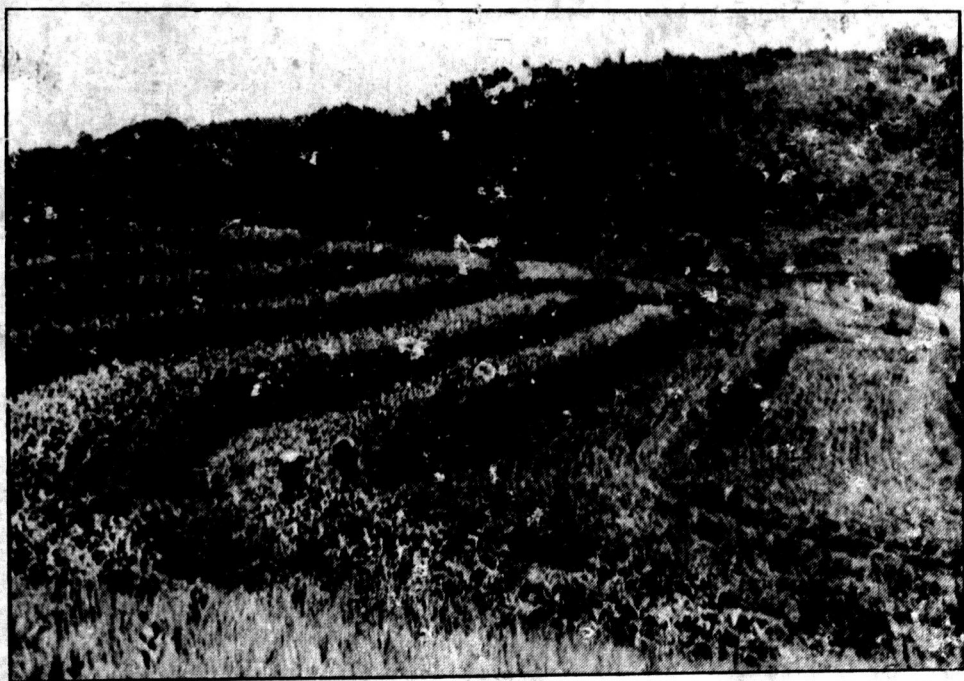


# AGRICULTURE OF THE NORTH EASTERN REGION

WITH SPECIAL REFERENCE  
TO HILL AGRICULTURE



BY  
DHIRENDRA NATH BORTHAKUR

**A COMPREHENSIVE ACCOUNT OF AGRICULTURE  
OF THE NORTH EASTERN REGION OF INDIA**

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# AGRICULTURE OF THE NORTH EASTERN REGION

**With Special Reference to  
Hill Agriculture**

**Dhirendra Nath Borthakur**

**BEECEE PRAKASHAN  
GUWAHATI**

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BEECEE PRAKASHAN  
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# FOREWORD

The N.E Region is characterised by high rainfall and humidity, wide variations in altitude ranging from near sea level to over 5000 m above MSL. undulating topography with spread out hills interspersed by fertile plains, inhabited by a large number of ethnic groups with diverse socio-economic features. All these make the region unique affecting agriculture in various ways.

The agricultural assets of the region include abundance of water, fertile soil, specially in the plains, vast biological diversity—being included under the tropical centres of diversity of flora and fauna. The region possesses nearly 50% of the total flora of the country. Similarly yak, mithun, Himalayan sheep and wild boar provide evidence of the genetic variability in animal resources. There is also large scale involvement of women in agriculture particularly among the tribal farmers in the region.

There are also special problems of agriculture in the region in the form of shifting cultivation, chronic devastation by floods, large scale degradation of the environment and problems of marketing due to geographical isolation and dearth of transport and communication facility. The research infrastructure in the region has been established properly only after 1975. The development of appropriate resource inventories, scientific exploitation of the endowments and handling of the problems are necessary for proper development of the region.

This book deals with the totality of agriculture of the region providing valuable insights into the endowments and problems. Relevant information, existing status of our knowledge and future approach to the problems have been discussed. The comprehensive information contained in this book will be of great help in development of the region.

This book also discusses the relevant aspects of hill agriculture in general through chapters on shifting cultivation, soil conservation and watershed management, farming systems and cropping patterns. Topics such as scientific landuse, water harvesting, tools and equipment, problems of post-harvest technology and marketing in the hills have been discussed. Thus, the book should be useful for hill agriculture in general.

The information of the main chapters have been further supplemented by important materials in the form of appendices.

Dr. Borthakur is eminently suited to write the book on agriculture of the North Eastern Region because of his vast experience in the area. He has spent his entire life time on problems relating to agricultural research and development of the North Eastern Region. He himself has made outstanding contributions to the development of the region.

The book fills a long felt need. The book should be useful to students, researchers and developmental administrators not only of the North Eastern Region but also to all concerned with agriculture in the hill areas.

We owe a deep sense of gratitude to Dr. Borthakur for this labour of love.

*M. S. Swaminathan*

(M.S. SWAMINATHAN)

President, National Academy of Sciences of India.

Honorary Director,

Centre For Research On Sustainable Agricultural  
And Rural Development.

# PREFACE

This book is intended to provide a comprehensive account of agriculture of the North Eastern Region. The stimulus for this work has been provided by the exposure to the present status of agriculture of the region and its potentialities during the last 35 years. For historical reasons, this region has remained behind the main stream of the country in agricultural development in many areas, although the potentialities of development of agriculture is rather vast. The transport and communication bottlenecks of the region have also contributed to such a state of affairs. Further, when taken as a unit, the North Eastern Region represents a wide diversity of agro-climate and hence of potentialities and problems. Although characterised by high rainfall, with the world's highest rainfall area being located in the region, there are also rain shadow belts. The humidity is also rather high. Hills, valleys and plateaus characterise the region with a wide range of altitude. The age old system of cultivation, namely shifting cultivation, is widely prevalent while there are regular and chronic floods in the lower valleys. The region is also known for its wide genetic diversity.

The technology for agriculture has to be geared to the needs of agriculture in the plains as well as those of the hills. It is necessary to have a comprehensive idea of the status of agriculture, problems and potentialities before a scientific endeavour can be made for improvement of agriculture in general which is also very much affected by the varying socio-economic cultures and traditions of the large number of ethnic groups residing in the area.

Of late, the Government of the various States comprising the region have become concerned with the development of their respective states and the Government of India have also laid special stress on development of the region. It is necessary to have complete information on the present status of agriculture, its potentialities, the available technology etc. so that a meaningful programme of development can be taken up. Another problem in this regard is the dearth of qualified technical personnel to cater to the needs of teaching research and development. Any programme of teaching, without imparting knowledge about the local conditions, the problems and solutions will not be complete and such persons will not be properly geared to tackle problems of this region. As such there is also a need to have such informations compiled properly to cater to such needs. It is also felt that such a book will provide the necessary exposure of all concerned to the scope and potentialities for development of agriculture in the region. It may be mentioned in this connection that so far there has been no such references on the North Eastern Region. The book has, therefore, been written with the sincere hope that it will provide the basic window through which the totality of agriculture of the region can be viewed properly.

As indicated earlier, the materials presented in the book have been based on the author's personal experience of research and development in the region, the exposure to the agricultural situations of the entire region as well as through associations with the various committees and bodies meant for development of the region. However, a large mass of information have also been taken from the various literatures available on the region and the papers either published or presented in the large number of seminars and workshops held during the past. The materials have also been taken from the large number of publications, particularly, of the Assam Agricultural University, the I.C.A.R. Research Complex for the North Eastern Hills Region, Tocklai Experimental Station as well as the concerned departments of the State Governments. The author would like to gratefully acknowledge all such persons and organisations whose publications have been consulted while writing the book. Help and assistance received from various individuals in the form of personal communications, photographs and suggestions etc. are also thankfully acknowledged.

Dr. Arun Varma, an eminent Research Scientist in animal science, working in the ICAR Research Complex for NEH Region for many years, has contributed the chapter on Live-stock Production in the N.E. Region. I am extremely grateful to him for enriching the value of the book by the contribution. An attempt was also made to include a chapter on Pisciculture. It could not be done due to non-receipt of favourable response on this topic.

I would also like to record my sincere appreciation of the assistance provided by Shri S. Gopalakrishna in the stenography work with utmost care and attention.

I am specially grateful to Dr. M.S. Swaminathan, F.R.S., President, National Academy of Science and Honorary Director, Centre for Research on Sustainable Agricultural And Rural Development, for his continuous encouragement in the work and for kindly writing the foreword of the book.



( D.N. Borthakur. )

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The North Eastern Region of India comprises States namely: Assam, Manipal, Mizoram, Nagaland and Tripura (Fig. 1). The region lies between 23°N and 27°N north latitude and 92°E and 96°E east longitude. The total geographical area of the region is 250,000 sq. Km. which is about 1% of the country's total area. The region is separated with the rest of the country through Assam by a narrow corridor of 50 Km. wide. This follows the foothills of Shillong and Khasi hills 150 Km. long part, 150 Km. long part, 90 Km. long boundary with Bangladesh in the South West and 150 Km. long part with India in the East. The boundary with Myanmar is only 38 Km. wide where the narrow corridor connecting the region with West Bengal.

### PHYSICAL FEATURES

The physiography of the region is divided into four distinct namely, Meghalaya Plateau, the Eastern Eastern Hills and down land and the Patkai Bura Valley. The North Eastern Hills and down land account for 60% of the total land area of the region. The Meghalaya Plateau and the Eastern Eastern Hills are

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# 1

## The North Eastern Region

### GEOGRAPHICAL POSITION

The North Eastern Region of India comprises of 7 states namely Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura (Fig. 1.1). The region lies between  $21^{\circ}57'$  degree and  $29^{\circ}28'$  north latitude and  $89^{\circ}40'$  to  $97^{\circ}255'$  east longitude. The total geographical area of the region is 2.55 lakh Sq.Km., which is about 8% of the country's total area. The region is connected with the rest of the country through West Bengal by a narrow corridor of 56 Km, which runs below the foothills of Bhutan and Sikkim. It has 1350 Km. long border with China in the North, 900 Km. long boundary with Bangladesh in the South West and 1350 Km. long border with Burma in the East. The boundary with rest of India is only 38 Km. which is the width of the narrow corridor connecting the region with West Bengal.

### PHYSICAL FEATURES

The physiography of the region is divided into three divisions, namely Meghalaya Plateau, the North Eastern Hills and Basin and the Brahmaputra Valley. The North Eastern Hills and Basin alone account for 65% of the total land area while the Brahmaputra valley and the Meghalaya

Plateau cover 22% and 13% of the area respectively.

*(ARUNACHAL HIMALAYAS)*  
**Arunachal Pradesh:** The elevation of the hills ranges from 150 metres to over 7,300 metres (Orichem in Kameng). The hill ridges in Arunachal Pradesh are situated in a very haphazard manner. As soon as one ridge ends, the other starts either in opposite direction or in a parallel manner. At these intervals, the wide and narrow valleys come into existence. Because of these ridges and the valleys, the surface of Arunachal Pradesh is found varied almost everywhere which also results into numerous geographical isolations of pockets caused by various rivers and streams traversing the region.

Arunachal Pradesh is the eastern stretch of the Himalayas and all the three sections of the Himalayas are represented here covering an area of 83,578 square Km. The forested Siwalik hills rise abruptly to 800 m above the Brahmaputra valley. Most of the ranges of the Lesser Himalayas are clothed with temperate forests.

Arunachal Pradesh has two major sections, the Mishmi hills and Patkai Bum (range). The former contains the loftiest ranges with many summits rising above 5,000 m. There are several basins. The largest, Taroan basin is surrounded by snow clad ranges with altitudes varying from 3,000 to 5,000 m and traversed by several south flowing tributaries of Tellu river (the Lohit). Daffla Bum (4,578 m) is one of the highest peaks of the Mishmi hills lying south of Lohit river. Many of the peaks of the Patkai Bum rise between 2,000 and 3,000 m. The range itself is built of strong sandstones of Tipam series.

*BRAHMAPUTRA VALLEY & BARAK VALLEY*  
**Assam :** Assam can be divided into two physiographic divisions the plains and the hills. The hills division separates the two valleys of the Brahmaputra and the Barak rivers. The Brahmaputra valley being formed by the river Brahmaputra which really is one of the greatest river systems of the world. The valley covers 56,000 Sq. Km. of alluvial plains interspersed with small hillocks and swampy low lands which are subject to annual floods. The Barak valley covering about 7000 Sq. Km. is an undulating plains area with small hillocks and swamps at intervals.

The hills division consists of part of Barail and Meghalaya ranges. The Northern face of the hills rises gradually to 930 metres while the Southern part is steep and falls abruptly into the Barak valley.

**Manipur :** The ridge-and-valley character of the eastern mountains is more pronounced in Manipur from the Tuensang hills in the north to about 24° N parallel in the south. There, the eastern boundary runs along the frontier between India and Burma and western boundary abuts against the Cachar plains and hills. The central part is a large basin, 50 km long and 30 km broad, surrounded on all sides by high mountains. This appears to be the bed of an old lake, a remnant of which occupies the south-east corner of the basin and is known as the Loktak lake, 12 km long and 8 km broad. It has centripetal drainage, and is finally drained by the south flowing Manipur river. The hill ranges on either side of the valley run practically to the same height a little over 2,500 m and have flat rolling tops. The Barak is the largest river in the Manipur hills. It arises from the Japvo peak and flows south-west for 180 km parallel to two ranges lying on either side, before turning its course first to north and then to the west through the Cachar plains of Assam.

**Meghalaya :** The Meghalaya plateau, though now a part of the north eastern ranges, is really an east ward extension of the massive block of peninsular India lying to the east of the great gap in the Archnehn terrain, subsequently filled up with alluvium deposited jointly by the Ganga and the Brahmaputra. This ancient land was submerged partially by the encroaching sea during the mesozoic and early tertiary times and was uplifted slowly from the flow of the Tethys. The organic movement was so slow and free bulking that the sedimentary beds retained their horizontal character and gave rise to structural platforms, well developed in the Cherrapunji area. From the Surma valley in the south, the central and eastern parts of Meghalaya appear as an imposing table-land bordered by a great scarp and sloping steeply towards the plains. Waterfall rush down very rapidly and carve deep valleys through which swift flowing rivers descend to the plains. It is the ascending monsoon clouds over the frontal slopes and the side valleys that have made Cherrapunji world famous as the meteorological station that

records the highest rainfall and they account for the regional name Meghalaya (megh-cloud, alaya-abode). Physiographically and administratively as well, the central and eastern parts can be grouped together under the name Khasi hills and Jaintia hills and the western part, the Garo hills which is lower in elevation and rise more gently from the southern plains.

**Garo Hills :** This hilly tract covers 800 km<sup>2</sup> and has enabled the Brahmaputra to change its course from the west to south along its western edge. The Surma plains with their marshed and meandering streams lie at its southern foot. The Tura range and the Simasang valley are the two most important physiographic units of this region. The Tura range extend the highest peaks of the Garo Hills, Nokrek (1,412 m), (Megonggiri 1,283 m) Meimiran (1,196 km) and Gowangdara (1,011 m). Along the northern fault line flows the Simsang river eastwards for about 45 km before turning south through a deep valley, separating the Tura range from the Kylas range and ultimately coming down to the plains near Baghmara. In the plains this river is called Someswari.

**Khasi & Jaintia Hills :** The central and the eastern parts of Meghalaya covers 14,375 km<sup>2</sup>. Physiographically it may be sub-divided into three sections, the northern hills, the central plateau and the southern hills. The northern section has an undulating hilly topography, rising almost to the same height and extending northwards to the Brahmaputra. The summits of these hills vary between 170 and 820 m. The Nongpoh village, lying half-way between Shillong and Guwahati standing on a flat top 700 m high, is a typical hill of this section.

The central plateau of the Khasi hills covers about 5,000 km<sup>2</sup>. Its outer limit is defined roughly by a 1,500 m contour line. This contains remnants of uneven surfaces, ranging in height from 1,500 m to 2,083 m. The Shillong hills towering above Shillong town contain the highest surface stretching E.S.E. - W.N.W., over which streams meander before plunging into the deep valleys of Umiam and the umkhen. The presence of many rapids and waterfalls in the neighbourhoods of Shillong town indicate to a recent uplift. To the south of the Shillong hills around

Myliem occurs a typical trinitic topography with rounded hills and shallow valleys. Further south occurs a vast structural platform on which stands Cherrapunji. This part of the central plateau is built of gently dipping sandstones of the Cretaceous age and over its edge the magnificent Mawmai waterfalls add to the scenic beauty. Small, rounded limestone hills of the Eocene age found scattered all over the Chatta plateau, some of them contain small caverns with narrow under-ground passages and characteristic cave deposits. From Cherrapunji the plateau slopes very gently southwards for about 6 km and then falls rapidly to the plains, the ground slope conforming to the high dip of the sedimentary rocks.)

**Mizoram** : Mizoram is situated in the extreme south of the NE region, the Mizo hills used to be known as the Lushai hills comprising long north-south spreading parallel ranges and intervening valleys which are unique in nature. A traverse from the Tripura border in the west to the eastern frontier along 23.45' N parallel will reveal the presence of eight smaller ranges of the eastern type. The slope is much steeper in the west than in the east.

**Nagaland** : This State is bordered on the east by the Naga range which (like the Patkai) forms the watershed between India and Burma. The Teju is the only river that has cut through the Naga range and flows east to the Chindwin river of Burma. Saramati is the highest peak (2,826 m) on the Naga range and there are other peaks over 2,000 m high. Further west are the Kohima hills, the highest

peak of which is Japve (2,995 m). The country rock is hard slaty shales of the tertiary and pre-tertiary age. On weathering it has given rise to a very ruddged topography. The range and valley type of topography dominates the greater part of the Kohima hills. Serrated ridges dotted with dense forests which are found to alternate with deep valleys containing fast-flowing rivers. The drainage is of the trellis type of folded structure.

**Tripura** : Tripura situated between 22°56' and 24°32' north latitude and 90°10' and 92° east longitudes comprises of long ranges alternating with valleys. This range and valley type of topography has rendered communications very difficult and the transport problem in the State has been acute since the creation of Pakistan Presently Bangladesh which almost encircles it. The Tripura hills can be divided physiographically into four valleys named after the towns of Dharmanagar, Kailasahar, Kamalpur and Khawai and one upland named after Agartala. The Gomti is the largest river. It receives a number of south flowing streams and cuts right across the ranges in a steep-sided valley from east to west before emerging out of the hills near Radhakishorepur. There are a number of waterfalls in its channel through the Dumbure hills and the landscape is exceedingly picturesque.

#### AREA AND POPULATION :

The geographical area of the seven states, total population, density of population, percentage of scheduled tribes and literacy are presented in Table- 1.1

TABLE 1.1  
AREA AND POPULATION OF N.E. REGION

States	Geographical Area (Sq.Km.)	Total Population (in '000)	Density of Population/ Sq.Km. (1981)	Percentage Of Scheduled Tribes (1971)	Percentage of Literacy (1981)
Arunachal Pradesh	83,578	632	7	79.07	20.09
Assam	78,523	19,897	253	10.98	NA
Manipur	22,356	1,421	63	31.12	41.52
Meghalaya	22,489	1,336	59	80.43	33.35
Mizoram	21,087	494	23	94.27	59.50
Nagaland	16,527	775	47	88.56	41.99
Tripura	10,477	2,053	195	28.92	41.78
Total	2,55,037	26,608			
All India	32,87,780	6,85,185	208		36.23

Nearly 90% of the population are rural and agriculture is the most dominant vocation of the people. Among the workers of the region 60.08% are cultivators, 9.28% are agricultural labourers while 7.82% of the workers are connected with livestock, forestry, fishery and such other allied activities. Out of the constituent states Assam accounts for 75% of the human population with the highest density of 253 persons per sq.Km. Tripura is next in the density of population having 195 persons per sq.Km. while the rest of the states are rather thinly populated, Arunachal Pradesh having only 7 persons per sq.Km. The percentage of schedule tribes population is rather high. The schedule tribes are divided into a large number of isolated ethnic groups having a wide diversity of culture and traditions. The percentage of literacy is highest in Mizoram being 59.5% which is one of the highest rate of literacy in the country also. The literacy percentage of the other states are Arunachal Pradesh-20.09, Manipur-41.52, Meghalaya-33.35, Nagaland-41.99, Tripura-41.78 respectively as per census of 1981. The land utilisation pattern and the area under irrigation are shown in Table-1.2

pockets representing sub-alpine, temperate, sub-tropical and tropical areas. Such variations are sometimes met within a small area itself, making the flora and the agricultural practices very specific to small units. The Himalayan range in Arunachal Pradesh extending to 5000 metres near Shela Pass and 3000 metres at Tawang, in the Kameng district, represent a typical temperate zone covering alpine areas. At low elevations there are the Naga hills, Mikir hills Shillong plateau within an altitude of 1300 to 2000 metres covering mild temperate to sub tropical climate. The Imphal valley at 750 metres elevation surrounded by the hills present a typical sub-tropical climate. The plains of Tripura, Assam and other states are mainly the tropical areas

North-East India lies to the south of the east end of the great Himalayan range. The jungle-covered hills of Patkai, the Chin hills and the Yomas with an average highest of 1,800 metres and rising places to 3,600 metres separate it from Burma. Important orographical features like Khasi-Jaintia and Garo Hills and, to some extent the Karbi Anglong hills, have an influence on climate of the area. Brahmaputra and

TABLE 1.2  
LAND UTILISATION PATTERN IN N.E. REGION 1985

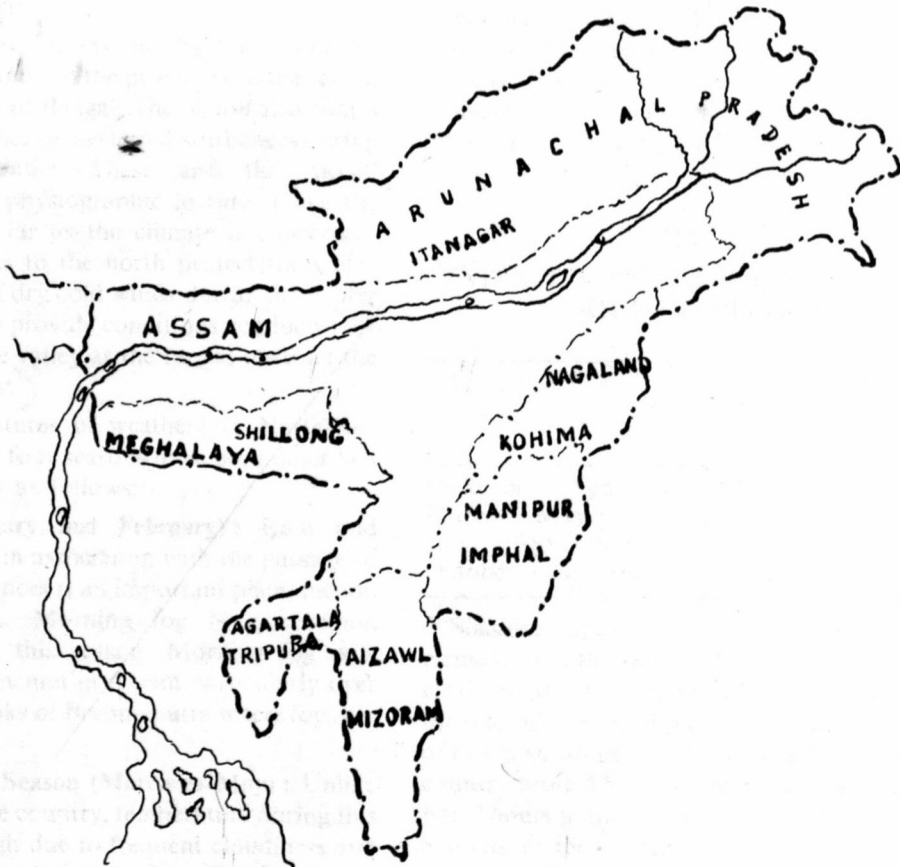
States	Reported Area (Sq.Km.)	Area under Forest (Sq.Km.)	Area not available for cultivation (Sq.Km.)	Net area sown ('000 ha)	Area sown more than one ('000 ha)	Cropping Intensity (%)	Area under food grains ('000 ha)	Total irrigated area ('000 ha)
Arunachal Pradesh	5559	5154	19	112	16	113.04	134	2
Assam	7852	1964	2415	2679	632	123.59	2505	57
Manipur	2211	602	1445	140	73	152.14	178	6
Meghalaya	2249	812	315	193	30	117.42	132	4
Mizoram	2102	1303	211	77	29	136.36	33	3
Nagaland	1042	288	49	150	NA	100.00	130	3
Tripura	1048	578	120	246	139	156.50	308	3

#### CLIMATE :

The wide altitudinal differences along with varied physiography contribute to great climatic variation in the entire region. There are definite

tributaries which pass almost through the middle also affect the climate of the region.

The Assam valley through which the Brahmaputra and its tributaries flow has only



**FIGURE 1-1 : MAP OF NORTH EASTERN REGION  
SHOWING THE SEVEN STATES**

gentle slope from the northeast to the west. The level of the valley ranges from 130 metres in the east to 30 metres in the west. The northern parts of the valley are characterised by a steep slope. The southern hill ranges, however, slope gradually to the southern edge of the valley. In the north and extreme north-eastern parts of the region there are marked variations in the topographical features. The consequent variations in altitudes, cause climatic conditions to vary considerably within short distances. Considerable contrasts in temperature and rainfall occur with heavy rainfall along the windward side of the hills and low rainfall with relatively warm conditions in the rain-shadow parts.

The southwest monsoon has considerable influence on account of the proximity of the region to the north Bay of Bengal. The region also comes under the influence of western disturbances during the winter months. These and the special orographic and physiographic features make the area unique so far as the climate is concerned. Mountain ranges to the north protect the valley from the flow of dry cold winds during the winter months and also provide conditions conducive for heavy rain in the valley as the ranges obstruct the monsoon current.

The main features of weather in North-east India during the four seasons have been described by I.M.D.(1982) as follows:

**Winter (January and February):** Rain and thundershowers in association with the passage of western disturbances is an important phenomenon in this seasons. Morning fog is a common phenomenon in this season. Morning fog is a common phenomenon in Assam particularly over the southern banks of Brahmaputra where fogs are frequent.

**Hot Weather Season (March to May):** Unlike other parts of the country, temperature during this season is not high due to frequent cloudiness and rain on a large number of the days. The weather is, however, very humid and is uncomfortable. Thunderstorms, frequently accompanied by squalls, are the main weather phenomena during this season.

**Monsoon Season (June to September):** South-West monsoon's relatively cool and humid current sets in over southern parts in the last week

of May. The monsoon advances into northern parts of the region during the first week of June. The major portion of the annual rainfall is received during this season. Floods are a regular feature during the monsoon season.

**Post Monsoon Season (October to December):** Though rainfall is the main phenomenon during the earlier parts of this season, morning fog occurs on some days towards the end.

**Radiation:** Energy from the sun is in the form of shortwave radiation. Radiation balance between the incoming shortwave radiation and outgoing longwave radiation determines the energy budget over an area. Apart from the geographical and other parameters like latitude, sun's declination angle etc. Weather factors like cloud and fog also control the energy budget. Table 1.3 gives the intensity of solar radiation received over North-east India during different periods.

TABLE 1.3

INTENSITY AND TOTAL ENERGY OF SOLAR RADIATION

Period	Energy in calories per cm <sup>2</sup> per day	Total energy in Billion KWH
December – February	350	1072
March – May	550	1721
June – September	500	2075
October – November	400	830

**Sunshine:** Sunshine is an important atmospheric element. It is the source of energy received by the earth and its atmosphere and the primary factor in the photosynthesis of plants. The average duration of bright sunshine over the area is the lowest in the country being 4 hours in the monsoon season. It is 6 to 7 hours in the pre and post monsoons and 7 to 8 hours in the winter.

**Temperature:** Heat and cold waves are very rare in North-east India. So far as temperature is concerned, there is not much difference between the hot weather and the monsoon seasons, average maximum temperature during the monsoon season being higher than that during the hot weather season at many places over the plains.

Temperatures are highest during July/August

inspite of the rains. The day temperatures in the monsoon season often increase due to decrease in cloudiness and rainfall during the periods of formation of monsoon depression over the head of Bay of Bengal. In the Brahmaputra Valley 'Föhn effect' may also be present. Nights in Assam also are very warm during July and August. Table 1.4 and 1.5 give the mean maximum and mean minimum temperatures respectively at a number of stations in North-east India.

**TABLE 1.4**  
**MEAN MAXIMUM TEMPERATURE (°C)**

Stations	Seasons			
	Winter	Pre-monsoon	Monsoon	Post monsoon
Dhubri	24.1	30.5	30.2	26.4
Guwahati	25.1	30.9	32.0	27.7
Tezpur	24.5	29.9	31.9	27.5
Sibsagar	23.3	28.4	31.9	26.8
Dibrugarh	23.1	28.0	30.5	26.9
Lumding	25.1	32.1	32.7	27.2
Silchar	26.3	31.0	31.5	28.9
Tura	25.0	31.1	29.2	26.7
Cherrapunji	16.3	21.5	22.6	19.7
Shillong	16.3	23.0	23.9	19.0

**Surface wind :** Surface winds are generally light during the year. During the premonsoon season,

**TABLE 1.5**  
**MEAN MINIMUM TEMPERATURE (°C)**

Stations	Seasons			
	Winter	Pre-monsoon	Monsoon	Post monsoon
Dhubri	13.0	20.9	25.0	18.4
Guwahati	11.9	19.8	25.4	17.1
Tezpur	12.5	19.9	24.8	16.9
Sibsagar	11.3	19.3	25.1	16.4
Dibrugarh	11.5	18.9	24.2	15.9
Lumding	9.6	18.6	24.5	15.8
Silchar	12.7	20.4	24.7	17.9
Tura	13.6	21.2	23.0	16.7
Cherrapunji	9.1	14.8	18.1	12.2
Shillong	5.3	13.4	17.5	8.0

they are slightly stronger – being particularly so on occasions of passage of low pressure systems to the north of the region. Winds are generally from the north in the winter months. They are, however, light easterly in the northern region in the pre-monsoon season. During the season, they are from the southeast in the southern parts and from the east in the northern parts of the region during the post-monsoon season. Table 1.6 gives the monthly mean wind speeds in Km/h at some stations in the area.

**TABLE 1.6**  
**MEAN WIND SPEED (Km. p.h.)**

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Decr.
Dhubri	4.4	5.1	7.0	8.5	8.0	6.8	6.1	5.4	5.3	5.0	4.5	4.5
Guwahati	2.3	3.1	4.0	4.5	4.1	3.5	2.9	3.2	3.0	2.9	2.4	2.3
Tezpur	2.4	3.2	5.0	6.7	4.5	2.8	2.5	2.3	2.3	1.9	2.1	2.1
Sibsagar	2.7	4.0	5.5	5.9	5.9	5.7	5.6	5.1	4.6	3.2	2.4	2.3
Dibrugarh	1.7	2.2	2.9	3.4	2.8	2.7	2.7	2.4	2.2	1.8	1.5	1.6
Silchar	1.4	1.8	2.5	2.7	2.4	1.9	1.9	1.8	1.6	1.4	1.5	1.2
Tura	5.3	6.8	7.8	10.1	10.2	6.4	6.4	5.6	5.1	4.6	4.6	5.1
Cherrapunji	6.7	9.3	11.8	11.9	11.7	11.9	11.5	8.5	7.0	6.1	5.3	5.4
Shillong	2.6	3.9	6.2	8.0	6.9	4.7	3.9	3.2	2.7	2.3	2.0	2.3

**Humidity :** Weather over North-east India is humid in all the seasons. The relative humidity rarely goes below 75%. This is the main cause of human discomfort, particularly during the hot weather and the monsoon seasons. Table 1-7 shows the mean seasonal relative humidity for the morning and evening hours (8:30 A.M. and 5:30 P.M.)

**TABLE 1-7**

**HUMIDITY (morning / evening) (in percentage)**

Stations	Seasons			
	Winter	Pre-monsoon	Monsoon	Post monsoon
Dhubri	80/60	72/60	87/85	83/74
Guwahati	83/62	75/60	85/80	87/74
Tezpur	81/67	73/64	86/81	81/79
Sibsagar	88/76	80/73	85/81	88/83
Dibrugarh	85/75	75/75	87/83	82/81
Silchar	81/60	75/64	86/81	83/74
Tura	73/65	72/64	89/86	81/77
Cherrapunji	62/76	73/78	91/93	68/84
Shillong	61/77	55/65	81/85	66/87

**Cloudiness :** Cloudiness is maximum over the region during the monsoon and minimum during the winter.

**Rainfall :** Rainfall occurs in all the seasons of the year in North-east India. Annual rainfall varies from about 2,000 mm to 4,000 mm in the area, the highest values being in the North-eastern parts and in the Khasi-Jaintia hill region. The hills and mountain ranges in the North-east India produce striking variations in rainfall over the region (Fig. 1.2). On the southern slopes of Khasi-Jaintia hills, the annual rainfall is over 10,000 mm. It drops down to 2,000 mm in the north of the Brahmaputra Valley.

The rainfall of Meghalaya varies considerably from place to place. The central parts of Meghalaya are famous for the phenomenally high rainfall experienced there. The average annual rainfall over the area exceeds 7,000 mm. The central upland zone has an east-west orientation and brings the northern and adjoining central Meghalaya in the rain-shadow region. This factor

is responsible for the large variations of rainfall from south to north. Cherrapunji in the south records an annual rainfall of 10,869 mm whereas Shillong which lies 50 kms to the north records an annual rainfall of 2,253 mm only. Even though the period of availability of rainfall data is not long, Mawsynram, a village situated about 16 kms west of Cherrapunji records the world's highest annual average rainfall of 11,406 mm. In contrast, the Imphal-Lumding region which partly lies in the rain shadow of the Mikir hill range records the lowest annual-monsoon rainfall as mentioned earlier.

**Winter Season :** During this season eastward passage of western disturbances along the foot hills of the Himalayas causes rainfall over North-east India. The average rainfall exceeds 50 mm. In the extreme North-east, the average rainfall exceeds 100 mm.

**Hot Weather Season :** A large part of the annual rainfall in North-east India occurs in this season. The seasonal rainfall varies from 300 mm to 800 mm. It exceeds 1,000 mm in the Cherrapunji, Halfong, Silchar region. Rain occurs mostly in association with thunderstorms. 25% of the total annual rainfall occurs during this season. Unlike most parts of the country, variability of rainfall is low, being about 20% over the area; it is even lower towards the North-east.

**Monsoon Season :** This is the principal rainy season for North-east India like most of the other parts of the country. Though there is a perceptible increase in the rainfall as monsoon sets in, the monsoon season merges with pre-monsoon season and the transition is not as sharp as in the other parts of the country. About 65% of the total rainfall occurs during the season. The amount of seasonal rainfall generally varies from 1,000 mm to 2,000 mm. The maximum of over 4,000 mm occurs over the Cherrapunji plateau (with Cherrapunji itself recording over 8000 mm) and in some places of Arunachal Pradesh. The minimum of less than 800 mm occurs over the Imphal-Lumding region. The variability of rainfall is less than 20% during this season in Assam and becomes less than 15% towards the extreme North-eastern parts of the region. Orographic influence of the Khasi and Jaintia and Mikir hills ranges protruding into Assam Valley almost in the middle plays a dominant role and considerably changes the

monsoon rainfall pattern in Assam, Meghalaya and the adjoining areas. Otherwise, rainfall generally increases from west to northeast.

**Post-monsoon Season:** Rainfall towards the beginning of the season is due to the retreating south west monsoon. Towards the end of the season it is mainly due to the eastward passage of western disturbances along the foot hills of the Himalayas. The rainfall is generally about 2,000 mm during this season which is about 7% of the total annual rainfall. Table 1.8 gives the seasonal and annual rainfall at selected stations.

**TABLE-1.8**  
**SEASONAL AND ANNUAL RAINFALL**  
(inmm)

Stations	Seasons				Annual
	Winter	Pre-monsoon	Monsoon	Post-monsoon	
Dhubri	29.7	623.8	1774.4	159.0	2586.9
Guwahati	35.6	455.4	1050.9	92.8	1634.1
Tezpur	40.9	477.0	1192.1	137.2	1847.2
Sibsagar	80.3	668.0	1613.7	177.3	2539.3
Dibrugarh	96.3	657.1	1841.3	201.7	1796.4
Halflong	56.9	708.2	1269.6	243.1	2277.8
Silchar	69.4	946.4	2082.3	249.6	3347.7
Lumding	45.0	303.5	819.2	150.3	1318.0
Imphal	51.6	341.6	867.4	151.9	1412.5
Kohima	45.2	336.3	1375.7	162.8	1920.0
Agartala	40.1	556.0	1237.5	190.8	2024.4
Passighat	151.4	876.9	3147.8	318.0	4494.2
Tura	82.0	701.8	2289.1	270.1	3293.1
Cherrapunji	71.6	2223.3	8016.5	558.8	10869.4
Shillong	43.2	497.9	1479.6	232.6	2253.3

**Evaporation:** In general, evaporation decrease from the south-west to the north-east of the region. The mean daily evaporation is generally about 5 mm in winter season. It varies from 15 to 20 mm during the premonsoon season being much less in the north-eastern parts of the region. It is generally about 15 mm during the monsoon season and less than 10 mm in the post monsoon season.

**Evapotranspiration:** The mean annual potential evapotranspiration is between 1000-1200 mm over the region. It varies from 100 to 150 mm in winter and 300 to 400 mm in the pre-monsoon season. It

is 400-500 mm in the south-west monsoon season and falls off to about 200 mm in the postmonsoon season. Table 1-9 gives the values of the normal seasonal and annual potential evapotranspiration (mm).

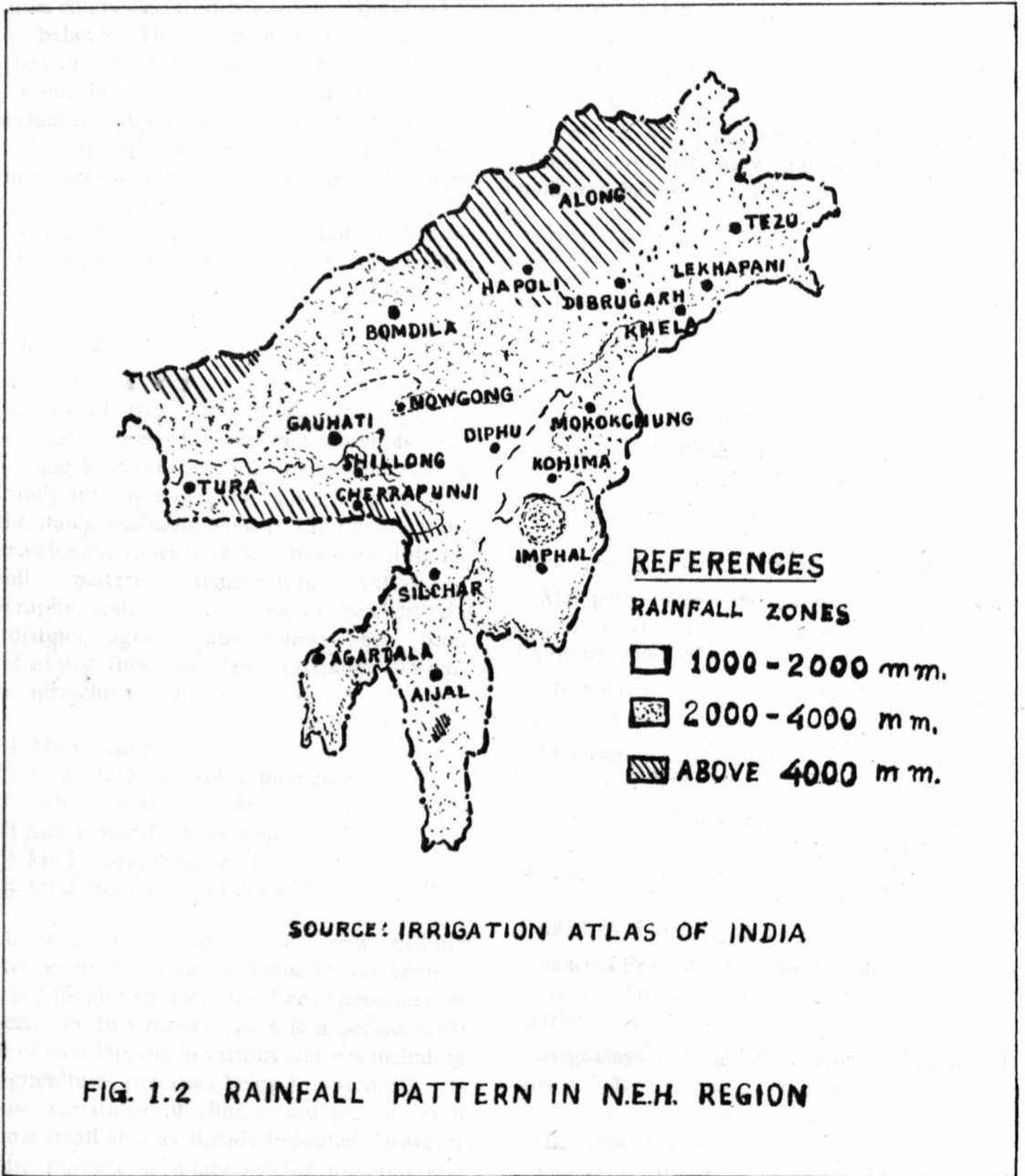
**TABLE-1.9**  
**NORMAL SEASONAL ANNUAL**  
**POTENTIAL EVAPOTRANSPIRATION**  
(in mm)

Station	Seasons				Annual
	Winter	Pre-monsoon	Monsoon	Post-monsoon	
Dhubri	137.8	417.5	444.6	236.0	1236.5
Guwahati	113.2	346.9	399.4	200.0	1061.0
Tezpur	124.2	375.1	449.2	217.6	1166.6
Sibsagar	114.7	373.0	543.1	225.4	1256.8
Dibrugarh	102.0	301.0	411.2	181.4	996.2
Silchar	137.6	370.9	430.7	237.2	1185.9
Tura	147.5	450.6	398.3	222.8	1219.6

**Fog:** Prevalence of fog is an important phenomenon over North-east India during the winter months. The Brahmaputra and its tributaries are the source of moisture in the Assam Valley. The prevailing mountain winds predominantly from the northeast tend to concentrate the moisture evaporated from the river beds and cause fog over the southern banks of the river. However, after the rains associated with western disturbances, widespread fog occurs even on the Northern banks. Frequency of occurrence of fog is more over the southern banks than over the northern banks. Another region of general occurrence of fog is the valleys of Arunachal Pradesh. Table 1.10 gives the average

**TABLE-1.10**  
**AVERAGE NUMBER OF DAYS OF**  
**OCCURRENCE OF FOG**  
**(DECEMBER AND JANUARY)**

South Bank	North Bank
Guwahati	35 Dhubri 16
Jorhat	44 Tezpur 10
Dibrugarh	36 North Lakhimpur 9
	Passighat 1



number, of days of occurrence of fog during December and January.

**Water Balance :** The idea of the water budget of any area can be had from the study of the climatic water balance. The water budget of the area depends on the precipitation, evapotranspiration and water holding capacity of the soil and is important from the agricultural point of view of an area. The annual water surplus is generally over 100 mm over the whole North-east India. It is over 200 cms over southern Meghalaya. However in the northern parts of the region including Assam, there is a slight annual water deficit being less than 20 cms.

### AGRO-CLIMATIC ZONES

There has not been much serious attempts at delineation of the entire region into specific agro-climatic zones. However some attempts have been made to divide the hills region and Assam separately into agro-climatic zones. (Fig 1.3) As for the states, excluding Assam, the classification of agro-climatic zones have been based on altitude, rainfall pattern, temperature variations, topography, soil etc. According to these criteria six distinct agro-climatic zones have been identified for these six states excluding Assam. These agro-climatic zones are :

- (1) Alpine zone
- (2) Temperate and sub alpine zone
- (3) Sub tropical hill zone
- (4) Sub tropical plains zone
- (5) Mild tropical hill zone
- (6) Mild tropical plain zone

Although the above groups show distinct differences in broad agro-climatic characteristics, yet it is difficult to draw a clear line of demarcation between any two zones. There is a considerable scope of over lapping in various features including the agricultural practices being followed. This is because variations of climate are present even within a small area as already indicated. However for the purpose of planning for research and development, the above delineation will serve the primary objectives.

Similarly based on rainfall, terrain and soil characteristics the State of Assam has also been broadly classified into six agro climatic zones.

These are :

- (1) North bank plains
- (2) Upper Brahmaputra valley
- (3) Central Brahmaputra valley
- (4) Lower Brahmaputra valley
- (5) Barak valley
- (6) The Hills zone

Some of the important areas covered by the above mentioned twelve agro-climatic zones are indicated below :

#### (i) Alpine Zone :

Gorichen, Upper Tawang, Tulungla, Bumla, Shela pass areas of West Kameng District, Jidu and adjoining areas of Northern Siang in Arunachal Pradesh.

#### (ii) Temperate and Sub Alpine Zone :

**Arunachal Pradesh** – Tawang, Dirang, Bomdila, Shergaon areas of West Kameng District, Dibang valley, Northern part of east Siang, Upper Subansiri district, part of West Siang around Anini and North Eastern part of Lohit district.

**Manipur** – Mao and Maran areas of North district, Ukru and adjoining areas of east district, Laithang areas of central district.

**Meghalaya** – Upper Shillong, Mawphlang and Mairang of East Khasi hills district.

**Mizoram** – Blue mountain, Halikhan, Tuipang, Nauzuarzo, Tiang.

**Nagaland** – Tuensang and Zuneboto district, Vangkong area of Wokha district, higher areas of Mokokchung district.

#### (iii) Sub Tropical hill zone :

**Arunachal Pradesh** – Changyak, Naga and Khonsa areas of Tirap district, Basar area of Siang district.

**Meghalaya** – Jowai sub-division of Jaintia hills, part of Nongstoin sub-division, Nokrek and Kailash areas of West Garo hills and Western part of East Garo hills.

**Mizoram** – Whole state except lower valleys of Northern and Western part, areas adjoining Cachar district and lower parts of Chhimituipuii district.

**Nagaland** – Mokokchung district, lower part of Kohima, Wokha district and Mon district.

**(iv) Sub Tropical plains zone :**

**Manipur** – Imphal valley

**Meghalaya** – Umkiang area of Jaintia hills.

**Nagaland** – Bhaghti and Longnak valley.

**(v) Mild Tropical hill zone :**

**Arunachal Pradesh** – Southern part of lower Subansiri district.

**Manipur** – Manipur West District including Juiban area, Churachandpur and Thanlon of South District, Morena area of Central District.

**Meghalaya** – Southern part of Jowai sub-division adjoining Karimganj, Cachar and North Cachar district of Assam, Southern part of Nongpoh sub-division of Khasi hills, Eastern part of East Garo hills and West Khasi hills.

**Mizoram** – Lower valley of Northern and Western parts and Chhimiupuii district.

**Nagaland** – Medziphema area of Dimapur sub-division.

**Tripura** – Jampui hills.

**(vi) Mild Tropical Plain Zone :**

**Arunachal Pradesh** – Pasighat area, Singphow area of Tirap district and lower parts of Lohit district.

**Meghalaya** – Lower part of West Garo hills district.

**Mizoram** – Areas adjoining Cachar districts of Assam and North Tripura district.

**Nagaland** – Southern part of Dimapur sub-division excluding Medziphema area.

**Tripura** – Major part of Tripura excepting Jampui hills.

**(vii) North Bank Plains Zone :**

Lakhimpur, Sonitpur and Mongoldoi districts of Assam.

**(viii) Upper Brahmaputra valley Zone :**

Dibrugarh, Sibsagar and Jorhat district including Majuli island.

**(ix) North Brahmaputra valley Zone :**

Nowgong district of Assam.

**(x) Lower Brahmaputra valley Zone :**

Kamrup, Borpeta, Kokrajhar and Goalpara districts of Assam.

**(xi) Barak valley Zone :**

Cachar district of Assam.

**(xii) Hills Zone :**

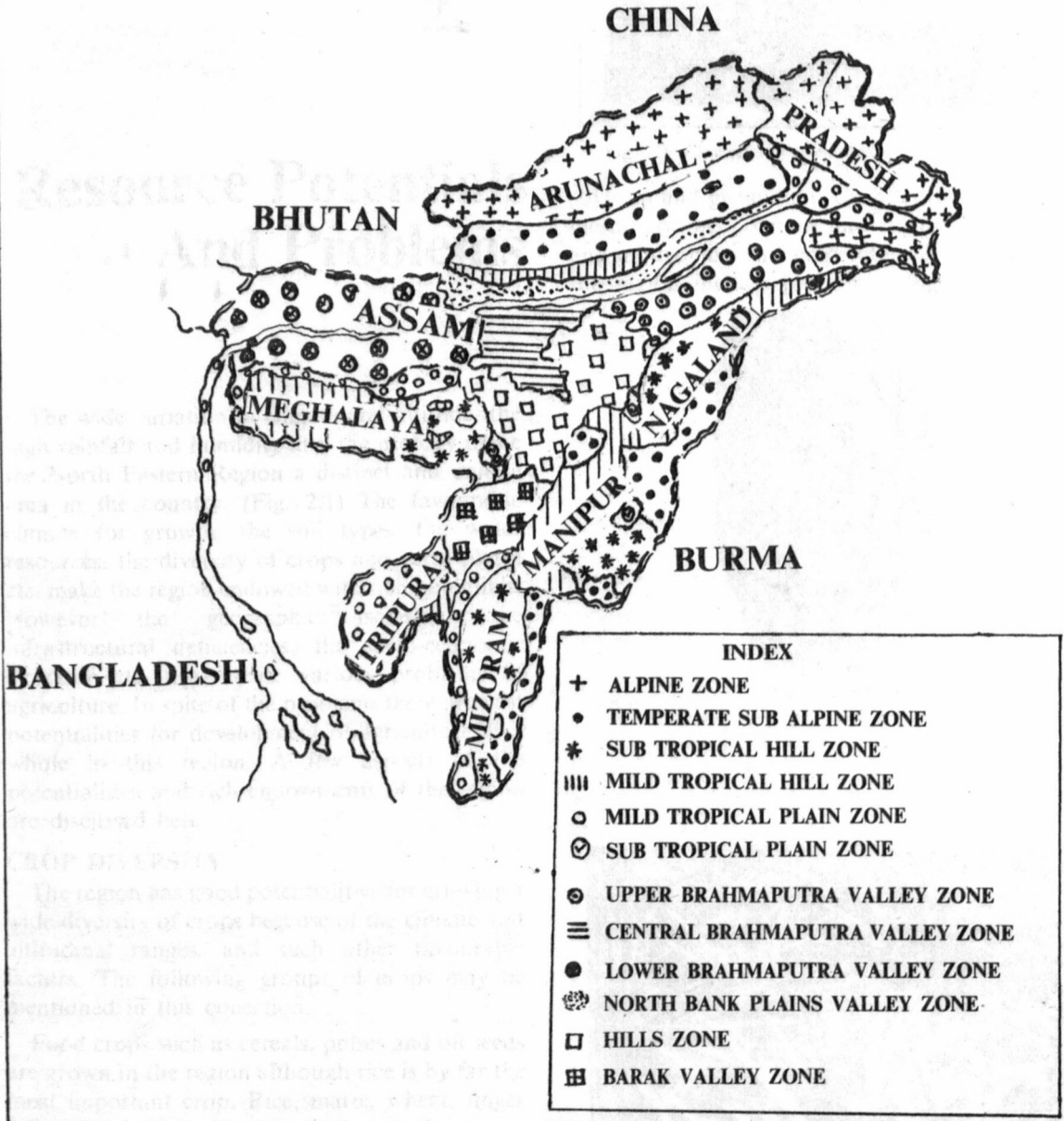
Karbi Anglong and North Cachar Hills districts of Assam.

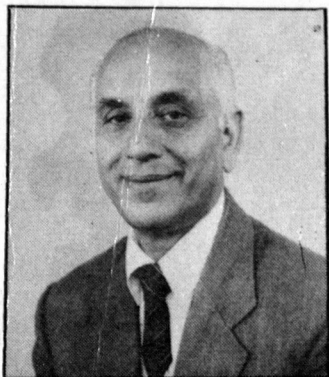
**VEGETATION**

The region is very rich in its natural vegetation. Plant hunters from various parts of the world have surveyed the region and yet there are areas which have not been fully surveyed or exploited. The Botanical Survey of India have discovered about 70 new species in the region belonging to 50 genera, not known to the world earlier. The Botanical Survey of India sources also report the existence of about 10,000 species in the region which is almost 50% of the total flora of the entire country. Still very little is known about the total rich forest vegetation of the region. (The region is also considered as the primary or secondary source of origin of many crops and plants. Large number of cultivated and wild species of various crops and plants are available. Besides, a large variety of economic plants such as medicinal and aromatic plants, tree fodders, fruit and food producing trees, oil seed and dye producing trees, spices and ornamentals including orchids grow wild in nature. The vegetation of the region shall be discussed in the concerned chapters of the crops.)

# MAP SHOWING THE AGRO-CLIMATIC ZONES OF N.E. REGION

FIG 1.3





*A Ph.D. in Plant Breeding and Genetics from the University of Missouri, U.S.A., Dr. Dhirendra Nath Borthakur started his service career as a research scientist in a tea research Institute in the year 1951. He has served for 35 years, in the north eastern region, in the fields of teaching, research and extension in agriculture in various capacities such as Lecturer & Associate Professor, Economic Botanist and Rice Specialist, Assam; Director of Research Director of Extension and Vice-Chancellor, Assam Agricultural University; Director, I.C.A.R. Research Complex for N.E.H. Region and Consultant, Agriculture & Allied Sectors, North Eastern Council. Besides being associated with development of improved varieties and production technology of rice, cropping pattern for flood-prone areas, alternative farming systems to replace shifting cultivation and collection & study of germplasm of the region, he was instrumental in development of research in all branches of agriculture as a research management scientist.*

*Dr. Barthakur is the author of over 140 scientific papers and also the Co-author, with Dr. J.M. Peehlman, of the book entitled "Breeding Asian Field Crop". He has been associated with the development of agriculture of the region and the country as a member of over 70 important committees constituted by the Govt. of India, I.C.A.R., Planning Commission, North Eastern Council and various State Govts. of the region. He has also visited several countries to study research and development in agriculture.*

*After retirement from service, he has been conducting research on impact of environment on crops and also working in two adopted villages for overall improvement through agriculture.*

This book is a comprehensive account of Agriculture in the North Eastern Region of India in its totality. The wide climatic as well as altitudinal variations within the region, combined with high rainfall, humidity and the acidic soils, make it an unique geographical area. There is also vast potential for agricultural development because of the wide variations mentioned above. However, there is no authentic compilation on the status of agriculture, its potentialities, the existing viable technology, the indigenous viable practices as well as the scope for development of the region. Further, the region also has specific problems of the unscientific and harmful method of cultivation known as Jhuming of shifting cultivation in the hills and the problem of chronic floods in the plains, affecting agricultural production. The book discusses all the relevant aspects of agriculture including the problems and possible solutions. The wide genetic diversity of various crops and plants have also been discussed in depth.

The problems of agriculture in the hill areas have also not been adequately discussed so far. This book specifically discusses the relevant aspects of agriculture in the hill region since the region primary comprises of the hills. The topics such as shifting cultivation, soil conservation and water-shed management, scientific land use, farming systems and cropping patterns for varying altitudes, horticultural development, sericulture and mushroom cultivation etc. are of common interest to the other hilly areas also. Similarly the problems and potentialities of the hills have been discussed in all other relevant chapters.

The chapter on Live-stock Farming of the region, written by expert on the subject, and the informations provided in the form of appendices make the book complete in all aspects of agriculture.