CHAPTER – 1

In a hundred ages of the Gods I could not tell you
of all the glories of the Himalayas.

An old Sanskrit poem.

INTRODUCTION:

'On the northern border of the British district of Darjiling, the main chain of the Himalayas throws out to the southward direction two enormous spurs – the Singalela and Chola ranges. These almost impassable barriers enclose three sides of a gigantic amphitheatre, hewn, as it were out of the Himalaya and sloping down on its southern or open side towards the plains of India. The tract of mountainous country thus shut consists of a tangles 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' as its offshoot. The steps of this amphitheatre make up the territory known as the Independent state of Sikhim (Sukhim or the 'new home'); encircling walls of peaks and passes from the north and east frontier of Tibet, while on the west and south-east it divides Sikkim and Darjiling from Nepal and Dichu forms the boundary between Sikkim and Bhutan. Passing our simile a little further, we may add that the lower levels of Sikhim amphitheatre, the valley of the Tista and Balasan and Mahanandi rivers are similar in character to and virtually form part of our frontier district of Darjiling'.

1.1. HISTORICAL BACKGROUND:

This beautiful and vivid description was made by H.H.Risley in the Introductory Chapter of the Gazetteer of Sikhim (1884) to describe '*Sikhim*' fondly known as ***Nelyan*** or '*place of caves' to* the aborigines and ***Den-jong*** or the '*country of rice and fruits*' to the Tibetans. Dhamala (1970) believes that the Bhutias gave the state the name '*Sikkim'* meaning ' a new home'. The once sovereign state of Sikkim, which lies on the Makinder's and Fawchett's boundary of south Asia in the great Eastern Himalayas between India and Chinese occupied Tibet (Shukla, 1976) was ruled by a king ' the Late Chyogyal', is now the 22nd state of the Indian Union by the thirty-eight Amendment Act, of the Indian Constitution 1975, which came into force with retrospective effect from the 26th. April 1975.

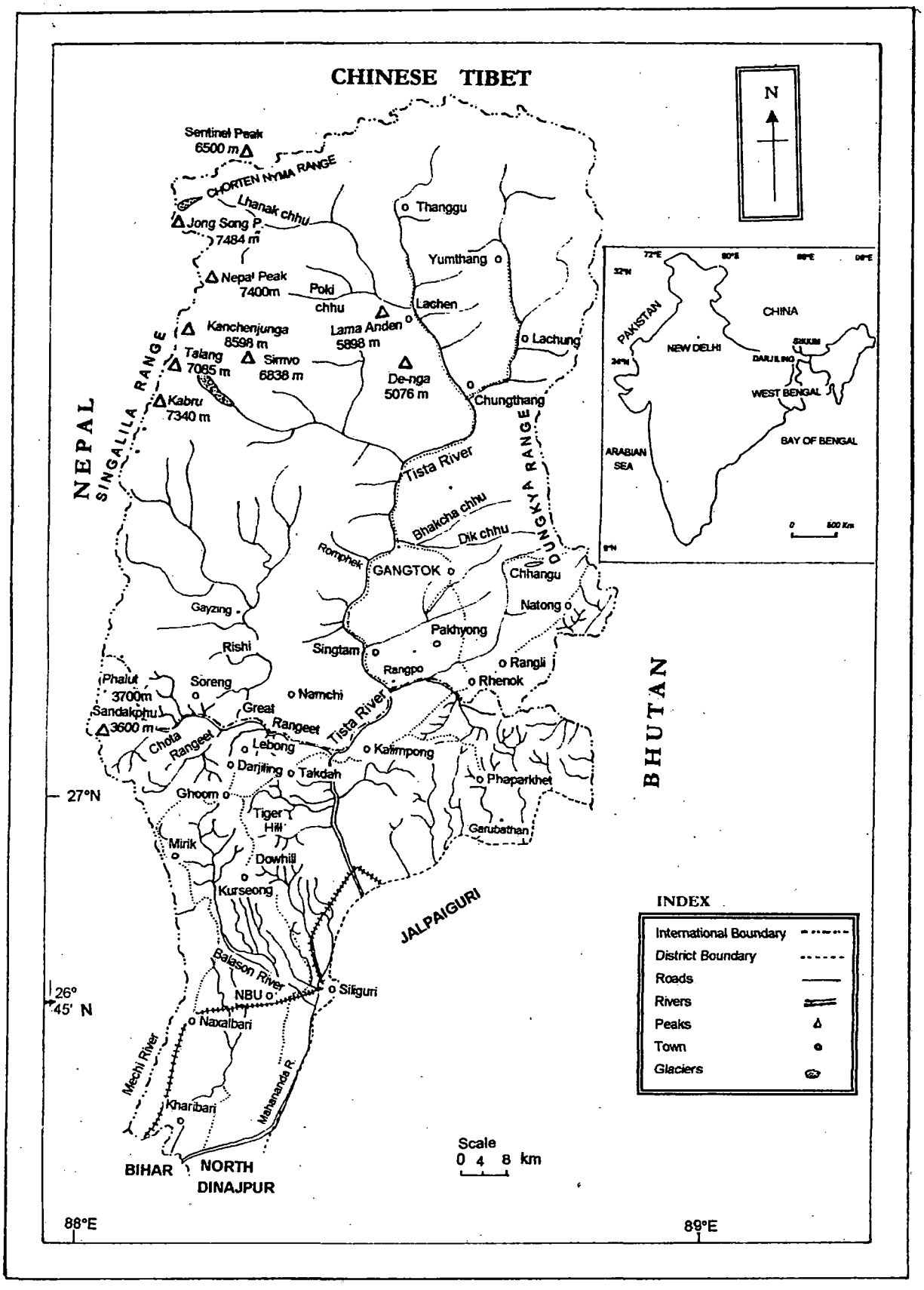
Darjyu Lyang, or 'the *land of God'* or 'heaven earth' is believed to have given Darjeeling (Darjiling, after the 1981 census), the northern most district of the Indian state of West Bengal, its name. It is also believed that the name is a corrupted form of *'Dorjee ling'* of the Lamaist religion, *'**Dorjee**'* the Celestial scepter of double-headed thunderbolt and *'ling'* or the land, and thus, literally means 'the *land of the thunderbolt'* after the famous Buddhist monastery, which stands atop the observatory hill and was known by the same name. It was a part of the sovereign state of Sikkim prior to 1789 A.D. Its creation dates to the 19thcentury through an almost accidental involvement of the British Indian Government in the affairs of Sikkim. The signing of the Sugali treaty between the two countries saw the return of the terai area and Darjiling part of its possession to the British India Government by Nepal. The signing of the Titleya treaty on 10th February 1817, whereby, the British restored this region to the King of Sikkim making it a buffer state 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 Darjiling 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 ceeded to the British Empire by the Sinchula treaty of November 10th, 1865 by the Government of Bhutan on a lease basis and was then notified as a subdivision of Dooars to be transferred to Darjiling in 1866. Since then, though the district has retained its geographical dimensions its administrative placement has kept on changing and its final annexure to the state of West Bengal was and automatic incident in 1947. The three hilly subdivisions of the district are now under the administrative purview of the Darjiling Gorkha Hill Council that came into effect on 22nd August 1988.

1.2. LOCATION:

The contiguous Darjiling and Sikkim Himalayas lie in between 26^0 31' to 28^0 07' N and 87^0 59' to 89^0 E longitudes has an area of 9020 sq. km. Lying between and 31^0 30' to 27.5^0 N latitudes 88^0 30' to 89^0 30' E longitude, Sikkim is located on the Makinder's and Fawchett's boundary of South Asia in the great Eastern Himalaya between India and Chinese occupied Tibet and is thus of great strategic importance. (Shukla, 1976) It has a rectangular outline that extends 112 km north to south and 64 km west to east it covers an area of 7696 sq km, (Surveyor General of India 1975) with a population of 4,06,457 (Shresta, 1991). It is bounded in the north and northeast near about 165 km by the vast Tibetan plateau, and shares a 90 km long border with Nepal in the west. In the east it is bounded by Bhutan and Chumbi valley of Chinese occupied Tibet with the southern boundary with the district of Darjiling in the state of West Bengal being about 45 km. On the other hand the district of Darjiling, lies between 26^0 30'05" to 26^0 27'10" N and 88^0 53' to 87^0 59'30" E longitudes has an area of over 3254.7 sq km appears as an inverted wedge. Of all the frontier districts of India, Darjiling has the most complicated boundaries. It shares its boundaries with international frontiers, with Nepal in the west and Bhutan towards the east; the River Teesta forms its northern border with the state of Sikkim with its southern border being with the districts of Jalpaiguri of West Bengal and Purnea of the state of Bihar. The borders of Nepal, Sikkim and Darjiling meet at the peak of Phalut (3700m) forming a tri-junction with a similar tri-junction at Rachela (Tinsimana, 3100m) between the subdivision of Kalimpong, Sikkim and Bhutan from where the river Jaldhaka flows down separating the countries of Bhutan and India. Excluding a part of the Siliguiri subdivision the District of Darjiling and the state of Sikkim are exclusively mountainous with the altitudinal range of Darjiling varying from ca. 132 m at Sukna to 3700m at Phalut and that of Sikkim covering a

Fig. 1.1. MAP OF DARJILING AND SIKKIM (THE STUDY AREA) SHOWING THE LOCATION OF SOME OF THE IMPORTANT PLACES AND THE COURSES OF DIFFERENT RIVERS AND STREAMS.



wider range of ca 180 m at Jorethang to 8598m at the summit of the third highest peak of the world mount Kanchenjungha.

Accessibility to the Darjiling and Sikkim is offered from the southern part only, through the districts of Jalpaiguri, North Dinajpur and Purnea district of Bihar and the plains of Nepal across the River Mechi. (Fig 1.1. shows the location map of the study area Plate 1.1 shows some of the locations in the study area).

1.3. ADMINISTRATIVE DIVISIONS:

The Darjiling–Sikkim Himalaya though a contiguous part of the Eastern Himalaya and though historically Darjiling was a part of the sovereign state of Sikkim, it is now a District of the state of West Bengal and thus remains separated by a politically demarcated boundary. While, the State of Sikkim is divided into four districts for administrative purposes, the district of Darjiling of the state of West Bengal has been divided into four major subdivisions.

The four districts of Sikkim are the East, West, North and the South Districts with no tehsil or taluk below the district level. The East District covering an area of 954 sq km it the most populous region having a population density of 185 persons/ km^2 with its district headquarter located at Gangtok, which is the main town and also the state capital. The North, West and South districts with areas of 4226 sq km, 1166 sq km and 750 sq km have a population density of 7, 83 and 133 persons / km^2, with their district head quarters located at Mangan, Namchi and Gyalsing respectively. According to the available data the distribution of the population in the state was 43.64% of the total in the East District (with a total of 761145), 7.72% in the North District (with a total of 31143), 23.99% for the West District (with a total of 98828) and 24.65% in the South Districts (with a total of 49496) (Shrestha 1991). The name of the other important towns include Chungthang, Lachung, Donkhong in the North, Singtam, Rangpo, Pakyong, Rhenok Sherathang Kupup in the East, Nayabazar, Kaluk, Uttarey, Yoksum, Dentam, Legship, Soreng in the West and Namthang, Jorethang Ravangla, Melli Temi in the South. The northernmost parts of Sikkim situated at high altitudes remain permanently covered with snow and is inhospitable and thus is thinly populated with widely isolated patches. The southern district is open fairly populated and an important agricultural centre of the state.

Darjiling, Kalimpong, Kurseong and Siliguiri sub-divisions constituting the northernmost district of the state of West Bengal occupying only an area of 3149 km^2 which is about 3.55 % of the total area of the state. The seven major municipal towns of the Darjiling district are Darjiling,

Kurseong, Kalimpong, Cart Road town, Uttar Bagdogra, Jaldhaka Hydel Project town and Siliguri (Census 1981). The distribution of the population in the four sub-divisions according to the 1981 census was 27.47% (2,81346) for Darjiling sub-division with the density / km^2 being 300.74; 15.50% for Kalimpong sub-division (1,58726) with the density per sq. km being 150.24; Kurseong 10.87%, the density being 261.70 and Siliguri sub-division having 46.17% (4,72895) with the density being 564.72. Thus, the entire district remains highly populated with the density being the least in Kalimpong sub-division, which chiefly comprise of large agricultural holdings and the highest in Siliguri, which is the largest metropolis and a major business centre.

1.4.TOPOGRAPHY AND GENERAL FEATURES:

1.4.1. TOPOGRAPHY

The Darjiling Sikkim Himalayas is essentially mountainous with the elevation towards the northern direction. Two transverse ranges running north south enclose it. They are the Singalila in the west and Dongkya in the east. In this part the great Himalayan range runs from Kanchenjunga (8598m) in the west to Chomolhari (7324m) in the east, which lies near the northern border of Sikkim with the Chumbi valley that forms a part of Tibet. The hills of Darjiling are the spurs of the Singalila range that stretches from Mt. Ghosla (3800) m in Sikkim and enters the district near Phalut. The highest points Sandakphu and Tonglu of the district after Phalut (3700m) are the continuation of the Ghosla-Phalut ridge. The Rechila and Thumsum peaks of the Kalimpong subdivision of the district lie on the eastern ridge and spreading from Lava. The Ghosla Phalut ridge enters the Tiger Hill node from where four ridges major radiate out along the four directions (Banerjee 1980; Das 1986; Bhujel 1996). *viz.* Darjiling ridge North which extends to Lebong through Jalapahar, Birch Hill and descends to the River Rangeet at Badamtam; the Takdah spur to the east spreads down to the Teesta Bazar; the Dow Hill ridge which is long and forms numerous spurs tolls down to the plains of Darjiling and Jalpaiguri district.

The northern border of Sikkim contain many important passes viz. Chorten, Nyima la, Naku la, Kongra la, Chulug la, Bom Chho la, Sese la. These passes link northern Sikkim with Tibet. The Khungyami la, Gora la, Nathu la, Jeelap la and Batan la link east Sikkim with the Chumbi valley of Tibet. From the very beginning Nathu la and Jeelap la are strategically important to both India and China. The Pako la pass links south-east Sikkim with Bhutan.The important peak of North Sikkim include Jousa peak, Lhonal peak, Chorten Nyima, Chawl, Chalaumakhang, Chomogam, Chhando, Khongjakiana, Pauhanari Nachego, Toagchu Kang, Chanking Gong and Simgupcheri.

The highest portion of Sikkim is in the northwest. A number of peaks over 7000 m occur in this region along with Kanchenjunga (8598m) the third tallest peak in the Himalayas, which is revered by the people of Sikkim. The western boundary with Nepal is separated by the Singalila range, which has many peaks and includes peaks like Lamgpo, pyramid tent, Goeha and the forked peak. Sikkim is connected to Nepal in the west through passes like Khanga la and the Uttare pass. The magnificent mountains bordering Nepal and Sikkim are Talung, Kabru, Kokteng, Daia la, Pang Merong, Lampharam, Bajen dada, Lonngjong, Pandechu, Simale chu with numerous glaciers descending from the eastern slopes of Kanchenjunga.

The southeast border of Sikkim with Bhutan is almost mountainous with Gylmochen being the important peak. The total Sikkim-Bhutan boundary is located on the Poungola range from north to south. Darjiling and the Teesta River bound the southern part with tributaries like Ranghong, Ranjeet, and Rishi. Geographically the catchments area of the Teesta river and all its different tributaries as far as the northern plains of West Bengal including the entire area of Darjiling hills form a wedge between Bhutan, Nepal and Tibet.

1.4.2. RIVERS AND 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 Darjiling and Sikkim 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 Darjiling 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 Gail khola constitutes its main tributaries on the right bank after its entry into the District of Darjiling. 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 Darjiling at the point on the northern boundary where it receives the Ramam river arising from Singalila and Rangu arising from Senchal in Darjiling on its right bank. Below the confluence the Teesta flows eastwards where it receives the Little Rangit form

Darjiling form where it enters the plains of North Bengal and finally joins the river Brahmaputra in Bangladesh.

The other important rivers of Darjiling include the Balason arising from the Ghoom saddle running south till it reaches the plains at an altitude of 304.8m 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 Dime 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 Teesta and Jaldhakha form the western and eastern boundaries of the sub-division of Kalimpong. A number of rivers and tributaries originate in this sub-division the principal ones 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.

The Gish if formed by the joining of two small rivulets, one originating below Lava 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 Lava-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. A number of hot springs are located in Sikkim the most important ones being Phut Sachu, Ralong Sachu, Yumthang and Momay (Chopra 1985).

1.5. GEOLOGY AND SOIL:

1.5.1. GEOLOGY

Nature has a way of writing her own history in her rocks. Indeed, the geological history of any region is a record of all the ancient changes or events geographical, climatic and pertaining to

its life that it has undergone or witnessed. Geographically, the Sikkim-Darjiling Himalaya is wedged between Central Nepal Himalaya to the west and the Bhutan Himalaya in the east.

Geological investigation of this region began as far back in 1854 where Hooker in his famous 'Himalayan Journals' reported regional gneissic domes, the overlying bedded sedimentary rocks and crinoidal limestones at the Tso Lhamo Lake during his extensive travels in many parts of Sikkim. An excellent account of the geology of the Darjiling district and its foothills has been made by Mallet (1875). Bose (1890,1891) compiled the mineral resources of Sikkim and Garwood, working on similar lines, presented the first general map of Sikkim in 1903. Northeastern Sikkim is included in Hayden's traverse to Lasha (1907) and von Loczy published a geological section from Darjiling to Kanchendzonga, which he observed as far back as 1878 (Gansser1964). Other notable works on the geology of the region include those made by workers like Dyhrenfurth (1931), Wager (1934,1939), Auden (1935), Wadia (1957), Roy (1945), Acharya (1968), Powde & Saha, (1982).

The Himalayan region is believed to be old geosynclines that were once occupied by a long arm of the sea called Tethys. A series of upheavals led to the elevation of the ancient sea of Tethys that led to the accumulation of the various sediments. The upheaval of the mountains is not a continuous process; it took place in four successive stages separated from each other by long intervals of time. The first upheaval took place in the Upper Eocene period, resulting in the breaking up of the continuity of the sea basin into smaller areas of sedimentation. The second upheaval of the Middle Miocene led to longitudinal depressions on the southern side where the succeeding Siwalik sediments were laid down. The third phase of Himalayan orogeny, during the Upper Pliocene period, gave rise to the present day Siwalik hills and the fourth that commenced in the Pleistocene led to the alluvial deposits being pushed up to their existing heights. This phase continues and the mountains are still believed to be getting higher as a result. The geological formations of Darjiling Sikkim Himalayas consist of unaltered sedimentary rocks. Morphologically the area is well defined. The sub-Himalayas are made up of Siwalik deposits of the Tertiary age. North of the Siwaliks is coal bearing lower Gondwana formations comparable to the Damudas of Peninsular India. The Darjiling gneiss succeeds the Pre-Cambrian Dalings that lie further north.

1.5.1.1. GEOLOGICAL FORMATIONS IN CHRONOLOGICAL ORDER:

a. Darjiling- Sikkim Sub-Himalayas

The Terai and the plains at the foothills (given in their present form) that arose after the final upheaval of the mountain system consist of almost horizontal layers of unconsolidated sand silt,

pebbles ad gravel. The Sikkim Himalayas are noteworthy for the abundance of sub-recent and recent alluvial terraces, which clearly display the last tectonic displacement. The raised terraces of the Pleistocene are made up of similar but well cemented and more compact alluvium detritus and sands, clay, gravel, pebbles, boulders etc. representing older flood plain deposits.

The Sub-Himalayas are made up of the Siwalik deposits of Tertiary that extend from Nepal, to as far as 20 km. east of the Teesta River. Further east, they disappear for about 10 km, and appear once again and finally disappear in Western Bhutan at the Jaldhaka River valley (Mallet, 1875; Pilgrim, 1906). Good Siwalik exposures are met along the River Teesta. The deepest outcrops, forming the southern margins of the Siwaliks, consist of bluish grey nodular marls and clays with micaceous fine-grained sandstones. There is great discrepancy in boulder sizes in the recent alluvial deposits as compared to the small pebbles embedded in the Upper Siwaliks, which supports the concept of very pronounced young morphogenic uplift of the Himalayas.

b. Darjiling- Sikkim Lower Himalayas

Along the foothills of Darjiling and south Sikkim, the Siwaliks is steeply over-thrust by formations belonging to the Damudas (Lower Gondwanas) the thrust zone, which is poorly exposed, appear to dip at 60-70° towards the North. This thrust fault coincides with the well-known Main boundary faults, which extends for the whole length-distance along the Himalayas. The Damudas are characteristic coal-bearing detritus rocks, containing fossil flora indicating a Lower Gondwana age. The predominant rocks are feldspathic, partly micaceous brownish sandstones, and shaly micaceous sandstones often with plant impressions, carbonaceous shales and coal seams. It appears that the Damudas are a tectonized relic where the presence of boulder beds suggests Lower Damudas or Barakars formation, while the flora and lithology of the coal bearing layers points to the Upper Damudas or Raniganj formation.

Northwards, the Damudas 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 Dalings, a term coined by Mallet, consists typically of greenish greasy-feeling clay slates to more or less green quartzite schist. Slaty and quartizitic layers often alternate, but the argillaceous type dominates. The Dalings are remarkable for their constant and monotonous lithology over a great thickness, characteristically representing the late Precambrain and early Cambrain sequence. The Dalings are well developed along the lower and middle course of the Teesta and form the over 50 km long core of the large north-south directed domal uplift dominating the Sikkim area.

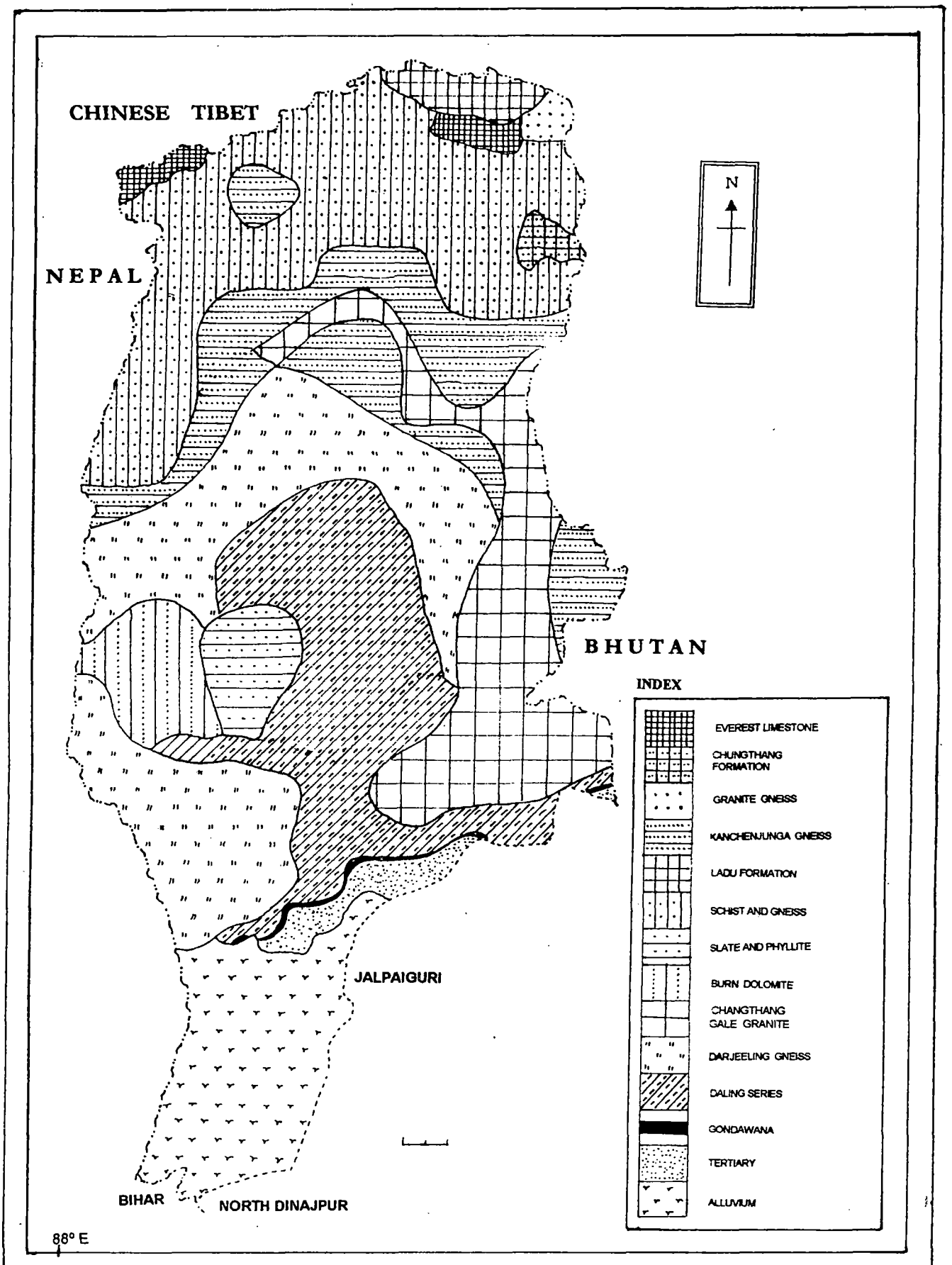
In the higher reaches of the hills the coarse grained quartzo-feldspathic Darjiling gneiss occupies a greater part of the region. The gneiss is highly micaceous and is composed of colourless or grey quartz, white opaque feldspar, muscovite and biotite. It often varies from fine grained to moderately grained coarse rock; lenticular layers of minerals of different degrees of coarseness are commonly interbanded with bands and lenses of pegmatite and aplite.

c. Sikkim Upper Himalayas

The Darjiling gneiss, surrounding the Teesta dome on its west, north and east can be followed into the Higher Himalayas of Sikkim. Towards northwest, they form the Kanchenjunga syncline. All the impressive peaks in Sikkim and further north show regional dips to the north, northeast or northwest. Kanchenjunga consists entirely of crystalline rocks in which thick-bedded augen gneisses of granitic origin dominate. They alternate with dark biotite west dipping gneisses. The light coloured granitic augen gneisses consist of porphyrolbastic orthoclase, as more or less stretched augens. Bands of silicate lime occur about 15 km. south of Kanchenjunga on the west face of Pandim Peak. Further north, calcareous sediments cover the gneisses and Dodang Nyima peaks.

Towards northeastern Sikkim, Auden (1935) distinguished a wide basin like zone of biotite-augen gneisses underlain by Para gneiss and schist giving them a banded appearance. On the southern faces at Sebo-chu sills, dykes and smaller masses of white fine-grained tourmaline granites occur. In the headwaters of the Lachen river (the northern continuation of the Teesta river) lies the Tso Lhamo. This locality and nearby Lachi hills became famous after the report of fossiliferous limestones by Hooker (1854). Quartzites, silts and shales, followed by a thin limestone band with corals and small gastropods, c erlie these limestones. Relatively rare pebbles of ungraded angular quartz with feldspar, serilite paste and mica occur belonging to Lachi series. Beyond this series are sandstones with plant remains (referred to as the Tso Lhamo series by Auden, 1935). It lies between the Gondwana rocks and the widespread Jurassic deposits of Tibet. West of the Phari plain lies the unfossiliferous formation which Hayden (1908) referred to as the Khombu series. Here the Khongbu pelites overlie the gneisses. Close to Phari Dzong, lies the Chumbi valley basin where the southernmost outcrop of the Tibetan Tethys sedimentary rocks are stretched along the Himalayan range coincides with the section of the Himalayas, where the Tibetan territory reaches furthest towards the Indian plains. (Fig. 1.2. shows the Geological map of the Darjiling-Sikkim Himalaya)

Fig. 1.3. GEOLOGICAL MAP OF THE DARJILING DISTRICT AND SIKKIM



1.5.2. SOIL

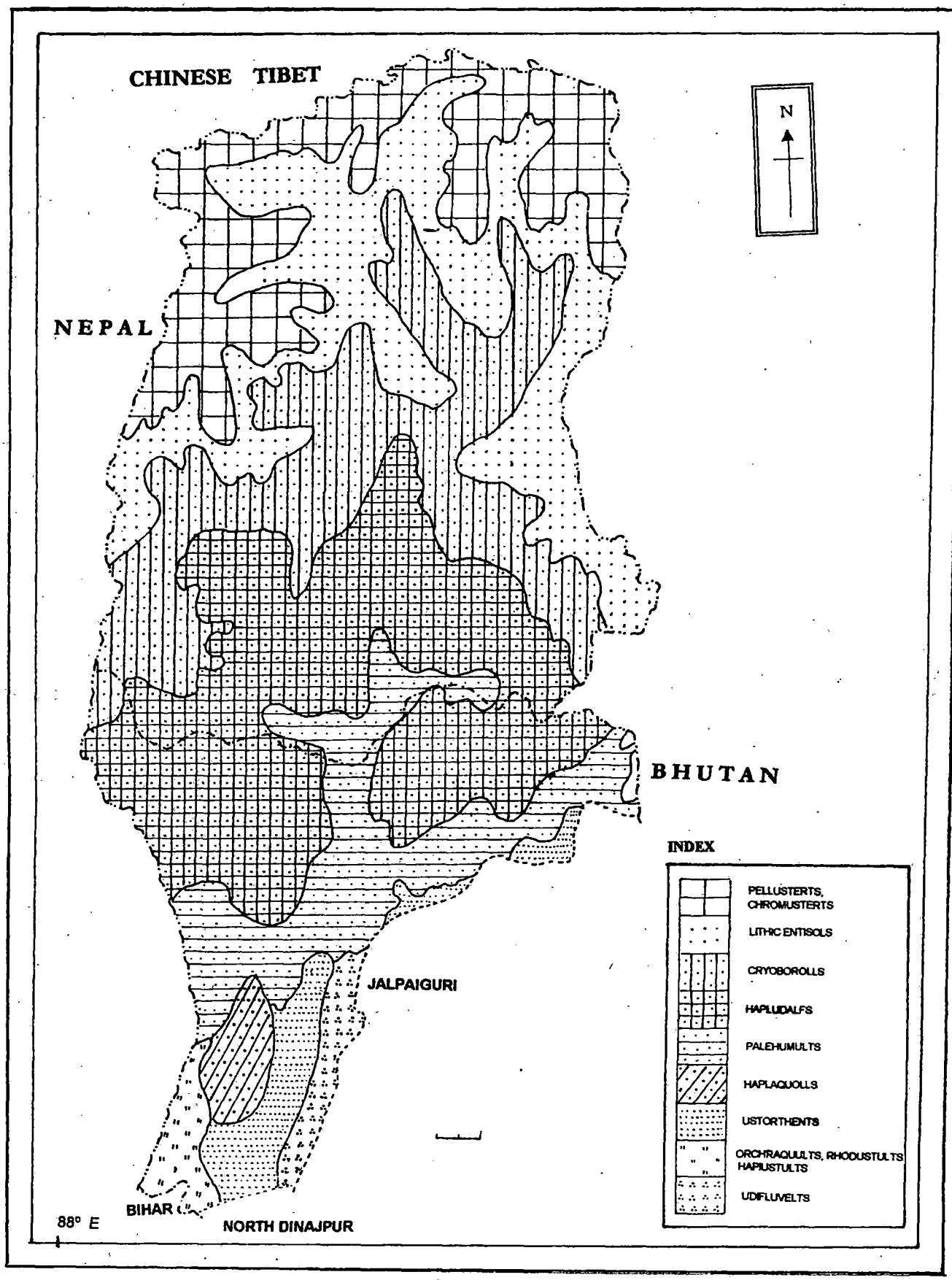
The Darjiling–Sikkim Himalayas enjoy a wide range of physiography, geology and vegetation that influence the formation of different kings of soils (Planning Commission 1981). In accordance with the physiographic sequence and terrain features soil of Darjiling Sikkim Himalayas is represented with 5 orders. The lower reaches comprise of the ultisols of the palehumultus group and comprises of red, brown and yellow soil with coarse texture. Further north the ultisols give way to the alfisols of the hapludalfs or submontane type. The alfisols are followed by the mollisols comprising or three suborders udolls, argiudolls and hapludolls occupies the steeper slopes under the temperate forests. The entisols with four sub orders arents, psamments, fluvents and orthents occur further to the north and the inceptisols with two sub-orders orchrepts and umbrepts make up the northern most part of the region. The depth of the soil vary from 0-100 cm in different regions, with texture varying from fine sandy, loamy to sandy.

The pH of the soil of the region is acidic due to heavy rainfall the region experiences leading to the leaching of bases from the soil surfaces to low horizons .The pH ranges from being slightly acidic between 5.6-6.5 in some parts with the major portion showing highly acidic soil with pH below 5.5. Almost everywhere the soil are derived from weathering of underlying rocks. The impervious clay is found mixed with the grains of quartz, feldspar and flakes of mica. This has a bearing to the massive landslips in the hilly regions. One of the major environmental problems of the region relates to its soil degradation. According to Dent (1984), the Himalaya is the most severely degraded region of the world. The weak and unstable geology along with monsoonal type of per humid climate and undulating terrain with diversified landforms are some of the natural processes helping soil degradation in Sikkim and other north eastern States (Patiram and Bhaduria 1995). This has been aggravated due to the pressure of the increasing population on land. (Fig. 1.3. shows the Soil map of the Darjiling-Sikkim Himalaya)

1.6 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 the Asian continent 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 Darjiling-Sikkim Himalayan shows its own climatic peculiarities caused by its geographical location, relief and a wide range of altitudinal variations

Fig. 1.2. SOIL MAP OF THE DARJILING DISTRICT AND SIKKIM



ranging from 300m to 8598m above sea level. It exhibits a typical monsoon climate, with wet summer and dry winter. 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 location of the region is located within the sub-tropical climatic regime it mountainous configuration has led to varied climates ranging from the subtropical to the temperate, alpine and even artic type. Thus, based upon the elevation the region shows four distinct climatic zones, viz. tropical, temperate, sub-alpine and cold deserts in the snowy north. This variation is responsible for the creation of the various types of vegetation and also in bringing about great biological diversity. Four climatic seasons can be recognized within the region (a) monsoon or rainy Season, (b) autumn, (C) winter, and (d) summer (spring). Spring and summer cannot be differentiated. Choudhury (1998), classified the climate of the region into six types based one of the most important single factor which is the altitude.

a. **Tropical Humid type:** The lower ridges of this region lying up to 800m experience high humidity and temperature. The rainfall remains high with very hot summers and warm winters. The terai of the Darjiling district and Jorethang in Sikkim experience such climate.

b. **Sub-tropical Humid type:** Areas lying between 800-1600m experiences a humid sub-tropical type of climate. The summers are hot and winters cool. The humid period is long extending from April to September with heavy rainfall during the monsoon. The lower reaches of the foot hills of the entire region exhibits this climate.

c. **Semi-temperate type:** In between 1600-2400m the summers are moderate and the winters generally dry and temperature falling below the freezing point only on a few days. The annual rainfall is very high about 3500mm with the rainfall being heaviest during the monsoons i.e. usually between June to August.

d. **Temperate type:** Slopes lying between 2400m-3200m show this type of climate where the summers are never hot with the temperature rarely exceeding 18 C°. The annual temperature in the valleys of north Sikkim such as Lachen and Lachung and Bakhim to Tshoka in the west and Bikhay bhanjyang in Darjiling experience an annual temperature do

not go over 17 C°. Rainfall is much lesser than the semi temperate type rarely exceeding 1700 mm annually. The winters are very cold and snowing is common with frosting being common at nights for most parts of the year.

e. **Alpine Snow forest type:** This type of climate is experienced between 3200-4000m. The temperature remains low for more than five months of the year with extremely cold winters. Rainfall begins from the end of May and usually continues till September. Precipitation if form of snow and slit is common in winter decreasing as one moves towards the north. Major part of this region is uninhabited due to harsh climate and includes places like Phalut in Darjiling, Yumthang and Tangu in North Sikkim and Dzongri, Thangsing and Samity in west Sikkim.

f. **Alpine Meadow or Tundra type:** The peripheral region of the snow capped areas in the extreme northern eastern and western sections of Sikkim experience this type of climate where the altitude is above 4000m. Air temperatures are very low often falling below freezing point. This coupled with low atmospheric pressure making living uncomfortable. Summer is short, barely three months in duration.

g. **Artic type:** The extreme northwestern part of the Sikkim where peaks soar over 6000m like Kabru, Talung, Kanchenjunga, Josang, Siniolchu fall under this category. Temperatures normally remain below freezing with precipitation in the form of slits and snow.

1.6.1.1. 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 Darjiling Sikkim region 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.

Variations in the degree of rainfall occur along the Teesta valley in mountainous slope of Sikkim. The whole state is a land of mountain crests. It 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-shoots (Risley 1989). Another more striking features of the state are the peculiar V-shaped valleys with steep and often precipitous slopes. The peculiar configurations of the mountainous region bring sharp changes in the rainfall. The rainfalls recorded from different locations are provided below in Tables: 1.1(a)-1.1(d).

Table 1.1. (a) Rainfall data of Darjiling sub-division from 1995-2000.
Rainfall in mm (Darjiling 2150 m.)

Years / Months	1995	1996	1997	1998	1999	2000	Average
January	29.4	52.3	26.7	-	9.2	-	19.6
February	14.5	5.4	15.9	5.5	0	22.6	10.65
March	25	41.8	15.9	125	3.6	15	37.72
April	33.2	81.9	146.4	220.6	31.9	139.6	108.93
May	130.8	74.9	116.1	110.3	253.2	319.4	167.45
June	597.4	464.1	462.6	352.1	863	474.4	535.60
July	846.3	585.7	571.1	1071.7	731.9	507.8	719.08
August	499.9	671.2	689.7	807.4	895.6	608.1	695.32
September	413.1	337	468.7	449.4	393.4	499.7	426.88
October	26.6	92	5.5	87.8	243.2	14.5	78.27
November	279	-	1.3	7.5	1.7	8.2	49.62
December	20.5	-	89	-	7.5	-	19.50
TOTAL	**2915.7**	**2406.3**	**2608.9**	**3237.3**	**3434.2**	**2609.3**	**2868.617**

(Source: Office of the Principal Agricultural Officer, DARJILING: 2150 m.)

Table 1.1. (b) Rainfall data of Kalimpong sub-division from 1995-2000.
Rainfall in mm (Kalimpong 975 m.)

Years / Months	1995	1996	1997	1998	1999	2000	Average
January	40.07	15.86	19.21	0.00	12.49	5.55	15.53
February	9.91	2.23	18.22	4.21	0.00	18.64	8.87
March	0.00	68.14	58.92	63.89	8.63	5.67	34.21
April	24.02	69.52	22.32	92.51	32.71	58.91	50.00
May	63.63	80.64	249.82	105.82	87.32	69.83	109.51
June	376.12	282.84	698.53	578.53	355.38	763.82	509.20
July	641.21	590.03	394.27	812.54	698.67	471.67	601.40
August	325.02	493.71	294.87	526.43	439.32	359.19	406.42
September	363.24	159.02	248.73	206.3	273.81	228.27	246.56
October	1.01	64.71	23.51	91.71	131.76	44.51	59.54
November	96.53	0	0	5.34	31.23	3.58	22.78
December	16.56	0	47.54	0	2.98	0	11.18
TOTAL	**1957.32**	**1826.7**	**2075.94**	**2487.28**	**2074.3**	**2029.64**	**2075.20**

(Source: Regional Sericulture Research station, 7th Mile Kalimpong 975m.)

Table 1.1. (c) Rainfall data of Kurseong sub-division from 1995-2000.
Rainfall in mm (Kurseong 1480m.)

Years / Months	1995	1996	1997	1998	1999	2000	Average
January	26.71	46.42	22.81	0.54	13.21	7.47	19.53
February	28.92	7.84	15.42	18.31	0	17.62	14.69
March	36.8	20.43	80.31	136.12	57.44	8.12	56.54
April	38.12	75.16	78.74	145.27	29.78	374.12	123.53
May	335.12	109.27	180.37	213.91	408.21	385.63	272.09
June	947.53	1044.29	671.21	694.42	867.42	921.97	857.81
July	1093.52	923.84	1064.76	1432.31	1084.31	1120.39	1119.86
August	749.24	1003.31	964.71	847.82	1119.91	598.72	880.62
September	747.26	725.97	493.5	658.18	596.42	517.43	623.13
October	70.31	108.98	8.63	84.12	192.37	17.88	80.38
November	92.23	23.67	5.13	17.52	22.34	14.23	29.19
December	233.61	2.21	655.51	4.89	4.67	0	150.15
TOTAL	**4399.37**	**4091.39**	**4241.1**	**4253.41**	**4396.08**	**3983.58**	**4227.49**

(Source: Office of the Mont Eviot Tea garden, Kurseong 1480m.)

Table 1.1. (d) Rainfall data for different stations for four districts of Sikkim.
Rainfall in mm .

Months / Stations with altitude	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Lachen (N*) 2697 m	52.7	54.3	143.2	98.2	161.2	241.7	245.4	270.2	229.2	112.1	74.5	19.2	1701.9
Geyzing (W*) 1524 m	24.7	24.4	56.0	105.0	181.2	392.3	563.6	480.2	380.6	148.3	23.0	10.0	2389.3
Gangtok (E*) 1818 m	39.6	57.7	130.4	255.3	500.7	629.0	652.5	594.4	411.9	155.2	45.9	20.9	3493.5
Damthang (S*) 1981 m	16.1	29.5	33.6	94.8	232.3	369.0	605.8	418.8	269.5	104.9	15.9	6.8	2197.0

(N* = North District, S*= South District; E = East District and S* = South District)

Source: Sikkim A Statistical Profile (1979-80 & 1991-92)

Fig. 1.4. Monthly Average Rainfall of the three hill sub-divisions of Darjling district.

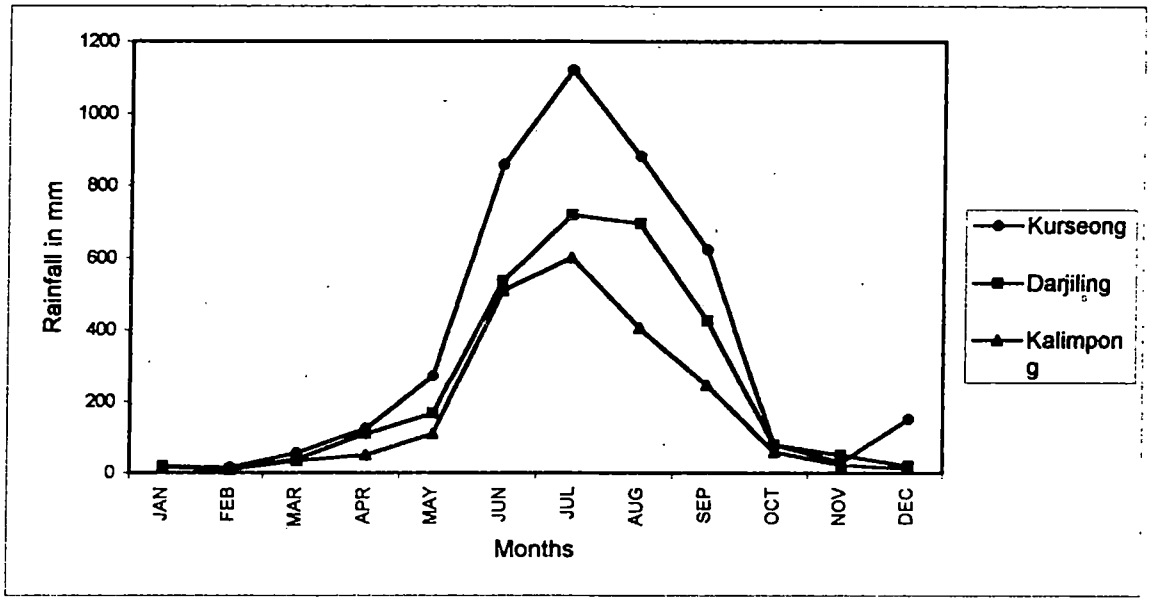
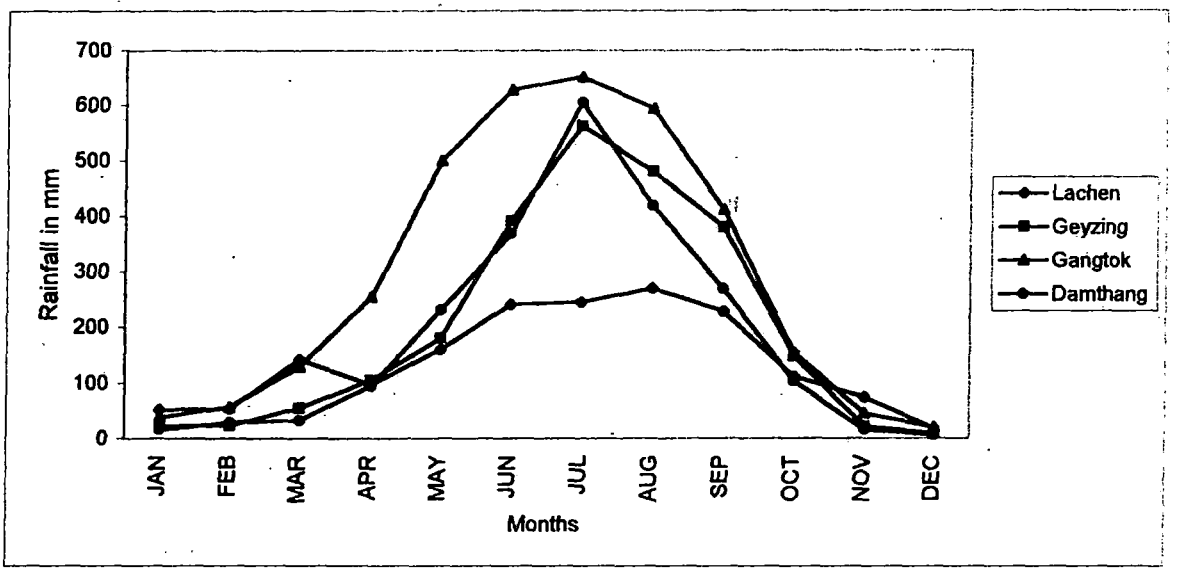


Fig. 1.5. Monthly Average Rainfall of the four locations of Sikkim



For the district of Darjiling the highest rainfall occurs at Kurseong the south facing town with an annual rainfall of exceeding 4000 mm followed by Darjiling 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 to February with occasional moderate showers during March to 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.

1.6.1.2. TEMPERATURE

The temperature of the Darjiling-Sikkim Himalayas district shows a great degree of variation with the altitude of the place being the most important factor. In the upper hilly regions the temperature (day and night) remains higher during rainy season than in the summer and spring while the range of fluctuation of temperature between the day and night is higher in the plains of Siliguri and terai region remains hot or warm till the withdrawal of southwest monsoon (from the month of November) and then the temperature falls rapidly throughout the region. This variation widely affects the vegetation of the region. Table 1.2. (a)-1.2(c) shows the detailed month-wise temperature record of Darjiling (2150m), Kurseong (1480m) and Kalimpong (972m) from 1995-200 and 1.2(d) the temperatures some of the regions of Sikkim. In the regions above the snowline the temperature remains at sub-zero level. Normally January is the coldest month and the daily temperature at Darjiling, Sonada and Labha often going down below 0°C.

Table 1.2. (a) Temperature data of Darjiling sub-division from 1995-2000. (Monthly Average) Temperature °C (Darjiling 2150 m.)

Years	1995		1996		1997		1998		1999		2000		AVERAGE	
Months	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
January	10.0	2.7	8.9	1.5	9.8	2.7	11.3	2.7	14.0	2.7	12.3	2.1	11.0	2.4
February	11.5	5.2	13.2	4.9	8.6	2.4	13.8	5.6	16.8	6.3	9.6	2.1	12.2	4.41
March	15.6	8.0	16.9	8.2	15.7	9.3	13.9	6.5	18.0	8.4	15.3	5.2	15.9	7.6
April	20.4	11.9	20.5	10.1	16.4	9.2	19.4	10.7	21.7	12.0	18.0	7.5	19.4	10.2
May	22.0	13.7	20.8	11.4	20.1	12.1	20.2	12.8	18.7	11.2	19.7	9.8	20.2	11.8
June	20.2	15.3	20.2	13.7	20.4	13.5	20.7	15.2	20.4	13.2	20.3	12.1	20.3	13.8
July	19.9	15.9	19.9	15.4	20.2	15.4	18.8	15.0	19.3	14.3	19.2	12.5	19.5	14.7
August	20.6	15.7	20.5	15.2	20.2	15.6	18.5	14.9	19.1	14.6	20.2	13.5	19.8	14.9
September	19.0	14.7	19.9	14.8	18.9	14.0	19.7	15.0	19.4	14.2	19.5	12.9	19.4	14.2
October	19.8	11.3	19.1	11.8	18.1	10.0	18.9	12.9	19.1	11.9	20.0	11.1	19.1	11.5
November	17.4	8.1	16.7	7.7	16.3	7.1	18.7	8.5	18.7	8.4	17.1	7.5	17.4	7.8
December	10.7	3.2	14.5	5.3	12.8	3.9	17.1	5.4	15.7	4.6	15.8	4.8	14.4	4.5

(Source: Office of the Principal Agricultural Officer, DARJILING: 2150 m.)

Table 1.2. (b) Temperature data of Kalimpong sub-division from 1995-2000. (Monthly Average). Temperature °C (Kalimpong 975 m.)

	1995		1996		1997		1998		1999		2000		AVERAGE	
Years	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
January	15.9	7.9	16.1	8.5	17.8	8.4	20.0	9.0	20.8	8.4	17.6	8.8	18.0	8.5
February	18.8	9.7	20.5	11.1	15.8	10.7	21.3	11.2	24.5	13.8	17.3	9.0	19.7	10.9
March	23.3	13.6	22.9	14.4	24.1	13.3	22.8	12.0	26.3	14.7	22.7	12.6	23.6	13.4
April	27.6	16.3	26.5	16.2	23.5	14.9	26.9	16.5	28.9	18.8	25.7	16.7	26.5	16.6
May	28.8	20.8	26.9	18.9	27.4	18.1	29.3	19.6	28.0	20.2	26.6	19.8	27.8	19.6
June	26.7	21.4	27.0	21.0	26.9	20.5	28.0	21.3	29.4	20.2	27.2	21.2	27.5	20.9
July	26.9	21.3	26.6	21.5	27.4	21.6	25.9	21.3	26.8	21.2	26.6	21.8	26.7	21.5
August	28.1	21.1	27.1	20.9	27.3	21.1	27.1	20.3	26.7	20.6	26.5	21.6	27.1	20.9
September	27.5	20.3	27.3	20.4	26.7	19.8	27.5	18.0	27.4	19.8	25.7	19.8	27.0	19.7
October	32.0	17.4	25.9	21.4	25.9	15.8	27.0	18.9	26.0	17.5	25.7	17.6	27.0	18.1
November	25.8	14.2	24.1	16.5	23.9	12.9	24.0	15.8	22.7	14.7	21.6	14.4	23.6	14.8
December	17.9	10.4	21.1	10.6	21.8	9.9	21.1	11.5	20.0	9.5	19.6	10.2	20.2	10.4

(Source: Regional Sericulture Research station, 7th Mile Kalimpong 975m.)

Table 1.2. (c) Showing Temperature data of Kurseong sub-division from 1995-2000 (Monthly Average). Temperature °C (Kurseong 1480 m.)

	1995		1996		1997		1998		1999		2000		AVERAGE	
Years	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
January	11.3	5.7	13.4	5.4	11.6	2.1	12.2	2.0	15.0	3.6	13.7	2.7	12.9	3.6
February	15.1	8.1	17.8	8.2	12.0	2.4	15.8	4.8	18.7	7.8	12.1	2.9	15.3	5.7
March	21.1	11.2	21.6	12.4	18.6	7.5	16.2	6.5	20.4	9.5	18.4	6.9	19.4	9.0
April	24.9	15.3	25.7	15.5	17.9	8.9	20.6	10.6	23.4	12.9	21.9	10.6	22.4	12.3
May	25.8	19.7	25.3	17.7	22.6	12.4	23.2	13.8	21.0	13.4	22.3	13.6	23.4	15.1
June	25.0	19.4	23.8	18.2	22.1	14.0	23.1	15.8	24.2	15.0	22.1	14.6	23.4	16.2
July	23.6	18.9	22.7	18.9	21.5	15.4	20.6	15.6	21.0	14.7	21.5	14.9	21.8	16.4
August	24.9	19.0	24.0	18.8	22.8	15.9	21.4	15.4	20.1	14.9	21.0	15.3	22.4	16.6
September	24.0	17.9	24.7	18.0	21.2	14.1	23.9	14.8	20.5	13.5	21.0	13.2	22.6	15.3
October	24.5	15.7	25.4	14.9	28.5	9.8	24.4	13.4	21.0	12.2	21.4	11.3	24.2	12.9
November	19.0	12.0	22.4	11.2	17.6	7.2	20.5	9.5	18.3	7.5	17.6	7.1	19.2	9.1
December	13.3	7.4	16.3	4.3	14.2	3.7	16.2	5.4	15.7	4.8	14.9	3.6	15.1	4.9

(Source: Office of the Monteviot Tea garden, Kurseong 1480m.)

Table 1.2. (d) Temperature of some stations of Sikkim.(Monthly Average) Temperature °C.

Stations	Gangtok 1818 m.		Lachen 2697 m.		Geyzing 1524 m.	
Months	Max.	Min.	Max.	Min.	Max.	Min.
January	13.9	4.2	6.9	-3.9	16.9	5.9
February	14.6	5.5	7.8	-4.2	17.3	7.1
March	21.7	8.5	10.3	-1.5	21.8	9.9
April	22.8	12.0	14.3	2.0	24.9	13.5
May	23.8	13.9	16.1	4.8	25.1	15.6
June	22.9	16.1	17.0	7.8	25.4	17.7
July	22.7	17.1	17.8	8.4	25.9	18.4
August	22.9	16.7	17.2	8.7	26.1	18.3
September	22.7	15.7	17.0	6.8	26.1	17.3
October	21.9	12.3	10.5	-1.4	24.5	14.1
November	18.5	8.6	7.9	-3.6	21.2	10.0
December	15.7	5.8	16.3	4.3	18.1	7.5

(Source: Sikkim A Statistical Profile (1979-80 & 1991-92))

1.6.1.3. RELATIVE HUMIDITY

The entire Darjiling-Sikkim Himalayas experiences a high relative humidity that remins uniformly spread. Generally the north facing slopes are colder and remain humid throughout the whole year. The relative humidity is higher towards 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 the relative humidity ranging between 45-60%. The Relative humidity for a period of six years for three locations in the hill sub divisions of Darjiling are given below in Tables1.3 (a)- 1.3(c) and for some stations in Sikkim in Table 1.3(d).

Table 1.3. (a) Average Monthly Relative humidity data of Darjiling sub-division from 1995-2000. (Mungpoo 1200 m.)

Years	1995		1996		1997		1998		1999		2000		AVERAGE	
Months	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
January	Mor.	Eve.	Mor.	Eve.	Mor.	Eve.	Mor.	Eve.	Mor.	Eve.	Mor.	Eve.	Mor.	Eve.
February	73	51	73	62	69	56	76	65	72	49	78	59	73.50	57.00
March	75	43	76	60	67	54	73	61	70	45	85	67	74.33	55.00
April	64	51	49	30	56	40	66	62	57	40	61	45	58.83	44.67
May	41	57	25	51	65	56	72	61	60	42	63	56	54.33	53.83
June	55	59	66	58	66	58	63	54	64	56	69	62	63.83	57.83
July	72	70	73	59	75	64	75	59	67	61	76	67	73.00	63.33
August	74	66	77	67	76	69	76	68	72	68	76	72	75.17	68.33
September	72	51	72	62	75	63	76	68	77	65	76	77	74.67	64.33
October	72	66	72	60	76	70	72	64	71	67	75	70	73.00	66.17
November	65	63	68	58	73	62	71	60	72	62	69	60	69.67	60.83
December	73	53	69	52	77	68	74	58	77	65	75	66	74.17	60.33

(Source: Research Laboratory, Directorate of Cinchona and other Medicinal plants, Mungpoo, 1200m.)

Table 1.3. (b) Average Monthly Relative humidity data of Kalimpong sub-division from 1995-2000. (7th Mile, Kalimpong 975 m.)

Years	1995		1996		1997		1998		1999		2000		AVERAGE	
Months	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
January	Mor.	Eve.	Mor.	Eve.	Mor.	Eve.	Mor.	Eve.	Mor.	Eve.	Mor.	Eve.	Mor.	Eve.
February	76	77	85	84	82	65	77	58	71	49	81	62	78.67	65.83
March	80	81	83	87	83	62	70	53	75	54	78	76	78.17	68.83
April	77	78	78	83	72	57	71	63	63	43	67	56	71.33	63.33
May	69	76	75	67	78	68	73	60	81	60	74	66	75.00	66.17
June	76	74	83	64	75	67	80	75	87	78	87	77	81.33	72.50
July	90	85	83	86	86	76	86	85	88	76	92	86	87.50	82.33
August	90	86	90	89	88	83	93	89	92	87	95	88	91.33	87.00
September	84	87	90	91	88	81	93	90	93	89	95	90	90.50	88.00
October	90	90	90	89	89	80	88	80	93	83	92	82	90.33	84.00
November	88	86	87	84	82	72	88	79	85	73	80	73	85.00	77.83
December	79	80	84	84	80	67	78	69	81	66	84	73	81.00	73.17

(Source: Regional Sericulture Research Station, 7th Mile, and Kalimpong, 975m.)

Table 1.3. (c) Average monthly Relative humidity data of Kurseong sub-division from 1995-2000. (Kurseong 1480 m.)

Years	1995		1996		1997		1998		1999		2000		AVERAGE	
Months	Mor.	Eve.	Mor.	Eve.	Mor.	Eve.	Mor.	Eve.	Mor.	Eve.	Mor.	Eve.	Mor.	Eve.
January	93	85	92	88	92	82	85	90	92	93	94	91	91.33	88.17
February	95	92	94	89	92	87	89	91	94	90	92	93	92.67	90.33
March	92	88	91	88	91	85	85	93	95	91	92	92	91	89.5
April	93	86	87	82	86	80	88	91	86	93	93	87	88.83	86.5
May	95	92	94	92	94	90	92	94	90	96	96	96	93.5	93.33
June	96	96	96	94	94	96	96	96	95	96	95	96	95.33	95.67
July	96	95	96	95	95	96	95	96	96	96	97	95	95.83	95.5
August	96	95	96	95	95	93	96	95	97	96	97	96	96.17	95
September	94	93	95	94	93	91	96	96	96	96	96	94	95	94
October	92	85	90	87	91	88	94	88	89	93	93	89	91.5	88.33
November	88	89	82	79	93	93	93	80	93	93	94	93	90.5	87.83
December	92	93	69	77	93	90	93	93	93	90	91	87	88.5	88.33

(Source: Experimental Watershed Area, Sonada)

Table 1.3. (d) Average monthly Relative humidity data of some stations of Sikkim.

Stations	Gangtok 1818 m.		Lachen 2697 m.		Geyzing 1524 m.	
Months	Mor.	Eve.	Mor.	Eve.	Mor.	Eve.
January	80	78	-	68	11	-
February	80	78	-	70	5	-
March	69	70	-	66	15	-
April	72	74	-	71	4	-
May	83	84	-	76	15	-
June	93	90	-	87	8	-
July	95	92	-	87	2	-
August	95	92	-	88	26	-
September	92	89	-	86	20	-
October	81	82	-	76	30	-
November	75	74	-	68	23	-
December	83	82	-	76	15	-

Source: Sikkim A Statistical Profile (1979-80 & 1991-92)

1.6.1.4. SUNSHINE AND CLOUDINESS

The Darjiling Sikkim Himalaya is a region of high precipitation and humidity with the rainy days as high as 218 per annum. Thus this region experiences very few days of sunshine. Not only during monsoon but, even during summer and winter sunshine remains disturbed due to the formation of dense smog and fog that sometimes creates situations of near zero visibility (Chopra 1985). Sunshine is more commonly distributed in the morning and late afternoon. During the monsoon, the rains continue uninterrupted for quite a few days without the sun being visible on those days. The recores of sunshine from the middle hill regions shows that, in average the highest is at Sonada during Novermber (5.84 hr/day) and the lowest at Kurseong in July (0.9hr/day). In Sikkim the recorded sunshine hours are lower with the highest being recorded at Tashiding in April (5.5 hr/day) and the lowest at Gangtok for the month of August (0.8 hr./day). While that annual average sunshine at Kurseong is 3.49hr/day it is only 1.86 hr./day at Gangtok.

1.7. GENERAL VEGETATION TYPE:

Phytogeographically speaking the contiguous Sikkim-Darjiling 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 (Takhtajan, 1986). The Eastern Himalayan Province lies almost entirely within the Indian subcontinent lying between $83^0$00' to $92^0$00' E and 27^0 30' to 29^0 30' N. It includes Nepal east of Kali river ($83^0$00') 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 spp. with a high percentage of endemic plants (Chatterjee 1940, Puri *et al* 1983, Myers 1988, Wilson 1992, Das 1995, Bhujel 1996). This province along with Khasi Manipur has the richest flora of the Indian subcontinent with the exception of Myanmar (Rao and Murti 1990). 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 1997).

Although, the Darjiling-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 km (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 elevation ranges and high humidity have a great role in the determination of the type of vegetation of the area. 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 above m.s.l. (Sahni 1981).

The altitude of the various hill ranges varies markedly and usually there is a distinct correlation between the 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 (1906), Cowan (1929), Champion (1936), and Kanai (1967), Rao (1974), Sahni (1982), Jain (1982), Bhujel (1996). These authors have essentially classified the 'flora and vegetation' according to altitudinal ranges, although they differ considerably in detail. Six major types of vegetation that are further subdivided into sub-types can be recognised as tabulated below in Table 1.4.

Table 1.4. Different types of the vegetation along with the altitudinal range of their occurrence in the Darjiling-Sikkim Himalayas.

Nos	Vegetation types	Altitudinal ranges
1.	Tropical and plains	Plains to 800m
2.	Subtropical	800-1600m
3.	Temperate	1600m-2400m
4.	Cold temperate	2400-3200m
5.	Sub-alpine	3200-4000m
6.	Alpine	4000 m and above

The tropical and subtropical represent the vegetation of the plains in part, but the remaining four form the true hill forests.

1. THE TROPICAL AND PLAINS VEGETATION (PLAINS TO 800 m)

High temperature and heavy rainfall characterize this zone leading to the development of a dense vegetation. The tropical vegetation is characterized by the presence of deciduous forests with *Shorea robusta* Gaertn. 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

a. The Riverain forest

This type of the forest 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* (Roxb.) Maxim., *Albizia procera* (Roxb.) Benth., *Albizia lebbeck* (L.) Benth., *Acacia lfructiculosus* Wall., *Alstonia scholaris* (L.) R.Br., *Lagerostroemia parviflora* Roxb. with *Acacia catechu* (L.f.) Wild. and *Dalbergia sissoo* Roxb. occurring as distinct patches in planted forests. *Saccharum spontaneum* L., *Mikania micrantha* Kunth, *Clerodendrum japonicum* (Thunb.) Sweet, *C. infortunatum* L., *Buddleja asiatica* Lour., *Oroxylum indicum* (L.), *Globba macroclada* Gagnepain etc. are of common occurrence in this region.

b. Sal *(Shorea robusta)* forest

Shorea robusta Gaertn.f. 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* Roth., *Aglaia lawii* (Wt.) Ramamoorthy, *Duabanga grandiflora* (Roxb. ex DC) Walp., *Eugenia kurzii* Duthie, *Dillenia pentagyna* Roxb., *Chukrasia tabularis* A.Juss., *Meliosma pinnata* (Roxb.)Maxim., *Lagerstroemia parviflora* Roxb., *Tetrameles nudiflora* R.Br. *Stereospermum chelonoides* (L.f.)DC *Anthocephalus chinensis* (Lamak.) A. Rich ex Walp. along with *Pavetta indica* L., *Clerodendrum japonicum* (Thunb.) Sweet, *Phlogacanthus thyrsiflorus* (Roxb.) Nees, *Barleria cristata* L. etc.

Pinus roxburghii Sarg. a normal inhabitant of the temperate to subtropical region can be also be seen associated with species like *Shorea robusta* Gaertn., *Ficus oligodon* Miq. *Pheonix humilis* Royle ex Becc. & Hook.f. 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 Rungeet .

c. The Dry mixed forest

This forest is represented by the presence of *Gmelina arborea* Roxb., *Tetrameles nudiflora* R.Br., *Beilschmiedia dalzellii* (Meisner) Kostermans, *Erythrina stricta* Roxb, *Bombax ceiba* L., *Alstonia neriifolia* D.Don, *Merremia emarginata* (Burm.f.) Hallier f., *M. hederacea* (Burm.f.) Hallier f., *Artocarpus lacucha* Buch-Ham, *Eugenia kurzii* Duthie etc.

d. 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 *Terminalia myriocarpa* Heurck & Muell., *Michelia champaca* L., *Sygzygium formosa* Wall., *Cinnamomum glaucescens* (Nees) Hand.-Mzt., *Litsea monopetala* (Roxb.) Pers., *Beilschmiedia roxburghiana* Nees, *Pterospermum acerifolium* (L.) Willd. Climbers include *Beaumontia grandiflora* (Roxb.) Wall., *Bauhinia vahlii* White & Arn., *Entada pursaetha* DC ssp. *sinohimalensis* Grierson & Long, *Cryptolepis buchananii* Roem. & Schult., *Mikania micrantha* Kunth, *Ipomea quamoclit* L, *Argyeria roxburghii* Choisy, with the lower strata and ground vegetation including *Ageratum conyzoides* L., *Boerhavia diffusa* L., *Blumea balsamifera* DC., *Sonchus asper* Hill., *Sauropus pubescens* Hook.f. etc.

2. SUB-TROPICAL FOREST (800 - 1600 m)

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* (Roxb.) A.DC, *Schima wallichii* (D.C) Korthals, *Gmelia arborea* Roxb., *Adina cordifolia* (Roxb.) Hook.f. ex Brandis, *Duabanga grandiflora* (DC.) Walp., *Gynocardia odorata* R.Br., *Bischofia javanica* Bl., *Callicarpa arborea* Roxb., *Alangium chinensis* (Lour.)Harms, *Terminalia alata* Roth., *T. bellirica* (Gaertn.) Roxb., *Sygzygium ramosissmum* (Bl.) Balakrishnan, constitute the dominant trees in this region. In addition *Castanopsis tribuloides* (Smith) A. DC., *Cinnamomum obtusifolium* Nees., *Magnifera sylvatica* Roxb., *Phoebe lanceolata* (Nees)Nees, *Litsea cubeba* (Lour.)Pers., *Fraxinus floribunda* Wall., *Helicia nilagirica* Beddl., *Phyllanthus emblica* L., *Mallotus philippensis* (Lamak.)Muel.. *Engelhardtia spicata* Bl. can be seen in some places. The undergrowths include

Mussaenda roxburghii Hook.f., *Dendrocalamus hamiltonii* Nees & Arn. ex Munro, *Osbeckia nepalensis* Hook., *Osbeckia stellata* D.Don, *Buddleja asiatica* Lour., *Embelia floribunda* Wall., *Croton caudatus* Geisel, *Thysanolaena maxima* (Roxb.) O.Kuntze, *Imperata cylindrica* (L.) P. Beauv., *Holmskioldia sanguinea* Retz., *Woodfordia fruticosa* (L.) Kurz, *Boehmeria glomerulifera* Miq. This forest is characterised presence of a good number of climbers such as *Bauhinia vahlii* Wight & Arnott., *Tinospora cordifolia* Meirs, *Cissampelos pareira* L., *Mucuna pruriens* DC., *Thunbergia fragrans* Roxb., *Vitex negundo* L. The common herbs include *Commelina benghalensis* L., *Cyanodon dactylon* (L.) Pers., *Pilea hookeriana* Weddell, *P. smilacifolia* Weddell, *Elatostema lineolatum* Wight, *Ageratum conyzoides* L., *Oxalis comiculala* L., *Urena lobata* L., *Triumfetta rhomboidea* Jacq. Exotic weeds like *Euptorium odoratum* L. and *Mikania micrantha* Kunth. grow profusely in the disturbed forests, while thickets of the tree fern *Cyathea brunoniana* (Hook.)Clarke & Baker is found in moist shady places.

3. TEMPERATE VEGETATION (1600 - 2400 m)

The temperate vegetation comprise of dense forest that includes areas extending from Kurseong, Toong, Sonada, Darjiling, Mirik, Sukhia Pokhri, Maneybhangyang, Rimbick, Lodhama, Kalimpong, Lava, ietc. In the Darjiling Himalaya and areas above Gyalshing in West Sikkim, Namchi in South, Chungthang in North and Gangtok and Pangthang in East Sikkim. The temperate forest occupies most of the region of the Darjiling-Sikkim 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 (1907), 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 (1966) and Grierson & Long (1983) classified the temperate forest of the region into three subtypes.

a. Temperate Deciduous forest

This forest type is characterized by the presence of trees like *Betula alnoides* D.Don, *Exbucklandia populnea* (Griff.) R.W. Brown, *Eleocarpus lanceifolius Roxb., E. sikkimensis* Masters, *Acer campbellii* Hiern., *A. sikkimensis* Miq., *Engelhardtia spicata* (R.Br.ex Griff.) R.W.Brown, *Lindera neesiana* (Nees) Kurz. *L. pulcherrima* (Nees) Benth. ex Hook.f, *Prunus napaulensis* (Ser.) Steu., *Alnus nepalensis* D.Don, *Rhododendron grande* Wight, *Rhododendron arboreum* Hook.f., *Eurya acuminata* DC.etc.

b. Evergreen Oak forest

This trees comprises of trees like *Quercus lamellose* Smith, *Q. lineata* Bl., *Q. oxydon* Miq., *Lithocarpus pachyphylla* (Kurz.) Rehder., *L. elegans* (Bl) Hatus ex Soep., *Acer hookerii* Miq., *Cinnamomum impressinervium* Meisner, *Eriobotrya petiolata Hook.f., Eurya acuminata* DC., *Pentapanax fragrans* (D.Don) Hara, *Litsea elongata* (Nees)Hook.f., *Litsea sericea* (Nees) Hook.f., *Juglans regia* L., *Leucosceptrum canum* Smith, *Lithocarpus pachyphyllus* (Kurz)Rehder, *Poplus ciliata* Royle. Shrubs like *Dichroa fabrifuga* Lour, *Viburnum erubescence* Wall, *Jasminum dispermum* Wall., *Nellia thyrsiflora* D .Don, *Arundinaria maling* Gamble, *Hypericum hookeriana* White & Arn., *Norysca urala* (Hamilt.)K.Koch , *Notochaete haemosa* Benth. with climbers like *Dicentra scandens* (D.Don) Walp., *Edgaria darjeelingensis* Clarke, *Holboellia latifolia* Wall., *Sechium edule* (Jacq.) Swartz, *Smilax ferox* Wall., *Codonopsis affinis* Hook.f. & Thom. , *Streptolirion voluble* Edgew., *Rubia manjith* Roxb. ex Flem. etc. and herbs like *Achyranthes bidentata* Bl., *Anaphalis contorta* (D.Don) Hook.f., *A.triplinervis* (Sims.) C.B.Cl., *Artemesia japonica* Thunb, *Bidens pilosa* L., *Potentila fulgens* Wall, *Plantago erosa* Wall., *Rumex nepalensis* Spreng., *Clinopodium umbrosa* (M.Bieb)C.Koch., *Gallium asperifolium* Wall., *Swertia chirayita* (Roxb.)Darsten, *S.bimaculata* (Sieb. & Zucc.) Hook.f. & Thom. ex C.B.Clarke *Impatiens arguta* Hook.f. & Thom.. *Lysimachia alternifolia* Wall. *Poulzolzia hirta* Hassk., *Hypoestes triflora* Roem. & Sch., *Hemiphragma heterophylla* Wall., *Erigeron karwinskianus* DC., *Fragaria nubicola* Lind. to name a few, forming the ground cover.

4. COLD TEMPERATE VEGETATION (2400 – 3200 m)

Regions lying above 2400m receive 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 1966; Bhujel 1996). The vegetation of this zone can be broadly classified as being of two types:

a. Mixed temperate forest of the Upper Hill region

The mixed temperate forest of the upper hill region extends to about 2800m and comprises of trees like *Brassaiopsis mitis* Clarke, *Quercus lamellosa* Smith, *Magnolia campbellii* Hook.f. & Thom., *Lithocarpus pachyphylla* (Kurz)Rehder, *Sorbus rhamnoides* (Decaisne)Rehder, *Ilex fragilis* Hook.f., *Prunus undulata* D.Don with climbers *Dicentra paucinerva* K.R.Stern, *Clematis buchaniana* DC, *Actinidia strigosa* Hook.f. & Thom. ex Benth, *Smilax glaucophylla* Klotzch, *Schisandra grandiflora* (Wall) Hook.f. & Thom. and shrubs like *Piptanthus nepalensis* (Hook.)

D.Don, *Elsholtzia fructioca* D.Don,. *Daphne involucrata* Wall., *Bistorta amplexicauli* (D.Don) Greene *Berberis insignis* Hook.f. & Thom., *Aconogonum campanulatum* (Hook.f.) Hara, *Rosa serecia* Lindley etc. with herbs like *Arisaema speciosum* (Wall.) Martius *Fragaria nubicola* Lind, *Ranunculus diffisus* DC, *Viola sikkimensis* W. Backer , *Ajuga lobata* D.Don, *Paris polyphylla* Sims., *Gentiana speciosa* (Wall.) Miq., *Geranium donianum* Sweet , *Pilea anisophylla* Wedd., etc. *Arundinaria maling* Gamble is found to invade large open areas in the region.

b. 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* Lindley, *R. falconeri* Hook.f., *R. hodgsonii* Hook.f., *R. decipiens* Lacaita, *Betula utilis* D.Don, *Abies densa* Griff., *Tsuga dumosa* (D.Don)Eichl, *Taxus baccata* L., *Acer pectinatum* Nichol., *A.stachyophyllum* Hiern., *Daphnephyllum himalense* (Benth.)Muller, *Ilex insignis* Hook.f., *Larix griffithiana* Carr, *Picea spinulosa* (Griff.) Henry. Shrubs include *Rosa sericia* Lindl., *Virburnum erubescence* Wall., *Viburnum nervosum* D.Don, *Ribes* spp. *Mecanopsis napaulensis* DC., *Neillia rubiflora* D.Don, *Potentilla fructicosa* L. *Berberis insignis* Hook.f. & Thom., *B.umbellate* Wall., *Daphne bholua* Ham. ex D.Don. Climbers include *Actinidia strigosa* Hook.f. & Thom. ex Benth., *Holboellia latifolia* Wall., *Aristolochia griffithii* Hook.f.& Thom., *Leptocodon gracilis* Hook.f. & Thom. etc. and herbs include *Aconitum spicatum* Stapf., *Aconitum Bisma* (Hamilt) Rapaics, *Fritillaria cirrhosa* D.Don, *Hemiphragma heterophyllum* Wall, *Valeriana wallichii* DC., *Primula capitata* Hook., *P. denticulata* Smith, *Gentiana capitata* Hamil. Ex Don, *G. bryoides* Burk., *G. glabriuscula* H. Smith, *Swertia dilatata* C.B.Clarke, *S. macrocsperma* (Clarke)C.B.Clarke etc.

5. SUB-ALPINE VEGETATION (3200 - 4000 m):

Ranging between 3200m upto around 4000m 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 1966). 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* Wall, *Acer caudatum* Wall, *Abies spectabilis* (D. Don) Eichler, *Cotoneaster frigidus* Lindley, *Salix sikkimensis* Ander. *Salix flabellaris* Anderson, *Sorbus microphylla* Wenzig., *Viburnum nervosum* D.Don, *Rhododendron cinnabarium* Hook.f, *R. campylocarpum* Hook.f., *R. campanulatum* D.Don, *Juniperus squamata* Hamilt. ex Lambert, *J. communis* L., *J. wallichiana* Hook.f. & Thom. etc. The herbs in the forests and meadows include *Rubus*

fragarioides Bertoloni, *Potentilla microphylla* D.Don, *P. atrosanguinea* Lodd., *Primula glabra* Klatt., *P. oblique* W.W..Smith, *Ranunculus adoxifolius* Hand. Mzt., *R. brotherusi* Freyn., *Anemone demissa* Hook.f et Thom., *Tithymalus sikkimensis* (Boiss.) Hurusawa & Y. Tanaka, *T.stracheyi* (Boiss.) Hurusawa & Y. Tanaka, *Saxifraga hispidua* D.Don, *S. latifolia* Hook.f. & Thom. *Viola biflora* L., *V. cameleo* Boiss., *Pedicularis mollis* Wall. ex Benth., *P. clarkei* Hook.f., *Picrorhiza scrophulariiflora* Pennell, *Rheum acuminatum* Hook.f. & Thom.

6. ALPINE VEGETATION (4000 – 5000m):

This zone extends from 4000m to roughly 5000m, lying just below the permanent snowline below the permanent snowline and above the tree line. The major components of this type of vegetation are (i) alpine forests, (ii) moist alpine scrubs and (iii) dry alpine scrubs.

In regions around Thangu in Lachen valley and Yomesamdong in Lachung valley in north Sikkim and Djongri and Thansing in west Sikkim the vegetation is represented by typical alpine moorland where the growth of trees are completey arrested. Stunted bushy growth of *Juniperus squamata* D.Don, *Rhododendron lepidotum* D.Don, *R.setosum* D.Don, *Salix caliculata* Anders, *S. oreophila* Anders, *Berberis concinna* Hook.f. & Thom. occur in this region The Llonakh valley situated in north-west Chholamau forming the extreme north-east of the state has a flora that has an affinity with Tibetan rather than the Himalayan flora. Herbs such as *Poterium filforme* Hook.f. *Primula sikkimensis* Hook.f, *P. tibetica* Watt., *Delphinium arafis* Kar & Kin., *D. drepanocentrum* (Bruhl) Munz, *Adonis nepalensis* Simonovicz, *Anaphalis xylorphisa* Hook.f. , *Lancea tibetica* Hook.f. cover the meadows every year from April to June. Higher up in the valley cliffs *Mecanopsis horridula* Hook. f. & Thom., *Saxifraga pulvinaria* Smith, *S. ramulosa* Wall., *Leontopodium monocephalum* Edgew, *L. hastioides* Hand.-Mazz., *Tanacetum gossypinum* Hook.f.&Thom. occur. Dwarf woody prostrate species of *Berberis, Spirea, Hippophae* and *Salix* grow in patches in this region.

1.8. PAST FLORISTIC WORKS:

The floristically rich Darjiling and Sikkim Himalayas has attracted plant explorers, botanists and researchers since the 18th century (Das 1995; Don 1821). The Indian flora was scientifically and systematically explored since the 1840's. The first two attempts led by Thomas Thomson who explored the North Western Himalayas. It was Sir J. D. Hooker in 1848 who, took up the third botanical expedition to the Eastern Himalayas and in doing so became the first ever-botanical explorer of the Eastern Himalayas while writing the Flora of British India as a whole (Burkill 1965). In all the previous works Darjiling and Sikkim have been considered together as

Darjiling was then a part of Sikkim.

Since then explorers from different far and wide have explored the region from time to time and a number of floras included their records and findings contributing outstanding works adding to the knowledge of the vegetation and floristic of the region. The major contributions include J. D. Hooker (1849-51,1854,1855,1872-1897,1907); T. Anderson(1832-1870); C. B. Clarke (1876,1885); H. J. Elwes (1877); George Watt (1881); G. A. Gammie (1893); R. Pantling with Sir George King (1989); Sir George King (1840-1909): Sir W. W. Smith (1911, 1913) ; C. C. Laccaita (1916); W. J. Buchanan (1916); P. Bruhl (1926); I.H. Burkill (1907,1965); P. C. Ducan (1935); H. Hara (1963, 1966, 1971); Hara *et al* (1978, 1979, 1982); M. Mizushima (1963); S. Nakao (1964); H. Ohashi (1975); A.J.C. Grierson and D. G. Long (1978, 1979, 1982, 1983, 1984, 1987, 1991) and H. J. Noltie (1993).

On the other hand workers like J. S. Gamble (1875, 1986), A.M. Cowan and J. M. Cowan (1929) have published floras floras from the Darjiling Himalaya taking the foresters' point of view. A large number of publications on the flora of the region has been made by the botanists from time to time They include M.J. Berkeley (1850), P. Bruhl (1926), Percy Brown (1936), H.P.V. Townend (1936); P.C. Duncan (1935); G.A. Gammie (1893-94), F. Kingdonward (1913.1942), M.Tamina (1964).

A very large number of Indian workers have contributed towards the Floristics of Darjiling and Sikkim Himalaya and include D. Chatterjee (1940); S. K. Mukherjee (1940, 1945, 1958); K. P. Biswas (1940, 1967); H. L. Chakraborty (1959); R. S. Rao (1964, 1964b); PN. Mehra and S.S. Bir (1964); B. D. Sharma and Ghosh (1971); G. S. Yonzone (1976); K. M. Mathew (1981); Sahni (1981); K. K. Tamang and G. S. Yonzone (1982); B. Mathew (1983); S. S. R. Bennet (1983); A. K. Mukherjee (1983); A. P. Das and R. B. Bhujel (1983); N. C. Muzumdar, B.Krishna and M.C. Biswas (1984); U. C. Pradhan and B. M. Rai (1983-85); A. P. Das and Chanda (1986, 1986a, 1987, 1990); R. B. Bhujel (1984, 1992,); P. C. Lama (1989); R. B. Bhujel *et al* (1994, 1996); T. Rai and L. Rai (1994) A. P. Das (1995, 1995a); A. K. Samanta and A. P. Das (1995, 1996); A.S. Chauhan (1998)

Although the region apparently appear to be well explored, closer scrutiny of literature which include travel itineraries and specimens reveal that large tracts of vegetation mainly forested, are yet to be surveyed. The rapidly increasing human population in the region leading to increase demand in habitational areas leading to steady dwindling forest cover, naturalization of numerous exotics, pollution, increase in grazing etc. are exerting tremendous pressure on the

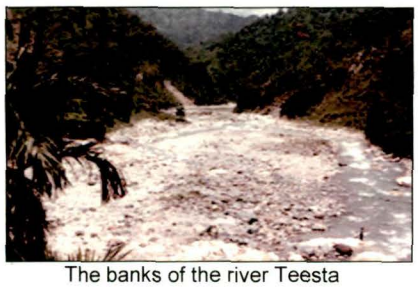
natural vegetation of this area (Das 1995, 1998) resulting in the loss of many species and leading to many becoming endangered.

1.9. OBJECTIVE OF PRESENT WORK:

With respect to its distribution of the genus *Acer* it has been said that it is "widely distributed but nowhere abundant is true for maples in all parts of their range ". Thus, after observation of the natural vegetation of the area that is being subjected to great disturbance and is dwindling at a very fast rate, a need to understanding this predominantly temperate genus was felt. Very little work has been done on this interesting genus in this part of the world. A number of species such as *A. acuminatum, A. stachyophyllum, A. caudatum, A. pectinatum* occur at the higher reaches where the regeneration remains very low and thus constituted a very vulnerable habit group of plants that need to be assessed and protected. So the present work has been undertaken with the following objectives:

a) to prepare a check list of the different species of *Acer* now growing in the Darjiling and Sikkim parts of the Himalaya;
b) to know the phytosociological status of the different species in this region and the association in which they like to grow
c) to determine the horizontal and altitudinal distribution of the different species of the genus;
d) to accumulate data on different aspects including phenology, palynology, cytology, leaf architecture and venation pattern to be utilised in future phylogenetic or other type of taxonomic evaluation;
e) to collect information that will be of use in determining the proper strategies for the conservation of this vulnerable group of plants.

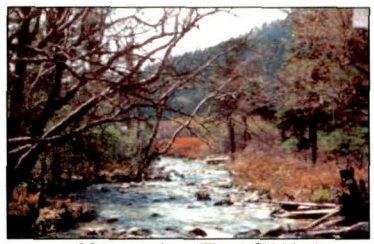
PLATE 1.1. SOME OF THE LOCATIONS IN THE STUDY AREA


The banks of the river Teesta

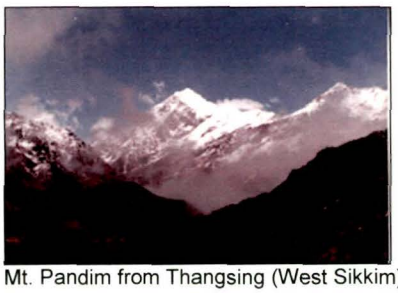

En route to Goechala

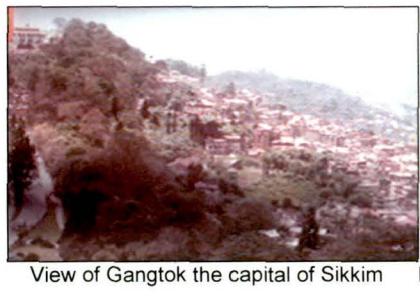

Damthang (South Sikkim)


Yumthang(North Sikkim)

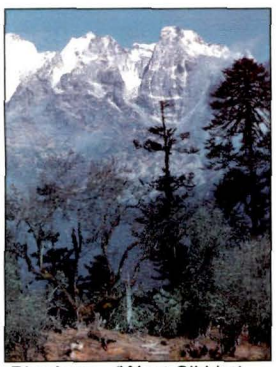

Memenchu (East Sikkim)

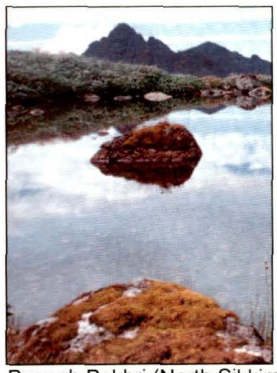

Ruins of Rabdentse Palace (West Sikkim)

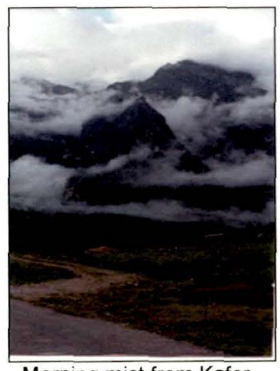

Mt. Pandim from Thangsing (West Sikkim)


View of Gangtok the capital of Sikkim

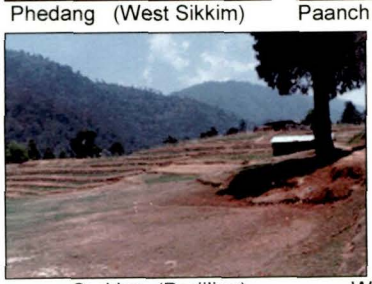

Kabi Lungcstok at Yoksum (West Sikkim)


Phedang (West Sikkim)


Paanch Pokhri (North Sikkim)

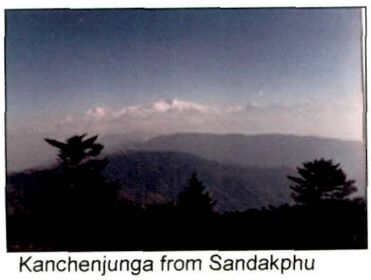

Morning mist from Kafer

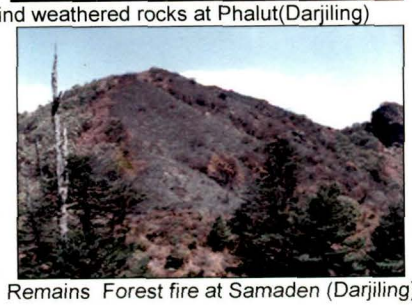

en route to Neora valley (Kalimpong)


Gorkhay (Darjiling)


Wind weathered rocks at Phalut(Darjiling)


Chorten at Bikhaybhanjyang (Darjiling)


Kanchenjunga from Sandakphu


Remains Forest fire at Samaden (Darjiling)


Stone throne of the first Chhyogyal of Sikkim at Yoksum West Sikkim