IOSR Journal Of Humanities And Social Science (IOSR-JHSS)
Volume 23, Issue 3, Ver. 1(March. 2018) PP 66-79
e-ISSN: 2279-0837, p-ISSN: 2279-0845.
www.iosrjournals.org

Physical Aspects of the Darjeeling Himalaya: Understanding from a Geographical Perspective

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Abstract: *Darjyu Lyang or the 'land of God' or 'heaven on earth' is believed to have given Darjeeling its name which is a corrupted form of Dorjee-ling of the Lamaist religion. Geographically, the Darjeeling Himalaya is wedged between the Central (Nepal) Himalaya to the west and the Bhutan Himalaya to the east. The region is highly complex with innumerable variety of micro and macro relief forms. The hills rise abruptly from the plains that is, approximately from about 150 m and the elevation increases north-westwards upto Sandakphu (3636 m). The two most important rivers are the river Teesta and the river Great Rangeet. Both these glacier fed rivers originate from Sikkim. While the Teesta originates from the Zemu glacier located in north Sikkim the Rangeet arises from the Rothong glacier in West Sikkim. The region shows its own climatic peculiarities caused by its geographical location, relief and a wide range of altitudinal variations ranging from 300 - 3700 m above sea level. It exhibits a typical monsoon climate, with wet summers and dry winters. With its bracing climate, unrivalled scenic beauty, enhanced further by the majestic view of Kanchendzonga resulted its emergence as the "Queen of All Hill Stations".*

Date of Submission: 20-02-201 Date of acceptance: 03-03-2018

I. Introduction

***Darjyu* Lyang:** or the 'land of God' or 'heaven on earth' is believed to have given Darjeeling, the northern most district of West Bengal its name. It is also believed that the name is a corrupted form of Dorjee-ling of the Lamaist religion derived from `Dorjee' the celestial scepter of double-headed thunderbolt and `ling' or the land that literally means 'the land of the thunderbolt' after the famous Buddhist monastery that stands atop the Observatory Hill.Darjeeling was a part of the sovereign state of Sikkim prior to 1789 A.D. Its creation dates to the 19th century, through the involvement of the British India Government. The signing of the Sugauli Treaty between the two countries saw the return of the terai area and part of Darjeeling that was in the possession of Nepal to the British India Government. The signing of the Titleya Treaty on 10th February 1817 ensured that the British restored this region to the King of Sikkim, making it a buffer-zone between Tibet and India.However, the search for a summer capital and a sanatorium to escape the sweltering summer heat of the Indian plains saw the visit of Captain Llyod and Mr. Grant to Darjeeling in 1887. On their proposal and persuasion, Lord Bentick initiated a dialogue with the then King of Sikkim, who handed over this area to the British as a token of friendship on 1st February 1835. Kalimpong on the other hand was ceded to the British Empire by the Sinchula Treaty on 10th November, 1865 by the Government of Bhutan, on a lease basis and was then notified as a subdivision of Dooars to be transferred to Darjeeling in 1866. Since then, though the district has retained its geographical dimensions, its administrative placement has kept on changing and it was finally annexed to the state of West Bengal in 1947. The three hilly subdivisions of the district are now under the administrative purview of the Darjeeling Gorkha Autonomous Hill Council that came into effect on 22nd August 1988.

II. Geology

The Himalaya is geologically, a complex mountain system. Geographically, the Darjeeling Himalaya is wedged between the Central (Nepal) Himalaya to the west and the Bhutan Himalaya to the east. Geological investigations in Sikkim and the adjoining Bengal region began in the middle of the 19th Century. Dr. Hooker, in his famous "Himalayan Journals" (1854) reports the geological results of his extensive surveys in the region. He traced the regional domal pictures of gneisses and observed the overlying, bedded sedimentary rocks. (Gansser, 1964). The first comprehensive and systematic geological examination of this region was made by F.R. Mallet in 1874. Since then, many observations have been made (Dutta, 1950; Gansser, 1964; Acharya, 1972; Powde and Saha, 1982; etc.). A geological map of the study area (Fig. No. 1) has been prepared based on Mallet, Gansser and the others to show the regional distribution of rocks; while the chronological sequence of the geological series of the study area has been shown in Table No. 1.

Geological formations in chronological order: The geological formations of the Darjeeling Himalaya consist essentially of unaltered sedimentary rocks. The Sub-Himalaya is made up of Siwalik deposits of the Tertiary age. North of the Siwaliks is the coal-bearing lower Gondwana formations. The Daling series (Pre-Cambrian) follows and is succeeded by the Darjeeling gneiss further north.

Table No. 1: Geological succession of Darjeeling Himalaya

Age	Series	Lithological Characteristics
Recent to Sub-recent	Alluvium	Younger flood plain deposits of rivers consisting of sands, pebbles, gravels, boulders etc.
Pleistocene to Lower Pleistocene (Lower Tertiary)	Siwalik	Micaceous sandstone with siltstone, clay, lignite lenticles, etc.
Thrust (Main Boundary Fault)		
Permian	Damuda (Lower Gondwana)	Quartzitic sandstone with slaty bands, seams of graphitic coal, lampophyre silt and minor bands of limestone.
Thrust (Fault Of Nappe Qutlier)		
Pre-Cambrian	Daling Series	Slate, chlorite-sericite schist, chlorite- quartz schist.
	Darjeeling Gneiss	Golden silvery mica-schist, carboniferous mica-schist, coarse grained gneiss.

Based on: Mallet, 1874; Gansser 1964 and Powde and Saha, 1982

Darjeeling Sub Himalaya

The Terai and the foothills were given their present form after the final upheaval of the Himalayan orogeny and consist of almost horizontal layers of unconsolidated sand, silt, pebbles and gravel. The Sub Himalaya is made up of the Siwalik deposits of the Tertiary and good Siwalik exposure is met along the Teesta River.

Damuda Series: Along the foothills of Darjeeling, the Siwaliks are steeply overthrust by the Damuda formations (Lower Gondwana). The thrust zone is badly exposed and appears to dip at 60° – 70° towards the North. This thrust coincides with the well-known main boundary fault, occurring throughout the entire Himalayan range. The sandstones are micaceous, feldspathic and brownish, often weathered in exposed thrust zones, with coal bearing detrital rocks. Frequently, the sandstones have been converted to quartzites; the shales into splinter-shales and the carboniferous shales to graphitic shales; while the coal has been altered to anthracite. There is a thin discontinuous band of limestone from Kalijhora to Rongtong.

Daling Series: Northwards, the Damuda Series is succeeded by the very uniform and characteristic Dalings. They border the Damudas with a very sharp thrust contact, dipping steeply towards the north. The Daling consist mainly of slates and phyllites, with silvery mica schists representing transition rocks. Feldspars and quartz layers are found lying alternate to each other.

Darjeeling Gneiss: The Darjeeling gneiss occupies a greater part of the region and is found along the higher reaches of the hills. The Darjeeling gneiss consists of garnetiferous mica-schists, quartzites, biotite-kyanite and sillimantic gneiss. The Darjeeling gneiss is met with traverses along Sukhia Pokhri - Maney Bhanjang - Tonglu-Sandhakphu-Phalut Road and also along the Phalut-Rammam-Rimbick-Jhepi-Pulbazar-Darjeeling Road. The gneisses are well foliated, much folded and crumpled and are well- jointed (40°-70° E-W) rocks (Fig. No. 1)

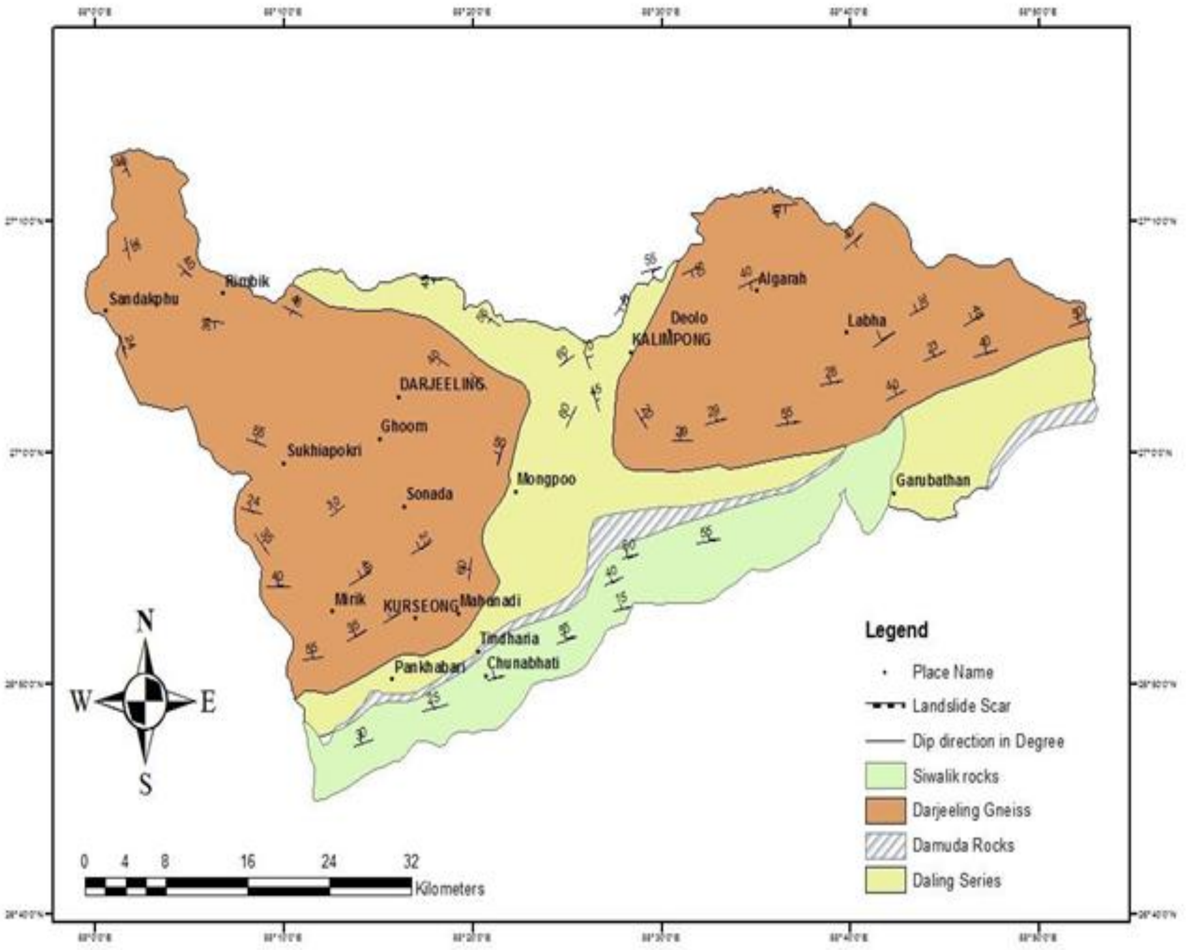

Fig. No.1: Geological map of Darjeeling Himalay

III. Physiography

Physiographically the Darjeeling Himalaya is highly complex with innumerable variety of micro and macro relief forms. The hills rise abruptly from the plains, that is, approximately from about 150 m and the elevation increases north-westwards upto Sandakphu (3636 m). Two transverse ranges running north-south enclose the Singalila in the west and the Dongkya in the east. Ravines, deep valleys, innumerable springs and jhoras dissect these landscapes, interspersed with a mosaic of micro-topographic units. This complex physical environment is due to different geomorphic processes, each of which has developed its own characteristic assemblage of landforms. The geomorphic configuration of this hilly tract is the joint product of geologic foundation and fluvial processes; although slope-wash, in particular mass-movements and related phenomena play a significant role in the final shaping of the landform. The region is characterized by a myriad of ridges and valleys because of the spurs ramifying into lateral spurs which give off lesser ones and these in turn cut the terrain into ridges and valleys, creating a mosaic of micro-topographical units (Fig. 2).

Lower hills: This region is bounded by contour heights of approximately 200 - 800 m and covers most of the central section of the study area. The rivers are mostly south-flowing and cut deep gorges and V-shaped valleys. The landscape is characterized by narrow ridges, deep incisions and numerous mass-movement scars. The average slope in this zone varies between 10° - 30°, with slope length sometimes exceeding 800 m. These lower hills are the most dissected and eroded tract in the Darjeeling Himalaya.

Middle hills: This is a rather narrow zone, sandwiched between the upper and lower hills and bounded by 800 m and 1400 m contours. Most of the western and north eastern part of the study area fall under this category. These hill slopes are mostly used by tea plantations.

Upper hills: The upper hills lie above the 1400 m contour line and have been identified along the Mahaldiram-Bagora region and above the Ghum-Sonada ridge. It is most prominent along the extreme north-western boundary of the region along the Singalila ridges with peaks like Sandhakphu and Phalut towering over the region.

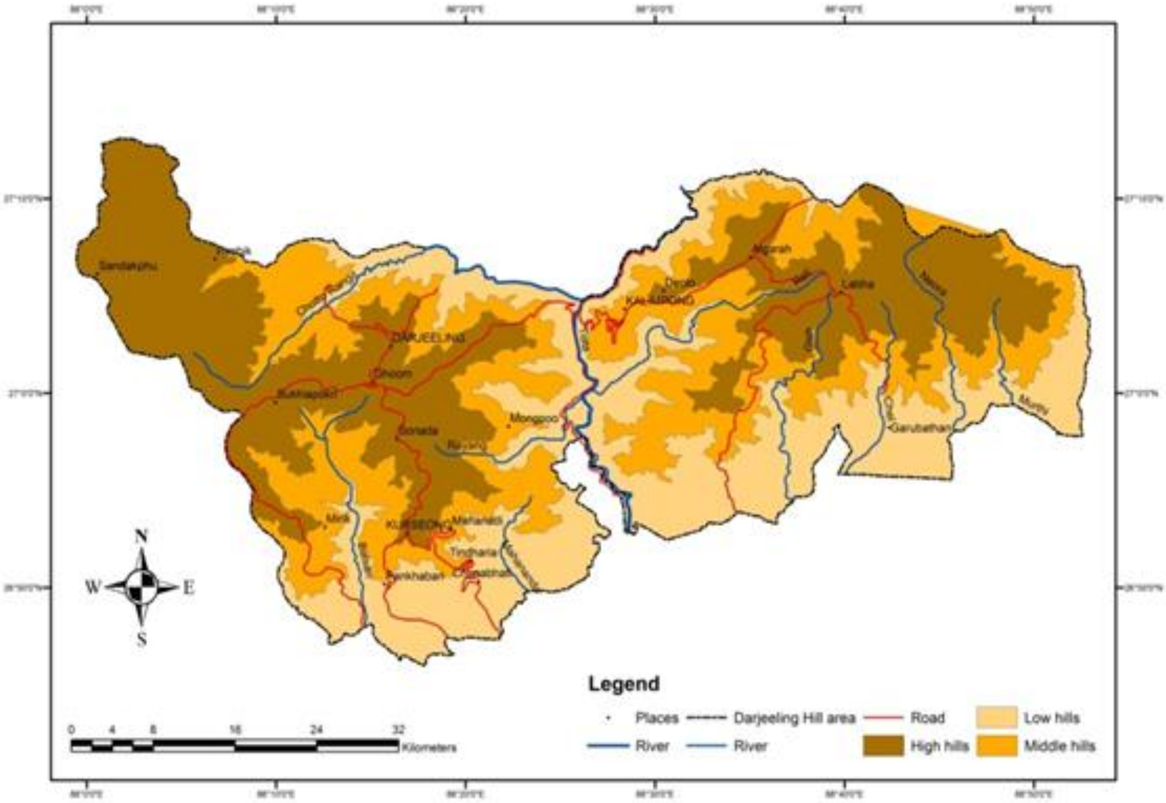

Fig. No. 2: Physiography of Darjeeling Himalaya

IV. Drainage

The rivers of the tract drain ultimately to the south but as the west to east ridges cross the tract at certain regions it causes a series of rivers and streams to flow northwards or eastwards direction before joining the main river system. The two most important rivers of Darjeeling are the river Teesta and the river Great Rangeet. Both these glacier fed rivers originate from Sikkim. While the Teesta originates from the Zemu glacier located in north Sikkim the Rangeet arises from the Rothong glacier in West Sikkim. The Teesta is a broad mountainous river with numerous shallows and rapids. It traverses a large part of the state of Sikkim and enters the district of Darjeeling at the point it meets with the Great Rangeet. The major tributaries in Sikkim include the Lachung chhu, the Zemu chhu, the Dhakung chhu, in the north district the Talung chhu and Tangpo chhu in the west district and Sethikhola Rangpo khola, Jolly khola in the east district, while the Reyang, originating from Mahaldiram Reserve Forest (2438m), Peshok and Geile khola constitute its main tributaries on the right bank after its entry into the District of Darjeeling.The main tributary of Teesta is the Great Rangeet, which arises from the Pathong glacier and confluences with Teesta at the Teesta Bazar. It enters the district of Darjeeling at the point on the northern boundary where it receives the Rammam river arising from Singalila and Rangu arising from Senchal in Darjeeling on its right bank. The Rammam demarcates the northern boundary between Sikkim and Darjeeling district. The Rammam originates at an altitude of 3600 m at Phalut in the Singalila range. The entire course of the river is interspersed with deep gorges. A very prominent gorge is found at the confluence of the Rammam with its main tributary; the Lodhoma Khola.The Little Rangeet arises at Chitre Pokhri (2380 m) and flows north, almost parallel to the Lodhoma Khola. The Little Rangeet winds sinuously within a maze of interlocking spurs and valleys. Below the Triveni confluence, the Teesta flows eastwards, where it receives the Little Rangeet from Darjeeling and enters the plains of North Bengal and finally joins the river Brahmaputra in Bangladesh.The Balason, which arises from Lepchajagat in the Ghum saddle, flows towards the south, scooping out deep gorges in the catchment area, till it reaches the plains and thereby turns southeast, where its valley is larger than that of the Mahanadi.The other important rivers of Darjeeling include the Balason, arising from the Ghoom saddle and running south till it reaches the plains at an altitude of 304 m and then turns south east and divides into two channels the New Balason and the Old Balason and subsequently joins the Mahanadi further south. It receives tributaries like Pulungdung khola, Rangbang khola, the Marma khola, Dudhia khola on the right bank and Rinchingtong khola, Rakti khola, Rohini khola, Jor khola etc on the left. The Mahanadi has its source near the Mahaldiram dome, east of Kurseong and flows southeast receiving a few sizable right side tributaries the Siva khola being the most important one. Its left bank tributaries include the Jholi khola, the Jogi khola, Gulma khola Babu khola and Ghoramara khola. The Mechi River, which is the western boundary of the study area, forms the Indo-Nepal boundary. The source of the river is the Rangbang spur of the Singalila range at an altitude of 1905 m. It flows through deep gorges in the hilly tracts and widens suddenly when it enters the Terai and the plains. The Mechi eventually joins the Mahananda.The Teesta and Jaldhakha form the western and eastern boundaries of the sub-division of Kalimpong. A number of rivers and tributaries that originate in this sub-division include the Lish which originates at the ridge of Pabringtar village and flows downwards receiving the Amlkhola on the western side and Turungkhola on the east further southwards it is joined by the Phangkhola and Chunkhola near the Bagrakote colliery and eventually joins the Teesta at the Kalagaiti Tea estate.

Table No. 2: Major rivers and tributaries in Darjeeling Himalaya

River / tributary	Length in kms	River / tributary	Length in kms
Balason	48.40	Murti	13.82
Chel	10.46	Neora	27.46
Cheng	62.58	Ni Cuh	14.90
Chhota Rangeet	23.77	Rammam	39.78
Gish	30.20	Rangnu	16.27
Great Rangeet	18.57	Rangpo Chu	9.66
Jaldhaka	19.47	Riyang	18.70
Lish	12.10	Raili	30.64
Mahananda	91.70	Rishi Chu	17.36
Mechi	63.21	Teesta	37.00

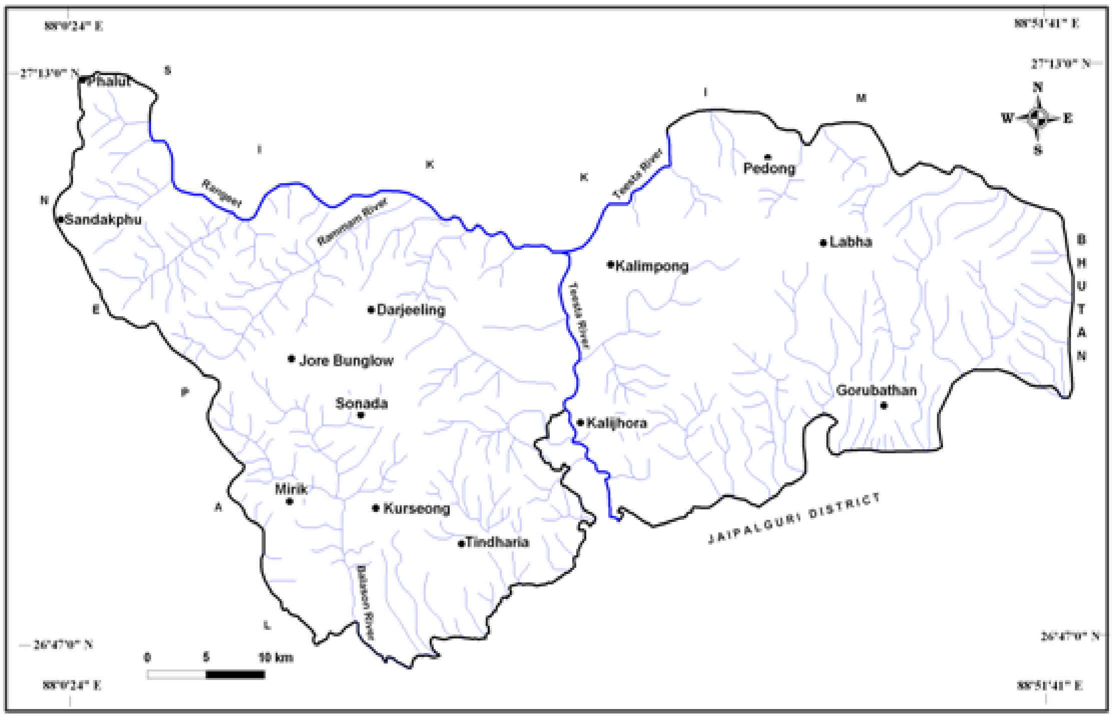

Fig. No. 3: Drainage in Darjeeling Himalaya

The Gish is formed by the joining of two small rivulets, one originating below Labha and the other below the Chumang reserve forest. Ramthi and Lethi form the major tributaries of the river. The Neora originates from the Rechila Chawk just below the Rechila danda and joins the Thosum chu at the boundary of Thosum and Rechila. It then flows southwards and eventually joins the Teesta. The Relli originates in Khempong Reserve Forest below Labha-Algarah and runs along the southern boundary of Saihur reserve forest after which it is joined by the Pala and Lolley khola and moving southwards it joins the Rani khola. Murti originates in the Mo block south of Thosum hills flowing through the reserve forest and emerging in the Samsing area and eventually joining the Jaldhaka River.Along with these, numerous small springs occur which meet to form small rivulets at the bottom of valleys. The rivers of the study area drain ultimately into the south. The relief of valley floors and river channels exhibit the youthful stage of evolution characterized by steep ungraded channels, narrow floors and steep valley sides. A number of tributaries of these rivers, along with many jhoras, form a complicated pattern of drainage over the myriad of interlocking spurs and ridges, essentially displaying a dendritic pattern (Table No. 2 & Fig. No. 3).

V. Climate

The climate of a locality is the synthesis of day-to-day values of the meteorological parameters like precipitation, temperature, humidity, sunshine and wind velocity. The great Himalayan range forms a complex system that separates the northern part of Asia from the southern part, the latter commonly known as the Indian subcontinent. The physical features of the Indian subcontinent are of great importance as they have profound influence on the wind systems, which ultimately affect the distribution of temperature, humidity and rainfall over the subcontinent and its neighborhood. The Darjeeling Himalaya shows its own climatic peculiarities caused by its geographical location, relief and a wide range of altitudinal variations ranging from 300 m – 3700 m above sea level. It exhibits a typical monsoon climate, with wet summers and dry winters. The condition is brought about by the direct exposure to the moisture laden southwest monsoon flowing upwards during May to October from the Bay of Bengal that lies at close proximity. The climate varies greatly corresponding to the variation in the altitude and the configuration of the neighbouring mountain ranges that greatly affect air movement, rainfall and temperature. Even within very short distances great climatic contrasts occur. Although the latitudinal extent of the region is located within the sub-tropical climatic regime its mountainous configuration has led to varied climates ranging from the subtropical to the temperate and alpine type. Thus, based upon the elevation, the region shows three distinct climatic zones, viz. tropical, temperate and sub-alpine. This variation is responsible for the creation of the various types of vegetal cover, thus bringing about great biological diversity. Four climatic seasons can be recognized within the region (i) pre monsoon season, (ii) monsoon season, (iii) post monsoon season, (iv) and winter season. Spring and summer cannot be much differentiated.

Rainfall: The whole region consists of a tangled series of interlacing ridges, rising range above range to the foot of the wall of high peaks and passes which marks the `abode of snow' and its off-shoot (Risley 1884). This configuration coupled with the altitude brings about sharp changes in the rainfall of the region. In general the south facing ridges receive the highest rainfall with the north facing ridges receiving lesser rainfall. The Darjeeling Himalaya is viewed as a stupendous stairway leading from the western border of Tibetan plateau down to plains of West Bengal. It is highly humid because its proximity to the Bay of Bengal and direct exposure to the effects of moisture-laden southwest monsoon configurations of the mountainous region bring sharp changes in the rainfall. The rainfall and temperature recorded from different locations are provided below in the following Table No. 3 and Fig. No. 4.

Table No. 3: Average rainfall and temperature characteristics of the Darjeeling Himalaya

	Darjeeling		Kalimpong		Kurseong	
Months	Rainfall In Mm	Temperature In °C	Rainfall In Mm	Temperature In °C	Rainfall In Mm	Temperature In °C
January	13.89	8.12	10.16	17.39	17.03	11.97
February	20.16	12.28	20.34	19.67	21.25	15.98
March	47.97	15.55	46.34	23.46	72.17	19.51
April	132.89	18.67	129.82	26.32	181.36	22.5
May	371.67	19.79	248.98	27.77	428.33	23.78
June	631.45	20.85	598.44	28.62	724.95	24.74
July	867.59	21.72	865.26	29.41	896.43	25.57
August	659.89	21.98	634.66	29.82	698.28	25.9
September	556.24	19.99	487.21	27.44	611.73	23.72
October	167.39	18.37	145.99	26.69	176.69	22.53
November	36.96	15.69	38.98	23.03	42.97	19.36
December	10.88	11.98	11.46	19.21	12.67	15.6

Source: *Tea Planters' Association, Darjeeling.*

For the district of Darjeeling the highest rainfall occurs at Kurseong, the south facing town with an annual rainfall of exceeding 4000 mm followed by Darjeeling and Kalimpong. The district experiences the highest rainfall during the months between June to September brought about by the southwest monsoons and the lowest between November - February with occasional moderate showers during March - May. Sikkim also shares the same monsoonal rainfall with the south facing slopes receiving the maximum amount of rains. The eastern, western and southern regions receive greater amounts of rainfall as compared to the north.

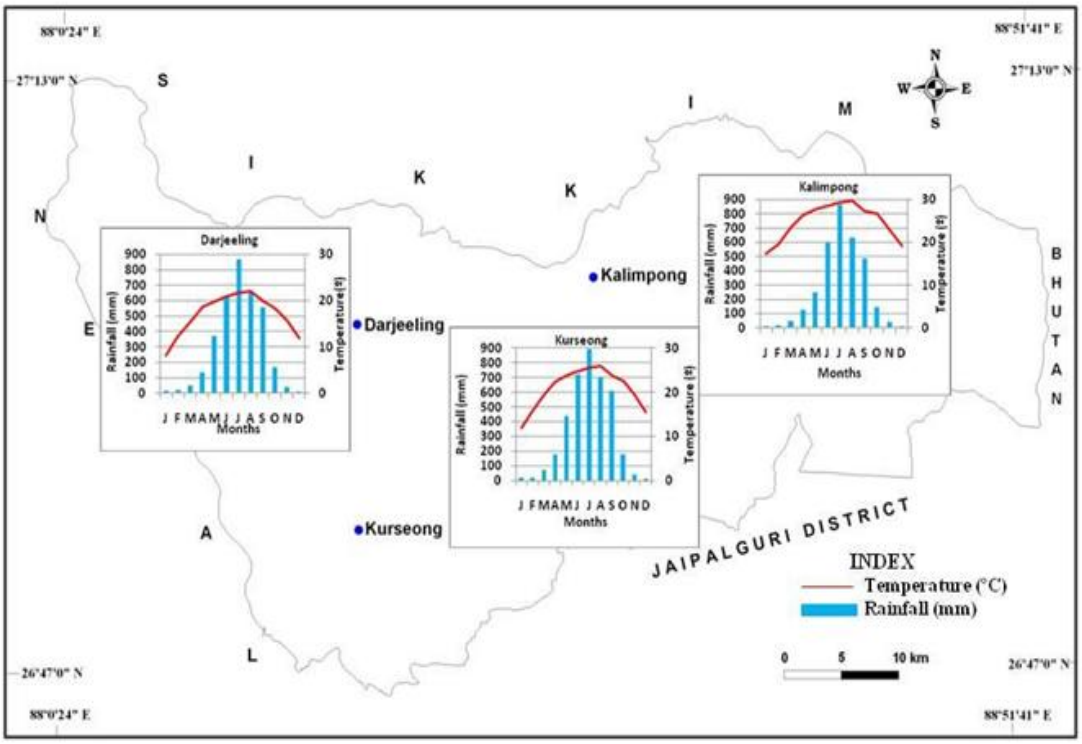

Fig. No. 4: Climatic Graph of Three Hill Sub-Divisions

Temperature: Temperature of the Darjeeling district shows a great degree of variation where altitude plays to be the most important factor. In the upper hilly regions the temperature (day and night) remains higher during the rainy season than in the summer and spring season. The range of fluctuation of temperature between day and night is higher in the plains of Siliguri and the terai region remains hot or warm till the withdrawal of southwest monsoon (i.e from the month of November). Thereafter, the temperature falls rapidly throughout the region. Such variation widely affects the vegetation of the region. Table No. 3 shows the average monthly temperature record of Darjeeling (2150 m asl), Kurseong (1480 m asl) and Kalimpong (972 m asl). Normally January is the coldest month when the diurnal temperature at Darjeeling, Sonada and Labha often go down below 0°C (Fig. No. 4).

Relative Humidity: The entire Darjeeling Himalaya experiences a high relative humidity that remains uniformly spread. Generally the north facing slopes are cooler and remain humid throughout the whole year. Relative humidity is higher at the higher altitudes (above 2000 m) ranging from 85 - 99 % during the monsoons, and the relative humidity generally decreases towards the lower elevations. The drier months of March and April are less humid with relative humidity ranging between 45 - 60 %.

Sunshine and Cloudiness: The Darjeeling Himalaya is a region of high precipitation and humidity with the rainy days as high as 218 days per annum. Thus, this region experiences very few days of sunshine. Not only during monsoons but even during summer and winter, sunshine remains disturbed due to the formation of dense fog that sometimes creates situations of near zero visibility (Chopra, 1985). Sunshine is more commonly distributed in the morning and late afternoon. During the monsoons, the rains continue uninterrupted for quite a few days without the sun being visible on those days. The records of sunshine from the middle hill regions shows that, on an average the highest is at Sonada during Novermber (5.84 hr/day) and the lowest at Kurseong in July (0.9hr./day). While that annual average sunshine at Kurseong is 3.49hr/day it is only 1.86 hr/day at Simana Busty.

VI. Soil conditions

The soil of upland is usually red and gritty while that of the plains are dark and more fertile. Along the banks of the Teesta, silty or silty loam predominates. Red and yellow soils are developed on the gneisses and schists formations in the higher slopes of the Darjeeling Himalaya. The greater portion of the hill area lies on the Darjeeling gneiss, which most commonly decomposes into a stiff reddish loam but may also produce almost pure sand or stiff red clay. The colour of the red soil is derived from weathering of gneisses and schists due to wide diffusion rather than to high proportion of iron content in the rocks. This type of soil is mainly siliceous and aluminous with free quartz as sand. It is usually poor in lime, magnesia, iron oxide, phosphorus and nitrogen, but fairly rich in potash, some areas being quite rich in potassium derived from the muscovite and feldspar of the gneiss. River alluvium is found in the southernmost part of the district.The podzolic soils in the hilly area are suitable for cultivation of tea. Parent material variations exert a stronger influence on soil characteristics of Darjeeling Himalayas than climate or vegetation. Very broadly the soil on Siwaliks is pale yellow and coarse in texture, on the Dalings, dark grey and porous; on the gneisses a brown clay, sometimes plastic, shallow and sticky. The soil on the Gondwana is generally sandy. Almost everywhere the soil is residual i.e., derived by the weathering of the underlying rocks. Weathering is selective in Darjeeling gneiss and proceeds along some susceptible bands, i.e., mica rich bands in preference to quartzose bands also along joints and shear planes. As a result, blocks of fresh rocks are generally found encircled on all sides by highly weathered rocks of the nature of clay. The impervious clay is found mixed with grains of quartz, feldspar and flakes of mica. This has got an important bearing on the massive landslips. The NBSSLUP (National Bureau of Soil Survey and Land Use Planning) of the ICAR (Indian Council of Agricultural Research) prepared a map of the soils of West Bengal including the hill zone in a 1:500,000 scale. The relevant portion of the map is presented in Fig. No. 5. According to records, there are five types of soils in the hill areas of Darjeeling: the dominating one is coarse-loamy (Typic Udorthents) followed by loamy skeletal (Typic Haplumbrepts). It is recorded that the nature of the soil of this eco-region is heterogeneous. The soils developed on steep hill slopes are shallow to very shallow, excessively drained with severe to very severe erosion hazard. Texture of the soils varies from gravelly loam to loam. The content of gravel exceeds 89% and organic carbon content ranges from 2% to 7% in the surface soil while pH is 5. The particle size class qualifies these soil families as loamy skeletal. These soils are classified as Lithic and Typic Udorthents. The soils developed on side hill slopes are moderately deep to deep, well drained and loamy in texture with severe to moderate erosion hazards. They show some degree of profile development and are classified as Umbric and Typic Distrochrepts, Lithic Udorthents and Lithic and/or Typic Haplumbrepts. These soils are strongly to moderately acidic in nature, are rich in organic carbon and have moderate to low base saturation.

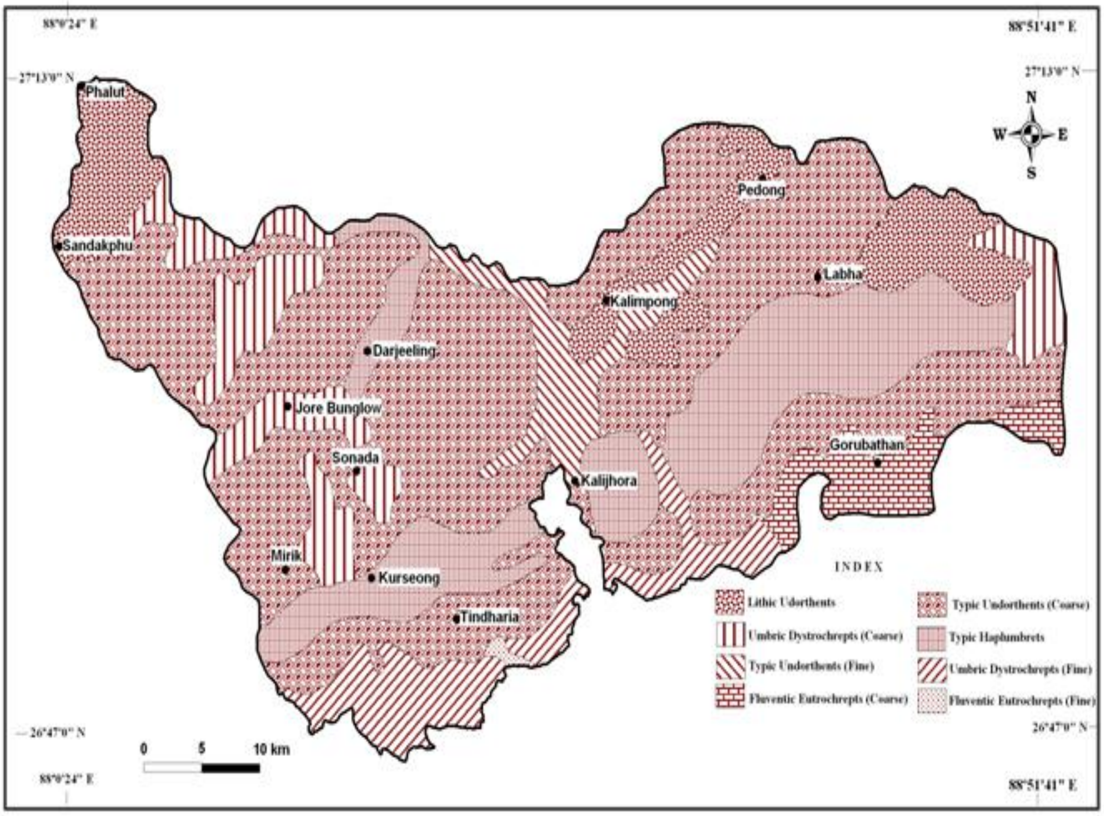

Fig. No. 5: Soil Map of Darjeeling Himalaya

VII. Vegetation

Phytogeographically, the Darjeeling Himalaya is a part of the Eastern Himalayan Province that in turn is one of the thirteen provinces of the Eastern Asiatic regional centre of endemism (Hooker 1896). The Eastern Himalayan Province lies almost wholly within the Indian subcontinent lying between $27^0$30'N to $29^0$30'N and $83^0$00'E to $92^0$00'E. It includes Nepal east of Kali river ($83^0$00'E) and extends to southeastern Tibet (the Tsangpo valley east of $92^0$00'E). It includes all the mountainous country east of the Kali River and north of the Bramhmaputra - Ganges flood plains. Floristically, the Eastern Himalaya is one of the richest regions in the world and is literally considered a botanist's paradise and has thus, attracted a large number of plant hunters and botanists during the last three centuries (Don 1821, Das 1995). Phytogeographically, it forms a meeting ground of the Indo-Chinese and Indo-Malaysian tropical lowland flora, the Sino-Himalayan East Asiatic flora and the Western Himalayan flora comprising about 9000 species with a high percentage of endemic plants (Chatterjee 1940, Puri et al 1983, Myers 1990, Wilson 1983, Das 1995, Bhujel 1996). This province along with Khasi-Manipur has the richest flora of the Indian subcontinent with the exception of Myanmar (Rao 1964). A comprehensive travelogue through the dense and magnificent forest and vegetation of this region is rather difficult to conceive due to the nature of Himalayan terrain and intricacy of the plant cover comparable to almost that of the tropical rainforest in some of the river valleys (Bhattacharya, 1992). Although, the Darjeeling-Sikkim Himalaya forms a very small part of this province covering an area of only 9020 sq km of a total area of 1,22,802 sq. kms (Negi, 1990) it shows a remarkable richness and variety in its flora. None other than Sir Joseph Dalton Hooker introduced the beauty and the floristic richness of this region to the outside world for the first time. The occurrences of a variety of physiographic, climatic and edaphic conditions often aided by biotic factors are responsible for such richness and variety. The configuration of the hills and mountains, pattern of rainfall distribution over the lower, middle and upper ranges and high humidity have a great role in determining the type of vegetation of the area (Fig. No. 6). The evenly distributed, highly humid climate is regarded as tree producing which is conducive to tree growth and as such the timber line or the upper vegetation in this sector goes up to 4750 m a.s.l. (Sahni, 1981).The altitude of the various hill ranges varies markedly and usually there is a distinct correlation between altitude and vegetation. Thus, altitude is one major factor that determines the range of distribution of different plant species and the associations that they form at different elevation ranges. Various workers have put forth the classification of the vegetation of this region and it includes workers like Gamble (1875), Hooker (1896), Cowan and Cowan (1929), Champion (1936), and Kanai (1963), Rao (1964), Sahni (1981), Jain (1983), Jain and Rao (1983), Bhujel (1996). These authors have essentially classified the 'flora and vegetation' according to altitudinal ranges, although they differ considerably in detail.

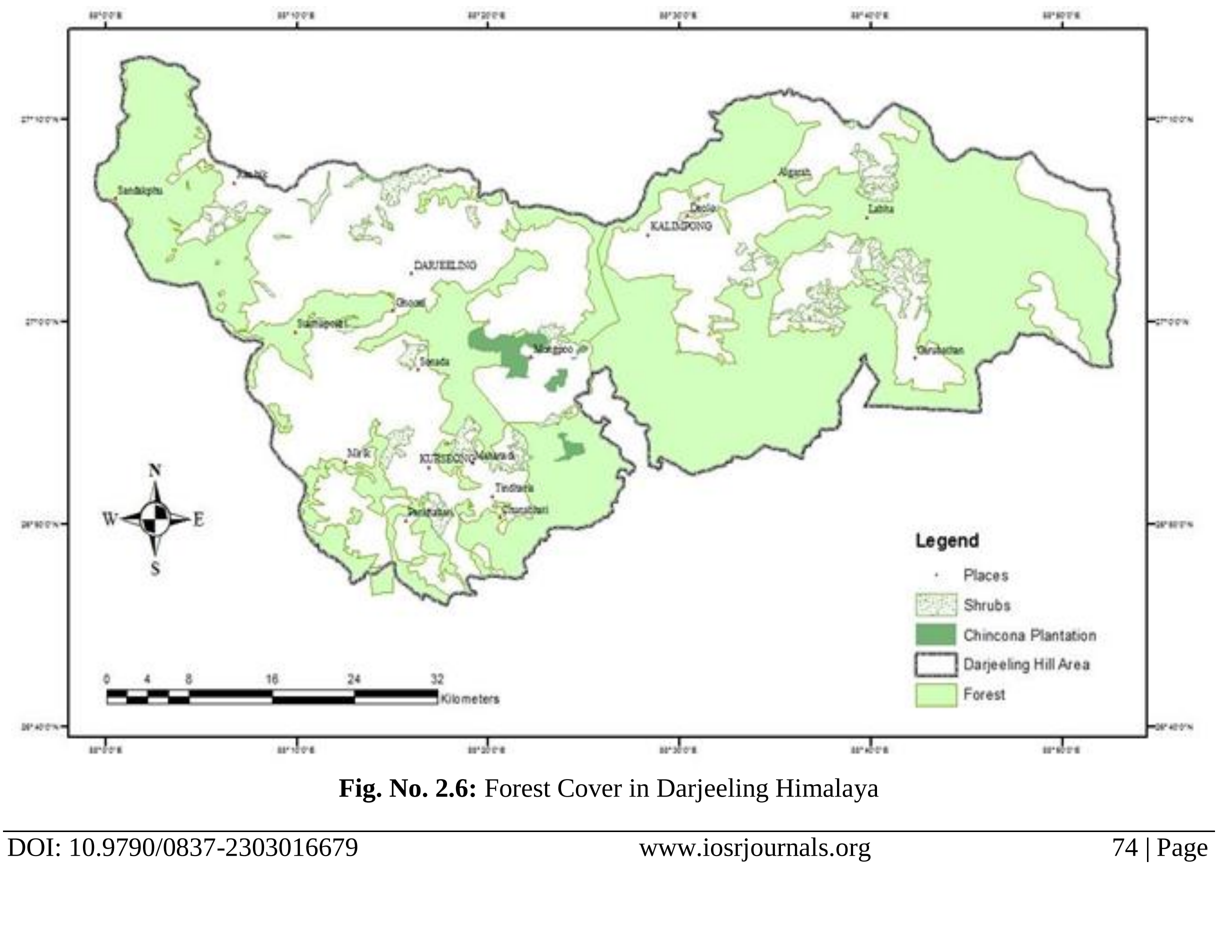

Fig. No. 2.6: Forest Cover in Darjeeling Himalaya

Five major types of vegetation which are further subdivided to sub-types can be recognized:

The Tropical Vegetation: High temperature and heavy rainfall characterize this zone resulting in the propagation of dense vegetation. The tropical vegetation is characterized by the presence of deciduous forests with Shorea robusta as a dominant species. Bhujel (1996) further divided it into four sub types:
a. Riverain forest b. Sal forest c. Dry mixed forest d. Wet mixed forest

The Riverain forests: It can be observed in small patches along the riverbeds of Teesta, Rangit, Balasan, Mahanadi, Sukuna, Relli, Chel, Lesh, Gish, Jaldhaka, Sevoke and Mechi. The forests remain dominated and perennial plants being dominated by shrubs and climbers. The common tree species found in this region include, *Meliosma pinnata*, *Albizia procera* , *Albizia lebbeck, Acacia lenticularis*, *Alstonia scholaris* , *Lagerostroemia parviflora* with *acacia catechu*. and *Dalbergia sissoo* occurring as distinct patches in planted forests**.** *Saccharum spontaneum*, *Mikania micrantha*, C*lerodendrum japonicum* , *C. infortunatum* , *Buddleja asiatica*, *Oroxylum* i*ndicum*, *Globba macroclada* cover the forest floor.

Sal *(Shorea robusta)* forest: *Shorea robusta*. is the conspicuous species growing in Lower Siwalik `Dry' Terai and Bhabar sal belt, ridges, spurs and well-drained loamy plains. The main associates of sal in this region include *Terminalia alata, Aglaia lawii, Duabanga grandiflora, Eugenia kurzii*, *Dillenia pentagynai.*, *Chukrasia tabularis, Meliosma pinnata*, *Lagerstroemia parviflora, Tetrameles nudiflora*, *Stereospermum chelonoides* and *Anthocephalus chinensis* along with *Pavetta indica*, *Clerodendrum japonicum, Phlogacanthus thyrsiflorusn* and *Barleria cristata*. *Pinus roxburghii* a normal inhabitant of the temperate to subtropical region can be also be seen associated with species like *Shorea robusta, Ficus oligodo* and *Pheonix humilis* in some drier valleys. Remnants of the once magnificent sal forests which has given way to the need of agricultural land can be seen along the banks of the River Rangeet.

The Dry mixed forest: This forest is represented by the presence of *Gmelia arborea*, *Tetrameles nudiflora*, *Beilschmiedia dalzellii*, *Erythrina stricta*, *Bombax ceiba*, *Alstonia nerifolia*, *Merremia emarginat*, *M. hederacea*, *Artocarpus lacucha*, *Eugenia kurzii* etc.

Wet mixed forest: Semi-evergreen trees along with a very large number of shrubs, climbers and herbs dominate the wet mixed forest. This zone is rich in epiphytes and stem-parasites giving it a distinct characteristic. The major tree species of this sub zone include *Terminali myriocarpa*, *Michelia champaca*, *Sygzygium formosa, Cinnamomum glaucescens*, *Litsea monopetala, Beilschmiedia roxburghiana*, *Pterospermum acerifolium* etc. Climbers include *Beaumontia grandiflora* , *Bauhinia vahlii* , *Entada pursaetha* ssp. *sinohimalensis*, *Cryptolepis buchananii*., *Mikania micranth*, *Ipomea quamoclit*, *Boerhavia diffusa, Argyeria roxburghii* with the lower strata and ground vegetation including *Ageratum conyzoides*, *Blumea balsamifera* , *Sonchus asper* , *Sauropus pubescens* etc.

Sub-Tropical forests: The vegetation of this region is effected by a seasonal climate of dry winter and a wet monsoon and thus consists largely of tropical genera and species (Grierson & Long, 1983). The mixed forest is mostly deciduous in nature. Several species tend into this zone from the tropical and plains zone. *Castanopsis indica*, *Schima wallichii*, *Gmelia arborea*, *Adina cordifolia*, *Duabanga grandiflora*, *Gynocardia odorata*, *Bischofia javanica*, *Callicarpa arborea*, *Alangium chinensis*, *Terminalia alata*, *T. bellirica*, *Sygzygium ramosissmum*, constitute the dominant trees in this region. In addition *Castanopsis tribuloides*, *Cinnamomum bejolghota*, *Magnifera sylvatica*, *Phoebe lanceolata*, *Litsea cubeba*, *Fraxinus floribunda*, *Helicia nilagirica*, *Phyllanthus emblica*, *Mallotus philippensis, Engelhardtia spicata* can be seen in some places. The undergrowths include *Mussaenda roxburghii Dendrocalamus hamiltonii, Osbeckia nepalensis, Osbeckia stellata* , *Buddleja asiatica*, *Embelia floribunda, Croton caudatus, Thysanolaena maxima*, *Imperata cylindrica*, *Holmskioldia sanguine*, *Woodfordia fruticosa* and *Boehmeria glomerulifera* This forest is characterised presence of a good number of climbers such as *Bauhinia vahlii, Tinospora cordifolia*, *Cissampelos pareira*, *Mucuna pruriens*, *Thunbergia fragrans*, *Vitex negundo*. The common herbs include *Commelina benghalensis*, *Cyanodon dactylon*, *Pilea hookeriana*, *P. smilacifolia*, *Elatostema lineolatum*, *Ageratum conyzoides***,** *Oxalis corniculala* , *Urena lobata Triumfetta rhomboidea*. Exotic weeds like *Euptorium odoratum* and *Mikania micrantha* grow profusely in the disturbed forests, while thickets of the tree fern *Cyathea brunoniana* is found in moist shady places.

Temperate vegetation: The temperate vegetation comprises of dense forest that includes areas extending from Kurseong, Tung, Sonada, Darjeeling, Mirik, Sukhia Pokhri, Maneybhanjyang, Rimbick, Lodhama, Kalimpong, Labha, etc. in the Darjeeling Himalaya. The temperate forest occupies most of the region of the Darjeeling Himalaya. The richness of the vegetation is displayed by the presence of the largest number of species and the widest diversity occurring in this region. J. D. Hooker (1896) remarked that the temperate vegetation of this region is roughly divisible into lower non-coniferous and upper coniferous and *Rhododendron* belt, but the line of demarcation between these varies so greatly with the exposure and humidity of the locality that they cannot be dealt apart. Kanai (1963) and Grierson & Long (1983) classified the temperate forest of the region into three subtypes.

Temperate Deciduous forest: This forest type is characterized by the presence of trees like *Betula alnoides, Exbucklandia populnea, Eleocarpus lanceifolius, E. sikkimensis Acer campbellii, A. sikkimensis, Engelhardtia spicata, Lindera neesiana, L. pulcherrima, Prunus napaulensis, Alnus nepalensis, Rhododendron grande, R. arboreum* and *Eurya acuminate* etc.

Evergreen Oak forest: This forest comprises of trees like *Quercus lamellose, Q. lineata, Q. oxydon, Lithocarpus pachyphylla, L. elegans, Acer hookerii, Cinnamomum impressinervium, Eriobotrya petiolata, Eurya acuminata, Pentapanax fragrans, Litsea elongata, Litsea sericea, Juglans regia, Leucosceptrum canum, Lithocarpus pachyphyllus, Poplus ciliata*. Shrubs like *Dichroa fabrifuga, Viburnum erubescence, Jasminum dispermum, Nellia thyrsiflora, Arundinaria maling, Hypericum hookeri, Norysca urala, Notochaete haemosa* with climbers like *Dicentra scandens* , *Edgaria darjeelingensis, Holboellia latifolia, Sechium edule, Smilax ferox, Codonopsis affinis, Streptolirion voluble, Rubia manjith* etc. and herbs like *Achyranthes bidentata, Anaphalis contorta, A.triplinervis, Artemesia japonica, Bidens pilosa, Potentila fulgens, Plantago erosa, Rumex nepalensis, Clinopodium umbrosa, Gallium asperifolium, Swertia chirayita, S.bimaculata, Impatiens arguta, Lysimachia alternifolia, Poulzolzia hirta, Hypoestes triflora, Hemiphragma heterophylla, Erigeron karwinskianus, Fragaria nubicola* to name a few, forming the ground cover.

Cold temperate vegetation: Regions lying above 2400 m usually receive snowfall and remain covered from a few days to few months (usually 3 - 4 months) during the year. As such there is a decrease in the diversity of the arboreal flora. Numerous herbs, many of which are endemic to the region inhabit this region (Hara 1971; Bhujel 1996). The vegetation of this zone can be broadly classified as being of two types:

Mixed temperate forest of the upper hill region: The mixed temperate forest of the upper hill region extends to about 2800 m and comprises of trees like *Brassaiopsis mitis, Quercus lamellosa, Magnolia campbellii, Lithocarpus pachyphyll, Sorbus rhamnoides, Ilex fragilis, Prunus undulate* with climbers *Dicentra paucinerva, Clematis buchaniana, Actinidia strigosa, Smilax glaucophylla, Schisandra grandiflora* and shrubs like *Piptanthus nepalensis, Elsholtzia fructioca, Daphne involucrate, Bistorta amplexicauli, Berberis insignis, Aconogonum campanulatum, Rosa serecia* etc. with herbs like *Arisaema speciosum Fragaria nubicola, Ranunculus diffisus, Viola sikkimensis, Ajuga lobata, Paris polyphylla, Gentiana speciosa, Geranium donianum* , *Pilea anisophylla*, etc. *Arundinaria maling* is found to invade large open areas in the region.

Rhododendron – Hemlock forest: The uppermost tier of the temperate forest is clearly dominated by different species of *Rhododendron* with few patches of other trees. The commonly occurring trees of this sub-region include *Rhododendron arboreum* subsp. *roseum, R. falconeri* , *R. hodgsonii, R. decipiens* Lacaita, *Betula utilis, Abies densa, Tsuga dumosa, Taxus baccata, Acer pectinatum, A.stachyophyllum, Daphnephyllum himalense, Ilex insignis, Larix griffithiana, Picea spinulosa*. Shrubs include *Rosa sericia, Virburnum erubescence, Viburnum nervosum, Ribes* spp. *Mecanopsis napaulensis, Nellia rubiflora, Potentilla fructicosa. Berberis insignis***,** *B.umbellate, Daphne bholua*. Climbers include *Actinidia strigosa, Holboellia latifolia, Aristolochia griffithii, Leptocodon gracilis*. etc. and herbs include *Aconitum spicatum, Aconitum bisma, Fritillaria cirrhosa, Hemiphragma heterophyllum, Valeriana wallichii, Primula capitata, P. denticulata, Gentiana capitata, G. bryoides, G. glabriuscula, Swertia dilatata, S. macrocsperma* etc.

Sub-alpine vegetation: Ranging between 3200 - 4000 m lies the sub alpine region. This region has been categorised by some as alpine region (Biswas 1959, Mitra 1951) while as temperate region by others (Gamble 1875; Kanai 1963). A sharp reduction in the temperature to subzero level during winter with precipitation in form of snow and hail that melts during the summer characterizes the climate of this zone. The common plant species observed in this zone include *Acer acuminatum, Acer caudatum, Abies spectabilis, Cotoneaster frigidus, Salix sikkimensis, S. flabellus, Sorbus microphylla, Viburnum nervosum, Rhododendron cinnabarium, R. campylocarpum, R. campanulatum, Juniperus squamata, J. communis, J. wallichiana* etc. The herbs in the forests and meadows include *Rubus fragarioides* , *Potentilla microphylla, P. monanthes, Primula glabra, P. obliqua, Ranunculus adoxifolius, R. brotherusi, Anemone demissa, Tithymalus sikkimensis, T.stracheyi, Saxifraga hispidua, S. latifolia, Viola biflora, V. cameleo, Pedicularis mollis, P. clarkei, Picrorhiza scrophulariaeflora, Rheum acuminatum* etc.

VIII. Landuse Landcover in Darjeeling Himalaya

During the earlier days Darjeeling hill areas were totally under forest cover. With the establishment of tea gardens and cinchona plantations, lands started to be used for human activities. More than 50 % of the total area was deforested within 1921. Deforestation continued for other uses of land till an apparently stable pattern arose. Current land use pattern is shown in the following Table No. 4. The landuse pattern of the Darjeeling hills reveals the dominance of forests, along with tea gardens and settlements. The present landuse pattern in Darjeeling Himalaya (Fig. No. 7) has however evolved in continuation of the British policies with a very little of the western section of the district coming under agriculture. Settlement density is consequently higher in these areas since no restrictions apply in the regional population that can be supported. Another feature resulting from the settlement vis-à-vis landuse pattern is that land pressure following the growth of population has a highly differential impact on the district.

Table No. 4: Landuse in the Darjeeling Himalaya (2008)

Landuse	Area in hectare	%
Total Geographical Area	289949.77	100.00
Settlements	97864.13	33.75
Forest	110180.88	37.99
Tea Plantations	49927.84	17.22
Cinchona Plantations	5475.75	1.89
Current Fallow	8804.01	3.04
Other Fallow	4009.04	1.38
Net Cropped Area	12419.11	4.28
Others	1269.01	0.44

Source: *Settlement office, Darjeeling*

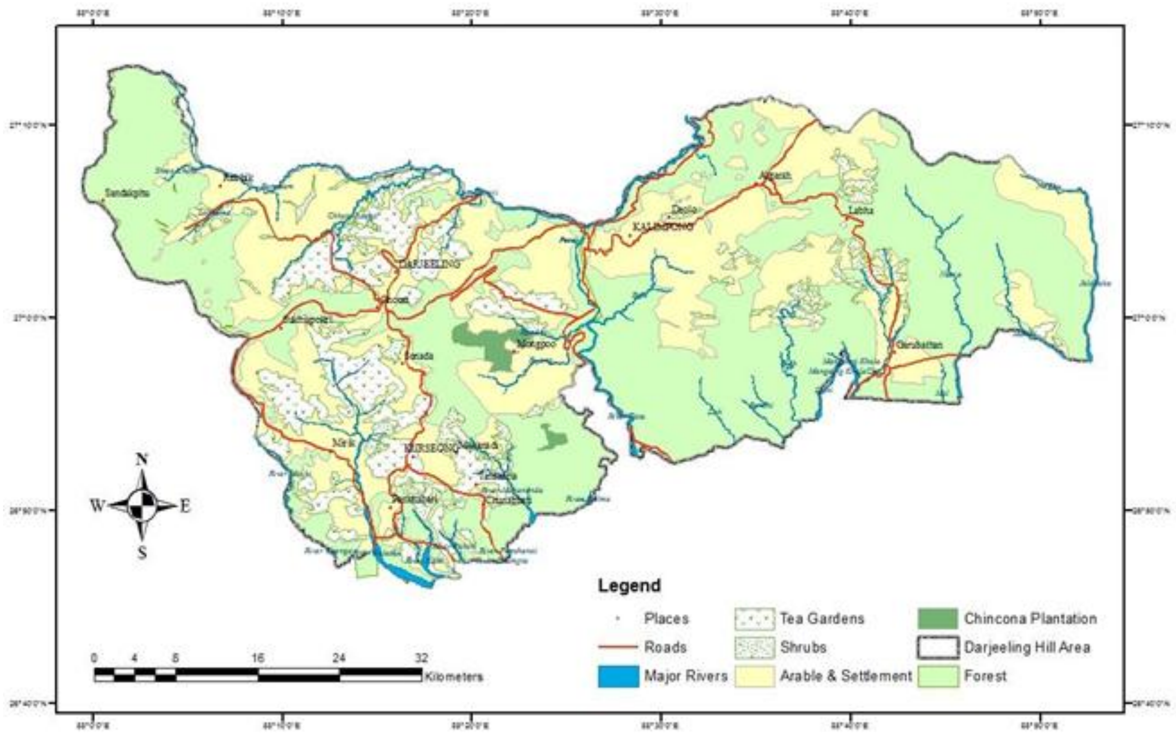

Fig.7: Landuse

Agricultural development in the western regions, blocked by twin constraints on its expansion along the extensive margin by limited access of the population to land since the major part of the area falls either under forests or tea gardens, or by agriculture along the intensive margin being debarred by geographical difficulty and adverse climatic situations. Highest lease-land commitments to tea and lowest to agricultural usage occur correspondingly. To the east, Kalimpong, with generally lower elevations has greater topographic and climatic suitability for rice-maize-millet cropping, while the lower regions in the southern fringes harbour reserve that are conductive to present and future revenue forestry.

IX. Conclusion

India in particular, and the world at large, revere the Himalaya - not just for being a physical feature with immense geo-strategic importance, nor just for being a haven of adventure and sports - or even a home for rare medicinal herbs. Since ages the Himalaya have represented a source of transcendental wisdom for mortals. The unparalled beauty and an aura of sanctity within its realms makes it one of the most important tourist centres, not only in India but throughout the world.Consequently, Darjeeling Himalaya, with its bracing climate, unrivalled scenic beauty, enhanced further by the majestic view of Kanchendzonga and above all, the exquisite taste exhibited by the British, in building the hill resort, commensurate with its physical setting, has resulted in its emergence as the "Queen of All Hill Stations" – attracting tourists, both from within as well as from outside the country.

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IOSR Journal Of Humanities And Social Science (IOSR-JHSS) is UGC approved Journal with Sl. No. 5070, Journal no. 49323.

Dr. Laitpharlang Cajee " Physical Aspects of the Darjeeling Himalaya: Understanding from a Geographical Perspective IOSR Journal Of Humanities And Social Science (IOSR-JHSS). vol. 23 no. 3, 2018, pp. 66-79.