal of Rangli Rangliot C.D block. In this forest area temperate evergreen variety is mainly found.

Chattakpur forest

This forest is located at Chattakpur village and upper Mamring Khasmahal of Kurseong C.D block. This is a tropical moist evergreen forest.

Bhalukhop and Birik forest

These forests cover Bhalukhop and Birik which are situated in northwestern part of Kalimpong-I, C.D Block. These forests are enriched with tropical evergreen variety.

Riyong forest

This forest is situated in left bank of Rayeng River near the confluence between Rayeng and Tista.

Cinchona plantation

Cinchona is the most spectacular plantation of the study area. The area between Rayeng and Rambi River is occupied by cinchona plantation. It is mainly found in the Mangpu area. This medicinal plant is being considered as a commercial plantation. Many of people of this basin are dependent on this plantation for their livelihood.

Conclusion

Form the entire discussion it is found that on the upper reaches of the basin dense vegetal covers are existed but in lower elevation of the basin vegetal covers have been removed due to encroachment of human settlement, practice of agriculture, establishment of tea garden. In the steep slope areas where vulnerability of landslide is severe, the vegetal covers have been destroyed due to landslide. The vegetal covers of the Rayeng Basin have an important influence on the basin hydrological cycle and drainage system. The ecological balance of the basin has been partly disturbed due to declining of the forest covered areas in the basin.

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