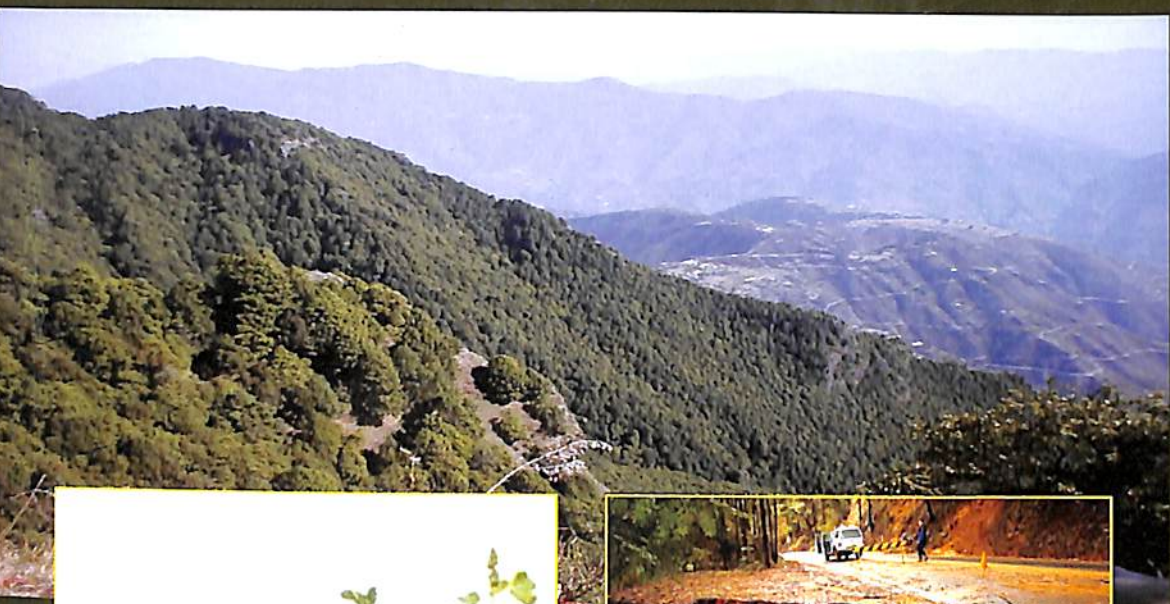


# Soil Resources of North Eastern States of India



**Utpal Baruah  
Anil Kumar Sahoo  
Dipak Sarkar**

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# Soil Resources of North Eastern States of India

This book, authored by three most experienced pedologists on "*Soil Resources of North Eastern States of India*" covers the gamut of soil resources in eight states of North Eastern India comprising Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. The Chapter I opens out with the Introductory chapter enumerating the general description of the states, the Chapter II deals with the Agroclimate of North Eastern Region. Soils and Land Uses in Different States of NER are described in detail in Chapter III. The Chapter IV elaborates on the Acid Soils of NER and their Extent, Distribution and Management. The Degraded and Waste Lands of NER and their Extent and Distribution are dealt in detail in Chapter V. Vulnerability of NER to Climate Change – A Severe Threat to Agricultural Sustainability and Food Security are highlighted in Chapter VI. The references cited in the text are given in the end of the book.

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### Foreword

Improving and sustaining the health of the soil resources which currently are reported to have been suffering from various ailments have been a matter of concern not only for those engaged in agriculture but also for those dependent on the food produced on these soils. It is now a well known fact that while some regions of the country are experiencing soil salinity, alkalinity etc., the regions like North Eastern part of the country are suffering from soil acidity and other related factors. In this region the leaching of top soil as well as the nutrients thereon under the influence of heavy rain bears greater significance.

Although researchers are engaged in improving the soil fertility status in the region with desired level of scientific output there from, a systematic survey covering the soils of entire North Eastern region and its availability to the user group was somehow missing. This missing link between what we have in our soil and what scientific steps to be taken has now been filled up through the publication of the present Book named "Soil Resources of North Eastern States of India" authored by Dr. Utpal Baruah, Dr. A.K. Sahu and Dr. D.Sarkar.

I am sure the researchers, Development departments and the farmers shall now be in a position to identify agro-climate similarity or dissimilarity of a particular eco-zone of a state with that of the other states of the region and take amelioration measures for their soils based on also the soil character of the state enumerated lucidly in this book. It will also help the planners to identify and develop suitable intervention measures for the degraded/eroded lands. What is more useful in this particular book is the chapter on the land use pattern and also the suggestion for moving on to the resource conserving and fertility status sustaining land use system.

With the upcoming importance of North Eastern Region in this era of globalisation and agri-trade particularly for trade between India and South East Asian nation, this book is seen as a vital resource for rejuvenating the health of its soil so as to make it conducive to produce food items 3-4 fold more than the current production so that the region is positioned well to capture the agri-trade opportunity by trading the surplus food produced on its soil so rejuvenated by developing the needed technological solutions as indicated under different chapters of the book.

I compliment the authors for carrying out the study and publishing it in the present form which, I am sure, will help the researchers, teachers, students, development departments and the people who appreciate the fact that the health status of the soil has to be maintained as they maintain their own health.

(K.M. Bujarbaruah)

# PREFACE

North eastern region of India comprising Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura, is often a talk about topic of primitive agriculture. It is, however, a land of enchanting cultural ethics nurtured in diversified climatic and topographical situations, which is still displaying, even in the 21<sup>st</sup> century, a scenario of backwardness, remoteness and inaccessibility amidst bountiful resources. Soils, the most important natural resource, that remains neglected over centuries in the North Eastern Region of India.

The book on **Soil Resources of North Eastern States of India** comprises of six chapters and it is the result of a novel exercise to highlight the state wise agro-climate, soil characteristics, soil genesis and classification, distribution of soils, land use, distribution of acid soils, status of degraded and wastelands including management issues of the soils of North-Eastern Region. After thorough and exhausting compilation of the various reports published by ICAR, New Delhi, NBSS & LUP (ICAR), Nagpur and its Regional Centre Jorhat and many others, it is attempted with utmost care to focus the main themes of the different topics in a comprehensive way.

We are extremely grateful to Dr. K.M. Bujarbaruah, Vice Chancellor, Assam Agricultural University, Jorhat for his suggestions and support for the publication of this book. We are thankful to him for writing the foreword of this book.

We are grateful to Today & Tomorrow's Printers & Publishers, New Delhi for helping us immensely by accepting to publish this book, which, we are sure will act as an important reference material on the subject.

It is believed that this publication will meet the growing needs of the students of soil science, environmental science, geography and may be useful to those interested in soil studies, including researchers, planners, and ultimately farmers, responsible for taking vital decisions on land use planning.

Utpal Baruah  
Anil Kumar Sahoo  
Dipak Sarkar

## LIST OF TABLES

CHAPTER	TABLE NO.	TITLE
II	2.1	Agro Ecological Regions of Planning Commission with corresponding NARP zones
	2.2	Agro Ecological Regions and Sub Regions of North East Region
	2.3	State wise Agro-ecological region, sub-region of North East Region
III	3.1	Physico-chemical characteristics of some dominant soils of Arunachal Pradesh
	3.2	Soil distribution in different categories in Arunachal Pradesh
	3.3	Various themes based on soil resource database of Arunachal Pradesh
	3.4	Description of Agro-ecological zones of Assam
	3.5	Physico-chemical characteristics of some dominant soils of Assam
	3.6	Distribution of soils in different categories in Assam
	3.7	Distribution of soils under different orders and sub orders in Assam
	3.8	Various themes based on soil resource data of Assam
	3.9	Description of Agro-ecological zones of Manipur
	3.10	Physico-chemical characteristics of some dominant soils of Manipur
	3.11	Soil distribution in different categories in Manipur
	3.12	Distribution of soil orders and sub orders of Manipur
	3.13	Various themes based on soil resource data base of Manipur
	3.14	Generalised solscape characteristics in thermic sub-region.
	3.15	Generalised soilscape characteristics in hyperthermic sub-region
	3.16	Physico-chemical characteristics of some dominant soils of Meghalaya
	3.17	Soil distribution of different categories in Meghalaya
	3.18	Various themes based on soil resource database in Meghalaya
	3.19	Description of Agro-ecological zones of Mizoram
	3.20	Physico-chemical characteristics of some dominant soils of Mizoram
	3.21	Soil distribution in different categories in Mizoram

- 3.22 Various themes based on soil resource database of Mizoram
  - 3.23 Description of Agro-eco zones in Nagaland
  - 3.24 Physico-chemical characteristics of some dominant soils of Nagaland
  - 3.25 Soil distribution in different categories in Nagaland
  - 3.26 Various themes based on soil resource database in Nagaland
  - 3.27 Physico-chemical characteristics of some dominant soils of Sikkim
  - 3.28 Major physiographic units and dominant soils of Sikkim
  - 3.29 Soil distribution in different categories in Sikkim
  - 3.30 Various themes based on soil resource data base of Sikkim
  - 3.31 Physico-chemical characteristics of some dominant soils of Tripura
  - 3.32 Soil distribution in different categories in Tripura
  - 3.33 Various themes based on soil resource database in Tripura.
- IV
- 4.1 Districtwise distribution of acid soils in Arunachal Pradesh
  - 4.2 Districtwise distribution of acid soils in Assam
  - 4.3 Districtwise distribution of acid soils in Manipur
  - 4.4 Districtwise distribution of acid soils in Meghalaya
  - 4.5 Districtwise distribution of acid soils in Mizoram
  - 4.6 Districtwise distribution of acid soils in Nagaland
  - 4.7 Districtwise distribution of acid soils in Sikkim
  - 4.8 Districtwise distribution of acid soils in Tripura
- V
- 5.1 Degraded and wasteland statistics of Arunachal Pradesh
  - 5.2 Degraded and wasteland statistics of Assam
  - 5.3 Degraded and wasteland statistics of Manipur
  - 5.4 Degraded and wasteland statistics of Meghalaya
  - 5.5 Degraded and wasteland statistics of Mizoram
  - 5.6 Degraded and wasteland statistics of Nagaland
  - 5.7 Degraded and wasteland statistics of Sikkim
  - 5.8 Degraded and wasteland statistics of Tripura

## LIST OF FIGURES

CH	FIG. NO.	TITLE OF THE FIGURE
I	1.1	North East India and its states
	1.2	Administrative map of Arunachal Pradesh
	1.3	Physiographic map of Arunachal Pradesh
	1.4	Administrative map of Assam
	1.5	Physiographic map of Assam
	1.6	Administrative map of Manipur
	1.7	Physiographic map of Manipur
	1.8	Administrative map of Meghalaya
	1.9	Physiographic map of Meghalaya
	1.10	Administrative map of Mizoram
	1.11	Physiographic map of Mizoram
	1.12	Administrative map of Nagaland
	1.13	Physiographic map of Nagaland
	1.14	Administrative map of Sikkim
	1.15	Physiographic map of Sikkim
	1.16	Administrative map of Tripura
	1.17	Physiographic map of Tripura
II	2.1	Agro climatic zones of India
	2.2	Agro climatic sub zones of NE India
	2.3	Bioclimatic map of NE India
	2.4 a.	Soil moisture regimes of NE India
	2.4 b.	Soil temperature regimes of NE India
	2.5	Model of determining length of growing period
	2.6	Length of growing periods of NE India
2.7	Agro-ecological subregions of NE India	
III	3.1	Agro-eco zones of Arunachal Pradesh
	3.2	Soil landform relationship in Hapoli Ziro area
	3.3	Soil landform relationship in Lower Subansiri area (Itanagar area)
	3.4	Soil landform relationship in Khonsa area
	3.5	Soil landform relationship in Namsai-Wakro area
	3.6	Soil depths of Arunachal Pradesh
	3.7	Surface texture of Arunachal Pradesh
	3.8	Agro-ecological zones of Assam
	3.9	Soil physiographic relationship in part of Assam
	3.10	Soil internal drainage of Assam
	3.11	Particle size distribution of Assam



## CONTENTS

	Page No.	
<b>Chapter I</b>	<b>General Description of the States of North Eastern Region</b>	<b>1</b>
	Arunachal Pradesh	4
	Assam	5
	Manipur	7
	Meghalaya	10
	Mizoram	12
	Nagaland	14
	Sikkim	17
	Tripura	19
<b>Chapter II</b>	<b>Agro-climate of North Eastern Region</b>	<b>22</b>
	Bioclimatic Regions	32
	Soil Moisture and Temperature Regimes	33
	Length of Growing Period	33
	Agro-ecological Regions and Sub Regions	35
<b>Chapter III</b>	<b>Soils and Land Uses in Different States of North Eastern Region</b>	<b>41</b>
	Soils and Land Uses of Arunachal Pradesh	41
	Soils and Land Uses of Assam	59
	Soils and Land Uses of Manipur	81
	Soils and Land Uses of Meghalaya	95
	Soils and Land Uses of Mizoram	108
	Soils and Land Uses of Nagaland	118
	Soils and Land Uses of Sikkim	130
	Soils and Land Uses of Tripura	146
<b>Chapter IV</b>	<b>Acid Soils of North Eastern Region – Their Extent, Distribution and Management</b>	<b>162</b>
	Arunachal Pradesh	163
	Assam	163
	Manipur	166
	Meghalaya	170
	Mizoram	171
	Nagaland	173
	Sikkim	174
	Tripura	176
<b>Chapter V</b>	<b>Degraded and Waste Lands of North Eastern Region – Their Extent and Distribution</b>	<b>180</b>
	Degraded and Waste Lands of Arunachal Pradesh	181

- 3.12 Agro-ecological zones of Manipur
- 3.13 Soil physiographic relationship in Tamenglong, Senapati and Imphal area of Manipur
- 3.14 Soil internal drainage of Manipur
- 3.15 Surface texture of Manipur
- 3.16 Agro-ecological zones of Meghalaya
- 3.17 Soil physiography relationship in East Khasi hills area of Meghalaya
- 3.18 Soil physiography relationship in Garo hills area of Meghalaya
- 3.19 Proportionate coverage of soils in Meghalaya
- 3.20 Soil depths of Meghalaya
- 3.21 Soil drainage of Meghalaya
- 3.22 Proportionate Soil Distribution of Mizoram
- 3.23 Soil internal drainage of Mizoram
- 3.24 Surface texture of Mizoram
- 3.25 Agro-ecological map of Nagaland
- 3.26 Proportionate coverage of soils of Nagaland
- 3.27 Soil drainage of Nagaland
- 3.28 Soil physiography relationship in part of Sikkim
- 3.29 Soil physiography relationship in Tripura
- 3.30 Land capability classes of Tripura
- IV 4.1 Acid soils of Arunachal Pradesh
- 4.2 Acid soils of Assam
- 4.3 Acid soils of Manipur
- 4.4 Acid soils of Meghalaya
- 4.5 Acid soils of Mizoram
- 4.6 Acid soils of Nagaland
- 4.7 Acid soils of Sikkim
- 4.8 Acid soils of Tripura
- V 5.1 Degraded and waste land of Arunachal Pradesh
- 5.2 Degraded and waste land of Assam
- 5.3 Degraded and waste land of Manipur
- 5.4 Degraded and waste land of Meghalaya
- 5.5 Degraded and waste land of Mizoram
- 5.6 Degraded and waste land of Nagaland
- 5.7 Degraded and waste land of Sikkim
- 5.8 Degraded and waste land of Tripura

# CONTENTS

	Page No.	
<b>Chapter I</b>	<b>General Description of the States of North Eastern Region</b>	<b>1</b>
	Arunachal Pradesh	4
	Assam	5
	Manipur	7
	Meghalaya	10
	Mizoram	12
	Nagaland	14
	Sikkim	17
	Tripura	19
<b>Chapter II</b>	<b>Agro-climate of North Eastern Region</b>	<b>22</b>
	Bioclimatic Regions	32
	Soil Moisture and Temperature Regimes	33
	Length of Growing Period	33
	Agro-ecological Regions and Sub Regions	35
<b>Chapter III</b>	<b>Soils and Land Uses in Different States of North Eastern Region</b>	<b>41</b>
	Soils and Land Uses of Arunachal Pradesh	41
	Soils and Land Uses of Assam	59
	Soils and Land Uses of Manipur	81
	Soils and Land Uses of Meghalaya	95
	Soils and Land Uses of Mizoram	108
	Soils and Land Uses of Nagaland	118
	Soils and Land Uses of Sikkim	130
	Soils and Land Uses of Tripura	146
<b>Chapter IV</b>	<b>Acid Soils of North Eastern Region – Their Extent, Distribution and Management</b>	<b>162</b>
	Arunachal Pradesh	163
	Assam	163
	Manipur	166
	Meghalaya	170
	Mizoram	171
	Nagaland	173
	Sikkim	174
	Tripura	176
<b>Chapter V</b>	<b>Degraded and Waste Lands of North Eastern Region – Their Extent and Distribution</b>	<b>180</b>
	Degraded and Waste Lands of Arunachal Pradesh	181

	Degraded and Waste Lands of Assam	183
	Degraded and Waste Lands of Manipur	185
	Degraded and Waste Lands of Meghalaya	186
	Degraded and Waste Lands of Mizoram	187
	Degraded and Waste Lands of Nagaland	189
	Degraded and Waste Lands of Sikkim	190
	Degraded and Waste Lands of Tripura	192
<b>Chapter VI</b>	<b>Vulnerability of North Eastern Region to Climate Change – A Severe Threat to Agricultural Sustainability and Food Security</b>	<b>194</b>

# Chapter-I

## General Description of the States of North Eastern Region

The North Eastern Region of India comprising contiguous of seven sisters states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura and the Himalayan state of Sikkim (Fig.1.1) occupies an area of about 26.2 m ha lies between  $21^{\circ}57'$  to  $29^{\circ}6'$  N latitude and  $89^{\circ}41'$  to  $97^{\circ}25'$  E longitude covering 8% and 1.3% of total area and population of the Country respectively. The Siliguri corridor in West Bengal with 21 to 40 km connects these regions with the main part of India. The region shares more than 4500 kms of international border (about 90% of its entire boundary) with China (South Tibet) in the North, Myanmar in the East, Bangladesh in the South West and Bhutan in the North West. Physiographically, this region is sub-divided into four broad zones: (i) Eastern Himalaya, (ii) Peninsular Plateau, (iii) Purvachal hills and (iv) Extension of Indo Gangetic alluvial plains.

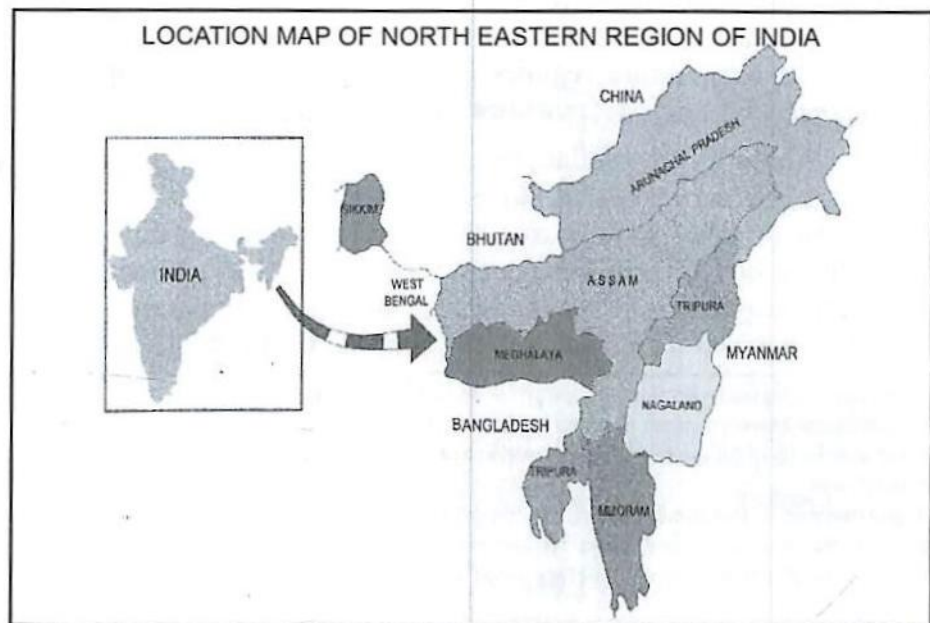


Fig. 1.1 North Eastern States of India

The eastern Himalaya is the great elevation of the Himalayan mountain system, in particular to its crystalline axis where the soft rock areas have been directly excavated by subsequent streams to form longitudinal valleys. The whole region is dissected by numerous rivers and their tributaries. Arunachal Pradesh and a little portion of northern Assam falls in this range. The Meghalaya Plateau comprising the Garo, Khasi, Jaintia and the outlying Karbi Anglong is a table land which is the eastward extension of the massive block of the Indian Peninsular shield. The plateau is mainly constituted by the rocks of the Pre-Cambrian age of a group of hard crystalline granites, gneisses and granulites.

The Purvachal hills comprise eastern part of Arunachal Pradesh, Nagaland, Manipur, Mizo hills and Tripura. The Eastern Himalaya takes a bend in Arakan ranges in NE to SW direction with consecutive ridges and narrow valleys with folding and faulting nature. The extension of Indo Gangetic alluvial plain is mainly represented by the Brahmaputra valley, a well demarcated physical unit within the girdle formed by the Eastern Himalaya, Patkai and Naga hills and the Garo-Khasi-Jaintia and the Mikir hills. Geologically the valley is built by the deposition of alluvium upon sag formed during the period of the rise of the Himalaya. Rice based mono cropping is the most dominant cropping pattern mostly in the valleys and flood plains whereas horticultural crops and plantation crops like tea grown mostly in the uplands, piedmonts and hill slopes. The temperature regimes of this region are \**Thermic*' and '*Hyperthermic*' and the moisture regime is mostly '*Udic*'.

About 14.02 million ha area (55%) is under forest cover, about 1.2 million ha. (4.70 %) is under cultivation and about 2.2 million ha (8.62%) is estimated to be not available for cultivation. The climate of the region varies from sub-tropical to extreme alpine type. The normal mean minimum and maximum temperatures vary between 18 °C to 32 °C in summer and 0 °C to 22 °C in winter.

---

**\*Thermic** – The mean annual soil temperature is 15°C or higher but lower than 22°C, and the difference between mean summer and mean winter soil temperatures is more than 5°C either at a depth of 50 cm from the soil surface or at a lithic or paralithic contact, whichever is shallower.

**Hyperthermic** – The mean annual soil temperature is 22°C or higher, and the difference between mean summer and mean winter soil temperature is more than 5°C either at a depth of 50 cm from the soil surface or at a lithic or paralithic contact, whichever is shallower.

**Udic** – The udic moisture regime implies that, in 6 or more out of 10 years, the soil moisture control section is not dry in any part for as long as 90 cumulative days per year.

Heavy fog is a common feature all over the hilly area. The NER falls under the high rainfall zone and the climate ranges from subtropical to alpine. The region is characterized by difficult terrain, wide variations in slopes and altitudes, land tenure systems and indigenous cultivation practices. Although cereals dominate the rain-fed hill ecosystem, dependence on livestock and horticulture as an alternative source of income is significant. The temperature in the snow-clad mountains is well below zero degrees. These hill states receive the maximum rainfall in the country and mean annual rainfall varies from 1400 mm to as high as 6000 mm in Arunachal Pradesh. Cherrapunji and Mawsynram (Meghalaya) are the wettest places in the world, which get annual rainfall of more than 11000 mm.

The region possesses a unique combination of landscape, geo-agro-climatic scenario which gives an excellent opportunity to study the development of soils under different landscape and climate. The shifting cultivation and deforestation in this region create a serious problem of soil erosion. For sustainable agricultural production and to meet up the needs of increasing population, it is required to know the characteristics of the soils of different landscape and their problems and potential for sustainable land use planning.

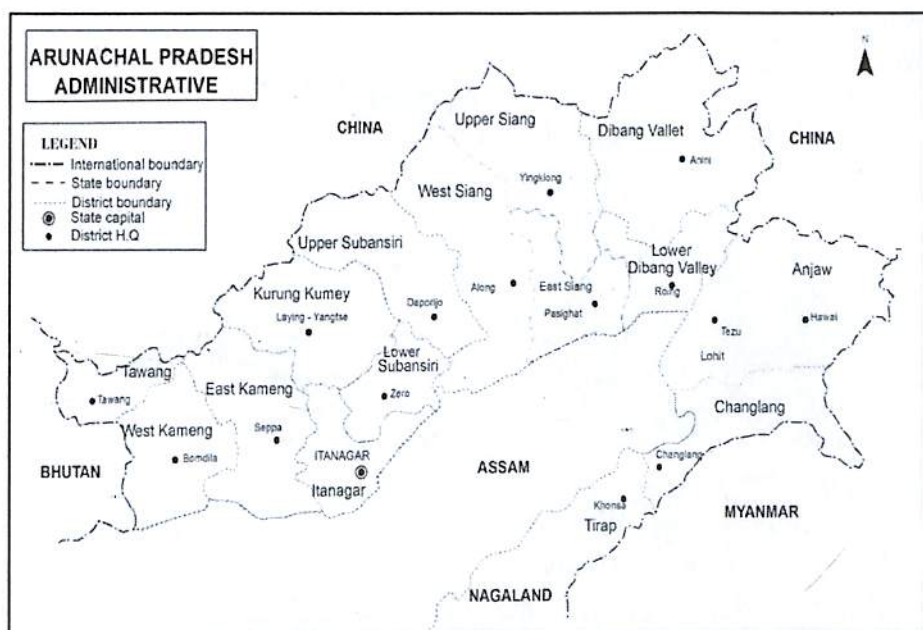


Fig. 1.2 Administrative map of Arunachal Pradesh

Brief description of each state of North Eastern Region is given below.

### Arunachal Pradesh

Arunachal Pradesh is situated between latitudes of  $26^{\circ}30'$  to  $29^{\circ}28'$  N and longitudes of  $91^{\circ}25'$  to  $97^{\circ}24'$  E and covers an area of 8374.3 thousand hectares. The state is bounded by China and Tibet in the north, Assam in the south, Myanmar and China in the east and Bhutan in the west. It has 16 administrative districts with Itanagar as its capital (Fig.1.2).

The state can broadly be divided into four distinct physiographic regions (Fig.1.3). The greater Himalayan range with snow-capped mountains with altitudes rising up to 5500 m above mean sea level (MSL), the lower Himalayan ranges up to an altitude of 2500 m above MSL, the Sub-Himalayan belt including the Siwalik hills having altitude up to 1500 m above MSL and the plains of the eastern continuity of Assam.

The geology is characterized by the presence of sedimentary and metamorphic rocks. Some important rock groups are Sela, Tenga and Bichom groups.

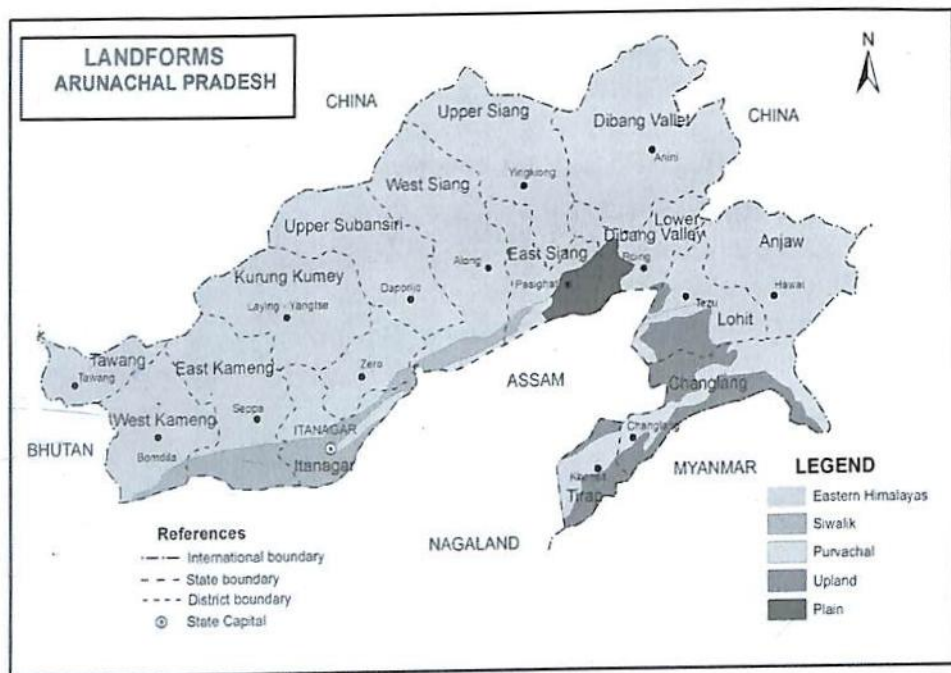


Fig. 1.3 Physiographic map of Arunachal Pradesh



The greater Himalayas are drained by Siang, Lohit, Dibang, Kamlong, Nao-Dihing, Tirap, Namchik and Manphuk (Buridihing), Dirak and Namsing rivers. The plains area are drained by Siang, Lohit, Dibang, Kamlong, Nao-Dihing, Tirap, Namchik and Manphuk (Buridihing), Dirak and Namsingh rivers.

The climate is humid to perhumid subtropical characterised by high rainfall and high humidity at Sub-Himalayan belt. The average annual rainfall varies from 1380 to 5000 mm. The minimum temperature is around 0°C in winter months in Bomdila and Tawang areas while it rises to 35°C (during summer months) in Namsai and Tezu areas of Lohit district. The mean annual air temperature in plains is 23.8°C and in hilly regions is 16.2°C (Nayak *et al.*, 1996).

The land use pattern of Arunachal for the year 2006-07 shows that out of the total geographical area, forest area, area not available for cultivation, other uncultivated lands, fallow lands, net sown area and area sown more than once and total cropped area covers 5154, 65, 122, 67, 109, 209, 66, 275 thousand hectares, respectively (Indiastat, 2012).

## Assam

Assam is situated in the central valley region of north-eastern India. It is bounded by two foreign countries and seven Indian states. To the north it is bordered by Bhutan and Arunachal Pradesh (Fig.1.4). The eastern part is bordered by the states of Arunachal Pradesh, Nagaland and Manipur. The southern boundary is shared by Mizoram and Meghalaya. West Bengal, Bangladesh and Tripura form the western boundary. The total area of the state is 7843.8 thousand hectares.

Assam has been divided into four physiographic regions viz., (i) the Brahmaputra Plain, (ii) the Barak Plain, (iii) the Karbi Plateau, and (iv) the North Cachar Hills (Fig.1.5). The geological history of the area reveals that Archaean, the late Cretaceous, Tertiary and Quaternary formation are predominant in Assam.

The geological formations in the state includes the Archaean Group comprising a metamorphic complex of gneisses and schists, the pre-Cambrian Group consisting of quartzites and phyllites, the lower Tertiary shelf (Eocene) sediments of Jaintia Group, the Upper Tertiary (Oligo-Mio-Pliocene) shelf and unclassified Older and

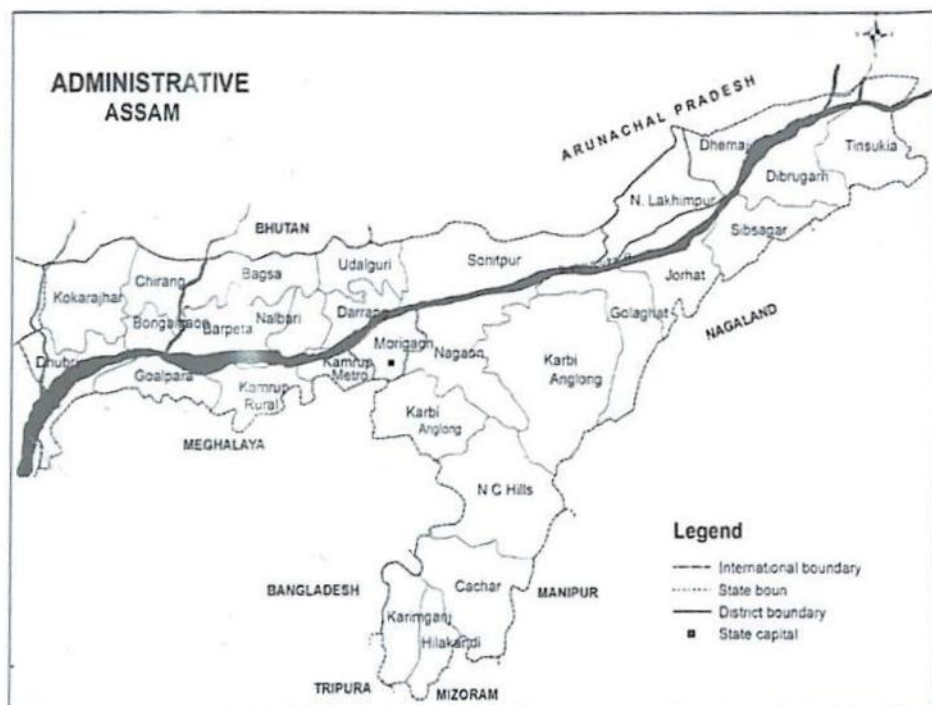


Fig. 1.4 Administrative map of Assam

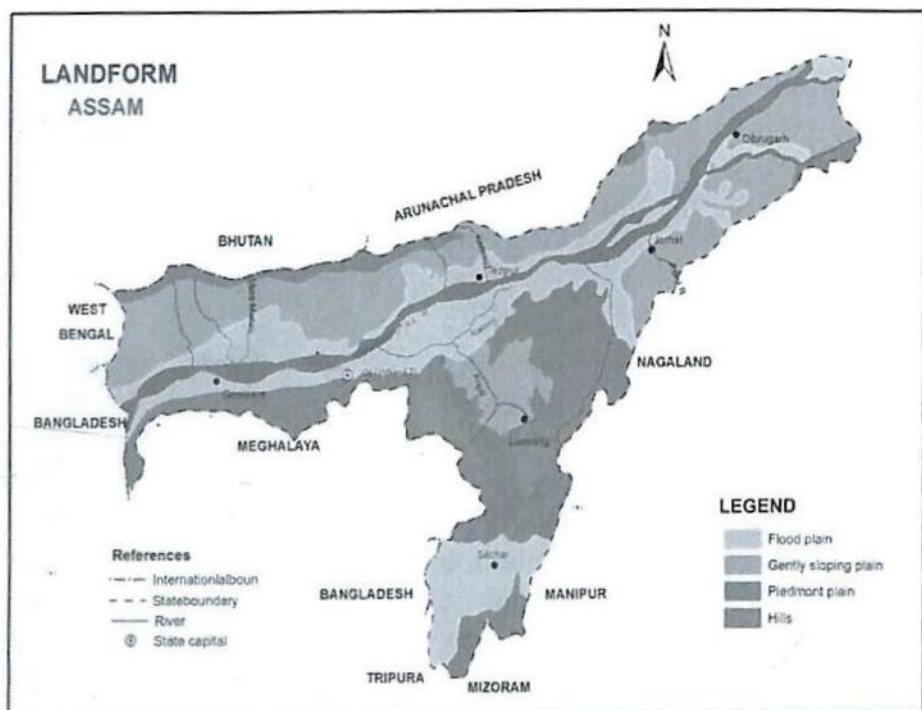


Fig. 1.5 Physiographic map of Assam

Newer Alluviums of Quarternary deposits (Anonymous, 1974). The geology is therefore very complex. Geologically, the Brahmaputra and Barak valleys are build up by deposition of alluvium of several hundred meters. The Karbi Plateau is dominated by Pre-Cambrian rocks. The Barail range and Naga hills are dominated by tertiary sandstones and related rocks.

The Brahmaputra flows through the middle of the valley from east to west and receives in the course more than 35 tributaries, among which on the north bank are the Subansiri, Bharali, Barnadi, Pagladia, Manas and the Sankosh and on the south bank the Lohit, Dihang, Noa-Dihing, Burhi-Dihing, Disang, Dikhow, Jhanji, Dhansiri, Kopili, Digaru, Kulsi, Singra, Dudhnai and the Krishna are the most important. Their drainage pattern is primarily of antecedent type. The Central Assam Range area is drained by the river Kopili, Doyang, Jamuna and Kaliani flowing north into the river Brahmaputra. The Barak is the principal river in the valley and it receives in its course numerous tributaries, amongst which the prominent being Jhiri, Jatinga, Sonai, Dhaleswari and Longlai.

The climate of Assam is neither too cold in winter nor too hot in summer. In general, it is of subtropical type influenced by the monsoon. The state receives large quantity of rainfall from June to August. A small quantity of rainfall is received during pre-monsoon (April and May) and post monsoon (September and October). Rainfall is scanty in winter months from November to February. Lakhimpur and Cachar districts receive the highest rainfall, while Nagaon and Karbi Anglong the least.

The natural flora of Assam is broadly divided into Evergreen and semi-evergreen forests, Deciduous forests, Riverine forests, Mixed deciduous forests, Savannah and Bamboo and Canes (Sen *et al.*, 1999). The land use pattern of Assam for the year 2006-07 shows that out of the total geographical area, area not available for cultivation, other uncultivated lands (excluding fallow land), fallow lands, net sown area and area sown more than once and total cropped area cover 1954, 2512, 445, 186, 2753, 957, 3553 thousand hectares; respectively (Indiastat, 2012).

## Manipur

The state of Manipur, lying between latitudes of 23°47' to 25°47' N and longitudes of 92°55' to 94°49' E, is situated in the

north eastern part of India, having an area of 2232.7 thousand hectares (Fig.1.6). There are nine districts in the state with Imphal as the capital. The state is surrounded in the north, west and south by hilly terrain of Nagaland, Assam and Mizoram respectively, whereas, Myanmar border is in the east.



Fig. 1.6 Administrative map of Manipur

Manipur is a hilly terrain with its distinct geographical entity. The hilly terrain surrounds a central valley elongating and tapering towards south dotted by isolated hillocks. The hill ranges are aligned in a series of north south parallel ridges (Fig.1.7). The eastern aspect of the hill terrain is relatively at higher elevation than that of western aspect. The general elevation of the ranges along the eastern aspect of the hill terrain varies between 1800 and 2500 m above MSL whereas, the western ranges get subdued from 1100 to 800 m above msl towards west. The Central valley with elevation ranging between 700 to 800 m above MSL is elongated in shape tapering towards south interrupted by isolated hillocks at places.

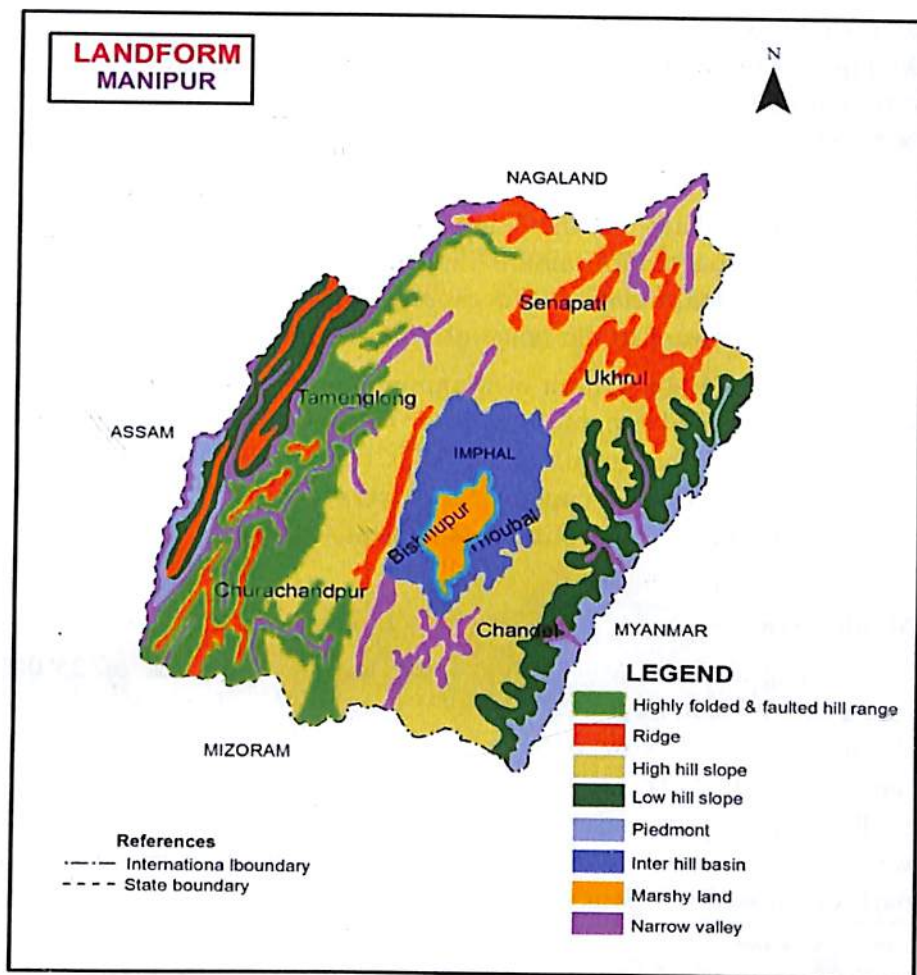


Fig. 1.7 Physiographic map of Manipur

The rock formations occurring in the state are the Cretaceous limestone, The Disang with Serpentinities (Lower and Middle Eocene upper Cretaceous), the Borails (Upper Eocene and Oligocene), the Surmas and the Tipams (Miocene) group are the major geologic formation.

The area drains from north to south. The drainage pattern is controlled by the structure and lithology of the area. The drainage pattern of the parallel hill ranges is of trellis type whereas the drainage patterns of lower elements of topography are sub-dendritic. The two main rivers (Manipur and Barak) flowing south-southwest are fed by numerous parallel streams and streamlets in the upper reaches of the thalweg. These two rivers are perennial in nature

and carry enough stream-loads to the south-southwest plains in Manipur. Loktak Lake is situated nearly 40 km south of Imphal city and covers an area of about 285 sq.km. The lake is the largest wetland in the North-Eastern region of India and is known as the lifeline of the people of the Manipur.

The climate of the state is humid with seasonal water deficiency. The average rainfall ranges between 2000 to 2400 mm. The mean annual temperature exceeds 22°C and experiences the summer temperature to the range of 35°C to 46°C (Sen *et al.*, 1996).

The land use pattern of Manipur for the year 2006-07 shows that out of the total geographical area, forest area, area not available for cultivation, other uncultivated lands (excluding fallow land), net sown area and total cropped area covers 1693, 27, 8, 224, 224 thousand hectares, respectively (Indiastat, 2012).

## Meghalaya

The state of Meghalaya, lying between latitudes of 25°00' to 26°10' N and longitudes of 89°45' to 92°47' E, is situated in the north eastern part of India covering an area of about 2242.9 thousand hectares (Fig.1.8). There are five districts in the state with Shillong as the capital. The state is bounded by north, east and west by Assam and shares an international boundary in south and part of west with Bangladesh.



Fig. 1.8 Administrative map of Meghalaya

The state can broadly be divided into three physiographic zones namely the Central plateau region with elevation ranging from 900-2000 m above MSL, Sub-montane region with elevation below 900 m and Border region which stretches southward abruptly from the Central plateau to the plains in the Bangladesh (Fig.1.9).

Geologically, the state is occupied by Archaen gneisses complex with acidic and basic intrusions, Shillong group of rocks, Lower Gondwana rocks, Sylhet traps and Cretaceous Tertiary sediments.

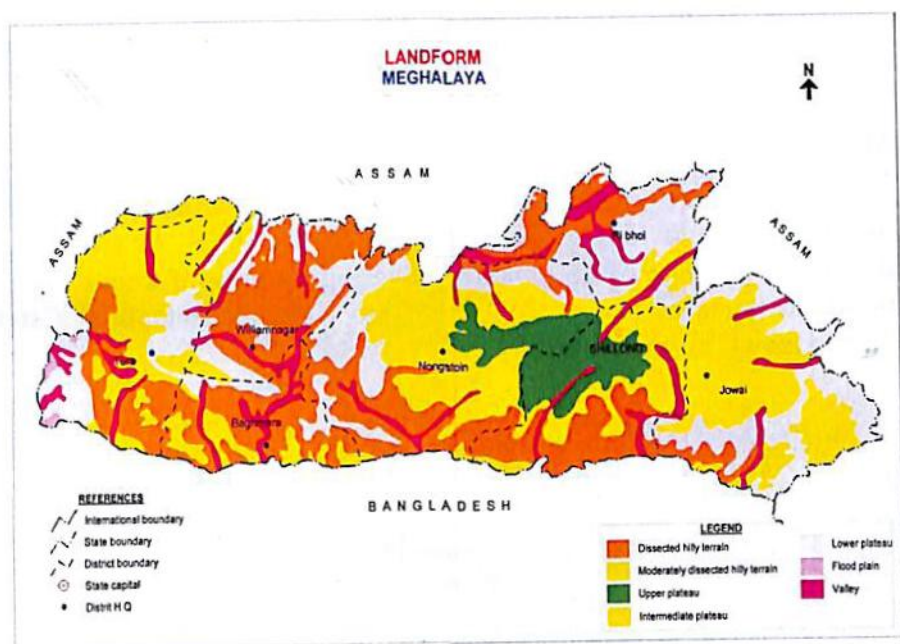


Fig. 1.9 Physiographic map of Meghalaya

The drainage pattern in the state shows an interesting feature revealing extraordinary straight course of the rivers and streams through the joints and faults. The state is drained in the north by Jinjiram, Krishnai, Dudhnai, Khri, Umiam, Barpani and Kopili and south by Lubha, Kynchiang or Jadukata, Someshwari and Kangha. The gorges formed by the rivers in Khasi, Jaintia hills and Garo hills are the result of massive headwork erosion by antecedent streams along the faults and joints of the sedimentary rocks over the blocks. The limestone covered region over the southern Garo, Khasi and Jaintia hills represents a typical karst topography.

The climate of the state is per-humid with small seasonal

water deficiency. The average rainfall ranges between 2000 to 4000 mm. However, the annual average rainfall in Cherapunji and Mousyngram is about 10,000 mm, which is one of the highest in the world. The mean summer temperature rises as high as 26°C and the mean winter temperature falling down to 9°C (Singh *et al.*, 1999).

The land use pattern of Meghalaya for the year 2006-07 shows that out of the total geographical area, forest area, area not available for cultivation, other uncultivated lands (excluding fallow land), fallow lands, net sown area and area sown more than once and total cropped area covers 942, 228, 608, 237, 213, 52, 265 thousand hectares, respectively (Indiastat, 2012).

## Mizoram

The state of Mizoram, located between latitudes of 21°33' to 24°20' N and longitudes of 92°06' to 93°20' E, is situated in the eastern fringe of the country covering an area of about 2108.1 thousand hectares (Fig.1.10). There are eight districts in the state with Aizawl as the capital.



Fig. 1.10 Administrative map of Mizoram



The terrain of Mizoram is young and immature. It shows prominent relief features with steep slopes and is still undergoing denudation in response to various exogenic and endogenic processes. Since the terrain is young, the geomorphic features of the state do not show much diversity in the formation of landforms. The major physiography includes low and high amplitudinal hills and narrow valleys (Fig.1.11).

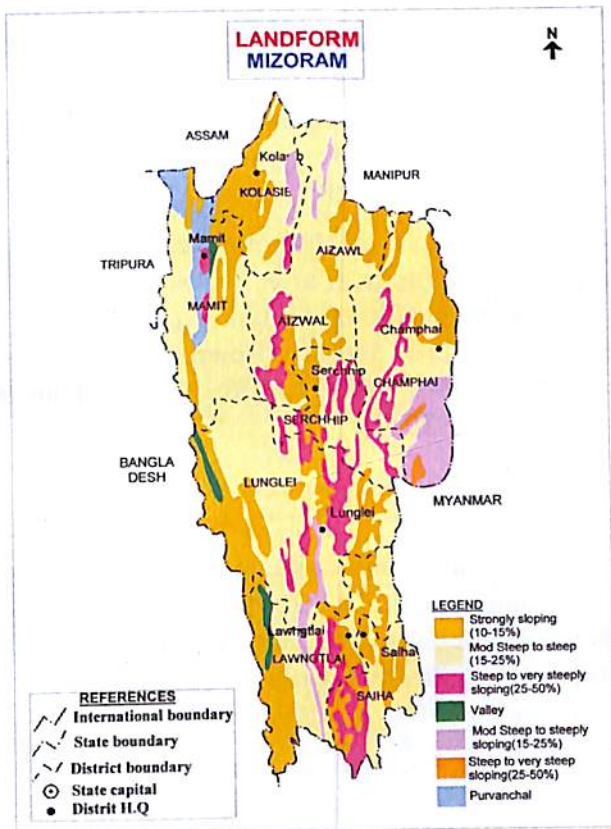


Fig. 1.11 Physiographic map of Mizoram

Geologically, Mizoram forms a part of Tripura, Mizoram geosynclinal depositional basin that extends to north and merges into the Surma valley. The hill regions forming the anticlinal crests expose relatively compact and resistant older rock types, while, the valleys are composed of younger and softer formations in the synclinal troughs. The sedimentary succession of Mizoram consists of repetitive sequence of alternating shale, silt stone, mudstone and fine grained sandstone in various proportions.

In the Mizo hills the major portion of the area is confined between 150 m and 900 m, though peaks of over 1500 m elevations are not rare. The most typical and undisturbed pattern of parallel drainage may be noted on the Mizo hills. The rivers have cut the hill ranges at suitable points almost at right angles resulting into barbed patterns.

The climate is humid tropical type. Mean annual humidity is 86.45 per cent. The winter temperature varies from 21°C and 27°C. The mean annual temperature is 20.3°C. The average annual rainfall is 2170 mm. The vegetation of Mizoram can broadly be divided into three categories of forest types, namely, Tropical wet evergreen forest, Tropical semi-evergreen forest and Sub-Montane tropical forest (Maji *et al.*, 2001).

The land use pattern of Mizoram for the year 2006-07 shows that out of the total geographical area, forest area, area not available for cultivation, other uncultivated lands (excluding fallow land), fallow lands, net sown area and area sown more than once and total cropped area covers 1594, 134, 21, 106, 92, 92 thousand hectares, respectively (Indiastat, 2012).

## Nagaland

The state of Nagaland is situated between latitudes of 25°06 to 27°04' N and longitudes of 93°21' to 95°21' E. It covers an area of 1657.8 thousand hectares. The state is bounded by Assam in the north and west, Myanmar and Arunachal Pradesh in the east and Manipur in the south. It has 7 administrative districts with Kohima as its capital (Fig.1.12).

The area can broadly be divided into four distinct physiographic regions. The zone at higher elevation is the Greater Himalayas with snow-capped mountains having altitudes rising up to 5500 m above mean sea level (MSL) (Fig.1.13). Below this zone, comes the Lower Himalayas range, having altitude upto 3500 mm above MSL. The Sub-Himalayas belt (altitude up to 1500 m above MSL) comprises the third physiographic zone. These are the plains of the eastern continuity of Assam. The dominant landforms of the state are dissected lands (42 percent), steep lands (39 per cent), rolling lands (7 percent) and gently sloping lands (2 per cent).

Nagaland is located in Northern extension of Arkan Yoma ranges, which are of Tertiary Cretaceous age and belongs to fairly



Fig. 1.12 Administrative map of Nagaland

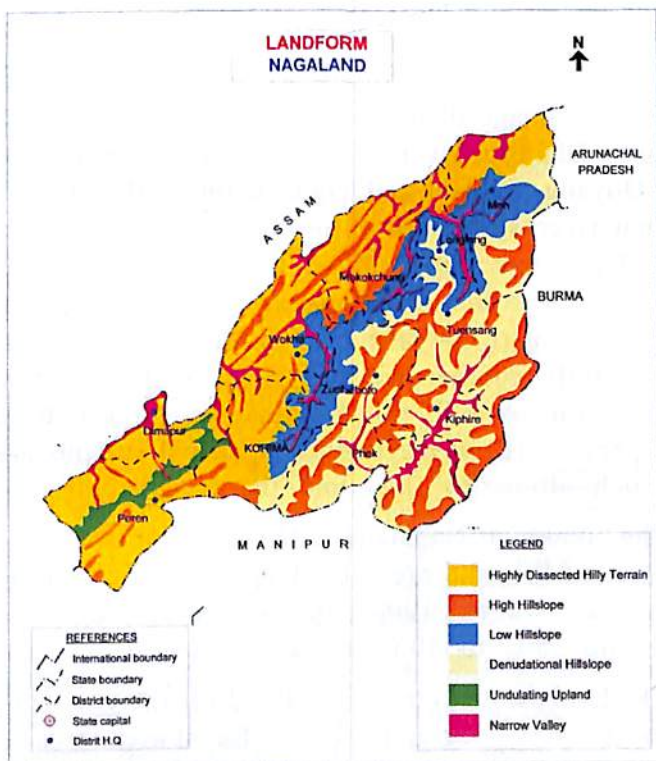


Fig. 1.13 Physiographic map of Nagaland

young mobile belt of the earth. The rock sequence is of the geosynclinal facies, represented by Disang group (Lower and Middle Eocene, Upper Cretaceous), the Borail group (Upper Eocene and Oligocene), the Surma and Tipam group (Miocene), the Nasang beds (Mio Pliocene) and the Dihing group (Pliocene – Pleistocene). Disang group consists of monotonous sequence of dark grey splintery shales with thin beds of sandstone. Borail groups are mostly well bedded sandstones with shale inter relations. The Borail range enters the state in south west corner and runs in north eastern direction almost upto Kohima. The Surma group, which is essentially an alteration of shales and sandstones with more thin conglomerates, overlies the Borails. This group thins out rapidly northward. The Tipam group consists of ferruginous sandstone of huge thickness of clay layers. These rocks are exposed in northern part of the districts. Dihing group represents pebble beds, thin clay and sand rest over the Namsang beds with a minor unconformity. The older alluvium comprises clay, coarse sand, gravels and boulder deposits occupies at various level cover the area along the Northwestern flank of Naga Patkai and part of Manipur.

The Borail and Japro range form the watershed of the state but none of the streams that are trembling down their slopes are of considerable dimension. Almost as far north as Mokokchung the whole of the drainage of northwestern face of hills ultimately finds its way into Dhansiri river. The other major river systems in the state are Doyang, Dikhou and Tigu, of these, the Dhansiri, Doyang and Dikhou river system flow towards west to meet Brahmaputra while the Tigu river system flows towards east and south east to meet the river Parwati in Myanmar. Diphupani is an important tributary to Dhansiri, Doyang river originates near Mao and flows in north easterly course and then flows northwest cutting across the main chain of hill till it joins its largest tributaries the Ramgamapani. North of Doyang the principal streams are Disai and Jhanzi which ultimately flow into the Brahmaputra.

The climate of Nagaland is hot to warm sub tropical in areas below 1000 m MSL and are sub-temperate in high altitudinal areas. Annual rainfall is about 1000 mm. Temperature varies 0°C to 10°C in winter and 25°C to 40°C in summer (Maji *et al.*, 2000).

The land use pattern of Nagaland for the year 2006-07 shows that out of the total geographical area, forest area, area not available

for cultivation, other uncultivated lands (excluding fallow land), fallow lands, net sown area and area sown more than once and total cropped are covers 863, 75, 177, 158, 322, 84, 406 thousand hectares, respectively (Indiastat, 2012).

## Sikkim

Sikkim state is located between  $27.04^{\circ}$  to  $28.07^{\circ}$  N latitude and  $88.01^{\circ}$  to  $88.55^{\circ}$  E longitude and spread over an area of 709.6 thousand hectares and comprises of four districts with Gangtok as capital (Fig. 1.14). The state is bounded in the north by the vast stretches of the Tibetan plateau, in the west by Nepal, in the east by Bhutan and Chumbi valley of Tibet. Darjeeling district of West Bengal stretches along its southern boundary.

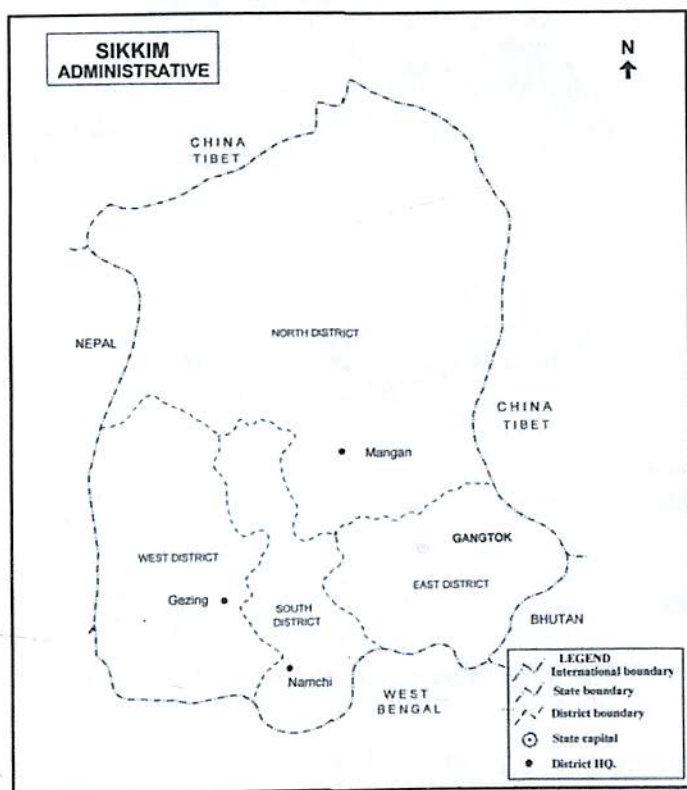


Fig. 1.14 Administrative map of Sikkim

The area of Sikkim can be divided into nine unequal geomorphic entities, namely, Summits and ridges, Escarpments, Very steep slopes, Steep slopes, Moderately steep slopes, Narrow

valleys, Cliff and precipitous slopes, Zones of glacial drifts/ moraines/ boulders and Perpetual snow. The elevation of the state ranges from 300 m at southern foothills to 5500 m above MSL in northern and north western boundaries (Fig.1.15).

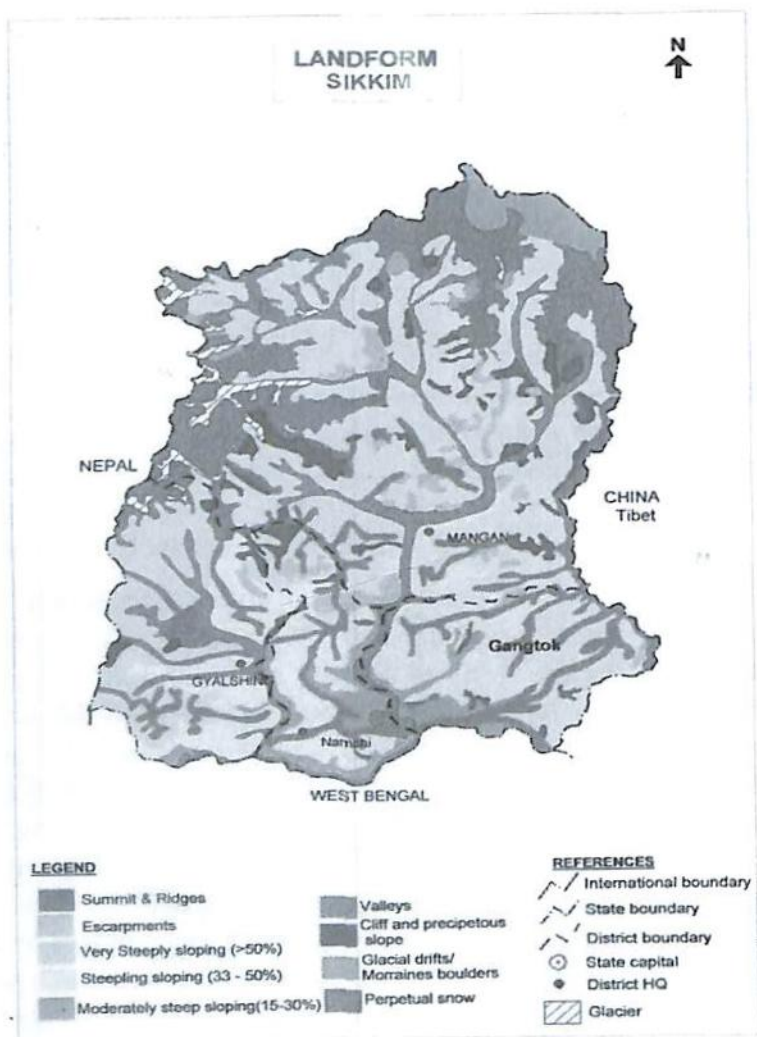


Fig. 1.15 Physiographic map of Sikkim

Sikkim is a part of the Lesser Himalayan terrain of eastern sector. Tectono-stratigraphically, it has been classified under four tectonic belts namely Foothill belt, Inner belt, Axial belt and Transaxial belt. The state is predominantly covered by the unfossiliferous metamorphic and crystalline rocks grouped under the inner and axial tectonic belts (Das *et al.*, 1996).

Sikkim is primarily the catchment of Tista drainage system. Tista river while flowing north to south divides the state into two parts. The river rises from north district fed by snows from Kanchenjunga; its other tributaries join it from Lhonak, Zemu, Talung glacier of Kanchenjunga group in the west. The chief tributary of Tista – the Great Rangit is fed from the snow of Narsing and Kabru peaks, south of Kanchenjunga. All along the high altitudes, near about snow line on eastern and western border and particularly in the North there are a large number of lakes; most of these lakes has been formed from receding glaciers by deposit of the terminal moraines at the outlet.

The climate of state generally varies from sub-tropical to alpine depending upon the elevation of the place. Mean annual rainfall varies from 2000 mm to 5000 mm with intensity ranging from drizzling to torrential rains.

The land use pattern of Sikkim for the year 2006-07 shows that out of the total geographical area, forest area, area not available for cultivation, other uncultivated lands (excluding fallow land), fallow lands, net sown area and area sown more than once and total cropped area covers 319, 250, 12, 35, 112, 11, 123 thousand hectares, respectively (Indiastat, 2012).

## **Tripura**

Tripura is situated between latitudes of  $22^{\circ}57'$  to  $24^{\circ}32'$  N and longitudes of  $91^{\circ}09'$  to  $92^{\circ}20'$  E and is covers an area of 1048.6 thousand hectares. It has 4 administrative districts with Agartala as capital. It is bounded by Bangladesh in the south, north west and south east and Mizoram is in the east and Assam in the north east (Fig.1.16).

The state has been divided into ten physiographic units namely steeply sloping and slightly dissected high relief, structural hills and ridges, moderately sloping with moderately dissected, medium relief parallel ridges, moderately sloping and highly dissected, low relief structural hills and ridges, moderate to gently sloping and moderately dissected, flat topped denudation hills, low lying residual hills with valleys, gently sloping, undulating plains with low mounds and narrow valleys, moderately to gently sloping, interhill valleys with uplands, moderately to gently sloping, interhill valleys with upland of alluvial plains, flood plains and rolling uplands (Fig.1.17).



Fig. 1.16 Administrative map of Tripura

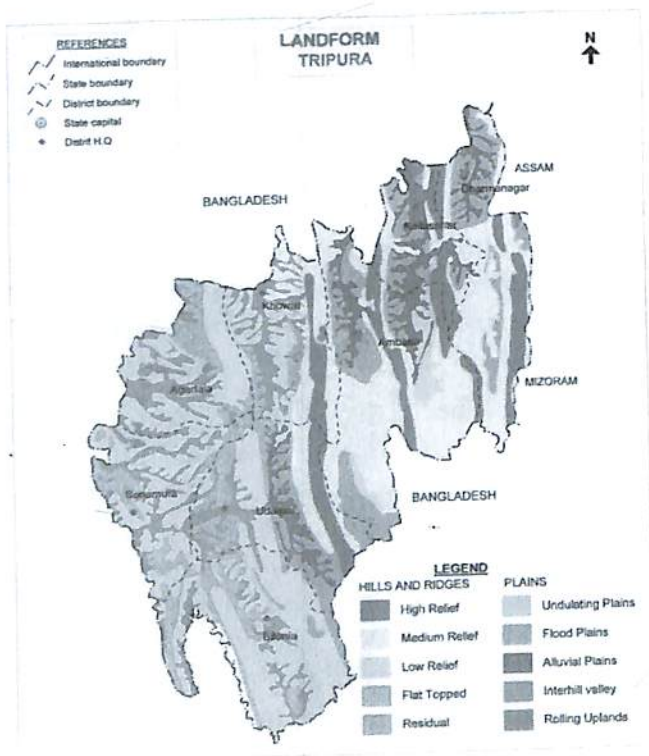


Fig. 1.17 Physiographic map of Tripura



Geology of the state is represented by sedimentary rocks which ranges in age from Miocene to loosely consolidated sediments of recent age. The rocks are sandstone, siltstone and shale grading into clay. Depending on their characters and the presence of fossils, these sedimentary rock sequences are divided into Surma group (the oldest), Tipam group and the Dupitila group (the youngest). Quite a larger part of South Tripura district is occupied by the recent fluvial deposits (Bhattacharyya *et al.*, 1996).

The drainage network of Tripura follows the north-south direction as is controlled by N-S alignment across the hill ranges. The Longai, manu, Dhalai and Khowai rivers flow to the north white Gumati, Muhari, Fenny and Haora rivers flow towards west. The tributaries are generally not suitable for navigation except few portion that too in particular season. Two tributaries namely Raima and Sarma join near Dumbur and form a waterfall. After that it takes the name of Gumati. The river Fenny forms the boundary between India and Bangladesh at the southern part of the state. The Sarma river, a tributary of Gumti originates from the Atharamura range, the Deo river from the Sakhan range, the Muhuri river from the Deotamura range. The Raina river, a tributary of the Gumati, Dhalai and Khowai originates from Longthorai range while Manu originates from Sakhan range. The Manu is the largest river. Other big rivers are Gumti, Khowai, Deo and Dhalai while Haora and Muhari rivers are smaller. The drainage patterns are of dentritic, parallel to subparallel and rectangular types.

The climate of the state is humid sub-tropical characterized by high rainfall. The annual rainfall ranges from 2000 to 3000 mm. The humidity ranges from 42 to 100 percent. The monsoon generally breaks out by the end of May.

The land use pattern of Trpura for the year 2006-07 shows that out of the total geographical area, forest area, area not available for cultivation, other uncultivated lands (excluding fallow land), fallow lands, net sown area and area sown more than once and total cropped area covers 606, 134, 28, 2, 280, 14, 294 thousand hectares, respectively (Indiastat, 2012).