

Chapter - 2

THE STUDY AREA

2.1 GENERAL FEATURES

2.1.1 Location and basic informations of the area

Darjeeling is a hilly district situated at the northernmost end of the Indian state of West Bengal. It has a hammer or an inverted wedge shaped appearance. Its location in the globe may be detected between latitudes of 26° 27' 05" N and 27° 13' 10" N and longitudes of 87° 59' 30" and 88° 53' E (Fig. 2.1). The southern-most point is located near Bidhan Nagar village of Phansidewa block the northernmost point at trijunction near Phalut; like wise the widest west-east dimension of the district lies between Sabarkum near Sandakphu and Todey village along river Jaldhaka. It comprises an area of 3,149 km².

Table 2.1. Some basic data for the district of Darjeeling

(Source: Administrative Report of Darjeeling District, 2011–12, <http://darjeeling.gov.in>)

| | | |
|-----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| Area | 3,149 km ² | |
| Area of Hill portion | 2417.3 km ² | |
| Terai (Plains) Portion | 731.7 km ² | |
| Sub Divisoins | 4 [Darjeeling, Kurseong, Kalimpong, Siliguri] | |
| Blocks | 12 [Darjeeling-Pulbazar, Rangli-Rangliot, Jorebunglow-Sukiapokhari, Kalimpong – I, Kalimpong – II, Gorubathan, Kurseong, Mirik, Matigara, Naxalbari, Kharibari & Phansidewa] | |
| Police Stations | 16 [Sadar, Jorebunglow, Pulbazar, Sukiapokhari, Lodhama, Rangli-Rangliot, Mirik, Kurseong, Kalimpong, Gorubathan, Siliguri, Matigara, Bagdogra, Naxalbari, Phansidewa & Kharibari] | |
| No. of Villages & Towns | Corporation - 01 (Siliguri) Municipalities – 04 (Darjeeling, Kurseong, Kalimpong, Mirik) Gram Panchayats - 134 | |
| Total Forest Cover | 1,204 km ² (38.23 %) [Source: State of Forest Report 2011] | |
| Agricultural Land | 1,762 km ² [Source: Agriculture contingency Plan/West Bengal, http://agricoop.nic.in] | |
| Tea gardens | 202.16 km ² | |
| Southern-most point | Near Bidhan Nagar village of Phansidewa [26° 27' 05" N; 88° 22' E] | |
| Northern-most point | Trijunction above Phalut [27° 13' 10" N; 88° 21' E] | |
| Western-most point | Between Sabarkum and Sandakphu [87° 59' 30" E; 27° 12' N] | |
| Eastern-most point | Today village [88° 53' E; 27° 04' N] | |
| Lowest elevation | About 98 m amsl at Phansidewa [Source http://www.maplandia.com/india/west-bengal/darjiling/phansidewa-hat/] | |
| Highest elevation | 3636 m amsl at Sandakphu | |
| Population | 1,846,823 [Source: Census of India 2011] | |
| Population Density | 585 / km ² [Source: Census of India 2011] | |
| Literacy | 79.92 % [Source: Census of India 2011] | |
| Length of State & International Borders | Sikkim Boarder : 54.33 km Bihar Boarder : 48.3 km | Nepal Boarder : 101.02 km Bhutan Boarder : 30.18 km Bangladesh Boarder : 19.32 km |

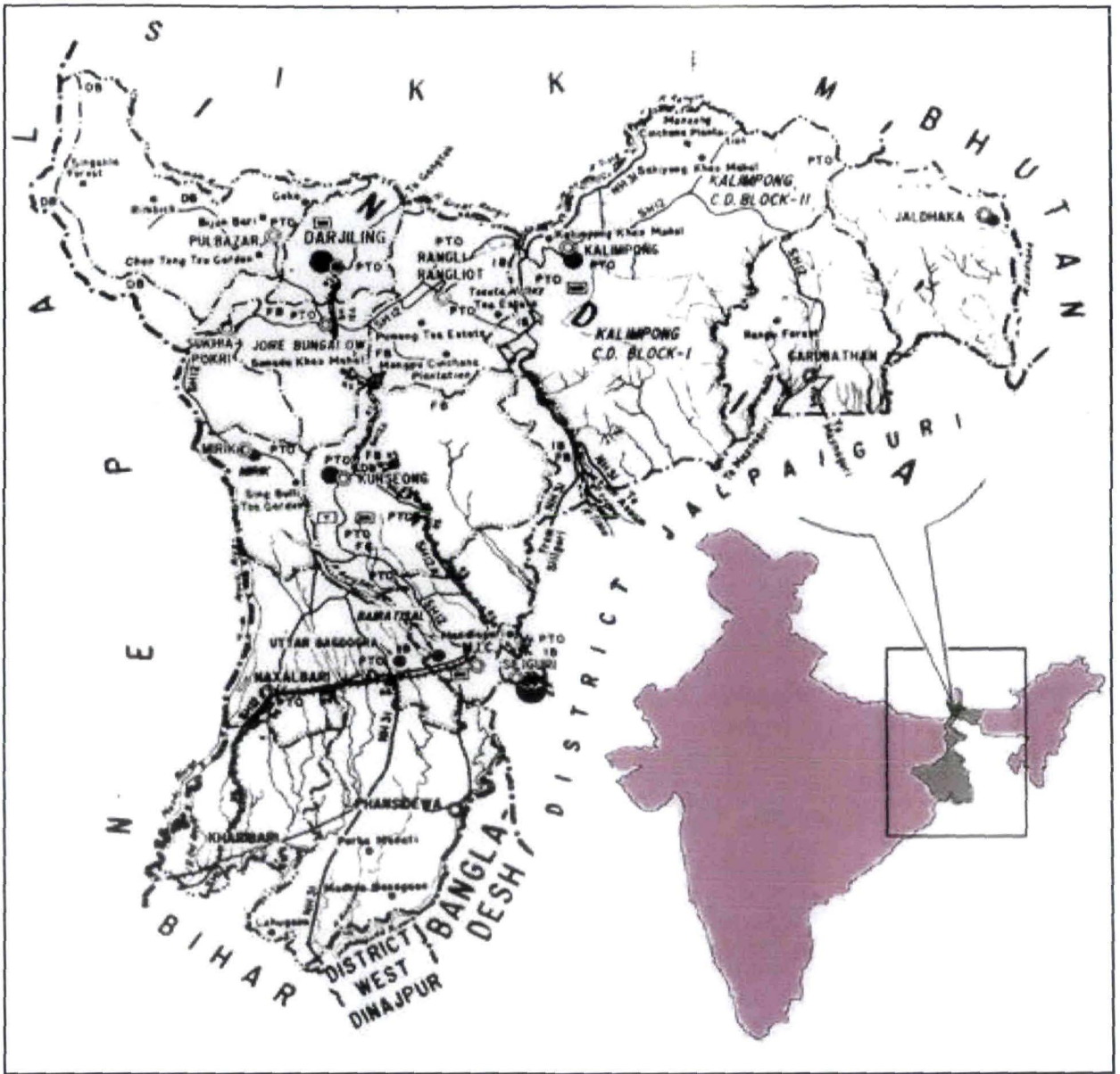


Figure 2.1. Location Map of Darjeeling District (not in scale)

2.1.2 The boundary

From the trijunction between Kishanganj district of Bihar and North Dinajpur district of West Bengal near Bidhan nagar, the District of Darjeeling starts its periphery at an altitude of about 98 m amsl where river Mahananda is the dividing boundary with the district of North Dinajpur. Along the river Mahananda it goes towards north-east up to near Phansidewa (98 m), where the next bank of the river is Bangladesh. Then bordering with Jalpaiguri district of West Bengal it leads up to Sevoke (250 m) and cross the river Tista and forward towards east through Bagrakote (250 – 300 m), Gorubathan (300 – 400 m), Samsing (300 – 400 m) along the foot hills of Dooars and reached in the Khumani forest up to the river Jaldhaka where it meets the Kingdom of Bhutan, another neighbouring country. Towards the north, Along river Jaldhaka (Dochu) and Nechu, it rises parallel to Bhutan up to another trijunction, *Tinsimana* of Rachila (Rishila) peak (3150 m) where it meet Sikkim and Bhutan. The boundary then passes down towards west

along Rishi khola (Rushattachu) and Ramphu Khola up to Ramphu (Rangpo) then along Tista up to the confluence with Rangit river near Malli (400 – 500 m), forwarding further along Rangit river to Singla (400 – 600 m) then it left river Rangit and catches river Rammam and passes along it via Karmatar, Saajbotey, Kolbong, Lodhoma (1000 – 1100 m), Then it rises towards north-west through Rimbick (2000 – 2200 m), Rammam, Samanden- Gorkhey (2400 – 2500 m) and meet another *Tinsimana* near Phalut (3600 m) where it meets Nepal. Then the boundary forward southwards via along the Singalila ridge to Sandakphu (3636 m) and drawn downwards to Tumling (3000 m), Maneybhanjyang (1900 – 2150 m), Pashupati Fatak, then along river Mechi with left ridge of Mirik, it falls down to foot hills of Lohagarh (200 – 300 m), then penetrating the plains of Terai reaching up to the border of Kishanganj district of Bihar after Khoribari (± 100 m) (Rai, 2006).

2.2 SIGNIFICANCE OF THE STUDY AREA

About two-third of the area of Darjeeling district is comprises of the hilly mountainous region unlike rest of the state which are basically plain. The mountainous region has its distinct ethnicity, culture and the vegetation as a result of varied topography. Different eco-zones within the district have given peculiarity for the vegetation to the district. The flora of the region is equally unique and rich. The floristic significance of the district is reflected this richness as the Himalayas is considered to be the meeting place for the two ancient Super-Continents i.e. the Pangaea (Gondwana) land and the Laurasia. According to the modern theory of plate tectonics, formation of the Himalaya is the result of continental collision or orogeny along the convergent boundary between the Indo-Australian Plate of the Gondwana Land and the Eurasian Plate of the Laurasia. (<http://en.wikipedia.org/wiki/Himalayas>). The region possesses indigenous floral elements of Himalayan and Sino-Himalayan origin intermixing with Tibeto-Chinese, S.E. Asian–Malaysian and Indian and Indian Sub-continental origins, and in addition, the introduced plants of Central and Afro-Asiatic, Eurasian, American and cosmopolitan origins have resulted a unique blend for it. In the higher altitudes the floristic composition is mainly formed of Himalayan and Sino-Himalayan elements, where as the lower hills are characterized by the elements from the S.E. Asian–Malaysian and Indian plains (Grierson & Long 1983). The area is located within Himalaya Hotspot recognised by IUCN (2010).

The shady forests give raise the scenery of Darjeeling a distinctive character, as they contain very luxuriant vegetation, ranging from the matted cane-brakes of the Terai and the tropical forms of the lower valleys to the oak and pine forests which clothe the highest ridges (O'Malley 1907). Therefore the district possesses almost all the vegetation zones as mentioned by Grierson & Long (1993) from tropical to the sub-alpine (Champion & Seth 1968; Puri 1960; Das 1986, 2004; Bhujel 1996) which ultimately given rise to extremely rich vegetation in the area. Only the alpine zone is absent from the study area where very little plant species can survive. Many spots are there within the district such as the reserved dense forests of Neora Valley and Singalila National parks, Senchal and Mahananda Wild life sanctuaries, the forests of east bank of river Tista to Pankhaban–Mungpong etc. which are still virgin and less touched which resulted into the formation of a significant plethora of diversity in regards to both the floral and faunal species.

The district is not only a treasure house of hundreds of much valuable timber producing trees but also of enormous resource of numerous Non-Timber Forest Produces (NTFPs) whose role in the sustenance of rural economy and daily livelihood are distinctly visible. The major components of NTFPs of the district are medicinal, fibre, food, vegetable, agricultural implements, construction of houses, making rope, handicrafts, household articles etc. Accumulated through the generations, the use of NTFPs is closely associated with the traditional and cultural practices of the rural people of this Himalayan district. (Pandit *et al* 2004; Rai *et al* 1998; Sarkar 2011; Choudhary *et al* 2011; Ghosh & Das 2007, 2011; Rai *et al* 2008; Saikia & Das 2008; Khan *et al* 2010; Das *et al* 2010; Basak *et al* 2010; Yonzon *et al* 2011; Singh & Sourabh 2012; Sarkar & Das 2011; Sharma 2012; Sharma *et al* 2012).

Natural resources including the uniquely varied landscapes have grown the significance of Darjeeling. Major portion of the district is occupied by the beautiful hills, valleys, rocky slopes, forests,

tea gardens, rivers, and close sight of huge mountain peaks of the gorgeous Mt Kanchanjanga. Such varied landscape and its beauty has given a status for the district hence it is renowned world wide as the “Queen of Hills”.

The region is extremely rich in flora as well as the fauna (4,166 species; Alfred *et al* 2004) with high level of endemism (Bhujel & Das 2002; Das 2004; CI 2010). It houses numerous species of rare and endangered aves, mammals, Salamanders and other amphibians, snakes and reptiles, varieties of fishes and various rare insects have decorated the biodiversity of the district (Mallick, 2012).

2.3. TOPOGRAPHY (Main source: O'Malley 1907)

2.3.1 Mountain systems

The three of four subdivisions of the Darjeeling district are formed of hill spurs originating from two distinct mountainous extensions, one from the north-west corner of the district through Phalut (3700 m at highest peak of the spur located at Sikkim side) from Mt. Ghosla (3800 m) of Sikkim the extensions of Singalila range of Kanchanjanga Mountains which forms all the hills of Darjeeling and Kurseong subdivisions and the other extensions from the north-east corner of the district through Rachila and Thosum peaks, the extensions of East Sikkim and Bhutan mountains, which covers whole the sub-division of Kalimpong.

I. The Singalila extensions:

‘From Kinchinjanga the Singalila range, an immense ridge 60 miles long, stretches south to the plains forming the boundary between Nepal and Darjeeling’ (O'Malley 1907). The Ghosla-Phalut ridge continuously extends from Phalut (a corruption of Lepcha name *Phak lut*, meaning ‘Peeled Summit’, Bhujel, 1996) towards south through Sabargram (3536 m) to Sandakphu (3636 m) the highest peak of the district. Then the ridge gradually descends through Kalpokhari (3108 m), Gairibans (2621 m), Tumling (3000 m), Tonglu (3070 m), Meghma (2900m), Chitrey (2500 m), and finally reaches at Maneybhanjyang (2150 m). All the way from Phalut to Maneybhanjyang the ridge forms the boundary with Nepal towards the western slopes.

From this Phalut to Maneybhanjyang main ridge many sub-ridges arise towards the east. From Phalut the spurs descend through Samanden (2700–2800 m), Gorkhey (2600–2800 m), (Rammam (2560 m), Rimbick (2300 m) and stumps at Lodhoma (1089 m); another ridge from Meghma slides down towards Dhotrey (2600 m), Batasey (2100 m) forms another hill of Samsu, Ramitay, and finally sat down at Jhepi (1250 m); this hill further extends through Kainjaley Bhanjyang (1460 m) forming the Bijanbari valley with highest point at Samalbong (1700 m) which gradually rolled down and ends at Singla (400 – 600 m).

From Maneybhanjyang, the main Phalut – Maneybhanjyang ridge bifurcates. One ridge continue towards south through Simana (2300 m) towards Mirik (1200 – 1500 m) Saureni (1000 – 1200 m) and finally settled down at foot-hills of Lohagarh, Changya, Panighatta etc (200 – 300 m). Another ridge from Maneybhanjyang extends at right angle towards east transversely through Sukiapokhari – Jorepokhari (2000 – 2500 m) to Ghoom-Jorebunglow (2250 m) where it again divides into three spurs. The first spur leads towards north through Jalapahar (2300 m) to Darjeeling town (2000 – 2200 m) extending further to Birch hill (2150 m), Lebong, Ging (1500 m) and finally Badamtam (500–600 m) at the bed of river Rangit.

The second spur extends toward east through 3rd Mile, 6th Mile and branches to form numerous spurs of Rangerung, Rungdung valley, Dabaipani etc towards north, Lopchu and Pesok towards east and Mungpoo, Takdah, Rangli-Rangliot, Geil etc. to the southern slopes. These all hills settle down at the basin of Rangit and Tista.

The third and the last branch of Ghoom-Jorebunglow ridge proceeds towards south through Senchale (2300 m), Tigerhill (2450 m), Mahaldiram (1800 m), Baggaurra (1500 – 2000 m), Dowhill (1900

m) and finally reaches Kurseong (1450–1600 m) from where all the hills abruptly fall towards the foothills of Sukna and at the bed of Mahananda Wildlife Sanctuary.

II. The Rachila extensions:

The Chola mountains range of East Sikkim, the Chumbi valley and western Bhutan enter from Tinsimana (3100 m), the north-eastern corner of the district through Rachila Chak – Jorepokhari (3040 m) to Rachila (Rishila) (a corruption of Lepcha and Bhutanese name *Richila*, meaning ‘Summit of God’ or ‘Land of Sages’ Bhujel, 1996) peak (3150 m) the highest peak of these extensions. From this Rachila peak, with its numerous ramifications, all the hill ridges of Kalimpong part have arisen in three directions.

The western ridge extends towards Labha (2100–2300 m) through Pankhasari (2200 – 2500 m) and Alubari (2380 m). From Labha many ridges rolled in different directions. The first forwards towards north-west to Algarah (1500 – 1900 m) where the ridge bifurcates one towards west to Kalimpong 1200 – 1450 m and Durpin danra (1500 m) which suddenly sit down at Sepkhola-Kamsi forest at Tista bed and the other ridge towards Damsang garhi (1800 – 2200 m) and Pedong (1000 – 1500 m), the second ridge extends towards south-east along south bank of Relli river towards Samthar – Pabringtar; and the third ridge descends down towards Loleygaun – Kafer (1800 – 2000 m) from where one side slopes down through Charkholey (1600 – 1700 m) towards Yangmakhum (1000 – 1600 m) and ultimately to Mangpong – Pankhaban forest (200 – 400 m) on Tista bank and other side through Nimbong (1000 – 1200 m) to Bagrakote (250 m).

The southern slopes of Rachila enter the spurs of Neora valley from Thosum (2500 – 2800 m), and then roll down towards Ruka peak (2480 m) ultimately to sit at Gorubathan (300 – 800 m) and Samsing (300 – 1200 m) foot hills.

The third and eastern slopes descend towards Tangta (2805 m), Todey (2000 – 2600 m) Godak (1200 m) and Jholung along the western slopes of Jaldhaka river.

2.3.2 Snow Ranges

Regular yearly snow falls occur during every winter from December to February at the places above 3000 m like Meghma (2900 m), Tonglu (3070 m), Kalpokhari (3108 m), Sandakphu (3636 m), Sabargram (3536 m) to Phalut (3600 m) and Rachila area (3150 m). Frequent snow falls occur in some winters at the places above 2200 m, such as above Sonada to Ghoom – Jalapahar (2250 – 2300 m) to Darjeeling town, Senchal (2300 m) Tiger hill (2450 m); Rammam (2560 m), Gorkhey (2600 – 2800 m), Gairibans (2621 m), Rachila Chak-Jorepokhari (3040 m) Tinsimana (3100 m), Pankhasari etc.

2.3.3 Drainage System

Most of the valleys in Darjeeling Hills are supporting are with a natural stream or a rivulet or a river. Most of the streams and rivulets are gradually merging together and finally forming or flowing into a river. Numerous small and large streams and rivers have irrigated and drained the district in various directions. Many primary and small rivers and streams initially may flow to different directions but finally all the larger rivers flow towards the southern plains. There are seven major river systems within the district, namely Tista, Rangit, Mahananda, Balasan, Jaldhaka, Rammam and Mechi. Most of these rivers flow almost in north to south direction except river Rammam which flows towards east. Jaldhaka and Mechi form the dividing boundaries with the Kingdom of Bhutan and Nepal to the east and west respectively and Rammam, Rangit, Tista and Ramphu rivers do so with Sikkim to the north. River Tista divides the district from the middle in two parts longitudinally. All the rivers and rivulets except Tista, Rangit, Mechi and Jaldhaka have their origin within the boundary of the district.

The Tista: Tista, the largest river of North Bengal is the lifeline of Darjeeling-Sikkim and originated from Cholamo (Tso Lhamo) lake at North-Western Sikkim at an elevation of 5,330 m amsl. The river is mainly fed by the Zemu and other tributary glaciers viz. Changame Khanpu, Talung etc of the Eastern Himalaya.

Tributaries join the Tista through all directions. The important among them within the district are Ramphu khola and Reshi originating in the Neora valley, Mundum khola in Algarah and Pedong reserve forest, Kashyong khola originating in Damsang garhi, Tar khola, Bhalu khola, the Great Rangit, Rambhi, Seti khola, Kali khola, Dam khola, Geil khola, Ryang, Relli khola etc. Tista after receiving the Rangit flows through the Darjeeling district and finally enters the plains of North Bengal and joins the mighty Brahmaputra in Bangladesh.

The Great Rangit: This is the second largest river of the district, which partially touches the northern boundary with Sikkim. It is originated from Rothong glacier of Kanchanjanga Mountains (4500 m) in western North Sikkim. This river enters the district at Singla bazaar opposite to Jorethang of South Sikkim and ends its life meeting Tista near Malli. It's important tributaries within the study area include Rammam, Little Rangit, Rungdung khola, Takdah khola, Lapchu khola, Peshok khola etc.

Balasan River system: Originating from Lapchayjagat forest (2200 m) and numerous rivulets of the Ghoom – Simana saddle the Balasan River flows through its valley between the hills of Kurseong and Mirik. Draining the wide area from south facing slope from Ghoom to Simana, east slope of Mirik and west slope from Ghoom to Kurseong it enters to Terai at Dudhey – Panighatta and met with Mahananda near Siliguri. Tributaries of this system on the right bank are Rangbhang, Plungdung, Marma, Malat, Dudhey khola etc and Rangmuk, Rinchingtong, Khaharay khola, Husel khola, Rakti khola, Rohini khola, Jor khola etc on the left bank. It is a rain-fed river.

According to the earlier records (O'Malley 1907) the Balasan, after entering the Terai was divided into two streams, the New Balasan straight towards south-east, and the Old Balasan towards south. But today, only the former is representing the river and the later have become a small rainy drain in the name of Buri Balasn. O'Malley (1907) writes in this regard as 'the new channel is said to have been formed about 60 years ago by some Meches damming up the old stream for the purpose of fishing'.

Rammam River System: The Rammam is an important medium-large sized river has taken its birth at Singalila Mountains (4500 m) near Phalut. Draining the entire Darjeeling – Sikkim border along the northern slope of Bijanbari hill spur, it ends at Singla, meeting the Great Rangit. Important tributaries of this river system from Darjeeling side are Samanden khola, Srikhola, Gurdum khola, Partham khola, Dilpa, Palmajua, Lodhoma khola, Jhepi khola, Neji khola, Rangdu khola etc.

Jaldhaka River System: The Jaldhaka (called as Dochu at origin) is a medium-large sized river originating from the Kupup lake (locally known as Bidang tsho, also known as Elephant lake for its appearance, 3896 m), a small glacial lake in North-East Sikkim, it flows southwards after flowing through Bhutan joins the district near Todey-Tangta of Neora Valley National Park. It drains down making a boundary with Bhutan. Murti is one of its important tributaries which is originating in the Mo block south of Thosum hills finally joins it between Samsing and Kumai area. Its important tributaries include Chutang, Kizing, Tapdong, Chichu, Jalchu, Rongo and Machu (Nechu), Assam, Mundhum, Bindu, Sipchu, Pareng, Naksal, Jiti, Chisang etc. Most among them are originated from Neroa valley National Park.

Mahananda River System: The Mahananda (Mahanadi at origin) is originated at hills of Mahaldiram (1900 m) of Kurseong, comes down draining the east-southern face of Kursong to Lathpanjar through Mahananda Wildlife Sanctuary to the Terai. Its tributaries are Sivakhola, Babukhola, Jotikhola, Jogikhola, Jholi khola, Ghoramara khola, Gulma and Panchanadi, Chamta and Balasan in the Terai. This river after meeting with the Balasan, passes towards south and south east forming the boundary between India and Bangladesh and that between Darjeeling and Uttar Dinajpur districts respectively.

Besides these other medium sized ever-flowing river systems of the district include the **Little Rangit**, originating from Maneybhanjyang (2150m), it flows through Bijanbari valley with tributaries like Kalikhola, Sarjam, Laring, Baluabas, Sidrabong etc; Mechi along western boundary with Nepal are the important ones. The **Relli** have its origine in Khempong reserve forest below Lava-Algarah saddle (2000m),

running along the southern boundary of Saihur reserve forest it joins Tumthang khola originating in Chumsering and Payong reserve forest, Pala khola, Lolley khola and the Rani khola and further receiving the water of numerous other smaller streams it finally joins the Tista near Najoke. The **Neora** is the second to Jaldhaka in size among the parallel south flowing rivers of the eastern Kalimpong slopes. It originates from the Rechila Chak of Neora valley National Park (3040m) and joins Thosam khola at the boundary of Thosum and Rechila. Then flowing southwards collects many smaller streams and finally joins the Tista. A number of the principal rivers and their tributaries originate in the south-eastern part of Kalimpong sub-division include the **Chel** originating from Pankhasari of Neora valley also meet the Tista receiving major tributaries like Dalim khola near Fagu and Nir khola at Ambeok. The **Lish** which originates at the ridge of Pabringtar village and flows downwards receiving the Amlakhola, Turungkhola, Phangkhola and Chunkhola and eventually joins the Tista at the Kalagaiti Tea estate Jalpaiguri. The **Ghish** arising from Samthar-Pabringtar saddle is joined by two small rivulets Ramthi and Lethi form the major tributaries of the river, which joins near Uttar Fulbari. The Lesh and Ghish, among them, become dry during the dry seasons. Further Chenga, Manja, Tepu, Hulia etc are other smaller but ever-flowing rivers in the Terai flowing parallel towards south. The important rivers, their origin and fate are shown in the table below:

Table 2.2. Origin and fate of some important rivers of Darjeeling district

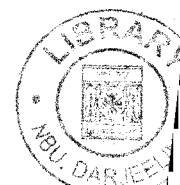
| Rivers | Place of Origin | Altitude (m amsl) | Fate (Joins with at) |
|---------------|--------------------------------------------|-------------------|-----------------------------------|
| Tista | Zemu glacier, Cholamo lake in North Sikkim | ±5,330 m | Brahmaputra in Bangladesh |
| Rangit | Rothong glacier in NW Sikkim | 4500 m | Tista at Tribeni near Tista bazar |
| Balasan | Lapchayjagat forest | 2300 m | Mahananda at Siliguri |
| Rammam | Singalila Mountains | 4500 m | Rangit at Singla |
| Jaldhaka | Kupup Lake fed by Glaciers in NE Sikkim | 3896 m | Brahmaputra in Bangladesh |
| Mahananda | Mahaldiram | 1900 m | Ganga in Malda |
| Neora | West face of Rachila | 3040 m | Jaldhaka in Jalpaiguri |
| Relli | Alghara-Labha | 2000 m | Tista at Najoke |
| Little Rangit | Maneybhanjyang | 2150 m | Rangit at Singla |
| Mechi | Antu Mountains of Nepal | ±2200 m | Mahananda in Bihar |
| Lish, | Samthar -Pabringtar | 1250 m | Tista in Jalpaiguri |
| Ghish, | West face of Labha | 1900 m | Tista in Jalpaiguri |
| Chel | Pankhasari of Neora Valley | 1800 m | Tista in Jalpaiguri |
| Reshi/Ramphu | North face of Rachila | 3000 m | Tista in Ramphu |

2.3.4 Lakes

As the hills of the district are like a labyrinth of ridge and narrow valleys. There are no open valleys or plains within the hills therefore no such lakes of remarkable size are formed here like that of high altitude mountains of Himalaya. Though six natural lakes of small and moderate sizes are situated within the district Mirik Lake (1494 m) is the largest one with 1.25 km length, 3.5 km periphery and maximum of 26 ft. depth. Other smaller lakes are situated at Kalapokhari (3108 m), 6th Mile (2050 m) above Takdah, Jorepokhari (twin lakes) in Sukiapokhari (2300 m) and with the same name in Rachila peak (3040 m) and Yangmakhum (1550 m), natural twin lakes of Senchale have been developed artificially for water supply to Darjeeling town. Some other small artificial lakes at Delo, Algarah and Labha have been created for this purpose.

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2.4 GEOLOGY (Main source: O'Malley 1907)

Investigation leading towards the geology of the Darjeeling Himalaya is still in its childhood. There are very little available literature about geological investigations of the region. Sir J. D Hooker was the pioneer of this task. During his extensive travels in many parts of Sikkim exploring the flora of the region in 1854, he also carried out some geological investigation of Sikkim and adjoining Bengal region. In his famous 'Himalayan Journal' he has reported the regional gneissic domes, the overlying bedded sedimentary rocks and crinoidal lime stones at the Tso Lhamo lake of Kanchanjangha mountains (Gansser 1964). The account of the geology of Darjeeling District had been contributed by H.H. Hayden, the then superintendent of Geological Survey of India, during the first decade of the 20th century (Hyden 1904, Hyden & Burrard 1908). Mallet has made an account of the geology of the Darjeeling district and its foothills. Other renowned workers who have worked upon the geology of the district or the Himalaya of this region include Von Loczy, who in 1878, published on a geological section from Darjeeling to Kanchanjangha (Gansser 1964); Ray (1947) studied the zonal metamorphism of the Darjeeling area; Choudhuri A. K. (1971); Sinha Roy (1974) studied polymorphism in daling rocks of Eastern Himalaya; Bose (1890, 91), Wager (1934), Auden (1935), Heim & Gansser (1939), Auden & Nickel (1960), Acharya (1968), Mukhopadhyay & Gangopadhyay (1971), Lahiri & Gangopadhyay (1974), Srimal (1974), Pawde & Saha (1976) including few others contributed to the geological findings for the region.

On the basis of the geological studies of the Great Himalaya, it has been revealed that earlier to the tertiary period there was an ancient sea, named Tethys in place of today's Himalaya. Continuous but interrupted deposition an accumulation of sediments in different ages and the tectonic conflicts gave rise to a series of upheavals led to increased elevation and formation of the world's highest peaks. This process of upheaval of the mountains was not a continuous process but took place in four successive stages and each stage was separated by long interval of time. The first upheaval broken down the continuity of the sea basin into smaller areas of sedimentation that took place in the Upper Eocene period. During Middle Miocene the second upheaval occurred that led to longitudinal depressions on the southern side where the succeeding Siwalik sediments were laid down. The third occurred during the Upper Pliocene period and gave rise to the present day Siwalik hills and the fourth and the last upheaval in the Pleistocene led to the alluvial deposits which pushed up to get their heights. The process is continuing so that the mountains of Himalaya are still believed to be growing their heights. (Monlar 1986).

Formation of hills of the district is primarily formed due to the erosional functions of the streams, rivers and rivulets which have exposed a full cross section of different tectonic units forming deep V-shaped valleys. The tectonic units of the lower Sub-Himalayan portion, the foot hills and big river beds are constituted of Siwalik and Gondwana systems and the inner and upper Himalayas, with the thrust sheets of Daling and Darjeeling group of crystalline rocks succeed over these.

According to the report of Geological Survey of India (Pawde & Saha 1976) the types of rock formations observed from outer to inner or south to north in the district are the Siwalik, the Damudas (Lower Gondwanas), the Dalings and The Darjeeling gneiss respectively over thrusting one upon another.

Siwalik formations: All along the foothills of and along the Tista River bed the Siwalik formations are deposited which are comprised of coarse grained sandstone, shale sand stone, siltstone and conglomerate.

Damuda formations: Siwalik series is over thrust by the Damuda formations belonging to the coal-bearing rocks of Gondwana age and most of them found in the Darjeeling hills area are believed to be an inverted section, which are highly tectonized and does not resemble the well known Damudas of Peninsular India. This thrust zone seems to be a characteristic representative of the late Precambrian to early Cambrian argillaceous sequence (Gansser 1964). The Damuda formations, comprises mainly of feldspathic and micaceous quartzitic sandstone, carbonaceous shales, thin lenses of crushed and shred coal, pebble and boulder beds which can be observed along the Tista river valley, Tindharay region, Lish and Gish Rivers etc.

Daling formations: Northward, the Damudas is succeeded by the Daling series which is comprised of chlorite shales, phyllites and schist associated with quartzite (Mallet 1974). The series are well developed all along the lower and middle course of the river Tista and form over 50 km long core of the large north-south directed domal uplift. The most important feature of this series is increasing metamorphism upwards, where slates form the lowest bed this is the most interesting geological feature of the lower Himalayas as well.

Darjeeling gneiss: Further northwards the Pre-Cambrian Dalings are succeeded by the more metamorphosed rocks known as the Darjeeling gneiss (Heim & Gansser 1939; Gansser 1964). It comprises garnetiferous biotite Gneiss, varieties of high grade schistose rocks and magnetite.

2.5. SOIL

Extreme variation in the formation of the soils of Darjeeling district is observed due to varied elevation, degree of slope, vegetative cover and geolithology of the area. Depending upon the underlying geological structure, formation of the soils on the ground have been developed by fluvial action lithological disintegration or weathering of underlying rocks.

In general, the soil on the Siwalik formation contains higher fraction of silty-clay, it is pale yellow to red brownish with coarse texture. This soil comprise of the *ultisols* of the palehumultus group. Daling series has given rise to clayey dark gray and porous soils. Higher percentage of sandy and coarse particles is seen in the soils of Damuda and Daling series. The topmost Gneiss developed to red and yellow-brown soils which are clayey, shallow and sticky. This soil contains a high proportion of potassium and mica but is poor in lime, iron oxides, magnesium, phosphorous, nitrogen etc.

According to the physiographic sequence and terrain features from lower to higher elevations or gradually from south to north, the soil of Darjeeling – Sikkim Himalayas is classified in 5 orders (Rai 2006) namely, (i) the **ultisols** of the palehumultus group which comprises of red, brown and yellow soil with coarse texture forming the foot-hills and river basins; (ii) the **alfisols** of the hapludalfs or sub-montane type; (iii) the **mollisols** comprising of three suborders udolls, argiudolls and hapludolls; (iv) the **entisols** with four sub orders arents, psamments, flubents and orthents; and (v) the **inceptols** with two sub-orders orchrepts and umbrepts make up the northern most part of the region.

In general, the soil of the district is acidic in nature due to heavy rainfall. Though in some places it is less acidic where pH ranges between 5.6 and 6.5, but the major portion of the region shows highly acidic soil with pH below 5.5. The depth of the soil in different regions varies from 0 – 100 cm. From the view point of fertility, the alluvial soil of the plains of Terai is very fertile. The black soils of forests of Terai and lower hills are thick mantle of humus, formed from decomposed plant and animal residues, is also favourable for the broad leaved deciduous trees. The greater portion of the district is formed with the reddish loam and yellow-brown clayey sticky soil which is not much fertile but favourable for good quality tea cultivation.

2.6. MINERAL WEALTH

Possibilities about the mineral wealth of the region were traced long back in 1849 by Sir J. D. Hooker when he reported coal bearing rocks from Pankhabari and Dalimkot. A coal mining enterprise was established at Dalimkot, Gorubathan which raised 7231 tones of coal during 1896 – 1900. Later on the mining was closed (Banerjee 1980), “because the result was not, apparently satisfactory, the difficulty of getting coal and the crushed nature of most of the seams probably acting as a bar to profitable exploitation” (O’Malley 1907). Existence of other minerals within the district is estimated. Very impure graphite occurs in the semi graphitic Gondwana schists of the Rakti river (O’Malley 1907). Occurrence of copper in Kalimpong, Peshok, Mirik, and Gorubathan; graphite embedded with mica schist along Darjeeling–Peshok ridge, Ghaiyabari, Mungpoo, Rakti valley, Singalila and Labha are also reported (O’Malley 1907, Bhujel 1996 Similarly Iron ores from Sakbir and Samalbong (Kalimpong) and Lohgarh; dolomite from Senchal

ridges, Pankhabari, Yangmakhum and Great Rangit river belt and even the occurrence of uranium have been traced in Yangmakhum-Tik ridge by the Geological Survey of India (GSI report, 1980–82), and an investigation for talc-steatite around Lapcha Basti and Singla in the extension areas of Gok-Karmi was made by the same [mines.gov.in/writereaddata, GSI, report (G-4) 2010–12].

2.7. COMMUNICATION NETWORK

After acquiring Darjeeling from Sikkim, in 1835, the British East India Company rapidly started the constructional works for the development of tea gardens and a sanitarium. The first ever motorable road connecting Darjeeling with the plains was constructed in 1839. This was Old Military road which runs from Siliguri to Darjeeling via Pankhabari, Dowhill and Ghoom. In 1869, the Hill cart road was constructed in between Siliguri and Darjeeling connecting Sukna, Rongtong, Tindhara, Mahanadi, Giddhey pahar, Kurseong, Mahaldiram and Sonada, this road is now named as Tenzing Norgay road and recognised as National Highway-55. The national highway 31 enters the district from Sonapur near Bidhannagar which forwards to Guwahati connecting Bagdogra, Matigara, Siliguri, Sevoke where the Coronation Bridge has been built in 1937 from where a branch Highway 31-A forward to connect Gangtok in Sikkim which runs parallel to the river Tista was completed in the beginning of 1900s. This road also connects Kalimpong. Another branch of NH-31 C leads towards Bihar from Bagdogra connecting Naxalbari and Khoribari blocks. The state highway-12 runs a semi-circular pathway from Matigara connects places like Mirik, Sukiapokhari, Ghoom, Lapchu, Pesok, Tista bazar, Kalimpong, Algarah, Labha, Gorubathan and ultimately meets NH 31 in Damdim (Jalpaiguri). Other important roads may be listed as Darjeeling to Lebong; Sukiapokhari to Rimbick via Manebhanjyang; Sukiapokhari to Pokhraybong, Djajey; Ghoom to Lodhoma connecting Bijanbari and Kainjalay; 6th Mile to 27th Mile connecting Takdah, Rangli and Geil; 3rd Mile to Rambhi bazar connecting Mangpoo; Algarah to Pedong; Bagdogra and Naxalbari to Panighatta; Matigara to Phansidewa. After the enforcement of the Pradhan Mantri Gram Sadak Yojana (PMGSY) since last decades, a large number of metalled and unmetalled roads have been constructed which have connected almost all the villages especially in the Terai though there are many inaccessible remote villages in the hills still to be connected with the mainstream of country.

The railway to Siliguri was constructed in 1878. The Darjeeling-Himalayan railway which now extends from New Jalpaiguri to Darjeeling, with a distance of 87.48 kms. The narrow gauge rail tract construction was started by Franklin Prestage in 1879 from Siliguri and completed up to Tindharia in March 1880. By the year end, it was constructed up to Kurseong and the line reached Darjeeling in July 1881. Now Siliguri has emerged as most important commercial city and the corridor for whole NE India, Bhutan and Nepal and well connected through the railways with the rest part of country. DHR was declared a World Heritage site by UNESCO in 1999, only the second railway to have this honour after Semmering Railway of Austria in 1998. (en.wikipedia.org/wiki/Darjeeling_Himalayan_Railway)

There is only one Airport in the district at Bagdogra has recently acquired the International status.

2.8. FOREST DIVISIONS

There are three Forest Divisions in Darjeeling district, namely Darjeeling, Kurseong and Kalimpong. There are few patches of forests in the Siliguri sub-division like Tukuria, Dulkajhar, Taipu, Bengdubi etc. but they are included under Kurseong Forest Division. With the view point of conservation, the forests of Darjeeling district have been recognised in three categories, namely Reserved Forests, Protected Forests, Unclassed State Forests & others. Detailed facts about the forests of Darjeeling have been shown below in Table 2.3.

Table 2.3. Forest Divisions of Darjeeling district and their facts

| Forest Divisions | Total forest Cover [km ²] | Reserved Forests [km ²] | Protected Forests [km ²] | Unclassed State Forests & others [km ²] | No. of Forest Villages |
|------------------|---------------------------------------|-------------------------------------|--------------------------------------|-----------------------------------------------------|------------------------|
| Darjeeling | 311.43 | 296.19 | 13.34 | 1.9 | 36 |
| Kurseong | 301.33 | 290.63 | 2.4 | 8.3 | 26 |
| Kalimpong | 591.24 | 582.59 | 1.15 | 7.5 | 29 |
| TOTAL | 1204 | 1169.41 | 16.89 | 17.7 | 91 |

2.9 VEGETATION

By virtue of variety of topographic, geographic, physiographic, adaphic and climatic features, extremely rich and varied vegetation have been developed in the area. In this sense there may be hardly any such district in India, comparable with this district so far as the variation in vegetational richness is concerned. Geographical position, structures of hills and mountains of the region, distribution of rainfalls, humidity, temperature ranges etc of this particular region are the important factors which determine the vegetation pattern. Rather, the most influencing factor for this is the variation in altitude, and this variation can easily be observed when one ascends vertically along a hill ridge and how the floras change their colours. In accordance with the altitude, the vegetation of the region is classified by many renowned botanists such as Gamble (1857), Hooker (1906), Cowan (1929), Champion (1936), Kanai (1963), Grierson & Long (1983) and Bhujel (1996).

The wide altitudinal range of the district starts from 98 m amsl at Phansidewa of Siliguri Terai to 3636 m amsl at Sandakphu, the Singalila Mountains. According to altitude, the flora of the district has been classified in five vegetation zones (Bhujel 1996) as follows:

Table 2.4. Classification of Vegetation zones of Darjeeling district

| Vegetation zones | Altitudinal range |
|--------------------|-------------------|
| Tropical Zone | 100 – 500 m |
| Sub-Tropical Zone | 500 – 1200 m |
| Sub-Temperate Zone | 1200 – 1850 m |
| Temperate Zone | 1850 – 3200 m |
| Sub-alpine Zone | 3200 – 3700 m |

2.9.1. Tropical Vegetation

The tropical forests of the plains, foot-hills and the hot river valleys up to the elevation of 500 m constitute this type of vegetation. This is mainly characterized by the broad-leaved deciduous forests. Such forests can further be categorised in following four sub-types:

- i) Riverain forests, ii) Dry mixed forests iii) Sal forests and iv) Wet mixed forests

The forests along the rivers in hot valleys are classified in **Riverain** type of forests vegetation. Along river Tista and Great Rangit and below 500m amsl of other rivers like Balasan, Mahananda, Rammam, Little Rangit, Relli, Jaldhaka, Lish, Gish, Chel, Mechi etc, this type of vegetation are observed. This vegetation is mostly dominated by tree species like *Albibizia procera*, *Terminalia alata*, *Acasia pinnata*, *A. catechu*, *Delbergia sissoo*, *Meliosma pinnata* etc. and the ground flora like *Saccharum spontanium*, *Eragrostis* species, *Clerodendron viscosum* etc.

Macaranga pustulata, *Acrocarpus fraxinifolius*, *Artocarpus lacucha*, *Leea asiatica*, *Bombax ceiba*, *Gamelina arborea*, *Erythrina stricta*, *Tetrameles nudiflora* etc are the common ingredients of the **dry mixed forests**.

The plantation forests of Terai, foothills and valleys are mostly the **Sal forests** (*Shorea robusta*). The important other components of these forests are *Tectona grandis*, *Churasia tubularis*, *Schima wallichii*, *Largestroemia parviflora*, *Dillenia pentagyna*, *Meliosma pinnata*, *Anthocephalus chinensis*, *sterospermum chelonoides*, *Phyllanthus urinaria*, *Clerodendron japonicum*, *Pollinia cilliata*, *Combretum decandrum*, *Milletia extensa* etc.

Presence of semi-evergreen tree species that occur in the shaded pockets of the larger river valleys is the characteristic of the **Wet mixed forests** type. *Terminellia myriocarpa*, *Michelia champaca*, *Litsea monopetala*, *Syzygium formosum*, *Blischmiedia roxborghiana*, *Musa balbisiana* are the important associations of this forest type.

The floor of the tropical vegetation zone is mostly covered by the grasses like *Saccharum spontanium*, *S. arundinaceum*, *Eragrostis* species, *Mnesithea laevis*, *Panicum auritum*, *Setaria pumila*, *Arundinella bengalensis*, *Panicum* spps., *Digitaria* spps, *Urochloa subquadriflora*, *Axonopus compressus*, *Sporobolus diander*, *Elusine indica*, *Cynodon dactylon*, *Centotheca lappacea*, *Imperata cylindrica*, *Chrysopogon aciculatus*; other herbs such as *Commelina benghalensis*, *Commelina diffusa*, *Commelina paludosa*, *Chlorophytum arundinaceum*, *Amorphophallus bulbifer*, *Floscopa scandens*, *Murdannia japonica*, *Costus speciosus*, *Cyperus compactus*, *Cyperus laxus*, *Cyperus pilosus*, *Scleria biflora*, *Scleria caricina*, *Clerodendron viscosum*, *Croton caudatus*, *Amaranthus spinosus*, *Ageratum conyzoides*, *Mikamia micrantha*, *Boerhavia diffusa*, *Pouzolzia zeylanica*, *Pouzolzia hirta*, *Borreria repens*, *Borreria alata*, *Hedyotis corymbosa*, *Solanum nigrum*, *S. myriacanthum*, *Coccinia grandis*, *Ipomia carnea* etc.

Climber associates like *Pothos scandens*, *Daemonorops jenkinsiana*, *Dioscorea belophylla*, *Dioscorea bulbifera*, *Dioscorea pubera*, *Dioscorea hispida*, *Smilax lancifolia*, *Smilax ovalifolia*; epiphytic orchids as *Acampe papillosa*, *Aerides multiflorum*, *Ascocentrum ampullaceum*, *Bulbophyllum careyanum*, *Cymbidium aloifolium*, *Dendrobium fimbriatum*, *Dendrobium moschatum*, *Eria lasiopetala*, *Oberonia mucronata*, *Papilionanthe teres*, *Pholidota imbricata* etc have increased the dimensions.

2.9.2. Sub-Tropical Vegetation

The sub-tropical type of vegetation are observed on slopes, ridges and spurs above 500m amsl along river Tista, Great and Little Rangit, Balasan, Mahananda, Rammam, Relli, Jaldhaka, Neora, Lish, Gish, Chel, Mechi etc. This vegetation is of deciduous nature and mostly consists of tropical flora as this is greatly affected by the seasonal climate of dry winter and humid monsoon (Grierson and Long 1993). The most dominant trees of this vegetation zone are *Schima wallichii*, *Alianthus intergifolia*, *Duabanga grandiflora*, *Gynocordia odorata*, *Gmelina arborea*, *Aesandra butyracea*, *Baccaurea ramiflora*, *Castanopsis indica*, *Castanopsis tribuloides*, *Cinnamomum bejolghota*, *Callicarpa arborea*, *Lithocarpus elegans*, *Litsea cubeba*, *Mallotus philippensis*, *Michelia champaca*, *Pterospermum acerifolium*, *Phoebe lanceolata*, *Phyllanthus imblica*, *Spondias pinnata*, *Syzygium ramosissimum*, *Terminalia alata*, *Terminallia*, *Pandanus furcatus* and associated with bamboos like *Dendrocalamus hamiltonii* etc.

The shrubs and the under growths of this vegetation association are *Calamus erectus*, *Phoenix acaulis*, *Musa balbisiana*, *Thysanolanana latifolia*, *Boehmeria glomerulifera*, *Croton caudatus*, *Leea guineensis*, *Eupatorium odoratum*, *Flueggea virosa*, *Holmskioldia sanguinea*, *Jasminum multiflorum*, *Phlogacanthus thyrsoiflorus*, *Rubus ellipticus*, *Woodfordia fruticosa*.

The most dominant epiphytes are *Bulbophyllum careyanum*, *Bulbophyllum crassipes*, *Coelogyne ovalis*, *Dendrobium aphyllum*, *Dendrobium transparens* etc.

Climbers which associate the vegetation are *Raphidophora glauca*, *Dioscorea bulbifera*, *Dioscorea prazeri*, *Smilax* species, *Bauhinia vahlii*, *Cissampelos pareira*, *Cissus simplex*, *Combretum decandrum*, *Entada rheedii*, *Milletia pachycarpa*, *Mucuna pruriens*, *Spatholobus roxburghii*, *Thunbergia fragrans*, *Tinospora cordifolia* etc.

Grasses such as *Apluda mutica*, *Capillipedium assimile*, *Eragrostis* species, *Microstegium vagans*, *Neyraudia arundinacea*, *Pogonetherum crinitum*, *Saccharum aurandinaceum*, *Saccharum longesetosum*, *Setaria palmifolia* and other herbs as *Commelina suffruticosa*, *Cyanotis cristata*, *Murdannia nudiflora*, *Cyperus cyperoides*, *Fimbristylis bisumbellata*, *Fimbristylis dicotoma*, *Kyllinga bervifolia*, *Kyllinga nemoralis*, *Ageratum conyzoides*, *Bidens bipinnata*, *Borreria repens*, *Caesulia axillaris*, *Drymeria villosa*, *Elatostema lineolatum*, *Eranthemum pulchellum*, *Hydrocotyle sibthorpioides*, *Oxalis corniculata*, *Phaulopsis imbricata*, *Pilea hookeriana*, *Pouzolzia sanguinea*, *Urena lobata* etc. have increased the flavour of the vegetation.

2.9.3. Sub-Temperate Vegetation

Bhujel (1996) described this vegetation zone between a short vertical distance of 1200 to 1850 m amsl as Sub-Temperate Vegetation Zone because this zone comprises the flora of both the sub tropical and temperate vegetation types which have extended their limit. One of the most important characteristics of this zone is absence of profuse mosses and lichens on trees which is the character of the Temperate zone. Vegetational composition of this zone is neither completely sub-tropical nor completely temperate, but of intermediate character.

This type of vegetation can be observed in the places like Saureni – Mirik, Gopaldhara – Seyok, Pokhrebong – Pusimbeng, Kurseong – Tung, Moondakothi – Kalej Valley, Mungpoo – Lathpanjar – Sitong, Peshok – Takdah, Ging – Tukvar, Marybong – Tamsang, Langurdang – Relling – Kainjalay – Samalbong – Kolbong, Lodhoma – Rimbick area etc in the Darjeeling and Kurseong divisions. Likewise in Kalimpong division the places along Kalimpong – Algarah – Kuwapani – Labha, Godak – Todye, Pedong, Nimbong, Kagay – Sinji – Git Dabbling etc. this kind of vegetation is found.

The extension of the temperate floral species below their normal range may be noticed as *Leucosceptrum cannum*, *daphne sureil*, *Edworthia gardneri* etc, similarly the species of sub-tropical vegetation that exceed above their normal range of distribution and prevail over this zone may be noted as *Schima wallichii*, *Phyllanthus imblica*, *Boehmeria glomerulifera*, *B. Macrophylla*, *Gamelina arborea* etc. Presence of *Engelhardia spicata*, *Agapetes sikkimensis*, *Alnus nepalensis*, *Brassaiopsis hispida*, *Buddleja asiatica*, *Camelia kissi*, *Casearia glomerata*, *Cestrum aurantiacum*, *Chonemorpha griffithii*, *Cinnamomum glaucescens*, *Clematis semilacifolia*, *Elatostema caveanum*, *Ficus oligodon*, *Grewia sapida*, *Hoya edeni*, *Indigofera dosua*, *Inula eupatorioides*, *Luculia gratissima*, *Macaranga indica*, *Micropanax dispermus*, *Osbeckia stellata*, *Ostoides paniculatus*, *Oxyspora paniculata*, *Persicaria thunb*, *Pilea glaberrima*, *Porana grandiflora*, *Schizandra propinqua*, *Solanum erianthum*, *Viola diffusa*, etc.

2.9.4. Temperate Vegetation

The temperate zone of vegetation covers the widest altitudinal range from 1850 m to 3200 m amsl, therefore covering most of the areas of Darjeeling district it also consists of maximum species of plants. Therefore, it can be taken in assumption, in broad sense, that the vegetation of the district is basically of temperate type. As it comprises a wide altitudinal variation different types of vegetation can be observed within its range. The lower elevations comprise of broad-leaved deciduous forests, middle portion of evergreen forests and the upper portion is covered with pine forests.

In accordance with the distinct vegetation types of the Temperate zone, it can be further subdivided into three sub-types (Kanai 1963; Grierson & Long 1983): (A) Temperate Broadleaved Deciduous Forests, (B) Evergreen Oak forests, and (C) Hemlock-Rhododendron forests.

A. Temperate deciduous forests (1850 – 2400 m):

This kind of vegetation can be observed between elevations of 1850 – 2400 m amsl. The vegetations of this type are composed of *Betula cylindrostachys*, *Betula utilis*, *Alnus nepalensis*, *Acer campbellii*, *Magnolia campbellii*, *Michelia doltsopa*, *Cotoneaster griffithii*, *Lyonia ovalifolia*, *Engelhardtia spicata*, *Exbuckliandia populnea*, *Quercus lamellosa*, *Q. pachyphylla*, *Q. lineata*, *Michelia*

cathcartii, *Betula alnoides*, *Prunus nepalensis*, *P. cerasoides*, *Castanopsis hystrix*, *C. tribuloides*, *Machilus edulis*, *Symplocos glomerata*, *S. theaeifolia*, *Erya japonica*, *Evodia fraxinifolia*, *Taxus baccata*, *Rhododendron arboreum*, *Rhododendron grande*, *Toona ciliata*, *Persea fructifera*, *Eleocarpus lanceifolius*, *Castanopsis hystrix*, *Pletocomia himalaica* etc.

Species of shrubs and undergrowths in this vegetation are like *Aucuba himalaica*, *Maesa chisia*, *Neillia thirsifloris*, *Gaultheria griffithiana*, *Elsoltzia fructifera*, *Ilex crenata*, *Rubus lineatus*, *Leycesteria formosa*, *Viburnum erubescence*, *Smilax aspara*, *Smilax aspericaulis*, and of various species of bamboos like *Drepanostachyum khasianum*, *Himalcalamus hookerianus*, *Yushania maling*, *Arundinaria racemosa*, *Drepanostachyum intermedium* etc. All the species together constitute a thick layer of dense shrubby canopy. Herbs of this canopy include the grasses like *Poa sikkimensis*, *Poa pratensis*, *Lolium multiflorum*, *Pennisetum clandestinum*, *Panicum notatum*, *Panicum khasianum*, *Oplismenus compositus*, *Tripogon filiformis*, *Yushania maling*, *Arundinaria racemosa*, *Agrostis micrantha*, *Saccharum rufipilum*, *Eulalia mollis* etc. And the other important herbs include *Iris clarkei*, *Molineria capitulata*, *Molineria crassifolia*, *Bulbostylis densa*, *Polygonatum oppositifolium*, *P. punctatum*, *Maianthemum oleraceum*, *Maianthemum fuscum*, *Remusatia hookeriana*, *Streptolirion volubile*.

Some predominant orchids of this zone are *Satyrium nepalense*, *Pleione hookeiana*, *Platanthera biermanniana*, *Platanthera latilabris*, *Pleione humilis*, *Pleione precox*, *Spiranthes chinensis*, *Malaxis muscifera*, *Calanthe truliformis*, and *Oreorchis micrantha* and so on.

B. Evergreen Oak forests (2400 – 2800 m):

The combination of *Acer*, *Quercus* and *Rhododendron* is the characteristic feature of this vegetation zone. The vegetations of this forest type are further distinguished by commendable occurrence of herbs, shrubs, and the sporadic appearance of climbers. The major components of broad-leaved Oak forest include *Quercus lineata*, *Q. lamellosa*, *Q. lanata*, *Lithocarpus pachyphylla*, *L. elegans*, *Aclimandra cathcartii*, *Litsea elongata*, *L. albescens*, *Juglans regia*, *Rhododendron falconeri* etc.

The notable shrubs observed under this vegetation are *Aconogonum molle*, *Agapetes saligna*, *Dichroa febrifuga*, *Gaultheria fragrantissima*, *Helwingia himalaica*, *Daphne bholua*, *Hoelboellia latifolia*, *Rubus lineatus*, *Rubus paniculatus*, *R. macilentus*, *Vaccinium retusum*, *Arundinaria malling*, *Smilax myrtilis*, *S. elegans*, *S. orthoptera*, *Vaccinium retusum*, *Lyonia ovalifolia*, *Piptanthus nepalensis*, *Prinsepia utilis*, *Rhododendron grande*, *R. falconeri*, *Viburnum erubescens*, *Zanthoxylum oxyphyllum* etc.

The important herbaceous ground flora most dominant in the vegetation viz. *Anemone vitifolia*, *Arisaema jacquemontii*, *Aster tricephalus*, *Cardamine impatiens*, *Fragaria vesca*, *Clintonia alpina*, *Hemiphragma heterophyllum*, *Primula denticulata*, *Gallium mollugo*, *Valeriana wallichii*, *Aristolochia griffithii*, *Gnaphalium affine*, *Potentilla fulgens*, *Elsholtzia strobilifera*, *Fragaria nubicola*, *Voila pilosa*, *Hydrocotyle himalaica*, *Remusatia vivipara*, *Tupistra aurantiaca*, and grasses like *Festuca gigantea*, *Glyceria tonglensis*, *Helictrotrichon virescens*, *Agrostis triaristata*, *Festuca polycolla*, *Festuca leptopogon*, etc.

C. Hemlock-Rhododendron forests (2800 – 3200 m):

The upper cold temperate vegetations of Darjeeling district ranges from 2800 – 3200 m is characterised with the presence of a mixed forest comprising of Hemlock (Conifers) and Rhododendrons. The major ingredients of this zone are *Tsuga dumosa*, *Abies densa*, *Betula utilis*, *Cotoneaster microphyllus*, *Rosa sericea*, *Rubus pentagonus*, *Rubus treutleri*, *Neillia rubiflora*, The most predominant shrubs in these forests are the species of *Rhododendron* e.g. *R. barbatum*, *R. edgeworthii*, *R. grande*, *R. arboreum*, *R. dalhousie*, *R. griffithianum*, *R. glaucophyllum*, *R. falconeri*, *R. hodgsoni*, *R. campylocarpum*, *R. thomsonii*, *R. decipiens* and *R. campanulatum* etc. In between the trees like *Larix griffithiana*, *Picea spinulosa*, and *Tsuga dumosa* appeared uniformly inside *Arundinaria racemosa* and mixed silver fir trees.

Significant under growths are comprised with of *Berberis wallichiana*, *Enkianthus deflexus*, *Euonymus frigidus*, followed by some species of *Lonicera*, *Rubus*, *Ribes*, *Gaultheria* etc. and some herbs found here are the *Valeriana wallichiana*, *Gallium mollugo*, *Fragaria rubiginosa*, *Podophyllum hexandrum*, *Panax pseudoginseng*, *Swertia chirayita*, *Arisaema propinquum*, *Arisaema nepenthoides*, *Arisaema griffithii*, *Tripogon trifidus*, *Trisetum spicatum*, *Garnotia acutigluma*, *Festuca rubra*. Different species of *Carex*, *Polygonatum* *Juncus* and *Kobresia* are densely dominant here some of them are *Carex pulchra*, *Caex remota*, *Caerx setosa*, *Caerx nubigena*, *Caerx obscura*, *Caerx baccans*, *Polygonatum verticillatum*, *Polygonatum cirrhifolium*, *Luzula plumosa*, *Juncus wallichianus*, *Juncus inflexus*, *Juncus grisebachii*, *Juncus effusus*, *Juncus bufonius*, *Kobresia uncinoides*.

2.9.5. Sub-alpine Vegetation

The high altitude ridges of Singalila Mountains fall under this vegetation zone. Above 3200 m the mountain spurs and slopes are mostly open and naked. The plants over this area are mostly bushy, shrubby and many thorny plants with xerophytic character. Though, this zone also comprises Rhododendrons and conifers association. *Abis densa*, *Sorbus microphyllus*, *Vibernum nervosum*, *Juniperus pseudosabina*, *salis sikkimensis*, *Acer caudatum*, *Salix sikkimensis*, *Skimmia laureola* etc are some dominant species over here. The scrubs formed of *Rhododendron*, *Berberis*, *Euonymus*, *Gaultheria*, *Vaccinium*, etc are the major elements of these vegetations. The most dominating herbs at this level are *Arisaema utile*, *Caerx inclinis*, *Juncus grisebachii*, *Luzula plumosa*, *Fritillaria cirrhosa*, *Danthonia cuminsii*, *Agrostis micrantha*, *Helictrotrichon virescens*, *Trisetum clarkei*, *Trisetum spicatum* ssp. *himalaicum*, *Tripogon filiformis*, *Tripogon trifidus*, *Festuca polycolea*, *Festuca rubra*, *Kobresia pygmaea*, *Kobresia fragilis*, *Anaphalis contorta*, *Primula capitata*, *P. sikkimensis*, *Cassiope fastigiata*, *Aconitum ferox*, *Meconopsis paniculatus*, *Sedum multicaule*, etc.

2.9.6. Planted Vegetation

With the view of production of high value timber yielding tree species were planted before and after independence. *Cryptomeria japonica*, an exotic conifer of Japanese origin has been planted extensively along the ridges and slopes of upper hills and has destroyed the entire ground flora. This tree has well adopted in the hills between 1500 – 2500 m. Similarly in the lower belts of tropical forest Sal (*Shorea robusta*), Teak (*Tectona grandis*) are very much popular.

Plantation of trees by the department of forest is mainly done under three main programme—Enrichment programme, Forestry Extension Programme, and Social Forestry programme. Some of the important tree species that has been planted according to the vegetational zones are as *Castanopsis hystrix*, *Pinus* spp., *Taxus bacatta*, *Thuja* sp. with other exotic conifers like *Pinus petula*, *Cupressus* spp. etc in some higher Sub-alpine and Temperate vegetation regions. *Alnus nepalensis*, *Albizia* spp., *Betula alnoides*, *Gmelia arborea*, *Juglans regia*, *Michelia champaka*, *Michelia doltsopa*, *Toona ciliata*, etc in the Sub-Temperate zone, *Acasia catechu*, *Aclimandra cathcartii*, *Chukrasia tabularis*, *Dalbergia sissoo*, *Eucalyptus globulosus*, *Terminalia alata*, *Terminalia myriocarpa*, etc in the Sub-Tropical and Tropical zones other than *Shorea robusta* and *Tectona grandis*.

In spite of these most of the ridges and slopes located in between 500–2000 m in the hills and almost the whole area of Terai (except few forest patches under Kurseong division) has been cleared either for tea plantation or cultivation. In areas like Mungpoo, Lathpanjar, Mansong, Gairibans (Dooars) plantation of medicinal plants like *Cinchona succirubra* and other species of *Cinchona*, *Rouwolfia serpentina*, *Epicac*, *Dioscorea deltoidea* etc is being done.

2.10. FAUNAL RESOURCES

As the district is rich in floral diversity, simultaneously it expresses richness in faunal resources. Up to the beginning of the last century the district was clothed with dense natural forests and so, the wild

carnivorous animals including leopard, ounce, clouded leopard, large tiger-cat, marbled tiger-cat, Himalayan Black Bear and the tigers and even the man-eaters, were met with in fairly large numbers (O'Mellay 1907). Possessing two National parks, three Wild life sanctuaries, many reserved and other forests and abundant social and private forest pockets the district also represents great faunal diversity and reserves numerous faunal species including mammals, birds, butterflies, beetles, snakes etc which contribute an additional significance to the biodiversity of the district. Approximately, 72% of West Bengal's mammal diversity is exhibited in Darjeeling Himalayan region, of which 53 species are not found in other ecosystems of West Bengal (Chakraborty & Agrawal 1993). Agrawal *et al.* (1992) recorded 128 species, Mitra (2004) 180 species and Sanyal *et al.* (2007) mentioned 126 species in Darjeeling. Ninety four species of birds, 276 species of insects and 38 species of other invertebrates have been identified in NVNP (Singhal & Mukhopadhyay 1998), Mallick (2012) reported 99 species of mammals from the district (specially the Kalimpong Hills). Among them 21 were the nationally threatened species like Red Panda (*Ailurus fulgens*), Oriental Small-clawed Otter (*Amblonyx cinereus*), Gaur (*Bos gaurus*), Golden Jackal (*Canis aureus*), Wolf sp. (*Capricornis sumatraensis*), Mainland Serow (*Canis indica*), Asian Golden Cat (*Catopuma temminckii*), Indian Wild Dog (*Cuon alpinus*), Indian Elephant (*Elephas maximus*), Common Indian Hill Otter (*Lutra lutra monticola*), Smooth Indian Otter (*Lutrogale perspicillata*), Himalayan Yellow-throated Marten or Indian Marten (*Martes flavigula*), Sloth Bear (*Melursus ursinus*), Brown Ghoral (*Naemorhedus goral*), Clouded Leopard (*Neofelis nebulosa*), Common Leopard (*Panthera pardus*), Tiger (*Panthera tigris*), Marbled Cat (*Pardofelis marmorata*), Brown-toothed Shrew (*Soriculus nigrescens*), Himalayan Black Bear (*Ursus thebetanus*) and Red Mountain Fox (*Vulpes vulpes montana*). The common mammals of the area include the Common Indian red-tailed Hare (*Lepus ruficudatus*), the monkeys, squirrels, moles, rats and mice.

Some of the rare birds found in the Darjeeling hills are Buzzard (*Butea sp*), Himalayan red-breasted Falconet (*Microhierax caerulescens*), Spotted Seops Owls (*Otus spilocephalus*), Himalayan Golden-breasted Tit-Babbler (*Aleippe chrysotis*), Golden Stadt's Redstart (*Phoenicurus erythrogaster*), Eastern Plain-colored Mountain Finch (*Leucostricte nemoricola*), Monal pheasant (*Lophophorus impejanus*), Crimson tragopan (*Tragopan satyra*), Blood pheasant (*Ithaginis cruentus*), Partridge (*Fancolinus sp*), Eagles (*Aquila sp*), Falcons sp, Hawks (*Spizaetus sp*), Scarlet Minivet, Kalij Pheasant (*Euplocamus leucomelanus*), Common Wood Partridge (*Arboreola torqueola*), Wood Cock (*Scolopax rusticola*), Red Jungle-Fowl (*Gallus ferrugineus*), Red Spur-Fowl (*Galloperdix spadiceus*), Pea-Fowl (*Pavo cristatus*), the Lesser Florican (*Sypheotydes bengalensis*), Satyr Tragopan, Brown and Fulvous Parrot-bills, Rufous-vented Tit etc (O'Mellay 1907). The area is also on the flyway of many migratory birds.

The Himalayan salamander (*Trilitotriton himalayana*), which is in the schedule I of Indian Wildlife conservation list have been found to occur in some places of Darjeeling like Jorepokhari, Lapcheyjagat, Sittong ect.

The district also harbours remarkable numbers of poisonous, less or non poisonous snake species. The most commons are the King Cobra (*Naja bungarus*), the common Cobra (*Naja tripudians*), the Karait (*Bungarus coeruleus*), the Banded Karait (*Bungarus fasciatus*), Viper (*Vipera russelli*) the Python (in the Terai) and several species of *Trimeresurus* etc (O'Mellay 1907). O'Mellay (1907) even reported the presence of long-nosed fish-eating Crocodile from the Mahanadi river, but today, it will be only a story as this river become completely dry during November to May, at least up to its entrance to the Terai.

Besides these, occurrence of various rare and endangered mammals like The Blue Sheep (Bharal) (*Pseudois nayaur*), Porcupine (*Hystrix indica*), Armadillos, Wild boar (*Sus scrofa cristatus*), Barking deer (*Muntiacus vaginalis*), Pangolin, Pika, the Hispid Hare (*Lepus hispidus*) etc. were confirmed from direct or indirect evidences (Mallick 2012).



Plate - 1. View of Singalila National Park: (a) Sandakphu, and (b) Phaloot



Plate - 2. Rivers and river valleys: (a) The Tista (b) Rammam (c) Confluence of Rivers Tista and the Great Rangit (d) River Neora with Neora Valley at the background (e) Eroitional bed of river Lish (f) Villages Lingten and Sumbuk, at the valley of River Rammam



Plate - 3. Vegetation types: (a) Sub-alpine Zone (3200 – 3700 m, Sandakphu, Singalila National Park); (b) Temperate Zone (1850 – 3200 m, Lava, Neora Valley National Park); (c) Sub-Temperate Zone (1200 – 1850 m, Lower portion of Lepchajagat Forest) (d & e) Sub-Tropical Zone (500 – 1200 m [(d) foothills of Samsing Fari, Neora Valley National Park (e) foothills of Rongtong Sukna, Mahananda WLS]; (f) Tropical Zone (upto – 500 m, Terai, Dulkajhar Forest)

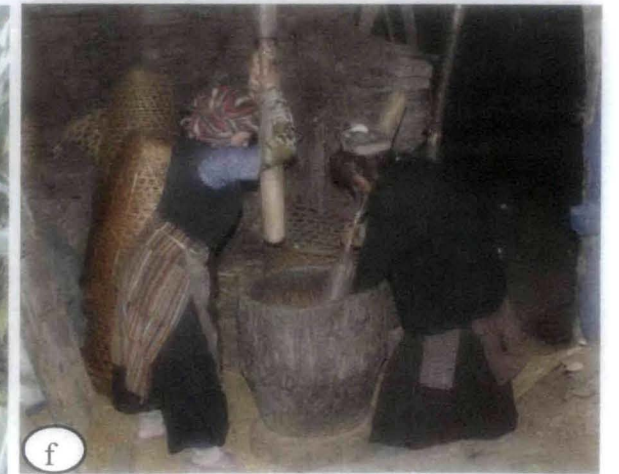


Plate - 4. Some Villages and Village Activities: (a) A village below Lava; (b) Village Samnden below Phaloot; (c) Weaving baskets of *Himalayacalamus hookerianus*; (d) Management of cooking fuel; (e) Sowing seedling of *Eleusine coracana* between *Zea mays*; (f) Making Rice.