

Flora of India
Series - 2

FLORA OF WEST BENGAL

Volume I

RANUNCULACEAE TO MORINGACEAE



BOTANICAL SURVEY OF INDIA



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BOTANICAL SURVEY OF INDIA

O Government of India

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FOREWORD

Botanical Survey of India has launched a programme to publish the accounts of plants under different series like a) National Flora, b) State Flora, c) District Flora, d) Flora of Fragile Ecosystem. e) Flora of Biosphere Reserve and National Park etc.

So far 6 volumes of National Flora out of planned 32 volumes, State Floras of Rajasthan; Tamil Nadu; Karnataka; Himachal Pradesh; Madhya Pradesh; Goa, Diu, Daman, Dadra & Nagarhaveli; Maharashtra, Arunachal Pradesh, Sikkim etc. and several district floras have been published. The State Flora of West Bengal is unique as it covers different altitudinal regions from sea-coast to alpine Himalayas. Since the establishment of Botanical Survey of India in 1890 at Calcutta

In the Presidency of Bengal, the Flora of the State attracted the attention of many Botanists and state was fairly well explored. Based on all available collections at Calcutta Herbarium, surveys and field explorations, Dr. David Prain published the Flora of erstwhile Bengal as Bengal Plants in 1903. This flora in addition to West Bengal included parts of Bihar, Orissa and Bangladesh but excluded Darjeeling Himalayas. Despite fairly thorough survey of plant wealth of this state of West Bengal with changed political boundaries, no modern flora is available, except for a few district floras. The Botanical Survey of India realised the need for publication of the State Flora and the First Volume of Flora of West Bengal State is the outcome of sincere efforts of all Scientists of Botanical Survey of India.

It gives me a great pleasure to thank all the contributors and authors of different chapters and families in the volume.

I like to thank Sri Utpal Chatterjee, Samran Roy and other staff members in Publication Unit of Botanical Survey of India without whose sincere efforts it would not have been possible to publish this Flora. I am sure this long awaited publication will cater to the needs of all those who are interested in knowing the plants of the State.

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Dillenia indica L.



Michelja cathcartli Hook. f. & Thorns.



Stephania Japonica (%unb.) Miers var. *discolor* (Bl.) Forman



Mahonia acanthifolia G. Don



Nelumbo nucifera Gaertn.



Argemone mexicana L.



Crateva religiosa Forst. f.



Cochlospermum religiosum (L.) Aston.



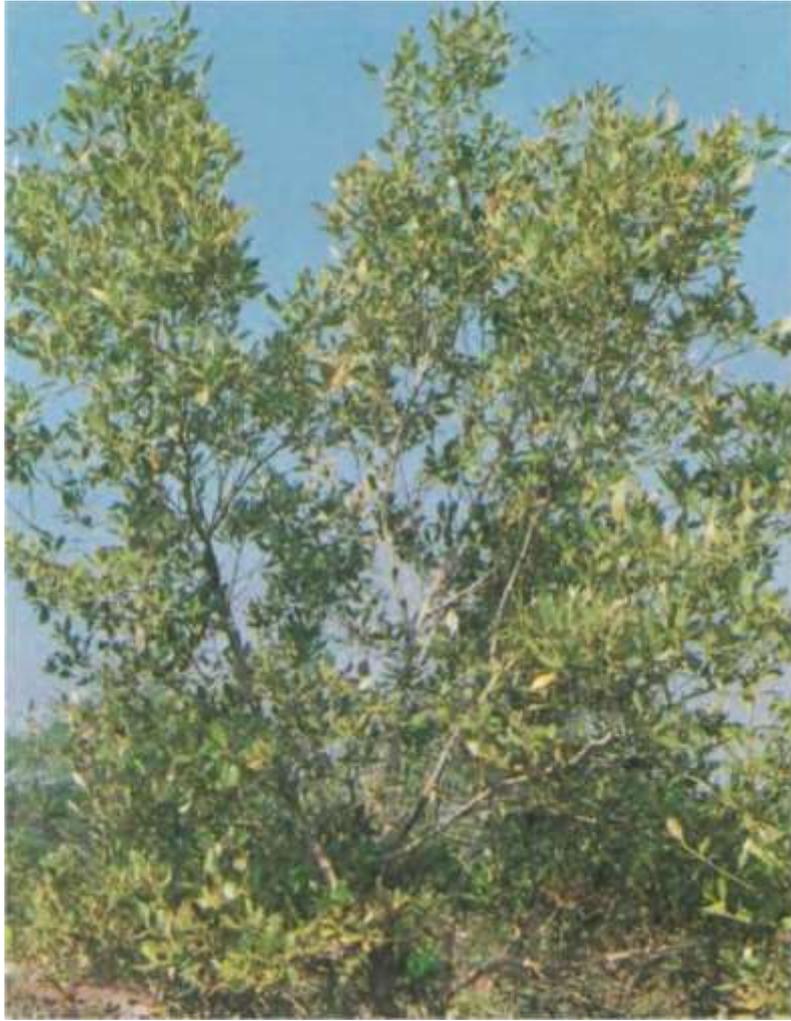
Polygala arallata Buch.-Ham. ex D Don



Sida acuta Burm. f.



Abroma augusta (L) L. f.



Hentlera fomes Buch.-Ham.



Elaeocarpus serratus L.



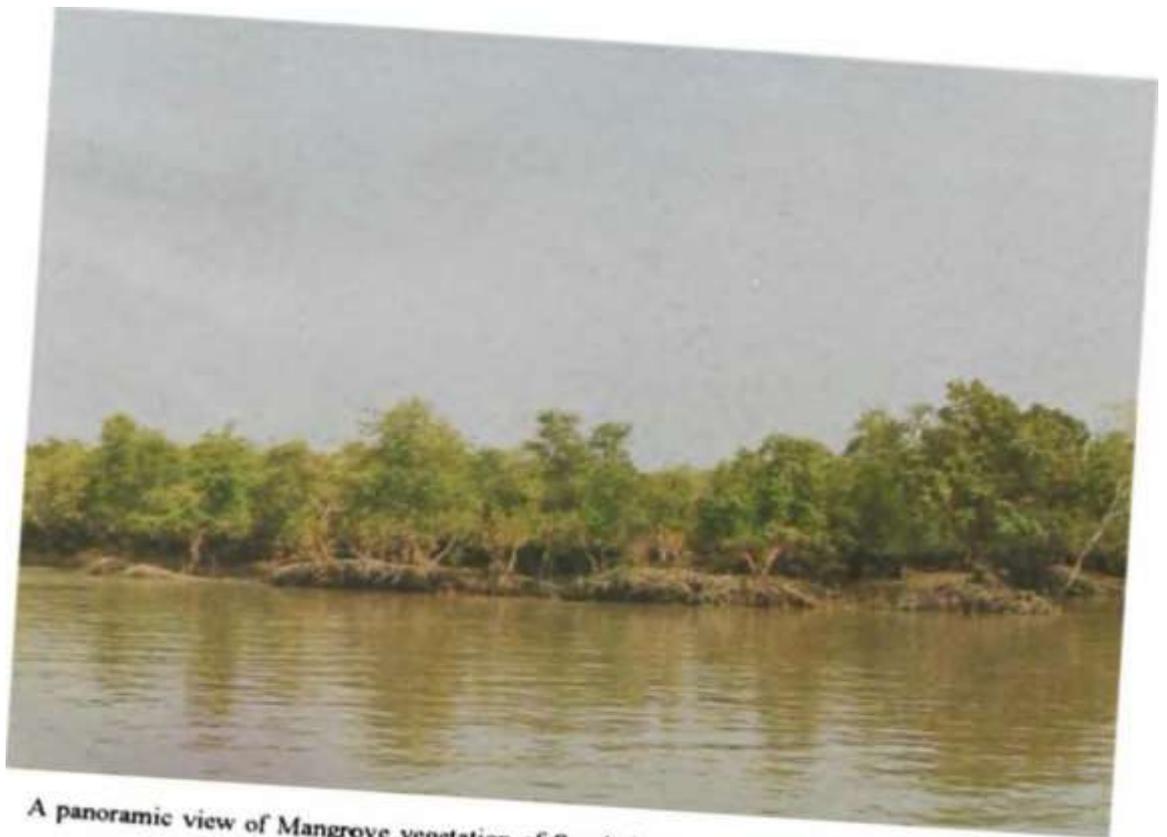
Oxalis martiana Zucc.



Averrhoa carambola L.



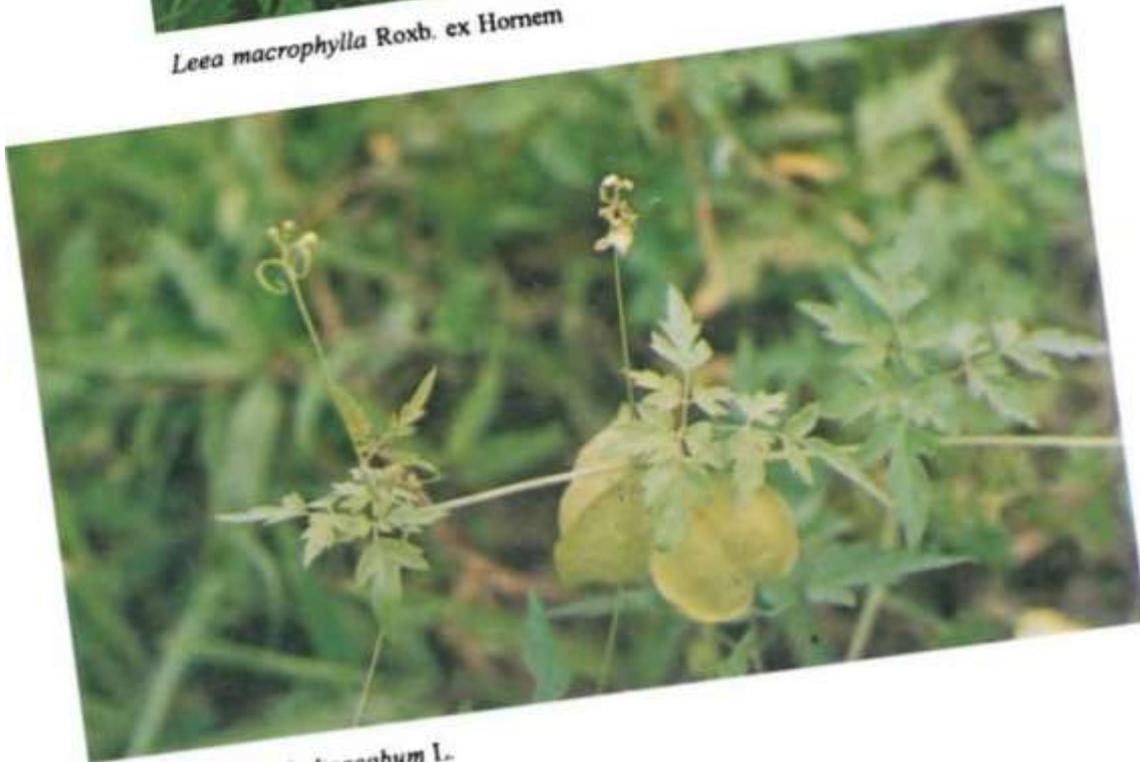
Anacardium occidentale L.



A panoramic view of Mangrove vegetation of Sundarbans



Leea macrophylla Roxb. ex Hornem



Cardiospermum L.

Cardiospermum hal, cacabum

INTRODUCTION

(U.C. Bhattacharyya)

Stretching between the high Himalayan territory in the northern limit and the Bay or Bengal In the south. the present political boundary of the state of West Bengal enjoys a unique landmark from floristic point of view. It is the only state in India which for its geographical location is endowed with a flora ranging right from the 'most impressive littoral forest of the Sundarbans to the luxuriant forests of the Himalayan foothills and the vegetation upwards culminating to the temperate and alpine zone in the district of Darjeeling. Excepting the spurs of western hilly tract of the bordering states of Bihar and Orissa, the major landmass of West Bengal can be divided into two natural geographical divisions viz.. the Northern Himalayan and the Plains Divisions. The latter, as a part of the massive Gangetic delta. extends from West Dinajpur in the north to the intricate deltaic system of creeks of the South 24-Parganas (Randhwa, Mitra and Mehta, 1964). The main features of vegetation of this plain. though broadly outlined by Prain (1903a) under various profiles. have been specified under four botanical divisions (Basak & Guha Bakshi, 1977) : (1) West Bengal Proper lying between the river Bhagirathi-Hooghly and the Chhotonagpur Plateau. (2) A part of the North Bengal covering the land north of Bhagirathi. (3) The strip of land lying east of Bhagirathi and (4) The western part of Sundarbans mainly occupied by the district of South 24-Parganas. The mountainous district of Darjeeling excluding the Siliguri sub-division being wholly Himalayan. the flora of this district is exceptionally different from the rest of the areas of West Bengal Plains. In order to reduce the volume of the Flora, Prain (l.c.) had purposefully omitted the plants of the Darjeeling district and proposed a separate account for it. Though collections have been gathered and sufficient information is available about the rich flora of this hilly district (Hooker. 1848, 1849. 1850; Clarke, 1876, 1885; Gamble, 1878, 1896; Biswas, 1966; Mathew, 1966, 1969, 1971; Hara, 1966, 1971, 1975; Yonzon, 1984; Das & Chandra. 1987) yet a complete workable Flora is still wanting. Considering the various aspects of socio-economic development in different parts of the state together with the prospect of rational exploitation of natural resources. inclusion of Himalayan Flora has been thought essential to prepare an updated Flora of West Bengal. Keeping

these aspects in view, plants of Darjeeling have also been included in preparing this State Flora.

Revision of Floras for all practical purposes is not only a responsibility of the botanists but also it is an obligation to the nation for utilization, development and conservation of the natural plant resources. Particularly a state like West Bengal after independence has been subjected to so much population pressure

by massive influx of uprooted migrants from Bangladesh that the very land use pattern is drastically changing. Botanical diversities associated with pre-existing forests, vast natural water bodies and natural vegetational tracts are being gulped by developmental programmes. More than thirty percent of the luxuriant forests of Sundarbans have been depleted due to human habitation and cultivation during the last two centuries and (reeds of Sundri (*Heritiera Ininor*) which dominated as a major forest component for coining the name of the forest are remaining only in small localized pockets (Naskar and Guha Bakshi, 1987). Industrial developments in the western part have also destroyed considerable forested areas where *Shorea robusta* had flourished and exotic trees of commercial forestry have replaced much of the natural forests in the northern hilly tracts. Biotic interference followed by partition of the erstwhile Bengal has been so drastic that not only the area of the state has been reduced to less than one third but also some of the fascinating areas with unique floristic composition

as given in the account of the Prain's (*l.c.*) Bengal Plants do not exist in the U 1 present West Bengal. However, for the purpose of first hand information Prain's contribution had been the only comprehensive account of vascular plants of the plains of West Bengal, including that of Sundarbans, during the first half of the present century. Though most of the plants of lower Gangetic plains had been meticulously included in his Flora yet the absence of highly interesting flora of the northern Himalayan section makes the provincial flora incomplete in accounting the total plant wealth of the state. Incorporation of the plants of Darjeeling district and providing precise descriptive account of individual species with their suitable identification keys have been a major step in preparation of the present Flora of West Bengal. Further, from utilitarian point of view, some other important and related aspects of botany have also been included in the present approach.

During the second half of the century the wealth of botanical information on West Bengal has accumulated to a remarkable extent due to active participation of a highly interested group of workers, and their contributions will be dealt with elsewhere. On account of extensive and intensive explorations not only a number of new species have been added to the existing flora but also the records of additional findings have accumulated a voluminous amount of material (Basak, 1973) for incorporation in an updated Flora of the state.

1.1 POSITION AND GEOGRAPHY

Overlooked by the magnificent Himalayan Peak of Kanchen Jungha in the northern extremity and washed by the waves of the rolling ocean in the south, the small state of West Bengal lies between 21°45' and 27°16' North latitude and 85°55' and 89°56' East longitude. Following independence of India in 1947 the state came into existence as the western part of the erstwhile Bengal and

area of the state was reduced to c. 87,676 sq. km or about one third of the prepartitioned Bengal. Partition by arbitrary demarcation rendered the state almost isolated from the northern three districts viz. Darjeeling, Jalpaiguri and Cooch Behar excepting a narrow corridor through West Dinajpur.

At present the state on the north is bounded by Sikkim and Bhutan, on the east by Assam and Bangladesh, the Bay of Bengal forms the southern boundary and on the west it is bounded by Orissa, Bihar and Nepal. The hilly district Purulia which belonged to Manbhum district of Bihar. became a part of West Bengal during the reorganisation of the states in 1955. A thin strip of Bihar was also included to the narrow corridor of West Dinajpur for facilitating better communication and management of border area.

Till the end of the seventies the state had 16 administrative districts grouped under three divisions. The districts Bankura, Birbhum, Burdwan, Hooghly, Midnapore came under Burdwan Division, whereas Calcutta, Howrah, Murshidabad, Nadia and 24-Parganas remained in the Presidency Division and Cooch Behar, Darjeeling, Jalpaiguri, West Dinajpur and Malda were kept under Jalpaiguri Division. In order to facilitate administrative control the district 24-Parganas with high density of population and having an international boundary with Bangladesh has been divided into two more districts as North and South 24-Parganas during recent years and in 1992 West Dinajpur has been further divided into South and North with their respective Hqs. at Balurghat and Raiganj. Due to a steady increase of density of population with more than 400/sq. km the state is under a severe threat of land use pattern and eventually the land and water bodies supporting natural vegetation are being brought under human habitation and related activities. It is, therefore, obvious that due to such intense biotic factors a good deal of natural habitats for plants are getting extinct.

1.2 GEOLOGY AND SOIL

1.2.1 Geology : Excepting the Himalayan sector of Darjeeling district and spurs of the mountains penetrating to the south and the marginal areas of the Western boundary, the major landmass of West Bengal plain is principally a thick alluvium deposition forming almost a trough along the Bhagirathi basin (Basak and Guha Bakshi, 1977). The plain, 40-80 km wide along the course of the Bhagirathi, is solely of alluvial origin with varying depth and is supposed to be not more than 400 m deep (Chatterjee, 1965). Hooker (1854) and Theobald (1881) are of the opinion that the present West Bengal plain was originally an **estuary**, which after receiving **the drainage** from the young folded mountains in the north got filled up in the post Tertiary period. Deep drilling in the Bengal basin has recently substantiated the

continuity of the complete tertiary flora of Rajmahal formations from Bihar to Assam below the massive alluvial deposition in the Central West Bengal. According to Oldham (1893) the development of this plain particularly the deltaic region is supposed to be a product of fluvial action and the platform for this action was initiated through the tectonic activities associated with the early tertiary epoch, giving rise to the formation of the Trans Eurasian lofty mountain chains. The rise of the Himalayas due to upheaval or Tethys created a trough on to its south while the movement of the Arakan-Yama-Andaman-Sumatra has helped in the formation of the Bay of Bengal (Singh, 1971). Under the two tensional forces i.e. one from the Sindhu-Ganga trough in the north and the downrapping of the Bay of Bengal in the south the pre-existing narrow neck of the Peninsular landmass had a rupture resulting in the formation of the Ruimahal Gap, through which the flow of the northern rivers found a drainage into the Bay of Bengal. Thus the huge silt of the original run off and subsequent erosion of the Himalayas by the rivers in the north had been responsible for contributing to the major landmass of the state. The recent Pleistocene alluvial deposition in the deltaic West Bengal and the absence of older alluvium in the strata of the plain is a significant proof in support of its origin through drainage. Whereas white lateritic deposition is remarkably extensive on the northern plains derived from the older basin. This accidental tectonic movement considerably influenced the riverine action of the tributaries flowing from the Himalayas and physical landscape also got very much re-oriented owing to the instability introduced in the river flow system. Due to such significant geological events there were also considerable disturbances in the isostatic equilibrium on the earth surface that affected the topography due to repeated subsidences, alluviations and diversion of rivers responsible for reshaping the deltaic region to its present state. Further, the presence of well developed beds with correct roots of *Heritiera* and massive peats occurring at about 6-11 m, and 15() m below the sea level is a clear indication and evidence of regular subsidence of the deltaic region (Singh, l.c.).

The western marginal land of the state on the other hand is variously rocky and covered by laterites and Gondwana formation, the latter, however, is prominently exposed in the Raniganj area of the Damodar Basin in Burdwan district. Other western districts of Birbhum, Bankura, Burdwan and West Midnapur covering the States of Bihar and Orissa also show the geological formation along with Gondwana system. These areas are projected from the western table land and got intermingled or replaced by lateritic or alluvium towards the eastern basin. The archaic rocks in those areas consist mainly of gneiss, and crystalline schist. However, the relative proportion of gneiss is considerably high in such rock formation. The rock, principally belonging to Bengal Gneiss is remarkable for its varied composition, consisting of successive bands of intermixed granite, granitic and dioritic gneisses and micaceous chloritic, hornblende schists with aluminated or foliated granitic intrusions. Stray distribution of conical hills are not uncommon in some of the bordering districts which are mainly composed of porphyritic or dome gneiss.

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1.2.2 Soil : The soil of the plains of West Bengal have been studied and described in details by different workers. In a number of district Floras and floristic accounts (Basak and Guha Bakshi, 1977) published in recent years. information about soil at micro level have been enriched our knowledge. In order to differentiate the main recognizable soil types of the overall area of the state. Singh (1971) has grouped them under (i) Alluvial soil, (ii) Laterite. (iii) Red earth, (iv) Terai soil and (v) Tidal soil. The nature and quality of the soil of West Bengal have been studied in detail by Chatterjee and Chatterjee (1957) where as stress on the general character of the soil of the state has been given while dealing with the distribution of forest types in the state by Champion and Seth (1968). General soil types of the state have also been outlined by Basak and Guha Bakshi (l.c.) while reviewing the floristic studies of West Bengal.

Among all the soil types described by various workers the Ganga alluvium covering the largest area of the plain of West Bengal (28,921.3 sq. km.) is considered most important. The major deltaic landmass of West Bengal is composed of this soil which originated mainly due to the activities of the river Ganga and its tributaries from late geological history. The soil of this kind is remarkably fertile due to richness in mineral contents and organic matter and have been found to be most suitable for agricultural purposes. This soil being alkaline in nature (pH 7.0-6.9) has also facilitated cultivation of various kinds of crops and fruit trees. Depending upon the source of alluvium origin the quality of the soil also varies considerably. Soils in the narrow alluvial strip bordering the laterite and red soil beds in parts of Murshidabad, Bankura, Burdwan, Hooghly and Midnapur are very much different in texture and quality. The bulk of this soil type constitutes the riverine tract of the Damodar and the Kansai river and their tributaries bringing silt from the western plateau and laterite deposits. Such soil profiles are characterized by alternating sand beds and irregular stratification.

The other important type of soil is represented by laterite which occupy an area next to alluvium. Lateritic soils are poor in water holding capacity and are mainly spread along the undulating stretches of well drained land of the western districts bordering the Chholanagpur Plateau and also in some of the areas in northern part of the state. Rocky lattices in this region holding such soils are rather acidic in nature and devoid of organic matters. This kind of soil with scanty water content supports a low grade Sal forest and other sparse deciduous types of forests. These soil beds are gradually thicker towards east.

The kind of soil transported from the laterites towards the eastern flanks of the districts under Burdwan Division, excluding Howrah and Hooghly, are known as Red Earth or Red Soil and are physically nothing but laterite alluvium. Considerable area under Rarh Plain and the Barind tract of Maida and West Dinajpur has such deposition of Red Earth. Such soil beds are sometimes mixed with lime or shallow depths and often mixed with morum and feldspar. These areas

after deforestation are now converted to cultivated lands which on the other hand has considerably accelerated the process of soil erosion.

The soils of nonspecific composition deposited at the foothills of Darjeeling Himalaya particularly in Siliguri tahsil and Jalpaiguri district are classified as Terai Soil. This kind of soil is acidic in nature and poor in plant nutrients and organic matter.

The coastal soils in the state are restricted in the districts of Midnapur, South 24-Parganas and in some parts of Howrah. The whole or Sundarbans soil in 24-Parganas come under this type of soil. The origin of this kind of soil is primarily due to interaction of the rivers and tides. These are saline and markedly alkaline and contain rich deposits of Ca and Mg along with semi-decomposed organic matters. The true saline soils are considered as physiologically dry and marks the true habitat of halophytes or mangroves. The Coastal soils with increasing distance from the tidal action is also considerably changed in its character. Consequently the character of the halophytes is also changed.

1.3 PHYSICAL FEATURES AND DRAINAGE

Major land area of West Bengal is a flat alluvial plain and its central and southern regions are solely derived from the silt depositions of the Ganga. The state has gradual slope from the north to the south and also from the western side to the east. The lowest height of the western boundary is marked by the point of entry of the river Ganga after rounding (the Rajmahal hills between Murshidabad and Malda districts of the main flow after bifurcating near Dhulian in Murshidabad, one turns to the south as Bhagirathi and the other flows to Bangladesh. The Bhagirathi, after bifurcating (the two main divisions viz. Burdwan and Presidency divisions of West Bengal, finally confluences at Bay of Bengal under the name Hooghly. The origin of the plain along the course of the Bhagirathi is associated with a long history of geological events and have been variously interpreted (Spatc, 1957 ; Ahmed, 1959). The lowland lying in the south of Midnapur and stretching towards west of the river Bhagirathi-Hooghly though not a part of the delta proper is also flat (Chatterjee, l.c.) with a gentle elevation towards the west. The major part of the plain covering the lower Ganga plain in West Bengal can be broadly divided under (i) The northern part of the delta of the Ganga and the Barind tract in West Dinajpur and Malda districts. (ii) The western part of the state consisting mainly of laterite plain and of Red earth (the Rarh areas) and the Coastal strip of the land. The latter along the sea coast is characterized by frequent sand dunes and salt marshes mingled with each other (Ghosh, 1976). The marshes are formed behind well developed sand bars; shifting sand dunes of great dimensions have a tendency to blow landwards with high velocity wind and encroach upon the lands under cultivation. It is not uncommon also to witness the coastline being eroded by the action of sea waves. (iii) The even and extensive plain of the proper Ganga delta having a span of 40-80 km on both sides of the river

Bhagirathi is further subdivided into Meribund area of Murshidabad, Nadia, Hooghly and Howrah. The plains in the northern half of 24-Parganas and Howrah marks the formation of Matured delta and active sections constitute the South Sunderbans and new islands amidst the creeks. Great thickness of alluvium in most of the plain districts of West Bengal has also been mentioned by others (Randhawa, Mitra and Mehta. l.c.).

The physical feature of the western part of Rarh Plain in the districts of IVI Midnapore, DanKura, DUI U Wan anu an luna UUUUJ"LVU1 rock terrain of Archaean Gneiss and other metamorphic rocks as well as coal belts of Gondwana specially in Burdwan district. Laterite soil together with red alluvium and gravels get interspersed due to penetration of the spurs of the Ohhc,tnnnvnr Platen') and low hillv areas bring a marked change of the topographical view in the districts of Purulia and Bankura. Laterite fringe and laterite debris are also noticed at the Goghat Thana of Hooghly district (Basak and Guha Bakshi, 1977).

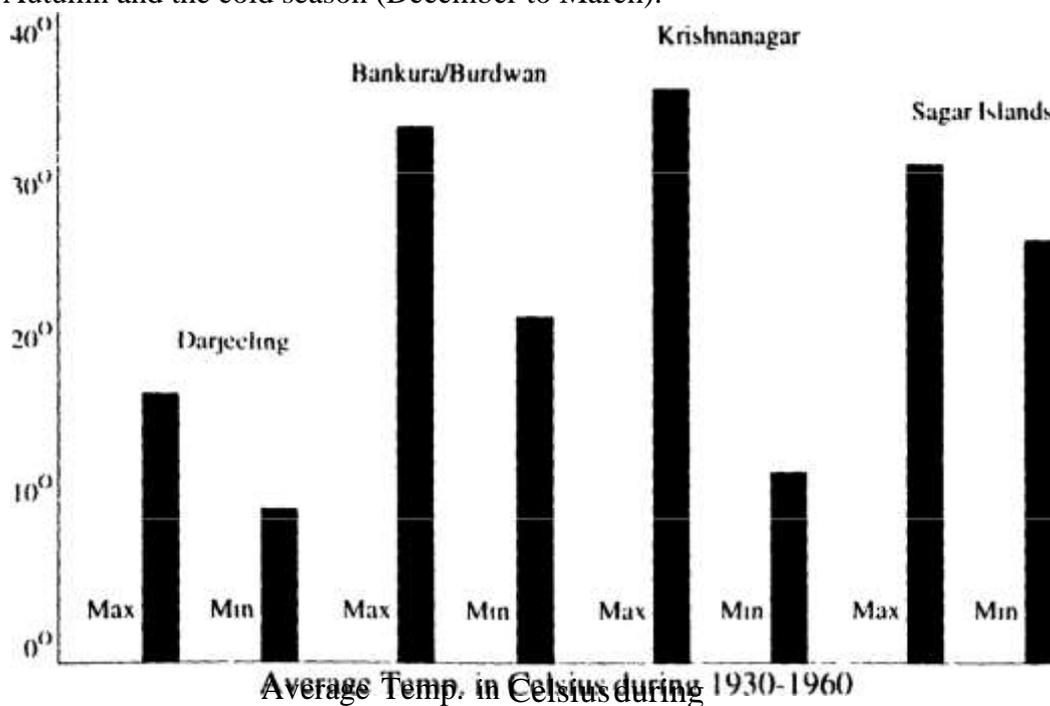
The northern extremity of the state terminates in the district Darjeeling where excepting the Siliguri sub-division being plain the rest of the area is covered by the extension of the high Singalila range of the Himalaya from the Nepal side. The plains of Siliguri with a gradual elevation towards north gives rise to the low thickly forested mountains of the outer range and gradually higher mountains rise up to 39(Y) m where almost alpine conditions prevail in Sandakphoo & Phaloot. Among the four subdivisions of the district Darjeeling has the highest altitude from 1800 - 3900 m where as Kurseong and Kalimpong are within 1000 m to m.

The entire land area to the west of the Bhagirathi being gradually elevated towards west all the rivers in Burdwan divisions have a course of their flow from west to east or south-east, whereas all the rivers east of the Bhagirathi flow north to south with a minor slant towards the east except the Jalangi and Churni in Nadia which have their flow westwards into the Bhagirathi Basin. The western region of the state is marked by the coalesced fans of seasonal flashy torrent tributaries of the Ajay, Damodar, Mayurakshi, Kangsabati, Rupnarayan, Anandpur and Haldi, all of which fall to a dead delta zone along the Hooghly river bank (Singh, l.c. and Basak & Guha Bakshi, l.c.). The physiography of the changing rivers like the Ganga, Damodar and others, explains the mode of formation of the surface or the plain in the southern part of West Bengal (Sen, 1968). The rivers in the north of the state have their origin from the Himalayas which after flowing through a short distance within the districts north of Bhagirathi-Padma enter Bangladesh. The Teesta, Jaldhaka, Mahananda, Nagar, Torsa, Atrai, Punarbhaba are some of the notable rivers which drain out massive water during rainy season from their catchment in

the Himalayas causing devastating floods in Jalpaiguri, Cooch Bchar, Malda and West Dinajpur districts. Many dry with boulders, pebbles and sand is a common feature in the northern part carrying thin flow of water in dry summer and which come into spate during monsoon. Indication of the remnants of old river beds is not uncommon in some of the districts of central West Bengal which form long stretches of marshes and small lakes. These are commonly known as Jheels and Bils and most of them are gradually utilized for temporary seasonal cultivation. Distributaries of the old river system occurring in the district of South 24-Parganas have converted the famous part of Sunderbans into an intricate network of tidal water system towards the sea. However, the salinity in the river here is reduced by freshwater after constructing a barrage at Farakka between Murshidabad and Malda.

1.4 CLIMATE

The climate of West Bengal is principally tropical. Tropic of Cancer passes through the northern part of the districts of Purulia, Bankura and Nadia and hot summer prevails in major part of the state. Except for a short duration of 3-4 months from late November to the end of February, winter is very mild and pleasant in the state. However, the mountainous region in the northern district of Darjeeling is cold throughout the year due to altitude. But on account of high percentage of atmospheric humidity relief of cold is more. According to classical traditions there are six seasons Summer, Rainy, Autumn, Mild Winter, Severe Winter and Spring. Practically only four clearly well marked seasons with a brief pause of Spring are observed namely the Hot season (April to June), the Rainy season (July to August), the post monsoon season (September to November) corresponding to Autumn and the cold season (December to March).



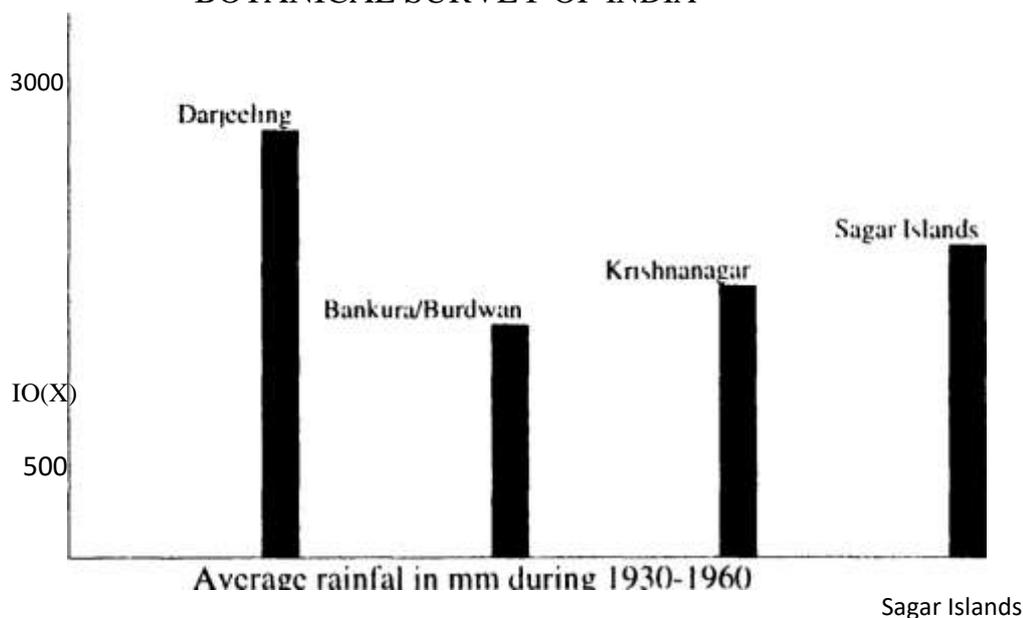
In West Bengal though broadly four seasons have been taken into consideration as major climatic periods (Ghosh, l.c.) the Spring is remarkably pronounced with

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onset of Southern Wind from the Bay of Bengal. The flow of this wind is very strong near coastal region in hot summer and causes the formation of shifting sand dunes. Following such hot spell, the water laden monsoon clouds reach the state generally by the second week of June. The hot season continues from March to June with the day temperature fluctuating from 38°C to 45°C in different parts of the state. The highest temperature with comparatively low humidity is recorded in the fringes of the plateau extended within West Bengal particularly in Purulia, Bankura and the Durgapur-Asansol industrial belt which is also extremely dry due to complete deforestation for developmental activities. The nights, however, bring pleasant relief with the cool sea breeze and flowing with moisture from the Bay of Bengal. As a result of high temperature often troughs of low pressure are formed on the plains causing sudden and forceful storms accompanied by lightning and thunder showers and are locally named as Kalbaisakhi, which often cause damage to the ripening fruits during the months of May to July. Though such storms bring heavy loss but at the same time they are beneficial to agricultural operations and also help the summer fruits to receive adequate sap for better development. The rains also help in ploughing land in preparation for the rabi crop of winter and into- and the sowing of the early Aus paddy crop. The Darjeeling district due to its altitude (1900 m) is comfortably cool during summer, the higher reaches however, often get enveloped in dense fog and help in the growth of luxuriant and rich temperate flora of the district.

The monsoon in West Bengal approaches with gorgeous preparation accompanied by cohorts of dense blue-black clouds generally by the middle of June. However, flash rains, pouring flooding water before the onset of true monsoon are also experienced. The short spells of rains start arriving before the major break of monsoon rains about a fortnight ahead and brings down the heat of summer with a pleasant break. The rains in Bengal are caused by the current of South West Wind which bring the heavy moisture laden clouds from the Bay of Bengal. The rain bearing clouds after moving northward get obstructed by the high barrier of Himalayas and pour down heavily on the mountains and the foothill areas of Duars. As such the average rainfall in the state being about 125 cm during the year, the mountains receive more than 1780 mm. The seasonal rainfall in Darjeeling area is generally above 3500 mm where as Duars receive about 3000 mm. In the western plateau fringes the rainfall is less than 1500 mm per year. Particularly during winter months the atmospheric humidity in these districts also comes down to very low and extreme dryness prevails from November to March when rainfall is only 1.0 mm to 25 mm. Particularly the districts of Bankura and Purulia are in a permanent state of extreme drought condition and the only way of improving the agricultural crop is through irrigation.

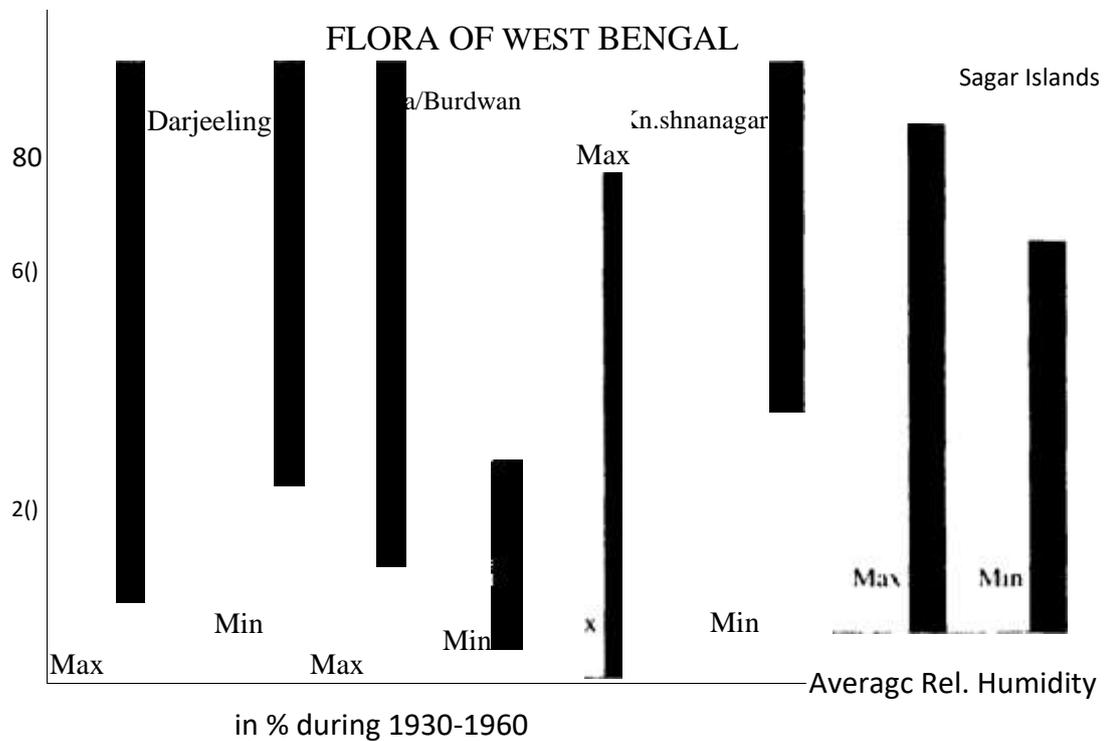
BOTANICAL SURVEY OF INDIA



Average rainfall in mm during

Monsoon in West Bengal sometimes shows some interesting features of variability and sudden breaks in rainfall is not uncommon and flooding heavy downpour is also experienced during the end of the monsoon. The states bordering the northern part of the Bay of Bengal, including Bangladesh, are prone to worst and devastating cyclonic conditions during September to November. Very often the low pressures created in the Bay of Bengal during those months develop into furious cyclonic storms accompanied by heavy rains and slashes the life and property of the coastal states including the districts in the southern part of the state.

Winter sets in the state following the flow of air current from the north across the Himalayas and becomes apparent when smoke from chimneys starts moving towards south.



The winter is mild over the plains and lasts for about three months when average temperature does not drop below 15°C. The season is accompanied by a cold and dry northern wind which appreciably causes lowering of the humidity level. However, short spell of smart rains with cloudy days are experienced during the end of December and in the 1st week of January due to incursion of the western monsoon coming all the way from the Arabian Sea. The weather becomes warmer by the middle of February which marks the welcome arrival of a short period of spring in the state and a fresh greenery with new foliage proclaims the end of the dormancy in the winter months. Most remarkable flowers noticed in this season are *Bondyax ceiba* (Simul), *Saraca asoka* (Ashoke), *Butea monospenna* (Palas), *Erythrina indica* (Mathar), *Crataeva nurvula* (Barun) etc. Sweet smell of blooming *Mangifera indica* (Aam), *Citrus* sp., *Michelia champaka* (Champa), *Jasminum* spp., abounds under cultivation in the gardens and forests. But the mellow season is too short and summer heat sets in from April, and seasonal cycle rolls on once again. A summarised normal climatic data during 1930-1960 as recorded by the Meteorological Department at Alipore observatory is diagrammatically represented from four climatic regional stations of West Bengal.

1.5 HISTORY OF BOTANICAL ACTIVITY IN WEST BENGAL

Botanical activity in West Bengal owes its initiation in Calcutta as early as in 1784 when W. Jones founded the Asiatic Society of Bengal to study various aspects of natural history and their relation with man and nature in the oriental countries. The year 1787 marks a glorious period in the history of Botanical studies in Bengal when Robert Kyd founded the Botanic Garden on the bank of the river Hooghly near Calcutta. Since its establishment some of the most important economic plants

like Tea, Jute, Cinchona, Teak and Mahogany were introduced for cultivation and development through this garden specially in Bengal. Such introduction had a remarkable effect on the local people in the awareness and utilization of those plants in practical life and gradually towards industry and also in plant life (Basak and Guha Bakshi, 1977). The earlier account of the economic plants of Bengal mainly centering round the Calcutta Botanic Garden were published by J. Fleming, W. Jones, W. Roxburgh, Buchanon-Hamilton and others (Santapau, 1958).

No major early work on the Botany of Bengal had been published by anybody prior to W. Roxburgh. His excellent contribution towards Indian botany have been duly recognized by naming him as the Father of Indian Botany. His eminence and great interest in plant life prompted him to collect plants, writing **descriptions and correspond liberally about the plants of this area. From the** letters written by Buchanon-Hamilton it is apparent that the manuscript copies of Roxburgh's Flora Indica were available for use at least by some of his friends

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(Prain, 1905) and possibly helped in preparing descriptive account of plants of the surrounding areas of Calcutta and Madras. The Hortus Bengalensis was published by Roxburgh (1814) which incorporated an interesting catalogue of 3500 species of plants under cultivation in the Botanic Garden at Calcutta. Roxburgh had a batch of eminent staff to help him in gathering plants as he could not move freely out of Calcutta for the interest of the garden. He prepared more than 2533 excellent coloured illustrations in 35 volumes (1776-1815) where many plants have been represented from the present political boundary of the state. Several of these illustrations serve as Iconotypes as per rules of International Code of Botanical Nomenclature. Subsequently an attempt was made to redraw those specimens and some 148 illustrations were separately published in six fascicles each containing 24-28 drawings during 1964-1973 (c.f. *Icons Roxburghianae* 1964, 1968, 1970, 1971 and 1973). The Flora Indica of Roxburgh came out in two volumes which were edited in part by Carey and Wallich (1820 and 1824) after including many of the latter's own collections. Carey at the request of Roxburgh's sons edited and published another edition of the Flora Indica in 3 volumes in 1832.

Contributions of two contemporary botanists viz. W. Carey and Buchanon-Hamilton in early Botanical and Horticultural research are of great significance to West Bengal (Ghosh, 1947; Srinivasan, 1961; Burkill, 1965; Basak, l.c.). Both of them actively helped Roxburgh to gather plants from Central Bengal and Sunderbans (Prain, l.c. a). The Hortus Suburbanus Calcuttensis by Voigt (1945) enlisted the plants grown in the Botanic Garden of Calcutta and that of Carey's Garden at Serampore up to 1841. It also included the plants which were entered in Master's incomplete Calcutta Flora (1839-40). The well known French botanist Jacquemont on his way for exploring in the N.W. India, travelled across the plains of Hooghly, Chandannagar, Burdwan and Raniganj in West Bengal in 1829 and threw some light on his botanical experience along his route (Jacquemont 1841). Most of his collections are now preserved in the Paris Herbarium (Stacton, 1945).

The history of Botanical researches in West Bengal and growing interest of local people in plants have a close link with the establishment of the Calcutta Herbarium (CAL). The nucleus of the Herbarium was founded by Roxburgh sometime in 1800 and excellent materials were gradually deposited by world fame botanists. Valuable collections and/or type specimens were contributed by Buchanon-Hamilton, Wallich, Hooker, Thomson, Griffith, McClelland, Clarke, Kurz, Prain and others from the Botanic Garden of Calcutta and different localities of W. Bengal. The utility of an authentic herbarium was realised by Griffith for identification of local plants and hence developed. A general herbarium as well as extensive series of local ones, so valuable for understanding

botanical geography and vegetable statistics of each part of British India (Mukherjee, 1959) with better knowledge about plants were established.

Gradually interest was focussed on the medicinal plant resources of Bengal which included areas in the present West Bengal as well. A garden depicting the useful plants of lower Bengal and medicinal plants labelled in Bengali was developed by Griffith for students of medical science (Burkill l.c.). Among the collections catalogued by T. Thomson (1856) the following are worth mentioning: A complete set of specimens gathered and dried in the Botanic Garden, Calcutta and labelled by N. Wallich, collections made by Hooker and Thomson till 1851 and a set of specimens Jessore. Extensive collections were made by Hooker from erstwhile Bengal and specially from Darjeeling and Sundarbans. The botanical findings during his travels have been systematically recorded by him (Hooker, 1848, 1849 a,b, 1850; 1852; 1854 a,b, 1904, 1907; Hooker and Thomson, 1855, Hooker et al. 1872-1897).

A few important publications brought out during the mid-nineteenth century by Long (1857-59) are on indigenous plants of Bengal, on plants of Calcutta by Anderson (1862) and on the Flora of Manbhatun (Purulia in W. Bengal) by Bal (1869).

Clarke showed much interest and paid serious attention to the herbaceous weeds in rice fields in the plains of Bengal specially on the families like Cyperaceae, Commelinaceae and herbaceous members of Scrophulariaceae (Clarke, 1871, 1874, 1875, 1885, 1898). His intimate knowledge about the topography and vegetation of the Sunderbans prompted him to address the _____ subject to the learned body of the Linnean Society (Clarke, 1896)._____

Gamble joined his services in North Bengal in 1872 and was exceedingly fascinated with the luxuriant and most varied forests in Terai and the Himalayan district of Darjeeling and described its forest types (Gamble, 1875). He made rich collections from Darjeeling and foothill areas of Jalpaiguri. A first hand list of Himalayan woody plants including climbers under various forest zones (Gamble, l.c.) of Darjeeling with lucid notes and phenological data were enumerated by him (Gamble, 1878, 2nd ed. 1896). It is interesting to note that Clarke also made thorough collections from the district and made a critical study of the plants and vegetation of the botanically rich valleys and prepared valuable notes [Clarke, 1875(-1876), 1885]. Clarke's entire set of collections was utilized in preparing the useful catalogue by Gamble (l.c.). Kvrz accumulated a very rich collection from the plains of Bengal and desired to publish a Flora of Bengal but he had to move from Bengal to Burma (Burkill, l.c.) leaving behind the collections. Various parts of North Bengal and Duars were subsequently explored also by King and Haines (1896, 1906) and Prain (1903 a).

Publication of the monumental Flora of British India by J.D. Hooker (1872-1897) switched on a new era in the History of Indian Botany. This excellent work

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paved a smooth way and gave a lot of impetus to prepare several Regional Floras by eminent botanists engaged in forest and other government services. Prain published the Flora of the Plains of Bengal as "Bengal Plants" (1903 a). This work stands out as the only comprehensive and useful Flora of the erstwhile Bengal with workable keys for identification of different taxa with vernacular names. In the introductory chapter Prain mainly dealt with the varied physical and broad outline of the vegetation and its associated forest types in the state and discussed their relationship with different phytogeographical regions of India and that of Malayan type. He, however, admitted his work on Bengal Plants as provisional and suggested a more critical study of the collections to bring out a standard Flora of erstwhile Bengal. Prain added further knowledge of floras of localized areas and published Flora of Sunderbans (Prain b) and the Flora of Howrah, Hooghly and 24-Parganas (Prain, 1905). He recorded 1316 species from these areas and isolated a precious collection of Bengal Plants which became an asset for Calcutta Herbarium (Basak, 1977).

Botanical researches on Bengal plants till 1920 or near about period were confined mostly to the Government departments like the Botanical Survey of India, The Agriculture and Forest departments. Thereafter his interest started spreading among the workers in various botanical research institutes, different universities and colleges and even in a number of individual workers (Bose, 1920; Burkill, 1920, 1922, 1926; Bancrjee, 1934; Arm, 1954; Ghosh, 1960; Dutta and Ganguly, 1967; Guha, 1968, 1971 and others). Masterly work for the Calcutta Herbarium by Prain (l.c.) and his valuable contributions through literature imparted excellent knowledge about the plants mainly of the plains of erstwhile Bengal including the adjoining areas of the states of Bihar and Orissa. The interesting flora of the Chittagong hill tracts and the districts bordering the floristically rich eastern states are now in Bangladesh and out of the purview while preparing the present Flora of West Bengal. Botanists and students of the premier colleges and of the universities in the state were no doubt very much benefitted by Prain's floras but felt the dearth of Himalayan flora of Darjeeling district to a great extent. However, in comparison to other branches of botany, research in taxonomy was neglected in W. Bengal particularly during the two decades between the World Wars I & II (Basak and Guha Bakshi, 1977).

Reorganization of the Botanical Survey of India under the dynamic abilities of Janaki Amntal in 1953-54 triggered a fresh outlook and revival of taxonomic research in India particularly at the Headquarters in Calcutta and in the four important Regional Circles, viz. Shillong, Dehra Dun, Pune and Coimbatore. Exploratory activities were remarkably augmented and as a result of intensive and extensive search, botanical information considerably accumulated, specially for the state of West Bengal. Taxonomists and botanical researchers in different universities, colleges, research institutions and various branches of forestry,

agricultural and medicinal plant services became more interested in the plants of West Bengal and published their observations and findings in a large number

Of publications (Basak, 1973; Basak and Guha Bakshi, 1977). With the revival of such botanical activities there were ample opportunities for taxonomic and floristic research centering around Calcutta with valuable collections and information added to the Central National Herbarium. As an outcome of such studies Flora of Howrah district was published by Bennet (1979). Similarly, Flora of Murshidabad district in central West Bengal was published by Guha Bakshi (1984). Apart from these two complete district floras a number of workers made thorough collections in different districts and floristically interesting areas in W. Bengal after the sixties of the present century and published their findings or submitted dissertations of their research for the award of doctoral degree, although publication of these accounts is still awaited. Other floristic accounts of such studies include contribution to the Flora of Purulia district by Mallick (1966), Herbaceous Flora of Jalpaiguri district excluding Cyperaceae, Poaceae and Pteridophytes by Sikdar and Samanta (1983), vegetation of Malda district by Krishna & Dutta (1983), enumeration of the plants of Burdwan district including the pteridophytic flora by Bhattacharyya (1986).

Floristic studies on interesting botanical zones and taxonomical contributions on various groups of plants include several publications such as by Chakraborty (1951) on the genus *Corchorus*; Mitra (1952, 1958) on the family Commelinaceae & Monocotyledons of eastern India; Majumdar (1956, 1962) on grasses and weed flora of 24-Parganas; Mukherjee (1965) on Jalpaiguri district; Biswas (1967) on plants of Darjeeling district; Guha (1968) on floristic survey _____ of Birbhum district; Datta and Majumdar (1966) on Flora of Calcutta and its _____ vicinity; Basak (1968) on distribution of several new plants for W. Bengal from Birbhum district; Banerjee (1968) on grasses of Burdwan; Banerjee & Pal (1974) enlisting the grasses of Indian Botanic Garden; Chaudhuri (1966) on grasses and sedges of Darjeeling; Maji and Sikdar (1983) enumerating the sedges and grasses of Bankura district; Sanyal (1974) dealing with the sedges and grasses of Bankura district; grasses new to W. Bengal and others. Apart from the aforesaid publications on floristics and vegetation brought out after fifties, dissertations on two district floras by Das on Nadia district in 1968 and Sen on Hooghly district in 1972 were submitted but not yet published. Similarly Mitra worked on Tollygunge and adjoining areas and Vuppuluri Sharma on the weed flora of the Indian Botanic Garden, both in the year 1970.

After publication of the Flora of British India by Hooker (l.c.) and Bengal Plants by Prain (l.c.) there have been reports of large number of new species and several new distributional records for the state of West Bengal. Calder, Narayanaswami and Ramaswami (1926) and Razi (1959) compiled two useful lists of such plants which included several taxa also from West Bengal. Other species, hitherto known from different parts of Indian subcontinent and many exotic species found to be growing wild in West Bengal have been published by various authors (Culshaw, 1952; Srinivasan and Agrawal, 1963; Maheshwari, 1964; Bennet, 1965 a,b,c, 1966, 1967, 1971; Rao and Mukherjee, 1965; Banerjee, 1966; Ghosh, 1966 a, b; Jain, 1966 a, b, c, 1968; Chandra, 1966; Chandra and Bhattacharyya, 1966; Datta and Majumdar, 1966; Santapau and Koriahali, 1967; Mitra, 1967, 1969, 1971; Guha Bakshi and N,mskar, 1966, 1967; Rao and Shanware, 1966; Jain and Banerjee, 1967; Korlahali, 1967; Rao, Mukherjee and Banerjee, 1967; Basak, 1968 a, h; Mukherjee and Banerjee, 1968; Jain and Pal, 1968; Guha Bakshi,

1969; Bancrjcc, 1969: Das, 1969: Mukherjec, 1969 a; Vuppuluri Sharma. 1969 ; Bancrjcc and Pal. 1970; Yonzone, Babu and Das, 1970; Banerjec 1971 a; Ghosh. Guha Bakshi. Mukherjec and Mondal, 1971; Bancrjec and Babu, 1971 ; Mitra and Roy, 1971; Krishna and Dutta, 1979; Krishna and Das, 1984).

Inspite of poor representation of endemic taxa in the Indo-gangetic Floristic Region (Chatterjee, 1939, 1962), a number of new species and varieties have been described in recent years from West Bengal including the northern hilly areas. such as *Cardanthera uliginosa* Buch.-Ham. var. *birb/unensis* Guha (1967) from Birbhum district; *Peristrophe bicalyculata* (Retz.) Nees var. *subaequibracteata* Bennet (1969) from Howrah district; *Cuscuta sharnuuun* Mukherjec & Bhattacharyya (1970) from Midnapore district; *Hydrocotyle hüналаica* Mukherjec (1969 b) from Darjeeling district; *Hypericum assanicum* Bl. swas (1971) from Assam and Darjeeling district; *Dalbergia duarensis* Thothathri (1975) from Alipurduar. North Bengal and *Panax asscunicus* Bancrjee (1968) from Darjeeling and Assam. It is worth mentioning that *Adiantum indicum*—a new species of pteridophyte has also been collected by Ghatak (1963) from Calcutta.

1.6 VEGETATION AND FOREST TYPES OF WEST BENGAL

The varied and unique physical features in the state have given rise to five well defined phytogeographical zones to support corresponding typical vegetational layout including the forest types. These are: 1. The Himalayan zone of Darjeeling, between 500-3800 m. 2. Sub-montane Terai region and the adjacent plain. 3. Vast alluvial plain on both sides of the Bhagirathi and its northern and western tributaries. 4. The Western dry flanks of Chhotanagpur plateau, and 5. Mangrove forest of Sunderbans mainly restricted to South 24-Parganas. In the broad outline of the areas mentioned above certain subdivisions of forest types and vegetational patterns have been further classified after critical analysis by the ecologists and plant sociologists (Champion and Seth, 1968; Naskar and Guha Bakshi. 1987; Malick, 1966; Gamble, 1875 etc.). However, the present picture of the vegetational pattern and forest types in the whole state is not the same as in the past and has undergone considerable modification due to continuous stress of intense biogeographical factors (Basak & Guha Bakshi 1977) which have been operative markedly during the last 50 to 60 years. Apart from those mentioned above the other typical plant groups belonging to the aquatic members, weed elements, horticultural and cereal crops along with components of forestry development also have markedly changed the vegetation in terms of quality and quantity and the details are treated under separate headings.

OF

The past vegetational pattern of West Bengal particularly that of the Lower Ganga Plain has been worked out and revealed quite interesting features (Chaudhuri, Mallik and Sen. 1962; Basak and Guha Bakshi l.c.). Anatomical studies

of the excavated wood from deep core have indicated the existence of a dominating mangrove forest which at present has migrated only to the southern part of the 24-Parganas (Ghosh, 1941; Ghosh and Ncogl, 1958). The analysis of pollen flora from the river Inud of estuarine region and also from some of the fresh water tanks showed the presence of pollens of the mangrove flora, the forests of which have shifted to the southern extremity of the Sunderbans (Das, 1961).

A thick deposition of peat around Calcutta and neighbouring regions with several metres of depth has shown no trace of mangrove pollens. Such peats under several vast swamps also indicate complete absence of mangrove elements and reveal the occurrence of *Suaeda nutritina*—a halophytic plant at different strata of the peat, suggesting that the origin of the flora of the peat has been due to riverine translocation of elements and not growing in situ. It is apparent that the stumps of *Heritiera* spp. and many others which had contributed a dominant forest in situ and located just beneath the peat had no role in the formation of the peat layer in Calcutta and surrounding area. Drifting of plant and other materials through riverine action is postulated to be responsible for the origin of Calcutta peat (Ghosh, 1964).

The vast coal basin of Raniganj area in the western part of the state is an outcome from the upper series of the Gondwana system and show remarkable prevalence of ferns, cycads and conifers whereas the lower series of Gondwana predominates with *Glossopteris*, *Equisetaceae* elements and Cordaites stems (Randhawa, Mitra and Mehta, 1964). It may be worth mentioning that apart from the past geological history of the forests and vegetation mentioned above there are reports and evidences of thickly wooded areas in large tracts of West Bengal even up to the end of the nineteenth century. Such forests were specially predominant in the districts of West Dinajpur and Malda, in large areas of the districts on the south western part of the state, particularly bordering Chhotanagpur plateau of Bihar and in the Sunderbans (Basak and Guha Bakshi, l.c.). Presence of dense forest stands in other parts of the plains were mainly near the fringes of the confluencing rivers and in the vast marshes and depressions. Formation of such forests were in the areas between the rivers Mahananda and Kalindi and between Punarbhava and Tangon in Malda, around the Hijal and Kalantar bils in Murshidabad; in the marshes between the Damodar and Bhagirathi in Hooghly district; between the Damodar and Saraswati in Howrah, in the marshy areas between Kalighai and Rupnarayan in Midnapore and the extensive saline marshes to the south east of Calcutta extending towards the fringes of the bay in the south. Reclamation of marshy lands for cultivation and habitation and continuous destruction of forests during the last one hundred

years have completely changed the whole face of the forest cover in W. Bengal and reveals an uncontrolled denudation of the forests and plant cover in wet and saline lands. The percentage of forest area to geographical area in the plain is about 1.1% and it varies from 3% in Birbhum to nearly 20% in Bankura and not less than 31% in Sunderbans (Anon., 1966; Basak and Guha Bakshi, l.c.).

It has already been emphasized that the geographical features and the plant life in relation to such conditions are more diverse in West Bengal than those of any state of India of comparable size. Apart from the Himalayan elements the flora of the plains of West Bengal falls into two sub-provinces, Bengal Proper and Sunderbans, as described by Hooker (1904) under his 4th botanical province of the Gangetic Plain. According to Champion and Seth (1968), the forests may be grouped under following types: 1) Subtropical to temperate forests of northern Himalayan region in Darjeeling; 2) Northern tropical dry deciduous Peninsular Sal forests¹; 3) Tropical seasonal swamp forest; 4) Dry deciduous scrub and 5) Littoral and swamp forest. Concise account with salient features of these forest types and their main components are described below:

I.6.1 Subtropical to temperate forests of northern Himalayan region in Darjeeling: A comprehensive travelogue through the dense and magnificent forests and vegetation for the district of Darjeeling is rather difficult to conceive due to the nature of the Himalayan terrain and the intricacy of the plant cover comparable to almost that of the tropical rain forests in some of the river valleys. However, much of our knowledge about the forests and plant wealth owes to the pioneering efforts of eminent botanists and forest officers of the last century (Basak, 1973). In spite of having a thorough knowledge of the life forms there is every possibility of missing the herbaceous elements which do not appear every year due to combination of various climatic and edaphic factors associated with the physiological behaviour of plants as it is noticeable in Strobilanthes, Lngotis, Lilies and many genera of Orchids. At the same time the richness of plant wealth with which the district nourished in the past has been considerably changed with the introduction of commercial and several exotic species and also due to large scale exploitation of the forest resources by the local inhabitants. Our knowledge about the species diversity in the district is almost complete, yet due to very interesting phytogeography along with the assemblage of so many species within this small section of the Himalaya it will be always a paradise for botanical explorations.

In introducing the forest types of Darjeeling district Gamble (1875) had expressed his views by saying that "The forests of Darjeeling district not those under the forest department. although it possesses specimens of most kind but the forests, are more varied probably than those of any other district in India". Further while presenting the distribution pattern of the various forest types within the district his impressions are vividly expressed in his remarks "deep valleys filled with strange vegetable forms, serpent like lianas, trees of monstrous size of

and shape, perhaps clothed with the fairy blossoms of epiphytic orchids or the delicate tracery of pendent ferns mount thence upwinding paths through dark forests whose only colour is that of the mossy hangings of the gigantic stems or the occasional flower of the scented Magnolia to the regions of winter snow where masses of Rhododendron cover with their gorgeous tincts the slopes of the upper hills and twist in every conceivable shape their wonderfully coloured limbs."

Most congenial condition for development of unique forest types and a flourishing growth of the forest cover is due to the fact that the heavy moisture laden clouds travelling northwards with the onset of monsoon get an easy passage

into the Teesta river valley within the district and strike first on the rugged precipices on either side of the basin and also those of the smaller valleys of the rivers Balsan, Mahananda, Cheil and Jaldhaka in the neighbouring areas and pour heavy rains and cling to the forest cover with a blanket of moisture. By dropping the burden of water as they travel upwards and penetrate into the lattice of higher valleys it provides most favourable condition for the lush growth of all kinds of plant life of the forest composition. An approach from the plains to the mountainous zone of Darjeeling district and gradually to the higher reaches and ultimately to cold subalpine to alpine summits of Tonglo and Sandakphoo, for any botanist is a unique and thrilling experience.

During his historical journey through Darjeeling to Sikkim, Hooker (1849) prepared an excellent narrative about the Himalayan vegetation right from its commencement at the foothills to the highest limit at Tonglo in the Singalila range. In his observation the vegetational zones were mainly dealt from the plains to 1600 m under tropical zone and beyond this and up to 3600 m under temperate zone. Clarke (1877, 1886) also made interesting botanical trips following Hooker's route and narrated his collections mostly from the temperate zones or Darjeeling to Tonglo and further up towards Sandakphoo. More than four hundred species enumerated by him include also an interesting list of nearly hundred species of ferns. Gamble (1896) as a master forest botanist did an excellent job by preparing an exhaustive and very critical list of more than 800 species of trees, shrubs and woody climbers from the district. Apart from his own rich collections the collections of other contemporary botanists helped him in preparing a very useful contribution with valuable information on forestry and botany along with critical phenological data. In order to describe the plants within specific forest community he classified the forests broadly under five categories viz. 1. Sal Forests (*Shorea robusta* up to 750 m); 2. Khair-Sissoo Forests (*Acacia catechu* & *Dalbergia sissoo*); 3. Savannah Forests; 4. Mixed Forests (with 3 subdivisions); 5. Temperate Forests (with 3 subdivisions). Cowan & Cowan (1929a) while revising Gamble's (l.c.) list added a large number of herbaceous species while dealing with the ecological aspect of distribution of forests in Darjeeling particularly of Kalimpong subdivision and recognised 3 broad zones viz. Tropical zone (upto 900 m); Sub-Tropical zone (900-2000 m)

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and Temperate zone (200()-350() m) or Upper Hill zone. Biswas in his flora also described species from the district and vegetation succession according to altitude following the pattern of Cowan. Hara (1966) in his Flora of the Eastern Himalaya included considerable collections from Darjeeling district and described the forest types under (i) Rain Green Deciduous Forest between 700-900 m with *Shorea robusta* as the dominating tree. (ii) Mixed Broad Leaved Forest between 1500-1700 m, where *Castanopsis indica* and *Schinus molle* are flourishing elements; (iii) Evergreen Oak Forest with *Quercus lantifolia*, *Q. pachyphylla* and others between 2500-2800 m and indicative species along with *Quercus* have been marked by *Engelhardtia gardneri* and *Acer cantoniense*. Trees, shrubby and other herbaceous associates in these forest types have also been mentioned. Banerjee (Anon., 1966) while preparing a short account of the forests of Darjeeling broadly treated the forests under I. Plain Forests and II. Hill Forests. The latter however, has been subdivided into three categories under Lower, Middle and Upper Hill Forests following Government's outlook.

The forested areas of the Darjeeling district are mainly under the control of the Directorate of Forests, Government of West Bengal and are maintained as Reserve Forests or Protected Forests. The different categories of forests and their respective areas recorded in 1966 under 3 sub-divisions (Anon. 1966) are summarised in the following Table

Name of Forest	Reserve Forest (Acres)	Protected Forest (Acres)	Unclassified state forests and under afforestation	Forest area for corporate bodies & Individuals	Grand Total (Area as on 31.3.1966)
Darjeeling	72,936	3,297	470	10,958	87,661
Kurseong	71,815	593	2,051	10,475	84,934
Kalimpong	1,43,957	285	1,870		1,46,102

Presently forests in this district are classified broadly under two groups : the plain forest and the hill forest as done by Banerjee (l.c). Such plains with sandy soil mainly adjoining the rivers are replaced by loamy soil with drifts from the river and the nature of forests are also changed. The main components in the forest composition both in the plains as well as in the hills as depicted under the classification by Gamble (1896) are mentioned below:

I. *Acacia catechu* *Dalbergia sissoo* (prest of the Tropical Plains (Khair Sissoo Forest) : The forests of this kind with *Acacia catechu* and *Dalbergia sissoo* as predominating species are found on sandy soil and characteristically prevalent on the river banks of the perennial and seasonal rivers. viz., Teesta, Scvak, Mahananda, Rakti, Balsam Meechi, Chel and others. *Dalbergia sissoo*, however, is in smaller number in comparison to almost pure stands of *Acacia catechu* and other commonly associated species are rather widely spaced which mainly include, *Acacia concinna*, *A. stipulata*, *Albizia procera*, *ceiba*, *Bridelia stipularis*, *B. tomentosa*, *Capparis olacifolia*, *Cassia tora*, *Coffra bengalensis*, *Cordia*

dichotonul, Crataeva nuzgna, Croton caudatus, Dalbergia hircina, Dalbergia lanceolaria, Dalbergia stipulacea, Deeringia awnaranthoides, Erythrina indica, Flueggea microcarpa. Chnelina arborea. Grewia laevigata. Lannea coronuulelica. Milletia auriculata. Natsiatlun herpeticunl. Prentna lati/blia, Pueraria tuberosa, Tinospora cordifolia, Toona ciliata, and Trenea nildiflora.

II. Savannah* Forest in the Tropical Plains of Darjeeling : Savannah type of Forest with tall grass cover though not very extensive in the district yet are chiefly found in Western Terai. Such grassy tracts with occasional trees or light forests are neither rich in Shorea robusta. nor in Dalbergia sissoo. These grasslands when dry and well grazed differ markedly from those under protection in composition and extent of growth form. Following their ecological characteristics Chaudhuri (1960) classified them under five types and common grasses growing in such forests excluding those in strict aquatic habitat include, Saccharum spontaneum, S. procerum. S. bengalense, Narenga porphyrocomit. Themeda arundinacea. Sclerostachya ficsca. Themeda villosa, Vetiveria zizanioides. Cymbopogon clandestinus, Erianthus longisetosus, Desmostachya bipinnata, Arundo (Dactyloctenium) aegyptium. Phragmites karka (generally in marshy areas). Arundinella bengalensis. Imperata cylindrica. Paspalum conjugatum, Eleusine indica, Cynodon dactylon. Paspalum flavidun. Setaria glauca, Leersia hexandra. Panicum repens and several others.

Along with the grasses of varying compositions a number of woody elements and trees commonly occurring and characteristically associated in this grass land are : *Acacia ferruginea*, *Adina cordifolia*, *Bauhinia malabarica*, *B. variegata*,

Butea monosperma. *Careya arborea*. *C. indicum*. *Clerodendrum serratum*, *Crotalaria stricta*. *C. sericea*. *Dalbergia latifolia*. *Eugenia operculata*. *Grewia sapida*. *Leea alata*. *L. crispa*. *L. nutcrophylla*, *Millena auriculata*, *Minusa rubicaulis*. *Ochna pumila*. *Oryzium indicum*, *Osbeckia rostrata*, *Prunella herbacea*. *Randia dinnetorum*. *R. idiginosa*, *Wendlandia exerta*. and *Ziziphus rugosa*.

The grassland of Terai region are mostly interspersed with *Shorea robusta* and other trees. Such sparsely wooded Forest lands have been covered by planting *Tectona grandis*. *Shorea robusta*. *Eucalyptus globulus*. *E. leucocylon* and other species of *Eucalyptus* under commercial plantation by forest department. Conversion of such lands for extensive Tea (*Thea sinensis*) or Pineapple (*Ananas comosus*) cultivation is a common feature of the district in the present days.

III. Mixed Plain Forest of the Tropical Plain : The flora in the mixed plain forest of Terai exhibits a rich growth of trees which are mainly of tropical evergreen type. Some of the deciduous species also take a prominent role in their composition. They also occur in the hill forests up to an elevation of 900m and

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associate with the predominating forest of *Shorea robusta*. From Dulka Jhar in the west to the whole of eastern Terai these forests are spread and occasional patches are found at the bases of the ridges. Common trees and woody climbers dominating the composition of the forest are : *Acacia ferruginea*, *A. intsia*, *A. pennata*, *A. procera*, *A. sinuata*, *A. stipulata*, *Actinodaphne obovata*, *Adina cordifolia*, *Aesculus assamica*, *Alstonia scholaris*, *Anthocephalus chinensis*, *Antidesma chinensis*, *Aporosa octandra*, *Artocarpus chucuna*, *Bauhinia anguinea*, *B. tnalabarica*, *B. purpurea*, *B. vahlii*, *B. variegata*, *Beaumontia grandiflora*, *Bridelia retusa*, *B. stipularis*, *B. tomentosa*, *Byttneria grandifolia*, *Calanthe flagellata*, *C. latifolia*, *Callicarpa arborea*, *Carallia brachiata*, *Careya arborea*, *Cassia fistula*, *Catunaregum spinosa*, *Chisocheton paniculatus*, *C. cecidophne*, *Cinnamomum tamala*, *Cissus repanda*, *Clerodendron indicum*, *C. serratum*, *Cochinocarpus sterculiaceus*, *Coffea bengalensis*, *Combretum roxburghii*, *Conocarpus suaveolens*, *Crateva magna*, *Croton caudatus*, *C. roxburghii*, *Daemonorops jenkinsianus*, *Dalbergia foliosa*, *D. latifolia*, *D. pinnata*, *D. stipularis*, *Desmodium gyroides*, *D. 1110torium*, *D. pulchellum*, *Dillenia indica*, *D. pentagyna*, *Duabanga grandiflora*, *Dysoxylum hanoultonii*, *Entellia ribes*, *E. robusta*, *Entada purpurea* SSP. *sinohimalensis*, *Eranthemum pulchellum*, *Ficus altissima*, *F. chanta*, *F. curtipes*, *F. cyrtophylla*, *F. infectoria*, *F. oligodon*, *F. repanda*, *F. rufinervis*, *F. semicordata*, *F. subincisa*, *Flacourtia rukam*, *F. strobilifera*, *Garuga pinnata*, *Glochidion gantlei*, *Glycosmis arborea*, *G. arborea*, *Grewia disperma*, *Holarrhena antidysenterica*, *Hymenocallis exelsa*, *L. rora undulata*, *Kentia lirifolia*, *Lagerstroemia parviflora*, *Lanea coriandricarpa*, *Leea acuminata*, *Lettsomia atropurpurea*, *L. strigosa*, *Litsaea lactata*, *L. monopetala*, *L. salicifolia*, *Macaranga indica*, *M. gambleri*, *Macrosolen cochinchinensis*, *Mallotus philippensis*, *Mangifera sylvatica*, *Melioselinia simplicifolia*, *Melioselinia cucullata*, *Micromelum minutum*, *Mimosa rubicaulis*, *Milletia auriculata*, *Morinda angustifolia*, *Mucuna* _____ *nigricans*, *M. monosperma*, *Murraya exotica*, *M. vaxopvillii* *simplicifolia*, *Olea dioica*, *Oryzium indicum*, *Pandanus minor*, *Phlogacanthus puberulus*, *P. thyrsoifolius*, *Phoebe lanceolata*, *Pinanga gracilis*, *Prenanthes copulbosa*, *P. scandens*, *Pueraria tuberosa*, *Psychotria calocarpa*, *P. erratica*, *Sapium baccatum*, *Santecarpus anacardiunum*, *Spatholobus parviflorus*, *Stereospermum chelonoides*, *Tabernaemontana divaricata*, *Ternstroemia bellirica*, *T. chebula*, *Tetraneura nudiflora*, *Toona ciliata*, *Travia nudiflora*, *Turpinia nepalensis*, *Wendlandia coriacea*, *W. vrallichii*, *Wrightia arborea*, *Ziziphus mauritiana* and *Z. rugosa*.

IV. Tropical Sal Forest (*Shorea robusta*) the plains of Darjeeling : Most impressive forests of *Shorea robusta* occupy the well drained areas of the district and occur on the plains with deep loamy soils of W. Terai and go up to 700 m from the Machi river on the west to the Chel river at Dalingkot. This type flourishes also along the valleys of Teesta, Rangit and Rungta on both sides and

extend continuously from the plains to the frontier of Sikkim (Gamble I.C.). Though *Shorea robusta* is the dominant component a number of other tree species grow with varying density mixed with several shrubby and herbaceous elements such as *Acacia ferruginea*, *A. pennata*, *Alstonia scholaris*, *Aphanantixis*

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polystachya, Barleria cristata. Bauhinia 'nalabarica. B. vahlii. Bridelia retusa, Caesalpinia bonduc. Calanms tenuis, Callicarpa arborea, Careya arborea, C. herbacea, Chilkrasia tabularis, Cissus repanda, C. indicunl, Clerodendrunl viscosilln. C. serration, Coffea bengalensis, Condn•etum roxburghii, Crotalaria sericea, Colebrookea oppositifolia, Cycas pectinata, D)aedalacantllus splendens. *modium*cephalotes, l). confertl(lil, D. gyroides. l). lati.fblitun. l). 'notoriuen, D. pulchellwn, D)il/enia pentag.vna, Duabanga grandiflora, Embelia robusta, Flaningia stricta, F. slrobili/era. Garuga pinnata, Gren•ia sapida, G. sclerophylla, Heteropanav Jiugrans. Holarrhena antidvsenterica. Indigofera pulchella, L.nnnea coronuuulelica. Leca alata. L. crisper, L. ntacrophylla, Litsea pnonopetala. Macrosolen cochinchinensis. Mallotus philippensis, Milletia auriculata. Mintosa rubicaulis, Mortnda angusti./blia. M. citri/blia, Oro.r.v/u;n indicunl, Pavetta crassicaulis, Phoeni.v acaulis. Prenura herbacea. Rivca ornala. Schinul n•allicllii. Semecarpus anacardiunw. Spatholobus ro vburghii, Spenuuict.von suavco/ens. Stereos•perl'llun chelonoides, Sv.:vgium cerasoides. S'. cunlini, Ternlina/ia bellirica, T. chebula. T. lcnnentosa. Wendlandia nullichii. Woodfordia trulicosa and Zi:iphus rugosa.

V. Tropical Hill Forests o/ *Darjeeling* and their vegetational contposilion: The vegetation of the lower hill forest\ of D)arieeling shows son)e charactcristic and has considerable density and diversity of species. The trees with high bionvass and lofty trunks cover the lower slopes and the basins of the river valleys and support dense growth of' lianoid climbers belonging to different families like Vitaceae, Fabaccae. Apocynaceae and Arecaccae. The forests within this zone are lrcquently impregnated Wilh Sal (Shorea robusta) no doubt but this is occasional in comparison to the predonunance of other lofty tree species belonging to tropical families like Stercullaceae. Meltaeeae. Burscraccae. Cclastraccae. Tiliaccae, Rutaceae. Datiscecae. Rublaeeac. Combretaccae. Sapotaccae, Lauraccae. Euphorbiaccae. Urticaceac. Juglandaceac and others. Some ol' the families like Rubiaceae. Euphorbiaccae. Verbenaeac. Moraceae and Lauraceac show a marked dominance in these forests in respect of number of genera and species. The following woody elernents (Gamble l.e.) are well represented in this zone : Abrus precatorius. Acacia intsia. A. lorta. Acrocarpus fraxinifolius. Acnwospenna clavi.f70rtun. Aclinodaphne obovata. Adhalodtl :.eylanica, Adina (ordi.fblia. Aesclilus assanuca, Aglaia edulis. Albi:ia chinensis, A. lebbeck, A. lucidior. A procera, Allophyllus :.e.vlanicus, Alchornea tiliaefblia, Alstonia scholaris. Anthocephalus chinensis, Antidesnltl acunlinanun. A. bunius, A. diandrtun. Aphania rubra, Aporosa roxburghii, Ardisia involucrala, A. solanacea, Aristolochia ro.vburghiana, Arlocarpus cluuna. Argyreia hookeri. A. nazirii, A. n•allichii, Arundinaria hookeriana. A. interntedia. Aspidoplerys indicat A. nutans. Baccaltrea sapida, Baynbusa nutans, Barleria cristala. Bassia butyracea, Bauhinia malabarica. B. purpurea, B. scandens. B. horsfeldii var. vahlii, B. variegata. B. "tallichii. Beauntontia grandiflora. BischQ/ia javanica. Boehneria rugulosa. Bownba.v ceiba,

Ougeilla oogeinensis, *Oreocarya indica*, *Paederia foetida*, *Pandanus nepalensis*, *Parabaena sagitata*, *Paranigra nuda*, *Pavetta crassicaulis*, *Phoenix rupicola*, *Pinchona gracilis*, *Pithecellobium*

OF

angulatum, *P. bigelinum*, *Platea latifolia*, *Plecospennum spinosum*, *Porana paniculata*, *Pouzolzia vintinea*, *Psychotria calocarpa*, *Pterospermum acerifolium*, *Pueraria tuberosa*, *P. wallichii*, *Randia sikkimensis*, *R. wallichii*, *Rauvolfia serpentina*, *Ruellia nepalensis*, *Rinorea bengalensis*, *Sabia paniculata*, *Sapindus baccatum*, *Sarcosenna arborea*, *Sauropus androgynus*, *Semecarpus anacardioides*, *Shorea robusta*, *Sloanea sterculiacea*, *Solanum erianthum*, *Spermatocarpus suaveolens*, *Spondias pinnata*, *Sterculia hantonioides*, *S. roxburghii*, *S. villosa*, *Syzygium cumini*, *S. formosum*, *S. operculatum*, *S. ramosissimum*, *S. toddaloides*, *S. wallichii*, *Stereospermum chelonoides*, *Tabernaemontana divaricata*, *Tenninalia bellirica*, *T. chebula*, *T. tomentosa*, *Thespesia lampas*, *Thunbergia grandiflora*, *Tetrameles nudiflora*, *Tephrosia candida*, *Trevesia palmata*, *Trewia nudiflora*, *Trema orientalis*, *T. politoria*, *Turpinia nepalensis*, *Ulmus lancifolius*, *Uncaria scandens*, *U. sessilifructus*, *Vernonia talauntifolia*, *V. volkammeriaefolia*, *Villebrunia frutescens*, *V. integrifolia*, *Wallichia densiflora*, *Wendlandia coriacea*, *W. heynei*, *W. wallichii*, *Woodfordia fruticosa*, *Wrightia arborea* and *W. sikkimensis*.

VI. Subtropical Middle Hill Forests of Darjeeling and their composition: The forests in the Middle Hill zone of the district are mainly distributed in the west of the Teesta River and preserve most valuable tree species of forestry interest. The whole of Darjeeling forest division is occupied by these forest components and the species gradually show more of temperate type towards the upper limit whereas many species of the upper limit of the lower hills merge with those in the middle hill forest. The principal species in the forests of this division are *Alnus nepalensis*, *Juglans regia*, *Betula alnoides*, *Machilus odoratissima*, *M. gammieana*, *Symingtonia populnea*, *Engelhardtia spicata*, *Phoebe lanceolata*, *Michelia cathartica*, *M. excelsa*, *Eurya japonica*, *Schima wallichii*, *Millettia macrocarpa*, *Saurauja griffithii*, *Pittosporum floribundum*, *Echinocarpus dasycarpus*, *Acronychia laurifolia*, *Celastrus paniculatus*, *Rhomnocalyx virgatus*, *Arpr thomsonii*, *Rhus* and some of the climbing legumes are represented by *Millettia monticola* and *Mucuna macrocarpa*. *Acrocarpus fraxinifolius* in blazing woods is also an attractive species in these forests. Many other well represented species include *Eriobotrya dubia*, *Dichroa febrifuga*, *Oryzopsis paniculata*, *Brassiaopsis mitis*, *Maesa indica*, *Embelia floribunda*, *Chonemorpha macrophylla*, a gigantic climber, *Clerodendrum colebrookianum* and others. The undergrowth in these forests though not very thick yet presents large number of herbaceous and shrubby species like *Astilbe rivularis*, *Laphne papyracea*, *Aechmanthera tomentosa*, *Helicia erratica*, *Ardisia macrocarpa*, *Arundinaria aristata*, *Lastrea dissecta*, *Maesa chisia*, *Neillia thyrsiflora*, *Plectocomia himalayana*, *Reinwardtia trigyna*, *Ranunculus diffusus*, *Draba gracillina*, *Viola*

serpens, *Stellaria patens*, *Skimmia laureola*, *Piptanthus nepalensis*, *Spiraea bella*, *Primula rotundifolia*, *Veronica cana*, *Ajuga lobata* and many others. The ferns make a dominant cover in these forests along with others. In Kurseong division the middle hill forest also abounds with many tree species which are common also in Darjeeling division. Common species in this division are *Alnus nepalensis*, *Terminalia myriocarpa*.

Schima wallichii, *Symingtonia populnea*, *Lithocarpus fenestrata*, *Betula alnoides*, *Erythrina arborescens*, and *Phoebe lanceolata*. Because of comparatively low altitude some of the species of the lower hills like *Toona ciliata*, *Adina cordifolia*, *Cinnamomum tamala*, *Engelhardtia spicata* and others are represented in very large number in the forests of middle hills in the district. Most characteristic feature of the trees is exhibited by their magnificent size both in height and girth. Some of the common tree-ferns like *Henklia brunoniana*, *Alsophila glauca*, *A. glabra*, *A. latebrosa* are represented in large numbers in these forests apart from *Angiopteris evecta* and thick masses of *Gleichenia glauca* and *G. linearis* growing on shady moist rocks and forest slopes.

The Middle Hill Forests in the Kalimpong Division are spread within an altitudinal limit of 1000 m with soil rich in sandy loam derived from the Daling series. The quality of the soil has been responsible for the development of magnificent forests abounding in evergreen trees with dense canopies, mainly represented by species like *Castanopsis triboldoides*, *C. indicata*, *Schinus molle*, *Phoebe lanceolata*, *Eurya cavaleriei*, *Betula cylindrostachya*, *Nyssa javanica*, *Alcimandra cathartica* and large climbers like *Actinidia callosa*, *Pentapanax racemosum*, *Mucuna macrocarpa* and *Rubus nivalis* of which the latter commonly grow with in a great altitudinal amplitude of 400 m to 3300 m. *Ostodes paniculata* represents a major associate in the Middle Hill Forests of Darjeeling amidst a thick herbaceous growth and common shrubby members are *Rubus ellipticus*, *R. niveus*, *Viburnum colebrookianum*, *Santbus hookeri*, *Strobilanthes wallichii*, etc. In comparatively moist areas the tree fern *Cyathea sinuata* is fairly common. Apart from the magnificent forest cover, large hilly areas within the Middle Hill Forest have been cleared from time to time for extensive cultivation of Tea (*Camellia sinensis*).

Plants of woody habit commonly represented in the Middle Hill Forests of Darjeeling are: *Acer oblongum*, *A. thomsoni*, *Acrocarpus fraxinifolius*, *Acronychia auriculata*, *Actinidia callosa*, *Actinodaphne sikkimensis*, *Agapetes saligna*, *Alcornea tiliacifolia*, *Alnus nepalensis*, *Aralia naontana*, *Ardisia thyrsoflora*, *Aphanamixis polystachya*, *Aristolochia planifolia*, *A. saccata*, *Beilschmiedia sikkimensis*, *Berchemia floribunda*, *Betula alnoides*, *Boehmeria haniltoniana*, *B. platyphylla*, *Brassiopsis nitis*, *B. speciosa*, *Buddleja macrostachya*, *Callicarpa vestita*, *Camellia sinensis*, *Caryopteris paniculata*, *Casuarina glomerata*, *Castanopsis indica*, *C. lanceifolia*, *Celastrus acuminata*, *C. naonosperma*, *C. paniculatus*, *Chasalia curviflora* var. *ophioxylodes*, *Chonemorpha macrophylla*, *Cinnamomum*

bejolghota, *C. impressinervium*, *willdenovii*, *Clematis acuminata*, *v. we wt*"J01ta,
c. munrocana,

Clerodendron colebrookeanum, *Cornus capitata*, *C. controversa*, *Cryptomeria japonica*, *Leboregeasia velutina*. *l. wallichiana*, *Dicroa frbrifuga*. *Dillenia pentagyna*.
Dobinaea vulgaris, *Drimycarpus racetnosus*, *Dyso.rylum procerum*,
l)endrophthoefalcata, *Ehretia wallichiana*, *Elaeocarpus serranes*•. *E. sikkimensis*,
Eleagnus latifolia, *Enlbelia floribunda*, *E. nagushia*. *Engelhardtia spicata*,
Eriobotrya dubia, *Erycibe schbnidtti*, *Erythrina arborescens*. *Eurya cerasifolia*,

E. japonica. Ficus cyrtophylla, F. hookeriana. F. sarmentosa, Glochidion nubigenum, Gonania tiliaefolia, Hedyotis scandens, Holboellia latifolia, Holostentma ada-kodien, Hymenopogon parasiticus, Jasmintun nepalense, Kadsura heteroclita. Lonicera glabrata, L. wnacrantha, Inranthus psilanthus, Luculia gratissima, Lyonia formosa. Macaranga denticulata, Machilus odoratissbna, Maesa indica, M. rugosa. Magnolia hodgsoni, Mallotus nepalensis, Medinilla erythrophylla. Melastoma 'nalabathricum, Melia dubia, Meliosnua dillenigefolia, M. pinnata var. barbulata, Michelia excelsa. M. lanuginosa, Microtropis discolor, Miliusa macrocarpa. Murraya koenigii, Mussaenda nuacrophylla, Myrsine capitellata. Microchites elliptica, Osbeckia stellata. Oxyspora paniculata, Periploca calophylla, Podocarpus neriifolia, Populus• ciliata, Pyricularia edulis, Quercus acuminata, Reevesia pubescens. Reinwardtia trigyna, Rhamnus virgata, Rhus senüalata, Sabia leptandra, S. parviflora, Saurauja fasciculata. S. grifithii. S. napaulensis. Stephania elegans, S. glabra, Symplocos cochinchinensis, Thunbergia coccinea, Toddalia asiatica. Trachelospernuun a.rillare. T. fragrans, Turpinia nepalensis, Zantho.rylum acanthopodiunz and Z. annattun.

V II. Tenperate Upper Hill Forest and vegetation of Darjeeling district : The characteristic North Temperate Upper Hill Forests, dominated by several species of age striken Quercus and many interesting species of Rhododendron with **different** hues are distributed in the greater part of Darjeeling division. In the other two divisions viz. Kurseong and Kalimpong. members of the family Lauraccac and Accraccac are represented markedly in higher densities. A number of exotic species like Eucalyptus tereticornis, E. globosus, E. obliqua, Cedrus deodara, Cupressus torulosa etc. with profuse undergrowth mainly represented by species like Rubus ellipticus, R. niveus. R. moluccanus, Strobilanthes wallichii, S. pentastemonoides and common ferns like Arthromeris himalayensis, Asplenium ensifonne, Athyrium asperum, Crypsinus malacodon. Dryopteris filix-ntos and many others make the general forest composition of the Upper Hilly belt of Kurseong division above 1700 m. Where as in Kalimpong division in the lower limit between 1700m to 1900 m high concentration of Engelhardtia spicata forms a special or the forest. In higher succession above 1800 m the common tree elements of the forests include Persea fructifera, Phoebe ^{lan}ceolata, Lindera pulcherrinta. Alcimandra cathcartii and others. Trees of comparatively lesser frequency are represented by Litsaea elongata,

Engelhardtia spicata, Castanopsis tribuloides, Schima wallichii, Brassiopsis hispida etc. On the southern aspects however, Macaranga pustulata, Betula alnoides. Brassiopsis hookeri etc. are not uncommon specially on lands which have been left after cultivation. Quercus lamellosa forms the dominant composition of the upper hill forests of both Darjeeling and Kalimpong divisions between 1900 to

2400 m which is followed by *Persea gammieana*, *Acer canvbellii*, *Litsaea elongata*, *Michelia kisopa*, *Alcimandra cathcartii* and others. High level Oak forest dominating on Singalila range is mainly represented by

Lithocarpus pachyphylla with which *Quercus lawnelloso* is a common associate.

The Upper Hill forests in Darjeeling division comprise a fascinating temperate vegetation predominated by *Quercus lanælosa*, *Q. lineata* and *Lithocarpus pachyphylla*. Its common associates include *Castanopsis purpurella*, *Magnolia campbellii*, *M. globosa*, *Michelia excelsa*, *Eurya acuminata*, *Ilex dipyrena*, *I. fragilis*, *Euonymus frigidus*, *Synplocos theaefolia* and others. Temperate herbs and shrubs common within these forests have a large number of typical plants belonging to the families of Rosaceae, Ranunculaceae, Acanthaceae, Berberidaceae, Grossulariaceae, Ericaceae, Primulaceae, Saxifragaceae etc. One of the common bamboos in this (Orchestraceae) zone is represented by *Arundinaria racemosa*. Apart from different species of *Rhododendron* which commonly occur in the high altitude forests the Conifers make a dominating vegetation in the higher limits. Though *Cryptomeria japonica* has been extensively planted in this division after its first introduction from Japan during later part of the 19th century yet it is flourishing more at the lower heights. The species however, does not thrive well above m. The temperate conifers mainly restricted to Singalila range include *Abies pindrovi*, *Larix griffithii*, *Tsuga brunoniana* and *Pinus roxburghii*; the latter is found only in dry inner valleys.

In addition to the general outline of the temperate or high hill forest vegetation and woody species of Darjeeling district given above, the other typical plants in the same altitudinal range above 1800 m are : *Acer campbellii*, *A. caudatum*, *A. hookeri*, *A. laevigatum*, *A. sikkimensis*, *Actinidia strigosa*, *Aucuba himalaica*, *Berberis angulosa*, *B. chitria*, *B. concinna*, *B. insignis*, *B. nepalensis*, *B. umbellata*, *Betula alnoides*, *B. utilis*, *Brassia hookeri*, *Buddleja colvillei*, *Castanopsis purpurilla*, *Celastrus stylosus*, *Clenatis buchananiana*, *C. nontana*, *Cornus capitata*, *Cotoneaster microphyllus*, *Daphne papyracea*, *Derris nonticola*, *Ilex dipyrena*, *I. fragilis*, *I. hookeri*, *I. insignis*, *I. sikkimensis*, *Jasminum dispersum*, *Juniperus recurva*, *Justicia biennans*, *Leucoseptrum canum*, *Lindera assamica*, *L. heterophylla*, *L. pulcherrima*, *L. elegans*, *Litsaea cubeba*, *L. elongata*, *L. sericea*, *Lonicera acuminata*, *Lyonia villosa*, *Meliosma dilleniaefolia*, *M. pinnata* var. *barbulaia*, *Mycelia longifolia*, *Osmanthus fragrans*, *O. suavis*, *Pentapanur leschenaultiana*, *Piptanthus nepalensis*, *Pittosporum floribundum*, *Potentilla fruticosa* var. *rigida*, *Prunus nepalensis*, *P. rufa*, *P. undulata*, *Pyrus foliolosa*, *P. lanata*, *P. microphylla*, *P. rhamnoides*, *Rhododendron arboreum*, *R. barbatum*, *R. cinnabarinum*, *R. dalhousiae*, *R. edgeworthii*, *R. fulgens*, *R. grande*, *R. hodgsonii*, *R. lepidotum*, *R. vaccinoides*, *Rhus acuminata*, *R. hookeri*, *Ribes acuminatum*, *Rosa sericea*, *Rubus andersonii*,

R. calycinus, *R. hookeri*, *R. paniculatus*, *R. thonæsoni*, *R. treutleri*, *R. macilentus*, *Sabia limoniacea*, *Sambucus adnata*, *S. hookeri*, *Sarcococca saligna*, *Schizandra grandiflora*, *Skimmia laureola*, *Sloanea dasycarpa*, *Spiraea bella*, *Stachyurus himalaicus*, *Styrax hookeri*, *S. serrulatum*, *Symplocos dryophylla*, *S. lucida*, *S. phyllocalyx*, *Taxus baccata*, *Vaccinum nununularia*, *V. retusum*, *Viburnum erubescens*, *V. mullaha*, *V. nervosum*, *Viscum album*, *V. articulatum*, and *Zanthoxylum nitidum*.

A journey to the higher reaches from Darjeeling to Tonglo and further up to the highest point of Singalila range not only offers an interesting succession and impressive composition of typical forests of temperate Eastern Himalaya but also abounds with fascinating herbaceous undergrowth with many temperate and alpine species of flowering herbs and handsome ferns. Some common flowering plants including orchids are : *Hemiphragmus angustifolium*, *Aconitum palmatum*, *Aeschynanthus bracteata*, *Agrostis alba*, *A. nervosa*, *A. vulgaris*, *Ainsliaea pteropoda*, *Ajuga lobata*, *Anaphalis adnata*, *A. araneosa*, *A. cinnamomea*, *A. contorta*, *A. triplinervis*, *Anemone obtusiloba*, *Anemone thomsoni*, *Anisadenia saxatilis*, *Anthogonium gracile*, *Aralia pseudoginseng*, *Arisaema costatum*, *A. erubescens*, *A. griffithii*, *A. jacquelinoides*, *A. nepanthoides*, *A. speciosum*, *A. tortuosum*, *Avena alpestris*, *Balanophora dioica*, *Begonia cathartica*, *B. josephi*, *B. genuipara*, *Bidens pilosa*, *Boeninghausenia albiflora*, *Bromus himalaicus*, *Calceolaria americana*, *Canpanula colorata*, *Cardamine trifoliata*, *C. bengalensis*, *Carex daltonii*, *C. decora*, *C. filicina*, *C. blanda*, *C. fusiformis*, *C. indica*, *C. nepalensis*, *C. nubigena*, *C. pellucida*, *C. phacelia*, *C. polycephala*, *C. remota*, *C. vesiculosa*, *Carpesium abrotanoides*, *C. cernuum*, *Chatwinia cuspidata*, *Chirita macrophylla*, *C. urticifolia*, *Chloopsis canescens*, *Chrysosplenium lanuginosum*, *C. nepalense*, *Clinopodium umbrosum*, *Clintonia alpina*, *Codonopsis inflata*, *Coeloglossum ciliolatum*, *C. praecox*, *Commelina maculata*, *Corydalis chaerophylla*, *C. sibirica*, *Crawfordia luteoviridis*, *Cranioides versicolor*, *Cynoglossum zeylanicum*, *Cyrtosia lindleyana*, *Dicentra thalictroides*, *Dichrocephala latifolia*, *Didymopanax aromaticum*, *D. albicalyx*, *Diosporum cantoniense*, *Draba gracillima*, *Edgaria darjeelingensis*, *Elatostemma dissectum*, *E. surculosum*, *E. hookeriana*, *E. ficoides*, *E. nasutum*, *E. obtusum*, *E. sessile*, *E. sikkimensis*, *Elsholtzia flava*, *E. strobilifera*, *Epilobium rosetum*, *Fragaria daltoniana*, *F. vesca*, *Fritillaria cirrosa*, *Galium mollugo*, *G. rotundifolium*, *G. hirtiflorum*, *Gentiana capitata*, *G. pedicellata*, *Geranium nepalense*, *G. polyanthes*, *Girardinia heterophylla*, *Gnaphalium luteo-album*, *Gynura angulosa*, *Habenaria pectinata*, *Hackelia uncinata*, *Hemiphragmus heterophyllum*, *Herniaria congesta*, *Herpetosiphon pedunculatus*, *Holcus lanatus*, *Hymenopogon parasiticus*, *Hypoxis aurea*, *Hypoxis arguta*, *I. longipes*, *I. puberula*, *I. racemosa*, *I. radiata*, *I. stenantha*, *Iris decora*, *Isachne liliacea*, *Isopyrum adiantifolium*, *Juncus bufonius*, *J. himalaicus*, *J. concinnus*, *Kobresia hookeri*, *Lepidoptera evittata*, *Lecanthus peduncularis*, *Lindenbergia indica*, *Liparis nepalensis*, *Lobelia*

e. *amidalis*, *Lysimachia Japonica*, L. L. eccmcnu, *Lysionotus ternifolia*,
 Malaxis acuminata, Mazus dentatus, M. surculossus. Meconopsis robusta,
 Melissa parviflora. Muehlenbergia duthieana, Myriactis nepalensis. M. wallichii,
 Notochaete hamosa, Ophiopogon wallichianus, Osbeckia crinita. Ophiorrhiza
 mungos, O. nutans, O. thcnsoni, Opliyneus compositus. Origanupn vidgare,
 Oxalis griffithii, Paris polyphylla, Pedicularis gracilis, Pentap[?]rygilln serpens.
 Pentapyxis stipulata, Peperontia reflexa. Perilla ocilnoides. Perncarpa carnosia,
 Pilea anisophylla, P. bracteosa, P. scripta, P. .wnilacifolia. P. synuneria, P.
 ternifolia, P. umbrosa, Poa alpina. P. annua, P. subsecunda, Polygonatmn

cirrifolium, *P. oppositifolium*, *P. punctatum*, *P. verticillatum*, *Polygonum antple. ricaule*, *P. capitatum*, *P. chinense*, *P. filicaule*, *P. nolle*, *P. runcinatum*, *P. perforatum*, *Potentilla nepalensis*, *Pouzolzia indica*, *Pratia begonifolia*, *Prunella petiolaris*, *P. rotundifolia*, *Prunella vulgaris*, *Ranunculus cymbalariae*, *R. diffusus*, *R. hirtellus*, *Rorippa montana*, *Rubia nutans*, *Rumex acetosa*, *R. nepalensis*, *Sarcopyrum nepalensis*, *Satyrium nepalense*, *Saussurea deltoidea*, *Saricoba purpurea*, *Scrophularia elatior*, *S. urticaefolia*, *Senecio alatus*, *S. chrysanthoides*, *S. tetranthus*, *S. nullochii*, *Siegesbeckia orientalis*, *Smilacina oleracea*, *S. purpurea*, *Smilax ferocissima*, *S. nenispennoidea*, *Spiranthes sinensis*, *Stellaria bulbosa*, *S. crispata*, *S. longissima*, *S. sikkimensis*, *Streptolirion volubile*, *Strobilanthes attenuatus*, *S. divaricatus*, *S. veallichii*, *Swertia binuacillata*, *S. chiravita*, *S. paniculata*, *Thalictrum chelidonii*, *Thladiantha calcarata*, *Thunbergia coccinea*, *T. lutea*, *Tiarella polyphylla*, *Trillium govanianum*, *Urtica parviflora*, *Utricularia nudicaulis*, *U. orbiculata*, *Valeriana hardwickii*, *Veronica cana*, *Vitis capriolata*, *V. tenuifolia*.

The temperate forest zone of Darjeeling shows also a characteristic distribution of scrub forest communities generally on the sites of abandoned shifting cultivation and specially in the areas which are excessively overgrazed or where trees have been ruthlessly lopped. Such secondary forests are mainly composed of dwarf conifers, mostly represented by the introduced trees or *Pinus griffithii* or saplings of *Quercus luteellosa*, *Lithocarpus pachyphylla*, *Quercus lineata* etc. These forests are easily recognized by their appearance on terraced lands which due to constant biotic interference are unable to establish and attain their climax formation. On the other hand where the valleys are deep, the soil in these forests is more moist due to seepage of water with minerals and help in the formation of mixed and mesophyllous communities which require adequate moisture and soil rich in nutrients.

V III. The Conifer-Rhododendron Forests : This type is predominant in the highest limit of the district, mainly in Darjeeling and to lesser extent, in Kalimpong Division. This zone however, is not represented in Kurseong Division. The dominating element in this forest is *Arundinaria racemosa* which is found to grow as a pure crop or as an element in the undergrowth of these high forests. It is stated (Banerjee, 1966) that greater part of this forest zone in Darjeeling Division had suffered great damage from serious forest fires in 1876, 1879, 1882, 1903, 1909 and 1939. Charred and blackened stems of crooked *Rhododendron* and *Quercus* succeding above pure stands of bamboo zone still represent the ravages of the past fire and give an indication of the nature of well grown forest and mode of invasion of the dwarf bamboos within the gutted forests in the past. The forests of this zone are chiefly represented by *Arundinaria racemosa*, different species of *Rhododendron* or with patches or conifers and scattered growth of *Lithocarpus pachyphylla*, *Quercus spicata*, *Acer campbellii* and *Magnolia campbellii* towards the lower heights. Among the conifers, *Taxus baccata* is scatteredly distributed at

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higher elevations of the Tonglu Range. But further upwards towards Phaloot *Taxus* is replaced to a large extent by *Tsuga dumosa* between 2400 m to 2800 m and thence higher up merge with *Abies spectabilis*. Ultimately this is replaced by *Rhododendron* of higher distribution and by *Betula utilis* in the highest limit. Pure forests of *Rhododendron arboreum* are not uncommon at the higher altitudes and sometimes Pasture lands are come across on the boundary of Nepal & West Bengal (Bancroft, l.c.)

A small area in Kalimpong Division is occupied by the kind of forest visible in Darjeeling above 2700 m where patches of conifers flourish with the main species being *Tsuga dumosa*, *Larix griffithiana* and *Taxus baccata*. Above 2800 m the entire ground is mostly covered with *Arundinaria racemosa* where occasional patches of *Rhododendron arboretum*, *R. grande* and the handsome *R. falconeri* are come across.

I.6.2: Vegetation of North Bengal : Out of the five vegetational zones of West Bengal mentioned earlier, the forest types and floristic composition of the mountainous Darjeeling district including its plain areas being greatly influenced by the Himalayan elements, its vegetation has been dealt with separately in the preceding part of this chapter, though it is situated in North Bengal.

The forests and vegetation of North Bengal show much resemblance with that of the mixed plain forests of Darjeeling. These needed special attention in isolation of other tracts of the state in view of its excellent climatic and edaphic factors, supporting most luxuriant growth of the forests along with rich bio-diversity of tropical evergreen forests. Due to the density and development of various kinds of forests including excellent Savanna type of thick grasslands in moist and swampy belt located in long stretch of Jalpaiguri district, the terrain has been favoured with the development of three wild life sanctuaries. viz.. Jaldapara in Buxa forest division, Garumara and Chapramari, of rather smaller dimensions, located in the north-eastern part of the district under Lower Tandu, Upper Tandu and Daina forest ranges. Apart from 13 kinds of mammals and 12 kinds of birds which are represented in large numbers, these game sanctuaries are preserving one of the most precious animals of the country, the single horned Rhinoceros in sizeable numbers. In order to protect such an important habitat and to understand its direct relationship with the famous and rich fauna of this submontane forest, the knowledge of the main biological component viz. the flora and vegetation of North Bengal need thorough investigation. Moreover, after declaration of Buxaduar as a tiger reserve in the same district, the flora of North Bengal require special attention to maintain the forest habitat favourable for the sustenance of the fauna. Keeping such ideas in view, the Botanical Survey of India had already launched research programmes to study the flora and vegetation of those areas. Mukerjee (1965) after studying the vegetation of Jalpaiguri prepared an account to sketch the main forest types and their major components to throw light on the interesting flora of the

district. The fascinating orchid flora of the plains of North Bengal also attracted his attention and an

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account on this interesting group of plants were published (Mukerjee 1975) In addition to such observations. he worked out (he fern flora of Jalpaiguri district which provides an ideal condition in the forest floor for regeneration and a rich growth of other herbaceous members. The works mentioned above also created interest in subsequent workers and Sikdar (1984) published an account on the Baikunthapur forest division of Jalpaiguri district. Based on the composition and distribution of the major floristic elements, he described five forest types and their typical components, as under:

I. Semi-evergreen forests : Common species like *Alstonia scholaris*, *Bauhinia variegata*, *Castanopsis tribuloides*, *Cinnamomum obtusifolium*, *Eugenia foeniculata*, *Litsea salicifolia*, *Meliosma simplicifolia*, *Syzygium cupanini* etc. Forests of such types are found in small patches near the rivers or streams. Other commonly occurring species in such forests are *Mesua ferrea*, *Aphananthe rubra*, *Achronychia pedunculata*, *Macaranga denticulata*, *Phoebe pallida*, *Viburnum colebrookianum* and species like *Osbeckia nepalensis*, *Mussaenda frondosa* etc.

II. Moist deciduous forest : The forests of this kind are described under moist tropical forest type and are categorised under Sub-Himalayan secondary wet mixed forest. The principal genera found in these forests are *Elaeocarpus*, *Eugenia*, *Dysoxylum*, *Litsea*, *Machilus* and others. Extensively growing climbers of *Vitaceae* are frequently found to grow on these trees and make an entangled lattice of climbers. Some of the well represented trees, and other associated shrubby elements are *Aphananthe polystachya*, *Callicarpa arborea*, *Casuarina vauca*, *Phlogotheca hirsutiflora*, *Aporosa roxburghii*, *Maesa indica*, *Styrax serrulata*, *Symplocos laurina*, *Thunbergia coccinea*, *Convolvulus bengalensis*. In wet localities *Carallia brachiata* is sometimes found to occur on the forest margins. Along with several herbaceous members like *Duchesnea indica*, *Lepidagathis incurva*, *Pseudobrassia polycantha* and large climbers of *Trichosanthes bracteata* with attractive red fruits are quite common. Some of the well represented grasses in these forests are *Setaria pabnaefolia*, *Gentotheca lappacea*, *Eragrostis unioloides*, *Pogonatherum paniceum*, *Oplismenus compositus* etc.

III. Dry deciduous forests : The vegetation in this forest type according to Champion and Seth (1968) is recognised as East Himalayan moist mixed deciduous forest where *Shorea robusta* is frequently come across along with various other trees and shrubby elements and the floor is densely covered with grasses following burning of ground cover. Along with dominating *Shorea robusta* other commonly growing species are *Lagerstroemia parviflora*, *Stereospermum personatum*, *Wrightia tomentosa*, *Sterculia villosa*, *Mallotus philippensis*, *Ervum stricta*, *Bridelia stipularis*, *Ziziphus rugosa* and straggling shrubs like *Holmskioldia sanguinea*, *Celastrus paniculatus* etc. Some of the common herbaceous species in

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the undergrowth of the forests are *Dicliptera roxburghiana*, *Blitnlea lacera*,
Lepidagathis hyalina. *Ludvvigia octovalvis*,