Chapter 1

INTRODUCTION

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Forest is one of the most important components of the life support system of our environment (Rai 2006). The technological society produced spite for the past 200 years, which can change the course of evolution processes of nature. As part of the biosphere, we are directly under the influence of the global changes, which has generated through our own activities (Hargrove 1994). The survival of all species in our ecosystem depends on the consumption and use of other species. As natural systems evolved, humanity learned to dominate by their way of life drastically by adopting land intensive systems of food production such as cropping and animal breeding. The superior human brain allowed the evolution of intelligence and inventions which led to the development of a changeable culture to generated high levels of demand on their environment.

As the so-called modern technology advances, so does our ability to change our surroundings, changes were made on the surface of earth today are more extensive and occurring more rapidly than ever before. The ramifications of these changes have become more significant with the increase in world population, resulting in the decline of available per capita land. Environment is losing its resilience where the intensity of human interventions is high (Rai 2006).

The Himalayan range created conditions favourable for migration of temperate species from mainland Asia in the rising altitude (Lakhanpal 1988). In the lower reaches of the Himalayas warm and humid climate with high precipitation prevailed. Numerous tropical to semi-evergreen taxa from Southeast Asia migrated, differentiated and produced new elements (Awasthi 1992; Sharma 2000). Palynological evidences from various places of the Himalayan region indicated sub-tropical to temperate vegetation in upper region of the newly formed mountain ranges, which had later developed cooler climate depending on the altitude and depth of the hill system (Sharma 2000; Sharma and Chauhan 1988; Lukose 1968; Nandi 1975; Singh and Saxena 1981). High degree of precipitation and atmospheric humidity supported by the topography and location of the different mountain ranges provided perfect situation along with the migration and mixing of different floras has facilitated the development and evolution of a rich and significantly original East Himalayan flora (Das 2004).

1.1 NORTH BENGAL FLORA

Both flora and ethnobotanical heritage of North Bengal is very rich. Recognition of as much as five National Parks has represented huge diversity of North Bengal those mainly belong to the Sal dominated tropical dry deciduous type of forests (Champion and Seth 1968). Workers like A.M Cowan and J. M. Cowan (1929), H. Ohashi (1975), A.J.C. Grierson and D.G. Long (1979, 1983 – 1991, 1999 – 2001, 1994 - 2000), Das (1986, 1995, 2004) intensively studied the flora of this region. Mukherjee (1965) prepared a sketch of the vegetation of Jalpaiguri District. Sikdar (1984) worked on Baikunthapur Forest division; Banerjee (1993), Pandit (1996), Das *et al.* (2003) and Pandit *et al*. (2004) worked on Jaldapara Wildlife Sanctuary that is now upgraded to Jaldapara National Park; Pandit *et al*. (2004) estimated the value of NTFP plants in Jaldapara Wildlife Sanctuary (JWLS), Sarkar (2014) worked on the NTFP plants of Buxa Tiger Reserve (BTR), Saha *et al*. (2013) worked on the medicinal plants of Gorumara National Park. Das *et al*. (2010) prepare a detailed list of medicinal plants in three MPCAs of Terai and Duars. Saha *et al*. (2015) worked on NTFPs of Gorumara National Park (GNP) and has recognized the occurrence of at least 335 species those can be treated as NTFPs and of which 58 species are used as food plants (commercial and non-commercial). However, till date, no attempt has taken to prepare the detail flora of Gorumara National Park.

Geographically, North Bengal can be divided into three prominent vegetational zones. The rolling plains extending from Dinajpur to the north bank of Ganga River, Terai-Duars region and Darjeeling Hills. All these three zones have their own characteristic features and are extremely rich in flora and fauna. GNP is located in the Duars region where the concentration of Protected Areas (PA) is maximum for the country. Apart from GNP other PAs located in Duars region include Jaldapara National Park, Buxa Tiger Reserve, Chapramari Wildlife Sanctuary, Buxa National Park, Sursuti Reserve Forests, etc. But, our knowledge on the flora and fauna of these PAs is extremely poor.

1.2 FLORA OF GORUMARA NATIONAL PARK

India is one of the 17 mega-diverse countries of the world covering only 2.4 % of the world's land area, 16.7 % of the world's human population and 18 % livestock, and it contributes about 8 % of the known global biodiversity (Olson *et al.* 2001; Olson and Dinerstein 2002). Gorumara National Park is located at the feet of the IUCN recognized Himalaya Biodiversity Hotspot and administratively falling in the Jalpaiguri District of West Bengal. Though this is a comparatively smaller national park (7945.28 hectare) but its location is very critical (Saha *et al*. 2013). The Park also belongs to the Bio-Geographical zone 7B (Lower Gangetic Plain) as recognized by Rodgers and Panwar (1990). Ecological boundary of this park extends up to Sibchu, Khumani and Jaldhaka blocks of Jalpaiguri and Kalimpong Forest Divisions respectively. The ecological boundary in the eastern fringe extends well beyond Gairkata, Central Diana upto Moraghat blocks of Jalpaiguri forest division whereas in the western part it assumes an area beyond Sursuti, Lataguri blocks of Jalpaiguri forest division, extending up to Apalchand and Kathambari forests of Baikunthapur forest division. Major significance of the national parks being the habitat of a number of schedule 1 animals, which are given maximum protection at the national level. The main endangered animal in GNP is Indian one horned rhinoceros (*Rhinoceros unicornis* L.). And, in addition, other giants like elephant, bison, Rock-Python are surviving here as co-inhabitants with quite high population structure. The Forest Action Plan (2002) for GNP has recorded the occurrence of only 326 identified plant species that include 158 species of trees, 35 herbs, 77 shrubs, 32 species of grasses, 15 species of climbers and 9 species of orchid. All Eco-Development Committees of the surrounding area are rendering protection of this forest as part of their agreement with the Forest Department (FD) during the implementation of Joint Forest management (JFM) program (Sarkar *et al.* 2009). Murti, Jaldhaka, Garati and Indong are the main rivers passing through this important Protected Area (Saha *et al.* 2013). The entire forest tract of GNP comes under the North Indian moist tropical forest type in Champion and Seth's (1968) classification. Average elevation of the park area is 90 m AMSL and chiefly covered with alluvial soil (Sarkar *et al.* 2009).

1.3 AMELIORATION OF FLORISTIC ELEMENTS

Article 2 of the CBD (2012), defines biodiversity as "variability among living organisms from all sources including, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part". In other words biodiversity refers to the variety and variability among living organisms and the ecosystem complexes in which they occur. Also, Biodiversity can be defined as sum of the species richness, i.e. number of species of plants, animals and microorganisms occurring in a given habitat.

As per WCMC, India is one of the 17 mega-diversity countries in the world. India possesses 10.78 % of flora in the world, which is the second richest country in the world after Brazil in concern of plant species. The family is one of the largest among angiosperm comprising 37 genera and ca. 1100 species distributed across the tropical and temperate regions of the world (Corner 1962; Berg *et al.* 2006). The MoEF (2009) have reported that in India, there are 45,364 plant species identified so far, of which 17,564 are of flowering plants belonging to 2,250 genera and 315 families. The vascular flora which covers different forest types in India, consist about 40 percent endemic plant wealth (Khoshoo 1984, 1986). Hooker (1904) remarked "the Indian flora is more varied than that of any other country of equal area in the Eastern Hemisphere, if not in the globe". Not only this, the presence

of a large number of primitive flowering plants in India led Takhtajan (1969) to render the north-eastern region of India to consider as "a cradle of flowering plants".

India holds about 11 percent of world's recorded plant species, making it the 10th country in floral diversity [http://www.hindustantimes.com/india/india-ranks-10th-in-world-in-plant-diversity/story-SKwpVETr40aJWr64lh81sO.html]. India has a total of 17527 angiosperm species representing 7 percent of the global angiosperm (flowering plants) diversity (Karthikeyan 2009; Singh et al. 2014). There are apparently many more species to be recorded especially in the lower plant groups and in the more inaccessible areas.

India with a total geographical area of 329 million hectares is one of the rich floristic regions of the world. Due to the diverse type of eco-climatic conditions and altitudinal variations, the region harbours a rich biodiversity. It is recognized as one of the megabiodiversity hotspots of the world representing about 18000 angiospermic species with 33 % endemism comprising ca. 5500 species under 140 genera and total 11,058 plant species are endemic to the country (MoEF 2009).

Hooker and his associates described 14,900 species of Angiosperms in his '*The Flora of British India'* (1872 – 1897). Talbot (1894) collected plants largely from southern part of Bombay Presidency and reported systematic list of trees, shrubs and woody climbers of the Bombay Presidency, which included 497 trees, 346 shrubs and 126 woody climbers. Cooke published '*Flora of the Bombay Presidency'* (1901-1908). Bor (1960) deals with the '*Grasses of Burma, Ceylon, India & Pakistan'*, reported around 1,243 species belongs to 247 genera. The Northeast region of the country is a rich floristic region with two biodiversity Hotpots - the 'Himalaya' and the 'Indo-Burma' diversity centers. It forms a unique biogeographic province encompassing major biomes recognized in the world with about 8,000 flowering plant species that nearly represents 50 % flora of the country (Babu and Arora 1999). It covers an area of 2,62,060 sq km constituting about 8 % of the country's total geographical area. All types, right from the grassland meadows, swamps, scrub forests, mixed deciduous forests, humid evergreen forests, temperate and alpine vegetation are found here. The varied forest types found in the region are home to numerous species of plants and animals. Specially, the region exhibits the richest diversity of various plant groups like Orchids, Pipers, Primulas, Bamboos, Canes, Zingibers, Yams, Figs, Legumes, Ferns, Rhododendrons, etc. Many primitive plant families such as Magnoliaceae, Illiciaceae, Lauraceae, Hamamelidaceae, Degeneriaceae, Tetracentraceae and Lardizabalaceae are well represented in the region. Besides the rich floristic diversity, the region also represents the high degree of endemism with nearly 40 % endemic taxa (Mao *et al*. 2009). A large number of wild relatives of economically important crop species that includes Citrus, Banana, Rice, Sugarcane, Pulses etc. have originated in this region (Mao *et al*. 2009).

Arunachal Pradesh is the largest state in Northeastern region of the country and comprises major part of the Eastern Himalaya with an area of 83,743 sq km. The total forest cover is about 67,410 sq km that is accounting for 80.50 % of total geographical area (FSI 2011). The state by virtue of its geographical position, climatic condition and altitudinal variation, is regarded as most biodiversity rich region in the whole of Northeast India with large tracts of tropical, sub-tropical, temperate and alpine forests housing rich floristic diversity with 4,117 species of flowering plants (Hajra and Mudgal 1997). Apart from the rich diversity in flora and fauna it also exhibits high degree of endemism with about 220 endemic species (Anonymous 1999) and is comparatively endowed with diverse vegetation having rich gene pool of both wild and domesticated plants.

Sharma *et al*. (1984) documented 3,924 species, 1,323 genera from 199 families, based on herbarium specimens and secondary literature. Nayar and Sastry (1987 – 1990) made intensive study on threatened plants of India and have reported 814 such taxa. They considered about 10 % of flowering plants of the Indian territory are threatened. Based on the floristic studies it reveals that the Angiospermic flora of West Bengal state harbours about 3580 species under 1333 genera in 200 families (Chakraverty *et al.* 1999). Besides, the state supports 21 species of Gymnosperms, 416 species of Pteridophytes, 771 species of Bryophytes, 873 species of Algae, 539 species of Fungi and 329 species of Lichens. There are 37 rare and threatened taxa in the state (Chakraverty *et al*. 1999) and 19 taxa have been described from West Bengal, which are not collected after their type collection

(Sanjappa *et al*. 2012). There are about 850 species of medicinal plants in the state and about 1600 species are used by various tribal communities in the state (Chakraverty *et al*. 1999). Jain and Sastry (1980) were first to list 17 rare and endangered pteridophytes from India while Dixit (1983) and Datta (1983) listed 25 rare and interesting and 5 rare pteridophytes respectively. Nayar and Sastry (1987, 1988, 1990) included 31 threatened pteridophytes in the volumes of the Botanical Survey of India's *Red Data Book of Indian Plants*. Bhardwaj *et al.* (1987) enumerated 36 endangered species belonging to 21 genera of ferns and fern-allies from Rajasthan. Bir (1988) listed 49 endangered species. Chandra *et al.* (2008) evaluated the status of 400 threatened pteridophytic taxa of India.

1.4 STATUS OF WETLANDS IN INDIA

According to the Ministry of Environment and Forests, Govt. of India (MoEF 2009), the total wetland area in India is amounts to 4.7 million ha; of which 1.5 Mha are natural, 2.6 Mha are man-made and 0.6 Mha is the house of mangrove vegetation (MoEF 1990). The survey of the nationwide wetland inventory (Garg *et al*. 1998) reveals that there are 27,403 wetland units in the country occupying 7.6 Mha, of which coastal wetlands are constituted by 3959 units with an aerial extent of 4.0 Mha, whereas inland wetlands represent 23444 units with a total area of 3.6 Mha. Recently, National Wetland Inventory (2011) Assessment by the Space Application Centre, ISRO, Ahmedabad estimated 15.260 Mha wetland areas, which is around 4.63 % geographic area of the country. Of these Inland-Natural wetlands accounted for around 43.4 % of the total area, while Coastal – Natural wetlands account for 24.3 %. The major wetland types in inland category are river/stream, reservoir, tank/pond and lake/pond. In coastal wetland category major types are inter-tidal mudflat, lagoon, and creek. Among all the wetland types, river/stream is the major type, occupying an area of 5.26 Mha (34.46 %); reservoirs occupy 2.48 Mha (16.26 %), inter-tidal mudflats occupy 2.41 Mha (15.82 %), tanks/ponds occupy 1.31 Mha (8.6 %), and lakes/ponds occupy 0.71 Mha (4.78 %). Mangroves, Coral reefs, Beach and High altitude lakes (>3000 m elevation), though contribute very small percentage to total wetlands, are some of the unique wetland types of India. There are 178 Lagoons and 4703 high altitude lakes in the country. So far India has designated 26 wetland sites as Ramsar sites of international importance (ISRO, 2013).

According to a comprehensive study by the Salim Ali Centre for Ornithology and Natural History (SACON), India lost about 38 % of its wetlands during the 1990s; in some districts, the loss is as high as 88 %. The wetland loss in India can be *acute* and *chronic* losses. The filling up of wet areas with soil constitutes acute loss, whereas the gradual elimination of vegetation cover with subsequent erosion and sedimentation of the wetlands over many decades is termed as chronic loss. Wetland loss refers to physical loss in the spatial extent or loss in the wetland functions/services. The loss of one km^2 of wetlands in India will have much greater impacts than the loss of same of wetlands in low population countries with abundant wetlands. Restoration of these converted wetlands is quite difficult once these sites are occupied for non-wetland uses.

1.5 CONSERVATION OF FLORA

A network of 668 Protected Areas (PAs) has been established throughout India, extending over 1,61,221.57 sq km (i.e. 4.90 % of total geographic area), with 102 National Parks, 515 Wildlife Sanctuaries, 47 Conservation Reserves and 4 Community Reserves. The State/Union Territory wise details of PAs in the country with year of notification and area is given at Annexure – I. There are 39 Tiger Reserves (Annexure – II) and 28 Elephant Reserves (Annexure – III) designated so far for species specific management of tiger and elephant habitats. UNESCO (2005) has designated 5 Protected Areas as World Heritage Sites. The Convention on Biological Diversity's Programme of Work on Protected Areas, IUCN categorized the protected areas in major six classes:

(Ia) Strict Nature Reserve, (Ib) Wilderness Area, (II) National Park, (III) Natural Monument or Feature, (IV) Habitat/Species Management Area, (V) Protected Landscape/Seascape and (VI) Protected Area with Sustainable Use of Natural Resources (IUCN and UNEP-WCMC 2014).

1.5.1. Sanctuary is an area of adequate ecological, faunal, floral, geomorphological, natural or botanical or zoological significance. The Sanctuary is declared for the purpose of protecting, propagating or developing wildlife or its environment. Certain rights of people living inside the Sanctuary could be permitted.

1.5.2. National Park is an area having adequate ecological, faunal, floral, geomorphological, natural or zoological significance. The National Park is declared for the purpose of protecting, propagating or developing wildlife or its environment, like that of a Sanctuary but that must be naturally. The difference between a Sanctuary and a National Park mainly lies in the vesting of rights of people living inside. Unlike a Sanctuary, where certain rights can be allowed, in a National Park, no rights are allowed. No grazing of any livestock shall also be permitted inside a National Park while in a Sanctuary, the Chief Wildlife Warden may regulate, control or prohibit it. In addition, while any removal or exploitation of wildlife or forest produce from a Sanctuary requires the recommendation of the State Board for Wildlife, removal etc., from a National Park requires recommendation of the National Board for Wildlife (*However, as per orders of Hon'ble Supreme Court dated 9th May 2002 in Writ Petition (Civil) No. 337 of 1995, such removal/ exploitation from a Sanctuary also requires recommendation of the Standing Committee of National Board for Wildlife*).

1.5.3. Conservation Reserves can be declared by the State Governments in any area owned by the Government, particularly the areas adjacent to National Parks and Sanctuaries and those areas which link one Protected Area with another and behave like a corridor (Das *et al*. 2008). Such declaration should be made after having consultations with the local communities. Conservation Reserves are declared for the purpose of protecting landscapes, seascapes, flora and fauna and their habitat. The rights of people living inside a Conservation Reserve are not affected.

1.5.4. Community Reserves can be declared by the State Government in any private or community land, not comprised within a National Park, Sanctuary or a Conservation Reserve, where an individual or a community has volunteered to conserve wildlife and its habitat. Community Reserves are declared for the purpose of protecting fauna, flora and traditional or cultural practices and values. As in the case of a Conservation Reserve, the rights of people living inside a Community Reserve are not affected.

1.5.5. Regulations/ laws relating to Protected Areas (PAs): The PAs in India are constituted and governed under the provisions of the Wild Life (Protection) Act, 1972, which has been amended from time to time, with the changing ground realities concerning wildlife crime control and PAs management. Indian Forest Act, 1927, Forest (Conservation) Act, 1980, Environment (Protection) Act, 1986 and Biological Diversity Act, 2002 and the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 are quite strong and implemented strictly then the biodiversity conservation in India will remain best in the world. The Wildlife Crime Control Bureau of the Central Government supplements the efforts of provincial governments in wildlife crime control through enforcement of CITES and control of wildlife crimes having cross-border, interstate and international ramifications. India is a party to major international conventions viz. Convention on International Trade in Endangered Species of wild fauna and flora (CITES), International Union for Conservation of Nature (IUCN), International Convention for the Regulation of Whaling, UNESCO-World Heritage Committee and Convention on Migratory Species (CMS).

1.6 FLORISTIC STRUCTURE IN INDIA

So far 35 such hotspots has been recognized distributed round the world that includes Himalaya which covers an area extending from Afghanistan-Pakistan border to Arunachal Pradesh in India (Mittermeier *et al*. 2004; Holsinger 2005). Biodiversity Hotspots are defined as areas featuring exceptional concentrations of endemic species and experiencing exceptional loss of habitat (Myers *et al*. 1988).

India is one of the 17 mega-diversity countries as recognized by IUCN (The World Conservation Union). This is the recognition to the country's extremely rich and diverse Biodiversity. At the same

time, like most other Biodiversity rich countries of the World this natural gift cum resource is under tremendous pressure and innumerable species are now under intolerable threat against their survival (WCMC 1992; Chowdhury 2009). India is among the leading countries in terms of endemics. The determining criteria for a Hotspot is that an area must contain at least 0.5 % or 1,500 of the world's 300,000 plant species and 27,298 vertebrates (including mammals, birds, reptiles and amphibians) as endemics, and the remaining primary vegetation is less than 30 % of its extant area (Sala *et al*. 2000). Three mega centers of endemic plants in India are (i) Eastern Himalaya harboring 10,000 species of plants with 3500 endemic species; (ii) Western Ghats possessing 5800 plant species with about 2000 endemics; and (iii) Western Himalaya with 1195 endemic species of plants. The Andaman and Nicobar Islands harbor about 83 % endemic species (Mayer 1996). The vegetation and forest types in India have been analyzed by Champion and Seth (1968), National Remote Sensing Agency (NRSA) (Anonymous 1979), Forest Survey of India (FSI) (Anonymous 2003), and Indian Institute of Remote Sensing (IIRS 2003).

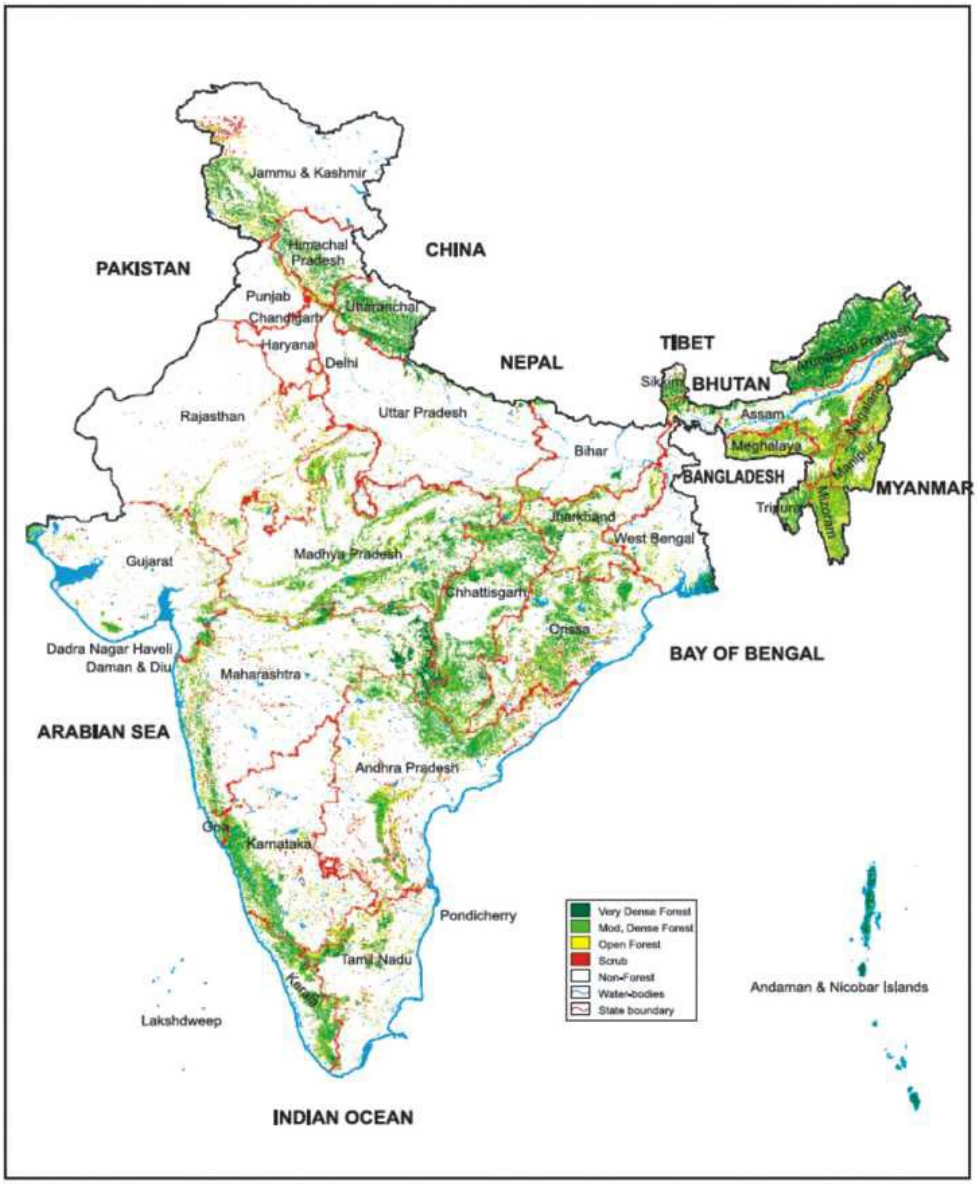

Fig.1.1: Vegetation map of India [after FSI 2003]

The FSI defines forest cover as 'all lands more than one hectare in area, with a tree canopy density of more than 10 %, irrespective of ownership and legal status'. For the present purpose, the terms 'forest area' and 'forest cover' (Fig.1.1) are used synonymously (SFR 1987).

Table 1.1: States wise forest cover in India (FSI 2007)

States/ UTs	Geographical areas (GA)	Forest Cover				Percent of GA	Change in forest cover	Scrub
		Very Dense Forest	Mod. Dense Forest	Open Forest	Total			
Andhra Pradesh	275,069	820	24,757	19,525	45,102	16.40	-129	10,372
Arunachal Pradesh	83,743	20,858	31,556	14,939	67,353	80.43	-119	111
Assam	78,438	1,461	11,558	14,673	27,692	35.30	-66	179
Bihar	94,163	231	3,248	3,325	6,804	7.23	-3	134
Chhattisgarh	135,191	4,162	35,038	16,670	55,870	41.33	-59	107
Delhi	1,483	7	50	120	177	11.94	0	1
Goa	3,702	511	624	1,016	2,151	58.10	-5	1
Gujrat	196,022	376	5,249	8,995	14,620	7.46	16	1,463
Haryana	44,212	27	463	1,104	1,594	3.61	-10	145
Himachal Pradesh	55,673	3,224	6,383	5,061	14,668	26.35	2	327
Jammu & Kashmir	222,236	4,298	8,977	9,411	22,686	10.21	-3	2,036
Jharkhand	79,714	2,590	9,899	10,405	22,894	28.72	172	683
Karnataka	191,791	1,777	20,181	14,232	36,190	18.87	-10	3,176
Kerala	38,863	1,443	9,410	6,471	17,324	44.58	40	58
Madhya Pradesh	308,245	6,647	35,007	36,046	77,700	25.21	-39	6,401
Maharashtra	307,713	8,739	20,834	21,077	50,650	16.46	-11	4,157
Manipur	22,327	701	5,474	11,105	17,280	77.40	328	1
Meghalaya	22,429	410	9,501	7,410	17,321	77.23	116	211
Mizoram	21,081	134	6,251	12,855	19,240	91.27	640	1
Nagaland	16,579	1,274	4,897	7,293	13,464	81.21	-201	2
Orissa	155,707	7,073	21,394	20,388	48,855	31.38	100	4,852
Punjab	50,362	0	733	931	1,664	3.30	4	20
Rajasthan	342,239	72	4,450	11,514	16,036	4.69	24	4,347
Sikkim	7,096	500	2,161	696	3,357	47.31	0	356
Tamil Nadu	130,058	2,926	10,216	10,196	23,338	17.94	24	1,206
Tripura	10,486	111	4,770	3,192	8,073	76.99	-100	75
Uttar Pradesh	240,928	1,626	4,563	8,152	14,341	5.95	-5	745
Uttarakhand	53,483	4,762	14,165	5,568	24,495	45.80	2	271
West Bengal	88,752	2,987	4,644	5,363	12,994	14.64	24	29
Andaman & Nicobar	8,249	3,762	2,405	495	6,662	80.76	-1	53
Chandigarh	114	1	10	6	17	14.91	0	1
Dadra & Nagar Haveli	491	0	114	97	211	42.97	-5	1
Daman & Diu	112	0	1	5	6	5.36	0	3
Lakshadweep	32	0	16	10	26	81.25	0	0
Pundicherry	480	0	13	31	44	9.17	2	0
Grand Total	**3,287,263**	**83,510**	**319,012**	**288,377**	**690,899**	**21.02**	**728**	**41,525**

India's forest cover in 2007 was 69.09 million ha which is 21.02 % of the geographical area (MoEF 2010). Of this, 8.35 million ha (2.54 %) is very dense forest, 31.90 million ha (9.71 %) is moderately dense forest, the rest 28.84 million ha (8.77 %) is open forest, and 0.46 million ha of mangrove vegetation. This data is excluding the 18.31 million ha of area situated above tree line and with this the forest cover of the country comes of 22.26 % (Table 1.1) (MoEF 2010).

In India there are many ecological studies on floristic and biodiversity. Ghate *et al.* (1997) assessed the plant diversity in Western Ghats, while Jhosi and Suresh (1997) carried out the diversity analysis in Nilgiri Biosphere Reserve. Adhikari *et al.* (1991) investigated the species composition and diversity in high altitude forests of Kumaon region (Western Himalaya). P. S. Ramakhrisnan and his associates (1980) (Singh and Mudgal, 1998; Saxena and Singh 1982) initiated ecological studies on the forests of Meghalaya in the 1980's.

Further studies on forest ecosystem of northeast India were carried out by Singh (1980), Khan *et al.* (1986, 1987), Barik *et al.*(1992), Rao (1992), Rao and Hajra (1986) and Rao *et al*. (1990). Barik *et al.* (1992) studied the species diversity in the sub-tropical forest of Meghalaya. Ganesh *et al.* (1996) studied plant diversity in mid-elevation evergreen forest of Western Ghats. Takhtajan (1969) considered northeast India as "*The cradle of ancient angiosperms*" due to the occurrence of large number of primitive and ancient flowering plant in the region.

Eastern Himalaya, including Sikkim, Darjeeling (of West Bengal) and Arunachal Pradesh is considered as a distinct phytogeographical region (Clarke 1885; Hooker 1907; Chatterjee 1940). Hooker (1904) commented, "The flora of British India is more varied than that of any other country of equal area in the Eastern hemisphere, if not in the globe". As such, being an integral part of the Eastern Himalaya and due to its immensely rich flora and fauna, this tiny Himalayan state of India is generally regarded as a "hotspot" of biodiversity. Its unique geographical position, varied topography, high annual precipitation, and maximum demographic pressure makes the area one of the richest botanical treasure house of the country (Singh and Chauhan 1998). Nearly 46 % of the total geographical area of the state is forest covered (FSI 2001).

Different groups of plants have invaded the region from numerous far and near localities and many of those, subsequently, have successfully been established in Eastern Himalaya (Das 2002). Today flora of the East Himalayan region is an admixture of taxa drawn from various countries. The great floristic diversity is largely attributed to its geographical and climatic factors that have helped not only the local flora to evolve but also plant species from surrounding places like China, Malaysia, Africa, Europe etc. to migrate and successfully established in the region (Brandis 1978; Das 1995, 2002; Bhujel and Das 2002; Moktan and Das 2013). A wide spectrum of climatic and ecological conditions within the region has supported plants of diverse floristic affinities to migrate, introduced and subsequently naturalized here.

Most importantly, orchid resources and its distribution is exceptionally distinct and deserves appreciations, as out of around 1200 species of the country (Misra 2007), it alone contributes for not less than 550 species (Lucksom 2008). Therefore, due to its sheer location and complex inter-relationship and species composition, Eastern Himalaya attracted a large number of researchers from different parts of the world. It arouses largely of interest among scientists and researchers (Rai *et al*. 1998).

1.7 FLORISTIC STRUCTURE OF WEST BENGAL

West Bengal is the only Indian state that is with marine-coast and mangroves (Sundarbans) in one side, semi-xeric hot habitat over a considerable area in the West, wide inland wetland vegetation, and then gradually extending to temperate and sub-alpine vegetation on high mountain Himalayan ranges reaching up to 3660 m AMSL on the northern extreme. This northern hilly part is the extension of the outer fringes of the Singalila Range of the Eastern Himalaya. The district of Darjeeling is forming such a Himalayan cap over the state of West Bengal. Major part of this district is hilly and the altitude ranges from 120 m to 3660 m in its different parts. This distribution of extreme ecological conditions within West Bengal helped it to support very wide range of vegetation structure supporting ever wider range of flora in its different corner. Terai and Duars region located at the feet of Darjeeling Hills is unique at it keeping close similarities with both, hill and pain-land vegetation and flora. West Bengal is classified in to five phyto-ecological zones (Anonymous 1997). These are:

(i) The Himalayan zone of Darjeeling

(ii) Sub-montane Terai region and the adjacent plains

(iii) Vast Alluvial plain on both sides of the Bhagirathi (Ganga) and its Northern and Western tributaries,

(iv) The Western dry flanks of Chotonagpur plateau, and

(v) Mangrove forests of Sundarbans.

Other than the broad outline, Gamble (1875), Malick (1966), Champion and Seth (1968), Naskar and Guha Bakshi (1987) classified the vegetation and forests of West Bengal on the basis of ecological and sociological structure of forests. There is large *Hijal* forest at the middle part of the state showing the continuation of riverine vegetation between the Rivers Mahananda and Kalindi and between Punarbhaba and Tangon up to Bihar (Anonymous 1997; Chowdhury 2009). Hooker (1904) described that apart from the Himalayan elements, West Bengal falls in to two provinces, *Bengal proper* and *Sundarbans*. Gamble (1875) considered "The forests of Darjeeling District .... more varied probably than those of any other district in India". In 1849 Hooker prepared an excellent narrative about the Himalayan vegetation in Darjeeling Himalaya. Depends on the floristic components, Gamble (1896) classified the vegetation of West Bengal in to eight classes. Those are –

i. *Acacia catechu – Dalbergia sisso forest of the Tropical Plains (Khair – Sissoo Forest)*

ii. *Savannah Forest in the Tropical Plains of Darjeeling (Shorea robusta* and *Dalbergia sissoo dominated),*

iii. *Mixed Plain Forest of the Tropical Plain (Shorea robusta dominated),*

iv. *Tropical Sal Forest of the plains of Darjeeling*

v. *Tropical lower Hill Forests of Darjeeling and their vegetational composition*

vi. *Subtropical Middle Hill Forests of Darjeeling and their composition*

vii. *Temperate Upper Hill Forest and vegetation of Darjeeling District,* and

viii. *The Conifer – Rhododendron Forests.*

1.8 FLORISTIC STRUCTURE OF DUARS

Out of its total geographical area of the state, 13.38 % comes under the recorded forest category compared to the national figure of 23.38 %. Of the total forest area of West Bengal, 59.38 %, 31.75 % and 8.87 % are categorised under reserved, protected and un-classed forests respectively. Furthermore, protected areas comprise 3.26 % of its geographical area consisting of 15 Wildlife Sanctuaries and 5 National Parks (Manoj 2013). Jalpaiguri has more recorded forest area (1,790 sq km) than Darjeeling (1,204 sq km) in terms of their respective geographical areas (Table 1.2). The district of Darjeeling is more forested (38.23 %) as compared to Jalpaiguri (28.75 %). More distinctively the data show that although Jalpaiguri is almost double the size of Darjeeling it lags behind the former by about 10 percentage points in terms of recorded forests. More disturbing scenario is observed for the Cooch Behar district, which is almost similar in size to Darjeeling but lags way behind in terms of the area under forest cover.

Table 1.2: Current status of forest areas in three districts of northern West Bengal (State Forest Report 2010 – 2011)

Forest Areas	3 Districts of North Bengal			West Bengal	India
	Jalpaiguri	Darjeeling	Coochbehar		
Geographical Area	6227	3149	3387	88752	3287240
Reserve forests	1483	1115	-	7054	423311
Protected Forests	217	-	42	3772	217245
Unclassified state forests and others	90	89	15	1053	127881
Total recorded forests areas	1790	1204	57	11879	768437
Recorded forest area in %	28.75	38.23	1.68	13.38	23.38

The Northern part of the state of West Bengal, covering six Districts located north of the River Ganga, is popularly referred as 'North Bengal'. State's major Biodiversity rich regions are located here and these include Terai, Duars and the Hills of Darjeeling. And, most of the protected areas of the state are located in these three areas. These include *Neora Valley National Park, Singalila National Park, Gorumara National Park, Mahananda Wildlife Sanctuary, Senchal Wildlife Sanctuary, Jaldapara National Park, Chapramari Wildlife Sanctuary*, *Buxa Tiger Reserve*, etc (Rodgers *et al.* 2000).

Out of the five vegetation zones (Anonymous 1997), the forest types and its floristic composition are most diverse and richest in Darjeeling Hills. This includes also the plain areas of the district that being greatly influenced by the Himalayan elements (Anonymous 1997). Mukherjee (1965) mentioned that the fascinating orchid flora of the Duars region also attracted his attention and then he worked out the fern flora of Jalpaiguri District. In 1984, Sikdar give a picture on floristic elements of Baikunthapur forest division of Jalpaiguri district and based on these elements, he described five forests types for the region –

i. *Semi-evergreen forest*

ii. *Moist deciduous forest*

iii. *Dry deciduous forests*

iv. *Sal forest* and

v. *Grasslands.*

Gorumara National Park is located in Duars and is falling within the territory of Jalpaiguri District of West Bengal. The entire forest tract of Gorumara National Park comes under the North Indian moist tropical forest of Champion and Seth's (1968) classification. The species which is commonly found within the forest and is most important from the economic and ecological stand points is *Shorea robusta.* This species occurs here with its usual associates like *Schima wallichii, Chukrasia tabularis, Magnolia champaca*, and *Terminalia bellirica*. The other important species which are also commonly seen in this park includes *Lagerstroemia parviflora, Terminalia myriocarpa, Duabanga grandiflora, Amoora wallichii, Aglaia wallichii, Bischofia javanica, Bombax ceiba, Acacia catechu, Dalbergia sisso, Albizia spp.,* etc.

Though this is a comparatively smaller park (7945.28 hectare) but its location is very critical and is forming a part of the chain of protected areas of different types in this region. It is connected to other protected areas like *Chapramari Wildlife Sanctuary* and *Jaldapara National Park* in Duars. Not only the plant diversity of the area is very rich but also the animal diversity is also unique and important. The gem animals in the park include Indian one-horned Rhino, Elephant, India Bison, Royal Bengal Tiger, Leopard, etc.

1.9 PREVIOUS FLORISTIC WORKS

The green diversity of Darjeeling Hills, Terai and Duars has attracted a large number of researchers and plant collectors from different parts of the world at least for the last three centuries (Don 1823, 1825; Das 1995, 2004). Soon after, the famous naturalist Griffith also explored Terai green belt in 1847. The famous botanist Sir J.D. Hooker made his visit to this area sometime during 1848 – '49 (Hooker 1849, 1904). Immediately after J.D. Hooker, no other botanist took up intensive floristic study of the Duars region. He explored the entire region and made a historic collection of approximately 2500 specimen of plants. His expedition and the account published by him include the *Flora of British India* (Hooker 1854, 1872 - 1897, 1904) is still one of the most comprehensive descriptions of botanical splendors for this region.

Significantly, botanists from different other parts of the world has latter made considerable contributions to the flora of Terai and Doors region of Jalpaiguri. They include Cowan and Cowan (1929), Ohashi (1975), Grierson and Long (1979, 1983 – 1991, 1999 – 2001, 1994 - 2000).

Champion and Seth (1968) also surveyed this region. Mukherjee (1965) prepared a sketch of

the vegetation of Jalpaiguri District. Sikdar (1984) worked on Baikunthapur Forest division, Banerjee (1993), Pandit (1996), Pandit *et al*. (2004) and Das *et al*. (2003) worked on the Jaldapara Wildlife Sanctuary (now Jaldapara National Park), and Biswas *et al*. (2012) published a detailed Dicotyledonous flora of Gossain Hat Beel. Wetlands of India was explored by Biswas and Calder (1937), Subramanyam (1962), Deb (1976), Cook (1996) and Fassett (2000). Pal *et al.* (2010) and Das (2013) worked on wetland of Assam. For Wetlands and their conservation, wetland macrophytes etc. of India are also reviewed by IUCN (1971), Gopal (1973), Wells (1992), WWF India (1993) and Williams (1997). Bandyopadhyay *et al.* (2005) listed aquatic and wetland vascular plants of Cooch Behar district. But, a detail study on Rasik Beel area was not done previously. Saha *et al*. (2013) worked on the medicinal plants of Gorumara National Park. Das *et al*. (2010) prepare a detail sketch of three MPCAs of Terai and Duars. These selected publications, on the other hand, showed the attractiveness of the plant diversity of this region. At the same time it is also clear that none of these works is complete and much more intensive explorations are essential for proper documentation from different aspects. Chowdhury (2009), explore the wetland vegetation of Malda district; Ghosh (2006), Sarkar (2011), Biswas (2015), Chowdhury (2015), Choudhury (2015) has explore the forest and wetland flora of Northern four district of West Bengal. Terai and Duars of Sub-Himalayan West Bengal are falling under 'Himalaya' Biodiversity Hotspot (Conservational International, 2005). The study area is harbouring a large number of floral species (Choudhuri, 1969; Das, 1995, 2004; Das and Chanda, 1987; Rai, 2001) in its wide range of habitat providing ample opportunity for ecological diversity (Champion and Seth 1968; Kadir 2001; Ghosh 2007; Sarkar 2011). High degree of endemism is the characteristic of its vegetation (Bhujel and Das 2002). But, continuous physical threats in very drastic manner, forced the indigenous floras to their extinction is imminent for the region (Das 1995, 2004; Bhujel and Das 2002). Sub-Himalayan wetlands are extending from Darjeeling to East bank of the River Ganga. The Terai and Duars region of West Bengal, Koch Behar district and low floodplains, lakes, streams, beels, seasonal waterlogged areas etc. (IWMED 1997) biodiversity rich areas. Highly favourable tropical to temperate climatic conditions, coupled with heavy rainfall, made these areas to support a large number of seasonal wetlands, covering wide areas, which are inhabited by diverse wet-loving aquatic or semi-aquatic plants. Innumerable anthropological activities like rapid expansion of civilization, construction of road, rail, increase of automobiles, implementation of mega-projects, population explosion, tourism related exploitation, rapid extension of crop field etc. are very rapidly converting these areas into fragmented wetlands and finally leading to the extinction of numerous wetlands. Random collection of wide array of useful plants, excessive agricultural activities, urbanization, pollution, filling for settlement areas and excessive tourism are causing the destruction of fertile and virgin wetlands. The rate and amount of exploitation of wetland areas are much above the sustainability limit (Sarkar 2014). Floristic survey of plant community provides information for analysing the diversity dynamics and structures of the vegetation. Wetland plants quickly respond to changes in water quality and have been used as bio-indicator for pollution (Tripathi and Shukla 1991).