Study Area

3.1. INTRODUCTION

Terai (or **Tarai = moist land**) refers to a belt of marshy region full of jungles situated at the foot of a hill especially at the foot of the Himalayas. The entire zone of marshy grasslands, savannas and forests at the base of the Himalayas and extending from the Yamuna River in the west to the Brahmaputra River in the east is known as Terai region and is distributed in India, Nepal and Bhutan.

On the other hand, the term 'Duars' which is derived from the word 'Doors' and means passages in both Assamese and Bengali languages. There were eighteen such passages through which the Bhutanese people used to communicate with the people living in the fertile flood plains at the foothills of the Eastern Himalaya in North-East India around Bhutan. Thus, the entire resource rich plain of West Bengal and Assam around Bhutan is known as Duars. It extends over 8,800 sq km and is divided by the Sankosh River into two parts – the eastern and the western Duars. Eastern Duars is in Assam whereas the Western Duars is included in the state of West Bengal.

3.2. LOCATION AND TOPOGRAPHY

Terai - Duars belt of West Bengal is the Sub-Himalayan or foot hills region of the Indian state that extends from Nepal to Assam. Geographically this area is located from 26°16′00" N to 27°00′00" N latitudes and from 87°59′30" E to 89°53′00" E Longitudes and bordered by Hilly region of Darjeeling district and Bhutan to the North and by Cooch Behar, North Dinajpur and Bangladesh to the South.

It consists of Jalpaiguri and Alipurduar districts, Siliguri sub-division and southern part of Kurseong sub-division of Darjeeling district. Sometimes Terai and Duars are used synonymously for this entire low-lying moist belt at the foot of majestic Himalayas. But the part of this belt consisting of entire Siliguri sub-division, southern and lower part of Kurseong sub-division and a small part of Jalpaiguri district lying west to the river Tista is known as Terai whereas the eastern part of Tista composed of remaining portion of Jalpaiguri and entire Alipurduar District is known as Duars.

The Bhabar, a forested belt of rock, gravel, and soil eroded from the Himalayas with deep seated (from 5 to 37 meters deep) water table is lies above the Terai belt. Below the Terai lies the great Upper Gangetic plain. Botanically, it is defined as the region of forest trees and the average altitude of the Terai ranges from 90 —100 m.

Duars is divided into two distinct types of land forms - plains and undulated areas. The land of Jalpaiguri district is bounded by the piedmont plains which gradually graded into the alluvial plains in further south (Mohanta, 2004). On the other hand, Alipurduar district appears quite hilly. The topography of Terai region is uneven and the altitude ranges from 62 to 350 m, whereas that of Duars ranges from 90 to 1750 m.

3.3. GEOLOGY AND SOIL

Mallet (1874) has made an excellent account of geology of the foothills along with the Sub-Himalayan areas. All along the foothills of the Darjeeling District the Siwaliks are steeply overthrust by Damudas formation (Lower Gondwanas). Damudas are coal-bearing rocks of Gondwana age and here it appears as an inverted section, highly tectonized and differs from Damudas of Peninsular India (Rai, 2006). Upper part of Duars mainly consists of Siwaliks and older Quaternary formation dominated by thick boulders and conglomerate horizons and the lower portion appears as a fluvial terrace deposit.

Soil of this marshy Sub-Himalayan belt consists of almost horizontal layers of unconsolidated sand, silt, pebbles and gravels (Ghosh, 2006). Jana (1997) described the soils of this zone as alternating bed of sand of different sizes, gravels and boulders. Soil is porous, deep, light textured, with moderate organic matter and low Phosphate, Potassium, and micronutrient contents (Bhattacharjee, 2001). The pH of the soil is acidic as leaching of the bases takes place from the surface of the soil to low horizon due to heavy rain (Rai, 2006). The Duars soil is of light texture and alluvial in nature. It is defined as sandy loam to loamy sand and has high permeability and porosity. This type of soil is the product of weathering of fluvial clastics. Soil of the basin between Jaldhaka and Tista is composed of hard black clay and that in the northern upland of Duars is ferruginous clay. Chakraborty *et al.* (2002) discussed the variability of Duars soils. He characterized the soil of the northern Duars as clay loam and sandy loam. Whereas, in the southern part of Duars the soil type is less varied consisting of light friable load. Variability in the depth of soil is an important geological feature in southern Duars (Das, 2000)

3.4. DRAINAGE SYSTEM

The Terai-Duars belt of West Bengal is criss-crossed by a large number of the monsoon-swollen Himalayan Rivers, rivulets and streams. Main rivers of Terai are Mahananda, Balason and Mechi. Tista is the major river in Duars which originated from the Zemu glacier in North Sikkim and joins the mighty Brahmaputra in Bangladesh. Torsa, Jaldhaka, Diana, Karatoya, Raidak and Kaljani are other important rivers passing through Duars. Most of these rivers originated from Himalayan hills, flow from North-east to South-West and are mostly rain fed, except the Tista and Jaldhaka which are glacier fed rivers. Lish, Ghish and Murti are other important rivers of Duars region. All these rivers and their tributaries carry down a huge amount of sediments and deposited in this area.

3.5. CLIMATE

The climate of Terai-Dooars belt is more or less similar to that of the remaining districts of North Bengal and mostly of humid subtropical type. Due to its proximity to the hills, it faces longer winter and receives heavier rainfall.

3.5.1. Seasons of the year

Being extended from the foothills of Himalaya in North to the Upper Gangetic Plains in South and diverse in topographical and altitudinal conditions, this belt shows difference in its climatic conditions from tropical to sub-tropical type. The seasons generally follow the course of adjacent Sub-Himalaya and plains together and led to the creation of various types of vegetation. Recognized main prevailing seasons are Summer, Monsoon or Rainy season, Autumn and Winter which circumscribe the entire year. March April and May – these three months comprises the summer which is characterized by brief squalls and thunderstorms that often arrive from the north or northwest and is known as *kaal-baisakhi*. Summer is mild and prevails for a very short duration of the year. Monsoon or the rainy seasons extends from June to September. The branch of the Indian-ocean-monsoon wind, which is called as the Bay of Bengal branch of monsoon wind, moves in a northwest direction during this season and brings the major parts of rain to this belt. Autumn which is very short in this belt extends from the mid to last of September up to first or second week of November and is characterized by clear visibility, light clouds and dry and pleasant weather. The last half of November to February comprises the winter which is mild over the plains in the southern portion with average minimum temperatures of 15° C. A cold and dry northern wind blows in the winter that reduces the humidity level. But the northern part of Terai – Duars belt experiences a little bit of harsh winter. Foggy nights and mornings with cold temperature are the characteristic features of the winter.

3.5.2. Temperature

Due to the variation in altitudinal range Terai – Duars region experiences spatial alteration in temperature also (Table 3.1).The plains are warm and hot throughout the year except a short period during winter. As it is located at the foot of Himalaya and contiguous with it, the temperature is rarely excessive in Terai-Duars belt. Average Monthly maximum temperature varies between 23˚C – 32˚C in January and September respectively whereas the average monthly minimum temperature ranges from 10°C in January to 24.6°C in September.

Sometimes in winter it falls down to 8.5° C. January is the coldest month and the minimum and maximum temperature ranges from 8.5˚C – 11.6˚C and 22.6˚C – 24.5˚C. From the end of March it begins to get warmer and from May to September it is rather hot – average monthly maximum and minimum temperature ranges from 31.15˚C – 32.19˚C and 21.74˚C – 24.67˚C respectively. Southern plain of this belt is comparatively hot whereas the northern undulating parts are relatively cooler.

3.5.3. Rainfall

The area receives rainfall almost throughout the year except the winter. The maximum amount of rainfall is brought about by the South-West monsoon .The South-West monsoon travelling across the Indian Ocean and the Bay of Bengal carries heavy moisture and causes showers throughout last quarter of April to first quarter of October and maximum amount of rainfall occurs in July. Minor amount of rain fall is also found during December to March as because of the retreating of North-East Monsoon. This area receives a high annual precipitation and the average annual rainfall received during 2000 – 2013 ranges from 418 – 545 cm amounting the average annual precipitation as 476.3 cm. This high rainfall is restricted within a period of 103 to 110 days during monsoon

Table 3.1. Average monthly maximum and minimum temperature during 2000 to 2013 [As recorded in Central Tobacco Research Institute, Dinhata, Coochbehar]

Month		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Aver
Jan	Max	22.7	22.8	23.2	22.1	22.6	23.8	22.4	22.1	24.5	23.6	23.5	22.8	22.6	23.7	23.03
	Min	10.0	8.7	10.7	8.4	9.3	8.5	10.9	8.9	10.6	11.6	9.8	10.2	10.6	10.4	9.90
Feb	Max	24.4	25.0	26.6	22.5	26.0	26.2	27.2	23.5	23.7	27.7	26.7	26.9	24.4	23.8	25.33
	Min	10.5	11.9	11.5	9.9	11.0	13.1	15.4	13.2	10.4	13.1	12.1	10.5	11.3	12.1	11.86
Mar	Max	28.2	30.6	29.3	27.7	30.8	29.3	30.8	28.3	28.4	31.0	30.2	28.9	29.5	29.4	29.46
	Min	15.8	15.1	15.6	13.6	17.2	15.2	16.0	15.2	16.8	15.5	15.7	17.2	16.5	16.1	15.82
Apr	Max	30.8	31.7	28.8	30.5	28.5	31.0	30.8	29.6	30.0	29.3	29.7	28.9	30.2	28.8	29.90
	Min	20.7	20.2	17.6	19.5	19.3	17.5	20.5	20.1	20.2	18.0	19.4	18.9	20.6	19.8	19.45
May	Max	31.0	31.2	30.1	32.1	31.9	30.6	27.2	32.5	31.2	31.6	30.2	32.5	32.1	31.9	31.15
	Min	22.5	22.4	21.7	21.1	21.3	18.7	22.7	23.2	22.2	18.9	22.4	22.7	23.2	21.3	21.74
Jun	Max	31.6	31.6	31.0	33.9	32.1	31.6	30.9	30.7	30.6	32.6	31.6	31.0	31.5	33.9	31.76
	Min	23.7	23.7	24.0	22.6	22.7	22.6	24.4	24.3	24.2	21.8	24.4	24.5	22.6	22.7	23.44
Jul	Max	31.7	31.7	30.4	32.7	31.3	29.5	32.1	30.5	30.9	32.7	31.6	30.4	29.8	31.2	31.18
	Min	25.2	25.2	24.2	24.2	23.0	25.2	25.6	24.8	25.1	24.1	23.6	24.1	23.5	22.8	24.33
Aug	Max	31.4	31.4	30.0	34.4	33.9	32.1	32.7	32.0	30.7	31.5	31.4	31.4	30.0	34.4	31.95
	Min	25.2	25.2	22.4	25.6	24.9	25.0	25.6	25.8	24.6	24.2	25.2	23.1	25.0	23.6	24.67
Sept	Max	31.1	31.1	32.0	34.5	32.1	33.2	31.0	30.9	31.6	33.1	31.2	33.6	31.2	34.1	32.19
	Min	24.0	24.0	23.6	24.5	23.6	24.8	24.2	24.5	24.3	23.6	22.6	23.2	24.8	23.7	23.96
Oct	Max	31.6	31.6	30.8	31.3	30.2	29.4	30.9	30.7	31.2	31.2	29.9	30.1	29.4	31.2	30.68
	Min	22.4	22.4	21.3	21.6	19.6	20.8	21.1	22.0	21.5	20.1	19.6	20.8	21.1	22.0	21.16
Nov	Max	27.5	27.5	28.0	28.9	29.0	27.9	26.8	28.7	28.0	27.8	28.7	26.8	27.9	27.7	27.94
	Min	17.1	17.1	16.4	17.2	14.6	15.4	16.5	16.9	15.1	14.8	15.7	17.0	15.4	16.3	16.11
Dec	Max	24.7	24.7	24.3	25.6	27.2	25.9	24.5	24.6	24.5	24.0	25.1	24.1	25.9	24.4	24.96
	Min	10.9	10.9	12.6	12.6	11.3	11.6	12.3	11.1	14.0	11.2	11.8	12.6	12.3	14.1	12.09

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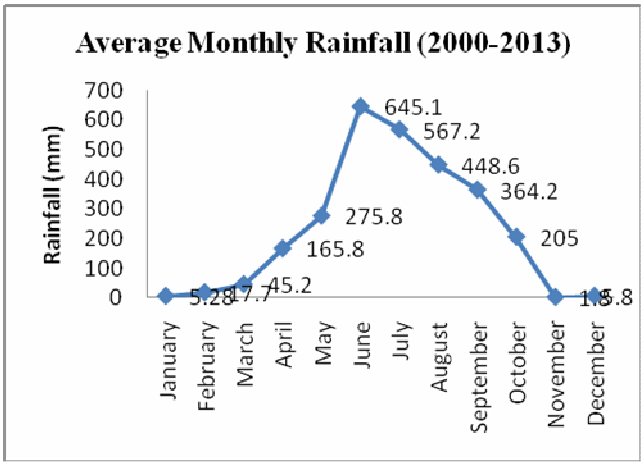

Figure 3.1. Average monthly Rainfall during 2000-2013 [as recorded in Central Tobacco Research Institute, Dinhata, Coochbehar].

3.5.4. Relative humidity

Terai-Duars, the belt of marshy region full of jungles at the foot of Himalayas, experiences a high relative humidity (RH) with only less variation. Annual average maximum and minimum relative humidity during 2000 – 2013 varied between 82.48 – 94 % and 69.33 – 79.33 % in this region.

Table 3.2. Relative humidity (RH %) during 2000 to 2013 [as recorded in Central Tobacco Research Institute, Dinhata, Coochbehar]

Year	Average Relative Humidity (%)		Year	Average Relative Humidity (%)	
	Max (at 06:32 hr)	Min (at 13:32 hr)		Max (at 06:32 hr)	Min (at 13:32 hr)
2000	94.00	79.33	2007	92.67	69.33
2001	82.48	77.25	2008	92.42	70.83
2002	89.67	76.92	2009	88.58	73.58
2003	90.50	75.67	2010	91.71	75.20
2004	90.08	71.00	2011	90.40	72.11
2005	90.67	76.08	2012	88.62	72.30
2006	93.33	75.17	2013	92.1	75.00
Maximum average 90.52			**Minimum average 74.27**		

3.6. FOG FORMATION AND SUN-SHINE

Fog formation during the winter is an important feature of Terai-Duars region. Fog consists of visible cloud, water droplets or ice crystals suspended in the air at or near the Earth's surface. Presence of numerous water bodies along with the other factor favourable for fog formation like wind condition and topography prevails in this belt, led to fog formation during winter and it reduces visibility to less than 1 kilometre and sometimes the visibility becomes zero. Transpiration from plants

which adds water vapour to the air also plays a vital role in fog formation during the winter nights.

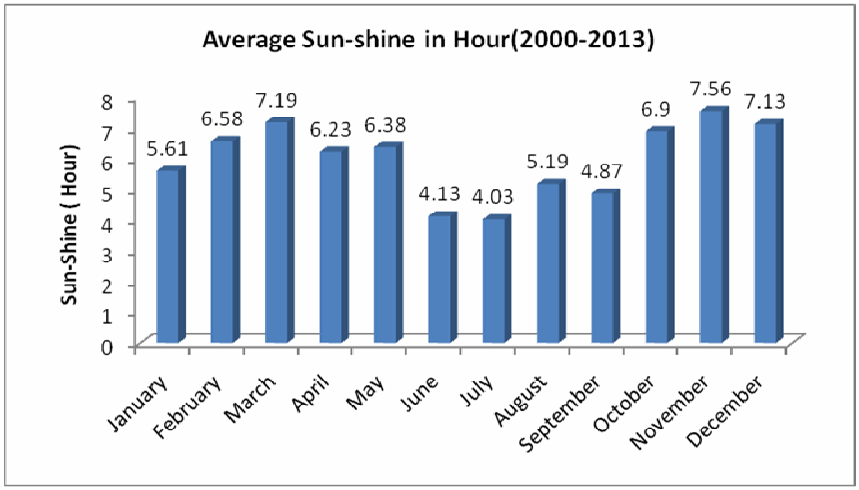

Figure 3.2. Average monthly Sun-shine in Terai-Duars belt during 2000 – 2013 [as recorded in CTRI, Dinhata, Coochbehar].

Terai-Duars region of West Bengal shows considerable variation in Sun-shine that it receives throughout the year. Minimum and maximum amount of relative sun-shine occurs during the Monsoon or rainy season i.e. in the month of June (4.13 h) and July (4.03h); and during summer (7.19h in March) as well as in autumn (7. 56h in September).

3.7. POPULATION AND THE TRIBES

Population of this belt is mixture of the native people and the people from adjoining areas. Native people this region is of Mongoloid origin. Numerous tribes who are the rich source of traditional knowledge system (Das *et al*. 2007), are scattering throughout this belt of huge biological resources. Rabha, Mech, Toto, Koch Rajbongshi, Tamang or Murmi, Limbu, Lepcha and Dhimal are dominant tribes over here (Bhattacharya, 2004). After establishment of stretches of tea gardens a large number of population were imported from Nepal, Chota Nagpur and Santhal Parganas to meet the demand for tea garden worker (Ghosh, 2006). Most of them belong to Oraons, Mundas, Kharia, Mahali, Lohara and Chik Baraik community.

3.8. BIOLOGICAL RESOURCES

The entire Terai-Duars belt is a part of the Eastern Himalaya which is renowned for its diverse and rich biological resources. This zone is regarded as one of the most resource rich centres of Bengal and its diverse habitats are ideal home for a large number of flora, fauna and microbes.

3.8.1. Flora and Vegetation

Terai - Duars belt of West Bengal is extremely rich in plant resources and its diverse floristic components are greatly influenced by the Himalayan elements. Different type of vegetation in this marshy belt of dense forests and the grasslands are unique home to a large number of endemic and/or threatened plants (Das, 1996; Das *et al.* 2003; Rai, 2006).

Forests and the Vegetation of Terai-Duars region mainly are of (i) Tropical and Plain Vegetation and (ii) Subtropical vegetation. Tropical and Plain Vegetation is characterized by high temperature and heavy rainfall and extended from plains to 800 m. Dominant feature of this vegetation is very dense deciduous forest with *Shorea robusta* as dominant species. Bhujel (1996) divided this vegetation into four sub types – Reverine forest, Sal forest, Dry mixed forest and Wet mixed forest. The Sub-tropical forest contiguously lies above the vegetation of Terai - Duars plain and extends upto 1600 m. This vegetation is affected by dry winter and wet monsoon and tropical genera and species form the main components. Both the Terai and Duars region have excellent Savannah type of thick and dense grasslands, which supported to development two Wildlife Sanctuary - Jaldapara Wildlife Sanctuary and Chapramari Wildlife Sanctuary, and two National Parks — Gorumara National Park and Buxa National Park in this zone (Anonymous, 1997).

Different workers (Mukerjee, 1965; Banerjee, 1993; Sikdar, 1984; Mohanta, 2004) worked on vegetation of Duars. On the basis of composition and distribution of the major floristic elements Sikdar (1984) described vegetation of Duars as following five types:

1. Semi-Evergreen Forest
2. Moist Deciduous Forest
3. Dry Deciduous Forest
4. Sal Forest; and
5. Grasslands

Vegetations of this zone broadly fall under Tropical moist deciduous forests along with different sub types as recognized by Champion and Seth (1968). Among those (i) Eastern Bhabar and Terai Sal Forest ($3C/C_{1b}$) and (ii) Northern Dry deciduous Seral Sal, Khair, Sissoo, Simul association ($5B/1S_2$) are dominant types.

However, Mohanta (2004) prepared a vegetation cover map using remote sensing and GIS and classified the vegetation of Duars as – (i) Semi-evergreen forest, (ii) Sal mixed forest, (iii) Mixed Sal forest, (iv) Sub-tropical broad leaved hill forest, (v) Sal forest, (vi) Bamboo brakes, (vii) Riverine forest, (viii) Forest plantation, (ix) Teak plantation, (x) Degraded forest, (xi) Savannahs, (xii) Scrubs, (xiii) Grass land, (xiv) Agriculture and (xv) Tea garden.