CHAPTER 1

General Introduction

The part of the Indian state of West Bengal, located on the north of the river **Ganga** is generally referred as **Uttar Banga** or **North Bengal** that constitutes of six civil districts, namely **Maldah, Dakshin Dinajpur, Uttar Dinajpur, Darjiling, Jalpaiguri** and **Cooch Behar**. The diversities in landscape, soil, population structure, economic resources, vegetation structure, biological resources etc all are widely recognisable.

1.1. Three 'T's of North Bengal

Three 'T's – "**Tea, Timber & Tourism**" formed the economic backbone for the people of this northernmost part of West Bengal. Darjiling Tea is famous world-wide for its aroma and, at the same time, dense forests of this region are the sources of huge amount of excellent quality timber produced by a large number of local species. Plantations of some species over wide areas also increased this potentiality. - - On the other hand, the scenic beauty of Darjiling in the background of the snow peaks of Mt Kanchanjangha and the thick vegetation covered altitudinal gradients and hill slopes made it a much attracted tourist place inviting innumerable tourists from each and every corner of this planet every year.

1.2 Richness of Biodiversity

For the Scientists, this northernmost part of the state is also important with a different reason that is for its rich biodiversity. Hills of Darjiling are forming a part of the Singalila Range of Eastern Himalaya, which is widely known for its extremely rich biodiversity before the world in general and botanists, horticulturists, floriculturists etc. in particular. Eminent plant explorers, including Sir J.D. Hooker studied the flora of this region. Numerous organisations even from far away countries tried to explore the flora of this region which include Tokyo University [*Flora of Eastern Himalaya*] (Hara 1966, 1971; Ohashi 1975), British Museum of Natural History [*Enumeration of the Flowering Plants of Nepal*] (Hara *et al* 1978, 1979; Hara & Williams 1982), Royal Botanic Garden, Edinburgh [*Flora of Bhutan*] (Grierson & Long 1983, 1984, 1987, 1991, 1999, 2001; Noltie 1994, 2000; Pearce & Cribb 2002) etc.

Darjiling is situated almost at the central part of Eastern Himalaya and is equally rich in biodiversity with its western and eastern fringes [Das 1986, 1995, 2002, 2004; Das & Chanda 1987; Bhujel & Das 2002; Bhujel *et al* (in press)]. Das (2005) has estimated that, apart from algae, fungi and other microbes, there are at least 3662 species (Table 1.1) (Bryophytes 200; Pteridophytes 250; Gymnosperms 12; Dicots 2200 and Monocots 700) growing in this district. Now it is also known that over 30% species of higher plants (i.e. Angiosperms) of this region are endemic (Grierson & Long 1983; Das 1995, 2004; Bhujel & Das 2002). This type of rich vegetation is not restricted to the hill regions only. Different types of vegetation in Terai and Duars are also equally rich. A fairly good number of endemic and/or threatened plants also inhabit in the grassland and herbland vegetation in Terai (Das 1996; Bhujel *et al* (in press); Das *et al* 2003).

Table 1.1: Numerical estimation for the flora of Darjiling (Das 2005).

TAXA	Algae	Fungi	Lichen	Bacteria & Virus	Bryo.	Pterodo.	Gymnos.	Dicots.	Monocots.	**TOTAL**
No. of Species	*No proper record*	*No proper record*	*No proper record*	*No proper record*	200	250	12	2200	700	**3662**

1.3 Darjiling is a Part of Himalayan Hotspot

In 1990 McNeely *et al* estimated that 70% of the world's flowering plants grow in 12 countries. They then referred these as '**Mega-diversity Countries**' and each of those countries are forming a **Mega-diversity Centre**. India was unique in the list at that time for the recognition of two Mega-diversity Centres [namely '***Indo-Burma Hotspot***' and '***Western Ghats – Sri Lanka Hotspot***'] within its territory. Table 1.1 presented the list of those 12 countries.

India was recognised as the 11^{th} Mega-diversity country (Table 1.2) in the said list with its estimated 17,500 species of higher plants. The country is occupying only 2.4% of the global land area but it harbours about 11% of the world's biota. According to a rough estimate Indian flora has more than 45,000 plant species including bacteria, fungi, algae, lichens, bryophytes, pteridophytes etc. (Singh & Chowdhery 2002).

Darjiling area was included in the **Indo-Burma Hotspot** at the beginning and until 2004 it was enjoying that status. But, the latest reallocation of world Hotspots has now changed the situation. IUCN in recent years has significantly modified the concept and included a precondition that the hotspots must hold at least 1500 endemic plant species and have lost 70 percent of its original habitat extent. The updated analysis (February 2005) of **Conservation International** reveals the existence of 34 biodiversity hotspots (Fig 1.1). These hotspots are estimated to have lost 86 percent of the habitat and the intact remnant of the hotspot now only covers 2.3 percent of the earth's land surface (CI, 2005). These hotspots hold astounding level of species endemism with an estimated 150,000 endemic plant species that accounts to 50 percent of the world's total. Such high level of endemism represents evolutionary potential, ecological diversity and the range of options for future human use.

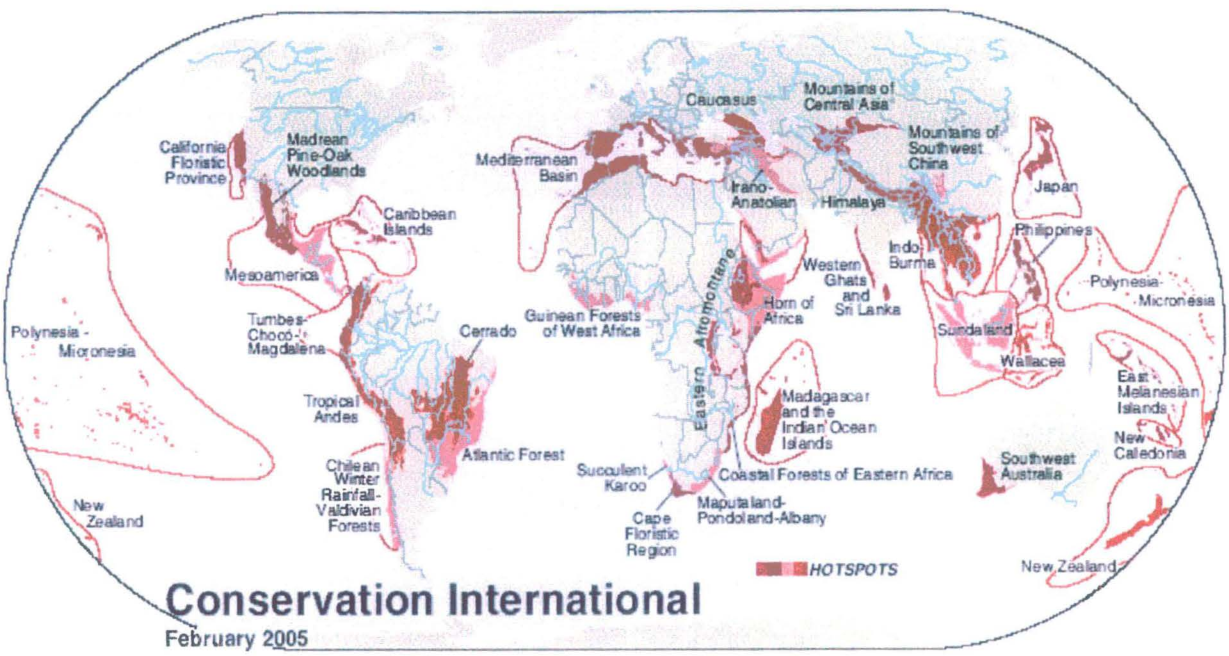


Figure 1.1: Distribution of IUCN recognized 34 Hotspots in the world [*Courtesy*: Conservation International].

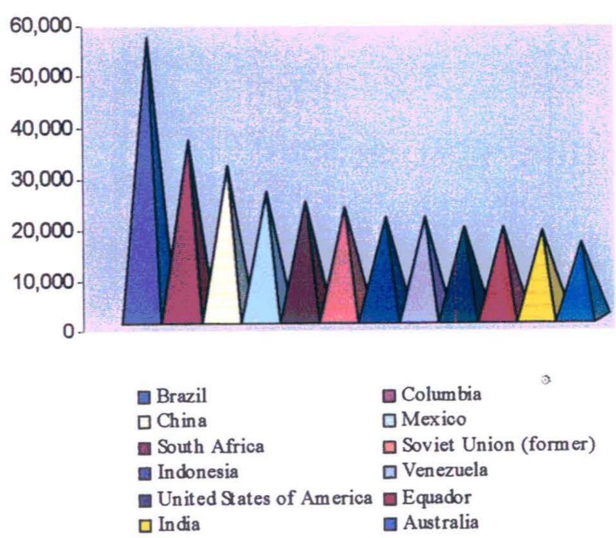
Table 1.2: Flowering Plant mega-diversity countries of World (Groombridge, 1992).

Sl. No.	Countries	Number of Flowering Plant species
1	Brazil	55,000
2	Columbia	35,000
3	China	30,000
4	Mexico	25,000
5	South Africa	23,000
6	Soviet Union (former)	22,000
7	Indonesia	20,000
8	Venezuela	20,000
9	United States of America	18,000
10	Equador	18,000
11	India	17,500

12	Australia	15,000

Figure 1.2: Map of the Himalayan Hotspot [*Courtesy*: Conservation International]

Fig. 1.3: Flowering plant mega-diversity countries of world



In this revised classification of Conservation International, updated in February 2005, a new Hotspot, **Himalayan Hotspot** (Fig 1.2), have been created in this region that covers the entire Himalayan region including the Eastern Himalaya, which were part of the previous Indo-

Burma hotspot; and that has been included amongst the top eight most important hotspots. So, Darjiling Hills region is now included in the Himalayan Hotspot.

[http://www.biodiversityhotspots.org/xp/Hotspots/hotspotsScience/hotspots_revisited.xml].

1.4 Early History of the Land

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 sceptre 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. In the 18th century and in the early part of 19th century, when Darjiling area was repeatedly getting transferred from one country to the other (Bhujel 1996; Das 2004), at that time there was no such township or any tea garden in the area covering the undulating hilltops (Das, 2001). Everything has developed after the Chogyal (the king) of Sikkim presented Darjiling to British Government on 1st February 1835 as a token of friendship (Table 1.3). Again, the history of the Kalimpong part of Darjiling hills is different, which was a part of Bhutan for a long time. The boundary of Nepal, Bhutan, Sikkim, Darjiling etc. were not so clearly demarcated earlier and the entire area was covered with very deep forest. So, there was every possibility that a specimen marked as Nepal might have actually collected from Sikkim or Darjiling's territory. Naturally, the history of floristic studies in Darjiling is intimately related to the same for Nepal and Sikkim, at least.

Table 1.3: The history of Darjiling Hill areas [Bhujel 1996; Das 2004].

Darjiling part: Prior to 1789: [called *Goondri Bazar* till 1886]	In the Sovereign state of Sikkim
1789 – 1817 (part west to Tista)	Gorkha army conquered it for Nepal
10th February 1817	British restored it for Sikkim
1827	Capt. Lloyd & Mr. Grant visited Darjiling
1st February 1835	Chogyal of Sikkim donated the place to British: token of friendship
1840	First motorable road to Darjiling
Till 1706	Kalimpong area was conquered by Bhutan from Sikkim

10th November 1865	Kalimpong ceded to British
1866	Kalimpong was transferred to Darjiling
1850	Darjiling was annexed to Rajsahi
1905	Darjiling was placed under Bhagalpur
1912	Again transferred to Rajsahi (now in Bangladesh)
1947 [at the time of India's independence]	Automatically included in West Bengal

The district is now divided into four subdivisions, three of which are now on hills namely Darjeeling, Kalimpong and Kurseong and the remaining Siliguri subdision is situated in the plains adjacent to the hills. The three hilly subdivisions of the district are now under the administrative purview of the 'Darjeeling Gorkha Hill Council' that came into effect on 22nd August 1988. The district head quarter as well as that of DGHC, both are located in Darjeeling, a thickly populated hill-town.

1.5 Initiation of Modification

Now, the British ruler of India discovered there a favourable climate for (i) establishing a sanatorium at Darjiling for the ailing Britons working in British-India and also for (ii) Tea cultivation. With this the history of Darjiling took a new turn. Forest cover started declining along with the inward migration of the amenities of modern civilisation into the area. British Government established one giant sawmill at Siliguri, on the bank of the river Mahananda, mainly to shape the giant Sal trees into railway-sleepers and for that they had slaughtered lakhs of trees, which, in turn, resulted into the clearing of forested areas.

In the first decade of the 20th century, British Government's forest department initiated plantation forest in Darjiling Hills [a clear-felled patch was planted with *Cryptomeria japonica*] (Das & Lahiri 1997). And, the first Tea garden at Lebong (±1900 m) was established in 1835, and its cultivation spread to Terai in 1862 and to Duars in 1874 (Ghosh *et al* 2004). Since then, in regular intervals, new tea gardens are coming up, sometimes in denuded forestland or by clearing the Herbland and/or Grassland vegetation. As the Herbland/ Grassland vegetation does not produce timber, apparently, those were thought to be useless. Today, in Darjiling district wide areas are under tea cultivation, and there are at least 85 large Tea Gardens (total area 17463

Ha) on hills and 65 large Tea Gardens (total area 16358 Ha) in Terai and, in addition, there are at least 5573 small gardens (total area 6500 Ha) in Terai (*Source*: Tea Board of India) situated in Darjiling district only covering an area of 38465 hectares and producing about 45 m kg of processed tea.

Figure 1.3: Map of India [*Courtesy*: Forest Survey of India]

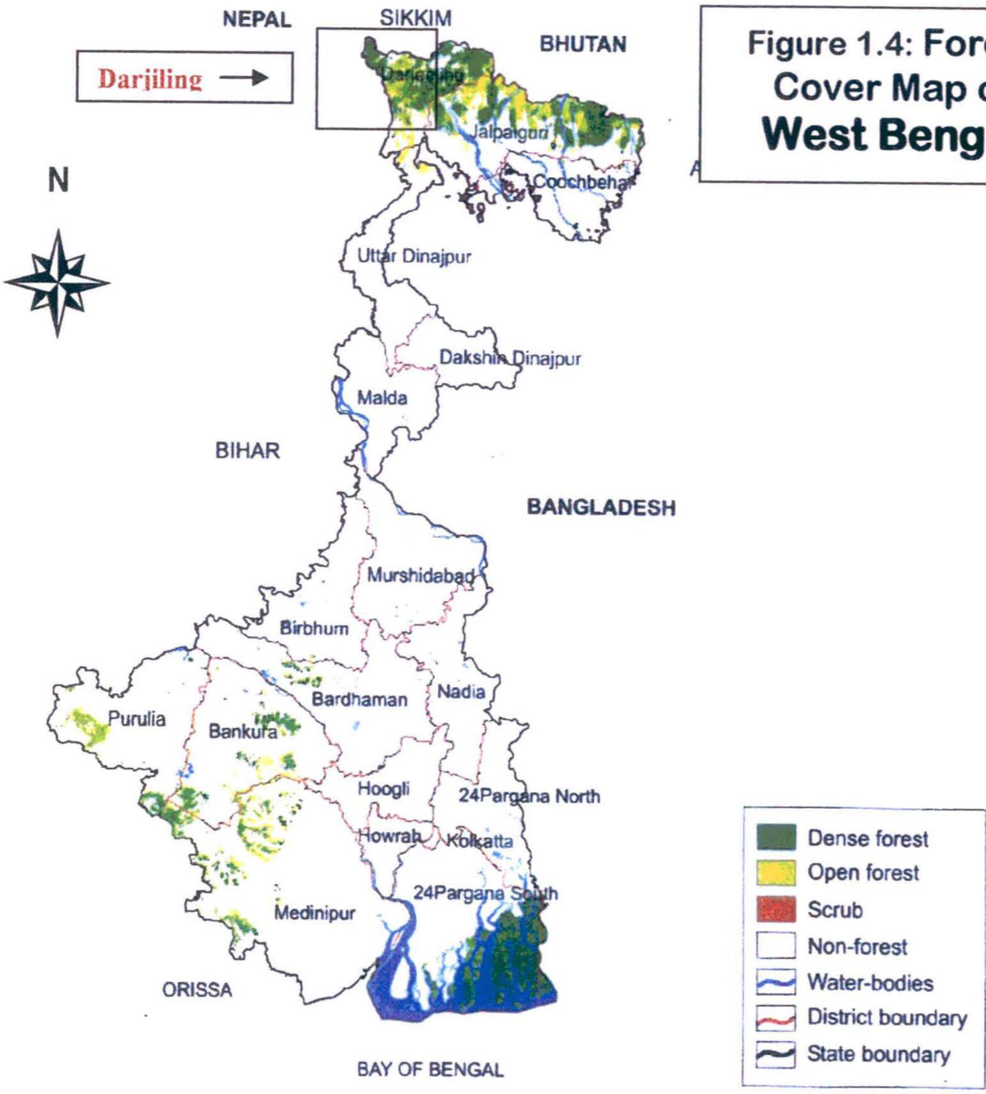


Figure 1.4: Forest Cover Map of West Bengal

1.6 Location and Boundary

Hills, Terai and Duars of Darjiling are located within 26° 31′ 05" and 27° 13′ 10"N latitude and between 87° 59′ 30" and 88° 53′ E longitude and is covering an altitudinal range of c. 132 m (at Siliguri) to 3660 m (at Phalut). 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 Tista 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 plains part of the district, situated at the feet of the hills, is divisible into two parts. The area west of Tista is referred as **Terai** and the area east of the river is **Duars**.

1.7 Topography and General Features

1.7.1. Topography

The Darjiling part of the Eastern Himalaya is essentially mountainous with the increase of elevation in 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 (8598 m) in the west to Chomolhari (7324 m) in the east, which lies near the northern border of Sikkim with the Chumbi valley, which forms a part of Tibet. The hills of Darjiling are actually the spurs of the Singalila range that enters India from Mt. Ghosla (3800 m) at Sikkim and enters the district near Phalut. The highest points Sandakphu and Tonglu of the district after Phalut (3660 m) are the continuation of the Ghosla-Phalut ridge. The Rechila (ca. 3100 m) and Thusum 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 major ridges radiate out along the four directions (Banerjee 1980; Das 1986; Bhujel 1996). *viz.* Darjiling ridge in the North which extends to Lebong through Jalapahar, BirchHill and descends to the River Rangeet at Badamtam; the Takdah spur to the east spreads down to the Tista Bazar; the Dow Hill ridge which is long and forms numerous spurs rolls down to the plains of Darjiling and Jalpaiguri districts.

1.7.2. Rivers and Drainage

The rivers of the tract drain ultimately to the south but the west to east ridges cross the tract and cause a series of rivers and streams to flow northwards or eastwards before joining the main river system. The two most important rivers of Darjiling are the river Tista and the river Great Rangeet. Both of these glacier fed rivers originated from Sikkim. While the Tista originates from the Zemu glacier located in north Sikkim the Rangeet arises from the Rothong glacier in West Sikkim.

The Tista 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 Tista is the Great Rangeet, which arises from the Pathong glacier and confluences with Tista at Tista 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 Tista flows eastwards where it receives the Little Rangit from Darjeeling from where it enters the plains of North Bengal and finally joins the river Brahmaputra in Bangladesh.

The other important rivers of Darjiling includes the Balason arising from the Ghoom saddle running south till it reaches the plains at an altitude of 304.8 m, then turns south east and divides into two channels the New Balason and the Old Balason and subsequently joins the Mahananda 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 Mahananda has its source near the Mahaldiram east of Kurseong and flows south-east 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 Tista 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 Amal khola on the western side and Turung khola on the east further southwards it is joined by the Phang khola and Chun khola near the Bagrakote Colliery and eventually joins the Tista at the Kalagaiti Tea estate. The river Gish is 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 for the river. The river 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 Tista. 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 (Chopra 1985).

1.8 Geology and Soil

1.8.1. 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 Darjiling part of the Himalayas is wedged between Central (Nepal) Himalaya to the west and the Bhutan Himalaya in the east.

Hooker (1854) 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). von Loczy published a geological section from Darjiling to Kanchendzonga, which he observed as far back as 1878 (Gansser 1964). Other notable works on the geology of the region were made by workers like Dyhrenfurth (1931), Wager (1934, 1939), Auden (1935), Wadra (1957), Roy (1945), Acharya (1968), Powde & Saha (1982).

The Himalayan region is believed to be an old geosyncline that was once occupied by a long arm of the sea called Tethys. A series of upheavals led to the considerable increase of elevation of the floor of Tethys. 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 part of the 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.

1.8.2 Geological Formations in Darjiling

Two distinct conditions can be recognized as follows:

1. Darjiling Sub-Himalaya

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 and 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 Tista 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 Tista. 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.

2. Darjiling Lower Himalaya

Along the foothills of Darjiling, the Siwaliks are 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 Barakar 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. These border the Damudas with a very sharp thrust contact, dipping steeply towards the north. The Dalings 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 Tista 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.

1.8.3. Soil

The Darjiling part of the Himalayas enjoys 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 Himalaya 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, flubents and orthents occur further to the north and the inceptols 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 lead to the leaching of bases from the soil surfaces to low horizons .The pH ranges from being slightly acidic between 5.6 and 6.5 in some parts with the major portion showing highly acidic soil with pH below 5.5. Almost everywhere the soils 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 Himalayas 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 & Bhaduria 1995). This has been aggravated due to the pressure of the increasing population on land.

1.9 Climate

The great Himalayan range forms a complex system that separates the northern part of the Asian continent from the southern 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 part of the Himalayas has its own climatic peculiarities due to its geographical location, relief and a wide range of altitudinal variations ranging from 135 m to 3669 m above mean 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 air flowing upwards during May to October from the Bay of Bengal. The great variation in altitude and the configuration of the neighboring mountain ranges greatly affect air movement, rainfall and temperature and leads to a greater range of variation in local climatic conditions. It is quite interesting to note that even in adjacent or in opposite slopes with little aerial distance there exists quite contrasting climatic characters. Although the latitudinal location of the region is in the sub-tropical climatic regime its mountainous configuration has led to varied climates ranging from the subtropical to the temperate to subalpine types. This major climatic variation in Darjiling is based mainly upon the elevation the region and that shows four distinct climatic zones, viz. Tropical, Subtropical, Temperate, and Sub-alpine. The distance from southern plains outside the hills and on the other side from the permanent snow covered regions also affect the local climate. This variation is also responsible for the creation of wide range of vegetation structure, which supports the survival of great biological diversity.

1.9.1 Seasons of the Year

Four climatic seasons can be recognized within the region (a) Monsoon or Rainy Season, (b) Autumn, (C) Winter, and (d) Summer (spring). However, it is difficult to differentiate Spring and Summer in this part of the hills (Das 1986; Bhujel 1996; Lama 2004). Choudhury (1998) classified the climate of the Darjiling-Sikkim region into six types based one of the most important single factor which is the altitude. Of these five types are recognizable in Darjiling Hills as follows:

(i) Tropical Humid type: The lower ridges of this region lying up to 800 m experience high humidity and temperature. The rainfall remains high with very hot summers and warmer winters.

(ii) Sub-tropical Humid type: Areas lay between 800 – 1600 m 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.

(iii) Semi-temperate type: In between 1600 – 2400 m the summers are moderate and the winters generally dry and temperature falling below the freezing point only very occasionally for very few days. The annual precipitation is quite high, about 3500 mm with the rainfall being heaviest during the monsoons i.e. usually between June to August.

(iv) Temperate type: Slopes laying between 2400 – 3200 m shows this type of climate where the summers are never hot with the temperature rarely exceeding 18° C. The annual temperature in the valleys of Bikhay Bhanjyang experience an annual temperature which never reaches beyond 17° C. Rainfall is much lesser than the semi temperate type rarely exceeding 1700 mm annually. The winters are very cold with high snowfall and frosting being common at nights for most parts of the year.

(v) Alpine Snow forest type: This type of climate is experienced in places situated above 3200 m. 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 in the form of snow and slit is common in winter. Major part of this region is uninhabited due to harsh climate and includes places between Sandakphu and Phalut.

1.9.2. Rainfall/ Precipitation

The whole region consists of a tangled series of interlacing ridges, rising range above range to the foot of the Wallich of high peaks and passes which marks the 'abode of snow' and its off-shoot (Risley 1894). This tangled assemblage of ridges and peaks coupled with altitude, aspect and exposure brings about sharp changes in the rainfall in any particular location of the region. In general the south facing ridges receive the highest rainfall in comparison with the north facing ridges.

The Darjiling (and 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 of its proximity to the Bay of Bengal and direct exposure to the effects of moisture laden southwest monsoon. Rainfall variation occurs along the entire stretch of the Tista valley. Another more striking feature of the region is the peculiar V-shaped valleys with steep and often precipitous slopes. This peculiar configuration of the mountainous region brings sharp changes in the rainfall. The rainfall recorded from different locations are provided below in Tables: 1.4(a) - 1.4(d).

Table 1.4(a): Rainfall data for the Darjiling sub-division during 1995 – 2000. Rainfall in mm (altitude: Darjiling Met. Stn., 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 1.4(b): Rainfall data for the Kalimpong sub-division during 1995 – 2000. Rainfall in mm (altitude: Kalimpong Met. Stn., 975 m)

Years ▸ Months ▾	1995	1996	1997	1998	1999	2000	Average
January	40.07	15.86	19.21	0	12.49	5.55	***15.53***
February	9.91	2.23	18.22	4.21	0	18.64	***8.87***
March	0	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 1.4(c): Rainfall data for the Kurseong sub-division during 1995 – 2000. Rainfall in mm (altitude: Kurseong Met. Stn., 1480m)

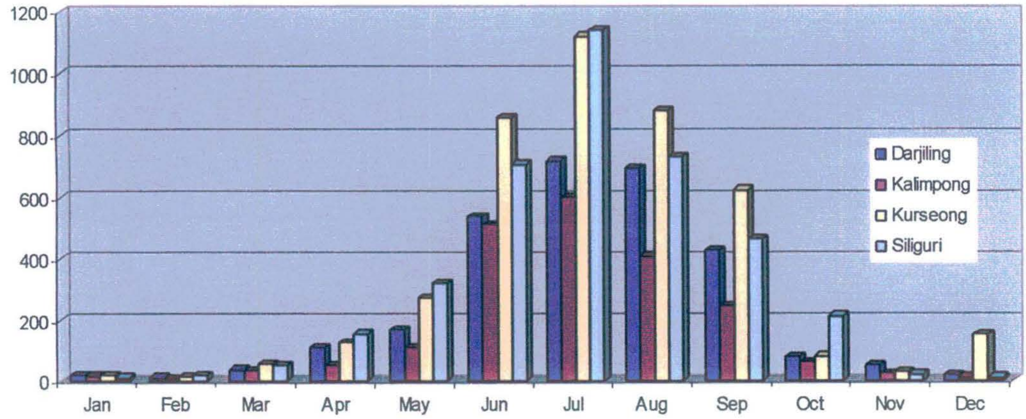
Years ▸ Months ▾	1995	1996	1997	1998	1999	2000	Average
January	26.71	46.42	22.81	0.54	13.21	7.47	***19.53***
February	28.92	7.84	15.42	18.31	0	17.62	***14.69***
March	36.8	20.43	80.31	136.12	57.44	8.12	***56.54***
April	38.12	75.16	78.74	145.27	29.78	374.12	***123.53***
May	335.12	109.27	180.37	213.91	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 1.4(d): Rainfall data at Sukna during 1997 – 2005. Rainfall in mm (altitude: Sukna Environmental Research Stn., 140m)

Years ▸ Months ▾	1997	1998	1999	2000	2001	2002	2003	2004	2005	Mean
Jan	9.8	0.8	0	1.4	2.2	27.8	18.8	26.8	14.6	***11.36***
Feb	20.6	3.6	0	20.2	23.2	0	104.7	0.0	6.8	***19.9***
Mar	35.5	198.2	10	1.9	16	42.1	37	18.5	102.6	***51.31***
Apr	157.9	232.1	49.5	299.6	104.5	143.5	180.8	128.8	91.8	***154.28***
May	134.7	275.3	448.5	614.6	535	267.6	201.2	313.8	103.2	***321.54***
Jun	680.9	821.1	661.3	809.2	909.9	671.5	873.4	522.9	426.1	***708.48***
July	940.1	1423	995.4	983.5	783.8	1402.3	1446.1	1443.3	830.7	***1138.69***
Aug	560.4	1150.6	1090.1	869.9	514.1	554.3	768.3	456.4	620.4	***731.61***
Spt	619.6	491.8	444.7	470	697.4	359.2	539.6	445.4	92.6	***462.26***
Oct	30.5	339.9	231.8	40.6	481.4	47.6	352.4	197.7	181.6	***211.5***
Nov	8.9	27.4	0.4	16.7	108.7	23	2.7	4.1	1.7	***21.51***
Dec	43.7	1.2	13.9	0	5.2	8.6	16	5.2	0.0	***10.42***
TOTAL	***3242.6***	***4965***	***3945.6***	***4127.6***	***4181.4***	***3547.5***	***4541***	***3562.9***	***2472.1***	**3842.86**

Fig. 1.6: Average Rainfall in Four sub-divisions of Darjiling District



For the district of Darjiling the highest rainfall occurs at Kurseong, the south facing township, with an annual rainfall of over 4000 mm followed by Darjiling and Kalimpong. The district experiences the highest rainfall during the months between June to September brought about by the south-west monsoons and the lowest between Novembers to February with occasional moderate showers during March to May.

Not only the total rainfall of an area influence the structure and composition of local flora, its annual distribution is also very important. Very high downpour within a very short period can damage the vegetation and can remove the top soil. This also means that there will be a prolonged dry period, which certainly have important role in the selection of the type and number of species. On the other hand, similar amount but widely distributed rainfall will select a different set of larger number of species as the water relation of the vegetation will remain favourable for a longer period. - - Out of the three hill subdivisions Kurseong not only receive very high rainfall [annual average of 422.75 cm] it is also distributed over a much larger average number of 210.2 days [Table 1.5] per annum. Hills of Kurseong area are forming the outermost peaks of the Darjiling part of the Himalayas and south facing. So, the moisture-laden monsoon air coming from the Bay of Bengal, hitting the hills for the first time, cooling down rapidly and causing heavy rain. The location and altitude of Kalimpong, on the other hand, is not suitable to receive the monsoon air directly and that is why the area receives very less precipitation and that distributed over 116.6 days (average) only. - - Again, the hills of Darjiling subdivision are much taller than Kurseong hills. Monsoon-air after releasing a considerable load of water at Kurseong goes up and enters inside the Darjiling Hills. Get cooled. And, release a major part of the carrying water in this region. However, the rain is well distributed and spreading over 154.6 days (average) in Darjiling area.

Table 1.5: Average number of rainy days in different subdivisions of Darjiling District [after Das 2004].

Subdivisions	No. of rainy days/ annum
Darjiling	154.6
Kalimpong	116.6
Kurseong	210.2
Siliguri (Sukna)	148.56

1.9.3. Tmperature

Being a hilly terrain and part of a great mountain system, the temperature in different localities of the Darjiling district shows a great degree of variation with the altitude of the place. 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. The temperature usually start increasing from the month of May and the days remain warm till the withdrawal of southwest monsoon (i.e. from the month of November) and then the temperature falls rapidly throughout the region. Normally January is the coldest month and the daily temperature at Darjiling, Sonada, Labha and Rechila often go down below 0°C. Table 1.6(a) – 1.6(c) shows the detailed month-wise temperature records for Darjiling (2150m), Kurseong (1480m) and Kalimpong (972m) subdivisions of the district, respectively.

However, the areas located above 3000 m, specially from Tonglu to Sandakphu to Phalut remain very cold for most of the time. Many places around Sandakphu and Phalut remain snow covered for 1 – 5 months of the year.

Table 1.6(a): Month-wise average temperature data in °C for Darjiling sub-division during 1995 - 2000. (*Altitude*: Darjiling Met. Stn. 2150 m)

Years ▸ Months ▾	1995		1996		1997		1998		1999		2000		AVERAGE	
	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 1.6(b): Month-wise average temperature data in °C for Kalimpong sub-division during 1995 - 2000. (*Altitude*: Kalimpong Met. Stn. 975 m)

Years ▸ Months ▾	1995		1996		1997		1998		1999		2000		AVERAGE	
	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 1.6(c): Month-wise average temperature data in °C for Kurseong sub-division during 1995 – 2000. (*Altitude*: Kurseong Met. Stn. 1480 m)

Years ▸ Months ▾	1995		1996		1997		1998		1999		2000		AVERAGE	
	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*

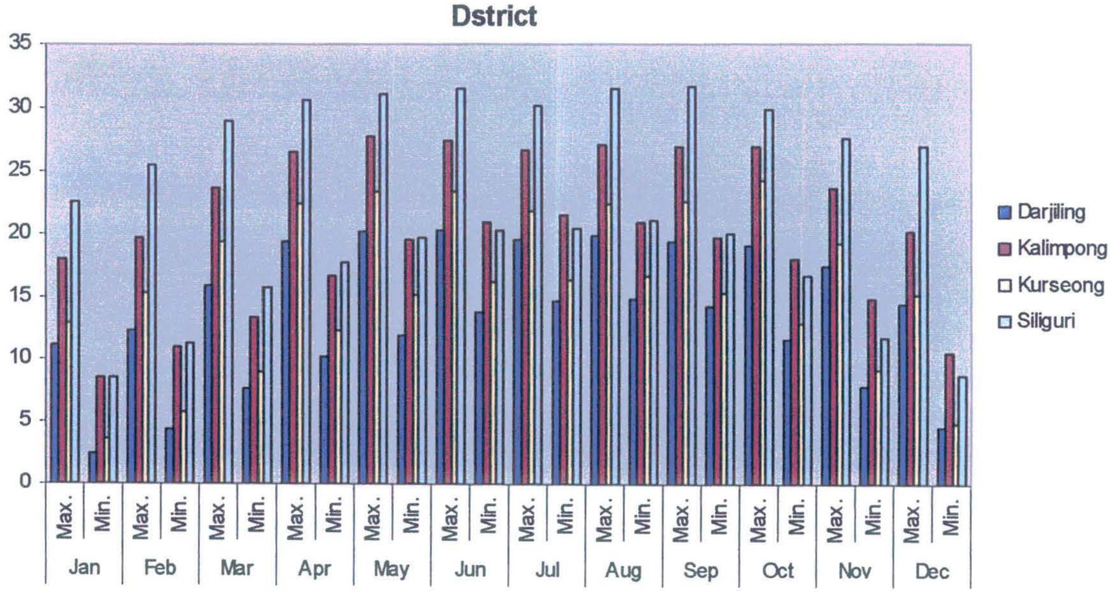
September	24.0	17.9	24.7	18.0	21.2	14.1	23.9	14.8	20.5	13.5	21.0	13.2	*22.6*	*15.3*
October	24.5	15.7	25.4	14.9	28.5	9.8	24.4	13.4	21.0	12.2	21.4	11.3	*24.2*	*12.9*
November	19.0	12.0	22.4	11.2	17.6	7.2	20.5	9.5	18.3	7.5	17.6	7.1	*19.2*	*9.1*
December	13.3	7.4	16.3	4.3	14.2	3.7	16.2	5.4	15.7	4.8	14.9	3.6	*15.1*	*4.9*

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

Table 1.6 (d): Month-wise average temperature data in °C for Sukna during 1995 – 2000. (*Altitude*: Environmental Research Stn., Sukna 140 m)

Years ▸ Months ▾	**2004**		**2005**		**AVERAGE**	
	Max.	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**
January	21.6	10.4	23.6	6.5	***22.6***	***8.45***
February	24.5	13	26.5	9.5	***25.5***	***11.25***
March	28.5	17.6	29.4	13.9	***28.95***	***15.75***
April	30.1	19.7	31	15.9	***30.55***	***17.8***
May	31.4	22	30.8	17.4	***31.1***	***19.7***
June	30.7	21.4	32.3	19.2	***31.5***	***20.3***
July	29.7	21.3	30.7	19.5	***30.2***	***20.4***
August	31.07	20.61	31.9	21.6	***31.49***	***21.11***
September	29.9	18.86	33.4	21	***31.65***	***19.93***
October	29.9	15.64	29.7	17.8	***29.8***	***16.72***
November	26.9	10.59	28.4	12.6	***27.65***	***11.6***
December	26.9	8.14	27.1	9.1	***27***	***8.62***

Fig. 1.7: Average Temperature in Four sub-divisions of Darjling Dstrict



1.9.4. Relative Humidity

Uniformly, the entire Darjiling-Sikkim Himalayas experiences a high relative humidity round the year. This factor according to Sahni (1981) is conducive for tree growth. 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 between 85 – 99% during monsoons, and it generally decreases towards the lower elevations. March and April are drier months and the relative humidity is maintained between 45 – 60%.

The Relative humidity recorded for a period of six years for three locations in the three hill sub divisions of Darjiling are given below in Tables 1.7(a) – 1.7(c).

Table 1.7(a): Month-wise Average Relative humidity data in % for Darjiling sub-division during 1995 – 2000. (Altitude: Mungpoo Met. Stn., 1200 m)

Years ▸ Months ▾	1995		1996		1997		1998		1999		2000		AVERAGE	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
January	73	51	69	57	73	61	74	59	75	52	75	65	73.17	57.50
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 1.7(b): Month-wise Average Relative humidity data in % for Kalimpong sub-division during 1995 – 2000. (Altitude: 7^{TH} MILE, Kalimpong 975m)

Years ▸ Months ▾	1995		1996		1997		1998		1999		2000		AVERAGE	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
January	77	78	84	83	80	65	76	65	77	56	83	69	79.5	69.33
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, Kalimpong, 975m]

Table 1.7(c): Month-wise Average Relative humidity data in % for Kurseong sub-division during 1995 – 2000. (Altitude: Kurseong Met. Stn., 1480 m)

Years ▸ Months ▾	1995		1996		1997		1998		1999		2000		AVERAGE	
	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]

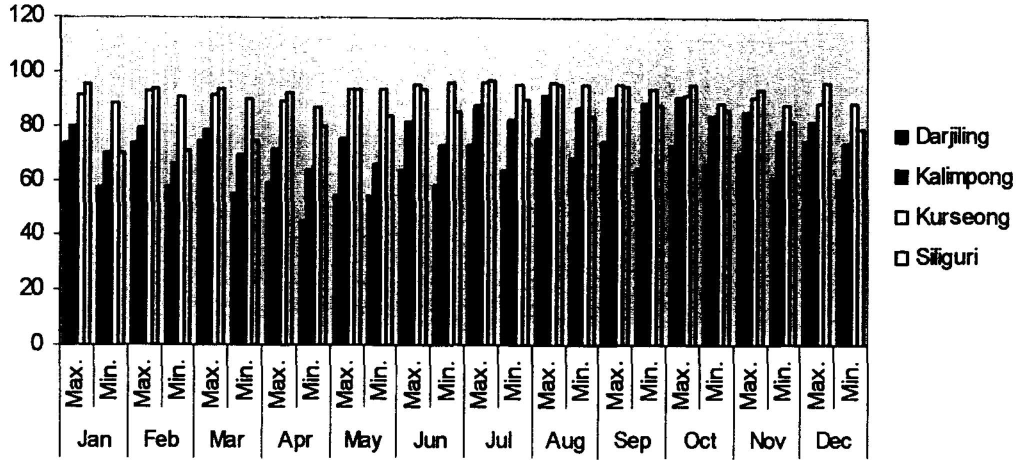
Table 1.7(d): Month-wise Average Relative humidity data in % for Sukna during 2004 – 2005. (Altitude: Environmental Research Stn., Sukna 140 m)

Years ▸ Months ▾	**Morning**				**Evening**			
	2004	**2005**	**Total**	**Mean**	**2004**	**2005**	**Total**	**Mean**
Jan	95	96	191	***95.5***	60	79	139	***69.5***
Feb	92	95	187	***93.5***	69	72	141	***70.5***
Mar	92	95	187	***93.5***	76	73	149	***74.5***
Apr	89	95	184	***92***	85	74	159	***79.5***
May	93	95	188	***94***	86	82	168	***84***
Jun	93	95	188	***94***	87	83	170	***85***
July	95	98	193	***96.5***	91	89	180	***90***
Aug	94	97	191	***95.5***	77	90	167	***83.5***
Spt	95	94	189	***94.5***	93	82	175	***87.5***
Oct	94	96	190	***95***	83	89	172	***86***
Nov	90	97	187	***93.5***	77	85	162	***81***
Dec	95	97	192	***96***	73	85	158	***79***
Mean	***93.08***	***95.83***	***188.91***	***94.46***	*79.75*	***81.92***	***161.67***	**80.84**

1.10. General Vegetation Type

The vegetation of Darjiling, phytogeographically, is contiguous with the vegetation of Sikkim and 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). Lying between 83°00' to 92°00' E and 27° 30' to 29° 30' N, the Eastern Himalayan Province is located almost wholly within the Indian subcontinent. It includes Nepal east of Kali River (83°00') and extends to southeastern Tibet (the Tsangpo valley east of 92°00' E). It includes all the mountainous country east of the Kali River and north of the Ganga-Bramhamaputra flood plains.

Fig. 1.8: Average Relative Humidity in Four sub-divisions of Darjiling District



Floristically, the Eastern Himalaya is one of the richest regions in the world that is literally considered as a *botanist's paradise* and has thus, attracted a large number of plant hunters and botanists at least during the last three centuries (Don 1821; Das 1995, 2004). 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, 2004; Bhujel 1996; Bhujel & Das 2002). This province along with Khasi Hills, Arunachal Pradesh and Manipur has the richest flora of the Indian subcontinent with the exception of Myanmar (Rao & 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 Himalayas 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 appreciated the beauty and the floristic richness of this region and preached it to the outside world for the first time. The occurrences of very large variation in physiographic, climatic and edaphic conditions often aided by biotic factors are responsible for such richness and diversity.

The configuration of the hills, 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 highly humid tree-producing climate 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.

Many workers have tried to classify the vegetation of this region and they includes workers like Gamble (1875), Hooker (1906), Cowan (1929), Champion (1936), Kanai (1967), Rao (1974), Sahni (1982), Jain (1982) and 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 which are further subdivided to sub types can be recognised (Table 1.8):

Table 1.8: Altitudinal distribution of major vegetation types in Darjiling-Sikkim part of Eastern Himalaya

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

The tropical and subtropical types represent the vegetation of the plains in part, but the remaining four are forming the true hill forests. However, in Darjiling part any form of Alpine vegetation is absent as the highest altitude achieved by any peak of this area is 3660 m, i.e. remaining below 4000m.

1. The Tropical and plains vegetation [plains to 800 m]

High temperature and heavy rainfall characterize this zone leading to the development 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. Riverine forest
b. Sal forest
c. Dry mixed forest
d. Wet mixed forest

a. The Riverine forests: These can be observed in small patches in the elevated riverbeds and/or in the land raised after shifting of rivers like Tista, Rangit, Balasan, Mahananda, Sukuna, Relli, Chel, Lesh, Gish, Jaldhaka, Sevoke and Mechi. The forests remain dominated by perennial plants mostly shrubs and climbers. The common species of trees found in this region include *Bombax ceiba* L., *Meliosma pinnata* (Roxburgh) Maximowicz, *Albizia procera* (Roxburgh) Bentham, *Albizia lebbeck* (L.) Bentham, *Acacia lenticularis* Bentham, *Alstonia scholaris* (L.) R.Br., *Lagerostroemia parviflora* Roxburgh with *Acacia catechu* (L.f.) Willdenow and *Dalbergia sissoo* DC. occurring as distinct patches in these forests. *Saccharum spontaneum* L., *Mikania micrantha* Kunth, *Clerodendrum japonicum* (Thunburgh) Sweet, *C. viscosum* Ventenat, *Buddleja asiatica* Loureiro, *Oroxylum indicum* L., *Globba macroclada* Gagnepain, etc are covering the forest floor.

b. Sal *(Shorea robusta)* forest: These are mostly tropical forests. *Shorea robusta* Gaertner 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* (Wight) Ramamoorthy, *Duabanga grandiflora* (Roxburgh ex DC.) Walpers, *Eugenia kurzii* Duthie, *Dillenia pentagyna* Roxburgh, *Chukrasia tabularis* A. Jussieu, *Meliosma pinnata* (Roxburgh) Maximowicz, *Lagerstroemia parviflora* Roxburgh, *Tetrameles nudiflora* R.Br., *Stereospermum chelonoides* (L.f.) DC. *Anthocephalus chinensis* (Lamarck) A. Rich ex Walpers along with *Pavetta indica* L., *Clerodendrum japonicum* (Thunburgh) Sweet, *Clerodendrum viscosum* Ventanat, *Phlogacanthus thyrsiflorus* (Roxburgh) Nees, *Barleria cristata* L. etc.

Pinus roxburghii Sarg., a normal inhabitant of the temperate to subtropical region can also be seen associated with species like *Shorea robusta* Gaertner f., *Ficus oligodon* Miquel, *Phoenix humilis* Royle ex Becc. & Hook.f. in some drier valleys like at Badamtam, below Ging. Remnants of once the magnificent sal forests which has given way to the need of the expansion of civilization can be seen along the banks of the River Rungeet.

c. The Dry Mixed Forest: Though the annual precipitation is high and with prevalent high atmospheric humidity for most of the period, the dominance of deciduous species of trees is quite prominent in foothill and Terai-Duars forests. This type of vegetation is characterized by the presence of *Gmelina arborea* Roxburgh, *Tetrameles nudiflora* R.Br., *Beilschmiedia dalzellii* (Meisner) Kostermans, *Erythrina stricta* Roxburgh, *Bombax ceiba* L., *Alstonia nerifolia* D. Don, *Merremia emarginata* (Burm.f.) Hallier f., *M. hederacea* (Burm.f.) Hallier f., *Artocarpus* *lacucha* Buch-Ham, *Eugenia kurzii* Duthie etc. It is common in the lower Tista Valley and on low altitude hills and in Terai & Duars.

d. The Wet Mixed Forests: Just reverse to the Dry-Mixed Forests, this type of vegetation is dominated by evergreen and semi-evergreen trees along with a very large number of shrubs, climbers and herbs. These are mainly evergreen forests mixed with taller deciduous trees in very low frequency, which Champion & Seth (1968) designated as 'Sub-Himalayan Secondary Wet Mixed Forest' [2B/2S_3]. Though in small patches but is met with in Terai and Duars of Darjiling. This zone is rich in epiphytes and stem-parasites and giving it a distinct characteristic structure. The major tree species of this sub zone include *Syzygium formosum* (Wallich) Masamune, *Syzygium cumini* (L.) Skeels, *Litsea glutinosa* (Loureiro) Roxburgh, *Litsea salicifolia* (Nees) Hook.f., *Mesua ferrea* L., *Knema erratica* (Hook.f. & Thomson) Sinclair, *Knema tenuinervia* de Wilde *Terminalia myriocarpa* Heurck & Mueller, *Michelia champaca* L., *Cinnamomum glaucescens* (Nees) Handle-Mazzetti, *Beilschmiedia roxburghiana* Nees, *Pterospermum acerifolium* (L.) Willdenow. There are a good number of climbers, some of those are liana, dominating the vegetation like *Beaumontia grandiflora* (Roxburgh) Wallich, *Bauhinia vahlii* Wight & Arnott, *Entada pursaetha* DC. ssp. *sinohimalensis* Grierson & Long, *Cryptolepis buchananii* Roem. & Schult., *Mikania micrantha* Kunth, *Ipomoea quamoclit* L., *Boerhavia diffusa* L., *Argyreia roxburghii* Choisy, etc. The ground cover vegetation is also very rich, which include annuals, perennial herbs, suffrutescent plants, root parasites, saprophytes etc. like *Ageratum conyzoides* L., *Blumea balsamifera* DC., *Sonchus asper* Hill., *Sauropus pubescens* Hook.f. etc.

2. Sub-Tropical forests [800 - 1600 m]

The vegetation of this region is contiguous with the vegetation of Terai and Duars and 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. Several species tend to remain in this zone from the tropical and plains zone. *Castanopsis indica* (Roxb.) A.DC, *Schima wallichii* (DC.) 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 bejolghota* (Ham.) Sweet, *Magnifera sylvatica* Roxb., *Phoebe lanceolata* (Nees) Nees, *Litsea cubeba* (Lour.) Pers., *Fraxinus floribunda* Wallich., *Helicia nilagirica* Beddl., *Phyllanthus* *emblica* L., *Mallotus philippensis* (Lamk.) Muel. *Engelhardtia spicata* Bl. can be seen in some places. The undergrowths include *Mussaenda roxburghii* Hook.f., *Dendrocalamus hamiltonii* Nees et Arn. ex Munro, *Osbeckia nepalensis* Hook., *Osbeckia stellata* D. Don, *Pandanus furcatus* Roxburgh, *Pandanus anguifer* Hook.f., *Buddleja asiatica* Lour., *Embelia floribunda* Wallich., *Croton caudatus* Geisel, *Thysanolena maxima* (Roxb.) O. Kuntze, *Imperata cylindrica* (L.) P. Beauv., *Holmskioldia sanguinea* Retz., *Woodfordia fruticosa* (L.) Kurz, *Boehmeria glomerulifera* Miq. This type of forest is characterised by the presence of a good number of climbers such as *Bauhinia vahlii* Wight et Arnott., *Tinospora cordifolia* Meirs, *Cissampelos pareira* L., *Mucuna pruriens* DC., *Thunbergia fragrans* Roxb., *Vitex negundo* L. The common herbs are *Commelina benghalensis* L., *Cynodon dactylon* (L.) Pers., *Pilea hookeriana* Weddell, *P. smilacifolia* Weddell, *Elatostema lineolatum* Wight, *Ageratum conyzoides* L., *Oxalis corniculala* L., *Urena lobata* L. and *Triumfetta rhomboidea* Jacq.

Exotic weeds like *Chromolaena odorata* L. and *Mikania micrantha* Kunth. grow profusely in disturbed forests, while thickets of the tree fern *Alsophila spinulosa* (Wallich *ex* Hooker) Tryon is found in moist shady places.

3. Temperate Vegetation [1600 - 2400m]

The temperate vegetation comprise of dense forest that includes areas extending from Kurseong, Toong, Sonada, Darjeiling, Mirik, Sukhia Pokhri, Maneybhangyang, Rimbick, Lodhama, Kalimpong, Lava, etc. 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 Himalayas. 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: It is characterized by the presence of trees like *Betula alnoides* D. Don, *Exbucklandia populnea* (Griff.) R.W. Brown, *Eleocarpus lanceifolius Roxb.*, *Eleocarpus 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 type comprises of trees like *Quercus lamellose* Smith, *Q. lineata* Bl., *Q. oxydon* Miq., *Lithocarpus pachyphylla* (Kurz.) Rehder., *Acer hookeri* Miq. *Lithocarpus elegans* (Bl.) Hatus ex Soep., *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* Wallich, *Jasminum dispermum* Wallich., *Nellia thyrsiflora* D .Don, *Yushania maling* (Gamble) R.B. Majumdar, *Hypericum hookeriana* Wtght et Arnott, *Norysca urala* (Hamilt.) K. Koch, *Notochaete haemosa Benth.* with climbers like *Dicentra scandens* (D. Don) Walp., *Edgaria darjeelingensis* Clarke, *Holboellia latifolia* Wallich., *Sechium edule* (Jacq.) Swartz, *Smilax ferox* Wallich., *Codonopsis affinis* Hook.f. & Thomson., *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* Wallich, *Plantago erosa* Wallich., *Rumex nepalensis* Spreng., *Clinopodium umbrosa* (M. Bieb) C. Koch., *Gallium asperifolium* Wallich., *Swertia chirayita* (Roxb.) Darsten, *S. bimaculata* (Sieb. & Zucc.) Hook.f. & Thomson. ex C.B.Clarke *Impatiens arguta* Hook.f. & Thomson. *Lysimachia alternifolia* Wallich. *Poulzolzia hirta* Hassk., *Hypoestes triflora* Roem. & Sch., *Hemiphragma heterophylla* Wallich., *Erigeron karwinskianus* DC., *Fragaria nubicola* Lindl. to name a few, forming the ground cover.

3. Cold Temperate Vegetation [2400 – 3200 m]

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. However, the region is inhabited by numerous herbs, many of which are endemic to the 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 2800 m and comprises of trees like *Brassaiopsis mitis* Clarke, *Quercus lamellosa* Smith, *Magnolia campbellii* Hook.f. & Thomson., *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. & Thomson. ex Benth, *Smilax glaucophylla* Klotzch, *Schisandra grandiflora*

(Wallich) Hook.f. & Thomson. like and shrubs like *Piptanthus nepalensis* (Hook.) D. Don, *Elsholtzia fructioca* D. Don, *Daphne involucrata* Wallich, *Bistorta amplexicauli* (D. Don) Greene *Berberis insignis* Hook.f. & Thomson., *Aconogonum campanulatum* (Hook.f.) Hara, *Arisaema speciosum* (Wallich.) Martius *Rosa serecia* Lindley with herbs like *Fragaria nubicola* Lindley, *Ranunculus diffisus* DC., *Viola sikkimensis* W. Backer, *Ajuga lobata* D. Don, *Paris polyphylla* Sims., *Gentiana speciosa* (Wallich) 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. The ground cover include *Rosa sericia* Lindl., *Virburnum erubescence* Wallich., *Viburnum nervosum* D. Don, *Ribes* spp. *Mecanopsis napaulensis* DC., *Nellia rubiflora* D. Don, *Potentilla fruticosa* L., *Berberis insignis* Hook.f. et Thomson., *B. umbellata* Wallich., *Daphne bholua* Ham. ex D. Don Climbers include *Actinidia strigosa* Hook.f. & Thomson. ex Benth., *Holboellia latifolia* Wallich., *Aristolochia griffithii* Hook.f. & Thomson., *Leptocodon gracilis* Hook.f. & Thomson. With herbs like *Aconitum spicatum* Stapf, *Aconitum bisma* (Hamilt.) Rapaics, *Fritillaria cirrhosa* D.Don, *Hemiphragma heterophyllum* Wallich., *Panax pseudoginseng* Wallich., *Valeriana wallichii* DC., *Primula capitata* Hook., *Pdenticulata* 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 3200 m upto around 4000 m lays the sub alpine region. This region has been categorized 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* Wallich, *Acer caudatum* Wallich, *Abies spectabilis* (D. Don) Eichler, *Cotoneaster frigidus* Lindley, *Salix sikkimensis* Anderson, *Salix flabellus* Anderson, *Sorbus microphylla* Wenzig., *Viburnum nervosum* D. Don, *Rhododendron cinnabarium* Hook.f., *Rhododendron* *campylocarpum* Hook.f., *Rhododendron campanulatum* D. Don, *Juniperus squamata* Hamilt. ex Lambert, *J. communis* L., *J. wallichiana* Hook.f. & Thomson etc. The herbs in the forests and meadows include *Rubus fragarioides* Bertoloni, *Potentilla microphylla* D. Don, *P. monanthes* Lindley, *Primula glabra* Klatt., *P. oblique* W.W. Smith, *Ranunculus adoxifolius* Hand.-Mzt., *R. brotherusi* Freyn., *Anemone demissa* Hook.f & Thomson, *Tithymalus sikkimensis* (Boiss.) Hurusawa & Ya. Tanaka, *T. stracheyi* (Boiss.) Durusawa et Ya. Tanaka, *Saxifraga hispidual* D. Don, *S. latifolia* Hook.f. & Thomson. *Viola biflora* L., *V. cameleo* Boiss., *Pedicularis mollis* Wallich *ex* Bentham, *P. clarkei* Hook.f., *Neopicrorhiza scrophulariiflora* (Pennell) Hong, *Rheum acuminatum* Hook.f. & Thomson.

1.11. Floristic Works in Darjiling Hills

The floristic richness of Darjiling, Sikkim and Nepal parts of the Himalayas has attracted naturalists, plant explorers, botanists and plant science researchers since the 18th century (Don 1821; Das 1995, 2004). The Indian flora was scientifically and systematically explored since the 1840's. Sir J. D. Hooker in 1848 took up the third botanical expedition to the Eastern Himalaya and became the first ever-botanical explorer of the Eastern Himalaya while writing the *Flora of British India* as a whole (Burkill 1965). In most of the previous works Darjiling and Sikkim have been considered together as Darjiling was then a part of Sikkim.

Explorers from different far and wide areas have explored the region in different times and a number of floras included their records and findings and thereby adding to the knowledge on the vegetation and flora of the region. Some such major overseas contributions include J. D. Hooker (1849 - 1851, 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); Bruhl (1926); Burkill (1907,1965); Ducan (1935); Hara (1963, 1966, 1971); Hara *et al* (1978, 1979, 1982); Mizushima (1963); Nakao (1964); Ohashi (1975); Grierson & Long (1978, 1979, 1982, 1983, 1984, 1987, 1991); Noltie (1994, 2000) and Pearce & Cribb (2002).

On the other hand, workers like J. S. Gamble (1875, 1986), A.M. Cowan & J. M. Cowan (1929) have published floras for the Darjiling part of the Himalayas taking the foresters' point of view. A large number of publications on the flora of the region have been made by these 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 – 1894), F.

Kingdonward (1913, 1942) and M. Tamina (1964).

In addition, a large number of Indian workers have also contributed towards the Floristic knowledge of Darjiling-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 (1964a, 1964b); P.N. Mehra & S.S. Bir (1964); B. D. Sharma & Ghosh (1971); G. S. Yonzone (1976); Mathew (1981); Sahni (1981); Tamang & Yonzone (1982); B. Mathew (1983); Bennet (1983); Mukherjee (1983); Das & Bhujel (1983); N. C. Muzumdar, B. Krishna & M.C. Biswas (1984); U. C. Pradhan & B. M. Rai (1983-85); Das & Chanda (1986, 1986a, 1987, 1990); Bhujel (1984, 1992, 1996); P. C. Lama (1989); Bhujel *et al* (1994, 1996); T. Rai & L. Rai (1994) Das (1995, 1995a, 2004); Samanta & Das (1995, 1996); A.S. Chauhan (1998) are some such important references.

Although the region apparently appears 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 is demanding more and more areas for habitations and other civilisation related activities causing rapid and steady dwindling of forest cover. Naturalization of numerous exotics, excessive increase of pollution, grazing etc. are exerting tremendous pressure on the natural vegetation and thereby the flora of this area (Das 1995, 1998, 2002, 2004) resulting in the loss or extinction of many species and leading many others to different levels of endangered status.

This entire discussion it can be understood that the flora as well as the vegetation of Darjiling Hills and its nearby Terai and Duars are extremely rich and diverse. Any sort of interference and/or modification in such vegetation will cause irreparable loss to the region's biodiversity.

1.12. Present Status of Vegetation

Before the establishment of human settlements in Darjiling Hills, almost the entire area was covered with dense forested vegetation. Rivers and fresh land-slips areas were the only blank areas. When first Lepchas entered this area they created very small hamlets thatched cottages. Their requirement for survival was nominal and the effects of their interference with the local vegetation were not alarming. But, with the visit of Capt. Lloyd and Mr. Grant to Gundari Bazar (present Darjiling) in 1827, the history of the land took a sharp turn and that was true for the local vegetation too. Very soon, the British Indian Government established a sanatorium and constructed road and rail links to Darjiling initiated disturbances in the vegetation.

1.12.1. Introduction of Three Trees: Discovery of a favourable climate for the cultivation of Tea [*Camellia sinensis*] in Darjiling Hills was probably the second dangerous incident in this respect. Now the wide plantations of this species in Terai, Duars and hills upto 2100 m have eliminated so much of important and dense local vegetations. Introduction of Dhupi (*Cryptomeria japonica*) in Darjiling to collect timber for Tea-boxes was another mistake as the species is now proved to be a great enemy for the local species of plants and as the timber produced from this species at Darjiling is not suitable for making Tea-boxes. Widespread plantation of *Cinchona* spp. in Mongpoo – Latpanchor area has also replaced much of local vegetation.

1.12.2. Migration of Work-force: The local population, comprising mostly Lepchas and some Nepali communities, was not enough to maintain different developmental activities in Darjiling. So, it becomes essential to introduce workers from outside. While numerous tribal people from Santhal Paragas, now in Jharkhand State of India, Western part of Bengal were brought to Terai and Duars areas, people from Nepal and Bhutan, in general migrated to the hilly regions of Darjiling (Ghosh & Das 2004).

Arrival of these people caused some changes and those are mainly related to their survival. New settlements were developed in this region to accommodate these people. More natural vegetations were cleared for the cultivation of different crops of their liking. Again, the requirement of firewood as cooking fuel and for running the driers in Tea Factories and for room heating started affecting local forests. Forests started depleting and the rate started accelerating with the increase of population.

1.12.3. Rapid Extension of Civilization: With the establishment of road, rail and air links with Darjiling and nearby areas different facilities of modern civilization continuously pouring into the different corners of this area. And to keep cope with the demand, people utilised more and more natural forest resources with the pass of time.

1.12.4. Fragmentation of Vegetation: The result of the explosion of population, extension of civilization including Tea Gardens, factories, roads, villages, townships, crop-fields etc. has made the Darjiling vegetation highly fragmented. It is now extremely difficult to find out a patch of vegetation that is free from anthropogenic interferences. Forests from wide areas are now completely missing or are highly degraded. And, all these have resulted into the very high fragmentation of forests or other type of natural vegetation. However, still today, there are some good patches of vegetation particularly in protected areas. But, all these patches are quite isolated and any type of migration or exchange of the inhabitants of these protected appears to be either impossible or difficult. Das *et al* (2005) projected some corridors to connect the four major protected areas located within this district, but none of these are either free from human settlements or is provided with a continuous patch of forested vegetation.

1.12.5. Loss of Habitat: The loss of forest cover in a locality where the prevailing environment is suitable for the development of dense forested vegetation is certainly affecting the local biodiversity. It is the common experience, evidenced from the previous literature, that numerous species of plants in this area are known to have extremely restricted distribution. Sometimes a species is known to grow only on a particular hill slope. So, clearing and/or modifying the vegetation on that slope will certainly affect the survival of that species (Das 1986, 1995, 2004). *Liparis tigerhillensis* AP Das & Chanda was collected from the northern slope of Tiger Hill in Darjiling is no more available and probably became extinct. So, the wide scale loss of habitat in Terai, Duars and Darjiling Hills is certainly exerting tremendous pressure on the survival of numerous weak/ new/ restricted distribution species.

1.12.6. Loss of Biodiversity: Survey of old literature on the flora and vegetation of the concerned area (Gamble 1896; Hooker 1872 - 1897; Cowan & Cowan 1929) shows that a good proportion of endemic species which were recorded growing in this area are not recorded during recent explorations. Samanta (1998) and Das (2004) presented a list of such angiospermic climbers and they also believe that proper search among the plants of other habit groups will also produce similar such lists. This is a dangerous situation as the habitat loss and fragmentation of habitat is increasing every day. Very soon, conservationists are afraid of even the protected areas will also loose their capability to conserve most of the species growing there today.

1.12.7. Attempts for Conservation: Realising the importance of the biodiversity in the Himalayas, IUCN has declared the Himalaya Hotspot and considered it one of the hotspots in danger (CI 2005). Even before that the hills of Darjiling part of the Himalayas was forming a part of the Indo-Burma Hotspot. So, there is a general realisation that the biodiversity in the region is under stress and something is to be done to protect it.

The realisation, specially after the Rio de Janeiro Earth Summit in 1992, has fermented into the idea of protecting existing less affected vegetations. This has led to the creation of four major protected areas within the boundary of Darjiling District itself. Two of these are National Parks and two are Wildlife Sanctuaries (Table 1.19).

Table 1.19: Protected areas in Darjiling [Bhujel 1996; Rai 2001].

Types of Protected Area	Protected Areas	Area in sq km	Altitude in m
National Parks	Neora Valley National Park	88	500 – 3150
	Singalila National Park	78.6	2624 – 3660
Wildlife Sanctuaries	Mahananda Wildlife Sanctuary	38.6	200 – 1000
	Senchal Wildlife Sanctuary	127.22	1800 - 2400

Apart from these, there are some Reserve Forests maintained by Forest Department, Government of West Bengal. But, considering the extent of diversity among the life forms, their endemicity and the threats they are facing, the present status of conservation in Darjiling is not yet satisfactory.

All the threatened species can not be saved when they are spotted in an *in situ* conservatory. Sometimes, *ex situ* conservatories are also required for saving a species and for increasing its population.