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Physical Aspects of The Kalimpong District, Darjeeling Himalaya: Understanding From A Geographical Perspective

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ABSTRACT: *Geographically, the Kalimpong District in Darjeeling Himalaya is that pocket that exists in vicinity of Nepal, Darjeeling, Bhutan and its foothill Duars, Sikkim and transnational Teesta River. A mountain environment has some unique characteristics, as it constitutes high and sloping lands, low laying valleys, forests and vegetations of various types as well as riverbeds and meadows. The altitudinal range of this hilly region varies from 130 to 3000 m. Due to their great variation, a wide array of climatic zones are available, which favor the luxuriant growth of diversified and rich vegetation. These unique features of mountain environments tend to be quite sensitive to disturbance and disruption by external factors. With ever-growing population, human interference have increased to such a level that it has adversely altered the integrity and balance of the natural system.*

KEYWORDS: *Geological formations, Kalimpong District, Landuse/ Land cover, Physical environment, Tourist centres.*

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I. INTRODUCTION

Until the mid-19th century, the Sikkimese and Bhutanese kingdoms ruled the area around Kalimpong intermittently. The indigenous Lepcha community and migrant Bhutia and Limbu tribes populated the area. The British East India Company controlled the Kalimpong area from 1865 following the Anglo-Bhutan War. The temperate climate of Kalimpong town led to the town being developed as a hill station, much like Darjeeling. It was also an important trading outpost between China and India because of its proximity to the Nathula and Jelepla passes into Tibet. From the late 1800's migration from Nepal led to a significant increase in the population of the Kalimpong area. Following independence in 1947, Kalimpong became part of the state of West Bengal. (Bengal District Gazetteers, Darjeeling, 2001). Now, from 14February, 2017, Kalimpong became the 21st district of West Bengal.

II. GEOLOGY

The study area is a part of extra peninsula, made up of rocks of ages ranging from pre-Cambrian to Quaternary. Three distinct geological formations are found in the region, which are as follows: 1. The Siwalik, 2. The Damudas and 3. The Daling - Darjeeling Gneiss. The outcrops of these form a series of bands, running parallel to the general trend of the Himalayas and dipping one beneath the other into the hills. The most curious feature of these subdivisions is that the younger formations always appear to underlie the older thus the Tertiary beds disappear under the Gondwanas, the Gondwanas under the Daling series, and the latter under the gneiss, the original order of superposition having been completely reversed by folding and faulting.

<u>Stratigraphic description:</u>

A brief description of the various formation of the study area is given below. The general geology of the area shows that the tectonic units occur in a reverse order of stratigraphic superposition represented by the Siwalik in the south followed towards north by trusted sheets of Gondowana, Daling and Darjeeling group of rocks (Figure 1). Different geological formations of the surrounding area as have been identified different experts such as Mallet, 1874; Auden, 1936; Gansser, 1964; Singh, 1971; Jangpangi, 1972; Lahiri and Gangopadhyay, 1974; Wadia, 1975; Directorate of forest, 1976 and Powde, 1982 can be summarized as follows (Table I):

Table No I. Stratigraphic sequence of Kalimpong District, Darjeeling Himalaya.

GEOLOGICAL PERIODS Age of beginning (Million year)	**SERIES (Nature of Formations)**	**LITHOLOGICAL CHARACTER**
Precambrian (3787 ± 85)	Darjeeling Gneiss	Golden and silvery mica schist, Quartzite, Carbonaceous mica-schists, garnetifeous mica-schists and coarse-grained gneiss.
	Daling Group (Sedimentary in origin and highly metamorphosed)	Slates, Phyllites and quartzites, Sericite-Chlorite Schist with bands of gritty schist injected with gneiss.
-------------------------------	----Thrust fault of nappe outlier----	---------------------------------------
Permian (280)	Damuda Series, Lower Gondwana (Sedimentary in origin with coal seams & few metamorphisms)	Hard and soft sandstones, shale & slates, Limestone and Semi anthracitic coal with basic intrusive.
--	Thrust (Main Boundary Fault)	
Pliocene to Lower Pleistocene (26)	Siwalik Group (Sedimentary in origin)	Shale, clays and Sandstones (gray in color), Conglomerates and silts with bands of limestone.
--------------------------------------	-- Himalaya Front Tectonic Line --	---

I.1 Daling-Darjeeling Group:

The Daling series and the Darjeeling gneiss of the surrounding area are the parts of the Daling and the Darjeeling series of Sikkim Dharwar. It should be worth mentioning that formerly the Darjeeling series was regarded as an older series over – trusted on the Daling. However, it has now been accepted that the apparently higher grade of the metamorphism of the Darjeeling group (which seems older) is not due to greater age, but due to interlaminated granite of a later date. Thus, the term Dalings and Darjeeling can be applied respectively lower and upper portion of a great sedimentary succeeding, the upper part of which has been injected and metamorphosed by granite magma under stress.

The Daling-Darjeeling group is remarkable in Himalayan Geology for their constant development and the monotonous lithology over a great thickness. They are a characteristic representative of the late Precambrian to early Precambrian argillaceous sequence exposed in far western Lower Himalaya and an important litho stratigraphic unit in Darjeeling Himalaya. The Dalings are well exposed all along the lower and middle course of Teesta River.

I.1.1The Darjeeling Gneiss:

It consist of garnetiferous mica schist, quartzite and biotite – kyanite and sillimanite gneiss. The gneiss is well – foliated, much folded and crumpted. It is highly micaceous and is composed of colorless and gray quartz, white opaque feldspar, muscovite and biotite. It varies in texture from a fine grained to moderately coarse rock. The Darjeeling gneiss dips in between angles of 35° to 45° towards North West.

I.1.2 The Daling Series:

The Daling comprise mica-schist, greenish fissile slate and Phyllite with bands of quartzite. The most impressive feature is the progressively higher grade of metamorphism of the Daling upwards. The surface exposure is bounded by the Darjeeling Gneiss to the north and by the rocks of the Damuda series to the south. Along river basins deposits of recent alluvium is found. The dip of the rock beds ranges from 30° to 80° towards mainly north and northeast. The rocks of the Daling series and Darjeeling gneiss are overlain by the rocks of Permian age along a thrust.

I.2 Gondwana Group:

During upper and middle Permian, the rocks of Lower Gondowana formation of Damuda series were deposited which constitute a narrow belt being sandwiched in between the Daling series on the north and Siwalicks of Tertiary on the south.

Along Teesta river section, Gondwana Group of rocks are exposed in a narrow strip of about a kilometer, north of Main Boundary Fault extending either side along the general strike varying between NE-SW and E-W. All along the foothills of Darjeeling district, south of Sikkim, the Siwaliks are steeply over thrust by formations belonging to Damudas (Lower Gondwana). The thrust zone is generally badly exposed, but judging from the unconnected outcrops along the Teesta River, the thrust planes are dipping at 60-70 degrees towards the north. This thrust zone coincides with the well-known Main Boundary fault, which extends for the whole distance along the Himalayan Range. The Damudas are characteristic coal bearing rocks, their fossil flora indicating a lower Gondwana (Permo- Carboniferous) age. A few outcrops of Gondwanas are also found as infolded imbricate slices within the Daling in some of the stream sections in Kalimpong Sub division, Darjeeling district.

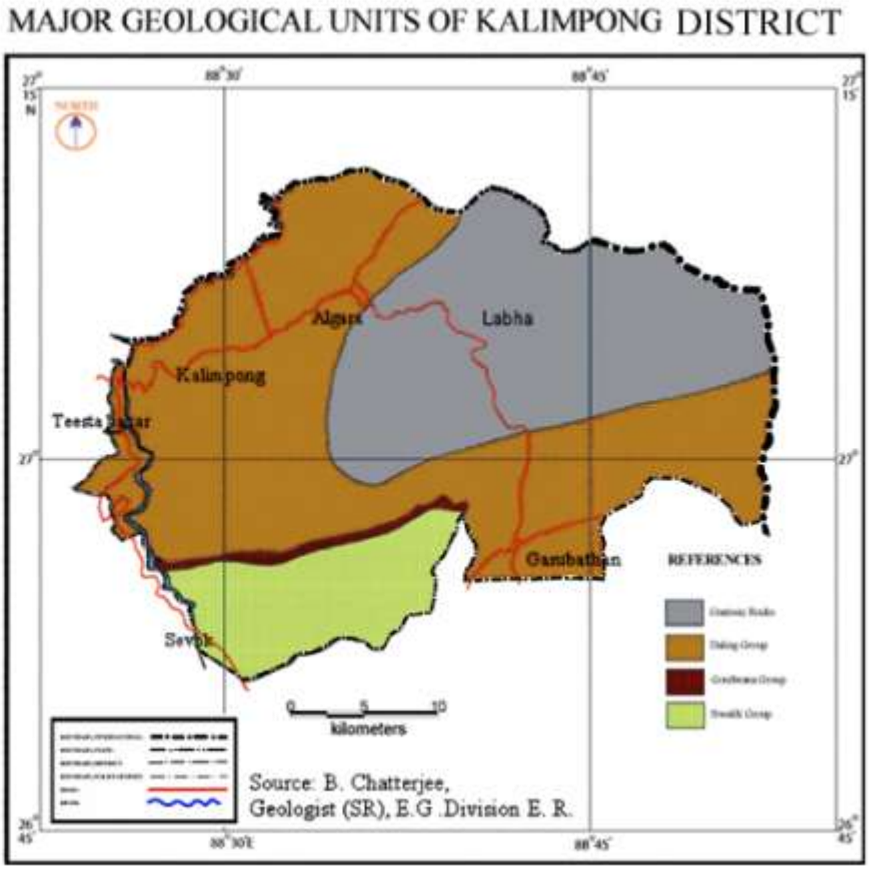


Figure 1: *Geological map of Kalimpong District.*

I.3 Siwalik Group:

The Darjeeling Sub Himalayas and the foothill belt are mainly constituted of Siwalik and younger group of rocks, varying in age from middle Miocene to Lower Pleistocene. Extending from Nepal border in the West, the Siwaliks are exposed in a narrow strip of hill range as far as 20 kilometers east of Teesta River. Good Siwallik exposures are met with along the Teesta River. The deepest outcrops forming the southern margin of the Siwalik Hills consist of bluish grey nodular marls and clays with micaceous fine grained sandstones over a distance of about 6 kilometers up to near Kalijhora along National highway 31A. ge from Pliocene to Pleistocene and dip ranges from 40° to 70° north – northeasterly.

III. PHYSIOGRAPHY

Physiographically the Kalimpong district in Darjeeling Himalaya is highly complex with innumerable variety of micro and macro relief forms. The Kalimpong hills are rather rugged with radials descending gullies and streams contributing to the Teesta and Jaldhaka Basins. The landform of the study area represents mega folded, faulted, trusted and later dissected by system of consequent and subsequent river courses. Due to the presence of tectonic lineaments and lithological heterogeneity, with approaching maturity of dissection, the region has attained a very high degree of relief. Simultaneous rejuvenation along with the operating erosion cycle has rendered the river vigorously aggrading in nature. In the process, a micro relief of parallel ridges and valleys has been etched out over the whole region. Relief map of Kalimpong District (Fig. 2) indicates that north-eastern portion of the study area is rugged where elevation is greater than 2000 metres. The elevation of southern and western portion is less than 400 metres and the elevation of the remaining part ranges between 400 to 2000 metres.

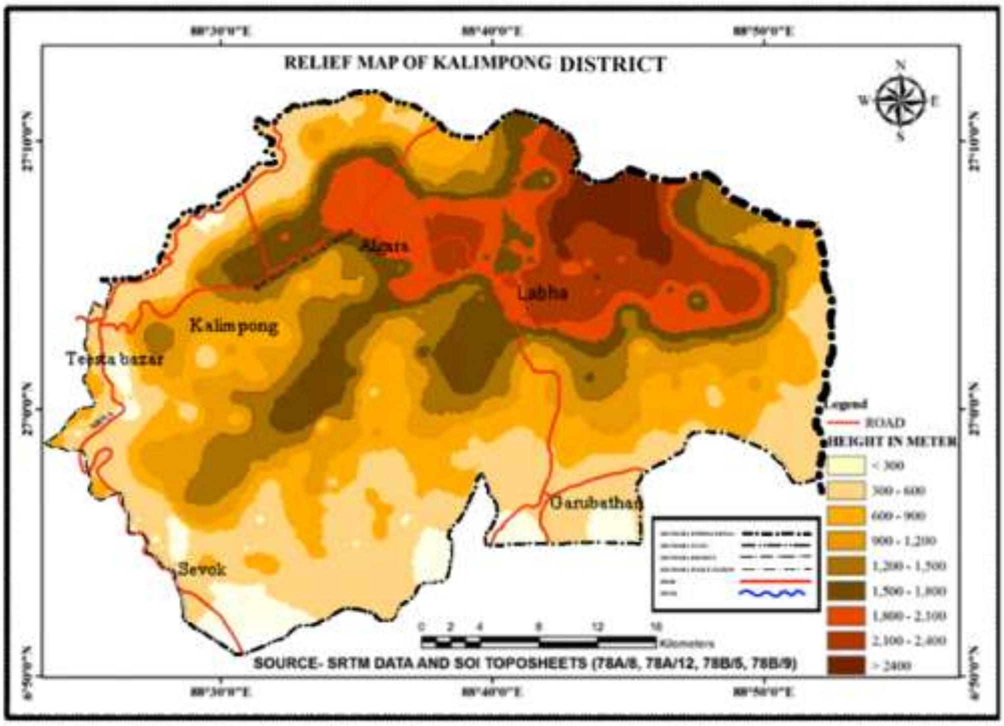


Figure 2. Relief map of Kalimpong District.

However the study area may be broadly divided into two regions. These are the valley regions (below 400 m.) and the mountain region (above 1000 m). It may be noted here that the mountain region can classify into three zones, these are low mountain zone(less than 1000 m), Medium Mountain zone (between 1000 m to 2000 m) and high mountain zone (above 2000 m to 3000 m).Therefore four major broad physiographic division of Kalimpong District are describe below,

i) One of the major physiographic divisions is valley region that is Teesta valley region which is found along the river Teesta, the main river of the study area from north to south direction. South-eastern part of the study area that is Chal valley region, also a part of the valley region.

ii) Another physiographic division is Low mountain region (less than 1000 m), which is found in the western and south-eastern portion of the study area in an around the valley region, that is Teesta and Chal river valley.

iii) The physiographic division of middle-mountain (1000 – 2000 m) are located in Kalimpong town and the Algara region. So that the whole northern part of the study area is a part of middle-mountain zone.

iv) The high-mountain region (2000 – 3000 m) is an important physiographic division, situated in Labha area that is north-eastern portion of the study area.

IV. DRAINAGE

The region fosters many perennial rivers which flow through deep gorges and belong to Himalayan or extra peninsular rivers. The rivers of this group are glacier, spring and rain-fed, originating from the Himalayans to traverse great alluvial Indo-Gangetic plains. The study area is drained by the Teesta and its tributaries, except the extreme eastern portion where the chief effluent is the Jhaldhaka. Teesta and its tributary Relli are the main channels here. Besides these Lish, Gish, Chel, Neora and Murti are also important rivers in southern portion of the Kalimpong subdivision (Figure 3).

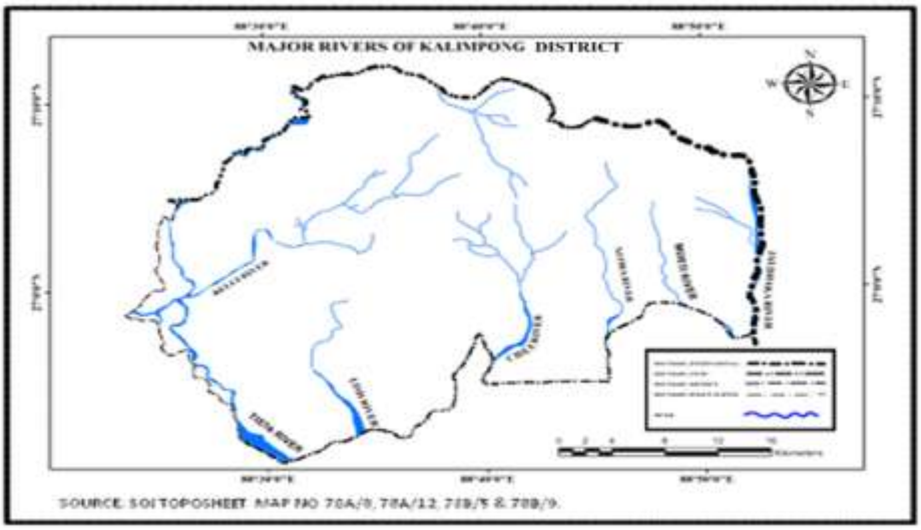


Figure 3. Major rivers of the study area.

The 'Teesta' is the biggest and by far most turbulent glacier fed river in study area. The term 'Teesta' is a Nepalese abbreviation of the Sanskrit word 'Tri-srota', meaning, it has three 'srotas' or currents. The Teesta forms the boundary of the Darjeeling district from the point where it is joined by the Rangpo chhu to its junction with the greay Rangit. From the latter point it flows entirely within the Darjeeling district through a deep gorge known as Sivok-Gola pass until it leaves it at Sevok. All through its course it has done toe erosion resulting into slope undercut and slides.

Hill-stream Relli or Rilli is a spring fed torrential left hand tributary of mighty river Teesta. 'Though popularly called river, the Relli is a hill-stream. The hill stream has its origin in the Algara-Labha ridge of Kalimpong subdivision of Darjeeling district in the Khampang reserve forest at an altitude of about 1800 meter msl. The total length of the stream Relli is about 32 km and joined to the river Teesta at an altitude of about 212 m.

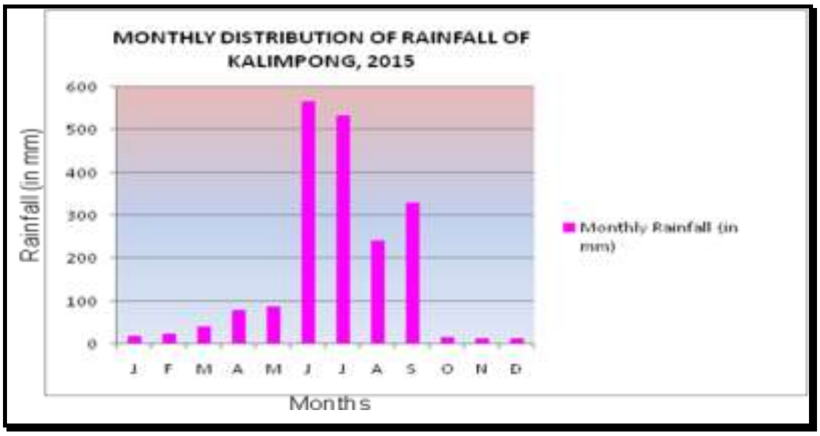
A little different longitudinal profile has the valleys directly dissecting the mountain edge. Among them are the valleys of Lish, Gish, Chel, Neora and Murti. Although gradients of headwaters are steep and controlled by lithology and mass-movements, as in the Teesta catchment, but going downstream, the valley floors start to be broader and aggradations prevail despite the relatively high gradient. Finally these mingle over the alluvial fans in the Terai zone and are either dissected in there apex or continuously aggrading. Like other parts of Eastern Himalayas, anastomosing network of juvenile rivers of various orders adequately drain the area. The entire area consists of 1^{st} order streams that join to form 2^{nd} and higher order streams are seen to be disappearing at a point and then reappearing somewhere down slope.

V. CLIMATE

The climate of Kalimpong Sub-division is interesting because of its position in relation to the Tibetan landmass, the wide differences in altitudes, the powerful effect of the monsoons against the Himalayan barrier and the peculiar configuration of the neighboring monsoons, which deflect winds and affect local temperature and rainfall.

Temperature and rainfall: Climate of the study area is tropical monsoonal in nature. In Kalimpong, the maximum summer temperature is 27°C and the minimum 16°C. The maximum temperature in winter is 17°C and the minimum 5°C. Kalimpong gets about 2,254 mm rainfall annually. The precipitation during the south-west monsoon constitutes about 80 percent of the rainfall, July being the wettest month. On an average, there are about 105 rainy days in a year. The relative humidity in Kalimpong ranges remains from 90 to 95% during rainy season. Sky remains heavily overcast during the monsoon. Fog or mist is very common from June to September but rare in December.

The second important characteristic of climate is the huge rainfall and its intensity and seasonal distribution. The mountain front is subjected to huge precipitation. The study area faces a wide alluvial gap between Rajmahal Hills to the west and Shillong Plateau in the east. Thus, there is no orographic obstacle for the southwestern monsoon originating from the Bay of Bengal which finds easy access to the foothills and lesser Himalayan Zone. This results in abnormally high precipitation during main rainfall months i.e. June – October.



Kalimpong Subdivision : **Monthly distribution of rainfall (in mm), 2015**

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year,2015	20.3	25	40.8	78.8	86.7	568	534.4	242.3	331.2	17	15.1	14.5
SOURCE : IMD												

Figure 4 and Table 2. Rainfall condition of the study area.

Graphical representation of rainfall, temperature and rainy day data of Kalimpong Subdivision, has been shown in figure 4. Here the rainfall data of 2015 (table 2) are analyzed by cartographic techniques. From the analysis, it is said that Kalimpong has five seasons, with the usual four being supplemented by "the monsoons". Most areas average above 3000 mm per year, and some areas are above 4000 mm. As well as this, much of this rainfall (about 80 percent) occurs in the four-month period of the monsoon. When combined with the rugged terrain, these monsoon conditions impose considerable limitations on various aspects of life in the Kalimpong area.

VI. SOIL CONDITIONS

Soils of the study area are heterogeneous in nature. The texture varies from gravely loam to loam and it is classified as luithic and typic udorthents. Anonymous (2002) reported that soil of study area belongs to 3 orders, 4 sub orders, 7 great groups and 14 sub groups. Alfisols are dominant and covers 52.96% of the area (Fig. 5) followed by Ultisols (36.27%). Darjeeling Himalayan soil generally classified into six types such

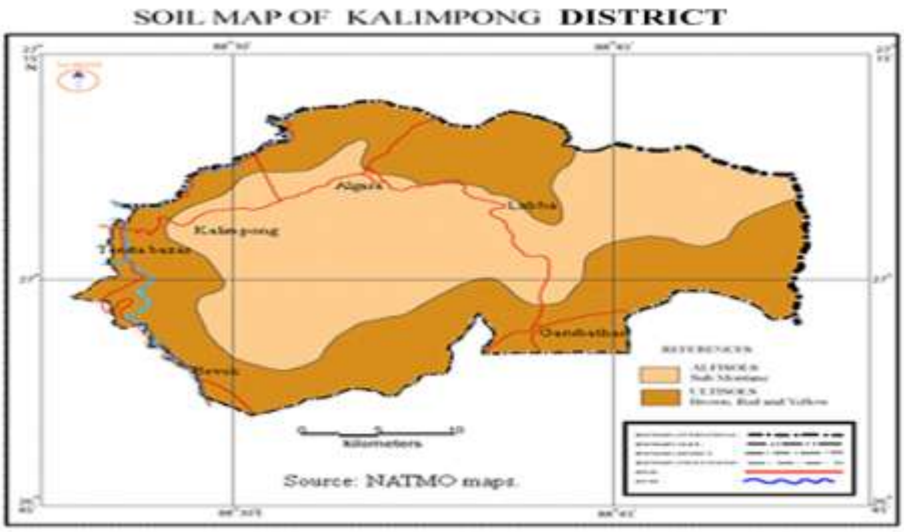


Figure 5. Soil types of the study area.

as Mountain glacial soil, Forest soil, Brown forest soil, Cinchona soil, Terai soil and Tea soil (De and Bera, 1990).

The soil developed on steep hill slopes is shallow, excessively drained to vary severe erosional hazards. These are mostly the residual of the eroded soil and lack profile development. The soil, developed on foothill slopes and valley are moderately deep-to-deep, well drained, loamy in texture with moderate erosional hazards, they show some degree of profile development and are classified as Umbric and/ or Fluventic Dystrocherpts, Luithic and/ or Typic Haplumbrepts. These soil are strongly to moderately acidic in reaction and are rich in humus content with moderate to low base saturation.

The basic soil types are yellow and red-brown soils and brown forest soils, all of siliceous and aluminous type. Red and yellow soils have developed on gneisses and schists along the upper part of slopes.

Over the Siwaliks are developed coarse pale yellow to red brown soils, on the Daling shales clayely dark grey soils and on the Gondwanas mainly sandy soils. Over the Darjeeling gneisses prevail red to brown silty and sandy soils. On the floors of main river valleys shallow sandy alluvial soils exits, which at the mountain foreland are more silty in nature.

The character of bedrock is reflected mainly in the grain size composition of soils. A very high percentage of sandy and coarse particles reaching upto 50-80% are a characteristic feature of grain composition of soils over the Darjeeling gneisses as well as Damuda and Daling series. On the steeper slope segments a high content of coarse debris is present. Soil textural map of the Kalimpong Subdivision area indicates that the entire area covered by coarse loamy and gravelly loamy soil. In the slope deposits disturbed by mass movements there exist with the horizons of various content of silty-clay fraction, influencing changes in the infiltration rate. On the contrary in the tea gardens and on the terraced slopes the spatial differentiation in physical properties of soil is connected mainly with agricultural practices.

VII. VEGETATION

High temperature and high rainfall lead the growth of dense tropical evergreen forest with thick undergrowth. The most remarkable features of the forests of the study area is the wonderful variety of species they contain; there are, in fact probably few places in the world in which so many different types of forest, exist within so small an area. All the forests in the study area are reserved forest controlled by the Forest Department.

The forest area is 52 percent of the total subdivision. Forest cover map of Kalimpong District has been shown in figure 6. The Kalimpong division comprises the reserved forests situated on the mountain slopes to the east of Teesta River, where they form a continuous belt extending round that portion of the area. East of Chel river, they extend northwards up to the frontiers of Sikkim and Bhutan. West of that river, they extend in a narrow strip along the southern boundary of the district westward as far as the Teesta, and then northwards up the left bank of that river to where the Rangpo constitutes the frontier of Sikkim. They are also connected with the broad tract of the forest east of the Chel River by a narrow belt of forest running from Paiengaon to Labha, where they enlarged up to the Sikkim frontier, thus forming a complete circle. Besides this, a narrow stretch extends from Labha some 12miles in a southwesterly direction into the interior of the circle thus formed.

The study area has different kinds of vegetation cover due to various climate, edaphic, topographical and altitudinal variations. The five major forest types according to altitudinal variation found in study areas are:

1. Tropical moist deciduous forest (300 – 1000m)
2. Tropical evergreen lower mountain forest (1000 – 2000m)
3. Tropical evergreen upper mountain forest (2000 – 3000m)
4. Temperate forest (3000 – 3500m)
5. Sub temperate forest (above 3500m)

Figure 6. Forest cover Map of Kalimpong District.

About 30% of the forest covers found in the lower hills are deciduous. Evergreen forest constitutes only about 6% of the total forest coverage. Shora robusta remains the most prominent species of Tropical moist deciduous forest along with heavy under growth. Tropical lower Montana evergreen forests are found on steep higher slopes, where drainage condition is good. Tropical upper Montana evergreen forests are found in the areas where drainage condition is good. Tropical upper Montana evergreen forests are found in the areas where high humidity along with dense fogs and less sunlight is available. Undergrowth is dense and contains Nettles, Raspberries, Farms and bamboos. On the steep ridges, Rhododendrons and bamboos are abundant. These forests, form belts along the left bank of the Teesta river and the northern boundary of the Jalpaiguri district, where they descends to 500 feet elevation; and they occupy the greater portion of the higher ground of the sub-division (5000 feet to 10,500 feet in elevation). In the greater part of the tract the rainfall is very heavy, amounting to over 200 inches a year on the southern foothills, and the soil and sub-soil, consisting for the most part of soft micaceous schist, are easily eroded.

VIII. LANDUSE LAND COVER IN KALIMPONG DISTRICT

In 2011, Darjeeling had the population of 1,846,823 of which male and female were 937,259 and 909,964 respectively. In 2001 census, Darjeeling had a population of 1,609,172 of which males were 830,644 and remaining 778,528 were females. There was change of 14.77 percent in the population compared to population as per 2001. In the previous census of India 2001, Darjeeling District recorded increase of 23.79 percent to its population compared to 1991.

In 2011, Kalimpong Subdivision had the population of 202,239 and in 2001 census; Kalimpong Sundivision had the population of 188,222. It is noticed that the population of Kalimpong District had been also rapidly increased, which influences the settlement pattern, landuse pattern and the pressure in the subsurface zone.

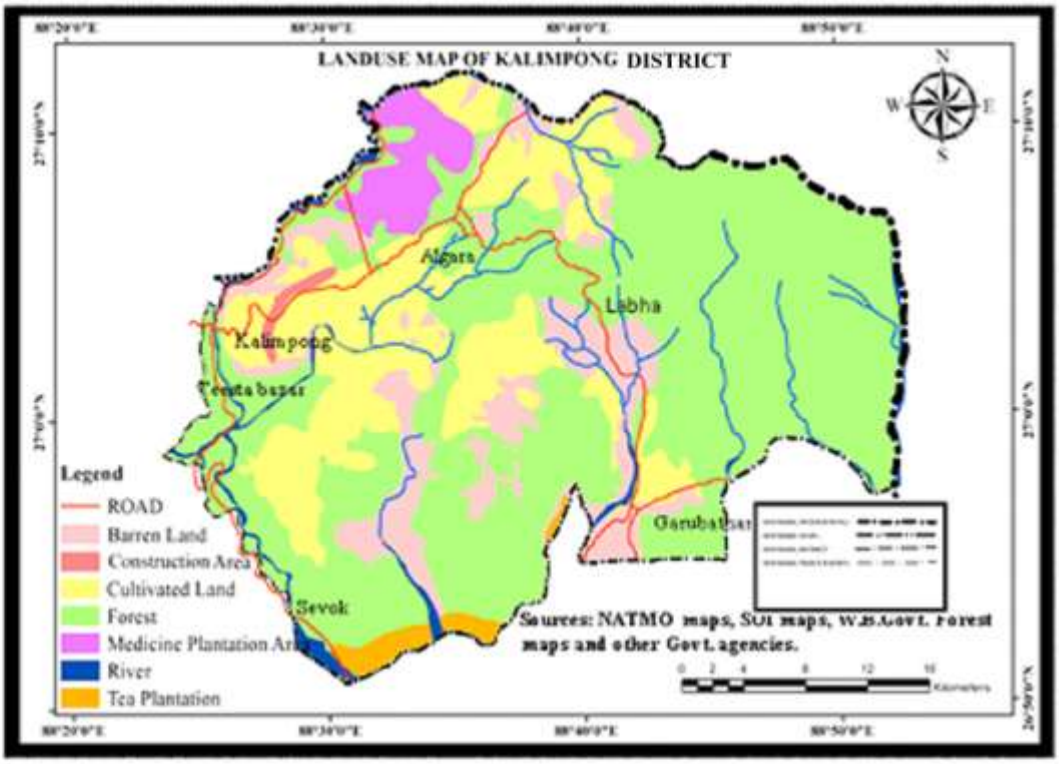


Figure 7. Land use Map of Kalimpong District.

The landuse in the study area mainly includes agricultural activities, tea and medicinal plant plantations, construction works along with forests, rivers, jhoras etc (Figure 7). From a general concept, it is true that forest as a whole reduces the degradation of slopes due to landslide processes, but deforestation cause rapid disintegration of the rocks, a phenomenon very common to the mid-slope region which are gradually encroached by human being. On unstable slope, thick bush type vegetation like tea and medicine plantation, offer good umbrella like protection against the impact of intense rain. Agricultural use is more common in the Kalimpong hill where intense weathering have resulted a thick soil profile, which is essential for such land use. The terraced cultivation for paddy growth leads to oversaturation of the slope rendering it unstable.

IX. CONCLUSION

One of the fundamental challenges to development in the Kalimpong area is the physical environment. As part of the Himalayan foothills, large rivers and smaller streams resulting in a series of ridges and valleys dissect the area. Thus, many villages are located on relatively steep hillsides, growing crops on a series of terraces. This topography, along with climatic conditions, result in particular challenges within the Kalimpong area. Whereas, the unparallel beauty, enhanced further by the majestic view of Kanchendzonga makes it one of the most important tourist centres attracting tourist, both from within as well as from outside the country.

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