Chapter I

Introduction

"The universe is the creation of the supreme power ment for the benefit to all his creations. Individual species must therefore learn to enjoy benefits by forming a part of the system in close relation with other species. Let not anyone species encroach upon the others right".

Isho-Upanishad

Darjeeling Himalaya is a part of Singalila range of Eastern Himalaya and a part of Himalayan Hotspot (Moktan & Das, 2011), and globally known as one of the mega biodiversity hotspot zones (Rai & Bhujel, 2011) and is known to provide shelter to a large number of endemic, rare and interesting plant species (Gajurel *et al*. 2006). Takhtajan (1969) based on the analysis of distribution of primitive angiosperms treated the Eastern Himalaya-Fiji region as the 'cradle of flowering plants', where angiosperm have diversified. Therefore, Eastern Himalayan flora has great phytogeographic significance. Eastern Himalaya directly confronts the moisture, monsoon winds, blowing in land across the Bay of Bengal, that leads to a high degree of precipitation which has no equal in the planets. Maximum humidity favours the migration of plant species widely from different bordering countries. The Eastern Himalayas is characterized by affluence in the flora and has attracted the plant lovers round the world (Das, 2011) and rich repository of plant wealth in varied ecological systems. 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). The floristic diversity in the Eastern Himalaya is enormous (Rao, 1994). According to Nayar (1996) the Eastern Himalayan region is one of the three 'mega-centres' of endemic plants harboring endemism at maximum. Eastern Himalaya is regarded as a natural sanctuary of ancient angiosperm taxa and higher endemism than the Western Himalaya due to their isolation because of the lofty mountain ranges and dry Tibetan plateau to the north, warm alluvial plants of the Brahmaputra in the south

which act as barriers of plant migration and also abounds in rare, interesting ferns and many gymnosperms with a discontinuous distribution (Rao, 1994). IUCN has recognized this region within the Himalaya Conservation Hotspot (Rai *et al*. 2011), with around 30% species of higher plants as endemic (Grierson & Long, 1983; Das, 1995, 2004; Bhujel & Das, 2002; Ghosh & Das, 2009). The climatic variation and heterogeneity of habitat structure and function in an extremely long and high mountain system creates favorable environment for development and evolution of species and the process is still continuing (Das, 1995, 2002, 2004). The richness of the flora can be attributed to four distinct ecological zones in the region. Moreover, it is influenced by spectra of habitat variation and thus, represents unique floristic diversity (Das, 1995). The region is well known for its diverse range of vegetation and as 'one of the richest in India' (Bhujel, 1986; Das, 1995; Rai, 2006; Yonzone *et al*. 2009). The vegetation and floristic information of this region has been described with the remark of very rich floristic diversity (Hara, 1966, 1971).

Darjeeling Himalaya is located in the Northern part of the state of West Bengal. Natural beauty as well as the biological wealth of Darjeeling is abundant (Das, 1986, 1995, 1996, 2002, 2004, 2005; Das & Chanda, 1987; Bhujel & Das, 2002; Das *et al*. 2003, 2007, 2008; Das & Ghosh, 2007; Ghosh & Das, 2011). The flora of this region is as varied as any other country of an equal area in Eastern Hemisphere, if not in the globe (Hooker, 1906). This region is blessed with wide variation in climatic condition and topography favouring luxuriant growth of myriad of species adding richness to the vegetation of the region. It harbours a large number of plant species with wide range of diversity and distribution (Das, 1995; Bhujel, 1996; Das & Chanda, 1987; Rai & Bhujel, 2007). In this region a representation of tropical, sub-tropical, temperate, sub-temperate and sub-alpine vegetation, with their characteristic species composition. The record of the *Flora of British India* (Hooker, 1872-1897) shows the presence of more than 4,000 angiospermic plants alone. Most importantly, the region is rich in Orchid diversity and harbours about 311 species (Yonzone *et al*. 2012a). The region is one of the 35 Biodiversity Hotspot of the world and one of the only three such zones falling in India.

Altitude too plays an important role in distribution of the species. Altitudinally, the floristic stretch in Darjeeling Hills ranges from as low as ±120 m amsl in the plains of Siliguri to as high as 3660 m amsl at Sandakphu. Due to great variation in altitude, wide range of climatic zones are available, which favour the lavish growth of diversified and affluent vegetation. Vegetation diversity of Darjeeling has been given by (Champion & Seth, 1968). They have undergone tremendous change over time (Rai & Das, 2004). This region has been regularly intruded by invasive alien plants and increasing population may result in the loss of genetic biodiversity and species extinction and thereby filtering and destroying the ecosystem (Moktan & Das, 2013).

The Darjeeling Himalayan region is a repository for a large number of temperate and tropical Orchids. When considered from agro-floricultural point of view, the region is known throughout the world as botanical paradise. Horticultural interest in Orchids has considerably increased in the region, because of their demand all over the world. The atmospheric humidity, rainfall, diurnal rhythm conditions existing in this region is also suitable for the abundance of Orchid species (Kumar *et al*. 2013) and these may be attributed to its ideal natural climatic conditions like high rainfall, high humidity and presence of maximum forest cover comprising of very rich vegetation. The presence of humus rich forest floor and moist microclimatic zones are ideal for growth of several terrestrial Orchid species like *Anoectochilus*, *Calanthe*, *Cheirostylis*, *Crepidium, Diplomeris*, *Goodyera*, *Habenaria*, *Herminium*, *Herpysma*, *Nephelaphyllum, Odontochilus, Peristylus, Phaius, Platanthera, Tainia, Tipularia*, *Zeuxine* etc.

Over the years, the region has witnessed indiscriminate collection of Orchids from wild habitat (Yonzone *et al*. 2014) along with the destruction of habitat by multiple anthropogenic activities. Many of these wild Orchids are the mother stock for developing new hybrids. Destruction of habitat by felling of trees, that harbour Orchids is contributing much to the vulnerability of Orchid flora. Construction of roads, developmental activities, reckless exploitation in habitat, expansion of human habitation and agriculture are also putting adverse effect on the wild Orchid population. A damage has already been done by the private nurseries that temporarily employ local people for the collection of various types of wild Orchids and they have extracted every species from the forests, slope areas, trees, stream banks etc. for

domestic as well as for export markets (Yonzone *et al*. 2014a). As a result, many species have already become rare and threatened and now appear to be on the verge of extinction.

Darjeeling Himalaya of West Bengal has a long history and even many hybrid Orchids were introduced in early fifties. The Orchid growers of Darjeeling have excelled themselves in producing fascinating hybrid varieties to keep pace with the demands of the international floricultural market rather than think on present condition of threat to diminish the Orchid population in the wild habitat. Orchids are of good ornamental value and have attracted a large number of horticulturists, botanists, orchidologists, Orchid collectors and floral businessmen since a long time in the region. The *Cymbidium* Orchids which rank among top ten cut-flowers sold on Dutch auctions can be grown successfully in the region. High relative humidity, good rainfall and cool temperature make the region an ideal place for commercial Orchid growing.

This region was botanically explored in the past by many botanists and naturalist from India and abroad (Yonzone *et al*. 2014c). But no study has been conducted considering Orchids alone as exclusive group from Darjeeling region. There is no documentation to assess the threatened categories of Orchids and its conservation. A holistic survey and study from the academic and conservation point of view is lacking in the region.

The Orchids diversity in the Darjeeling Himalaya is fast depleting with every passing day. Although, new infraspecific and specific taxa are being discovered, and new reports coming out, we are far from knowing about taxonomic diversity of this most economically important and diverse group of flowering plant. Moreover, many of them are still unknown and are yearning to be discovered. Since King & Pantling, (1898), no comprehensive study has been carried out taking Darjeeling Hills in recent times. Therefore, there is an urgent need for taxonomic revision and ecological study of the group throughout the Himalayan region. It is extremely important at this point to carry out proper scientific study on the present Orchid flora of the region under discussion and assess methods for conservation and sustainable utilization.

Present study attempts to document the Orchid flora of Darjeeling Himalaya. The study is expected to give a comprehensive understanding on Orchid species diversity, regional distribution, altitudinal range, present availability status, new distributional records, new taxa, economic important, endemic, phenology and general distribution to understand the exact number of species in the region.

1.1. History of Orchid Classification

Orchidaceae is one of the largest group of flowering plants with about 25,000 species (Misra, 2014), 30,000 species under 800 genera (Garay, 1960), 22,000-35,000 species under 700-800 genera (Goel & Roy, 2007), over 22,500 species with 779 genera (Mabberly, 2008), about 25,000 to 30,000 species (Chowdhery & Agrawala, 2013), with world-wide distribution but reach their maximum diversity in the tropical climates (Akhter *et al*. 2011), and the family has to be divided into smaller groups such as subfamilies, tribes and sub tribes.

Carl von Linnenaeus in *Species Plantarum* (ed. 1, 1753) classified plants on the basis of reproductive characters often known as sexual system based on the number and position of the stamens and pistils. He placed Orchids in the class XX-GYNANDRIA (stamen adnate to the pistil), Diandria (two stamens) and further established eight Orchid generic names *viz*., *Orchis, Ophrys, Satyrium, Serapias, Limodorum, Arethusa, Cypripedium* and *Epidendrum*. Later he published 102 species under those eight genera in his second edition of *Species Plantarum* in 1762-1763 and described 30 species under the same genus *Epidendrum*.

Antoine Laurent de Jussieu (1748 – 1836) assigned characters common to the group of species, and termed as orders (families) and proposed a division of the Plant Kingdom into classes and all plants were divided into Acotyledons (Cryptogams), Monocotyledons, and Dicotyledones. Based on the disposition of the stamens, monocotyledons were divided into three groups and the so-called Orchids in Class IV, with the stamens epigynous. He recognized Orchids as one of the '*Ordines naturales*' in his *Genera Plantarum* (1789) and he coined the family name Orchidaceae.

Augustin Pyramus de Candolle (1778 – 1841), in his book '*Prodromus Systematis Regmi Vegetabilis*' (1824), arranged plants in accordance with his natural system. He divided vascular plants (plants with cotyledons) into the Exogens or Dicotyledons and the Endogens or Monocotyledons, which included the Orchids.

Olof Swartz (1760 – 1818) published the enumeration of West Indian plants in 1788, including Orchids, for the first time in the book entitled '*Prodromus Descriptionum Vegetabilium…..in Indian Occidentalem*'. He was the follower of Linnaean system and described the species belonging to seven Orchid genera. In *Flora Indiae Occidentalis* (1797 – 1806) he described 13 genera and 77 species of Orchids with brief generic descriptions of floral parts and its relative position, but the species description dealt with roots, bulbs or stems, leaves, inflorescence, and fruit along with synonyms and habitat. In the book, there were notes on the flowering season or a short note distinguishing the plant from other related species.

Swartz (1800a) published earliest article of Orchids of 25 genera with two groups: 1. Orchids with one anther (MONANDRAE) comprising with 24 genera and 2. Orchids with two anthers (DIANDRAE) only one genus (*Cypripedium*). He had first time classified the family Orchidaceae into Monandrae and Diandrae and further published another monograph dealing with 16 Orchid genera (1800b). He had further subdivided the monandrous Orchids into three groups *viz*., *Anthera subterminali*, *Anthera erecta* and *Anthera operculari* corresponding to Orchidoids, Neottioids, and Epidendroids groups in modern system of Orchids classification.

Robert Brown (1773 – 1858) published Orchids in W.T. Aiton's *Hortus Kewensis* (A Catalogue of the Plants cultivated in the Royal Botanic Garden, Kew) in 1813. He followed the Linnaean and Swartz's system of division and described 46 genera and 115 species with short descriptions and synonyms, the native country, date of introduction and the flowering time.

L.C. Richard (1754 – 1821) published European Orchids in 1817, critically studied and described the structure of pollinia and gynostegium in key and critical characters

on a plate with the title '*Genitalia Orchidearum*'. Later in (1818) he had reviewed the previously published work along with detailed account of all parts of the Orchid plants, mainly flower, pollen nature, using a specific and often new terminology; a key to the European Orchid genera; sketch of floral structures of each genus and species with their synonyms.

Carl Ludwig Blume (1796 – 1862), described several new concepts in details and divided Orchids into three groups on the basis of granular, powdery, or waxy nature of the pollen (1825). His generic concepts of *Agrostophyllum, Spathoglottis,* and *Phalaenopsis,* etc., are still in vogue, but the genera like *Dendrolirium* and *Trichotosia,* etc., have been reduced to synonyms or transferred to sections of other larger genera. Later his monumental work, '*Flora Javae et Insularum adtacentium*' (1858), included detailed description already described many species of Orchids and some novelties.

John Lindley (1799 – 1865), known as the 'Father of Orchidology' and founder of modern orchidology, for the first time used a category between family and tribe in Orchid in 1826. He divided the Orchids into four groups *viz*., *Neottieae, Orchiceae, Epidendreae* and *Cyperipedieae*, and are recognized as sub-families and modified his own classification several times. In 1833, he placed three families *viz*., Orchideae, Cypripedieae and Apostasieae in 'cohors Gynandrae' and in 1836 he proposed a new family Vanillaceae for the genus *Vanilla* and *Epistephium* on the basis of their succulent fruits and unusual seeds and further in 1841, he founded the horticultural journal, '*The Gardeners Chronicle*', wherein published his many discoveries and new Orchid species. His monumental work on Orchids '*The Genera and Species of Orchidaceous Plants*' published in parts in between 1830 and 1840 was the most comprehensive treatment on the classification of Orchid up to his time. He has identified many Orchid species and studied a large number of specimens received from various places and enumerated and described all the known Orchid species from all parts of the world. His classification is based on the number of anthers and pollen structure and classified seven divisions or tribes of Orchidaceae *viz*., Malaxideae, Epidendreae, Vandeae, Ophrydeae, Arethuseae, Neottieae and Cyperipedieae. In 1847, he referred three families *viz*., Burmanniaceae, Orchidaceae and Apostasiaceae under

Orchidales. In between 1852 and 1859, he published a series of monographs of all known Orchid genera in '*Folia Orchidacea*' wherein he mentioned larger genera and their species with keys, *viz*., *Brassia, Calanthe, Coelogyne, Epidendrum, Miltonia, Oberonia, Odontoglossum, Oncidium, Pleurothallis, Sobralia, Stanhopea, Stelis* and *Vanda* but unable to complete the series of monographs.

Charles Darwin (1809 – 1882) studied the role played by insects in the pollination and he published a book in (1877) entitled "*The Various Contrivances by which Orchids are Fertilized by Insects*". Heinrich Gustav Reichenbach (referred as Rchb. f.) (1824 – 1889), remained expert on Orchids and his herbarium became the repository of Orchid specimens from all over the world. He published a large number of articles in different journals namely *Linnaea* to *Botanische Zeitung, Gardeners' Chronicle* and *Bonplandia,* and the Orchid part in *Icones Florae Germanicae et Helveticae* (vol. 13 and 14). These were published in 22 volumes in 1850 – 1851 by his father and his most noteworthy publication – the *Xenia Orchidaceae* – was published in 3 volumes between 1854 and 1900; *Beitriige zur Kenntniss der Orchideen* or the "Contributions to the Knowledge of the Orchids" was published in three volumes but he did not classify Orchids by any new system of classification.

George Bentham (1800 – 1884), proposed three modern systems of classification and published in the *Journal of the Linnean Society*. His system of classification was more or less same as classification of Lindley with slender modification. He proposed Epidendreae (by merging Lindley's Malaxideae and Epidendreae); Vandeae; Neottieae (by merging Lindley's Arethuseae and Neottieae); Ophrydeae; and Cypripedieae. Later, his classification was published in Volume III of *Genera Plantarum* (1883). Ernst Hugo Heinrich Pfitzer (1846 – 1906) classify Orchids in (1887) different from the earlier classifications of Swertz, Lindley and Bentham, and published significant works on Orchid morphology. In his classification, he retained the divisions Diandrae and Monandrae, but he dichotomously subdivided the monandrous Orchids into Basitonae (with basal pollinium stalks) and Acrotonae (with apical pollinium stalks). Further division of Acrotonae into Acranthae (with species having terminal inflorescence) and Pleuranthae (species having lateral inflorescences). Further division of these groups were based on the structure or type of pseudobulbs and monopodial or

sympodial nature of plant growth. Later his treatment of Orchidaceae appeared in Engler and Prantl's '*Die Naturlichen Pflanzenfamilien*' (1889). Pfitzer included the apostasioids in 'Diandrae', of which *Neuwiedia* having more than two stamens was named as '*Pleonandrae*' and published '*Das Pflanzenreich*' (1903) with detailed treatment of Cypripedilinae with four genera *viz*., *Selanipedilum* [=*Selanipedium*], *Cyperipedilum* [=*Cyperipedium*], *Phragmopedilum* [=*Phragmipedium*] and *Paphiopedilum* [=*Paphiopedilum*], with synonymy, line drawings and artificial keys to the species.

R.A. Rolfe (1855 – 1921) published the 'revision of the genus *Phalaenopsis'* in the Gardeners' Chronicle in 1886 and started popular Orchid journal *Orchid Review* in 1893 and established himself as an authority on the Orchidaceae. His valuable publications are 'a revision of the genus *Vanilla* (1896)'; Orchid monographs in the '*Flora of Tropical Africa*' (1897 – 1898); Orchidaceae in the '*Flora Capensis*' and '*An Enumeration of Hybrid Orchids of Artificial Origin*' published in 1909.

Fritz Kranzlin (1847 – 1934), published *Orchidacearum Genera et Species*, volume 1 (1901) with monographs on Apostasieae, Cypripedieae and Ophrydeae, and volume 2 (part-1) in 1903 – 1904 consisting of the monograph on the Chloraceae (Monandrae, Neottiinae of Pfitzer), with keys and plates. Further he had published monographs on Coelogyninae co-authored by E. Pfitzer in *Das Pflanzenreich* in 1907, the Dendrobiinae (part-1) in 1901; the Dendrobiinae (part-2) in 1911; *Oncidium, Leochilus, Sigmatostalix* and *Cryptarrhena* in 1922; the Pseudomonopodiales in 1923. His monographs on other Orchid genera, *viz*., *Masdevallia, Lothiania, Scaphosepalum, Cryptophoranthus, Pseudoctomeria* and *Polystachya* were published in *Fedde Repertorium Specierum Novarum Regni Vegetabilis* Beihefte 34 (1925) and 39 (1926). Besides monographs, he described many new Orchid species from Tibet, China, the Pacific Islands, Middle and South America, and Africa.

H.N. Ridley (1855 – 1956), the Director of the Botanic Gardens, Singapore and published detailed accounts of the Orchids of Madagascar (1885), Borneo and Malay Peninsula (1896a, 1896b, 1907, 1924). His monograph on the genus *Liparis*, revision

of the genus *Microstylis, Malaxis* and *Bromheadia* with several new taxa were published in the *Journal of the Linnean Society* from 1886 to 1891.

J.J. Smith (1867 – 1947), the Director of the Government Botanic Gardens at Buitenzorg, published Orchid Flora of Amboina (1905), Java (1905 – 1939), Borneo (1931), Sumatra (1933); a detailed flora of Dutch New Guinea 'Artificial Key to the Orchid Genera of the Netherlands, Indies together with those of New Guinea (1909 – 1934), the Malay Peninsula and the Philippines' (*Blumea*, 1934); and '*Icones Orchidacearum Malayensium*' (1929 – 1938), etc. Friedrich Richard Rudolf Schlechter (1872 – 1925), made valuable contribution and one of the most eminent orchidologists published more than 300 research papers, monographs on Orchids based on his collections from Africa, Sumatra, Java, Celebes, Borneo, New Guinea and Australia, and books including Orchids cultivation manual. His monumental floristic work, '*Die Orchidaceen von Deutsch Neu Guinea'*, published in between 1911 and 1928, described nearly 1350 species of which 1100 were new Orchids. He further published monographs on 28 different Orchid genera in various journals between 1894 and 1922, and 18 more in the journal *Orchis* between 1911 and 1920. His most outstanding contribution to Orchids dealing with Orchid species and Orchid culture is '*Die Orchideen*' (1914-1915). He published enumeration of new-world Orchids and the key to the family Orchidaceae in 1926. After Schlechter, R. Mansfeld (1901 – 1960) described several new Orchid species from the West Indies, different parts of South America, East Africa, South China, etc., and published Orchid monographs with many new concepts.

Victor Samuel Summerhayes (1897 – 1974) studied the Orchids of Africa, particularly those of the *Habenaria* group, *Polystachya*, *Eulophia*, and Sarcanthinae. Oakes Ames (1874 – 1950), published 'Orchidaceae: Illustrations and Studies of the Family Orchidaceae' in seven fascicles between 1905 – 1922. and described monographs, hundreds of new species from Philippine, Middle America, West Indies, and Orchids of Mt. Kinabalu, British North Borneo, etc. and his other publications include Orchids of United States and Canada (1924); Orchidaceae in flora of Panama Canal zone (1928), Costa Rica (1937); Orchids of Guatemala (1952 – 1953); *Schedulae Orchidianae* in between 1922 and 1930); monographs on the American

species of the genus *Spiranthes* (1905); *Habenaria* (1910); *Pogonia* (1922); *Epidendrum* (1936); 'Drawings of Florida Orchids' (1947).

George King and Robert Pantling (1898) published the Orchids of the Sikkim Himalaya and classified the Orchideae into seven tribes *viz*., Malaxideae, Epidendreae, Vandeae, Listereae, Goodyereae, Ophrydeae and Cypripedieae.

Seidenfaden (1908 – 2001) contributed to Orchid taxonomy in great details and arranged more than 20 expeditions in Thailand between 1956 and 1982 and collected more than 10,000 Orchid specimens and published Orchid genera of Thailand. Other published works were the Orchids of North-Western Himalaya, Western Ghats, Malaysia, Singapore, Laos, Cambodia and Vietnam.

Ribert Dressler and C.H. Dodson (1960) reviewed Schlter's system and classify the Orchids with keys to tribes and subtribes and all the names in accordance with ICBN. They changed Diandrae (Pleonandrae) to subfamily Cypripedioideae with two tribes Cyperidieae and Apostasieae, while changing Monandrae to subfamily Orchidoieae having three tribes *viz*., Neottieae, Orchideae and Epidendreae, which were further divided into three, four and 27 subtribes, respectively. Book of Dressler '*The Orchids: Natural History and Classification*' published in 1981.

Pieter Vermeulen (1966) upgraded the subfamily to family and distinguished three families in the order Orchidales: Apostasiaceae, Cypripediaceae and Orchidaceae with detailed analysis of the structure of gynostemium and arrangement of sepals and petals and their structures in these three families in his classification. He divided Orchidaceae into two subfamilies: Orchidoideae and Epidendroideae. The subfamily Epidendroideae was further divided into contribe Neottianthae (with 3 tribes, Neottieae, Arethuseae and Vanilleae) and Epidendranthae (with 2 tribes, Epidendreae and Vandeae). Dressler in the year 1993 revised his classification and divided Orchidaceae into five subfamilies: Apostasioideae, Cyprepedioideae, Orchidoideae, Spiranthoideae and Epidendroideae. He dropped the earlier proposed Vandoideae considering it to be polyphyletic and the tribe Neottieae (*Aphyllorchis, Cephalanthera,*

Epipactis, Limodorum, Listera, and *Neottia*) was integrated in the sub-family Epidendriodeae.

Dauiusz L. Szlachetko (1995) classified Orchidaceae in the book entitled '*Systema Orchidalium*'. He followed the three-family scheme of Vermeulen (1966) and divided the order Orchidales into three families *viz*., Apostasiaceae, Cypripediaceae and Orchidaceae. In his classification, he divided Orchidaceae into eight subfamilies: Thelymitroideae, Orchidoideae, Tropidioideae, Spiranthoideae, Neottioideae, Vanilloideae, Epidendroideae and Vandoideae.

1.2. Orchids in India

The Indian Orchids have played a significant role in the international Orchid trade. Indian Orchids were brought to the notice of the world by Charak in his classic book on herbal medicines – '*CHARAK SAMHITA*', (3^{rd} – 2^{nd} century B.C.). It provided description of *Flickingeria, Malaxis* and *Eulophia*. The first scientific account of Indian Orchids came through in the 17^{th} century by van Rheede, who for the first time described Orchids from Malabar region of India in his classical work '*HORTUS MALABARICUS*' (1678 – 1693). Linnaeus (1753) included 12 species of Indian Orchids in his '*SPECIES PLANTARUM*'. John Lindley (1830-1859), studied about the Orchid and successfully laid the foundation of the science of Orchid called 'Orchidology'. Subsequently William Roxburgh (1832), Griffith (1847-1854), Atkinson (1882) and other botanists made valuable contributions to the Indian Orchids. After the establishment of Botanical Survey of India in 1890 at Royal Botanic Garden, Calcutta, the studies on the Indian flora gained significant momentum. The taxonomic studies on the Indian Orchids resulted in the classic works of Hooker (1888-1890, 1895), King & Pantling (1898), Duthie (1906), Pradhan (1976, 1979), Kumar & Manilal (1994), Bose & Bhattacharjee (1980) and Misra (2007). Similar work followed by several publications on the regional floras by Prain, 1903, Cooke, 1908, Fyson, 1920, Haines, 1924, Gamble, 1925, Bruhl, 1926, Fischer, 1938 etc. which have contributed significantly towards the knowledge of Orchids of India.

A large number of publications dealing with detailed accounts of Orchids of Meghalaya (Kataki, 1986), North West Himalaya (Deva & Naithani, 1986), Nilgiri (Joseph, 1987), Arunachal Pradesh (Chowdhery, 1998), Nagaland (Hynniwta *et al*. 2000), Kerala (Kumar & Manilal, 2004), Manipur (Ghatak & Devi, 1986), Mizoram (Singh *et al*. 1998), Sikkim (Lucksom, 2007), Kamrup (Barua, 2001), West Himalaya (Chowdhery & Agrawala, 2013), Odisha (Misra, 2014) have been brought out making significant contribution to the existing knowledge of Indian Orchids.

Orchids are considered to be the most highly evolved among the monocotyledons (Hajra & De, 2011) having remarkable specialization for pollination, water uptake and storage (Chowdhery & Agrawala, 2013), and comprise one of the significant components of extremely rich and diversified floristic wealth of India (Goel & Roy, 2007). They have attracted and mesmerized the people world over (Deb & Imchen, 2011), and exhibit incredible diversity in shape, size, structure, colour and fragrance of flowers (Kalita, 2006) and three different life forms *viz*. epiphytic, terrestrial and saprophytic and are pretty admired among the professional and amateur Orchid lovers of the world (Arora, 1985) and best known for its commercial and ornamental value (Dash, 2012), and considered as the most beautiful of flowering plants (Kalita, 2006) and considered as gem in the field of horticulture (Hedge, 1984). Orchids are characterized by distinct floral morphology, pollination mechanism, association with unique fungal partners and miniscule seeds. In India, Orchids form 10% of the world Orchid flora with Himalayas as their natural home (Medhi & Chakrabarti, 2009) and the largest and commercially important flowering plants (Mulgaonkar & Dabhade, 2010). Sir J.D. Hooker (1872-1897), described 1600 species from British India, which included Pakistan, Nepal, Bhutan, Bangladesh, Burma (Myanmar), Malay Peninsula and Ceylon (Sri Lanka). Pradhan (1976, 1979) described a total of 810 species from the present India. Bose & Bhattacharjee (1980) listed 996 species under 162 genera from India. Jain & Mehrotra, 1984, listed all the known species of Indian Orchids and their distribution. A total of about 1072 species in 157 genera occur within the present boundaries of India (Manilal & Kumar, 1985). In India about 1250 species are found principally in three major centres *i.e*., North East Himalayas, Western Ghats and Southern Hills, and Andaman and Nicobar Islands (Khoshoo, 1985). Subsequently, Jain & Mehrotra (1984) listed about 925 species

under 144 genera; Kumar & Manilal (1994) reported 166 genera and 1141 species; Karthikeyan (2000) listed 1229 species under 184 genera; Singh *et al*. (2001) estimated 1195 species belonging to 177 genera; Goel & Roy (2007) reported 1200 species under 170 genera; Misra (2007) reported 1331 species; Chowdhery & Agrawala, (2013) reported about 1340 species respectively from the present India.

Orchids are found in diverse climatic situations (Udupa, *et al*. 2011). In India, Orchids are found from the sea level to Alpine regions but their abundance varies in different regions according to prevailing climatic conditions. According to Kumar & Manilal, (1994), there are about 1141 species belonging to 166 genera of Orchids in India. Hedge, (1997), there are 1140, (Kalita, 2006), there are 1195 Orchid species occurring in India, many of them are epiphytes with 750 species in 108 genera and other 392 species are terrestrial forms and among the terrestrials, 36 species in 15 genera are saprophytes. There are 1331 species belonging to 186 genera widely distributed throughout the country (Chowdhery, 2009). Out of different phytogeographical regions in India, the Himalayan region is the richest in terms of the number of species and genera of Orchids of which Eastern Himalaya along accounts for about 700 species (Chowdhery, 1998). As many as 545 Orchid species are reported from the Eastern Himalayan and 244 from the Trans, North West, and West Himalayan regions (Pangtey *et al*. 1991). Around 1,300 Orchid species have been estimated to occur in India; the Eastern Himalayas, the Western, and South Indian hills are the Orchid rich areas in the country (Bose *et al*. 1999). About 245 species in 75 genera are reported from Western Ghats which includes 112 species in 30 genera to be endemic (Sharief, 2011). The East Himalayas and North-Eastern India; North-West Himalayas; Peninsular India; and Andaman and Nicobar Islands are the major Orchid rich regions in India (Vij, 1995). There are 173 species in 45 genera from North Western Himalayas (Duthie, 1906), about 89 species in 35 genera from Mussoorie, an outstation of the Western Himalayas (Raizada *et al*. 1981). The two phytogeographic regions *viz*. North-Eastern India and the Eastern Himalayas having 650 and 612 species respectively are the richest Orchid habitats. There are 250 species each from Peninsular India and Western Himalayas followed by 130 species from Eastern India, 60 species from Central India and Gangetic Plains and 5 species from Western India (Hedge, 1997). There are about 700 species (Chowdhery, 1998); 690 species (Kataki

et al. 1984); 825 species (Hedge, 2000); 800 species (Barua, 2001); 850 species (Kalita, 2006); 900 species in 165 genera (Rao, 2007); 835 species (Goel & Roy, 2007) from North East India and considered to be one of the significant genetic treasures house of bioresources in the world (Baruah *et al*. 2011), and richest area in the country for natural Orchids (Kalita, 2006). There are 557 species belonging to 134 genera from Sikkim and North East India. Out of which 523 species from Sikkim (Lucksom, 2007). In the Himalayan region along, there are approximately 600 species in some 100 genera (Pradhan & Pradhan, 1997). Abraham & Vatsala (1981) reported about 150 South Indian Orchids. Seidenfaden (1983) described 73 species belonging to 36 genera for Tamil Nadu and Karnataka based on collections made by k.m. Mathew and others. Vij *et al*. (1983) recorded 112 species from Nainital and adjacent hills in the Central Himalayas.

1.3. General Note

The Darjeeling Himalaya, the northernmost district of the state of West Bengal of India, is floristically a part of the Eastern Himalayas. The Himalayan region underwent large scale geological changes during the tertiary and quaternary era that resulted in the formation of continuous mountain tract along the northern border. With altitudinal variation climatic condition also change. This has led to the migration, adaptation, establishment and evolution of flora from neighbouring countries. Due to the great variation in altitude, width of the hill system etc. a wide array of climatic condition is available in different parts, most of which favoured growth of a good and dense vegetation throughout the area, covering almost all major groups of plants including high number of endemics (Biswas 1940; Chatterjee 1940; Das, 1995; Das & Chanda, 1987; Samanta & Das, 1995). The richness in its flora can be attributed to the above factors along with survival of many ancient elements with recent ones and having evolved and differentiated into new species and races (Hara, 1966). Three ‘T’ – “Tea, Timber and Tourism” formed the economic backbone of Darjeeling (Ghosh, 2006).

1.4. Location of Study Region

Darjeeling district is the Northernmost district of the state of West Bengal, India and comprises of both major part hills and some part of rolling plains of terai and the Doars. While the hilly region of the district lies in between 26º 27' 05"and 27º 13' 10" North latitude and between 88 º53'00" and 87 º59'30" East longitude, covering an area of 3149 sq. km. of which 2196 (69.74%) is under forest cover (Rai, 2006); the terai and the Doars plain lies between 26 º30'00" and 26 º45'00 North and between 88 º and 88 º30'East with an area of 934.7 sq. km (Rai, 2002), and the altitude varies between 120 m amsl at Bidhan Nagar of Siliguri Terai to 3660 m amsl at Sandakphu (Ghosh & Das, 2011), Nirola & Das, 2011). The district therefore has an area of 3254.7 sq. km. which is 3.68% of the total area of the state of West Bengal.

The district resembles an irregular triangular shape with its base resting on Sikkim. Of all the frontier districts of India, the Darjeeling district has the most complicated boundary. It shares international boundaries with Nepal in the west and Bhutan in the East and Bangladesh in the South. Its Eastern boundary with Bhutan is separated by the river Jaldhaka and its Western boundary with Nepal by the rivers Mechi. It shares its Northern boundary with the state of Sikkim being separated by the rivers Ramam, great Rangit, Rangpu and Teesta at different locations. The Southern boundaries is somewhat complicated as it shares boundaries with the districts of Jalpaiguri and West Dinajpur of the state of West Bengal, Purnea district to Bihar and international boundary with Bangladesh. The boundaries with Sikkim and Bhutan meets with that of Darjeeling district at a trijunction at Rachela (3150 m) of Kalimpong Sub-Division with another trijunction formed between Darjeeling Sub-Division, Sikkim and Nepal at Phalut (3600 m) of the Darjeeling Sub-Division. (Fig. 1.1).

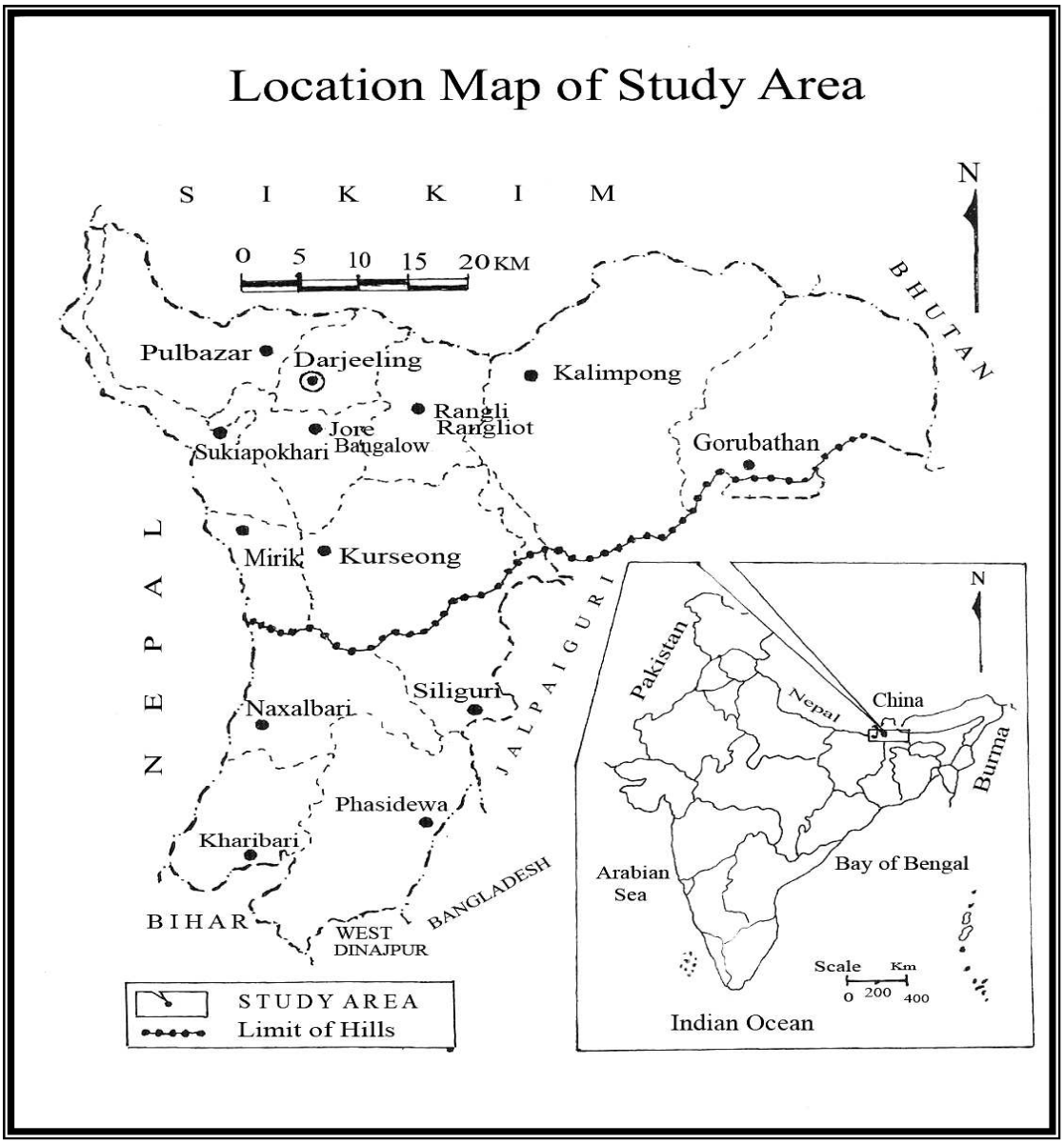


Fig. 1.1: Location Map of study area (Darjeeling Himalaya of West Bengal, India)

The Darjeeling District has been divided into four major administrative Sub-Divisions. These include Darjeeling (935.5 sq. km), Kalimpong (1056.5 sq. km), Kurseong (425.3 sq. km) and Siliguri (837.4 sq. km). While the former three Sub-Divisions fall under the hill region, Siliguri Sub-Division falls under the terai and Doars plain. The principal towns include Darjeeling, Kalimpong, Kurseong and Siliguri. While Darjeeling is located in 27º03'N latitude and 88º16' E longitude is the administrative head-quarter of the district Siliguri is the largest township in the district.

The three Hill Sub-Divisions *viz*., Kalimpong, Kurseong and Darjeeling sadar consisting of eight developmental blocks and occupying an area of 2417 sq. km. comprise the Darjeeling Himalaya (Chhetri *et al*. 2005).

1.5. A Brief History of Darjeeling

The name Darjeeling is believed to have derived from two sources, (i) the Tibetan word '*Dorje ling*' where '*Dorje'* the celestial spectre or double headed thunderbolt and '*ling'* is the land. Thus it literally means the place of thunderbolt of lamaist religion and (ii) the Sanskrit word '*Durjay Ling*', means Siva of invincible prowess who rules the Himalayas (Rai, 2002; Lama, 2004). The evidence of the worship place, which stands atop the observatory hill, corroborates the sources and thus the district came to be known by the same name (Rai, 2006).

Darjeeling has had a complicated and controversial history ever since it has been recorded. The creation of present district of Darjeeling in the 19th century was a result of the involvement of the British India Government in the affairs of neighbouring Himalayan states. The present day district of Darjeeling was a part of the dominion of the Raja of the sovereign state of Sikkim. In 1706, the region which today comprises of the Sub-Division of Kalimpong along with some tracts of terai and Doars plains lying east of the river Teesta was conquered and annexed by Bhutan from Sikkim. This took place during the rule of Gaeboo Achook Pano, the Lepcha king who is still remembered and revered as the last king of Kalimpong by the Lepchas. The Gorkhas who seized power and had brought about the unification of Nepal invaded Sikkim in 1780. Between 1788-1799, the Gorkhas under the command of General Jahar Singh and commandant Damodar Panday re-invaded Sikkim and defeated the then king Tepsing Namgyal annexing large tracts of land lying west of the river Teesta belonging to Sikkim. Thus, Darjeeling was conquered and occupied by Nepal from 1788-1816 and was restored to Sikkim by the British in 1817 (Pradhan, 1991). During that period when the Gorkhas were spreading and annexing territories the East India Company established itself in the Indian Territory. Owing to disagreement over the frontier policy of the Gorkhas the East India Company declared war on behalf of the

raja of Sikkim against the Gorkhas towards the end of 1813 (Subba, 1992). On the 2nd of December, 1815 the treaty of *Sugaulee* was signed that led to Nepal handing over annexed region of Darjeeling and the terai to the British India Government. This was soon followed by the signing of the treaty of *Titalaya* on 10th February, 1817 through which all the regions that had been conquered by the Gorkhas, lying between the river Mechi and Teesta were restored to the Raja of Sikkim by the British guaranteeing its sovereignty making Sikkim a buffer state between Tibet and British India (Bhujel, 1966).

In 1828, the visit by Captain William Lloyd and Mr. Grant to Darjeeling, led them to propose and persuade their government to establish a civil sanitorium and summer capital due to the favourable climatic conditions that suited the British. The then Governer General of British India, Lord Bentick initiated a dialogue that led the Raja of Sikkim handing over the area as a token of friendship to the British Government on the 1st of February, 1835. In the wake of an internal rebellion led by the Lamas and other leading men of Sikkim a punitive expedition was sent by the British in February 1850, leading to the terai or the plains bounded by the rivers Ramam and the Great Rangit towards the North and by the river Teesta on the East and the sated of Nepal to the West with an area about 1657.6 sq. km. being annexed to Darjeeling.

Thus, Darjeeling along with the terai region that were annexed came under the direct control of superintendent who from the 8th of May, 1850 was designated as the Deputy Commissioner (Banerjee, 1980). The cool climate and natural beauty of Darjeeling attracted large number of British families who began to settle in Darjeeling between 1835-1852. Along with the British establishment tea plantation in the region started from 1854.

A war in 1864, between the East India Company and Bhutan led to the defeat of Bhutan that resulted in the present day Sub-Division of Kalimpong being ceded to the British Empire by Bhutan through the signing of the treaty of *Sinchula* on 11th November, 1865 on lease. It was initially notified as Sub-Division of Duars but after a year transferred to Darjeeling district in 1866 (Subba, 1992).

The present dimension of the district has been retained since 1880, when Siliguri was taken out of the district of Jalpaiguri and included into the district of Darjeeling. However, its administrative placement has been constantly changed. The district was once included in the Rajsahi division (now in Bangladesh) until October, 1905. The partition of Bengal, led to it being transferred to the Bhagalpur division (Bengal, Bihar and Orissa then being undivided). With the reorganization of the provinces, it was re-transferred to the Rajsahi division in March 1912. The final inclusion in the state of West Bengal was an automatic incident that took place in August 1947, when India got her freedom.

The district of Darjeeling was a 'non-regulated area' till late 1874; a scheduled district till 1919 and a "Backward Tract" up to 1935. From 1935 to 1947 when India got her Independence, it was a partially excluded area under the Government of India Act, 1935. The Indo-Nepal Treaty of 31st July, 1950 led to the open border between the two countries with the national being treated as reciprocals. This led to a state of uncertainty with respect to the status of the Indian Gorkhas (often being labeled as foreigners). A violent agitation in the mid 1980s, questioning the identity, gave a momentum for a separate statehood demand and the matter was temporarily put to rest with the formation of the Darjeeling Gorkha Hill Council on 22nd August, 1988 in the purview of an autonomous administration (Liwang, 2000). The three hilly Sub-Divisions of the district are now under the administrative purview of the Gorkhaland Territorial Administration (GTA) that came into effect on 18 August 2011.

1.6. Topography and General Features

1.6.1. Mountain System

Darjeeling Himalaya falls under the Singalila and Chola range of the Sub-Himalayan region. The ridges and spurs, that radiate out and are contiguous with the outer hills, forming 'V' shaped, complex valleys with the absence of open valleys. The snow range lies far beyond the limits of the district to the North, forming a beautiful

long range of snow covered peaks that stretch from the East to West that form the backbone of Darjeeling Himalaya. The Darjeeling Himalaya are spurs of the Singalila range that enter the district near Phalut from Mt. Gosa (3800 m) and Chiwabhangyang (3400-3600 m) in West Sikkim. The ridge from Phalut (3600 m) leads to Sabargam (3546 m) and Sandakphu (3636 m), the highest peak of the district. This ridge also forms a boundary between Nepal and Darjeeling district. The ridge descends in the southeastern direction to Kalpokhri (3186 m), Gairibans (2625-2800 m) Tonglu (3000 m) ending at Maneybhangyang (1900 m). Peaks attaining over 3200 m are only found along this ridge. Another ridge descends from Phalut through Samanden (2400 m), Gorkhey (2367 m), Ramam (2560 m), Sirikhola (2100 m) and finally ends at Rimbick (2000 m). The Gosa-Phalut ridge descends down to Tiger Hill (2450 m) that forms a node from which four major ridges radiate out:

(a) Darjeeling Ridge to the North

The Darjeeling ridge stretches in a northward direction through Senchel (2300 m) Tiger Hill (2450 m) reaching Ghoom (2250 m) and through Jalapahar-Katakpahar (2300 m), Chowrasta (2150 m), Mahakal Danra (Observatory Hill, 2175 m) from where one of the spur leads downwards to Singamari – Tukvar (1900-1200 m) and the other towards Lebong-Badamtam (1800-1200 m) finally descending to the River Rangit.

(b) Takdah Spur to the East

One of the spurs from Tiger hill continues in North East direction and ends at the banks of the river great Rangit through Simkuna (2100 m) and Takdah (1800 m).

(c) Dow Hill ridge to the South

Another ridge from the Tiger Hill node extends along the Southern direction being quite a long ridge that extends into Dow Hill (1900 m), Kurseong (1450-1600 m), Mahaldiram (1800 m) to Baggonra (2000 m) from where numerous small spurs spreading into Sittong-Selphu (1800 m) and Latpanjar (1700

m) towards arise and the roll down the banks of the river Teesta upto the Terai in Darjeeling and Jalpaiguri district.

(d) Ghoom ridge to the West

The ridges falling to the Siddhi khola and river Mechi have four bases at Lohaghar (250 m), Tireni (300 m), Panighatta (250 m) and Ghaiyabari (450 m) from where an upraised ridge leads to Mirik (1000-1200 m), Simana (2200 m) Sukhiapokhari-Jorepokhari (2000-2350 m) where it meets a ridge from Maneybhangyang.

These major ridges are interlaced with numerous small ridges and spurs.

The Himalayan region East of the river Teesta and West river Jaldhaka fall under the Chola range that enters from South East Sikkim and Western Bhutan that meet at a trijunction between the Kalimpong Sub-Division of the Darjeeling district, Bhutan and Sikkim at Rachela peak (3150 m). The ridge arising from Mungpong-Pankhaban forest (250-400 m) leads to Yangmakum (800-1200 m), and to Charkholay (1600 m) where its meet with its sister ridge arising from Bagrakot (250 m) across Nimbong (1000-1200 m) and together they enter Lolaygoan-Kafer (1800-2300 m) and to Lava (2150 m). A ridge ascending from Depkhola-Kumsi forest (300-800 m) traverses across Durpin (1550 m), Kalimpong town (1250 m) on its saddle. From here it rises up further into Dello (1800 m), Algarah (1900 m) and to Lava (2150 m). A ridge from the banks of the river Reshi rises through Pedong (1000-1500 m) to Damsang forest (1800-2200 m) and joins the former at Algarah. In the far Eastern region a ridge arising from Gorubathan (300 m) and Samsing (350 m) leads to Thosum (2500-2800 m) and Rupa peak (2480 m) and finally joins with the Rachela peak (3150 m). The ridge then descends to the West to join Lava through Aloobari (2380 m) and Pankhasari (2200-2500 m), forming the central meeting point of the Kalimpong Sub-Division (Fig. 1.2).

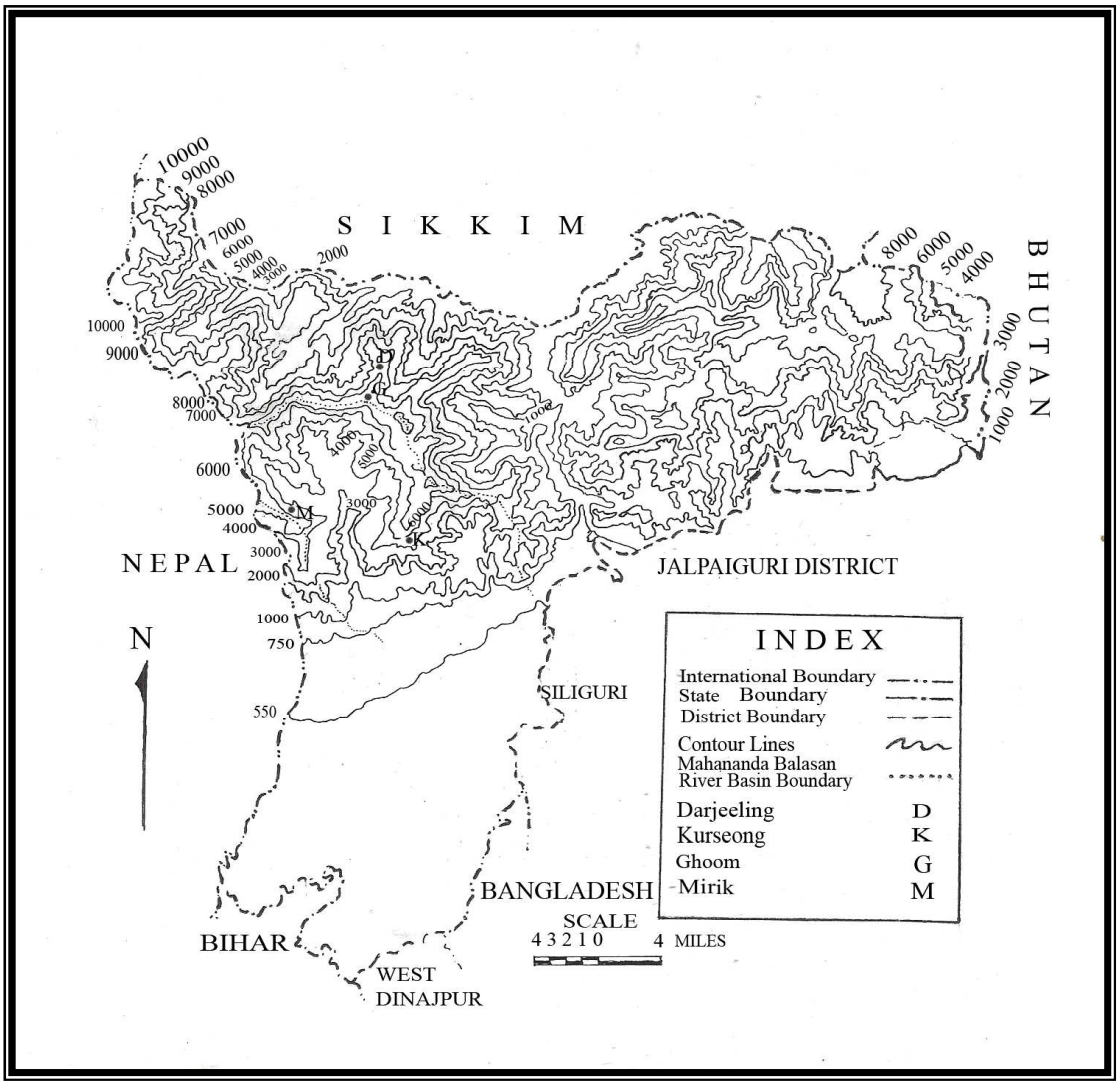


Fig. 1.2: Map showing Contour Lines of Darjeeling Himalaya

1.6.2. River System and Drainage

Darjeeling Himalaya fosters many perennial rivers, most of which flow freely southwards. Some of the rivers and streams that originate from the Ghoom and Lava saddle however, flow northwards. The complicated network of the spurs and ridges govern the direction of the flow along different directions (Fig. 1.3). Taking into consideration the length and volume, these water bodies may be classified into three categories.

a. Major rivers:

The rivers Teesta and Rangit fall into this group. Teesta is a perennial glacier fed river originates from the mountainous region of North Sikkim. The Yumthang-Chu and Lachung-Chu originating from Yume-Samdung; Lachen-Chu originating in Gorudongma and Chu-Lamu (a sacred place of the Buddhist) meet the main stream at Chunthang and is named Teesta. The river Rangit, the main tributary of Teesta on the other hand originates from the mountainous region of West Sikkim. Within the limit of the district, these rivers are further fed by numerous tributaties that arise from perennial streams. These two major river meet near Teesta bazar which is about 17 km. away from Kalimpong town.

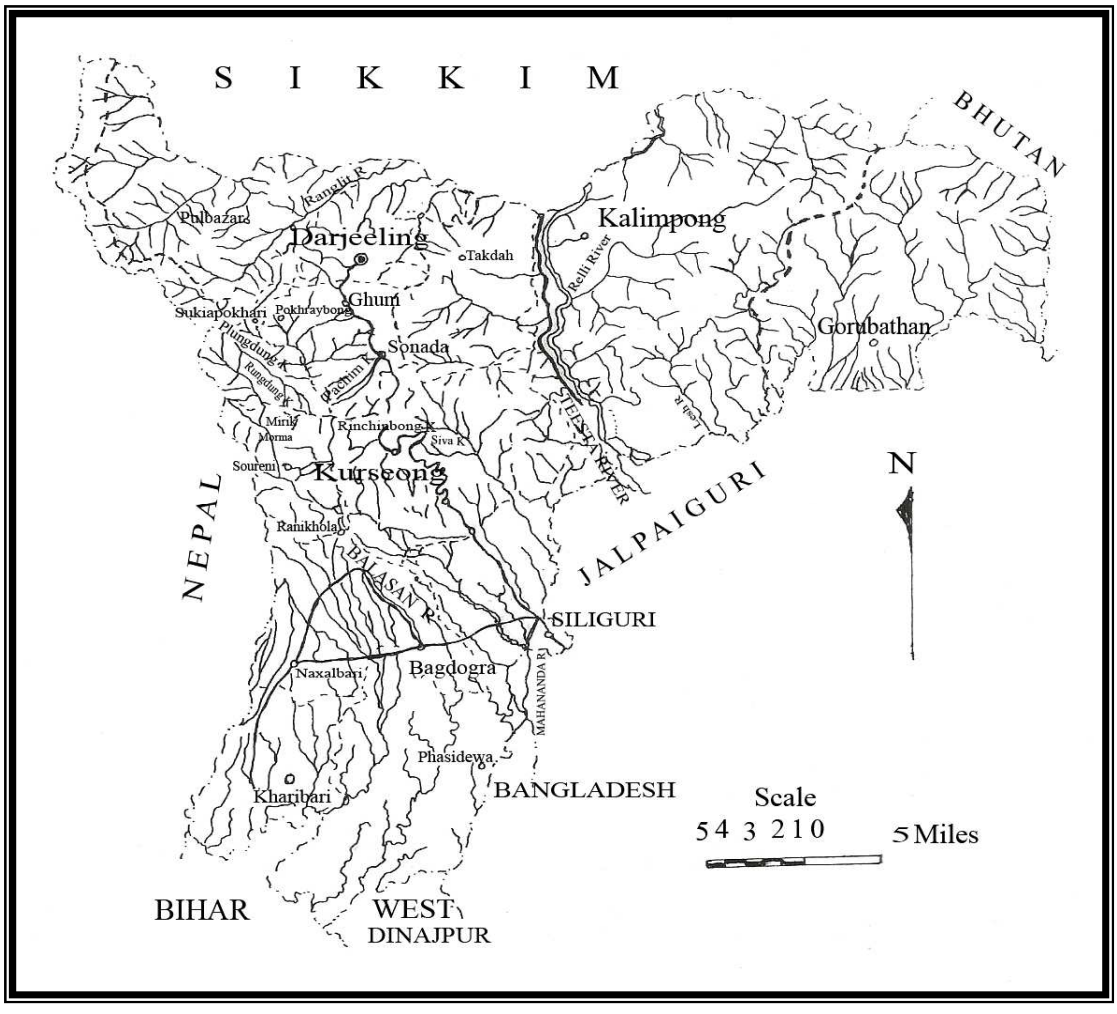


Fig. 1.3: Map of Darjeeling Himalaya showing Roads and Rivers

b. Medium sized rivers:

A large number of rivulets that originate from perennial springs or are rain fed occur in the district. The more important ones based upon the length and volume are presented in Table 1.1.

c. Streams:

The district has a very large number of streams that originate from perennial springs along the mountain ridges, and the saddles of low-level ridges and spurs. These grow stronger during the rainy seasons.

Some of the important steams located in the Darjeeling Sub-Division include Dipla khola, Geil khola, Gurdum khola, Jhepi khola, Kali khola (1), Kali khola (2), Laring khola, Lodhoma khola, Lapchu khola, Rithu khola, Rungdung khola, Sirikhola and Siddhi khola.

Assam khola, Bindu khola, Bhalu khola, Neora khola, charkholay, Chisang khola, Dhaula khola, Gir khola, Jiti khola, Khani khola, Kashyong khola, Mundum khola, Murti khola, Naksal khola, Nichel khola, Pala khola, Panbu khola, Pareng khola, Ramphoo khola, Simana khola, Sipchu khola, Tar khola and Thosum khola are the important streams in the Kalimpong Sub-Division.

Table 1.1: Showing medium sized Rivers along with their places of origin

Sl. No.	Name of the river	Place of origin	Sub-Division where located
1	Relli khola	Algarah-Lava ridge,1800 m	Kalimpong
2	Reshi khola	North face of Rachela, 3000 m	Kalimpong
3	Chel	Surface of Lava Saddle, 1900 m	Kalimpong
4	Jaldhaka	Mountain of East Sikkim, 4000 m	Kalimpong
5	Gish khola	Western face of Lava, 1900 m	Kalimpong
6	Neora	West face of Rachela,3100 m	Kalimpong
7	Lesh khola	Nimbong-Pabringtar, 1250 m	Kalimpong
8	Balasan	Lapchay Jagat,2200 m	Darjeeling
9	Little Rangit	Senchel-Ghoom ridge, 2500 m	Darjeeling
10	Rammam	Singalila range, 3600 m	Darjeeling
11	Mechi	Mountian of East Nepal, 3800 m	Darjeeling
12	Mahanandi	Mahaldiram, 1900 m	Kurseong

The important streams occurring in the Kurseong Sub-Division include Ashli khola, Babul khola, Bhim khola, Chenga khola, Dam khola, Dudhay khola, Goramara khola, Gulma khola, Jogi khola, Kali khola (3), Kyang khola, Majuwa khola, Mana khola, Manju khola, Marma khola, Paschim khola, Tinchinpong khola, Rohini khola, Rungsung khola, Riyang khola, Seti khola, Sevike khola, Singhi khola and Shiv khola. Some of the rivers of Darjeeling Himalaya have hydroelectric power stations.

1.6.3. Lakes and Tanks

The District has a number of lakes, both natural and man made along with tanks that serve as the major source of drinking water. The most important natural lakes include Kalpokhri (3186 m), (Plate 1.A), two small ponds at Sandakphu (3660 m) that serve as the main sources of drinking water. The natural lake at Jorepokhri that was once a natural habitats of the endangered Himalayan Salamander *Tylototriton verrucossus* has been converted into an artificial reserviour. Three artificial lakes at Senchel (2300 m) fed by 26 perennial springs serve as a reservoir for the supply of drinking water to Darjeeling town and its adjoining areas; with an artificial tank at Dawhill (1900 m) being the main reservoir as source of drinking water for Kurseong town. The Samendu Lake at Mirik is one of the largest artificial lakes built for recreation of tourist and local alike. A small natural lake remains hidden at Baghkhor (1830 m) and a seasonal lake at Namring (1800 m) are located in the Kurseong Sub-Division. However, human interference has led to the once revered water body gradually drying up. The Himalayan Salamander still inhabit this water body. In the Neora Valley region of the Kalimpong Sub-Division, a pair of natural lakes Jorepokhari are located at Rachela (3100 m), (Plate 1.B). Two other natural lakes *viz.*, Dallaypokhari and Lampokhari are important wetlands of this area. Five artificial tanks in the Lava ridge serve as reservoirs that supply drinking water to Kalimpong town and its adjoining regions, while Algarah, Baluwakhani and Lava each have an artificial tank that serve as drinking water reservoirs.



Plate 1: **A.** Natural Lakes at Kalpokhari below Sandakphu (3186 m) at Singalila National Park). **B.** Jorepokhari of Rachela forest (3100 m) at Neora Valley National Park.

1.6.4. Geology

The great Himalayan range was formed during the tertiary period about 65 million years when the Indian landmass slammed against mainland Asia, at the site of the ancient Tethys sea. Its further advancement led to it ploughing enormous pile of sediments that had accumulated since the mesoprotozoic period (nearly 2000 million years ago) in the trench and on the sea floor. The Indian landmass finally welded to mainland Asia about 55 million years ago. The junction where the collision occurred and is at present occupied by the rivers Sindhu and Tsangpo is known as the Indus-Tsangpo Suture (Valdiya, 1998).

Five types of rock formation are observed as we move from the South to the North in the district of Darjeeling (Powde & Saha, 1976 (Fig. 1.4). These formations include:

1. Siwalik formation: It comprises of the sediments deposited by the ancient Himalayan rivers in their channels and flood plains in the last 1-1.5 million years. Coarse grained sand stone, shaly sandstone, siltstone and conglomerate are the major components of this formation.

2. Gondwana formation: It is predominantly made up of fespatheic and micaceous quaetizitic sand carbonaceous shales and thin lenses of crushed siltstones and conglomerate being the main components.

3. Buxa formation: It comprises mainly of dolomite, arthoquartzite, variegated phyllite interbanded with quartzites/dolomites.

4. Daling formation: It chiefly comprises of slates, phyllite, quartzose phyllite inter banded with quartzites, quartz-chlorite, sericite-schist, epidorite, carbonaceous phyllite, and quartzite sulphide. Mineralization is mostly located in the quartz-chlotite schist horizon.

5. Darjeeling formation: It is chiefly made up of gametiferous biotite gneiss, varieties of high-grade schistose rocks and migmatite.

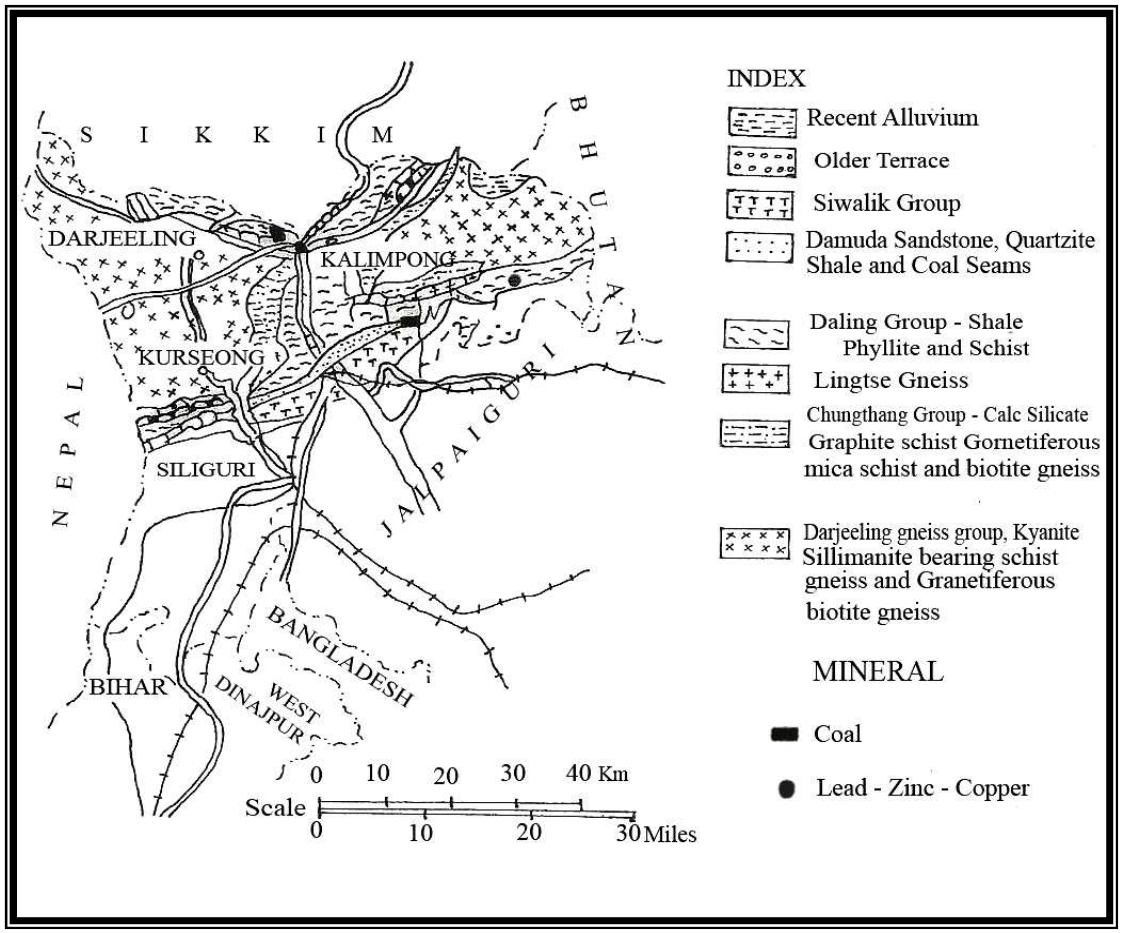


Fig. 1.4: Map of Geology and Minerals of Darjeeling Himalaya

1.6.5. Soil

The geological deposition of the underlying rock determines the nature and quality of soil. In accordance with the physiographic sequence and terrain features soil of Darjeeling–Sikkim Himalayas is represented in five orders. The lower reaches comprise of the ultisols of the palehumultus group and comprise of red, brown and yellow soil with coarse texture. Further North the ultisols give way to the alfissols of the hapludalfs or submontane type. The alfisols are followed by the mollisols comprising of three suborders udolls, argiudolls and hapludolls which occupied 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.

Generally there are four different colours of soil found in Darjeeling Himalayan region *viz.* white clay (*Kamero mato*), gritty red (*Lishailo mato*), brown clay (*Chimte mato*) and black (*Kalo mato*). The black soil has been found to be very fertile, white clay the least fertile where brown clay and gritty red soil occupy a rather intermediate position. The variations of the parent materials exert a strong influence on soil characterization rather than the climate and vegetation. In broad consideration the soil in the Siwalik is pale yellow and coarse in texture, on the daling dark grey and porous, on the gneisses a brown clay sometimes plastic, shallow and sticky, where the soil on Gondwana is generally sandy. However, the parent material of Darjeeling soil is Darjeeling gneiss.

Red and yellow soil have developed in the higher slopes of Himalayas where the greater portion of the area lies under Darjeeling gneiss which commonly decomposes to stiff reddish loam, stiff red clay and pure sand, a condition favourable for cultivation of tea. Silt is predominant along the banks of river Teesta, Rangit, Balasan and Mechi.

The soil in the plain or terai region is a fertile alluvium a light sandy loam or even wholly sandy or gravelly on which the fertility of soil varies accordingly. In the forest area, a thick mantle of humus soil formed by death and decomposition of plant and animal remains cover the ground surface.

Almost everywhere the soil is residual *i.e.,* derived from withering of underlying rocks. The impervious clay is found mixed with the grains of quartz, feldspar and flakes of mica. The quartz soil is washable by the rainwater and has a bearing to the massive landslips in the hills.

1.6.6. Mineral Wealth

Darjeeling Himalayan region contains huge number of valuable mineral deposits on its southern parts and none has been exploited successfully so far. The existence of coal bearing rocks was first reported by Sir J.D. Hooker in 1848 from

Pankhabari and Gorubathan (Dalimkot). Trace of coal is also noticed all alone the area from near Balasan river, Lesh river, Lethi river and Ramthi river. The first and only attempt to work the coal on a commercial scale was undertaken by a Calcutta (present Kolkata) firm at Gorubathan (Dalimkot). During 1896-1900 A.D, a total of 7,231 tons of coal was raised until the enterprise was closed (Banerjee, 1980).

The occurrence of copper ore was reported from Kalimpong, Peshok, Chel river bed near Gorubathan, East of Mirik and East-Northeast of Mahanadi. The occurrence of graphite as embedded masses in a band of mica schist was reported from Ghaiyabari on the Darjeeling Hill Cart Road, West of Peshok and river Rakti valley. It is believed that coal beds at three places have been converted into graphite because of intense metamorphism.

The occurrence of iron varying from a strong ferruginous clay to an impure brown hematite are reported from Lohagarh and high grade magnetite and Micaceous Hematite, free from sulphur and phosphorus are reported from Samalbong and Seokbir of Kalimpong Sub-Division. Three possible sources of lime *viz*. dolomite, limestone bands and calcareous tufa have been reported from Pankhabari, Senchel ridge, Yangmakum and river Rangit valley. According to the geological survey of India, the positive indication of occurrence of Uranium have been traced from Yangmakum-Tik ridge of Kalimpong Sub-Division.

1.7. Climate

The massive landmass of lofty mountains stretching from the South Tibet to Nepal across the Northern boarder acts as the Himalayan barrier. The peculiar configuration with neighbouring mountains has played a vital role in the determination of the climate of different district. The huge ranges in the altitudinal variation and diverse physiography caused a wide range of climatic condition, affecting the powerful wind blow. Depending upon the various changes in altitudinal ranges, from 120-3660 m, the temperature also changes in great extremities from warmer to colder. This change in fact, produces a bracing and congenial climate in the upper hills. The

climate of the terai and plain is almost similar to the neighbouring districts of West Bengal and Bihar state.

Within the district, the annual climatic condition remains very typical exhibiting wet summer and a dry winter. Such condition is brought about by the moisture laden monsoon wind flowing from the Bay of Bengal from June to September. Sometimes any occasional depression on the Bay of Bengal also affects the weather of the district. The climate (rainfall, temperature and humidity) varies from one part of the district to another corresponding to the altitudes, and configurations of different areas. Elevation wise the district is unique in having three distinct climatic zones, namely tropical, temperate and sub–alpine. This is immensely significant for the creation of tropical, temperate and sub-alpine vegetations, and bringing about the richness in biological diversity (Bhujel, 1996).

The district has five distinct climatic seasons, namely 1. Spring, 2. Summer, 3. Monsoon/Rainy, 4. Autumn and 5. Winter. These seasons are usually marked from the mid of the months following the English calendar spring season usually prevails from the mid of February to mid April during which the upper regions above 3000 m experience frequent hail storm and occasional snowfall.

The summer season starts from mid of April and continues to the mid of June when the district has a short hot weather. The terai regions show hotter summer. The rainy season starts from the mid of June and lasts up to the mid of September, during which the district experiences the continuous rainfall, thick clouds, fog and mist. The autumn season starts from the later half of September and lasts up to November. It is marked by the clear blue sky, free from clouds, dust and mist. The winter season starts from the later half of November and lasts up to the mid of February during which the average temperature drops down causing a cold weather. Generally, the winter and the monsoon/rainy seasons are longer than the other seasons.

1.7.1. Rainfall

The peculiar configuration of the mountainous region brings sharp changes in the rainfall. The area receives rainfall throughout the year, except for a short spell

during the winters. Maximum rainfall is brought about by the south-west monsoon, which picks up the moisture from across the Indian Ocean and the Bay of Bengal and showers in the form of torrential rains. The district experiences highest rainfall between June to September and lowest between November to February, and moderate from March to May. The open valleys or the lower hill slopes receive higher rainfall than the upper hilly regions but remain highly humid during the rainy seasons. The south facing hill receives the highest rainfall compared to north facing places, which receives lesser amount.

Table 1.2, 1.3, and 1.4 show the annual rainfall data of Darjeeling, Kalimpong and Kurseong recorded for past 5 years.

Table 1.2: Average annual rainfall data of Darjeeling Sub-Division
Source: Office of the Principal Agricultural Officer, Darjeeling (2150 m).

Years months	**2007 mm**	**2008 mm**	**2009 mm**	**2010 mm**	**2011 mm**	**Average mm**
January	0.0	9.6	0.0	0.0	0.0	1.92
February	114.4	0.0	0.0	0.0	38.5	30.58
March	60.0	36.2	21.1	403.9	13.7	106.98
April	70.9	7.1	54.1	50.9	47.9	46.18
May	141.8	185.2	580.8	126.4	122.7	231.38
June	367.3	674.4	173.0	446.9	628.2	457.96
July	939.3	540.5	573.9	860.6	960.3	774.92
August	450.2	569.5	595.8	572.5	667.0	571
September	737.2	180.5	506.0	283.4	437.3	428.88
October	36.6	83.3	322.0	88.3	14.3	108.9
November	0.0	5.0	0.0	11.5	7.3	4.76
December	0.0	1.5	3.1	0.0	0.0	0.92
Total	**2917.7**	**2292.8**	**2829.8**	**2844.4**	**2937.2**	**2764.38**

Table 1.3: Average annual rainfall data of Kalimpong Sub-Division
Source: Regional Sericulture Research Station, Kalimpong (972 m).

Years months	1996 mm	1997 mm	1998 mm	1999 mm	2000 mm	Average mm
January	15.8	198.0	0.0	12.5	5.5	46.2
February	2.2	17.0	4.0	0.0	18.6	8.36
March	68.1	61.0	63.9	8.6	5.6	207.2
April	69.5	331.0	100.5	32.6	58.9	592.5
May	80.64	1149.0	105.8	115.6	69.8	304.16
June	182.84	498.5	278.5	355.38	263.8	315.80
July	394.2	912.5	783.4	471.6	297.0	571.74
August	493.7	295.0	526.4	609.7	359.19	456.79
September	159.0	248.0	206.3	273.8	228.2	1115.3
October	64.7	23.5	91.7	131.0	44.5	71.08
November	0.0	0.0	5.4	31.0	3.5	7.98
December	0.0	47.5	0.0	2.5	0.0	10.
Total	**1530.68**	**3781**	**2165.9**	**2024.28**	**1354.59**	**3707.11**

Table 1.4: Average annual rainfall data of Kurseong Sub-Division
Source: Office of the Monteviot Tea Garden, Kurseong (1480m).

Years months	1996 mm	1997 mm	1998 mm	1999 mm	2000 mm	Average mm
January	46.4	22.8	0.5	3.0	7.4	16.02
February	7.1	15.2	18.0	0.0	17.0	11.46
March	20.0	80.3	136.1	57.4	8.1	60.38
April	75.1	78.7	145.2	29.7	374.1	140.56
May	109.2	180.3	213.9	408.2	385.6	259.44
June	744.2	527.0	694.4	867.4	721.9	710.98
July	923.0	1064.7	1432.3	1084.3	720.3	1044.92
August	1003	964.7	847.8	1119.9	598.7	906.82
September	525.9	493.5	358.1	596.4	517.4	498.26
October	108.9	8.6	84.1	192.0	17.8	82.28
November	0.0	5.0	17.5	22.3	14.0	11.76
December	0.0	655.5	5.0	4.6	0.0	133.02
Total	**3553.1**	**3506.3**	**3970.9**	**4365.2**	**3382**	**322.99**

1.7.2. Temperature

The temperature of the Darjeeling district varies from place to place depending upon the altitudes. In the 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 goes up from the month of may and the day remains hot or warm till with drawl of South West monsoon (from the month of November) and then the temperature falls rapidly throughout the district. Normally January is the coldest month and the daily temperature at Darjeeling, Sonada, Lava and Rachela often go down below 0^0C. The plains are warm or hot throughout the year except a brief period during winters. During summers, the mercury hovers to around 27^0C; in winters the temperature falls down to 8.5^0C or less. Whereas, the upper hills, is relatively cool with temperature hovering to a maximum of around 21^0C.

Table 1.5, 1.6, 1.7 show the detailed monthwise temperature record of Darjeeling (2150 m), Kalimpong (972 m) and Kurseong (1480 m) for past 5 years.

1.7.3. Relative Humidity

Darjeeling Himalayan region experiences a high humidity. The atmosphere remains humid and colder in the North facing slopes throughout the year. In the higher places (2000m above) the relative humidity ranges between 85–99 during rainy season. The relative humidity decreases gradually towards the lower elevations. During the drier months of March-April, the humidity ranges between 45–60. The relative humidity increases and ranges from 95-100% when the district is one of the dampest in India.

1.7.4. Sunshine – Cloudiness

During the monsoon season, the sky remains heavily overcast with clouds. The fog and mist prevail during July and August throughout the district. In the higher elevations of the district, cloud is observed from the month of June to September. The

other seasons are moderately clouded while winter mornings are frequently filled with lifted fog. The clear sky and sunny days are frequent in autumn and spring. The summer (or spring) exhibits a smoggy sky through the district with a variation in sunlight.

1.7.5. Wind Velocity

During the months from November to May, the district faces higher wind velocity and the later two months become more stronger and often rise to gale or hurricane force in the higher hills above 3000 m. with the advent of monsoon season there is conspicuous reduction in the wind speed. However, the stormy (rain mixed) wind gives a frequent threat at the places like Sandakphu (3636 m), Phalut (3600 m) and Tonglu (3187 m) of Darjeeling Sub-Division. Kalimpong Sub-Division has its bearing with river Teesta at it's feet face highest wind velocity in the district. However, the district does not exceed wind velocity 6 miles/hr. (Banerjee, 1980). The wind velocity recorded at experimental watershed station of Sonada for six years shows the average wind speed ranges from 1.18-2.11 km/hr.

Table 1.5: Temperature data of Darjeeling Sub-Division. Source: Office of the Principal Agricultural Officer, Darjeeling (2150 m).

Year	2007		2008		2009		2010		2011		Average	
Months	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**
January	12.3	2.3	12.3	3.1	15.2	2.8	14.1	3.2	9.9	1.3	63.8	12.7
February	12.4	3.0	12.5	3.2	11.4	4.2	13.9	4.2	15.1	4.3	65.3	18.9
March	16.9	5.5	17.58	8.46	18.0	6.6	11.1	7.1	19.1	7.6	82.68	35.26
April	20.6	9.6	18.7	8.0	18.3	8.7	21.0	11.8	19.7	8.0	98.3	46.1
May	20.2	13.5	19.8	11.3	20.2	9.9	19.8	11.8	20.0	12.3	100	58.8
June	20.3	14.5	20.2	13.9	20.3	13.3	20.9	13.8	19.4	14.5	101.1	70
July	19.9	14.7	19.9	15.2	19.4	11.2	19.9	15.2	18.5	15.0	97.6	71.3
August	19.8	15.3	20.3	14.7	20.7	15.3	20.3	15.1	19.9	14.8	101	75.2
September	20.0	14.1	18.7	13.5	20.6	13.9	19.2	13.9	20.2	14.2	112.2	69.6
October	20.8	12.0	19.4	10.8	20.5	10.8	21.0	12.0	18.8	12.7	100.5	58.3
November	16.5	6.9	19.8	6.9	18.6	7.4	17.1	7.8	12.0	6.8	84	35.8
December	14.5	3.7	17.4	3.8	12.6	3.3	16.5	3.9	12.5	4.5	73.5	19.2
Average	**17.85**	**9.59**	**18.04**	**112.86**	**17.98**	**8.95**	**17.9**	**9.98**	**17.09**	**9.66**	**89.99**	**47.59**

Table 1.6: Temperature data of Kalimpong Sub-Division. Source: Regional Sericulture Research Station, 7th Miles, Kalimpong (972 m).

Year	1996		1997		1998		1999		2000		Average	
Months	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**
January	16.16	8.58	17.83	8.45	20	9.08	20.8	8.4	17.68	8.84	18.49	8.67
February	20.58	11.17	15.8	10.7	21.39	11.23	24.5	13.8	17.3	9	19.91	11.18
March	22.96	14.48	24.13	13.35	22.87	12.06	26.31	14.79	22.7	12.6	23.79	13.45
April	26.53	16.26	23.5	14.97	26.9	16.53	28.9	18.8	25.71	16.71	26.30	16.65
May	26.96	18.96	27.4	18.1	29.3	19.6	28	20.2	26.64	19.84	27.66	19.34
June	27	21	26.9	20.5	28	21.3	29.4	20.2	27.2	21.2	27.7	20.84
July	26.67	21.51	27.45	21.65	25.9	21.3	26.8	21.2	26.2	21.8	26.60	21.49
August	27.19	20.96	27.39	21.19	27.11	20.33	26.7	20.6	26.54	21.62	26.98	20.94
September	27.33	20.4	26.7	19.83	27.5	19.8	27.4	19.8	25.71	19.88	26.92	19.94
October	25.97	21.48	25.9	15.8	27.09	18.99	26	17.5	25.7	17.6	26.13	18.27
November	24.16	16.56	23.93	12.93	24.06	15.86	22.7	14.7	21.6	14.4	23.29	14.89
December	21.19	10.68	21.87	9.93	21.16	11.5	20.04	9.52	19.6	10.2	20.77	10.36
Average	**24.22**	**16.83**	**24.06**	**15.61**	**25.10**	**16.47**	**25.63**	**16.63**	**23.55**	**16.14**	**24.54**	**16.33**

Table 1.7: Temperature data of Kurseong Sub-Division. Source: Office of the Monteviot Tea Garden, 1480 m.

Year	1996		1997		1998		1999		2000		Average	
Months	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**
January	13.4	5.4	11.6	2.1	12.2	2	15	3.6	13.9	2.7	13.22	3.16
February	17.8	8.2	12	2.4	15.8	4.8	18.7	7.8	12.1	2.9	15.28	5.22
March	21.6	12.4	18.6	7.5	16.2	6.5	20.4	9.5	18.4	6.9	19.04	8.56
April	25.7	15.5	17.9	8.9	20.6	10.6	23.4	12.9	21.9	10.6	21.9	11.7
May	25.3	17.7	22.6	12.4	23.2	13.8	21	13.4	22.3	13.6	22.88	14.18
June	23.8	18.2	22.1	14	23.1	15.8	24.2	15	22.1	14.6	23.06	15.52
July	22.7	18.9	21.5	15.4	20.6	15.6	21	14.7	21.5	14.9	21.46	15.9
August	24	18.8	22.8	15.9	21.4	15.4	20.1	14.9	21	15.3	21.86	16.06
September	24.7	18	21.2	14.1	23.9	14.8	20.5	13.5	21	13.2	22.26	14.72
October	25.4	14.9	28.5	9.8	24.4	13.4	21	12.2	21.4	11.3	24.14	12.32
November	22.4	11.2	17.6	7.2	20.5	9.5	18.3	7.5	17.6	7.1	19.28	8.5
December	16.3	4.3	14.2	3.7	16.2	5.4	15.7	4.8	14.9	3.6	15.46	4.36
Average	**21.9**	**13.63**	**19.22**	**9.45**	**19.84**	**10.63**	**19.94**	**10.82**	**19.01**	**9.73**	**19.98**	**10.85**

1.8. Communication Network

The Darjeeling Himalaya is well connected by two national and state highways in addition to number of motorable roads. A large number of metalled and unmetalled roads have come up since 1988 after the formation of Darjeeling Gorkha Hill Council connecting the once inaccessible remote parts of the country with the mainstream. The first motorable road connecting Darjeeling with Siliguri was constructed as far back as in 1842. This Old Military road runs from Siliguri to Darjeeling via Pankhabari, Downhill running along to crest of Ghoom ridge. The present national highway NH-50, the Hillcart Road, an alternative to the old military road was completed and became operational in 1869 connecting Sukuna, Rongtong, Tindharia, Gidhey Pahar, Mahaldiram, Sonada in between these two major towns of Darjeeling district. The National Highway connecting Siliguri town with Gangtok in Sikkim runs parallels to the river Teesta was completed in the beginning of 1900s. This road connects Kalimpong town with the rest of the areas in the plains and the hills. The state highway connects places like Mirik, rest of the areas in the plains and the hills. The state highway connects places like Mirik, Sukhia, Peshok, Kalimpong, Pedong, Bijanbari, Lebong, etc. in addition, other motorable connects places like Takdah, Gail, Badamtam, Nimring, Rimbik, Maneybhanjang, Pokhriabong, Gorubathan, Lava, Todey, Suruk, Samthar etc.

1.8.1. Socio-Economic Status

General economic condition of the hills people is not very good; it is more of subsistence type. The region lacks co-operate industries because of its poor location, infrastructure and other resources. Tea is other industrial sectors and is known world over and highly sought after. Large sections of the population are employed in this sector. However, its cultivation is restricted to lower hills of Darjeeling and Kurseong Sub-Divisions, and few in the Kalimpong Sub-Division. Tourism is another sector that provides employment to large number of population directly or indirectly. Yet another industrial sector is the Cinchona industry. These industries have helped to uplift the economic condition to large section of the hill people. However, much of the population depends on agriculture sector with 26.58% of the hill population being directly involved in agriculture (Census, 1991).

1.9. Vegetation

1.9.1. Forest Profile

The district of Darjeeling covers 3.68 percent of the geographical areas of West Bengal state. Most of the hill areas of Darjeeling and Kurseong Sub-Division are covered by the tea plantation. At present, there are 87 Tea Estates in the district (Anonymous, 1991). Kalimpong Sub-Division is an exception with the major part under agriculture and cultivation although a few tea estates are present on its South-Eastern part.

The Siliguri Sub-Division with a geographical area of 837.4 sq. km. does not have any accountable forest area. 37.42% (75.52%) of green cover including Tea gardens, Cinchona plantation and forest area of the area is under forest cover in the district of Darjeeling including Siliguri Sub-Division, where the state of West Bengal as a whole has (18.93% FSI, 2013) of such an area. As per the prescription of national forest policy of India, a hill region must invariably have at least 60% of its geographical area under the forest cover. The census figures of the past several decennial periods show that the total forest area of the region has been steadily on the decline. The recent surveys however, indicate that the area under the actual forest cover in the district is below 35% (Bhujel, 1996).

1.9.2. Forest Divisions and Management

Many of the forest areas of the Darjeeling district in the past were changed into tea estates. Under the Wildlife Protection Act and Indian Forest Act. XVI of 1972, the forests of Darjeeling were subsequently notified as the protected forest, reserve forest, national park and wildlife sanctuaries, suggesting the conservation of forest. On the administrative ground, under the government of West Bengal, the forest of Darjeeling (Fig. 1.5) has been divided into three forest divisions. The plain region of Siliguri Sub-Division does not have such a forest. Among the three hill Sub-Divisions, Kalimpong occupies the largest forest cover. The forests of Darjeeling hill region have been categorized into reserve forests, protected forests and unclassified state forests (Gorkhaland Territorial Administration).

Both the reserve and protected forests are constituted from the forest land or wasteland on which the government has proprietary right. The principal objective of such forests is to protect the biological resources. The unclassified state forest is a forest resumed from the private ownerships by the forest department. A major portion of the unclassified forests in Darjeeling is now under the jurisdiction of the Gorkhaland Territorial Administration. However, due to the lack of adequate infrastructure the protection measures in these forests have not been stringent.

1.9.3. National Parks and Wildlife Sanctuaries

There are two National Parks and three Wildlife Sanctuaries in the district covering an area of 364.66 sq. km. (Bhujel, 1996; Rai, 2002).

National Parks: Singalila National Park (Darjeeling division)
Neora Valley National Park (Kalimpong division)

Wild Life Sanctuaries: Senchel Wildlife Sanctuary (Darjeeling division)
Mahananda Wildlife Sanctuary (Kurseong division)

Singalila National Park

The National Park was declared in 1992 and covers an area of 108.7 sq. km. with a core zone of 78.6 sq. km. The remaining 30.17 sq. km. area is the buffer zone. The park is separated from Sikkim by the river Babongla Khola in the North, and by a motorable road which acts as the boundary to separate it from Nepal in the South-West. The National Park on the Eastern side is marked from Maneybhangyang (2150m). The geographical elevations of the zone range from 2400-3660m. The park harbours a small, naked sub alpine zone at its highest elevation. There are two ranges *viz*. North and South and six beats viz. 1. Gairibas, 2. Kalpokhari, 3. Sandakphu, 4. Sabargam, 5. Phalut and 6. Ramam.

Neora Valley National Park

Covered by the oldest reserve forest this was declared as a national park in 1986, which occupies an area of 88 sq km. the boundaries of Sikkim and Bhutan meet at this park at Rachela (3150 m) forming a trijunction while its Southern boundary meets the district of Jalpaiguri. There are four beats *viz*. 1. Rachela, 2. Thosum, 3.

West Ner and 4. East Ner ranging from 500-3150 m altitudes. Rachela chak is a settlement area of 3 hecters inside the National Park.

Senchel Wildlife Sanctuary

It is located in Darjeeling Sub-Division in the South Ward extension of Singalila range. Established in 1940, it is one of the oldest Sanctuary and covers an area of 38.88 sq. km. with different elevations ranging from 1067 to 2600 m. There are two ranges east and west, five beats *viz*. 1. Sixth mile, 2. Third mile (Simkuna), 3. Jorebunglow, 4. Sonada and 5. Rambi.

Mahananda Wildlife Sanctuary

Located in Kurseong Sub-Division, it was reserved forest until 1976. From the West bank of river Teesta, it occupies as area of 129.04 sq. km. spreading over both in terai and the hills. The elevations range from 200-1000 m. There are nine beats namely 1. Kalijhora, 2. Latpanjar, 3. Punding, 4. Sukuna, 5. Gulma, 6. Toribari, 7. Sevoke, 8. Seventh mile and 9. Laltong.

1.9.4. General Vegetation and Forest types

Darjeeling is known as the “Queen of the Hills”. The region is known for its natural aesthetic beauty, lovable weather, immensely rich biodiversity and varied types of forests, wildlife sanctuaries and national parks. The vegetation of the Darjeeling district is peculiarly rich in the number of species and peculiarly varied in its character as might be expected from a consideration of its climate and physiography (Molley, 1907).

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 valley (Bhattacharya, 1997). The physiographic configuration of the hills and valleys, the slopes facing different directions and the altitudinal ranges are generally effected by the distribution of rainfall, wind velocity, and have the great role in the determination of the vegetation types. The areas

developed the moist temperate vegetation characterized by the trees with densely clad mosses, lichens, epiphytes and climbers.

The composition and distribution of vegetation is also determined by the variations corresponding to the altitudes, which range from as low as ±130 m at Siliguri to 3660 m at Sandakphu. On further extension to 3800 m at Gosa (West Sikkim border) this Himalaya enters the great mountain system of Mt. Kanchandzonga (8598 m), the third highest peak of the world (Rai, 2002).

Attempts have been made to classify the vegetation of this region thoroughly from time to time by (Gamble, 1875), Hooker, J.D. 1906), Cowan & Cowan, 1929), Champion, 1936, and Kanai, 1966). However, these authors variously considered the mode of classification according to the altitudinal ranges. After a long gap of three decades, (Chauhan, 1996, Bhattacharya, 1997) made the general outline of classification of the entire flora and vegetation with few modifications. But, in the line of classification and modifications, the determining factors such as climate and altitude and its impacts on the regional vegetation, should be considered (Bhujel, 1996).

Table 1.8: (Bhujel, 1996) classified the Darjeeling vegetations under five categories:

Sl. No.	Vegetation types	Altitudinal ranges
1	Plain and tropical	Plains to 300 m (-500 m)
2	Sub tropical	500-1200 m
3	Sub temperate	1200-1850 m
4	Temperate	1850-3200 m (-3500 m)
5	Sub alpine	3200-3636 m (-3800 m)

1. Plain and Tropical Vegetation 300 m (–500 m)

This type of vegetation is distributed to an altitudinal range of 500 m where the annual rainfall is 150-200 cm. It is characterized by the deciduous forest of pristine or man made plantation. This can be further sub divided:

a. Riverain forest

b. Sal-Teak forest
c. Dry mixed forest
d. Wet mixed forest
e. Grass lands

a. **Riverain forest** – This type of forest can be observed in the small patches along the river banks of Balasan, Chel, Gish, Jaldhaka, Mahanadi, Mechi, Rangit, Relli and Teesta. The common shrub and tree species are *Acacia catechu, Acacia pinnata, Albizia lebbeck, Albizia procera, Cassia fistula, Cassia tora, Clerodendrum viscosum, Croton bonplandianus, Croton caudatus, Lagerstroemia hirsuta* and *Pandanus nepalensis.* The common climbers are *Dioscorea composita, Dioscorea glabra, Dioscorea pentaphylla, Mikania scandens* etc.

b. **Sal – Teak forest** – The forest of this category *Shorea robusta* and *Dalbergia sisso* are the predominating trees found in the Bhabar belt and well-drained sandy soil. Preferred for its valuable timber, it is planted by the department of forest in association with *Anthocephalus cadamba, Chukrasia tabularis, Combretum decandrum, Dillenia pentagyna* etc.

This type of forest is well flourished along the valleys of river Teesta and Rangit up to the Southern border of Sikkim, and from the Eastern part of river Teesta to the banks of river Jaldhaka to its Bhutan boarder.

c. **Dry – Mixed forest** – This type of forest is represented by deciduous to semi evergreen species of *Acrocarpus fraxinifolius, Artocarpus lacucha, Bombax ceiba, Clerodendrum japonicum, Clerodendrum viscosum, Erythrina stricta, Gmelina arborea, Leea guineensis, Sterculia villosa* etc.

d. **Wet – Mixed forest** – This type of forest is represented by semi evergreen to evergreen species of *Cinnamomum glaucescens, Cinnamomum bejolghota, Duabanga grandiflora, Litsea monopetala, Syzygium formosum, Terminalia alata, Terminalia myriocarpa* etc.

e. **Grassland vegetation** - This type of vegetation is represented by some woody grasses along the banks of river Balasan, Jaldhaka, Mahanadi, Rangit and Teesta. The dominating species are *Cymbopogon nardus, Neyraudiana aurandinaceca, Saccharum arundinecum, Saccharum spontaneum*. The other herbaceous members found are *Ageratum conyzoides, Chromolaena odorata, Pouzolzia zeylanica* etc.

2. Sub Tropical Vegetation (500 – 1200 m)

It is generally affected by the seasonal climate of dry winter and wet monsoon, the forests are greatly of deciduous type (Grierson & Long, 1983). This type of forest is found in the valley of river Balasan, Chel, Gish, Jaldhaka, Neora, Rambi, Rangit, Riyang and Teesta. The dominating tree members are the *Baccaurea ramiflora, Betula cylindrica, Callicarpa arborea, Castanopsis indica, Diploknema butyracea, Dendrocalamus hamiltonii, Ficus semicordata, Gynocardia odorata, Mallotus philippensis, Phoebe lanceolata, Schema wallichii, Terminalia bellirica, Terminalia chebula, Toona ciliata, Zanthoxylum nitidum* etc.

The dominating shrubs are *Ageratina adenophora, Boehmeria glomerulifera, Calotropis gigantean, Chromolaena odorata, Costus speciosus, Croton caudatus, Combretum decandrum, Datura suaveolens, Holmskioldia sanguine, Lantana camera, Leea macrophylla, Leea guineensis, Melastoma normale, Mussaenda macrophylla, Phlogacanthus thyrsiformis, Pouzolzia sanguine, Premna scandens, Solanum myriacanthum, Solanum torvum, Thysanolaena latifolia, Toddalia asiatica, Vitex negundo* etc.

The climbers are *Ampelocissus barbata, Cissampelos pareira, Dioscorea hamiltoni, Dioscorea pentaphylla, Dittoceras andersoni, Entada rheedi* var. *sinohimalensis, Millettia pachycarpa, Mucuna pruriens, Stephania japonica, Stephania glabra, Tinosphora cordifolia* etc.

The herbs are *Ageratina adenophora, Ageratum conyzoides, Bidens pilosa, Hydrocotyl asiatica, Lindenbergia grandiflora, Peristylus parishii, Pouzolzia zeylanica* etc. Besides some of the cultivated species of trees are *Citrus auranticum, Citrus maxima, Citrus medica, Citrus reticulata, Cyphomendra betacea, Mangifera sylvatica, Psidium guajava, Punica granatum* etc.

3. Sub Temperate Vegetation (1200 – 1850 m)

A short zone between 1200 – 1850 m represents a different type of vegetation which are located as the small pocket at the places of Rambi forest. Takdah-Peshok, Algarah-Pedong, Kafer-Nimbong and Simana-Mirik. The dominating shrub and tree members are *Brassiopsis hainla, Buddleja asiatica, Daphne sureil, Dichroa febrifuga, Edgeworthia gardneri, Elaeocarpus lanceifolia, Engelhardia spicata* var. *acerifolia, Leucosceptrum canum, Macaranga indica, Maesa chisia, Mussaenda treutleri, Osbeckia nutans, Osbeckia stellata* var. *crinite, Ostodes panbiculata, Oxyspora paniculata, Vaccinium vacciniaceum* etc.

The climbing members are *Dicentra scandens, Holboellia latifolia* var. *angustifolia, Tetrastigma rumicispermum, Tricosanthes wallichiana, Vitis heyneana* etc.

The plantation tree species are *Alnus nepalensis, Cryotomeria japonica, Exbucklandia populnea, Michelia doltsopa* and *Michelia velutina*.

4. Temperate Vegetation (1850 – 3200 m)

This type of vegetation is truly represented by the evergreen forest of closed canopy along with the deciduous tree members. The large and old trees are festooned with mosses, ferns, epiphytes and few parasites. On gradual increase of altitude also influence the pattern of succession and its composition. Due to the greater altitudinal variations and huge number of floristic elements occurring in this zone, it can be further classified under the following sub types in accordance to (Kanai, 1966) and Grierson & Long, 1983).

a. Temperate Deciduous forest
b. Evergreen – Oak forest
c. Hemlock – Rhododendron forest

a. **Temperate Deciduous forest** – It is characterized by the presence of *Acer cambellii, Acer sterculiaceum, Alnus nepalensis, Betula alnoides, Castanopsis hystrix, Elaeocarpus lanceifolia, Exbucklandia populnea, Lindera neesiana, Lyonia ovalifolia, Lindera pulcherrima, Magnolia cambelli, Michelia doltsopa,*

Pentapanax fragrans, Persea fructifera, Rhododendron arboretum, Rhododendron grande etc.

b. **Evergreen – Oak forest** – This type of forest is characterized by the species like *Acer thomsoni, Acer hookeri, Cinnamomum impressinerium, Elsholtzia fruticosa, Gamblea ciliata, Juglans regia, Lithocarpus pachyphyllus, Rhododendron falconeri, Quercus lamellose* etc.

   The under growth shrubs are *Aconogonum molle, Agapetes hookeri, Arundinaia maling, Astilbe rivularis, Daphne bholua, Dichroa febrifuga, Eurya carasifolia, Helwingia himalaica, Rubus acuminatus, Rubus lineatus, Rubus paniculatus, Vaccinium vaccinoides, Viburnum erubescens, Zanthoxylum oxyphyllum* etc.

   Within this sub type vegetation the climbing members are represented by the species of *Clematis acuminata, Clematis buchananiana, Clematis grewiiflora, Clematis montana, Dicentra lichiangensis, Dicentra scandens, Edgaria darjeelingensis, Holboellia latifolia, Mucuna macrocarpa, Smilax lanceifolia, Thunbergia lutea, Trichosanthes lepiniana, Vitex heyneana* etc.

   The ground mass is covered by the herbaceous members of *Carex cruciata* var. *argecarpa, Clinopodium umbrosum, Cyperus rotundus, Fragaria vesca, Potential lineate, Ophiopogon wallichii, Viola thomsonii* etc.

c. **Hemlock (Tsuga Dumosa)** – Rhododendron forest - A distinct uppermost canopy layer apart from the former two sub types characterizes this sub type vegetation. The shrub and tree members represented by the members of *Abies densa, Arundinaria griffithiana, Betula utilis, Cotoneaster microphyllus, Daphne bhulua* var. *gracialis, Hypericum hookerianum, Neillia rubiflora, Rhododendron arboretum* var. *roseum, Rhododendron barbatum, Rosa resicea, Rubus pentagonus, Tsuga dumosa* etc. [Plate 2.A]

The ground cover is represented by the herbaceous members of *Aconitum bisma, Aconitum spicatum, Cremastra appendiculata* var. *appendiculata, Gentian capitata, Goodyera vittata, Hemiphragma heterophylla, Herminium quinquelobum,*

Meconopsis nepalensis, Odontochilus elwesii, Primula denticulata, Primula listeri, Swertia bimaculata, Swertia nervosa etc.

5. Sub Alpine Vegetation (3200 – 3800 m)

The upper most region of the Darjeeling Himalaya ranging between 3200 to 3800 m (3660 m) characterizes the sub alpine vegetation of dwarf and stunted habit of flora. The Sandakphu – Phalut ridge extending to Gosa (3800 m) display the sub alpine meadow of conspicuous vegetation. This type of vegetation is characterized by the dwarf shrubs and tree members of *Abies densa, Arundinaria maling, Berberis angulosa, Berberis hookeri, Cotoneaster sandakphuensis, Gaultheria trichophylla, Llex intricata, Juniperus recurva, Lyonia ovalifolia, Rhododendron anthopogon, Rhododendron campanulatum, Rhododendron cinnabarium, Rhododendron hodgsonii, Rhododendron setosum, Rheum acuminatum* etc. [Plate 2.B]

The herbaceous members found in the meadow and forest are *Allium wallichii, Anemone demissa, Gentian bryoides, Geranium polyanthes, Geum sikkimense, Goodyera fusca, Impatiens kingie, Meconopsis nepaulensis, Peristylus nematocaulon, Phlomis macrophylla, Pilea racemosa, Potentilla abruscula, Primula sikkimensis, Satyrium nepalensis, Saxifrage hispidula* etc.

6. Plantation forest

The Department of Forest, Government of West Bengal and Gorkhaland Territorial Administration have developed several patches of forest in selected areas under aforestation programme, forestry programme and social forestry programme. The major forest consist of *Albizia lebbeck, Alnus nepalensis, Betula alnoides, Castanopsis hystrix, Castanopsis indica, Chukrasia tabularis, Cryptomeria japonica, Cupressus corneyana, Dalbergia sissoo, Eucalyptus globulosus, Exbucklandia populnea, Gmelina arborea, Juglans regia, Macaranga indica, Michelia champaca, Michelia doltsopa, Ostodes paniculata, Pinus roxburghii, Quercus acuminata, Schima wallichii, Shorea robusta, Tectona grandis, Terminalia myriocarpa, Thuja orientalis, Toona ciliata* etc.

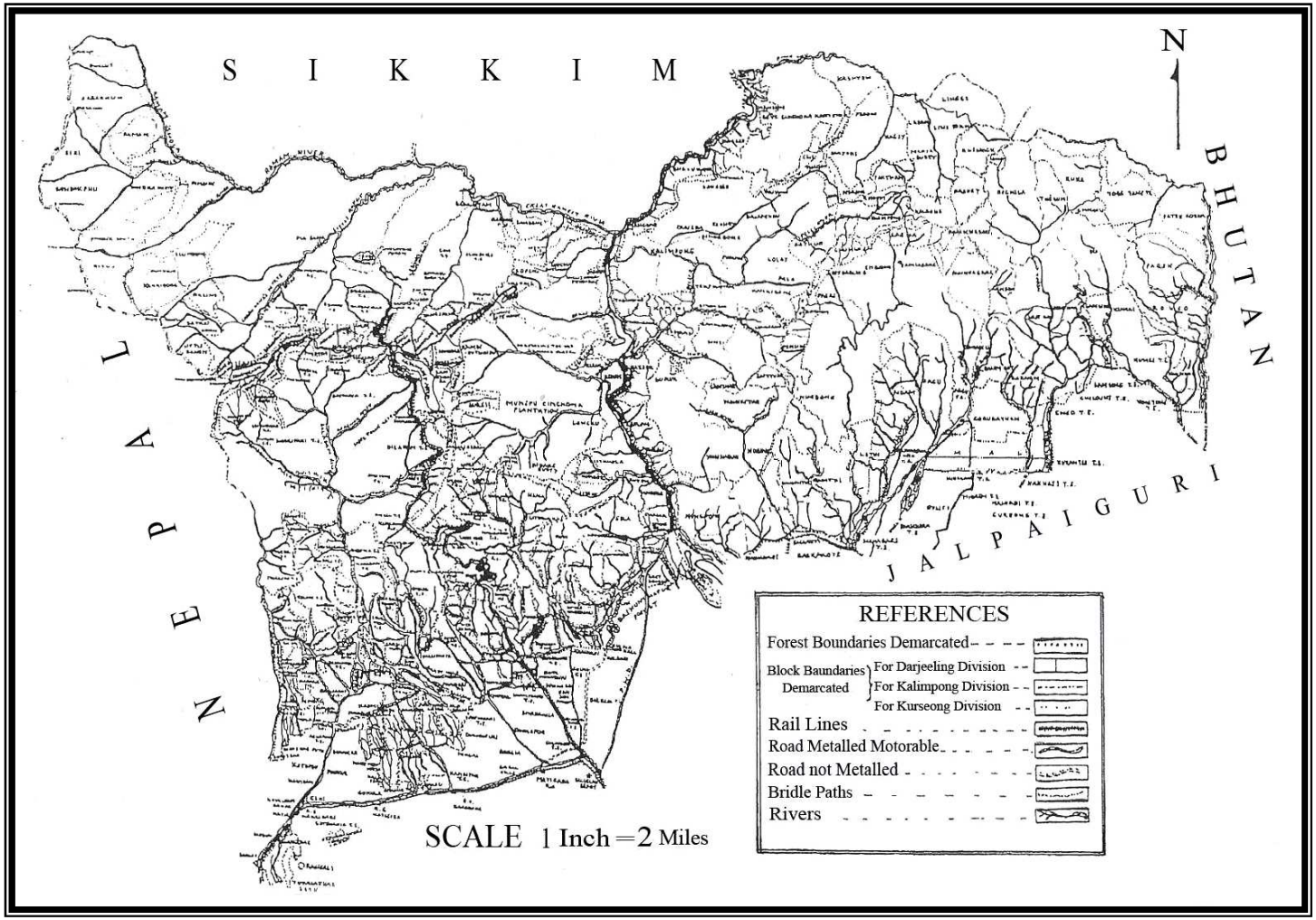


Fig. 1.5: Forest Divisions of Darjeeling Himalaya



Plate 2: **A.** Temperate Rhododendron forest at Rachela (under Neora Valley National Park); **B.** Sub-Alpine forest in between Sandakphu and Phalut (under Singhalila National Park).