# India : Physical Environment

Textbook in Geography for Class XI

# Contents

# UNIT I

## INTRODUCTION

*This unit deals with*

- *Location — space relations and India's place in the world*

CHAPTER

1

# INDIA – LOCATION

You have already seen the map of India in the previous classes. Now you closely examine the map of India (Figure 1.1). Mark the southernmost and northernmost latitudes and the easternmost and westernmost longitudes.

The mainland of India, extends from Kashmir in the north to Kanniyakumari in the south and Arunachal Pradesh in the east to Gujarat in the west. India's territorial limit further extends towards the sea upto 12 nautical miles (about 21.9 km) from the coast. (See the box for conversion).

| | | |
|---|---|---|
| Statute mile | = | 63,360 inches |
| Nautical mile | = | 72,960 inches |
| 1 Statute mile | = | about 1.6 km (1.584 km) |
| 1 Nautical mile | = | about 1.8 km (1.852 km) |

Our southern boundary extends upto 6°45' N latitude in the Bay of Bengal. Let us try to analyse the implications of having such a vast longitudinal and latitudinal extent.

If you work out the latitudinal and longitudinal extent of India, they are roughly about 30 degrees, whereas the actual distance measured from north to south extremity is 3,214 km, and that from east to west is only 2,933 km. What is the reason for this difference? Consult Chapter 3 on the topic Latitude, Longitude and Time in the book *Practical Work in Geography – Part I* (NCERT, 2006) to find out.

This difference is based on the fact that the distance between two longitudes decreases towards the poles whereas the distance between two latitudes remains the same everywhere. Find out the distance between two latitudes?

From the values of latitude, it is understood that the southern part of the country lies within the tropics and the northern part lies in the sub-tropical zone or the warm temperate zone. This location is responsible for large variations in land forms, climate, soil types and natural vegetation in the country.

Now, let us observe the longitudinal extent and its implications on the Indian people. From the values of longitude, it is quite discernible that there is a variation of nearly 30 degrees, which causes a time difference of nearly two hours between the easternmost and the westernmost parts of our country. You are familiar with the concept of Indian Standard Time (IST). What is the use of the standard meridian? While the sun rises in the northeastern states about two hours earlier as compared to Jaisalmer, the watches in Dibrugarh, Imphal in the east and Jaisalmer, Bhopal or Chennai in the other parts of India show the same time. Why does this happen?

There is a general understanding among the countries of the world to select the standard meridian in multiples of 7°30' of longitude. That is why 82°30' E has been selected as the 'standard meridian' of India. Indian Standard Time is ahead of Greenwich Mean Time by 5 hours and 30 minutes.

There are some countries where there are more than one standard meridian due to their vast east-to-west extent. For example, the USA has seven time zones.


**Figure 1.1 : India : Administrative Divisions**

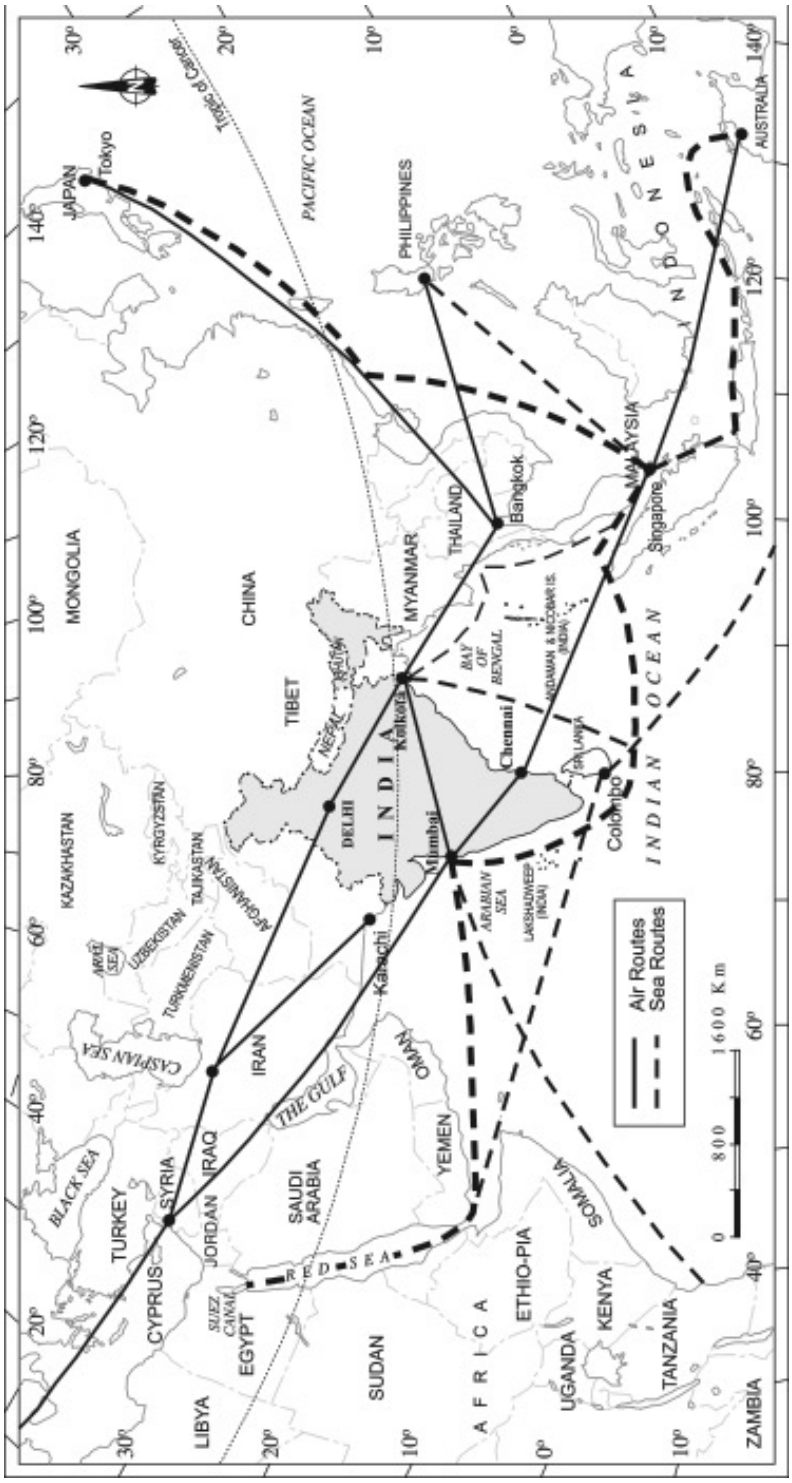


**Figure 1.2 : Location of India in the Eastern World**

Name a few place in India through which the standard meridian passes?

India with its area of 3.28 million sq. km accounts for 2.4 per cent of the world's land surface area and stands as the seventh largest country in the world. Find out the names of the countries which are larger than India.

### Size

The size of India has endowed her with great physical diversity. Thus, you may appreciate the presence of lofty mountains in the north; large rivers such as Ganga, Brahmaputra, Mahanadi, Krishna, Godavari and Kaveri; green forested hills in northeast and south India; and the vast sandy expanse of *Marusthali*. You may further appreciate that bounded by the Himalayas in the north, Hindukush and Sulaiman ranges in the north-west, Purvachal hills in the north-east and by the large expanse of the Indian ocean in the south, it forms a great geographic entity known as the *Indian subcontinent.* It includes the countries — Pakistan, Nepal, Bhutan, Bangladesh and India. The Himalayas, together with other ranges, have acted as a formidable physical barrier in the past. Except for a few mountain passes such as the Khyber, the Bolan, the Shipkila, the Nathula, the Bomdila, etc. it was difficult to cross it. It has contributed towards the evolving of a unique regional identity of the Indian subcontinent.

By referring to the physical map of India you can now describe the physical variations which you would come across while travelling from Kashmir to Kanniyakumari and from Jaisalmer in Rajasthan to Imphal in Manipur.

Peninsular part of India extends towards the Indian Ocean. This has provided the country with a coastline of 6,100 km in the mainland and 7,517 km in the entire geographical coast of the mainland plus the island groups Andaman and Nicobar located in the Bay of Bengal and the Lakshadweep in the Arabian Sea. Thus India, as a country, is a physically diverse land providing occurrence of varied resources.

### India and its Neighbours

Examine the location map of India (Figure 1.2). You will notice that India is located in the south-central part of the continent of Asia, bordering the Indian ocean and its two arms extending in the form of Bay of Bengal and the Arabian Sea. This maritime location of Peninsular India has provided links to its neighbouring regions through the sea and air routes.

Prepare a list of India's neighbouring countries by consulting the map.

Sri Lanka and Maldives are the two island countries located in the Indian Ocean, which are our neighbours. Sri Lanka is separated from India by the Gulf of Mannar and Palk Strait.

Differentiate between a Gulf and a Strait

Do you think that physical barrier is a hindrance in interaction with our neighbouring countries in modern times? Give some examples how we have overcome these difficulties in the present day.

## EXERCISES

1. Choose the right answer from the four alternatives given below.

   (i) Which one of the following latitudinal extent is relevant for the extent of India's area?

   (a) 8°41'N - 35°7'N (c) 8°4'N - 35°6'N
   (b) 8°4'N - 37°6'N (d) 6°45'N - 37°6'N

   (ii) Which one of the following countries shares the longest land frontier with India?

   (a) Bangladesh (c) Pakistan
   (b) China (d) Myanmar

(iii) Which one of the following countries is larger in area than India?

(a) China (c) France

(b) Egypt (d) Iran

(iv) Which one of the following longitudes is the standard meridian for India?

(a) 69°30'E (c) 75°30'E

(b) 82°30'E (d) 90°30'E

2. Answer the following questions in about 30 words.

(i) Does India need to have more than one standard time? If yes, why do you think so?

(ii) What are the implications of India having a long coastline?

(iii) How is the latitudinal spread of India advantageous to her?

(iv) While the sun rises earlier in the east, say Nagaland and also sets earlier, how do the watches at Kohima and New Delhi show the same time?

**Project/Activity**

*Activity based on Appendix I (Teachers may help in the exercises by explaining and getting it done by the students).*

(i) On a graph paper, plot the number of districts in Madhya Pradesh, Karnataka, Meghalaya, Goa, Kerala, Haryana. Do the number of districts have some relationship with the area of the state?

(ii) Which state amongst Uttar Pradesh, West Bengal, Gujarat, Arunachal Pradesh, Tamil Nadu, Tripura, Rajasthan and Jammu and Kashmir is the most thickly populated and which one is the least densely populated?

(iii) Find out the relationship between the area of the state and the number of districts.

(iv) Identify the states with coastal boundaries.

(v) Arrange the states from west to east which have only land boundary.

*Activity based on Appendix II*

(i) List the Union Territories which have coastal location.

(ii) How do you explain the variation in the area and population of NCT Delhi and the Andaman and Nicobar Islands?

(iii) On a graph paper, draw a bar diagram to show the area and population of all the Union Territories.

# UNIT II

# PHYSIOGRAPHY

*This unit deals with*

- *Structure and Relief; physiographic divisions*
- *Drainage systems: concept of water sheds — the Himalayan and the Peninsular*

CHAPTER

2

# STRUCTURE AND PHYSIOGRAPHY

Do you know that our earth also has a history. The earth and its landforms that we see today have evolved over a very long time. Current estimation shows that the earth is approximately 460 million years old. Over these long years, it has undergone many changes brought about primarily by the endogenic and exogenic forces. These forces have played a significant role in giving shape to various surface and subsurface features of the earth. You have already studied about the Plate Tectonics and the movement of the Earth's plates in the book *Fundamentals of Physical Geography* (NCERT, 2006). Do you know that the Indian plate was to the south of the equator millions of years ago? Do you also know that it was much larger in size and the Australian plate was a part of it? Over millions of years, this plate broke into many parts and the Australian plate moved towards the southeastern direction and the Indian plate to the north. Can you map different phases in the movement of the Indian plate? This northward movement of the Indian plate is still continuing and it has significant consequences on the physical environment of the Indian subcontinent. Can you name some important consequences of the northward movement of the Indian plate?

It is primarily through the interplay of these endogenic and exogenic forces and lateral movements of the plates that the present geological structure and geomorphologic processes active in the Indian subcontinent came into existence. Based on the variations in its geological structure and formations, India can be divided into three geological divisions. These geological regions broadly follow the physical features:

(i) The Penisular Block
(ii) The Himalayas and other Peninuslar Mountains
(iii) Indo-Ganga-Brahmaputra Plain.

## THE PENINSULAR BLOCK

The northern boundary of the Peninsular Block may be taken as an irregular line running from Kachchh along the western flank of the Aravali Range near Delhi and then roughly parallel to the Yamuna and the Ganga as far as the Rajmahal Hills and the Ganga delta. Apart from these, the Karbi Anglong and the Meghalaya Plateau in the northeast and Rajasthan in the west are also extensions of this block. The northeastern parts are separated by the Malda fault in West Bengal from the Chotanagpur plateau. In Rajasthan, the desert and other desert–like features overlay this block.

The Peninsula is formed essentially by a great complex of very ancient gneisses and granites, which constitutes a major part of it. Since the Cambrian period, the Peninsula has been standing like a rigid block with the exception of some of its western coast which is submerged beneath the sea and some other parts changed due to tectonic activity without affecting the original basement. As a part of the Indo-Australian Plate, it has been subjected to various vertical movements and block faulting. The rift valleys of the Narmada, the Tapi and the Mahanadi and the Satpura block mountains are some examples of it. The Peninsula mostly consists of relict and residual mountains like the Aravali hills, the Nallamala hills, the Javadi hills, the Veliconda hills, the

Palkonda range and the Mahendragiri hills, etc. The river valleys here are shallow with low gradients.

You are aware of the method of calculating the gradient as a part of your study of the book *Practical Work in Geography– Part I* (NCERT, 2006). Can you calculate the gradient of the Himalayan and the Peninsular rivers and draw the comparisons?

Most of the east flowing rivers form deltas before entering into the Bay of Bengal. The deltas formed by the Mahanadi, the Krishna, the Kaveri and the Godavari are important examples.

### The Himalayas and other Peninsular Mountains

The Himalayas along with other Peninsular mountains are young, weak and flexible in their geological structure unlike the rigid and stable Peninsular Block. Consequently, they are still subjected to the interplay of exogenic and endogenic forces, resulting in the development of faults, folds and thrust plains. These mountains are tectonic in origin, dissected by fast-flowing rivers which are in their youthful stage. Various landforms like gorges, V-shaped valleys, rapids, waterfalls, etc. are indicative of this stage.

**Figure 2.1 : A Gorge**

### Indo-Ganga-Brahmaputra Plain

The third geological division of India comprises the plains formed by the river Indus, the Ganga and the Brahmaputra. Originally, it was a geo-synclinal depression which attained its maximum development during the third phase of the Himalayan mountain formation approximately about 64 million years ago. Since then, it has been gradually filled by the sediments brought by the Himalayan and Peninsular rivers. Average depth of alluvial deposits in these plains ranges from 1,000-2,000 m.

It is evident from the above discussion that there are significant variations among the different regions of India in terms of their geological structure, which has far-reaching impact upon other related aspects. Variations in the physiography and relief are important among these. The relief and physiography of India has been greatly influenced by the geological and geomorphological processes active in the Indian subcontinent.

### Physiography

'Physiography' of an area is the outcome of structure, process and the stage of development. The land of India is characterised by great diversity in its physical features. The north has a vast expanse of rugged topography consisting of a series of mountain ranges with varied peaks, beautiful valleys and deep gorges. The south consists of stable table land with highly dissected plateaus, denuded rocks and developed series of scarps. In between these two lies the vast north Indian plain.

Based on these macro variations, India can be divided into the following physiographic divisions:

(i) The Northern and Northeastern Mountains
(ii) The Northern Plain
(iii) The Peninsular Plateau
(iv) The Indian Desert
(v) The Coastal Plains
(vi) The Islands.

### The North and Northeastern Mountains

The North and Northeastern Mountains consist of the Himalayas and the Northeastern hills. The Himalayas consist of a series of parallel mountain ranges. Some of the important ranges are the Greater Himalayan range, which includes the Great Himalayas and the Trans-Himalayan range, the Middle Himalayas and


**Figure 2.2 : India : Physical**

the Shiwalik. The general orientation of these ranges is from northwest to the southeast direction in the northwestern part of India. Himalayas in the Darjiling and Sikkim regions lie in an eastwest direction, while in Arunachal Pradesh they are from southwest to the northwest direction. In Nagaland, Manipur and Mizoram, they are in the northsouth direction. The approximate length of the Great Himalayan range, also known as the central axial range, is 2,500 km from east to west, and their width varies between 160-400 km from north to south. It is also evident from the map that the Himalayas stand almost like a strong and long wall between the Indian subcontinent and the Central and East Asian countries.

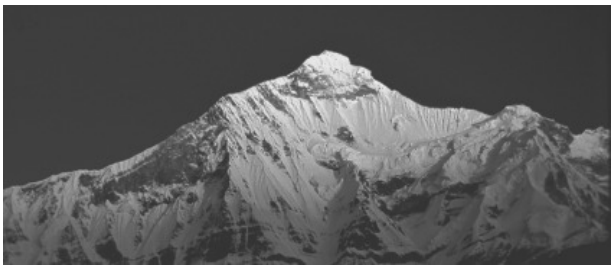

**Figure 2.3 : The Himalayas**

Himalayas are not only the physical barrier, they are also a climatic, drainage and cultural divide. Can you identify the impact of Himalayas on the geoenvironment of the countries of South Asia? Can you find some other examples of similar geoenvironmental divide in the world?

There are large-scale regional variations within the Himalayas. On the basis of relief, alignment of ranges and other geomorphological features, the Himalayas can be divided into the following sub-divisions:

(i) Kashmir or Northwestern Himalayas
(ii) Himachal and Uttaranchal Himalayas
(iii) Darjiling and Sikkim Himalayas
(iv) Arunachal Himalayas
(v) Eastern Hills and Mountains.

### *Kashmir or Northwestern Himalayas*

It comprise a series of ranges such as the Karakoram, Ladakh, Zaskar and Pir Panjal. The northeastern part of the Kashmir Himalayas is a cold desert, which lies between the Greater Himalayas and the Karakoram ranges. Between the Great Himalayas and the Pir Panjal range, lies the world famous valley of Kashmir and the famous Dal Lake. Important glaciers of South Asia such as the Baltoro and Siachen are also found in this region. The Kashmir Himalayas are also famous for Karewa formations, which are useful for the cultivation of *Zafran*, a local variety of saffron. Some of the important passes of the region are Zoji La on the Great Himalayas, Banihal on the Pir Panjal, Photu La on the Zaskar and Khardung La on the Ladakh range. Some of the important fresh lakes such as Dal and Wular and salt water lakes such as Pangong Tso and Tso Moriri are also in this region. This region is drained by the river Indus, and its tributaries such as the Jhelum and the Chenab. The Kashmir and northwestern Himalayas are well-known for their scenic beauty and picturesque landscape. The landscape of Himalayas is a major source of attraction for adventure tourists. Do you know that some famous places of pilgrimage such as Vaishno Devi, Amarnath Cave, Charar-e-Sharif, etc. are also located here and large number of pilgrims visit these places every year?

**Karewas**
Karewas are the thick deposits of glacial clay and other materials embedded with moraines.

Srinagar, capital city of the state of Jammu and Kashmir is located on the banks of Jhelum river. Dal Lake in Srinagar presents an interesting physical feature. Jhelum in the valley of Kashmir is still in its youth stage and yet forms meanders – a typical feature associated with the mature stage in the evolution of fluvial land form (Figure 2.4). Can you name some other fluvial landforms in the mature stage of a river?

**Figure 2.4 : Meandering Jhelum**

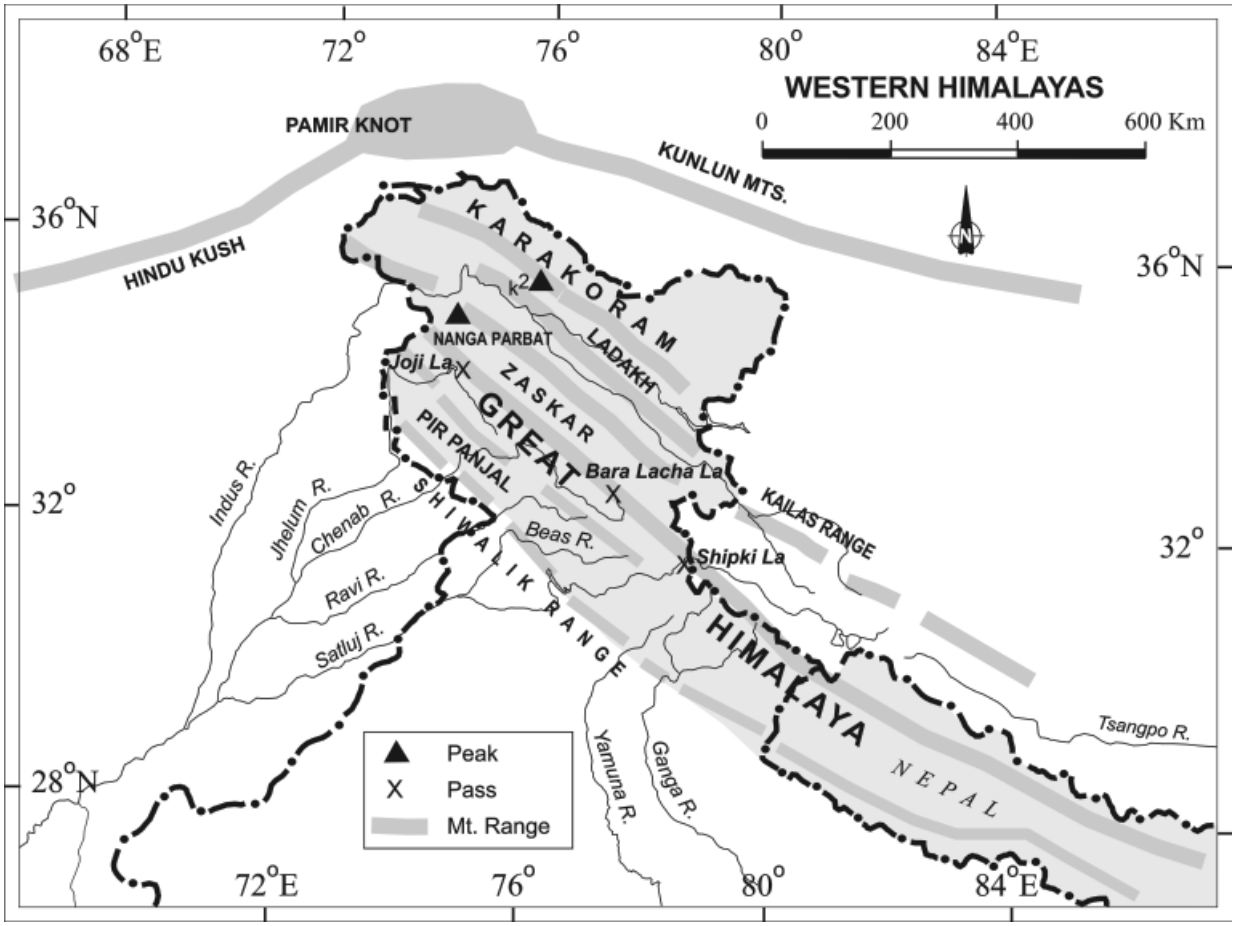


**Figure 2.5 : Western Himalayas**

**An Interesting Fact**

In Kashmir Valley, the meanders in Jhelum river are caused by the local base level provided by the erstwhile larger lake of which the present Dal Lake is a small part.

The southernmost part of this region consists of longitudinal valleys known as 'duns'. Jammu dun and Pathankot dun are important examples.

*The Himachal and Uttaranchal Himalayas*

This part lies approximately between the Ravi in the west and the Kali (a tributary of Ghaghara) in the east. It is drained by two major river systems of India, i.e. the Indus and the Ganga. Tributaries of the Indus include the river Ravi, the Beas and the Satluj, and the tributaries of Ganga flowing through this region include the Yamuna and the Ghaghara. The northernmost part of the Himachal Himalayas is an extension of the Ladakh cold desert, which lies in the Spiti subdivision of district Lahul and Spiti. All the three ranges of Himalayas are prominent in this section also. These are the Great Himalayan range, the Lesser Himalayas (which is locally known as Dhaoladhar in Himachal Pradesh and Nagtibha in Uttaranchal) and the Shiwalik range from the North to the South. In this section of Lesser Himalayas, the altitude between 1,000-2,000 m specially attracted to the British colonial administration, and subsequently, some of the important hill stations such as Dharamshala, Mussoorie, Shimla, Kaosani and the cantonment towns and health resorts such as Shimla, Mussoorie, Kasauli, Almora, Lansdowne and Ranikhet, etc. were developed in this region.

The two distinguishing features of this region from the point of view of physiography are the 'Shiwalik' and 'Dun formations'. Some important duns located in this region are the

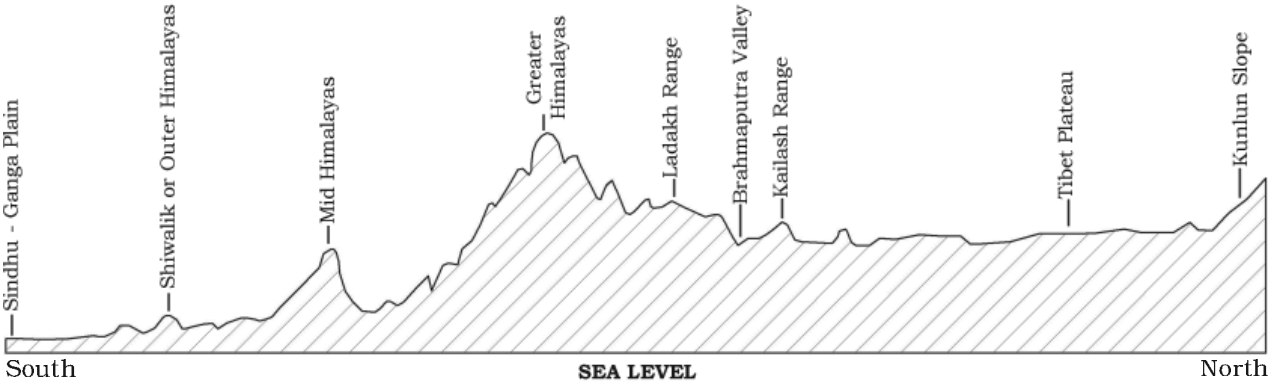


**Figure 2.6 : Himalayan Mountain Complex : Cross Sectional View from South to North**

**The Shiwalik**

The word *shiwalik* has its origin in the geological formation found in and around a place called Sivawala near Dehra Dun which was once a headquarter of the Imperial Survey and which subsequently established its permanent headquarters at Dehra Dun.

Chandigarh-Kalka dun, Nalagarh dun, Dehra Dun, Harike dun and the Kota dun, etc. *Dehra Dun* is the largest of all the duns with an approximate length of 35-45 km and a width of 22-25 km. In the Great Himalayan range, the valleys are mostly inhabited by the Bhotia's. These are nomadic groups who migrate to 'Bugyals' (the summer glasslands in the higher reaches) during summer months and return to the valleys during winters. The famous 'Valley of flowers' is also situated in this region. The places of pilgrimage such as the Gangotri, Yamunotri, Kedarnath, Badrinath and Hemkund Sahib are also situated in this part. The region is also known to have five famous Prayags (river confluences) as mentiond in Chapter 3 of this book. Can you name some other famous *prayags* in other parts of the country?

*The Darjiling and Sikkim Himalayas*

They are flanked by Nepal Himalayas in the west and Bhutan Himalayas in the east. It is relatively small but is a most significant part of the Himalayas. Known for its fast-flowing rivers such as Tista, it is a region of high mountain peaks like Kanchenjunga (Kanchengiri), and deep valleys. The higher reaches of this region are inhabited by Lepcha tribes while the southern part, particularly the Darjiling Himalayas, has a mixed population of Nepalis, Bengalis and tribals from Central India. The British, taking advantage of the physical conditions such as moderate slope, thick soil cover with high organic content, well distributed rainfall throughout the year and mild winters, introduced tea plantations in this region. As compared to the other sections of the Himalayas, these along with the Arunachal Himalayas are conspicuous by the absence of the Shiwalik formations. In place of the Shiwaliks here, the 'duar formations' are important, which have also been used for the development of tea gardens. Sikkim and Darjiling Himalayas are also known for their scenic beauty and rich flora and fauna, particularly various types of orchids.

*The Arunachal Himalayas*

These extend from the east of the Bhutan Himalayas up to the Diphu pass in the east. The general direction of the mountain range is from southwest to northeast. Some of the important mountain peaks of the region are Kangtu and Namcha Barwa. These ranges are dissected by fast-flowing rivers from the north to the south, forming deep gorges. Bhramaputra flows through a deep gorge after crossing Namcha Barwa. Some of the important rivers are the Kameng, the

Subansiri, the Dihang, the Dibang and the Lohit. These are perennial with the high rate of fall, thus, having the highest hydro-electric power potential in the country. An important aspect of the Arunachal Himalayas is the numerous ethnic tribal community inhabiting in these areas. Some of the prominent ones from west to east are the Monpa, Daffla, Abor, Mishmi, Nishi and the Nagas. Most of these communities practise *Jhumming*. It is also known as shifting or slash and burn cultivation. This region is rich in biodiversity which has been preserved by the indigenous communities. Due to rugged topography, the inter-valley transportation linkages are nominal. Hence, most of the interactions are carried through the duar region along the Arunachal-Assam border.

### *The Eastern Hills and Mountains*

These are part of the Himalayan mountain system having their general alignment from the north to the south direction. They are known by different local names. In the north, they are known as Patkai Bum, Naga hills, the Manipur

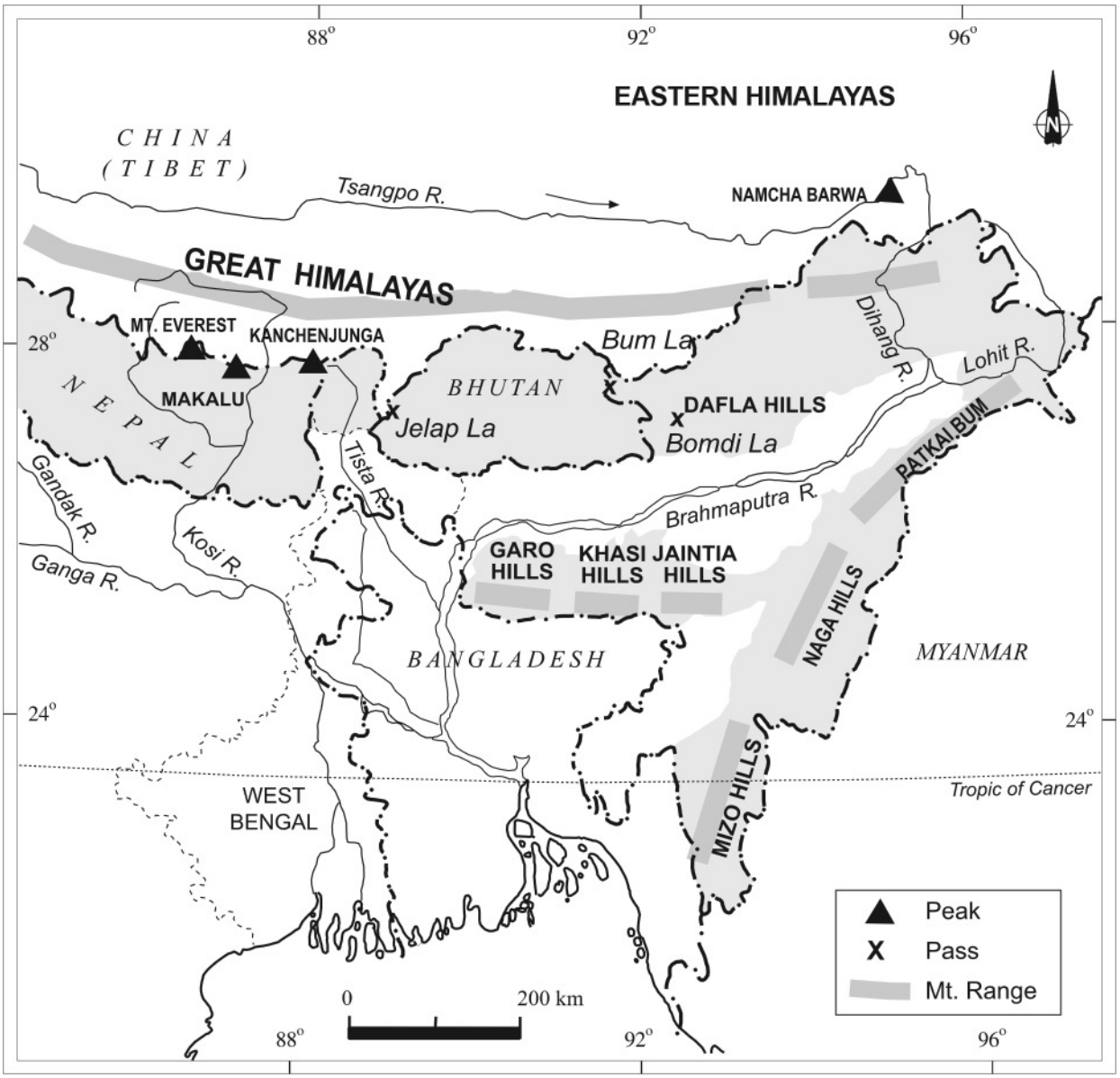


**Figure 2.7 : Eastern Himalayas**

hills and in the south as Mizo or Lushai hills. These are low hills, inhabited by numerous tribal groups practising Jhum cultivation.

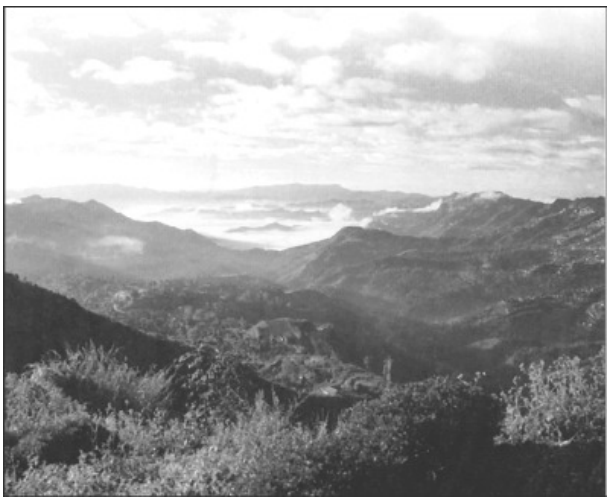

**Figure 2.8 : Mizo Hills**

Most of these ranges are separated from each other by numerous small rivers. The Barak is an important river in Manipur and Mizoram. The physiography of Manipur is unique by the presence of a large lake known as 'Loktak' lake at the centre, surrounded by mountains from all sides. Mizoram which is also known as the 'Molassis basin' which is made up of soft unconsolidated deposits. Most of the rivers in Nagaland form the tributary of the Brahmaputra. While two rivers of Mizoram and Manipur are the tributaries of the Barak river, which in turn is the tributary of Meghna; the rivers in the eastern part of Manipur are the tributaries of Chindwin, which in turn is a tributary of the Irrawady of Myanmar.

**Figure 2.9 : Loktak Lake**

**The Northern Plains**

The northern plains are formed by the alluvial deposits brought by the rivers – the Indus, the Ganga and the Brahmaputra. These plains extend approximately 3,200 km from the east to the west. The average width of these plains varies between 150-300 km. The maximum depth of alluvium deposits varies between 1,000-2,000 m. From the north to the south, these can be divided into three major zones: the *Bhabar*, the *Tarai* and the alluvial plains. The alluvial plains can be further divided into the *Khadar* and the *Bhangar*.

*Bhabar* is a narrow belt ranging between 8-10 km parallel to the Shiwalik foothills at the break-up of the slope. As a result of this, the streams and rivers coming from the mountains deposit heavy materials of rocks and boulders, and at times, disappear in this zone. South of the *Bhabar* is the *Tarai* belt, with an approximate width of 10-20 km where most of the streams and rivers re-emerge without having any properly demarcated channel, thereby, creating marshy and swampy conditions known as the *Tarai*. This has a luxurious growth of natural vegetation and houses a varied wild life.

The south of *Tarai* is a belt consisting of old and new alluvial deposits known as the *Bhangar* and *Khadar* respectively. These plains have characteristic features of mature stage of fluvial erosional and depositional landforms such as sand bars, meanders, ox-bow lakes and braided channels. The Brahmaputra plains are known for their riverine islands and sand bars. Most of these areas are subjected to periodic floods and shifting river courses forming braided streams.

The mouths of these mighty rivers also form some of the largest deltas of the world, for example, the famous Sunderbans delta. Otherwise, this is a featureless plain with a general elevation of 50-150 m above the mean sea level. The states of Haryana and Delhi form a water divide between the Indus and the Ganga river systems. As opposed to this, the Brahmaputra river flows from the northeast to the southwest direction before it takes an

**Figure 2.10 : Northern Plain**

almost 90° southward turn at Dhubri before it enters into Bangladesh. These river valley plains have a fertile alluvial soil cover which supports a variety of crops like wheat, rice, sugarcane and jute, and hence, supports a large population.

## The Peninsular Plateau

Rising from the height of 150 m above the river plains up to an elevation of 600-900 m is the irregular triangle known as the Peninsular plateau. Delhi ridge in the northwest, (extension of Aravalis), the Rajmahal hills in the east, Gir range in the west and the Cardamom hills in the south constitute the outer extent of the Peninsular plateau. However, an extension of this is also seen in the northeast, in the form of Shillong and Karbi-Anglong plateau. The Peninsular India is made up of a series of patland plateaus such as the Hazaribagh plateau, the Palamu plateau, the Ranchi plateau, the Malwa plateau, the Coimbatore plateau and the Karnataka plateau, etc. This is one of the oldest and the most stable landmass of India. The general elevation of the plateau is from the west to the east, which is also proved by the pattern of the flow of rivers. Name some rivers of the Peninsular plateau which have their confluence in the Bay of Bengal and the Arabian sea and mention some landforms which are typical to the east flowing rivers but are absent in the west flowing rivers. Some of the important physiographic features of this region are tors, block mountains, rift valleys, spurs, bare rocky structures, series of hummocky hills and wall-like quartzite dykes offering natural sites for water storage. The western and northwestern part of the plateau has an emphatic presence of black soil.

**Figure 2.11 : A Part of Peninsular Plateau**

This Peninsular plateau has undergone recurrent phases of upliftment and submergence accompanied by crustal faulting and fractures. (The Bhima fault needs special mention, because of its recurrent seismic activities). These spatial variations have brought in elements of diversity in the relief of the Peninsular plateau. The northwestern part of the plateau has a complex relief of ravines and gorges. The ravines of Chambal, Bhind and Morena are some of the well-known examples.

On the basis of the prominent relief features, the Peninsular plateau can be divided into three broad groups:

(i) The Deccan Plateau
(ii) The Central Highlands
(iii) The Northeastern Plateau.

### *The Deccan Plateau*

This is bordered by the Western Ghats in the west, Eastern Ghats in the east and the Satpura, Maikal range and Mahadeo hills in the north. Western Ghats are locally known by different names such as Sahyadri in Maharashtra, Nilgiri hills in Karnataka and Tamil Nadu and Anaimalai hills and Cardamom hills in Kerala. Western Ghats are comparatively higher in elevation and more continuous than the Eastern Ghats. Their average elevation is about 1,500 m with the height increasing from north to south. 'Anaimudi' (2,695 m), the highest peak of

Peninsular plateau is located on the Anaimalai hills of the Western Ghats followed by Dodabetta (2,637 m) on the Nilgiri hills. Most of the Peninsular rivers have their origin in the Western Ghats. Eastern Ghats comprising the discontinuous and low hills are highly eroded by the rivers such as the Mahanadi, the Godavari, the Krishna, the Kaveri, etc. Some of the important ranges include the Javadi hills, the Palconda range, the Nallamala hills, the Mahendragiri hills, etc. The Eastern and the Western Ghats meet each other at the Nilgiri hills.

*The Central Highlands*

They are bounded to the west by the Aravali range. The Satpura range is formed by a series of scarped plateaus on the south, generally at an elevation varying between 600-900 m above the mean sea level. This forms the northernmost boundary of the Deccan plateau. It is a classic example of the relict mountains which are highly denuded and form discontinuous ranges. The extension of the Peninsular plateau can be seen as far as Jaisalmer in the West, where it has been covered by the longitudinal sand ridges and crescent-shaped sand dunes called *barchans*. This region has undergone metamorphic processes in its geological history, which can be corroborated by the presence of metamorphic rocks such as marble, slate, gneiss, etc.

The general elevation of the Central Highlands ranges between 700-1,000 m above the mean sea level and it slopes towards the north and northeastern directions. Most of the tributaries of the river Yamuna have their origin in the Vindhyan and Kaimur ranges. Banas is the only significant tributary of the river Chambal that originates from the Aravalli in the west. An eastern extension of the Central Highland is formed by the Rajmahal hills, to the south of which lies a large reserve of mineral resources in the Chotanagpur plateau.

*The Northeastern Plateau*

In fact it is an extension of the main Peninsular plateau. It is believed that due to the force exerted by the northeastward movement of the Indian plate at the time of the Himalayan origin, a huge fault was created between the Rajmahal hills and the Meghalaya plateau. Later, this depression got filled up by the deposition activity of the numerous rivers. Today, the Meghalaya and Karbi Anglong plateau stand detached from the main Peninsular Block. The Meghalaya plateau is further sub-divided into three: (i) The Garo Hills; (ii) The Khasi Hills; (iii) The Jaintia Hills, named after the tribal groups inhabiting this region. An extension of this is also seen in the Karbi Anglong hills of Assam. Similar to the Chotanagpur plateau, the Meghalaya plateau is also rich in mineral resources like coal, iron ore, sillimanite, limestone and uranium. This area receives maximum rainfall from the south west monsoon. As a result, the Meghalaya plateau has a highly eroded surface. Cherrapunji displays a bare rocky surface devoid of any permanent vegetation cover.

**The Indian Desert**

To the northwest of the Aravali hills lies the Great Indian desert. It is a land of undulating topography dotted with longitudinal dunes and *barchans*. This region receives low rainfall below 150 mm per year; hence, it has arid climate with low vegetation cover. It is because of these characteristic features that this is also known as *Marusthali*. It is believed that

**Figure 2.12 : The Indian Desert**

Can you identify the type of sand dunes shown in this picture?

during the Mesozoic era, this region was under the sea. This can be corroborated by the evidence available at wood fossils park at Aakal and marine deposits around Brahmsar, near Jaisalmer (The approximate age of the wood-fossils is estimated to be 180 million years). Though the underlying rock structure of the desert is an extension of the Peninsular plateau, yet, due to extreme arid conditions, its surface features have been carved by physical weathering and wind actions. Some of the well pronounced desert land features present here are mushroom rocks, shifting dunes and oasis (mostly in its southern part). On the basis of the orientation, the desert can be divided into two parts: the northern part is sloping towards Sindh and the southern towards the Rann of Kachchh. Most of the rivers in this region are ephemeral. The Luni river flowing in the southern part of the desert is of some significance. Low precipitation and high evaporation makes it a water deficit region. There are some streams which disappear after flowing for some distance and present a typical case of inland drainage by joining a lake or playa. The lakes and the playas have brackish water which is the main source of obtaining salt.

### The Coastal Plains

You have already read that India has a long coastline . On the basis of the location and active geomorphological processes, it can be broadly divided into two: (i) the western coastal plains; (ii) the eastern coastal plains.

The western coastal plains are an example of submerged coastal plain. It is believed that the city of Dwaraka which was once a part of the Indian mainland situated along the west coast is submerged under water. Because of this submergence it is a narrow belt and provides natural conditions for the development of ports and harbours. Kandla, Mazagaon, JLN port Navha Sheva, Marmagao, Mangalore, Cochin, etc. are some of the important natural ports located along the west coast. Extending from the Gujarat coast in the north to the Kerala coast in the south, the western coast may be divided into following divisions – the Kachchh and

**Figure 2.13 : Coastal Plains**

Kathiawar coast in Gujarat, Konkan coast in Maharashtra, Goan coast and Malabar coast in Karnataka and Kerala respectively. The western coastal plains are narrow in the middle and get broader towards north and south. The rivers flowing through this coastal plain do not form any delta. The Malabar coast has got certain distinguishing features in the form of *'Kayals'* (backwaters), which are used for fishing, inland navigation and also due to its special attraction for tourists. Every year the famous *Nehru Trophy Vallamkali* (boat race) is held in *Punnamada Kayal* in Kerala.

As compared to the western coastal plain, the eastern coastal plain is broader and is an example of an emergent coast. There are well-developed deltas here, formed by the rivers flowing eastward in to the Bay of Bengal. These include the deltas of the Mahanadi, the Godavari, the Krishna and the Kaveri. Because of its emergent nature, it has less number of ports and harbours. The continental shelf extends up to 500 km into the sea, which makes it difficult for the development of good ports and harbours. Name some ports on the eastern coast.

### The Islands

There are two major island groups in India – one in the Bay of Bengal and the other in the Arabian Sea. The Bay of Bengal island groups consist of about 572 islands/islets. These are situated roughly between 6°N-14°N and 92°E -94°E. The two principal groups of islets include the Ritchie's archipelago and the Labrynth island. The entire group of island is

On 26 December 2004, the Andaman and Nicobar islands experienced one of the most devasting natural calamity. Can you name the calamity and identify some other areas which were adversely affected by the same calamity? What was its major consequence?

divided into two broad categories – the Andaman in the north and the Nicobar in the south. They are separated by a water body which is called the Ten degree channel. It is believed that these islands are an elevated portion of submarine mountains. However, some smaller islands are volcanic in origin. *Barren island*, the only active volcano in India is also situated in the Nicobar islands.

Some important mountain peaks in Andaman and Nicobar islands are Saddle peak (North Andaman – 738 m), Mount Diavolo (Middle Andaman – 515 m), Mount Koyob (South Andaman – 460 m) and Mount Thuiller (Great Nicobar – 642 m).

The coastal line has some coral deposits, and beautiful beaches. These islands receive convectional rainfall and have an equatorial type of vegetation.

The islands of the Arabian sea include Lakshadweep and Minicoy. These are scattered between 8°N-12°N and 71°E -74°E longitude. These islands are located at a distance of 280 km-480 km off the Kerala coast. The entire island group is built of coral deposits. There are approximately 36 islands of which 11 are inhabited. *Minicoy* is the largest island with an area of 453 sq. km. The entire group of islands is broadly divided by the Eleventh degree channel, north of which is the Amini Island and to the south of the Canannore Island. The Islands of this archipelago have storm beaches consisting of unconsolidated pebbles, shingles, cobbles and boulders on the eastern seaboard.

**Figure 2.14 : An Island**

## EXERCISES

1. Choose the right answer from the four alternatives given below.
   (i) In which part of Himalayas do we find the Karewa formation?
   (a) North-eastern Himalayas (c) Eastern Himalayas
   (b) Himachal-Uttaranchal Himalayas (d) Kashmir Himalayas
   (ii) In which of the following states is Loktak lake situated?
   (a) Kerala (c) Manipur
   (b) Uttaranchal (d) Rajasthan
   (iii) Which one of the water bodies separates the Andaman from the Nicobar?
   (a) 11° Channel (c) 10° Channel
   (b) Gulf of Mannar (d) Andaman Sea
   (iv) On which of the following hill range is the 'Dodabeta' peak situated?
   (a) Nilgiri hills (c) Cardamom hills
   (b) Anaimalai hills (d) Nallamala hills
2. Answer the following questions in about 30 words.
   (i) If a person is to travel to Lakshadweep, from which coastal plain does he prefer and why?

(ii) Where in India will you find a cold desert? Name some important ranges of this region.

(iii) Why is the western coastal plain is devoid of any delta?

3. Answer the following questions in not more than 125 words.

(i) Make a comparison of the island groups of the Arabian Sea and the Bay of Bengal.

(ii) What are the important geomorphological features found in the river valley plains?

(iii) If you move from Badrinath to Sunderbans delta along the course of the river Ganga, what major geomorphological features will you come across?

**Project/Activity**

(i) Make a list of major Himalayan peaks from the west to the east with the help of an atlas.

(ii) Identify the major landforms of your state and analyse the major economic activity practised by the people in each landform.

CHAPTER

3

# DRAINAGE SYSTEM

You have observed water flowing through the rivers, *nalas* and even channels during rainy season which drain the excess water. Had these channels not been there, large-scale flooding would have occurred. Wherever channels are ill-defined or choked, flooding is a common phenomenon.

> The flow of water through well-defined channels is known as 'drainage' and the network of such channels is called a 'drainage system'. The drainage pattern of an area is the outcome of the geological time period, nature and structure of rocks, topography, slope, amount of water flowing and the periodicity of the flow.

Do you have a river near your village or city? Have you ever been there for boating or bathing? Is it perennial (always with water) or ephemeral (water during rainy season, and dry, otherwise)? Do you know that rivers flow in the same direction? You have studied about slopes in the other two textbooks of geography (NCERT, 2006) in this class . Can you, then, explain the reason for water flowing from one direction to the other? Why do the rivers originating from the Himalayas in the northern India and the Western Ghat in the southern India flow towards the east and discharge their waters in the Bay of Bengal?

**Figure 3.1 : A River in the Mountainous Region**

A river drains the water collected from a specific area, which is called its 'catchment area'.

An area drained by a river and its tributaries is called a drainage basin. The boundary line

**Important Drainage Patterns**

(i) The drainage pattern resembling the branches of a tree is known as "dendritic" the examples of which are the rivers of northern plain.

(ii) When the rivers originate from a hill and flow in all directions, the drainage pattern is known as 'radial'. The rivers originating from the Amarkantak range present a good example of it.

(iii) When the primary tributaries of rivers flow parallel to each other and secondary tributaries join them at right angles, the pattern is known as 'trellis'.

(iv) When the rivers discharge their waters from all directions in a lake or depression, the pattern is know as 'centripetal'.

Find out some of the patterns in the topo sheet given in Chapter 5 of *Practical Work in Geography– Part I (NCERT, 2006).*

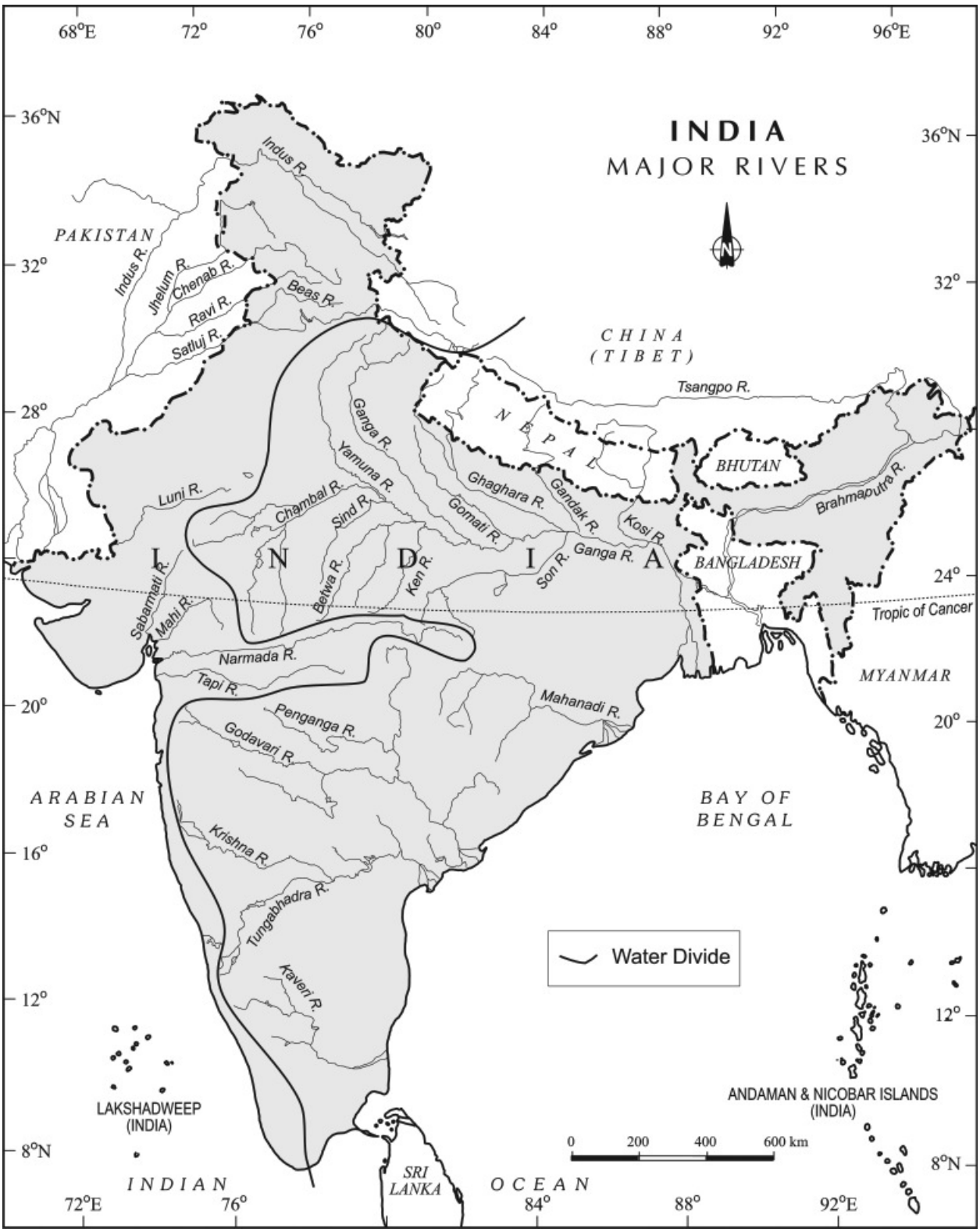


**Figure 3.2 : Major Rivers of India**

separating one drainage basin from the other is known as the watershed. The catchments of large rivers are called river basins while those of small rivulets and rills are often referred to as watersheds. There is, however, a slight difference between a river basin and a watershed. Watersheds are small in area while the basins cover larger areas.

River basins and watersheds are marked by unity. What happens in one part of the basin or watershed directly affects the other parts and the unit as a whole. That is why, they are accepted as the most appropriate micro, meso or macro planning regions.

Indian drainage system may be divided on various bases. On the basis of discharge of water (orientations to the sea), it may be grouped into: (i) the Arabian Sea drainage; and (ii) the Bay of Bengal drainage. They are separated from each other through the Delhi ridge, the Aravalis and the Sahyadris (water divide is shown by a line in Figure 3.1). Nearly 77 per cent of the drainage area consisting of the Ganga, the Brahmaputra, the Mahanadi, the Krishna, etc. is oriented towards the Bay of Bengal while 23 per cent comprising the Indus, the Narmada, the Tapi, the Mahi and the Periyar systems discharge their waters in the Arabian Sea.

On the basis of the size of the watershed, the drainage basins of India are grouped into three categories: (i) Major river basins with more than 20,000 sq. km of catchment area. It includes 14 drainage basins such as the Ganga, the Brahmaputra, the Krishna, the Tapi, the Narmada, the Mahi, the Pennar, the Sabarmati, the Barak, etc. (Appendix III). (ii) Medium river basins with catchment area between 2,000-20,000 sq. km incorporating 44 river basins such as the Kalindi, the Periyar, the Meghna, etc. (iii) Minor river basins with catchment area of less than 2,000 sq. km include fairly good number of rivers flowing in the area of low rainfall.

If you look at the Figure 3.1 you can see that many rivers have their sources in the Himalayas and discharge their waters either in the Bay of Bengal or in the Arabian Sea. Identify these rivers of North India. Large rivers flowing on the Peninsular plateau have their origin in the Western Ghats and discharge their waters in the Bay of Bengal. Identify these rivers of the South India.

The Narmada and Tapi are two large rivers which are exceptions. They along with many small rivers discharge their waters in the Arabian Sea.

Name these rivers of the western coastal region from the Konkan to the Malabar coast.

On the basis of the mode of origin, nature and characteristics, the Indian drainage may also be classified into the Himalayan drainage and the Peninsular drainage. Although it has the problem of including the Chambal, the Betwa, the Son, etc. which are much older in age and origin than other rivers that have their origin in the Himalayas, it is the most accepted basis of classification. Hence, this scheme has been followed in this book.

## Drainage Systems of India

Indian drainage system consists of a large number of small and big rivers. It is the outcome of the evolutionary process of the three major physiographic units and the nature and characteristics of precipitation.

## The Himalayan Drainage

The Himalayan drainage system has evolved through a long geological history. It mainly includes the Ganga, the Indus and the Brahmaputra river basins. Since these are fed both by melting of snow and precipitation, rivers of this system are perennial. These rivers pass through the giant gorges carved out by the erosional activity carried on simultaneously with the uplift of the Himalayas. Besides deep gorges, these rivers also form V-shaped valleys, rapids and waterfalls in their mountainous

**Figure 3.3 : Rapids**

course. While entering the plains, they form depositional features like flat valleys, ox-bow lakes, flood plains, braided channels, and deltas near the river mouth. In the Himalayan reaches, the course of these rivers is highly tortous, but over the plains they display a strong meandering tendency and shift their courses frequently. River Kosi, also know as the 'sorrow of Bihar', has been notorious for frequently changing its course. The Kosi brings huge quantity of sediments from its upper reaches and deposits it in the plains. The course gets blocked, and consequently, the river changes its course. Why does the Kosi river bring such huge quantity of sediments from the upper reaches? Do you think that the discharge of the water in the rivers in general and the Kosi in particular, remains the same, or does it fluctuate? When does the river course receive the maximum quantity of water? What are the positive and negative effects of flooding?

### Evolution of the Himalayan Drainage

There are difference of opinion about the evolution of the Himalayan rivers. However, geologists believe that a mighty river called Shiwalik or Indo-Brahma traversed the entire longitudinal extent of the Himalaya from Assam to Punjab and onwards to Sind, and finally discharged into the Gulf of Sind near lower Punjab during the Miocene period some 5-24 million years ago (See the table of geological times scale in Chapter 2 of *Fundamentals of Physical Geography*, NCERT, 2006). The remarkable continuity of the Shiwalik and its lacustrine origin and alluvial deposits consisting of sands, silt, clay, boulders and conglomerates support this viewpoint.

It is opined that in due course of time Indo–Brahma river was dismembered into three main drainage systems: (i) the Indus and its five tributaries in the western part; (ii) the Ganga and its Himalayan tributaries in the central part; and (iii) the stretch of the Brahmaputra in Assam and its Himalayan tributaries in the eastern part. The dismemberment was probably due to the Pleistocene upheaval in the western Himalayas, including the uplift of the Potwar Plateau (Delhi Ridge), which acted as the water divide between the Indus and Ganga drainage systems. Likewise, the down-thrusting of the Malda gap area between the Rajmahal hills and the Meghalaya plateau during the mid-pleistocene period, diverted the Ganga and the Brahmaputra systems to flow towards the Bay of Bengal.

### The River Systems of the Himalayan Drainage

The Himalayan drainage consists of several river systems but the following are the major river systems:

#### The Indus System

It is one of the largest river basins of the world, covering an area of 11,65,000 sq. km (in India it is 321, 289 sq. km and a total length of 2,880 km (in India 1,114 km). The Indus also known as the Sindhu, is the westernmost of the Himalayan rivers in India. It originates from a glacier near Bokhar Chu (31°15' N latitude and 81°40' E longitude) in the Tibetan region at an altitude of 4,164 m in the Kailash Mountain range. In Tibet, it is known as *'Singi Khamban*; or Lion's mouth. After flowing in the northwest direction between the Ladakh and Zaskar ranges, it passes through Ladakh and Baltistan. It cuts across the Ladakh range, forming a spectacular gorge near Gilgit in Jammu and Kashmir. It enters into Pakistan near Chillar in the Dardistan region. Find out the area known as Dardistan.

The Indus receives a number of Himalayan tributaries such as the Shyok, the Gilgit, the Zaskar, the Hunza, the Nubra, the Shigar, the Gasting and the Dras. It finally emerges out of the hills near Attock where it receives the Kabul river on its right bank. The other important tributaries joining the right bank of the Indus are the Khurram, the Tochi, the Gomal, the Viboa and the Sangar. They all originate in the Sulaiman ranges. The river flows southward and receives 'Panjnad' a little above Mithankot. The Panjnad is the name given to the five rivers of Punjab, namely the Satluj, the Beas, the Ravi, the Chenab and the Jhelum. It finally discharges

into the Arabian Sea, east of Karachi. The Indus flows in India only through the Leh district in Jammu and Kashmir.

The Jhelum, an important tributary of the Indus, rises from a spring at Verinag situated at the foot of the Pir Panjal in the south-eastern part of the valley of Kashmir. It flows through Srinagar and the Wular lake before entering Pakistan through a deep narrow gorge. It joins the Chenab near Jhang in Pakistan.

The Chenab is the largest tributary of the Indus. It is formed by two streams, the Chandra and the Bhaga, which join at Tandi near Keylong in Himachal Pradesh. Hence, it is also known as Chandrabhaga. The river flows for 1,180 km before entering into Pakistan.

The Ravi is another important tributary of the Indus. It rises west of the Rohtang pass in the Kullu hills of Himachal Pradesh and flows through the Chamba valley of the state. Before entering Pakistan and joining the Chenab near Sarai Sidhu, it drains the area lying between the southeastern part of the Pir Panjal and the Dhauladhar ranges.

The Beas is another important tributary of the Indus, originating from the Beas Kund near the Rohtang Pass at an elevation of 4,000 m above the mean sea level. The river flows through the Kullu valley and forms gorges at Kati and Largi in the Dhaoladhar range. It enters the Punjab plains where it meets the Satluj near Harike.

The Satluj originates in the Rakas lake near Mansarovar at an altitude of 4,555 m in Tibet where it is known as Langchen Khambab. It flows almost parallel to the Indus for about 400 km before entering India, and comes out of a gorge at Rupar. It passes through the Shipki La on the Himalayan ranges and enters the Punjab plains. It is an antecedent river. It is a very important tributary as it feeds the canal system of the Bhakra Nangal project.

### The Ganga System

The Ganga is the most important river of India both from the point of view of its basin and cultural significance. It rises in the Gangotri glacier near Gaumukh (3,900 m) in the Uttarkashi district of Uttaranchal. Here, it is known as the Bhagirathi. It cuts through the Central and the Lesser Himalayas in narrow gorges. At Devprayag, the Bhagirathi meets the Alaknanda; hereafter, it is known as the Ganga. The Alaknanda has its source in the Satopanth glacier above Badrinath. The Alaknanda consists of the Dhauli and the Vishnu Ganga which meet at Joshimath or Vishnu Prayag. The other tributaries of Alaknanda such as the Pindar join it at Karna Prayag while Mandakini or Kali Ganga meets it at Rudra Prayag. The Ganga enters the plains at Haridwar. From here, it flows first to the south, then to the south-east and east before splitting into two distributaries, namely the Bhagirathi and the Hugli. The river has a length of 2,525 km. It is shared by Uttaranchal (110 km) and Uttar Pradesh (1,450 km), Bihar (445 km) and West Bengal (520 km). The Ganga basin covers about 8.6 lakh sq. km area in India alone. The Ganga river system is the largest in India having a number of perennial and non-perennial rivers originating in the Himalayas in the north and the Peninsula in the south, respectively. The Son is its major right bank tributary. The important left bank tributaries are the Ramganga, the Gomati, the Ghaghara, the Gandak, the Kosi and the Mahanada. The river finally discharges itself into the Bay of Bengal near the Sagar Island.

The Yamuna, the western most and the longest tributary of the Ganga, has its source in the Yamunotri glacier on the western slopes of Banderpunch range (6,316 km). It joins the Ganga at Prayag (Allahabad). It is joined by the Chambal, the Sind, the Betwa and the Ken on its right bank which originates from the Peninsular plateau while the Hindan, the Rind, the Sengar, the Varuna, etc. join it on its left bank. Much of its water feeds the western and eastern Yamuna and the Agra canals for irrigation purposes.

Name the states which are drained by the river Yamuna.

The Chambal rises near Mhow in the Malwa plateau of Madhya Pradesh and flows northwards through a gorge up wards of Kota

in Rajasthan, where the Gandhisagar dam has been constructed. From Kota, it traverses down to Bundi, Sawai Madhopur and Dholpur, and finally joins the Yamuna. The Chambal is famous for its badland topography called the Chambal ravines.

The Gandak comprises two streams, namely Kaligandak and Trishulganga. It rises in the Nepal Himalayas between the Dhaulagiri and Mount Everest and drains the central part of Nepal. It enters the Ganga plain in Champaran district of Bihar and joins the Ganga at Sonpur near Patna.

The Ghaghara originates in the glaciers of Mapchachungo. After collecting the waters of its tributaries – Tila, Seti and Beri, it comes out of the mountain, cutting a deep gorge at Shishapani. The river Sarda (Kali or Kali Ganga) joins it in the plain before it finally meets the Ganga at Chhapra.

The Kosi is an antecedent river with its source to the north of Mount Everest in Tibet, where its main stream Arun rises. After crossing the Central Himalayas in Nepal, it is joined by the Son Kosi from the West and the Tamur Kosi from the east. It forms Sapt Kosi after uniting with the river Arun.

The Ramganga is comparatively a small river rising in the Garhwal hills near Gairsain. It changes its course to the southwest direction after crossing the Shiwalik and enters into the plains of Uttar Pradesh near Najibabad. Finally, it joins the Ganga near Kannauj.

The Damodar occupies the eastern margins of the Chotanagpur Plateau where it flows through a rift valley and finally joins the Hugli. The Barakar is its main tributary. Once known as the 'sorrow of Bengal', the Damodar has been now tamed by the Damodar Valley corporation, a multipurpose project.

The Sarda or Saryu river rises in the Milan glacier in the Nepal Himalayas where it is known as the Goriganga. Along the Indo-Nepal border, it is called Kali or Chauk, where it joins the Ghaghara.

The Mahananda is another important tributary of the Ganga rising in the Darjiling hills. It joins the Ganga as its last left bank tributary in West Bengal.

The Son is a large south bank tributary of the Ganga, originating in the Amarkantak plateau. After forming a series of waterfalls at the edge of the plateau, it reaches Arrah, west of Patna, to join the Ganga.

### The Brahmaputra System

The Brahmaputra, one of the largest rivers of the world, has its origin in the Chemayungdung glacier of the Kailash range near the Mansarovar lake. From here, it traverses eastward longitudinally for a distance of nearly 1,200 km in a dry and flat region of southern Tibet, where it is known as the Tsangpo, which means 'the purifier.' The Rango Tsangpo is the major right bank tributary of this river in Tibet. It emerges as a turbulent and dynamic river after carving out a deep gorge in the Central Himalayas near Namcha Barwa (7,755 m). The river emerges from the foothills under the name of Siang or Dihang. It enters India west of Sadiya town in Arunachal Pradesh. Flowing southwest, it receives its main left bank tributaries, viz., Dibang or Sikang and Lohit; thereafter, it is known as the Brahmaputra.

The Brahmaputra receives numerous tributaries in its 750 km long journey through the Assam valley. Its major left bank tributaries are the Burhi Dihing, Dhansari (South) and Kalang whereas the important right bank tributaries are the Subansiri, Kameng, Manas and Sankosh. The Subansiri which has its origin in Tibet, is an antecedent river. The Brahmaputra enters into Bangladesh near Dhubri and flows southward. In Bangladesh, the Tista joins it on its right bank from where the river is known as the Yamuna. It finally merges with the river Padma, which falls in the Bay of Bengal. The Brahmaputra is well-known for floods, channel shifting and bank erosion. This is due to the fact that most of its tributaries are large, and bring large quantity of sediments owing to heavy rainfall in its catchment area.

### The Peninsular Drainage System

The Peninsular drainage system is older than the Himalayan one. This is evident from the broad, largely-graded shallow valleys, and the

maturity of the rivers. The Western Ghats running close to the western coast act as the water divide between the major Peninsular rivers, discharging their water in the Bay of Bengal and as small rivulets joining the Arabian Sea. Most of the major Peninsular rivers except Narmada and Tapi flow from west to east. The Chambal, the Sind, the Betwa, the Ken, the Son, originating in the northern part of the Peninsula belong to the Ganga river system. The other major river systems of the Peninsular drainage are – the Mahanadi the Godavari, the Krishna and the Kaveri. Peninsular rivers are characterised by fixed course, absence of meanders and non-perennial flow of water. The Narmada and the Tapi which flow through the rift valley are, however, exceptions.

### The Evolution of Peninsular Drainage System

Three major geological events in the distant past have shaped the present drainage systems of Peninsular India: (i) Subsidence of the western flank of the Peninsula leading to its submergence below the sea during the early tertiary period. Generally, it has disturbed the symmetrical plan of the river on either side of the original watershed. (ii) Upheaval of the Himalayas when the northern flank of the Peninsular block was subjected to subsidence and the consequent trough faulting. The Narmada and The Tapi flow in trough faults and fill the original cracks with their detritus materials. Hence, there is a lack of alluvial and deltaic deposits in these rivers. (iii) Slight tilting of the Peninsular block from northwest to the southeastern direction gave orientation to the entire drainage system towards the Bay of Bengal during the same period.

### River Systems of the Peninsular Drainage

There are a large number of river systems in the Peninsular drainage. A brief account of the major Peninsular river systems is given below:

The Mahanadi rises near Sihawa in Raipur district of Chhattisgarh and runs through Orissa to discharge its water into the Bay of Bengal. It is 851 km long and its catchment area spreads over 1.42 lakh sq. km. Some navigation is carried on in the lower course of this river. Fifty three per cent of the drainage basin of this river lies in Madhya Pradesh and Chhattisgarh, while 47 per cent lies in Orissa.

The Godavari is the largest Peninsular river system. It is also called the Dakshin Ganga. It rises in the Nasik district of Maharashtra and discharges its water into the Bay of Bengal. Its tributaries run through the states of Maharashtra, Madhya Pradesh, Chhattisgarh, Orissa and Andhra Pradesh. It is 1,465 km long with a catchment area spreading over 3.13 lakh sq. km 49 per cent of this, lies in Maharashtra, 20 per cent in Madhya Pradesh and Chhattisgarh, and the rest in Andhra Pradesh. The Penganga, the Indravati, the Pranhita, and the Manjra are its principal tributaries. The Godavari is subjected to heavy floods in its lower reaches to the south of Polavaram, where it forms a picturesque gorge. It is navigable only in the deltaic stretch. The river after Rajamundri splits into several branches forming a large delta.

The Krishna is the second largest east-flowing Peninsular river which rises near Mahabaleshwar in Sahyadri. Its total length is 1,401 km. The Koyna, the Tungbhadra and the Bhima are its major tributaries. Of the total catchment area of the Krishna, 27 per cent lies in Maharashtra, 44 per cent in Karnataka and 29 per cent in Andhra Pradesh.

The Kaveri rises in Brahmagiri hills (1,341m) of Kogadu district in Karnataka. Its length is 800 km and it drains an area of 81,155 sq. km. Since the upper catchment area receives rainfall during the southwest monsoon season (summer) and the lower part during the northeast monsoon season (winter), the river carries water throughout the year with comparatively less fluctuation than the other Peninsular rivers. About 3 per cent of the Kaveri basin falls in Kerala, 41 per cent in Karnataka and 56 per cent in Tamil Nadu. Its important tributaries are the Kabini, the Bhavani and the Amravati.

The Narmada originates on the western flank of the Amarkantak plateau at a height of about 1,057 m. Flowing in a rift valley between the Satpura in the south and the Vindhyan range

in the north, it forms a picturesque gorge in marble rocks and Dhuandhar waterfall near Jabalpur. After flowing a distance of about 1,312 km, it meets the Arabian sea south of Bharuch, forming a broad 27 km long estuary. Its catchment area is about 98,796 sq. km. The Sardar Sarovar Project has been constructed on this river.

The Tapi is the other important westward flowing river. It originates from Multai in the Betul district of Madhya Pradesh. It is 724 km long and drains an area of 65,145 sq. km. Nearly 79 per cent of its basin lies in Maharashtra, 15 per cent in Madhya Pradesh and the remaining 6 per cent in Gujarat.

Luni is the largest river system of Rajasthan, west of Aravali. It originates near Pushkar in two branches, i.e. the Saraswati and the Sabarmati, which join with each other at Govindgarh. From here, the river comes out of Aravali and is known as Luni. It flows towards the west till Telwara and then takes a southwest direction to join the Rann of Kuchchh. The entire river system is ephemeral.

### Smaller Rivers Flowing Towards the West

The rivers flowing towards the Arabian sea have short courses. Why do they have short courses? Find out the smaller rivers of Gujarat. The Shetruniji is one such river which rises near Dalkahwa in Amreli district. The Bhadra originates near Aniali village in Rajkot district. The Dhadhar rises near Ghantar village in Panchmahal district. Sabarmati and Mahi are the two famous rivers of Gujarat.

Find out the places of confluence of these rivers. Find out some important west flowing rivers of Maharashtra.

The Vaitarna rises from the Trimbak hills in Nasik district at an elevation of 670 m. The Kalinadi rises from Belgaum district and falls in the Karwar Bay. The source of Bedti river lies in Hubli Dharwar and traverses a course of 161 km. The Sharavati is another important river in Karnataka flowing towards the west. The Sharavati originates in Shimoga district of Karnataka and drains a catchment area of 2,209 sq. km.

Find out the name of the river on which the Gersoppa (Jog) fall is found.

Goa has two important rivers which can be mentioned here. One is Mandovi and the other is Juari. You can locate them on the map.

Kerala has a narrow coastline. The longest river of Kerala, Bharathapuzha rises near Annamalai hills. It is also known as Ponnani. It drains an area of 5,397 sq. km. Compare its catchment area with that of the Sharavati river of Karnataka.

The Periyar is the second largest river of Kerala. Its catchment area is 5,243 sq. km. You can see that there is a marginal difference in the catchment area of the Bhartapuzha and the Periyar rivers.

Another river of Kerala worth mentioning is the Pamba river which falls in the Vemobanad lake after traversing a course of 177 km.

**Teachers may explain the comparative importance of west flowing small rivers**

| *River* | *Catchment area sq. km* |
|---|---|
| Sabarmati | 21,674 |
| Mahi | 34,842 |
| Dhandhar | 2,770 |
| Kalinadi | 5,179 |
| Sharavati | 2,029 |
| Bharathapuzha | 5,397 |
| Periyar | 5,243 |

### Small Rivers Flowing towards the East

There are a large number of rivers flowing towards the east along with their tributaries. Can you name some of these rivers? There are small rivers which join the Bay of Bengal, though small, these are important in their own right. The Subarnrekha, the Baitarni, the Brahmani, the Vamsadhara, the Penner, the Palar and the Vaigai are important rivers. Find out these rivers from the atlas.

**Teachers may explain the comparative importance of east flowing small rivers**

| *River* | *Catchment area sq. km* |
|---|---|
| Subarnarekha | 19,296 |
| Baitarni | 12,789 |
| Brahmani | 39,033 |
| Penner | 55,213 |
| Palar | 17,870 |

**Table 3.1 : Comparison between the Himalayan and the Peninsular River**

| *Sl. No.* | *Aspects* | *Himalayan River* | *Peninsular River* |
|---|---|---|---|
| 1. | Place of origin | Himalayan mountain covered with glaciers | Peninsular plateau and central highland |
| 2. | Nature of flow | Perennial; receive water from glacier and rainfall | Seasonal; dependent on monsoon rainfall |
| 3. | Type of drainage | Antecedent and consequent leading to dendritic pattern in plains | Super imposed, rejuvenated resulting in trellis, radial and rectangular patterns |
| 4. | Nature of river | Long course, flowing through the rugged mountains experiencing headward erosion and river capturing; In plains meandering and shifting of course | Smaller, fixed course with well-adjusted valleys |
| 5. | Catchment area | Very large basins | Relatively smaller basin |
| 6. | Age of the river | Young and youthful, active and deepening in the valleys | Old rivers with graded profile, and have almost reached their base levels |

## River Regimes

Do you know that the quantity of water flowing in a river channel is not the same throughout the year? It varies from season to season. In which season do you expect the maximum flow in Ganga and Kaveri? The pattern of flow of water in a river channel over a year is known as its regime. The north Indian rivers originating from the Himalayas are perennial as they are fed by glaciers through snow melt and also receive rainfall water during rainy season. The rivers of South India do not originate from glaciers and their flow pattern witnesses fluctuations. The flow increases considerably during monsoon rains. Thus, the regime of the rivers of South India is controlled by rainfall which also varies from one part of the Peninsular plateau to the other.

The discharge is the volume of water flowing in a river measured over time. It is measured either in cusecs (cubic feet per second) or cumecs (cubic metres per second).

The Ganga has its minimum flow during the January-June period. The maximum flow is attained either in August or in September. After September, there is a steady fall in the flow. The river, thus, has a monsoon regime during the rainy season.

There are striking differences in the river regimes in the eastern and the western parts of the Ganga Basin. The Ganga maintains a sizeable flow in the early part of summer due to snow melt before the monsoon rains begin. The mean maximum discharge of the Ganga at Farakka is about 55,000 cusecs while the mean minimum is only 1,300 cusecs. What factors are responsible for such a large difference?

The two Peninsular rivers display interesting differences in their regimes compared to the Himalayan rivers. The Narmada has a very low volume of discharge from January to July but it suddenly rises in August when the maximum flow is attained. The fall in October is as spectacular as the rise in August. The flow of water in the Narmada, as recorded at Garudeshwar, shows that the maximum flow is of the order of 2,300 cusecs, while the minimum flow is only 15 cusecs. The Godavari has the minimum discharge in May, and the maximum in July-August. After August, there is a sharp fall in water flow although the volume of flow in October and November is higher than that in any of the months from January to May. The mean maximum discharge of the Godavari at Polavaram is 3,200 cusecs while the mean minimum flow is only 50 cusecs. These figures give an idea of the regime of the river.

## Extent of Usability of River Water

The rivers of India carry huge volumes of water

per year but it is unevenly distributed both in time and space. There are perennial rivers carrying water throughout the year while the non-perennial rivers have very little water during the dry season. During the rainy season, much of the water is wasted in floods and flows down to the sea. Similarly, when there is a flood in one part of the country, the other area suffers from drought. Why does this happen? Is it the problem of availability of water resource or that of its management? Can you suggest some measures to mitigate the problems of floods and droughts simultaneously occuring in different parts of the country? (See Chapter 7 of the book).

Can these problems be solved or minimised by trasfering the surplus water from one basin to the water deficit basins? Do we have some schemes of inter-basin linkage?

**Teachers may explain the following examples**

- Periyar Diversion Scheme
- Indira Gandhi Canal Project
- Kurnool-Cuddapah Canal
- Beas-Satluj Link Canal
- Ganga-Kaveri Link Canal

Have you read in the newspapers about the linking of rivers? Do you think that digging a canal is enough to transfer water from the Ganga basin to the Peninsular river? What is the major problem? Consult Chapter 2 of this book and find out the difficulties posed by the unevenness of the terrain. How can the water be lifted from the plain area to the plateau area? Is there sufficient surplus water in the north Indian rivers which can be transferred on a regular basis? Organise a debate on the whole issue and prepare a write up. How do you rank the following problems in using river water?

(i) No availability in sufficient quantity
(ii) River water pollution
(iii) Load of silt in the river water
(iv) Uneven seasonal flow of water
(v) River water disputes between states
(vi) Shrinking of channels due to the extension of settlements towards the thalweg.

Why are the rivers polluted? Have you seen the dirty waters of cities entering into the rivers? Where do the industrial affluents and wastes get disposed of ? Most of the cremation grounds are on the banks of rivers and the dead bodies are sometimes thrown in the rivers. On the occasion of some festivals, the flowers and statues are immersed in the rivers. Large scale bathing and washing of clothes also pollute river waters. How can the rivers be made pollution free? Have you read about Ganga Action Plan, or about a campaign for cleaning the Yamuna at Delhi? Collect materials on schemes for making rivers pollution free and organise the materials in a write up.

## EXERCISES

1. Choose the right answer from the four alternatives given below.

(i) Which one of the following rivers was known as the 'Sorrow of Bengal'?
(a) The Gandak (c) The Kosi
(b) The Son (d) The Damodar

(ii) Which one of the following rivers has the largest river basin in India?
(a) The Indus (c) The Ganga
(b) The Brahmaputra (d) The Krishna

(iii) Which one of the following rivers is not included in 'Panchnad'?
(a) The Ravi (c) The Indus
(b) The Chenab (d) The Jhelum

(iv) Which one of the following rivers flows in a rift valley?
(a) The Son (c) The Yamuna
(b) The Narmada (d) The Luni

(v) Which one of the following is the place of confluence of the Alkananda and the Bhagirathi?

(a) Vishnu Prayag (c) Karan Prayag

(b) Rudra Prayag (d) Deva Prayag

2. State the differences between the following.

(i) River Basin and Watershed

(ii) Dendritic and Trellis drainage pattern

(iii) Radial and Centripetal drainage pattern

(iv) Delta and Estuary

3. Answer the following questions in about 30 words.

(i) What are the socio-economic advantages of inter-linking of rivers in India?

(ii) Write three characterstics of the Peninsular river.

4. Answer the following questions in not more than 125 words.

(i) What are the important characteristic features of north Indian rivers? How are these different from Peninsular rivers?

(ii) Suppose you are travelling from Hardwar to Siliguri along the foothills of the Himalayas. Name the important rivers you will come across. Describe the characteristics of any one of them.

**Project/Activity**

Study the Appendix III and answer the following questions.

(i) Which river has the largest proportion of catchment area in the country?

(ii) Make a comparative bar diagram on a graph paper to show the length of the courses of the rivers.

# UNIT III

# CLIMATE, VEGETATION AND SOIL

*This unit deals with*

- *Weather and climate – spatial and temporal distribution of temperature, pressure, winds and rainfall; Indian monsoons: mechanism, onset and variability – spatial and temporal; climatic types*
- *Natural vegetation – forest types and distribution; wild life conservation; biosphere reserves*
- *Soils – major types and their distribution, soil degradation and conservation*

CHAPTER

4

# CLIMATE

We drink more water during summers. Your uniform during the summer is different from the winters. Why do you wear lighter clothes during summers and heavy woollen clothes during winters in north India? In southern India, woollen clothes are not required. In northeastern states, winters are mild except in the hills. There are variations in weather conditions during different seasons. These changes occur due to the changes in the elements of weather (temperature, pressure, wind direction and velocity, humidity and precipitation, etc.).

> Weather is the momentary state of the atmosphere while climate refers to the average of the weather conditions over a longer period of time. Weather changes quickly, may be within a day or week but climate changes imperceptively and may be noted after 50 years or even more.

You have already studied about the monsoon in your earlier classes. You are also aware of the meaning of the word, "monsoon". Monsoon connotes the climate associated with seasonal reversal in the direction of winds. India has hot monsoonal climate which is the prevalent climate in south and southeast Asia.

### UNITY AND DIVERSITY IN THE MONSOON CLIMATE

The monsoon regime emphasises the unity of India with the rest of southeast Asian region. This view of broad unity of the monsoon type of climate should not, however, lead one to ignore its regional variations which differentiate the weather and climate of different regions of India. For example, the climate of Kerala and Tamil Nadu in the south are so different from that of Uttar Pradesh and Bihar in the north, and yet all of these have a monsoon type of climate. The climate of India has many regional variations expressed in the pattern of winds, temperature and rainfall, rhythm of seasons and the degree of wetness or dryness. These regional diversities may be described as sub-types of monsoon climate. Let us take a closer look at these regional variations in temperature, winds and rainfall.

While in the summer the mercury occasionally touches 55°C in the western Rajasthan, it drops down to as low as minus 45°C in winter around Leh. Churu in Rajasthan may record a temperature of 50°C or more on a June day while the mercury hardly touches 19°C in Tawang (Arunachal Pradesh) on the same day. On a December night, temperature in Drass (Jammu and Kashmir) may drop down to minus 45°C while Tiruvanantapuram or Chennai on the same night records 20°C or 22°C. These examples confirm that there are seasonal variations in temperature from place to place and from region to region in India. Not only this, if we take only a single place and record the temperature for just one day, variations are no less striking. In Kerala and in the Andaman Islands, the difference between day and night temperatures may be hardly seven or eight degree Celsius. But in the Thar desert, if the day temperature is around 50°C, at night, it may drop down considerably upto 15°-20°C.

Now, let us see the regional variations in precipitation. While snowfall occurs in the Himalayas, it only rains over the rest of the country. Similarly, variations are noticeable not only in the type of precipitation but also in its amount. While Cherrapunji and Mawsynram in the Khasi Hills of Meghalaya receive rainfall over 1,080 cm in a year, Jaisalmer in Rajasthan rarely gets more than 9 cm of rainfall during the same period.

Tura situated in the Garo Hills of Meghalaya may receive an amount of rainfall in a single day which is equal to 10 years of rainfall at Jaisalmer. While the annual precipitation is less than 10 cm in the north-west Himalayas and the western deserts, it exceeds 400 cm in Meghalaya.

The Ganga delta and the coastal plains of Orissa are hit by strong rain-bearing storms almost every third or fifth day in July and August while the Coromandal coast, a thousand km to the south, goes generally dry during these months. Most parts of the country get rainfall during June-September, but on the coastal areas of Tamil Nadu, it rains in the beginning of the winter season.

In spite of these differences and variations, the climate of India is monsoonal in rhythm and character.

## Factors Determining the Climate of India

India's climate is controlled by a number of factors which can be broadly divided into two groups — factors related to location and relief, and factors related to air pressure and winds.

### Factors related to Location and Relief

*Latitude :* You already know the latitudinal and longitudinal extent of the land of India. You also know that the Tropic of Cancer passes through the central part of India in east-west direction. Thus, northern part of the India lies in sub-tropical and temperate zone and the part lying south of the Tropic of Cancer falls in the tropical zone. The tropical zone being nearer to the equator, experiences high temperatures throughout the year with small daily and annual range. Area north of the Tropic of Cancer being away from the equator, experiences extreme climate with high daily and annual range of temperature.

*The Himalayan Mountains :* The lofty Himalayas in the north along with its extensions act as an effective climatic divide. The towering mountain chain provides an invincible shield to protect the subcontinent from the cold northern winds. These cold and chilly winds originate near the Arctic circle and blow across central and eastern Asia. The Himalayas also trap the monsoon winds, forcing them to shed their moisture within the subcontinent.

*Distribution of Land and Water :* India is flanked by the Indian Ocean on three sides in the south and girdled by a high and continuous mountain-wall in the north. As compared to the landmass, water heats up or cools down slowly. This differential heating of land and sea creates different air pressure zones in different seasons in and around the Indian subcontinent. Difference in air pressure causes reversal in the direction of monsoon winds.

*Distance from the Sea :* With a long coastline, large coastal areas have an equable climate. Areas in the interior of India are far away from the moderating influence of the sea. Such areas have extremes of climate. That is why, the people of Mumbai and the Konkan coast have hardly any idea of extremes of temperature and the seasonal rhythm of weather. On the other hand, the seasonal contrasts in weather at places in the interior of the country such as Delhi, Kanpur and Amritsar affect the entire sphere of life.

*Altitude :* Temperature decreases with height. Due to thin air, places in the mountains are cooler than places on the plains. For example, Agra and Darjiling are located on the same latitude, but temperature of January in Agra is 16°C whereas it is only 4°C in Darjiling.

*Relief :* The physiography or relief of India also affects the temperature, air pressure, direction and speed of wind and the amount and distribution of rainfall. The windward sides of Western Ghats and Assam receive high rainfall

during June-September whereas the southern plateau remains dry due to its leeward situation along the Western Ghats.

**Factors Related to Air Pressure and Wind**

To understand the differences in local climates of India, we need to understand the mechanism of the following three factors:

(i) Distribution of air pressure and winds on the surface of the earth.
(ii) Upper air circulation caused by factors controlling global weather and the inflow of different air masses and jet streams.
(iii) Inflow of western cyclones generally known as disturbances during the winter season and tropical depressions during the south-west monsoon period into India, creating weather conditions favourable to rainfall.

The mechanism of these three factors can be understood with reference to winter and summer seasons of the year separately.

**Mechanism of Weather in the Winter Season**

*Surface Pressure and Winds :* In winter months, the weather conditions over India are generally influenced by the distribution of pressure in Central and Western Asia. A high pressure centre in the region lying to the north of the Himalayas develops during winter. This centre of high pressure gives rise to the flow of air at the low level from the north towards the Indian subcontinent, south of the mountain range. The surface winds blowing out of the high pressure centre over Central Asia reach India in the form of a dry continental air mass. These continental winds come in contact with trade winds over northwestern India. The position of this contact zone is not, however, stable. Occasionally, it may shift its position as far east as the middle Ganga valley with the result that the whole of the northwestern and northern India up to the middle Ganga valley comes under the influence of dry northwestern winds.

*Jet Stream and Upper Air Circulation :* The pattern of air circulation discussed above is witnessed only at the lower level of the atmosphere near the surface of the earth. Higher up in the lower troposphere, about three km above the surface of the earth, a different pattern of air circulation is observed. The variations in the atmospheric pressure closer to the surface of the earth have no role to play in the making of upper air circulation. All of Western and Central Asia remains under the influence of westerly winds along the altitude of 9-13 km from west to east. These winds blow across the Asian continent at latitudes north of the Himalayas roughly parallel to the Tibetan highlands (Figure 4.1). These are known as jet streams. Tibetan highlands act as a barrier in the path of these jet streams. As a result, jet streams get bifurcated. One of its branches blows to the north of the Tibetan highlands, while the southern branch blows in an eastward direction, south of the Himalayas. It has its mean position at 25°N in February at 200-300 mb level. It is believed that this southern branch of the jet stream exercises an important influence on the winter weather in India.

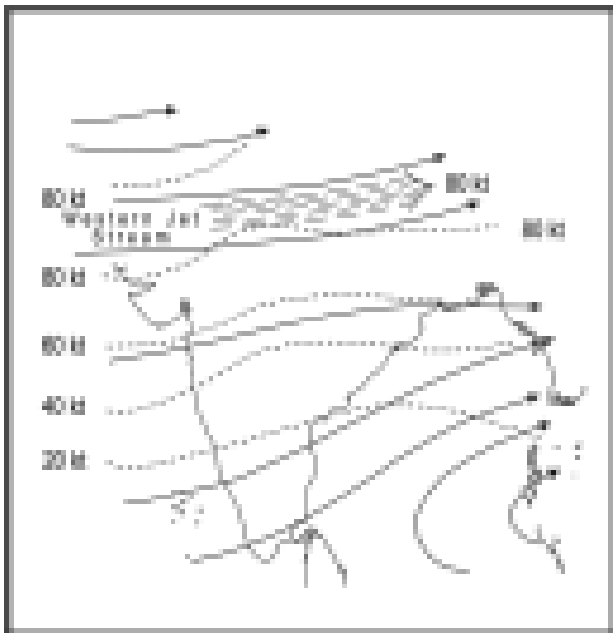

**Figure 4.1 : Direction of Winds in India in Winter at the Height of 9-13 km**

*Western Cyclonic Disturbance and Tropical Cyclones :* The western cyclonic disturbances which enter the Indian subcontinent from the west and the northwest during the winter months, originate over the Mediterranean Sea and are

brought into India by the westerly jet stream. An increase in the prevailing night temperature generally indicates an advance in the arrival of these cyclones disturbances.

Tropical cyclones originate over the Bay of Bengal and the Indian ocean. These tropical cyclones have very high wind velocity and heavy rainfall and hit the Tamil Nadu, Andhra Pradesh and Orissa coast. Most of these cyclones are very destructive due to high wind velocity and torrential rain that accompanies it. Have you seen their movement in the weather report in the television?

**Mechanism of Weather in the Summer Season**

*Surface Pressure and Winds :* As the summer sets in and the sun shifts northwards, the wind circulation over the subcontinent undergoes a complete reversal at both, the lower as well as the upper levels. By the middle of July, the low pressure belt nearer the surface [termed as Inter Tropical Convergence Zone (ITCZ)] shifts northwards, roughly parallel to the Himalayas between 20° N and 25° N. By this time, the westerly jet stream withdraws from the Indian region. In fact, meteorologists have found an interrelationship between the northward shift of the equatorial trough (ITCZ) and the withdrawal of the westerly jet stream from over the North Indian Plain. It is generally believed that there is a cause and effect relationship between the two. The ITCZ being a zone of low pressure, attracts inflow of winds from different directions. The maritime tropical airmass (mT) from the southern hemisphere, after crossing the equator, rushes to the low pressure area in the general southwesterly direction. It is this moist air current which is popularly known as the southwest monsoon.

*Jet Streams and Upper Air Circulation :* The pattern of pressure and winds as mentioned above is formed only at the level of the troposphere. An easterly jet stream flows over

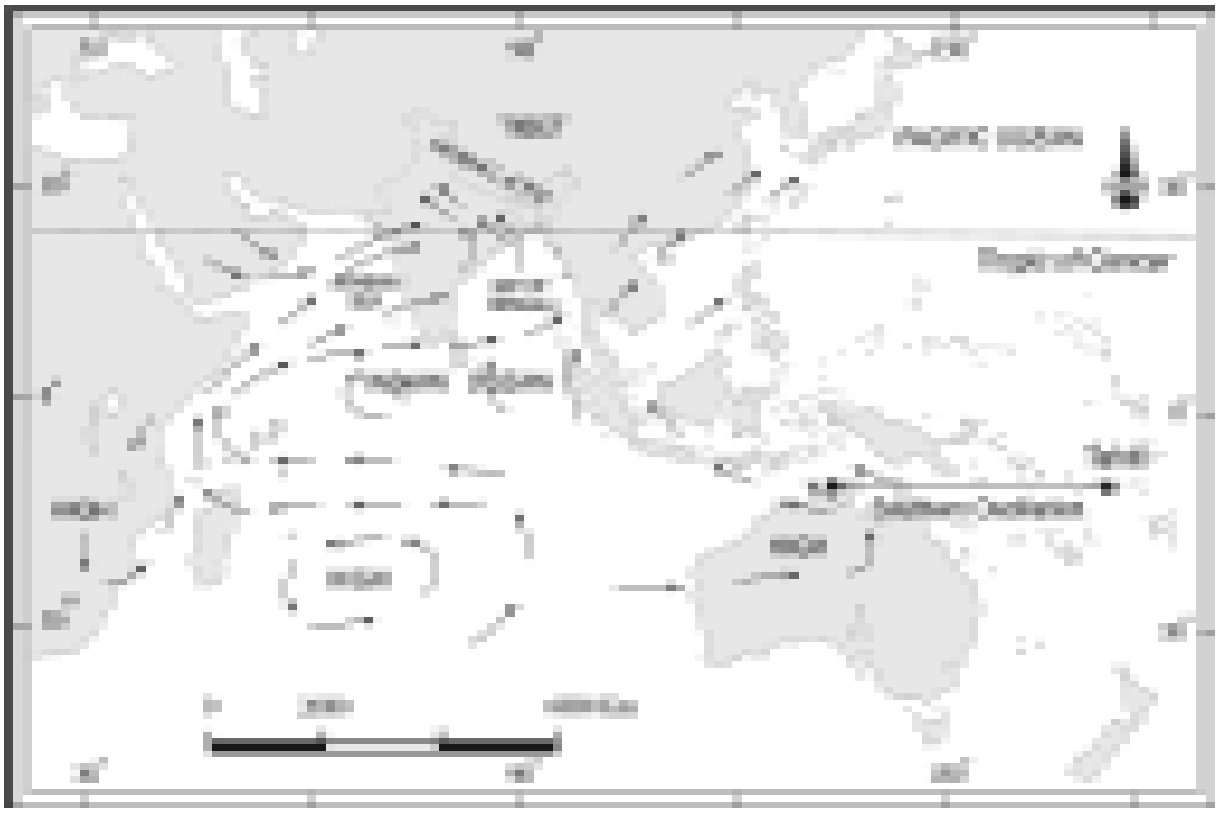

**Figure 4.2 : Summer Monsoon Winds : Surface Circulation**

**Inter Tropical Convergence Zone (ITCZ)**

The Inter Tropical Convergence Zone (ITCZ) is a low pressure zone located at the equator where trade winds converge, and so, it is a zone where air tends to ascend. In July, the ITCZ is located around 20°N-25°N latitudes (over the Gangetic plain), sometimes called the monsoon trough. This monsoon trough encourages the development of thermal low over north and northwest India. Due to the shift of ITCZ, the trade winds of the southern hemisphere cross the equator between 40° and 60°E longitudes and start blowing from southwest to northeast due to the Coriolis force. It becomes southwest monsoon. In winter, the ITCZ moves southward, and so the reversal of winds from northeast to south and southwest, takes place. They are called northeast monsoons.

the southern part of the Peninsula in June, and has a maximum speed of 90 km per hour (Figure 4.3). In August, it is confined to 15°N latitude, and in September up to 22° N latitudes. The easterlies normally do not extend to the north of 30° N latitude in the upper atmosphere.

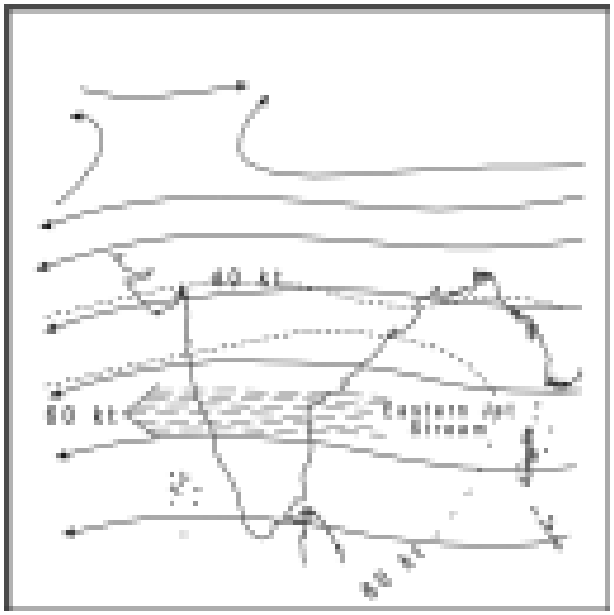

**Figure 4.3 : The Direction of Winds at 13 km Altitude in Summer Season**

*Easterly Jet Stream and Tropical Cyclones :* The easterly jet stream steers the tropical depressions into India. These depressions play a significant role in the distribution of monsoon rainfall over the Indian subcontinent. The tracks of these depressions are the areas of highest rainfall in India. The frequency at which these depressions visit India, their direction and intensity, all go a long way in determining the rainfall pattern during the southwest monsoon period.

## The Nature of Indian Monsoon

Monsoon is a familiar though a little known climatic phenomenon. Despite the observations spread over centuries, the monsoon continues to puzzle the scientists. Many attempts have been made to discover the exact nature and causation of monsoon, but so far, no single theory has been able to explain the monsoon fully. A real breakthrough has come recently when it was studied at the global rather than at regional level.

Systematic studies of the causes of rainfall in the South Asian region help to understand the causes and salient features of the monsoon, particularly some of its important aspects, such as:

(i) The onset of the monsoon.
(ii) Rain-bearing systems (e.g. tropical cyclones) and the relationship between their frequency and distribution of monsoon rainfall.
(iii) Break in the monsoon.

### Onset of the Monsoon

Towards the end of the nineteenth century, it was believed that the differential heating of land and sea during the summer months is the mechanism which sets the stage for the monsoon winds to drift towards the subcontinent. During April and May when the sun shines vertically over the Tropic of Cancer, the large landmass in the north of Indian ocean gets intensely heated. This causes the formation of an intense low pressure in the northwestern part of the subcontinent. Since the pressure in the Indian Ocean in the south of the landmass is high as water gets heated

**Figure 4.4 : Onset of Monsoon**

slowly, the low pressure cell attracts the southeast trades across the Equator. These conditions help in the northward shift in the position of the ITCZ. The southwest monsoon may thus, be seen as a continuation of the southeast trades deflected towards the Indian subcontinent after crossing the Equator. These winds cross the Equator between 40°E and 60°E longitudes.

The shift in the position of the ITCZ is also related to the phenomenon of the withdrawal of the westerly jet stream from its position over the north Indian plain, south of the Himalayas. The easterly jet stream sets in along 15°N latitude only after the western jet stream has withdrawn itself from the region. This easterly jet stream is held responsible for the burst of the monsoon in India.

*Entry of Monsoon into India :* The southwest monsoon sets in over the Kerala coast by 1st June and moves swiftly to reach Mumbai and Kolkata between 10th and 13th June. By mid-July, southwest monsoon engulfs the entire subcontinent (Figure 4.5)

## Rain-bearing Systems and Rainfall Distribution

There seem to be two rain-bearing systems in India. First originate in the Bay of Bengal causing rainfall over the plains of north India. Second is the Arabian Sea current of the south-west monsoon which brings rain to the west coast of India. Much of the rainfall along the Western Ghats is orographic as the moist air is obstructed and forced to rise along the Ghats. The intensity of rainfall over the west coast of India is, however, related to two factors:

(i) The offshore meteorological conditions.
(ii) The position of the equatorial jet stream along the eastern coast of Africa.

### EI-Nino and the Indian Monsoon

EI-Nino is a complex weather system that appears once every three to seven years, bringing drought, floods and other weather extremes to different parts of the world.

The system involves oceanic and atmospheric phenomena with the appearance of warm currents off the coast of Peru in the Eastern Pacific and affects weather in many places including India. EI-Nino is merely an extension of the warm equatorial current which gets replaced temporarily by cold Peruvian current or Humbolt current (locate these currents in your atlas). This current increases the temperature of water on the Peruvian coast by 10°C. This results in:

(i) the distortion of equatorial atmospheric circulation;
(ii) irregularities in the evaporation of sea water;
(iii) reduction in the amount of planktons which further reduces the number of fish in the sea.

The word EI-Nino means 'Child Christ' because this current appears around Christmas in December. December is a summer month in Peru (Southern Hemisphere).

EI-Nino is used in India for forecasting long range monsoon rainfall. In 1990-91, there was a wild EI-Nino event and the onset of southwest monsoon was delayed over most parts of the country ranging from five to twelve days.

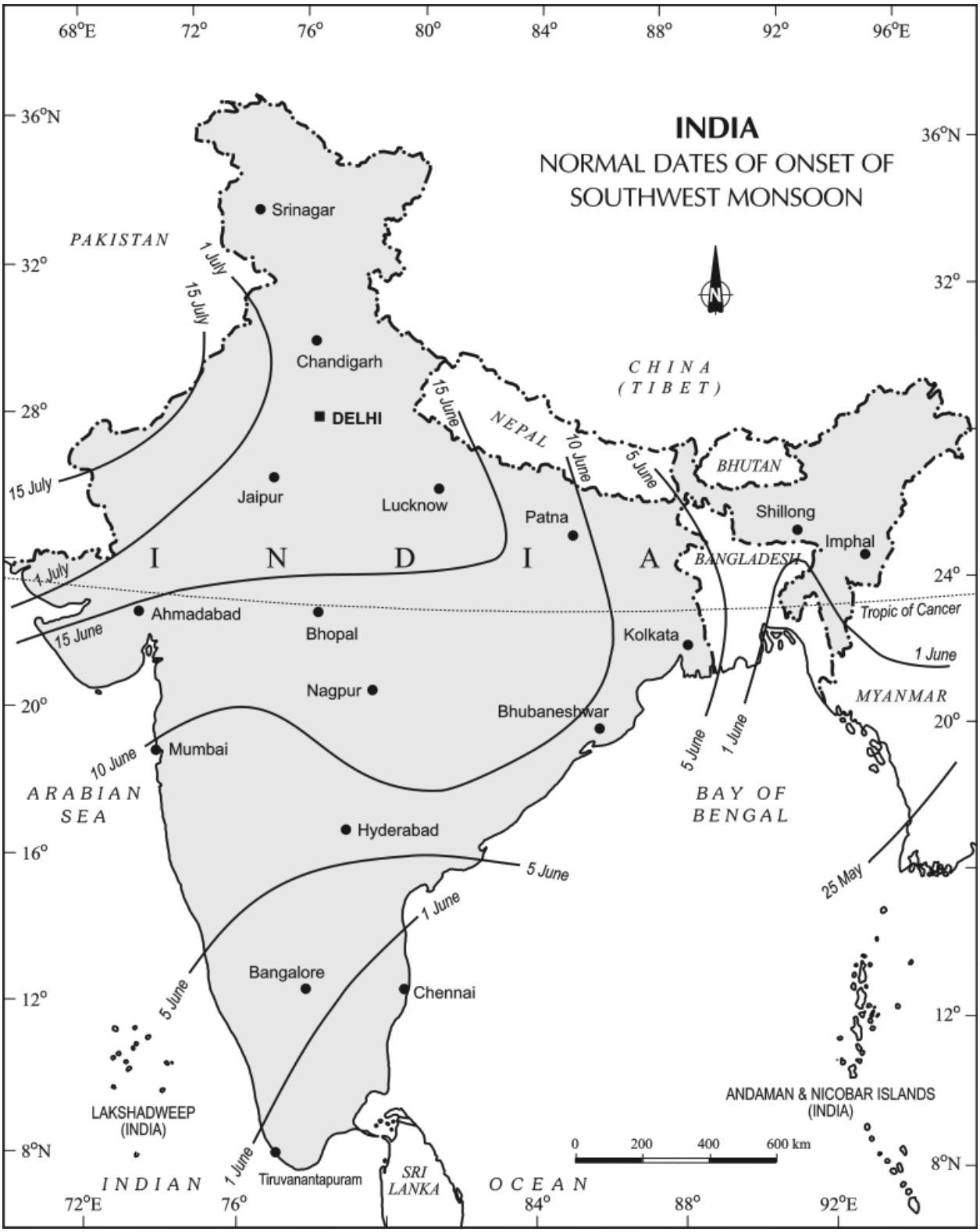


**Figure 4.5 : India : Normal Dates of Onset of the Southwest Monsoon**

The frequency of the tropical depressions originating from the Bay of Bengal varies from year to year. Their paths over India are mainly determined by the position of ITCZ which is generally termed as the monsoon trough. As the axis of the monsoon trough oscillates, there are fluctuations in the track and direction of these depressions, and the intensity and the amount of rainfall vary from year to year. The rain which comes in spells, displays a declining trend from west to east over the west coast, and from the southeast towards the northwest over the North Indian Plain and the northern part of the Peninsula.

### Break in the Monsoon

During the south-west monsoon period after having rains for a few days, if rain fails to occur for one or more weeks, it is known as break in the monsoon. These dry spells are quite common during the rainy season. These breaks in the different regions are due to different reasons:

(i) In northern India rains are likely to fail if the rain-bearing storms are not very frequent along the monsoon trough or the ITCZ over this region.

(ii) Over the west coast the dry spells are associated with days when winds blow parallel to the coast.

## The Rhythm of Seasons

The climatic conditions of India can best be described in terms of an annual cycle of seasons. The meteorologists recognise the following four seasons :

(i) the cold weather season
(ii) the hot weather season
(iii) the southwest monsoon season
(iv) the retreating monsoon season.

### The Cold Weather Season

*Temperature :* Usually, the cold weather season sets in by mid-November in northern India. December and January are the coldest months in the northern plain. The mean daily temperature remains below 21°C over most parts of northern India. The night temperature may be quite low, sometimes going below freezing point in Punjab and Rajasthan.

There are three main reasons for the excessive cold in north India during this season :

(i) States like Punjab, Haryana and Rajasthan being far away from the moderating influence of sea experience continental climate.

(ii) The snowfall in the nearby Himalayan ranges creates cold wave situation; and

(iii) Around February, the cold winds coming from the Caspian Sea and Turkmenistan bring cold wave along with frost and fog over the northwestern parts of India.

**Understanding the Monsoon**

Attempts have been made to understand the nature and mechanism of the monsoon on the basis of data collected on land, oceans and in the upper atmosphere. The intensity of southwest monsoon winds of southern oscillation can be measured, among others, by measuring the difference in pressure between Tahiti (roughly 20°S and 140°W) in French Polynesia in East Pacific and port Darwin (12°30'S and 131°E) in northern Australia. Indian Meteorological Department (IMD) can forecast the possible behaviour of monsoons on the basis of 16 indicators.

The Peninsular region of India, however, does not have any well-defined cold weather season. There is hardly any seasonal change in the distribution pattern of the temperature in coastal areas because of moderating influence of the sea and the proximity to equator. For example, the mean maximum temperature for January at Thiruvanantapuram is as high as 31°C, and for June, it is 29.5°C. Temperatures at the hills of Western Ghats remain comparatively low (Figure 4.6).

*Pressure and Winds :* By the end of December (22nd December), the sun shines vertically over the Tropic of Capricorn in the southern hemisphere. The weather in this season is characterised by feeble high pressure conditions over the northern plain. In south

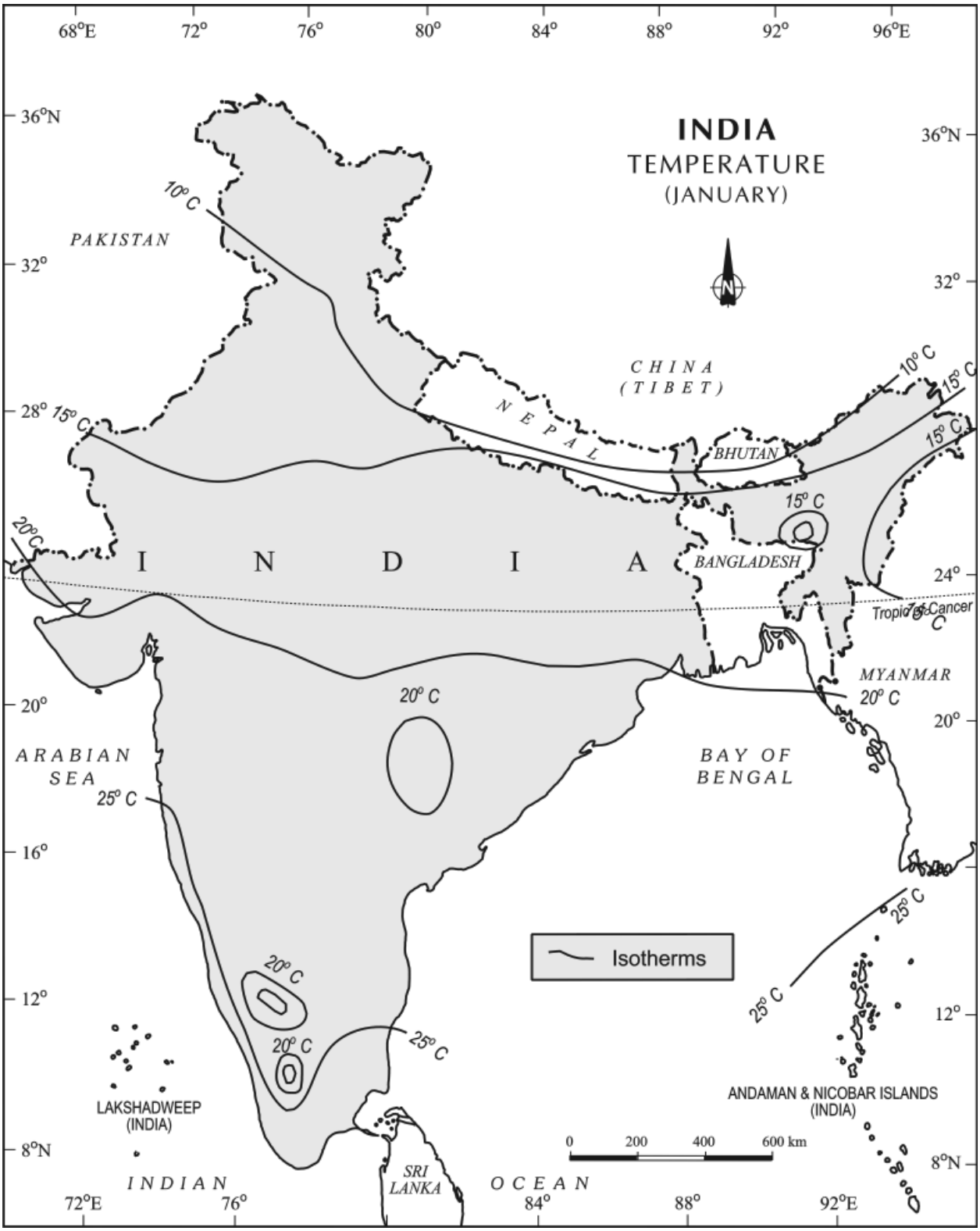


**Figure 4.6 : India : Mean Monthly Temperatures of the Day in January**

India, the air pressure is slightly lower. The isobars of 1019 mb and 1013 mb pass through northwest India and far south, respectively (Figure 4.7).

As a result, winds start blowing from northwestern high pressure zone to the low air pressure zone over the Indian Ocean in the south.

Due to low pressure gradient, the light winds with a low velocity of about 3-5 km per hour begin to blow outwards. By and large, the topography of the region influences the wind direction. They are westerly or northwesterly down the Ganga Valley. They become northerly in the Ganga-Brahmaputra delta. Free from the influence of topography, they are clearly northeasterly over the Bay of Bengal.

During the winters, the weather in India is pleasant. The pleasant weather conditions, however, at intervals, get disturbed by shallow cyclonic depressions originating over the east Mediterranean Sea and travelling eastwards across West Asia, Iran, Afghanistan and Pakistan before they reach the northwestern parts of India. On their way, the moisture content gets augmented from the Caspian Sea in the north and the Persian Gulf in the south. What is the role of Westerly Jet Streams in steering these depressions in India?

*Rainfall :* Winter monsoons do not cause rainfall as they move from land to the sea. It is because firstly, they have little humidity; and secondly, due to anti cyclonic circulation on land, the possibility of rainfall from them reduces. So, most parts of India do not have rainfall in the winter season. However, there are some exceptions to it:

(i) In northwestern India, some weak temperate cyclones from the Mediterranean sea cause rainfall in Punjab, Haryana, Delhi and western Uttar Pradesh. Although the amount is meagre, it is highly beneficial for rabi crops. The precipitation is in the form of snowfall in the lower Himalayas. It is this snow that sustains the flow of water in the Himalayan rivers during the summer months. The precipitation goes on decreasing from west to east in the plains and from north to south in the mountains. The average winter rainfall in Delhi is around 53 mm. In Punjab and Bihar, rainfall remains between 25 mm and 18 mm respectively.

(ii) Central parts of India and northern parts of southern Peninsula also get winter rainfall occasionally.

(iii) Arunachal Pradesh and Assam in the northeastern parts of India also have rains between 25 mm and 50 mm during these winter months.

(iv) During October and November, northeast monsoon while crossing over the Bay of Bengal, picks up moisture and causes torrential rainfall over the Tamil Nadu coast, southern Andhra Pradesh, southeast Karnataka and southeast Kerala.

**The Hot Weather Season**

*Temperature:* With the apparent northward movement of the sun towards the Tropic of Cancer in March, temperatures start rising in north India. April, May and June are the months of summer in north India. In most parts of India, temperatures recorded are between 30°-32°C. In March, the highest day temperature of about 38°C occurs in the Deccan Plateau while in April, temperature ranging between 38°C and 43°C are found in Gujarat and Madhya Pradesh. In May, the heat belt moves further north, and in the north-western part of India, temperatures around 48°C are not uncommon (Figure 4.8).

The hot weather season in south India is mild and not so intense as found in north India. The Peninsular situation of south India with moderating effect of the oceans keeps the temperatures lower than that prevailing in north India. So, temperatures remain between 26°C and 32°C. Due to altitude, the temperatures in the hills of Western Ghats remain below 25°C. In the coastal regions, the north-south extent of

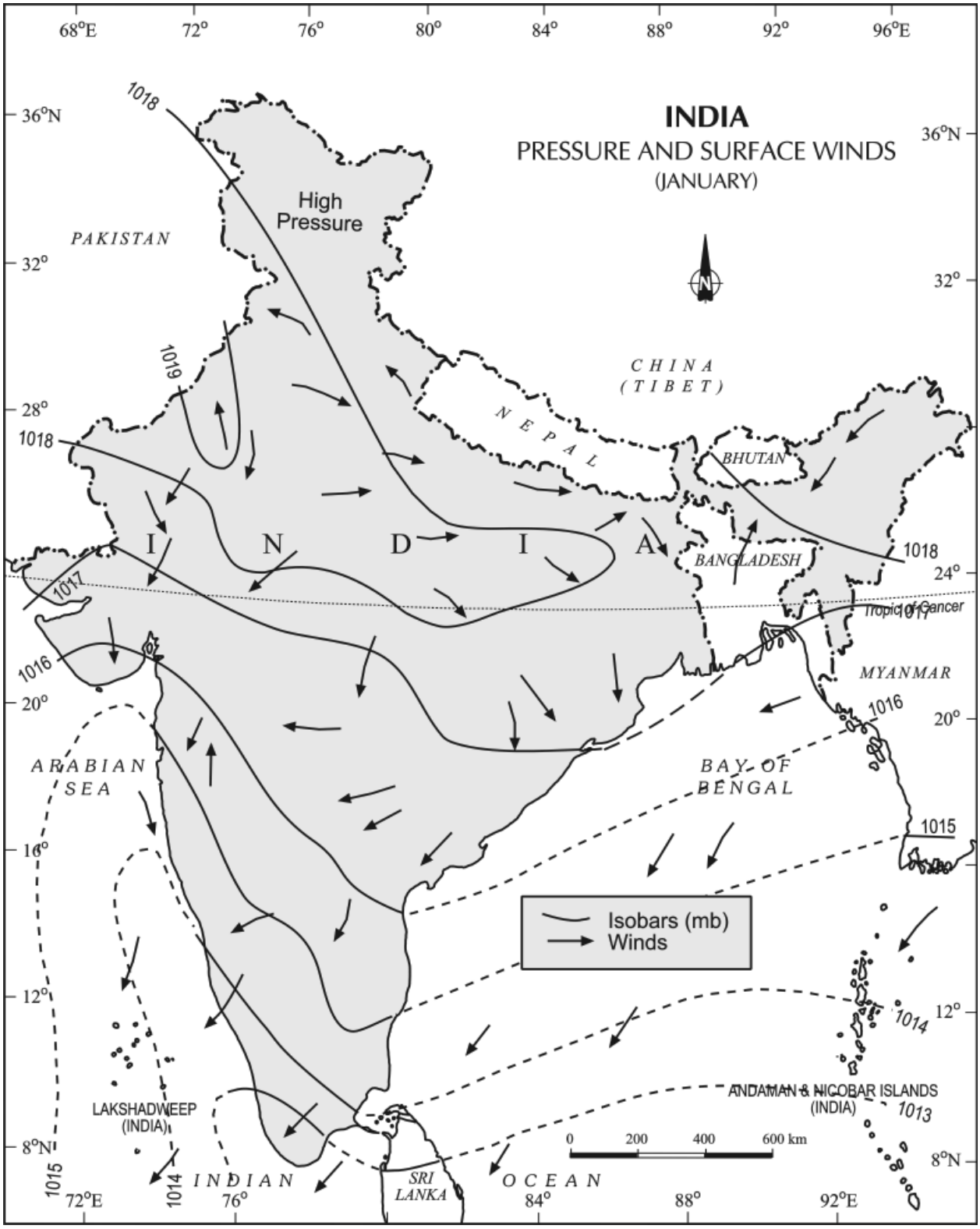


**Figure 4.7 : India : Pressure and Surface Winds (January)**

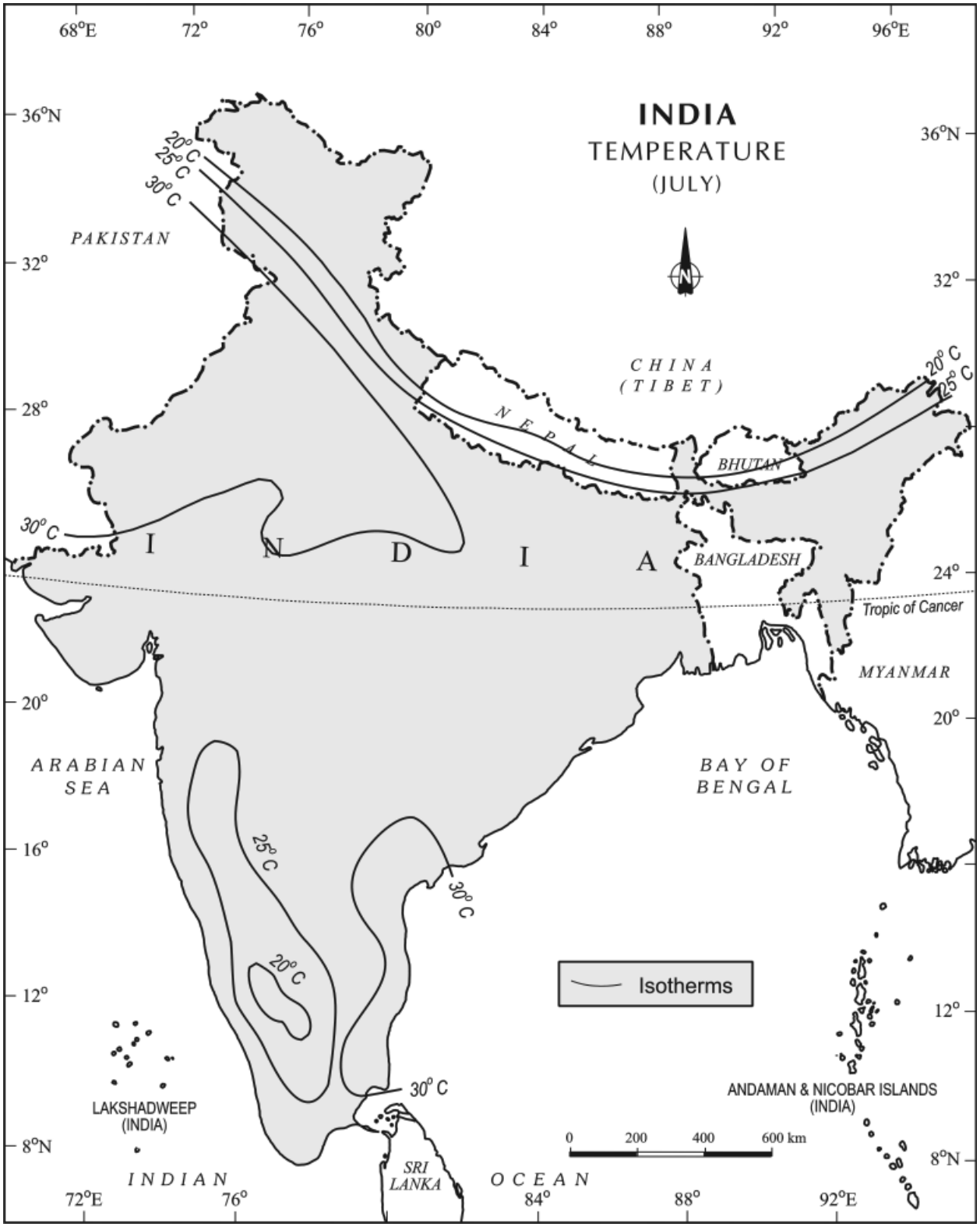


**Figure 4.8 : India : Mean Monthly Temperature of the Day in July**

isotherms parallel to the coast confirms that temperature does not decrease from north to south rather it increases from the coast to the interior. The mean daily minimum temperature during the summer months also remains quite high and rarely goes below 26°C.

*Pressure and Winds :* The summer months are a period of excessive heat and falling air pressure in the northern half of the country. Because of the heating of the subcontinent, the ITCZ moves northwards occupying a position centred at 25°N in July. Roughly, this elongated low pressure monsoon trough extends over the Thar desert in the north-west to Patna and Chotanagpur plateau in the east-southeast (Figure 4.9). The location of the ITCZ attracts a surface circulation of the winds which are southwesterly on the west coast as well as along the coast of West Bengal and Bangladesh. They are easterly or south-easterly over north Bengal and Bihar. It has been discussed earlier that these currents of southwesterly monsoon are in reality 'displaced' equatorial westerlies. The influx of these winds by mid-June brings about a change in the weather towards the rainy season.

In the heart of the ITCZ in the northwest, the dry and hot winds known as *'Loo'*, blow in the afternoon, and very often, they continue to well into midnight. Dust storms in the evening are very common during May in Punjab, Haryana, Eastern Rajasthan and Uttar Pradesh. These temporary storms bring a welcome respite from the oppressing heat since they bring with them light rains and a pleasant cool breeze. Occasionally, the moisture-laden winds are attracted towards the periphery of the trough. A sudden contact between dry and moist air masses gives rise to local storms of great intensity. These local storms are associated with violent winds, torrential rains and even hailstorms.

**Some Famous Local Storms of Hot Weather Season**

(i) *Mango Shower :* Towards the end of summer, there are pre-monsoon showers which are a common phenomena in Kerala and coastal areas of Karnataka. Locally, they are known as mango showers since they help in the early ripening of mangoes.

(ii) *Blossom Shower :* With this shower, coffee flowers blossom in Kerala and nearby areas.

(iii) *Nor Westers :* These are dreaded evening thunderstorms in Bengal and Assam. Their notorious nature can be understood from the local nomenclature of *'Kalbaisakhi'*, a calamity of the month of *Baisakh*. These showers are useful for tea, jute and rice cultivation. In Assam, these storms are known as *"Bardoli Chheerha"*.

(iv) *Loo :* Hot, dry and oppressing winds blowing in the Northern plains from Punjab to Bihar with higher intensity between Delhi and Patna.

## The Southwest Monsoon Season

As a result of rapid increase of temperature in May over the northwestern plains, the low pressure conditions over there get further intensified. By early June, they are powerful enough to attract the trade winds of Southern Hemisphere coming from the Indian Ocean. These southeast trade winds cross the equator and enter the Bay of Bengal and the Arabian Sea, only to be caught up in the air circulation over India. Passing over the equatorial warm currents, they bring with them moisture in abundance. After crossing the equator, they follow a southwesterly direction. That is why they are known as southwest monsoons.

The rain in the southwest monsoon season begins rather abruptly. One result of the first rain is that it brings down the temperature substantially. This sudden onset of the moisture-laden winds associated with violent thunder and lightening, is often termed as the "break" or "burst" of the

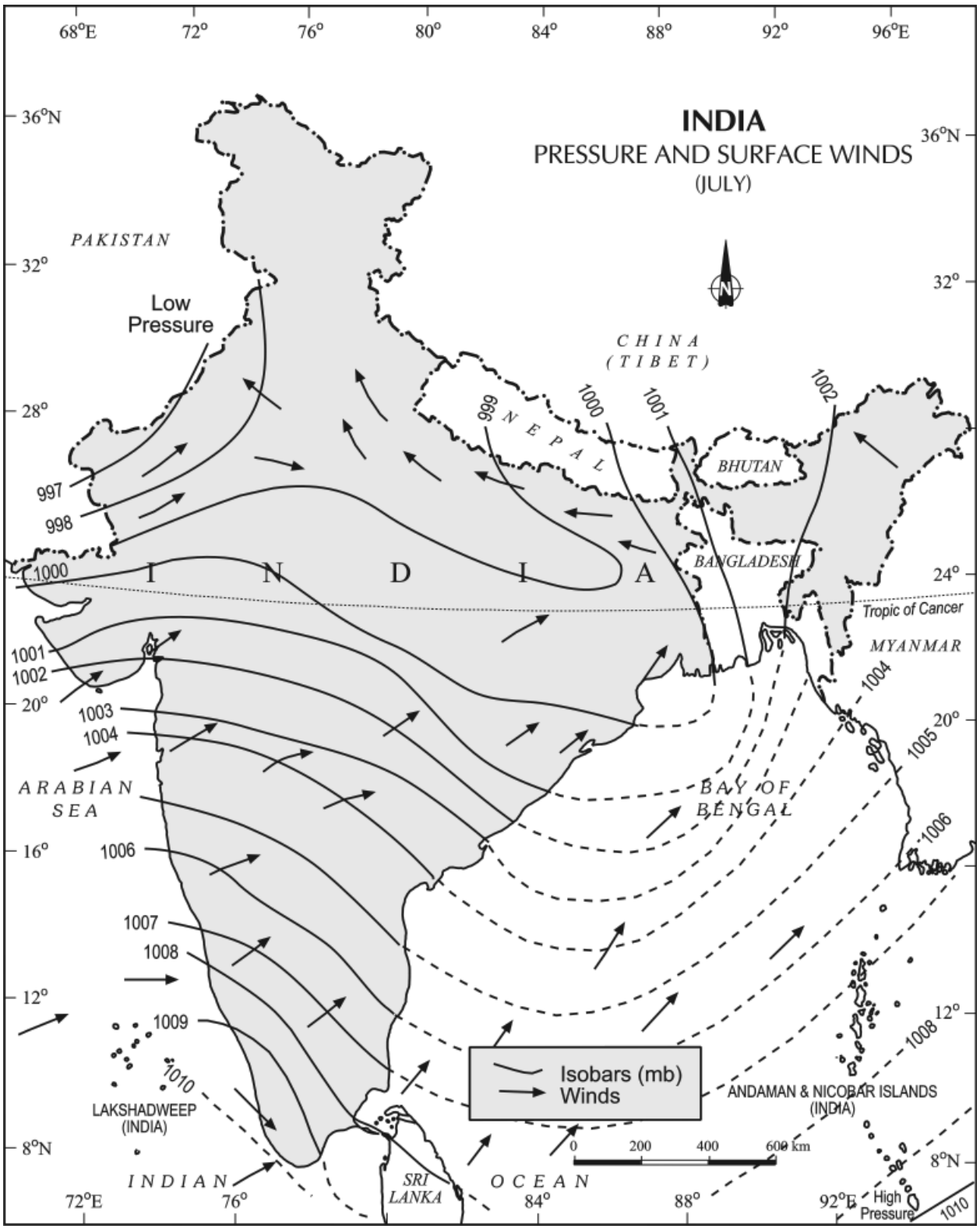


**Figure 4.9 : India : Pressure and Surface Winds (July)**

monsoons. The monsoon may burst in the first week of June in the coastal areas of Kerala, Karnataka, Goa and Maharashtra while in the interior parts of the country, it may be delayed to the first week of July. The day temperature registers a decline of 5°C to 8°C between mid-June and mid-July.

As these winds approach the land, their southwesterly direction is modified by the relief and thermal low pressure over the northwest India. The monsoon approaches the landmass in two branches:

(i) The Arabian Sea branch
(ii) The Bay of Bengal branch.

**Monsoon Winds of the Arabian Sea**

The monsoon winds originating over the Arabian Sea further split into three branches:

(i) Its one branch is obstructed by the Western Ghats. These winds climb the slopes of the Western Ghats from 900-1200 m. Soon, they become cool, and as a result, the windward side of the Sahyadris and Western Coastal Plain receive very heavy rainfall ranging between 250 cm and 400 cm. After crossing the Western Ghats, these winds descend and get heated up. This reduces humidity in the winds. As a result, these winds cause little rainfall east of the Western Ghats. This region of low rainfall is known as the rain-shadow area. Find out the rainfall at Kozhikode, Mangalore, Pune and Bangalore and note the difference (Figure 4.10).

(ii) Another branch of the Arabian sea monsoon strikes the coast north of Mumbai. Moving along the Narmada and Tapi river valleys, these winds cause rainfall in extensive areas of central India. The Chotanagpur plateau gets 15 cm rainfall from this part of the branch. Thereafter, they enter the Ganga plains and mingle with the Bay of Bengal branch.

(iii) A third branch of this monsoon wind strikes the Saurashtra Peninsula and the Kachchh. It then passes over west Rajasthan and along the Aravallis, causing only a scanty rainfall. In Punjab and Haryana, it too joins the Bay of Bengal branch. These two branches, reinforced by each other, cause rains in the western Himalayas,

**Monsoon Winds of the Bay of Bengal**

The Bay of Bengal branch strikes the coast of Myanmar and part of southeast Bangladesh. But the Arakan Hills along the coast of Myanmar deflect a big portion of this branch towards the Indian subcontinent. The monsoon, therefore, enters West Bengal and Bangladesh from south and southeast instead of from the south-westerly direction. From here, this branch splits into two under the influence of the Himalayas and the thermal low is northwest India. Its one branch moves westward along the Ganga plains reaching as far as the Punjab plains. The other branch moves up the Brahmaputra valley in the north and the northeast, causing widespread rains. Its sub-branch strikes the Garo and Khasi hills of Meghalaya. Mawsynram, located on the crest of Khasi hills, receives the highest average annual rainfall in the world.

Here it is important to know why the Tamil Nadu coast remains dry during this season. There are two factors responsible for it:

(i) The Tamil Nadu coast is situated parallel to the Bay of Bengal branch of southwest monsoon.
(ii) It lies in the rainshadow area of the Arabian Sea branch of the south-west monsoon.

**Characteristics of Monsoonal Rainfall**

(i) Rainfall received from the southwest monsoons is seasonal in character, which occurs between June and September.
(ii) Monsoonal rainfall is largely governed by relief or topography. For instance the windward side of the Western Ghats register a rainfall of over 250 cm. Again, the heavy rainfall in the northeastern states can be attributed to their hill ranges and the Eastern Himalayas.

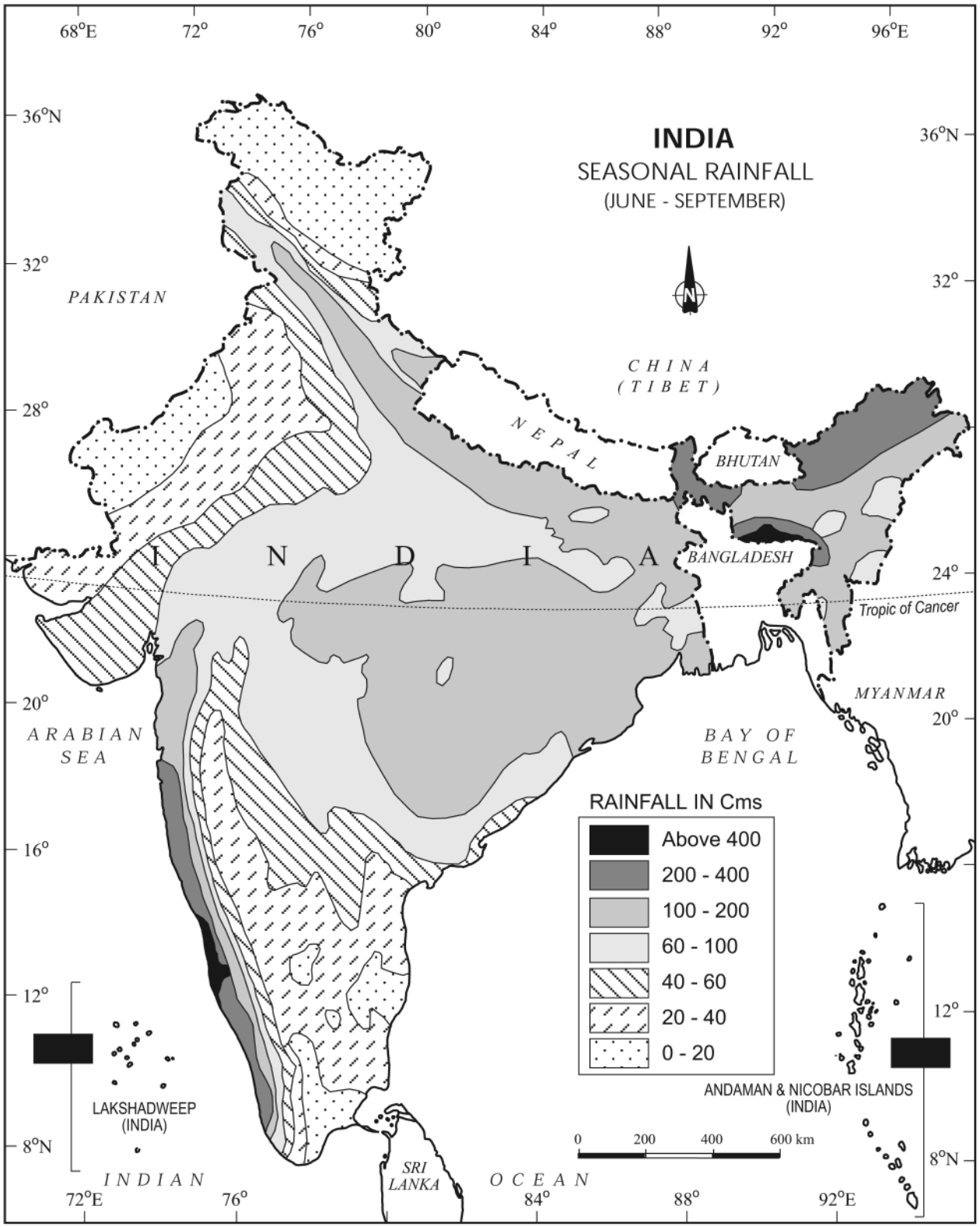


**Figure 4.10 : India : Seasonal Rainfall (June-September)**

(iii) The monsoon rainfall has a declining trend with increasing distance from the sea. Kolkata receives 119 cm during the southwest monsoon period, Patna 105 cm, Allahabad 76 cm and Delhi 56 cm.

(iv) The monsoon rains occur in wet spells of few days duration at a time. The wet spells are interspersed with rainless interval known as 'breaks'. These breaks in rainfall are related to the cyclonic depressions mainly formed at the head of the Bay of Bengal, and their crossing into the mainland. Besides the frequency and intensity of these depressions, the passage followed by them determines the spatial distribution of rainfall.

(v) The summer rainfall comes in a heavy downpour leading to considerable run off and soil erosion.

(vi) Monsoons play a pivotal role in the agrarian economy of India because over three-fourths of the total rain in the country is received during the south-west monsoon season.

(vii) Its spatial distribution is also uneven which ranges from 12 cm to more than 250 cm.

(viii) The beginning of the rains sometimes is considerably delayed over the whole or a part of the country.

(ix) The rains sometimes end considerably earlier than usual, causing great damage to standing crops and making the sowing of winter crops difficult.

### Season of Retreating Monsoon

The months of October and November are known for retreating monsoons. By the end of September, the southwest monsoon becomes weak as the low pressure trough of the Ganga plain starts moving southward in response to the southward march of the sun. The monsoon retreats from the western Rajasthan by the first week of September. It withdraws from Rajasthan, Gujarat, Western Ganga plain and the Central Highlands by the end of the month. By the beginning of October, the low pressure covers northern parts of the Bay of Bengal and by early November, it moves over Karnataka and Tamil Nadu. By the middle of December, the centre of low pressure is completely removed from the Peninsula.

The retreating southwest monsoon season is marked by clear skies and rise in temperature. The land is still moist. Owing to the conditions of high temperature and humidity, the weather becomes rather oppressive. This is commonly known as the 'October heat'. In the second half of October, the mercury begins to fall rapidly, particularly in northern India. The weather in the retreating monsoon is dry in north India but it is associated with rain in the eastern part of the Peninsula. Here, October and November are the rainiest months of the year.

The widespread rain in this season is associated with the passage of cyclonic depressions which originate over the Andaman Sea and manage to cross the eastern coast of the southern Peninsula. These tropical cyclones are very destructive. The thickly populated deltas of the Godavari, Krishna and Kaveri are their preferred targets. Every year cyclones bring disaster here. A few cyclonic storms also strike the coast of West Bengal, Bangladesh and Myanmar. A bulk of the rainfall of the Coromondal coast is derived from these depressions and cyclones. Such cyclonic storms are less frequent in the Arabian Sea.

### Traditional Indian Seasons

In the Indian tradition, a year is divided into six two-monthly seasons. This cycle of seasons, which the common people in north and central India follow is based on their practical experience and age-old perception of weather phenomena. However, this system does not match with the seasons of south India where there is little variation in the seasons.

| *Seasons* | *Months (According to the Indian Calendar)* | *Months (According to the Indian Calendar)* |
|---|---|---|
| Vasanta | Chaitra-Vaisakha | March-April |
| Grishma | Jyaistha-Asadha | May-June |
| Varsha | Sravana-Bhadra | July-August |
| Sharada | Asvina-Kartika | September-October |
| Hemanta | Margashirsa-Pausa | November-December |
| Shishira | Magha-Phalguna | January-February |

**Distribution of Rainfall**

The average annual rainfall in India is about 125 cm, but it has great spatial variations (Figure 4.11).

*Areas of High Rainfall* : The highest rainfall occurs along the west coast, on the Western Ghats, as well as in the sub-Himalayan areas is the northeast and the hills of Meghalaya. Here the rainfall exceeds 200 cm. In some parts of Khasi and Jaintia hills, the rainfall exceeds 1,000 cm. In the Brahmaputra valley and the adjoining hills, the rainfall is less then 200 cm.

*Areas of Medium Rainfall* : Rainfall between 100-200 cm is received in the southern parts of Gujarat, east Tamil Nadu, northeastern Peninsula covering Orissa, Jharkhand, Bihar, eastern Madhya Pradesh, northern Ganga plain along the sub-Himalayas and the Cachar Valley and Manipur.

*Areas of Low Rainfall* : Western Uttar Pradesh, Delhi, Haryana, Punjab, Jammu and Kashmir, eastern Rajasthan, Gujarat and Deccan Plateau receive rainfall between 50-100 cm.

*Areas of Inadequate Rainfall*: Parts of the Peninsula, especially in Andhra Pradesh, Karnataka and Maharashtra, Ladakh and most of western Rajasthan receive rainfall below 50 cm.

Snowfall is restricted to the Himalayan region.

Identify the pattern of rainfall after consulting the rainfall map.

**Variability of Rainfall**

A characteristic feature of rainfall in India is its variability. The variability of rainfall is computed with the help of the following formula:

$$\text{C.V.} = \frac{\text{Standard Deviation}}{\text{Mean}} \times 100$$

where C.V. is the coefficient of variation.

The values of coefficient of variation show the change from the mean values of rainfall. The actual rainfall in some places deviates from 20-50 per cent. The values of coefficient of variation show variability of rainfall in India. A variability of less than 25 per cent exists on the western coasts, Western Ghats, northeastern Peninsula, eastern plains of the Ganga, northeastern India, Uttaranchal and Himachal Pradesh and south-western part of Jammu and Kashmir. These areas have an annual rainfall of over 100 cm. A variability of over 50 per cent exists in the western part of Rajasthan, northern part of Jammu and Kashmir and interior parts of the Deccan plateau. These areas have an annual rainfall of less than 50 cm. Rest of India have a variability of 25-50 per cent and these areas receive an annual rainfall between 50 -100 cm (Figure 4.12).

**Climatic Regions of India**

The whole of India has a monsoon type of climate. But the combination of elements of the weather, however, reveal many regional variations. These variations represent the sub-types of the monsoon climate. It is on this basis that the climatic regions can be identified. A climatic region has a homogeneous climatic condition which is the result of a combination of factors. Temperature and rainfall are two important elements which are considered to be decisive in all the schemes of climatic classification. The classification of climate, however, is a complex exercise. There are different schemes of classification of climate. Major climatic types of India based on *Koeppen's* scheme have been described below:

Koeppen based his scheme of Climatic classification on monthly values of temperature and precipitation. He identified five major climatic types, namely:

(i) Tropical climates, where mean monthly temperature throughout the year is over 18°C.

(ii) Dry climates, where precipitation is very low in comparison to temperature, and hence, dry. If dryness is less, it is semi-arid (S); if it is more, the climate is arid(W).

(iii) Warm temperate climates, where mean temperature of the coldest month is between 18°C and minus 3°C.

(iv) Cool temperate climates, where mean temperature of the warmest month is over 10°C, and mean temperature of the coldest month is under minus 3°C.

(v) Ice climates, where mean temperature of the warmest month is under 10°C.

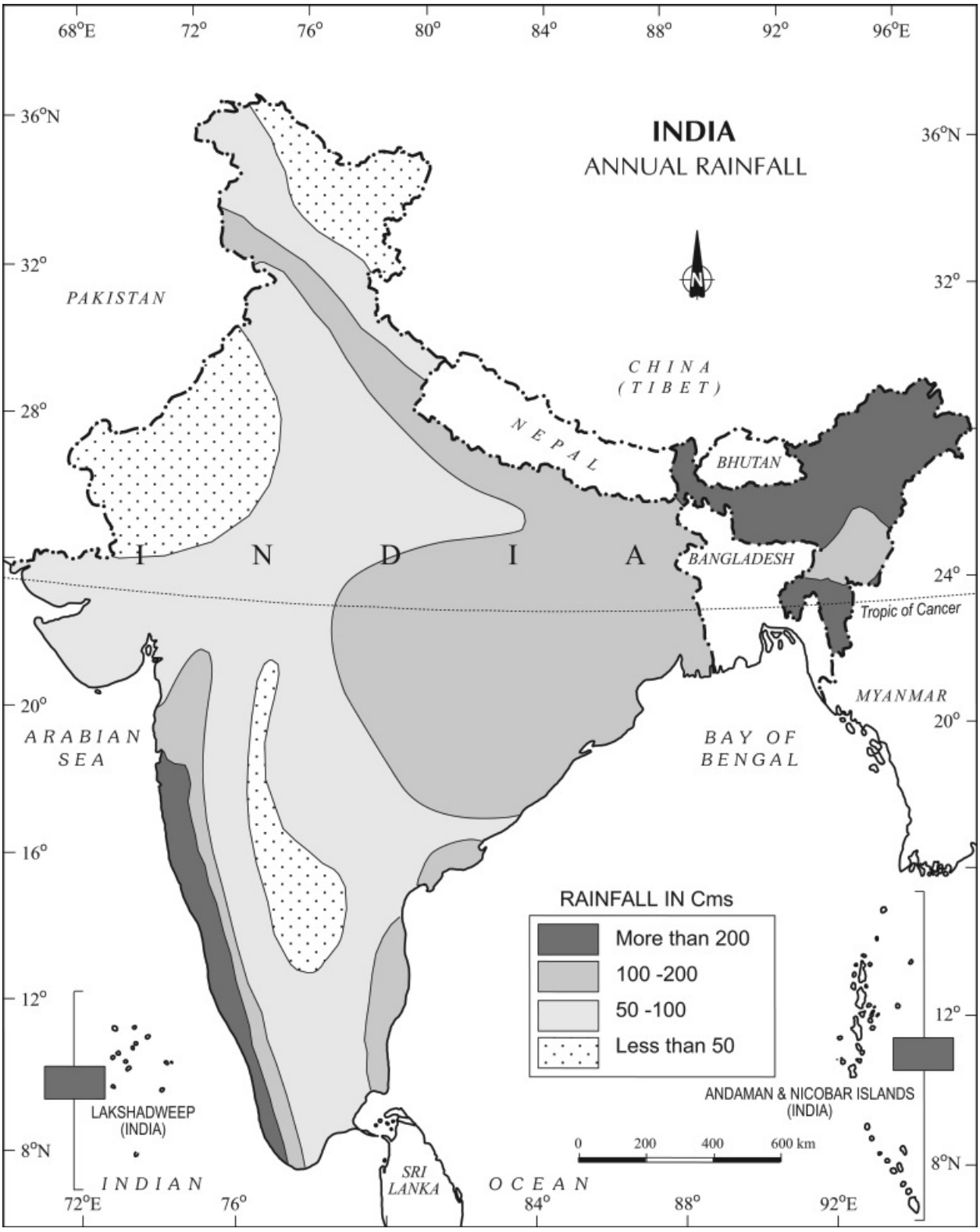


**Figure 4.11 : India : Annual Rainfall**

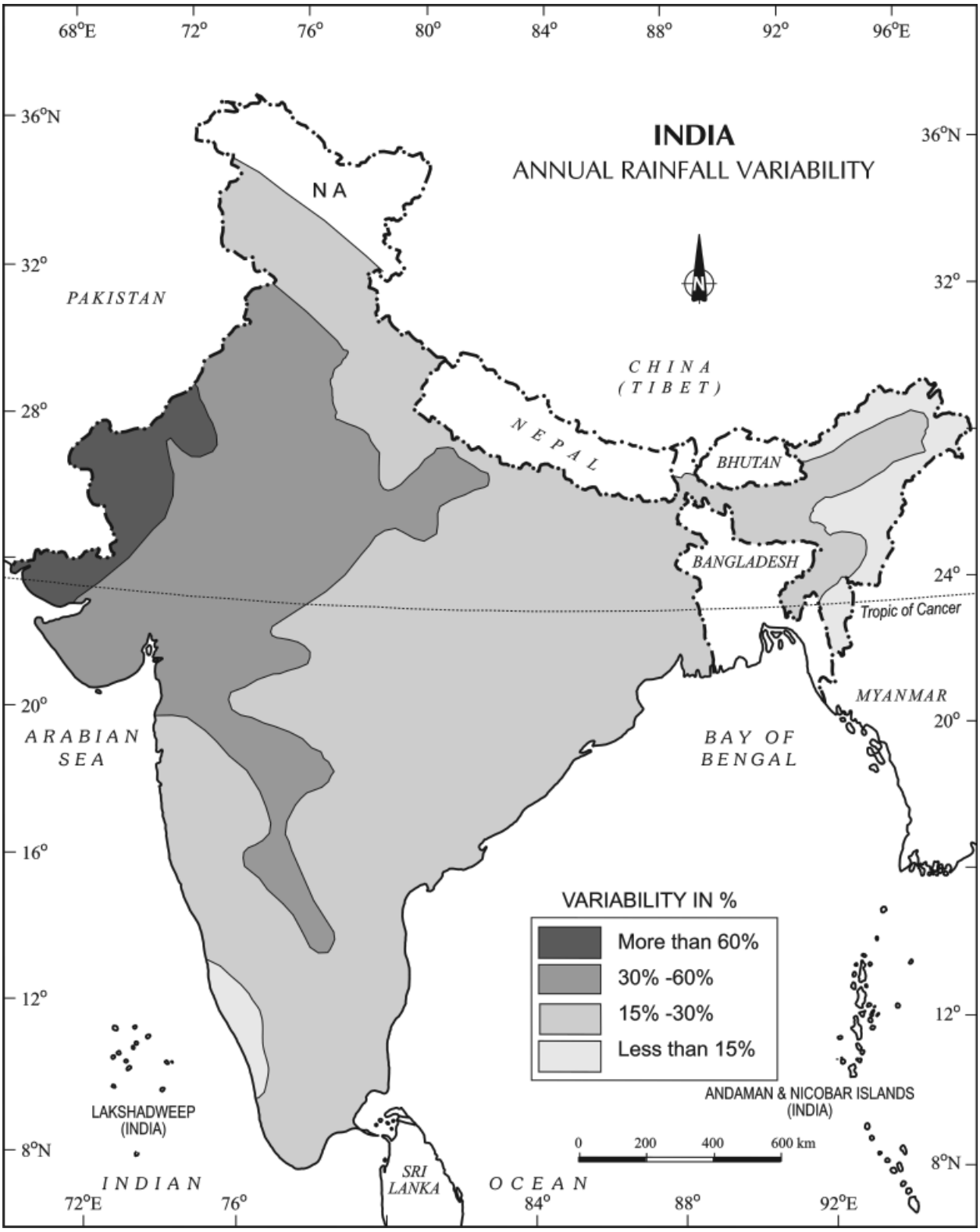


**Figure 4.12 : India : Variability of Annual Rainfall**

Koeppen used letter symbols to denote climatic types as given above. Each type is further sub-divided into sub-types on the basis of seasonal variations in the distributional pattern of rainfall and temperature. He used S for semi-arid and W for arid and the following small letters to define sub-types: f (sufficient precipitation), m (rain forest despite a dry monsoon season), w (dry season in winter), h (dry and hot), c (less than four months with mean temperature over 10°C), and g (Gangetic plain). Accordingly, India can be divided into eight climatic regions (Table 4.1; Figure 4.13).

**Table 4.1 : Climatic Regions of India According to Koeppen's Scheme**

| *Type of Climate* | *Areas* |
|---|---|
| Amw Monsoon with short dry season | West coast of India south of Goa |
| As – Monsoon with dry summer | Coromandel coast of Tamil Nadu |
| Aw – Tripical savannah | Most of the Peninsular plateaus, south of the Tropic of Cancer |
| Bwhw – Semi-arid steppe climate | North-western Gujarat, some parts of western Rajasthan and Punjab |
| Bwhw – Hot desert | Extreme western Rajasthan |
| Cwg – Monsoon with dry winter | Ganga plain, eastern Rajasthan, northern Madhya Pradesh, most of North-east India |
| Dfc – Cold humid winter with short summer | Arunachal Pradesh |
| E – Polar type | Jammu and Kashmir, Himachal Pradesh and Uttaranchal |

### Monsoons and the Economic Life in India

(i) Monsoon is that axis around which revolves the entire agricultural cycle of India. It is because about 64 per cent people of India depend on agriculture for their livelihood and agriculture itself is based on southwest monsoon.

(ii) Except Himalayas all the parts of the country have temperature above the threashold level to grow the crops or plants throughout the year..

(iii) Regional variations in monsoon climate help in growing various types of crops.

(iv) Variability of rainfall brings droughts or floods every year in some parts of the country.

(v) Agricultural prosperity of India depends very much on timely and adequately distributed rainfall. If it fails, agriculture is adversely affected particularly in those regions where means of irrigation are not developed.

(vi) Sudden monsoon burst creates problem of soil erosion over large areas in India.

(vii) Winter rainfall by temperate cyclones in north India is highly beneficial for rabi crops.

(viii) Regional climatic variation in India is reflected in the vast variety of food, clothes and house types.

### Global Warming

You know that change is the law of nature. Climate has also witnessed change in the past at the global as well as at local levels. It is changing even now but the change is imperceptible. A number of geological evidences suggest that once upon a time, (see geological time scale in Chapter 2 of *Fundamentals of Physical Geography*, NCERT, 2006) large part of the earth was under ice cover. Now you might have read or heard the debate on global warming. Besides the natural causes, human activities such as large scale industrialisation and presence of polluting gas in the atmosphere are also important factors responsible for global warming. You might have heard about the "green house effect" while discussing global warming.

The temperature of the world is significantly increasing. Carbon dioxide produced by human activities is a major source of concern. This gas, released to the atmosphere in large quantities by burning of fossil fuel, is increasing gradually. Other gases like methane, chlorofluorocarbons, and nitrous oxide which are present in much smaller concentrations in the atmosphere, together with carbon dioxide are known as green house gases. These gases are better absorbers of long wave radiations than carbon

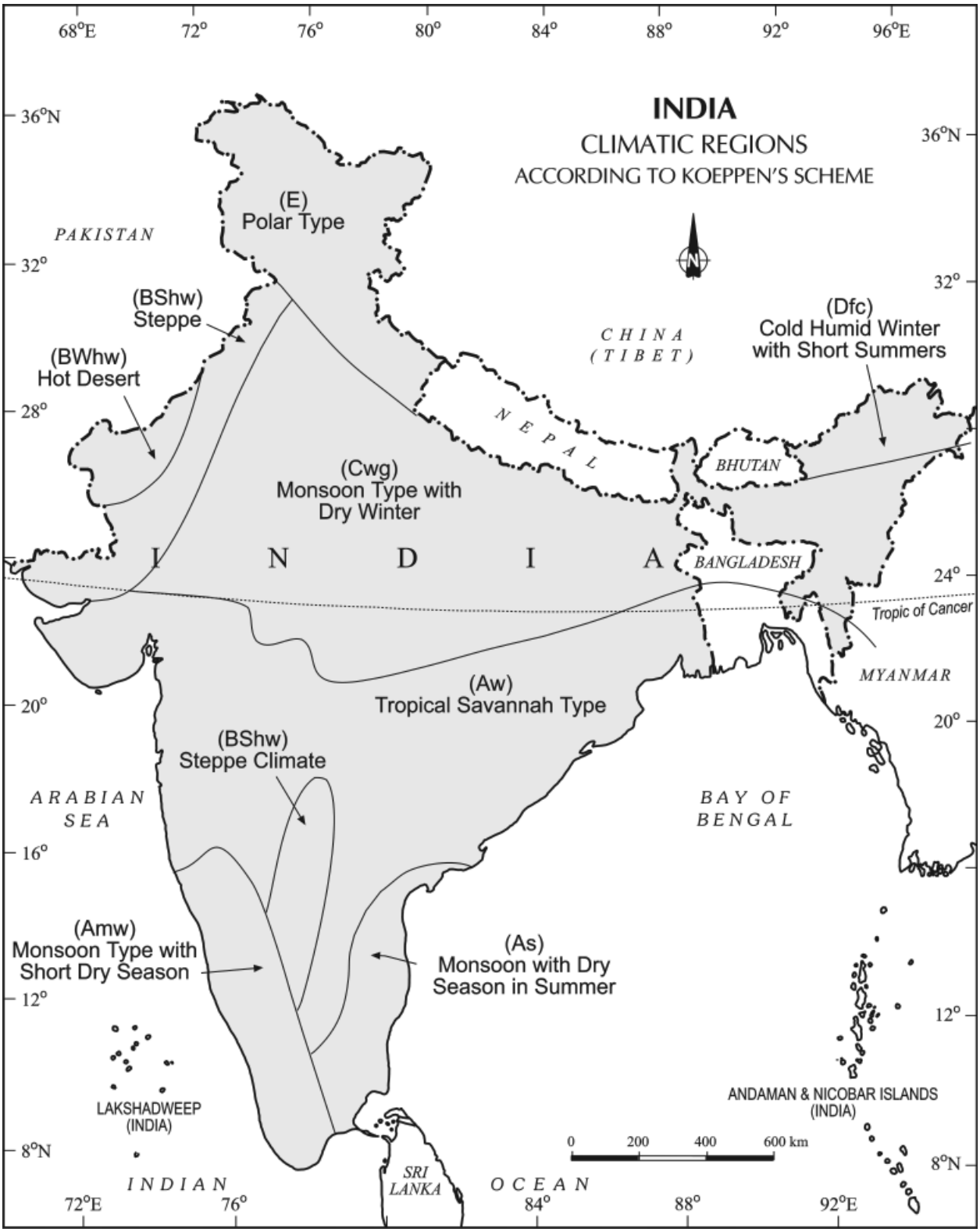


**Figure 4.13 : India : Climatic Regions According to Koppen's Scheme**

dioxide, and so, are more effective at enhancing the green house effect. These gases have been contributing to global warming. It is said that due to global warming the polar ice caps and mountain glaciers would melt and the amount of water in the oceans would increase.

The mean annual surface temperature of the earth in the past 150 years has increased. It is projected that by the year 2,100, global temperature will warm about 2°C. This rise in temperature will accompany many other changes: one of these is a rise in sea level, as glacier and sea ice melt in response to warming. According to the current prediction, on an average, the sea level will rise 48 cm by the end of twenty first century. This would increase the incidence of annual flooding. Climatic change would promote insect-borne diseases like malaria, and lead to shift in climatic boundaries, making some regions wetter and others drier. Agricultural pattern would shift and human population as well as the ecosystem would experience change. What would happen to the Indian sea coasts if the sea level rises 50 cm above the present one?

## EXERCISES

1. Choose the right answer from the four alternatives given below.

   (i) What causes rainfall on the coastal areas of Tamil Nadu in the beginning of winters?

   (a) South-West monsoon (c) North-Eastern monsoon

   (b) Temperate cyclones (d) Local air circulation

   (ii) What is the proportion of area of India which receives annual rainfall less than 75 cm?

   (a) Half (c) Two-third

   (b) One-third (d) Three-fourth

   (iii) Which one of the following is not a fact regarding South India?

   (a) Diurnal range of temperature is less here.

   (b) Annual range of temperature is less here.

   (c) Temperatures here are high throughout the year.

   (d) Extreme climatic conditions are found here.

   (iv) Which one of the following phenomenon happens when the sun shines vertically over the Tropic of Capricorn in the southern hemisphere?

   (a) High pressure develops over North-western India due to low temperatures.

   (b) Low pressure develops over North-western India due to high temperatures.

   (c) No changes in temperature and pressure occur in north-western India.

   (d) 'Loo' blows in the North-western India.

   (v) In which of the following states in India do we find 'As' type of climate as per Koeppen's classification?

   (a) In Kerala and coastal Karnataka

   (b) In Andaman and Nicobar Islands

   (c) On Coromandal coast

   (d) In Assam and Arunachal Pradesh

2. Answer the following questions in about 30 words.
   (i) What are the three important factors which influence the mechanism of Indian weather?
   (ii) What is the Inter-Tropical Convergene Zone?
   (iii) What is meant by 'bursting of monsoon'? Name the place of India which gets the highest rainfall.
   (iv) Define 'climatic region'? What are the bases of Koeppen's classification?
   (v) Which type(s) of cyclones cause rainfall in north-western India during winter? Where do they originate?
3. Answer the following questions in not more than 125 words.
   (i) Notwithstanding the broad climatic unity, the climate of India has many regional variations. Elaborate this statement giving suitable examples.
   (ii) How many distinct seasons are found in India as per the Indian Meteorological Department? Discuss the weather conditions associated with any one season in detail.

**Project/Activity**

On the outline map of India, show the following:
   (i) Areas of winter rain
   (ii) Wind direction during the summer season
   (iii) Areas having variability of rainfall over 50 per cent
   (iv) Areas having less than 15°C temperature in January
   (v) Isohyte of 100 cm.

CHAPTER

5

# NATURAL VEGETATION

Have you ever been to a forest for a picnic? You might have surely gone to a park if you live in a city or to a mango, guava or coconut orchard, if you live in a village. How do you differentiate between the natural vegetation and the planted vegetation? The same variety may be found growing wild in the forest under natural conditions and the same tree may be the planted one in your garden under human supervision.

Natural vegetation refers to a plant community that has been left undisturbed over a long time, so as to allow its individual species to adjust themselves to climate and soil conditions as fully as possible.

India is a land of great variety of natural vegetation. Himalayan heights are marked with temperate vegetation; the Western Ghats and the Andaman Nicobar Islands have tropical rain forests, the deltaic regions have tropical forests and mangroves; the desert and semi desert areas of Rajasthan are known for cactii, a wide variety of bushes and thorny vegetation. Depending upon the variations in the climate and the soil, the vegetation of India changes from one region to another.

On the basis of certain common features such as predominant vegetation type and climatic regions, Indian forests can be divided into the following groups:

## TYPES OF FORESTS

(i) Tropical Evergreen and Semi Evergreen forests
(ii) Tropical Deciduous forests
(iii) Tropical Thorn forests
(iv) Montane forests
(v) Littoral and Swamp forests.

### Tropical Evergreen and Semi Evergreen Forests

These forests are found in the western slope of the Western Ghats, hills of the northeastern region and the Andaman and Nicobar Islands. They are found in warm and humid areas with an annual precipitation of over 200 cm and mean annual temperature above 22°C. Tropical evergreen forests are well stratified, with layers closer to the ground and are covered with shrubs and creepers, with short structured trees followed by tall variety of trees. In these forests, trees reach great heights up to 60 m or above. There is no definite time for trees to shed their leaves, flowering and fruition. As such these forests appear green all the year round. Species found in these forests include rosewood, mahogony, aini, ebony, etc.

The semi evergreen forests are found in the less rainy parts of these regions. Such forests have a mixture of evergreen and moist deciduous trees. The undergrowing climbers provide an evergreen character to these forests. Main species are white cedar, hollock and kail.

**Figure 5.1 : Evergreen Forest**

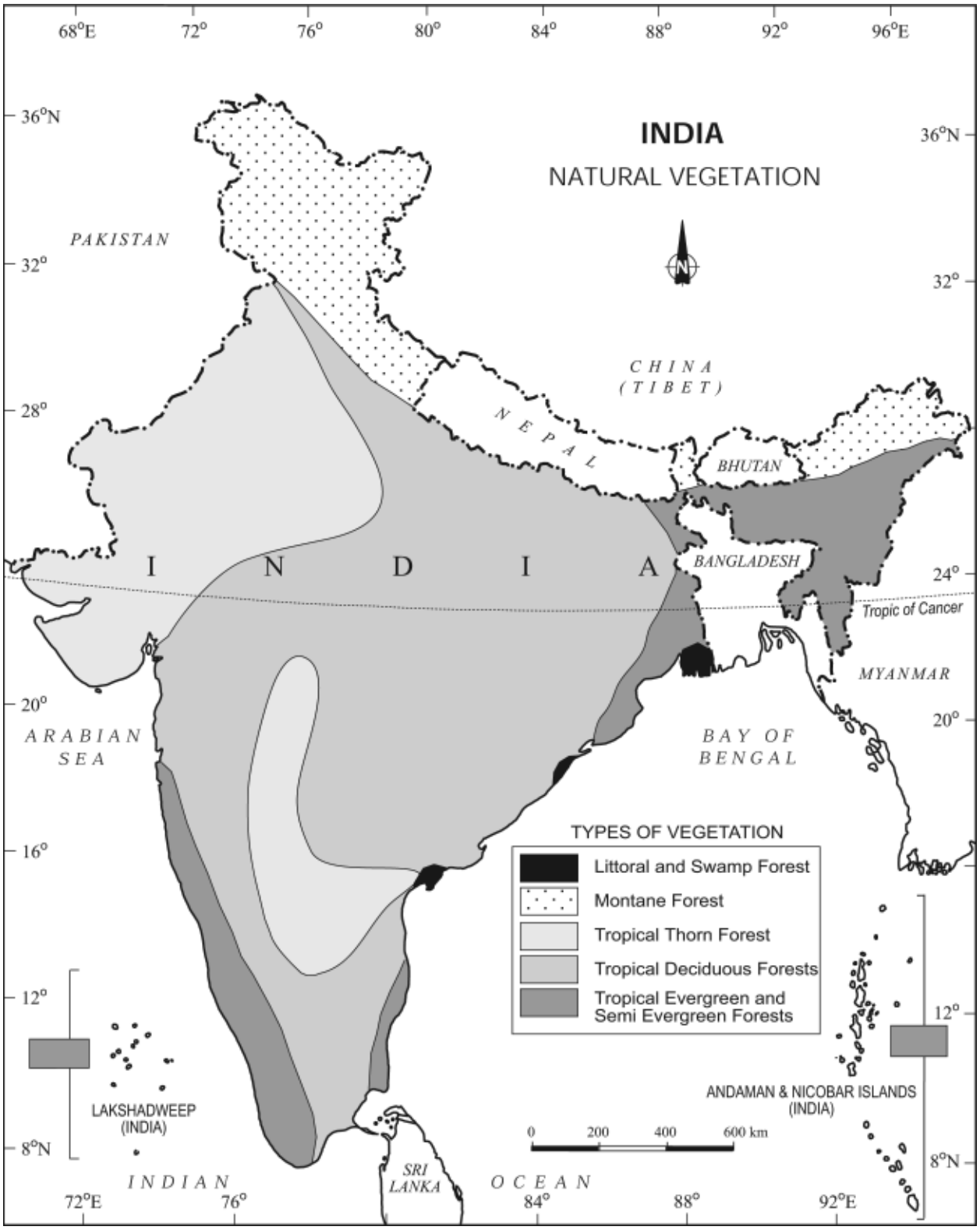


**Figure 5.2 : Natural Vegetation**

The British were aware of the economic value of the forests in India, hence, large scale exploitation of these forests was started. The structure of forests was also changed. The oak forests in Garhwal and Kumaon were replaced by pine (chirs) which was needed to lay railway lines. Forests were also cleared for introducing plantations of tea, rubber and coffee. The British also used timber for construction activities as it acts as an insulator of heat. The protectional use of forests was, thus, replaced by commercial use.

### Tropical Deciduous Forests

These are the most widespread forests in India. They are also called the monsoon forests. They spread over regions which receive rainfall between 70-200 cm. On the basis of the availability of water, these forests are further divided into moist and dry deciduous.

**Figure 5.3 : Deciduous Forests**

*The Moist deciduous forests* are more pronounced in the regions which record rainfall between 100-200 cm. These forests are found in the northeastern states along the foothills of Himalayas, eastern slopes of the Western Ghats and Orissa. Teak, *sal, shisham, hurra, mahua, amla, semul, kusum,* and sandalwood etc. are the main species of these forests.

*Dry deciduous forest* covers vast areas of the country, where rainfall ranges between 70 -100 cm. On the wetter margins, it has a transition to the moist deciduous, while on the drier margins to thorn forests. These forests are found in rainier areas of the Peninsula and the plains of Uttar Pradesh and Bihar. In the higher rainfall regions of the Peninsular plateau and the northern Indian plain, these forests have a parkland landscape with open stretches in which teak and other trees interspersed with patches of grass are common. As the dry season begins, the trees shed their leaves completely and the forest appears like a vast grassland with naked trees all around. *Tendu, palas, amaltas, bel, khair,* axlewood, etc. are the common trees of these forests. In the western and southern part of Rajasthan, vegetation cover is very scanty due to low rainfall and overgrazing.

### Tropical Thorn Forests

Tropical thorn forests occur in the areas which receive rainfall less than 50 cm. These consist of a variety of grasses and shrubs. It includes semi-arid areas of south west Punjab, Haryana, Rajasthan, Gujarat, Madhya Pradesh and Uttar Pradesh. In these forests, plants remain leafless for most part of the year and give an expression of scrub vegetation. Important species found are *babool, ber*, and wild date palm, *khair, neem, khejri, palas*, etc. Tussocky grass grows upto a height of 2 m as the under growth.

**Figure 5.4 : Tropical Thorn Forests**

### Montane Forests

In mountainous areas, the decrease in temperature with increasing altitude leads to a corresponding change in natural vegetation. Mountain forests can be classified into two types, the northern mountain forests and the southern mountain forests.

The Himalayan ranges show a succession of vegetation from the tropical to the tundra, which change in with the altitude. Deciduous forests are found in the foothills of the Himalayas. It is succeeded by the wet temperate type of forests between an altitude of 1,000-2,000 m. In the higher hill ranges of northeastern India, hilly areas of West Bengal and Uttaranchal, evergreen broad leaf trees such as oak and chestnut are predominant. Between 1,500-1,750 m, pine forests are also well-developed in this zone, with Chir Pine as a very useful commercial tree. Deodar, a highly valued endemic species grows mainly in the western part of the Himalayan range. Deodar is a durable wood mainly used in construction activity. Similarly, the *chinar* and the walnut, which sustain the famous Kashmir handicrafts, belong to this zone. Blue pine and spruce appear at altitudes of 2,225-3,048 m. At many places in this zone, temperate grasslands are also found. But in the higher reaches there is a transition to Alpine forests and pastures. Silver firs, junipers, pines, birch and rhododendrons, etc. occur between 3,000-4,000 m. However, these pastures are used extensively for transhumance by tribes like the Gujjars, the Bakarwals, the Bhotiyas and the Gaddis. The southern slopes of the Himalayas carry a thicker vegetation cover because of relatively higher precipitation than the drier north-facing slopes. At higher altitudes, mosses and lichens form part of the tundra vegetation.

**Figure 5.5 : Montane Forests**

*The southern mountain forests* include the forests found in three distinct areas of Peninsular India viz; the Western Ghats, the Vindhyas and the Nilgiris. As they are closer to the tropics, and only 1,500 m above the sea level, vegetation is temperate in the higher regions, and subtropical on the lower regions of the Western Ghats, especially in Kerala, Tamil Nadu and Karnataka. The temperate forests are called *Sholas* in the Nilgiris, Anaimalai and Palani hills. Some of the other trees of this forest of economic significance include, magnolia, laurel, cinchona and wattle. Such forests are also found in the Satpura and the Maikal ranges.

### Littoral and Swamp Forests

India has a rich variety of wetland habitats. About 70 per cent of this comprises areas under paddy cultivation. The total area of wet land is 3.9 million hectares. Two sites — Chilika Lake (Orissa) and Keoladeo National Park (Bharatpur) are protected as water-fowl habitats under the Convention of Wetlands of International Importance (Ramsar Convention).

> An international convention is an agreement among member states of the United Nations.

The country's wetlands have been grouped into eight categories, viz. (i) the reservoirs of the Deccan Plateau in the south together with the lagoons and other wetlands of the southern west coast; (ii) the vast saline expanses of Rajasthan, Gujarat and the Gulf of Kachchh; (iii) freshwater lakes and reservoirs from Gujarat eastwards through Rajasthan (Keoladeo National Park) and Madhya Pradesh; (iv) the delta wetlands and lagoons of India's east coast (Chilika Lake); (v) the freshwater marshes of the Gangetic Plain; (vi) the floodplains of the Brahmaputra; the marshes and swamps in the hills of northeast India and the Himalayan foothills; (vii) the lakes and rivers of the montane region of Kashmir and Ladakh; and (viii) the mangrove forest and other wetlands of the island arcs of the Andaman and Nicobar Islands. Mangroves grow along the coasts in the salt marshes, tidal creeks, mud flats and estuaries.

They consist of a number of salt-tolerant species of plants. Crisscrossed by creeks of stagnant water and tidal flows, these forests give shelter to a wide variety of birds.

**Figure 5.6 : Mangrove Forests**

In India, the mangrove forests spread over 6,740 sq. km which is 7 per cent of the world's mangrove forests. They are highly developed in the Andaman and Nicobar Islands and the Sunderbans of West Bengal. Other areas of significance are the Mahanadi, the Godavari and the Krishna deltas. These forests too, are being encroached upon, and hence, need conservation.

## Forest Cover in India

According to state records, the forest area covers 23.28 per cent of the total land area of the country. It is important to note that the forest area and the actual forest cover are not the same. The forest area is the area notified and recorded as the forest land irrespective of the existence of trees, while the actual forest cover is the area occupied by forests with canopy. The former is based on the records of the State Revenue Department, while the latter is based on aerial photographs and satellite imageries. In 2001, the actual forest cover was only 20.55 per cent. Of the forest cover, the share of dense and open forests was 12.60 per cent and 7.87 per cent rerspectively.

Both forest area and forest cover vary from state to state. Lakshadweep has zero per cent forest area; Andaman and Nicobar Islands have 86.93 per cent. Most of the states with less than 10 per cent of the forest area lie in the north and northwestern part of the country. These are Rajasthan, Gujarat, Punjab, Haryana and Delhi. Most of the forests in Punjab and Haryana have been cleared for cultivation. States with 10-20 per cent forest area are Tamil Nadu and West Bengal. In Peninsular India, excluding Tamil Nadu, Dadra and Nagar Haveli and Goa, the area under forest cover is 20-30 per cent. The northeastern states have more than 30 per cent of the land under forest. Hilly topography and heavy rainfall are good for forest growth.

There is a lot of variation in actual forest cover, which ranges from 9.56 per cent in Jammu and Kashmir to 84.01 per cent in Andaman and Nicobar Islands. From the table showing the distribution of forests in India (Appendix IV), it is clear that there are 15 states where the forest cover is more than one-third of the total area, which is the basic requirement for maintaining the ecological balance.

On the basis of the percentage of the actual forest cover, the states have been grouped into four regions:

| *The Region* | *Percentage Cover of the Forest* |
|---|---|
| (i) The region of high concentration | > 40 |
| (ii) The region of medium concentration | 20-40 |
| (iii) The region of low concentration | 10-20 |
| (iv) The region of very low concentration | < 10 |

Taking the data from Appendix IV, list the states under the four regins of forest cover

## Forest Conservation

Forests have an intricate interrelationship with life and environment. These provide numerous direct and indirect advantages to our economy and society. Hence, conservation of forest is of vital importance to the survival and prosperity of humankind. Accordingly, the Government of India proposed to have a nation-wide forest conservation policy, and adopted a forest policy in 1952, which was further modified in 1988. According to the new forest policy, the Government will emphasise sustainable forest management in order to conserve and expand forest reserve on the one hand, and to meet the needs of local people on the other.

The forest policy aimed at : (i) bringing 33 per cent of the geographical areas under forest

cover; (ii) maintaining environmental stability and to restore forests where ecological balance was disturbed; (iii) conserving the natural heritage of the country, its biological diversity and genetic pool; (iv) checks soil erosion, extension of the desert lands and reduction of floods and droughts; (v) increasing the forest cover through social forestry and afforestation on degraded land; (vi) increasing the productivity of forests to make timber, fuel, fodder and food available to rural population dependant on forests, and encourage the substitution of wood; (vii) creating of a massive peoples movement involving women to encourage planting of trees, stop felling of trees and thus, reduce pressure on the existing forest.

**Forests and Life**

To a vast number of tribal people, the forest is a home, a livelihood, their very existence. It provides them food, fruits of all kinds, edible leaves, honey, nourishing roots and wild game. It provides them with material to build their houses and items for practising their arts. The importance of forests in tribal economy is well-known as they are the source of sustenance and livelihood for tribal communities. It is commonly believed that the tribal communities live in harmony with nature and protect forests. Out of a total of 593 districts 187 (2001) have been identified as tribal districts. The tribal districts account for about 59.8 per cent of the total forest cover of the country whereas the geographical area of 187 tribal districts forms only 33.6 per cent of the total geographical area of the country. It demonstrates that tribal districts are generally rich in forest cover.

Forest and tribals are very closely related. The age-old knowledge of tribals regarding forestry can be used in the development of forests. Rather than treating tribals as minor forest produce collectors they should be made growers of minor forest produce and encouraged to participate in conservation.

Based on the forest conservation policy the following steps were initiated:

### Social Forestry

Social forestry means the management and protection of forests and afforestation on barren lands with the purpose of helping in the environmental, social and rural development.

The National Commission on Agriculture (1976) has classified social forestry into three categories. These are Urban forestry, Rural forestry and Farm forestry.

Urban forestry pertains to the raising and management of trees on public and privately owned lands in and around urban centres such as green belts, parks, roadside avenues, industrial and commercial green belts, etc.

Rural forestry lays emphasis on promotion of agro-forestry and community-forestry.

Agro-forestry is the raising of trees and agriculture crops on the same land inclusive of the waste patches. It combines forestry with agriculture, thus, altering the simultaneous production of food, fodder, fuel, timber and fruit. Community forestry involves the raising of trees on public or community land such as the village pasture and temple land, roadside, canal bank, strips along railway lines, and schools etc. Community forestry programme aims at providing benefits to the community as a whole. Community forestry provides a means under which the people of landless classes can associate themselves in tree-raising and thus, get those benefits which otherwise are restricted for landowners.

### Farm Forestry

Farm forestry is a term applied to the process under which farmers grow trees for commercial and non-commercial purposes on their farm lands.

Forest departments of various states distribute seedlings of trees free of cost to small and medium farmers. Several lands such as the margins of agricultural fields, grasslands and pastures, land around homes and cow sheds may be used for raising trees under non-commercial farm forestry.

## Wildlife

You would have visited a zoo and may have seen animals and birds in captivity. Wildlife of India is a great natural heritage. It is estimated that about 4-5 per cent of all known plant and animal species on the earth are found in India. The main reason for this remarkable diversity of life forms is the great diversity of the ecosystem which this country has preserved and supported through the ages. Over the years, their habitat has been disturbed by human activities and as a result, their numbers have dwindled significantly. There are certain species that are at the brink of extinction.

Some of the important reasons of the declining of wildlife are as follows:

(i) Industrial and technological advancement brought about a rapid increase in the exploitation of forest resources.
(ii) More and more lands were cleared for agriculture, human settlement, roads, mining, reservoirs, etc.
(iii) Pressure on forests mounted due to lopping for fodder and fuelwood and removal of small timber by the local people.
(iv) Grazing by domestic cattle caused an adverse effect on wildlife and its habitat.
(v) Hunting was taken up as a sport by the elite and hundreds of wild animals were killed in a single hunt. Now commercial poaching is rampant.
(vi) Incidence of forest fire.

It is being felt that conservation of wildlife is of great significance to the national as well as the world heritage along with the promotion of ecotourism. What steps have been initiated by the government in this direction?

## Wildlife Conservation in India

The protection of wildlife has a long tradition in India. Many stories of *Panchtantra* and *Jungle Books*, etc. have stood the test of time relating to the love for wildlife. These have a profound impact on young minds.

In 1972, a comprehensive Wildlife Act was enacted, which provides the main legal framework for conservation and protection of wildlife in India. The two main objectives of the Act are; to provide protection to the endangered species listed in the schedule of the Act and to provide legal support to the conservation areas of the country classified as National parks, sanctuaries and closed areas. This Act has been comprehensively amended in 1991, making punishments more stringent and has also made provisions for the protection of specified plant species and conservation of endangered species of wild animals.

There are 92 National parks and 492 wildlife sanctuaries covering an area of 15.67 million hectares in the country.

Wildlife conservation has a very large ambit with unbounded potential for the well-being of humankind. However, this can be achieved only when every individual understands its significance and contributes his bit.

For the purpose of effective conservation of flora and fauna, special steps have been initiated by the Government of India in collaboration with UNESCO's 'Man and Biosphere Programme'.

Special schemes like Project Tiger (1973) and Project Elephant (1992) have been launched to conserve these species and their habitat in a sustainable manner.

Project Tiger has been implemented since 1973. The main objective of the scheme is to ensure maintenance of viable population of tigers in India for scientific, aesthetic, cultural and ecological values, and to preserve areas of biological importance as natural heritage for the benefit, education and enjoyment of the people. Initially, the Project Tiger was launched in nine tiger reserves, covering an area of 16,339 sq. km, which has now increased to 27 tiger reserves, encompassing 37,761sq. km of tiger habitats distributed in 17 states. The tiger population in the country has registered an increase from 1,827 in 1972 to 3,642 in 2001-2002.

Project Elephant was launched in 1992 to assist states having free ranging population of wild elephants. It was aimed at ensuring long-term survival of identified viable population of elephants in their natural habitat. The project is being implemented in 13 states.

**Figure 5.7 : Elephants in their Natural Habitat**

Apart from this, some other projects such as Crocodile Breeding Project, Project Hangul and conservation of Himalayan Musk deer have also been launched by the Government of India.

## Biosphere Reserves

A Biosphere Reserve is a unique and representative ecosystem of terrestrial and coastal areas which are internationally recognised within the framework of UNESCO's Man and Biosphere (MAB) Programme. The Biosphere Reserve aims at achieving the three objectives as depicted in Figure 5.8.

There are 14 Biosphere Reserves in India (Table 5.1, Figure 5.9). Four Biosphere Reserves, namely (i) Nilgiri; (ii) Nanda Devi;

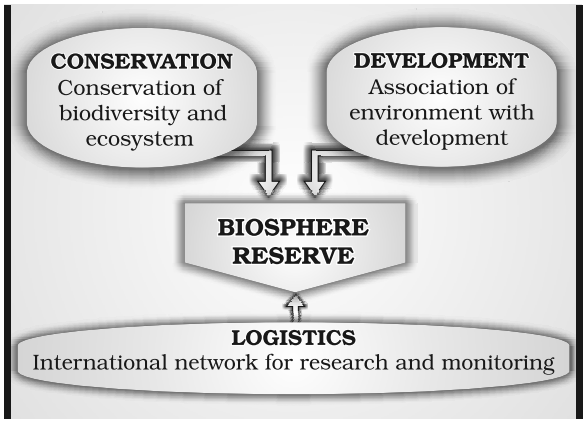


**Figure 5.8 : Objectives of a Biosphere Reserve**

**Table 5.1 : List of Biosphere Reserves**

| *Sl. No.* | *Name of the Biosphere Reserve* | *Total Geographical Area (km²)* | *Location (States)* |
|---|---|---|---|
| 1. | * Nilgiri | 5,520 | Part of Wynad, Nagarhole, Bandipur and Mudumalai, Nilambur, Silent Valley and Siruvani Hills (Tamil Nadu, Kerala and Karnataka) |
| 2. | * Nanda Devi | 2,236.74 | Part of Chamoli, Pithoragarh and Almora districts (Uttar Pradesh) and part of Garo Hills (Meghalaya) |
| 3. | Nokrek | 820 | Part of Garo Hills (Meghalaya) |
| 4. | Manas | 2,837 | Part of Kokrajhar, Bongaigaon, Barpeta, Nalbari, Kamrup and Darrang districts (Assam) |
| 5. | * Sunderbans | 9,630 | Part of delta of Ganges and Brahmaputra river system (West Bengal) |
| 6. | * Gulf of Mannar | 10,500 | Indian part of Gulf of Mannar between India and Sri Lanka (Tamil Nadu) |
| 7. | Great Nicobar | 885 | Southernmost islands of the Andaman and Nicobar (A & N Islands) |
| 8. | Similipal | 4,374 | Part of Mayurbhanj district (Orissa) |
| 9. | Dibru-Saikhowa | 765 | Part of Dibrugarh and Tinsukia districts (Assam) |
| 10. | Dihang Dibang | 5,111.5 | Part of Siang and Debang valley in Arunachal Pradesh |
| 11. | Kanchenjunga | 2,619.92 | Parts of North and West Sikkim |
| 12. | Pachmari | 4,926.28 | Parts of Betul, Hoshangabad and Chindwara districts of Madhya Pradesh |
| 13. | Agasthyamalai | 1,701 | Agasthyamalai Hills in Kerala |
| 14. | Achanakmar- Amarkantak | 3,835.51 | Parts of Anupur and Dindori district of MP and parts of Bilaspur district of Chhattisgarh |

* have been recognised by the UNESCO on World Network of Biosphere Reserves

*Source : Annual Report* (2004-05), Ministry of Environment and Forests, Government of India


**Figure 5.9 : India : Biosphere Reserves**

(iii) Sunderbans; and (iv) Gulf of Mannar have been recognised by the UNESCO on World Network of Biosphere Reserves.

### Nilgiri Biosphere Reserve

The Nilgiri Biosphere Reserve (NBR), the first of the fourteen biosphere reserves of India, was established in September 1986. It embraces the sanctuary complex of Wyanad, Nagarhole, Bandipur and Mudumalai, the entire forested hill slopes of Nilambur, the Upper Nilgiri plateau, Silent Valley and the Siruvani hills. The total area of the biosphere reserve is around 5,520 sq. km.

The Nilgiri Biosphere Reserve possesses different habitat types, unspoilt areas of natural vegetation types with several dry scrubs, dry and moist deciduous, semi-evergreen and wet evergreen forests, evergreen *sholas*, grasslands and swamps. It includes the largest known population of two endangered animal species, namely the Nilgiri Tahr and the Lion-tailed macaque. The largest south Indian population of elephant, tiger, gaur, *sambar* and *chital* as well as a good number of endemic and endangered plants are also found in this reserve. The habitat of a number of tribal groups remarkable for their traditional modes of harmonious use of the environment are also found here.

The topography of the NBR is extremely varied, ranging from an altitude of 250 m to 2,650 m. About 80 per cent of the flowering plants reported from the Western Ghats occur in the Nilgiri Biosphere Reserve.

### Nanda Devi Biosphere Reserve

The Nanda Devi Biosphere Reserve situated in Uttaranchal includes parts of Chamoli, Almora, Pithoragarh and Bageshwar districts.

The major forest types of the reserve are temperate. A few important species are silver weed and orchids like latifolie and rhododendron. The biosphere reserve has a rich fauna, for example the snow leopard, black bear, brown bear, musk deer, snow-cock, golden eagle and black eagle.

Major threats to the ecosystem are the collection of endangered plants for medicinal use, forest fires and poaching.

### Sunderbans Biosphere Reserve

It is located in the swampy delta of the river Ganga in West Bengal. It extends over a vast area of 9,630 sq. km and consists of mangrove forests, swamps and forested islands. Sunderbans is the home of nearly 200 Royal Bengal tigers.

The tangled mass of roots of mangrove trees provide safe homes for a large number of species, from fish to shrimp. More than 170 birds species are known to inhabit these mangrove forests.

Adapting itself to the saline and fresh water environment, the tigers at the park are good swimmers, and they hunt scarce preys such as *chital* deer, barking deer, wild pig and even macaques. In the Sunderbans, the mangrove forests are characterised by Heritiera fomes, a species valued for its timber.

### Gulf of Mannar Biosphere Reserve

The Gulf of Mannar Biosphere Reserve covers an area of 105,000 hectares on the southeast coast of India. It is one of the world's richest regions from a marine biodiversity perspective. The biosphere reserve comprises 21 islands with estuaries, beaches, forests of the nearshore environment, sea grasses, coral reefs, salt marshes and mangroves. Among the Gulf's 3,600 plant and animal species are the globally endangered sea cow (Dugong dugon) and six mangrove species, endemic to Peninsular India.

## EXERCISES

1. Choose the right answer from the four alternatives given below.

   (i) Sandalwood is an example of:

   (a) Evergreen forest
   (b) Deciduous forest
   (c) Deltaic forest
   (d) Thorny forest

(ii) Which one of the following was the purpose of Project Tiger?

(a) to kill tigers (c) to protect tigers from illegal hunting

(b) to put tigers in the Zoo (d) to make films on tigers

(iii) In which one of the following states is the Nandadevi Biosphere reserve situated?

(a) Bihar (c) Uttaranchal

(b) Uttar Pradesh (d) Orissa

(iv) How many of the following numbers of Biosphere reserves are recognised by the IUCN?

(a) One (c) Three

(b) Two (d) Four

(v) Which one of the following proportion of area of the country was targeted to be under forest in Forest Policy of India?

(a) 33 (c) 55

(b) 44 (d) 22

2. Answer the following questions in about 30 words.

(i) What is natural vegetation? Under what climatic conditions are tropical evergreen forests develop?

(ii) What do you understand by social forestry?

(iii) Define Biosphere reserves?

(iv) What is the difference between forest area and forest cover?

3. Answer the following questions in not more than 150 words.

(i) What steps have been taken up to conserve forests?

(ii) How can people's participation be effective in conserving forests and wildlife?

**Project/Activity**

1. On the outline map of India, mark and label the following.

(i) Areas having Mangrove forests.

(ii) Biosphere reserves of Nanda Devi, Sunderbans, Gulf of Mannar and Nilgiri.

(iii) Mark the location of Forest Survey of India Head Quarter.

2. List the trees, bush and shrub species found around your school. Write their local names and their uses.

CHAPTER

6

# SOILS

Have you ever thought about the most important factor which supports trees, grasses, crops and numerous life-forms over the earth's surface? Can one grow a blade of grass without soil? While some plants and organisms which are aquatic in nature can sustain in water, do they not derive nutrients from soil through water? You will realise that soil is the most important layer of the earth's crust. It is a valuable resource. The bulk of our food and much of our clothing is derived from land-based crops that grow in the soil. The soil on which we depend so much for our day-to-day needs has evolved over thousands of years. The various agents of weathering and gradation have acted upon the parent rock material to produce a thin layer of soil.

Soil is the mixture of rock debris and organic materials which develop on the earth's surface. The major factors affecting the formation of soil are relief, parent material, climate, vegetation and other life-forms and time. Besides these, human activities also influence it to a large extent. Components of the soil are mineral particles, humus, water and air. The actual amount of each of these depend upon the type of soil. Some soils are deficient in one or more of these, while there are some others that have varied combinations.

Have you ever dug a pit in the field of your school to plant a tree while celebrating Van-Mahotsava? Was the pit of uniform layer of soil or did you notice different colours from the top to the bottom of the pit?

If we dig a pit on land and look at the soil, we find that it consists of three layers which are called horizons. 'Horizon A' is the topmost zone, where organic materials have got incorporated with the mineral matter, nutrients and water, which are necessary for the growth of plants. 'Horizon B' is a transition zone between the 'horizon A' and 'horizon C', and contains matter derived from below as well as from above. It has some organic matter in it, although the mineral matter is noticeably weathered. 'Horizon C' is composed of the loose parent material. This layer is the first stage in the soil formation process and eventually forms the above two layers. This arrangement of layers is known as the soil profile. Underneath these three horizons is the rock which is also known as the parent rock or the bedrock. Soil, which is a complex and varied entity has always drawn the attention of the scientists. In order to understand its importance, it is essential to attempt a scientific study of the soil. Classification of the soil is an effort to achieve this objective.

## CLASSIFICATION OF SOILS

India has varied relief features, landforms, climatic realms and vegetation types. These have contributed in the development of various types of soils in India.

In ancient times, soils used to be classified into two main groups – *Urvara* and *Usara*, which were fertile and sterile, respectively. In the 16th centrury A.D., soils were classified on the basis of their inherent characteristics and external features such as texture, colour, slope of land and moisture content in the soil. Based on texture, main soil types were identified as

sandy, clayey, silty and loam, etc. On the basis of colour, they were red, yellow, black, etc.

Since Independence, scientific surveys of soils have been conducted by various agencies. Soil Survey of India, established in 1956, made comprehensive studies of soils in selected areas like in the Damodar Valley. The National Bureau of Soil Survey and the Land Use Planning an Institute under the control of the Indian Council of Agricultural Research (ICAR) did a lot of studies on Indian soils. In their effort to study soil and to make it comparable at the international level, the ICAR has classified the Indian soils on the basis of their nature and character as per the United States Department of Agriculture (USDA) Soil Taxonomy.

**ICAR has classified the soils of India into the following order as per the USDA soil taxonomy**

| *Sl. No.* | *Order* | *Area* (in Thousand Hectares) | *Percentage* |
|---|---|---|---|
| (i) | Inceptisols | 130372.90 | 39.74 |
| (ii) | Entisols | 92131.71 | 28.08 |
| (iii) | Alfisols | 44448.68 | 13.55 |
| (iv) | Vertisols | 27960.00 | 8.52 |
| (v) | Aridisols | 14069.00 | 4.28 |
| (vi) | Ultisols | 8250.00 | 2.51 |
| (vi) | Mollisols | 1320.00 | 0.40 |
| (viii) | Others | 9503.10 | 2.92 |
| | **Total** | | **100** |

*Source : Soils of India, National Bureau of Soil Survey and Land Use Planning, Publication Number 94*

On the basis of genesis, colour, composition and location, the soils of India have been classified into:

(i) Alluvial soils
(ii) Black soils
(iii) Red and Yellow soils
(iv) Laterite soils
(v) Arid soils
(vi) Saline soils
(vii) Peaty soils
(viii) Forest soils.

### Alluvial Soils

Alluvial soils are widespread in the northern plains and the river valleys. These soils cover about 40 per cent of the total area of the country. They are depositional soils, transported and deposited by rivers and streams. Through a narrow corridor in Rajasthan, they extend into the plains of Gujarat. In the Peninsular region, they are found in deltas of the east coast and in the river valleys.

**Figure 6.1 : Alluvial Soil**

The alluvial soils vary in nature from sandy loam to clay. They are generally rich in potash but poor in phosphorous. In the Upper and Middle Ganga plain, two different types of alluvial soils have developed, viz. *Khadar* and *Bhangar*. *Khadar* is the new alluvium and is deposited by floods annually, which enriches the soil by depositing fine silts. *Bhangar* represents a system of older alluvium, deposited away from the flood plains. Both the *Khadar* and *Bhangar* soils contain calcareous concretions *(Kankars).* These soils are more loamy and clayey in the lower and middle Ganga plain and the Brahamaputra valley. The sand content decreases from the west to east.

The colour of the alluvial soils varies from the light grey to ash grey. Its shades depend on the depth of the deposition, the texture of the materials, and the time taken for attaining maturity. Alluvial soils are intensively cultivated.

### Black Soil

Black soil covers most of the Deccan Plateau which includes parts of Maharashtra, Madhya Pradesh, Gujarat, Andhra Pradesh and some parts of Tamil Nadu. In the upper reaches of the Godavari and the Krishna, and the north

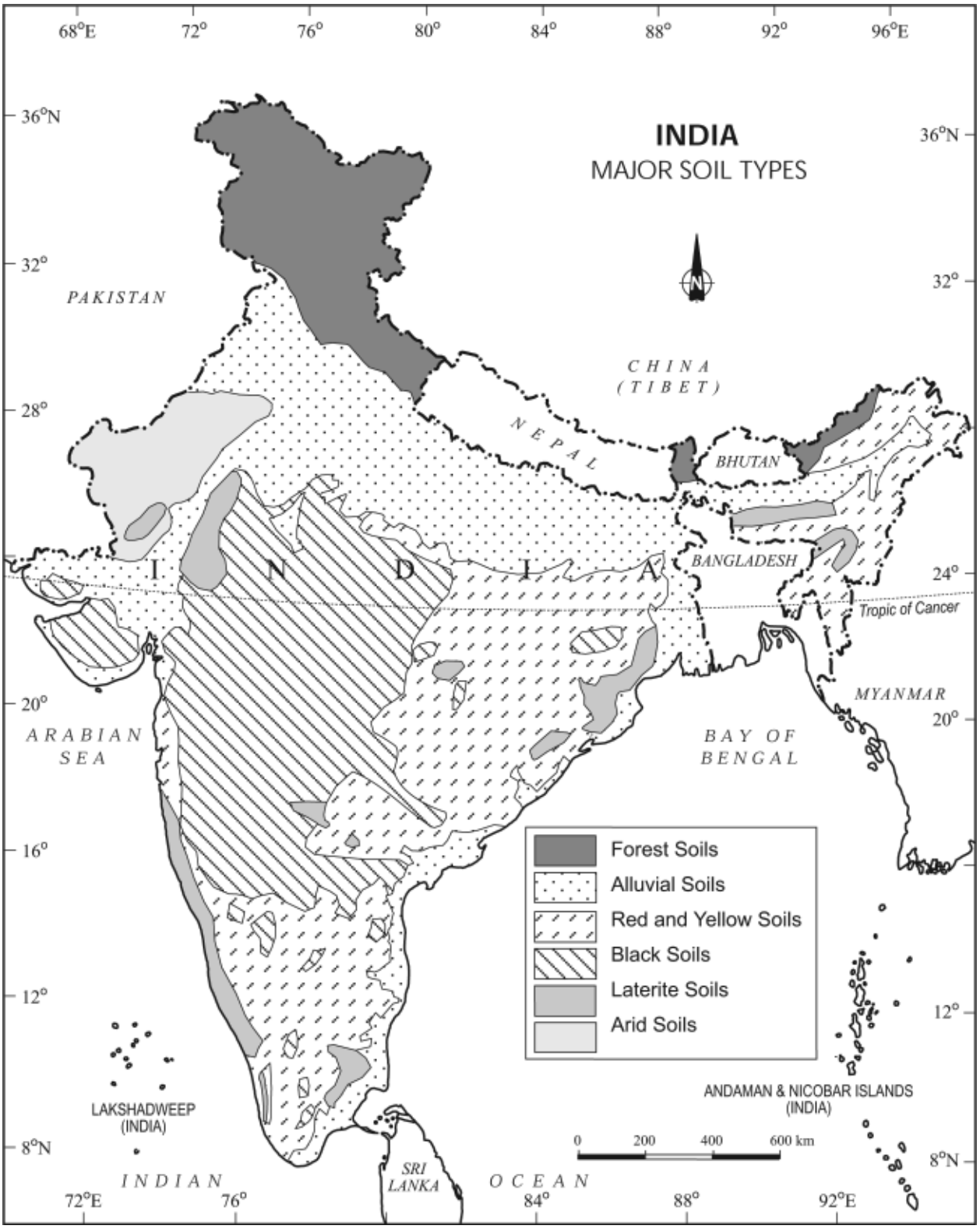


**Figure 6.2 : Major Soil Types of India**

western part of the Deccan Plateau, the black soil is very deep. These soils are also known as the 'Regur Soil' or the 'Black Cotton Soil'. The black soils are generally clayey, deep and impermeable. They swell and become sticky when wet and shrink when dried. So, during the dry season, these soil develop wide cracks. Thus, there occurs a kind of *'self ploughing'*. Because of this character of slow absorption and loss of moisture, the black soil retains the moisture for a very long time, which helps the crops, especially, the rain fed ones, to sustain even during the dry season.

**Figure 6.3 : Black Soil During Dry Season**

Chemically, the black soils are rich in lime, iron, magnesia and alumina. They also contain potash. But they lack in phosphorous, nitrogen and organic matter. The colour of the soil ranges from deep black to grey.

### Red and Yellow Soil

Red soil develops on crystalline igneous rocks in areas of low rainfall in the eastern and southern part of the Deccan Plateau. Along the piedmont zone of the Western Ghat, long stretch of area is occupied by red loamy soil. Yellow and red soils are also found in parts of Orissa and Chattisgarh and in the southern parts of the middle Ganga plain. The soil develops a reddish colour due to a wide diffusion of iron in crystalline and metamorphic rocks. It looks yellow when it occurs in a hydrated form. The fine-grained red and yellow soils are normally fertile, whereas coarse-grained soils found in dry upland areas are poor in fertility. They are generally poor in nitrogen, phosphorous and humus.

### Laterite Soil

Laterite has been derived from the Latin word *'Later'* which means brick. The laterite soils develop in areas with high temperature and high rainfall. These are the result of intense leaching due to tropical rains. With rain, lime and silica are leached away, and soils rich in iron oxide and aluminium compound are left behind. Humus content of the soil is removed fast by bacteria that thrives well in high temperature. These soils are poor in organic matter, nitrogen, phosphate and calcium, while iron oxide and potash are in excess. Hence, laterites are not suitable for cultivation; however, application of manures and fertilisers are required for making the soils fertile for cultivation.

Red laterite soils in Tamil Nadu, Andhra Pradesh and Kerala are more suitable for tree crops like cashewnut.

Laterite soils are widely cut as bricks for use in house construction. These soils have mainly developed in the higher areas of the Peninsular plateau. The laterite soils are commonly found in Karnataka, Kerala, Tamil Nadu, Madhya Pradesh and the hilly areas of Orissa and Assam.

### Arid Soils

Arid soils range from red to brown in colour. They are generally sandy in structure and saline in nature. In some areas, the salt content is so high that common salt is obtained by evaporating the saline water. Due to the dry climate, high temperature and accelerated evaporation, they lack moisture and humus. Nitrogen is insufficient and the phosphate

**Figure 6.4 : Arid Soil**

content is normal. Lower horizons of the soil are occupied by *'kankar'* layers because of the increasing calcium content downwards. The *'Kankar'* layer formation in the bottom horizons restricts the infiltration of water, and as such when irrigation is made available, the soil moisture is readily available for a sustainable plant growth. Arid soils are characteristically developed in western Rajasthan, which exhibit characteristic arid topography. These soils are poor and contain little humus and organic matter.

### Saline Soils

They are also known as *Usara* soils. Saline soils contain a larger proportion of sodium, potassium and magnesium, and thus, they are infertile, and do not support any vegetative growth. They have more salts, largely because of dry climate and poor drainage. They occur in arid and semi-arid regions, and in waterlogged and swampy areas. Their structure ranges from sandy to loamy. They lack in nitrogen and calcium. Saline soils are more widespread in western Gujarat, deltas of the eastern coast and in Sunderban areas of West Bengal. In the Rann of Kuchchh, the Southwest Monsoon brings salt particles and deposits there as a crust. Seawater intrusions in the deltas promote the occurrence of saline soils. In the areas of intensive cultivation with excessive use of irrigation, especially in areas of green revolution, the fertile alluvial soils are becoming saline. Excessive irrigation with dry climatic conditions promotes capillary action, which results in the deposition of salt on the top layer of the soil. In such areas, especially in Punjab and Haryana, farmers are advised to add gypsum to solve the problem of salinity in the soil.

### Peaty Soils

They are found in the areas of heavy rainfall and high humidity, where there is a good growth of vegetation. Thus, large quantity of dead organic matter accumulates in these areas, and this gives a rich humus and organic content to the soil. Organic matter in these soils may go even up to 40-50 per cent. These soils are normally heavy and black in colour. At many places, they are alkaline also. It occurs widely in the northern part of Bihar, southern part of Uttaranchal and the coastal areas of West Bengal, Orissa and Tamil Nadu.

### Forest Soils

As the name suggests, forest soils are formed in the forest areas where sufficient rainfall is available. The soils vary in structure and texture depending on the mountain environment where they are formed. They are loamy and silty on valley sides and coarse-grained in the upper slopes. In the snow-bound areas of the Himalayas, they experience denudation, and are acidic with low humus content. The soils found in the lower valleys are fertile.

It is evident from the foregoing discussions that soils, their texture, quality and nature are vital for the germination and growth of plant and vegetation including crops. Soils are living systems. Like any other organism, they too develop and decay, get degraded, respond to proper treatment if administered in time. These have serious repercussions on other components of the system of which they themselves are important parts.

## Soil Degradation

In a broad sense, soil degradation can be defined as the decline in soil fertility, when the nutritional status declines and depth of the soil goes down due to erosion and misuse. Soil degradation is the main factor leading to the depleting soil resource base in India. The degree of soil degradation varies from place to place according to the topography, wind velocity and amount of the rainfall.

## Soil Erosion

The destruction of the soil cover is described as soil erosion. The soil forming processes and the erosional processes of running water and wind go on simultaneously. But generally, there is a balance between these two processes. The rate of removal of fine particles from the surface is the same as the rate of addition of particles to the soil layer.

Sometimes, such a balance is disturbed by natural or human factors, leading to a greater rate of removal of soil. Human activities too are responsible for soil erosion to a great extent. As the human population increases, the demand on the land also increases. Forest and other natural vegetation is removed for human settlement, for cultivation, for grazing animals and for various other needs.

Wind and water are powerful agents of soil erosion because of their ability to remove soil and transport it. Wind erosion is significant in arid and semi-arid regions. In regions with heavy rainfall and steep slopes, erosion by running water is more significant. Water erosion which is more serious and occurs extensively in different parts of India, takes place mainly in the form of sheet and gully erosion. Sheet erosion takes place on level lands after a heavy shower and the soil removal is not easily noticeable. But it is harmful since it removes the finer and more fertile top soil. Gully erosion is common on steep slopes. Gullies deepen with rainfall, cut the agricultural lands into small fragments and make them unfit for cultivation. A region with a large number of deep gullies or ravines is called a badland topography. Ravines are widespread, in the Chambal basin. Besides this, they are also found in Tamil Nadu and West Bengal. The country is losing about 8,000 hectares of land to ravines every year. What types are prone to gully erosion?

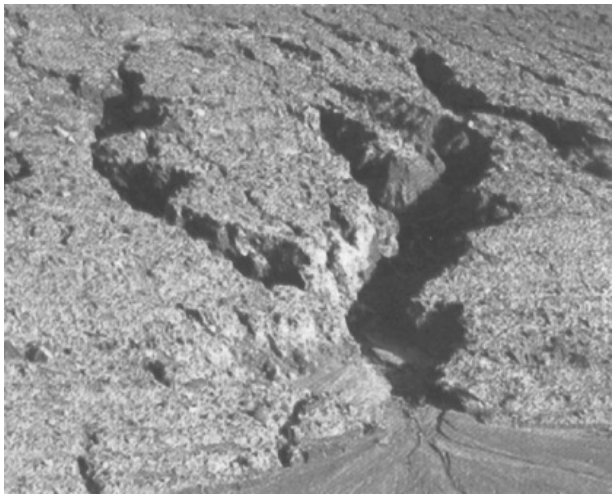

**Figure 6.5 : Soil Erosion**

Soil erosion is a serious problem for Indian agriculture and its negative effects are seen in other spheres also. Eroded materials are carried down to rivers and they lower down their carrying capacity, and cause frequent floods and damage to agricultural lands.

Deforestation is one of the major causes of soil erosion. Plants keep soils bound in locks of roots, and thus, prevent erosion. They also add humus to the soil by shedding leaves and twigs. Forests have been denuded practically in most parts of India but their effect on soil erosion are more in hilly parts of the country.

A fairly large area of arable land in the irrigated zones of India is becoming saline because of over-irrigation. The salt lodged in the lower profiles of the soil comes up to the surface and destroys its fertility. Chemical fertilisers in the absence of organic manures are also harmful to the soil. Unless the soil gets enough humus, chemicals harden it and reduce its fertility in the long run. This problem is common in all the command areas of the river valley projects, which were the first beneficiaries of the Green Revolution. According to estimates, about half of the total land of India is under some degree of degradation.

Every year, India loses millions of tonnes of soil and its nutrients to the agents of its degradation, which adversely affects our national productivity. So, it is imperative to initiate immediate steps to reclaim and conserve soils.

### Soil Conservation

If soil erosion and exhaustion are caused by humans; by corollary, they can also be prevented by humans. Nature has its own laws of maintaining balance. Nature offers enough opportunities for humans to develop their economy without disturbing the ecological balance. Soil conservation is a methodology to maintain soil fertility, prevent soil erosion and exhaustion, and improve the degraded condition of the soil.

Soil erosion is essentially aggravated by faulty practices. The first step in any rational solution is to check open cultivable lands on slopes from farming. Lands with a slope gradient of 15 - 25 per cent should not be used

for cultivation. If at all the land is to be used for agriculture, terraces should carefully be made. Over-grazing and shifting cultivation in many parts of India have affected the natural cover of land and given rise to extensive erosion. It should be regulated and controlled by educating villagers about the consequences. Contour bunding, Contour terracing, regulated forestry, controlled grazing, cover cropping, mixed farming and crop rotation are some of the remedial measures which are often adopted to reduce soil erosion.

**Figure 6.6 : Terrace Farming**

Efforts should be made to prevent gully erosion and control their formation. Finger gullies can be eliminated by terracing. In bigger gullies, the erosive velocity of water may be reduced by constructing a series of check dams. Special attention should be made to control headward extension of gullies. This can be done by gully plugging, terracing or by planting cover vegetation.

In arid and semi-arid areas, efforts should be made to protect cultivable lands from encroachment by sand dunes through developing shelter belts of trees and agro-forestry. Lands not suitable for cultivation should be converted into pastures for grazing. Experiments have been made to stabilise sand dunes in western Rajasthan by the Central Arid Zone Research Institute (CAZRI).

The Central Soil Conservation Board, set up by the Government of India, has prepared a number of plans for soil conservation in different parts of the country. These plans are based on the climatic conditions, configuration of land and the social behaviour of people. Even these plans are fragmental in nature. Integrated land use planning, therefore, seems to be the best technique for proper soil conservation. Lands should be classified according to their capability; land use maps should be prepared and lands should be put to right uses. The final responsibility for achieving the conservation of land will rest on the people who operate on it and receive the benefits.

## EXERCISES

1. Choose the right answer from the four alternatives given below.

   (i) Which one of the following is the most widespread and most productive category of soil?

   (a) Alluvial Soil (c) Black Soil
   (b) Laterite Soil (d) Forest Soil

   (ii) 'Regur Soil' is another name for the.

   (a) Saline Soil (c) Black Soil
   (b) Arid Soil (d) Laterite Soil

   (iii) Which one of the following is the main reason for the loss of the top soil in India?

   (a) Wind erosion (c) Excessive leaching
   (b) Water erosion (d) None of these

(iv) Arable land in the irrigated zones of India is turning saline due to which of the following reasons?

(a) Addition of gypsum (c) Over irrigation

(b) Over grazing (d) Use of fertilisers

2. Answer the following questions in about 30 words.

(i) What is soil?

(ii) What are the main factors responsible for the formation of soil?

(iii) Mention the three horizons of a soil profile.

(iv) What is soil degradation?

(v) What is the difference between *Khadar* and *Bhangar*?

3. Answer the following questions in not more than 125 words.

(i) What are black soils? Describe their formation and characteristics.

(ii) What is soil conservation? Suggest some measures to conserve soil.

(iii) How do you know that a particular type of soil is fertile or not? Differentiate between naturally determined fertility and culturally induced fertility.

**Project/Activity**

1. Collect various samples of soil and prepare a report on the type(s) of soils found in your region.

2. On an outline map of India, mark the areas coverd by the following soil categories.

(i) Red soil

(ii) Laterite soil

(iii) Alluvial soil.

# UNIT IV

# NATURAL HAZARDS AND DISASTERS: CAUSES, CONSEQUENCES AND MANAGEMENT

*This unit deals with*

- *Floods and droughts*
- *Earthquakes and tsunami*
- *Cyclones*
- *Landslides*

CHAPTER

7

# NATURAL HAZARDS AND DISASTERS

You might have read about tsunami or seen the images of horror on television set immediately after it happened. You may also be aware of the severe earthquake in Kashmir on both sides of the Line of Control (LOC). The damage caused to human life and properties during these episodes has moved us all. What are these as phenomena and how they are caused? How can we save ourselves? These are some questions which come to our minds. This chapter will attempt to analyse some of these questions.

Change is the law of nature. It is a continuous process that goes on uninterruptedly involving phenomena, big and small, material and non-material that make our physical and socio-cultural environment. It is a process present everywhere with variations in terms of magnitude, intensity and scale. Change can be a gradual or slow process like the evolution of landforms and organisms and it can be as sudden and swift as volcanic eruptions, tsunamis, earthquakes and lightening, etc. Similarly, it may remain confined to a smaller area occurring within a few seconds like hailstorms, tornadoes and dust storms, and it can also have global dimensions such as global warming and depletion of the ozone layer.

Besides these, changes have different meanings for different people. It depends upon the perspective one takes while trying to understand them. From the perspective of nature, changes are value-neutral (these are neither good nor bad). But from the human perspective, these are value-loaded. There are some changes that are desirable and good like the change of seasons, ripening of fruits, while there are others like earthquakes, floods and wars that are considered bad and undesirable.

> Observe the environment you live in and prepare a list of changes, which take place over a long period of time and those, which take place within a short period of time. Do you know why some changes are considered good and others bad? Prepare a list of changes, which you notice in your daily life and give reasons why some of these are considered good and others bad.

In this chapter, we will read about some of these changes, which are considered bad and have haunted humankind for a long time.

Disasters in general and natural disasters in particular, are some such changes that are always disliked and feared by humankind.

> **What is a Disaster?**
>
> "Disaster is an undesirable occurrence resulting from forces that are largely outside human control, strikes quickly with little or no warning, which causes or threatens serious disruption of life and property including death and injury to a large number of people, and requires therefore, mobilisation of efforts in excess of that which are normally provided by statutory emergency services".

For a long time, geographical literature viewed disasters as a consequence of natural forces; and human beings were treated as innocent and helpless victims in front of the mighty forces of nature. But natural forces are

not the only causes of disasters. Disasters are also caused by some human activities. There are some activities carried by human beings that are directly responsible for disasters. Bhopal Gas tragedy, Chernobyl nuclear disaster, wars, release of CFCs (Chlorofluorocarbons) and increase of green house gases, environmental pollutions like noise, air, water and soil are some of the disasters which are caused directly by human actions. There are some other activities of human beings that accelerate or intensify disasters indirectly. Landslides and floods due to deforestation, unscientific land use and construction activities in fragile areas are some of the disasters that are the results of indirect human actions. Can you identify some other human activities going on in and around your neighbourhood and schools that can lead to disasters in the near future? Can you suggest some measures to prevent it? It is a common experience that human-made disasters have increased both in their numbers and magnitudes over the years and concerted efforts are on at various levels to prevent and minimise their occurrences. Though the success has been only nominal so far, it is possible to prevent some of these disasters created by human actions. As opposed to this, very little is possible to prevent natural disasters; therefore, the best way out is to emphasise on natural disaster mitigation and management. Establishment of National Institute of Disaster Management, India, Earth Summit at Rio de Janeiro, Brazil, 1993 and the World Conference on Disaster Management in May 1994 at Yokohama, Japan, etc. are some of the concrete steps towards this direction initiated at different levels.

Most often it is observed that scholars use disasters and natural hazards as interchangeable. Both are related phenomena, yet quite distinct from each other. Hence, it is necessary to distinguish between the two.

*Natural Hazards are elements of circumstances in the Natural environment that have the potential to cause harm to people or property or both.* These may be swift or permanent aspects of the respective environmental settings like currents in the oceans, steep slope and unstable structural features in the Himalayas or extreme climatic conditions in deserts or glaciated areas.

As compared to natural hazards, *natural disasters are relatively sudden and cause large scale, widespread death, loss of property and disturbance to social systems and life over which people have a little or no control.* Thus, any event can be classed as disaster when the magnitude of destruction and damage caused by it is very high.

Generally, disasters are generalised experiences of people the world over, and no two disasters are similar and comparable to each other. Every disaster is unique in terms of the local socio-environmental factors that control it, the social response it generates, and the way each social group negotiates with it. However, the opinion mentioned above is indicative of three important things. Firstly, the magnitude, intensity, frequency and damages caused by natural disasters have increased over the years. Secondly, there is a growing concern among people the world over to deal with the menace created by these so that the loss of human life and property can be minimised. And finally, significant changes have taken place in the pattern of natural disasters over the years.

There has also been a change in the perception of natural disasters and hazards. Previously, hazards and disasters were seen as two closely associated and interrelated phenomena, i.e. areas prone to natural hazards, were more vulnerable to disasters. Hence, people avoided tampering with the delicate balance that existed in a given ecosystem. People avoided intensification of their activities in such areas and that is how disasters were less damaging. Technological power has given large capacity to human intervention in nature. Consequently, now, human beings tend to intensify their activities into disaster prone areas increasing their vulnerability to disasters. Colonisation of flood plains of most of the rivers and development of large cities and port-towns like – Mumbai and Chennai along the coast, and touching the shore due to high land values, make them vulnerable to the occurrence of cyclones, hurricanes and tsunamis.

These observations can also be corroborated by the data given in Table 7.1 showing the magnitude of deaths caused by twelve serious natural disasters in the past sixty years in different countries of the world.

It is evident from the table that natural disasters have caused widespread loss of life and property. Concerted efforts are on at various levels to take appropriate measures to deal with the situation. It is also being felt that the damages caused by natural disasters have global repercussions that are beyond the means and capabilities of individual nation-states to cope up with. Hence, this issue was raised at the *U.N. General Assembly* in 1989 and it was finally formalised at the *World Conference on Disaster Management* in May 1994 at Yokohama, Japan. This was subsequently called the *Yokohama Strategy and Plan of Action for a Safer World.*

## Classification of Natural Disasters

Human beings the world over have experienced disasters and have faced and lived with them. Now people are becoming aware and various steps have been initiated at different levels for mitigating the effects of disasters. Identification and classification of disasters is being considered as an effective and scientific step to deal promptly and efficiently with the disasters. Broadly, natural disasters can be classified under four categories (See Table 7.2).

India is one of those countries which has experienced most of the natural disasters mentioned in Table 7.2. Every year it loses thousands of lives and property worth millions of rupees due to these natural calamities. In the following section, some of

**Table 7.1 : Top Twelve Natural Disasters Since 1948**

| *Year* | *Location* | *Type* | *Deaths* |
|---|---|---|---|
| 1948 | The Soviet Union (now Russia) | Earthquakes | 110,000 |
| 1949 | China | Floods | 57,000 |
| 1954 | China | Floods | 30,000 |
| 1965 | East Pakistan (now Bangladesh) | Tropical Cyclones | 36,000 |
| 1968 | Iran | Earthquakes | 30,000 |
| 1970 | Peru | Earthquakes | 66,794 |
| 1970 | East Pakistan (now Bangladesh) | Tropical Cyclones | 500,000 |
| 1971 | India | Tropical Cyclones | 30,000 |
| 1976 | China | Earthquakes | 700,000 |
| 1990 | Iran | Earthquakes | 50,000 |
| 2004 | Indonesia, Sri Lanka, India, etc. | Tsunamis | 500,000* |
| 2005 | Pakistan, India | Earthquakes | 70,000* |

*Source* : United Nations Environmental Programme (UNEP), 1991
**News Report* from National Institute for Disaster Management, Government of India, New Delhi

**Table 7.2 : Classification of Natural Disasters**

| *Atmospheric* | *Terrestrial* | *Aquatic* | *Biological* |
|---|---|---|---|
| Blizzards<br>Thunderstorms<br>Lightning<br>Tornadoes<br>Tropical Cyclone<br>Drought<br>Hailstorm<br>Frost, Heat Wave or *Loo*.Cold Waves, etc. | Earthquakes<br>Volcanic Eruptions<br>Landslides<br>Avalanches<br>Subsidence<br>Soil Erosion | Floods<br>Tidal Waves<br>Ocean Currents<br>Storm Surge<br>Tsunami | Plants and Animals as colonisers (Locusts, etc.). Insects infestation—fungal, bacterial and viral diseases such as bird flu, dengue, etc. |

**Yokohama Strategy and International Decade for Natural Disaster Reduction (IDNDR)**
**Yokohama Strategy and Plan of Action for a Safer World**

All the member states of the United Nations and other states met at the **World Conference on Natural Disaster Reduction** in the city of Yokohama from May 23rd-27th 1994. It acknowledged that the impact of natural disasters in terms of human and economic losses has risen in recent years, and society, in general, has become vulnerable to natural disasters. It also accepted that these disasters affected the poor and disadvantageous groups the worst, particularly in the developing countries, which are ill-equipped to cope with them. Hence, the conference adopted the Yokohama strategy as a guide to rest of the decade and beyond, to mitigate the losses due to these disasters.

The resolution of the World Conference on Natural Disasters Reduction is as mentioned below:

(i) It will note that each country has the sovereign responsibility to protect its citizens from natural disasters;
(ii) It will give priority attention to the developing countries, particularly the least developed, land-locked countries and small-island developing states;
(iii) It will develop and strengthen national capacities and capabilities and, where appropriate, national legislation for natural and other disaster prevention, mitigation and preparedness, including the mobilisation of non-governmental organisations and participation of local communities;
(iv) It will promote and strengthen sub-regional, regional and international cooperation in activities to prevent, reduce and mitigate natural and other disasters, with particular emphasis on:
(a) human and institutional capacity-building and strengthening;
(b) technology sharing: the collection, the dissemination and utilisation of information; and
(c) mobilisation of resources.

It also declared the decade 1990-2000 as the *International Decade for Natural Disaster Reduction (IDNDR).*

the highly devastating natural disasters have been discussed, particularly in the context of India.

## Natural Disasters and Hazards in India

It was discussed in one of the previous chapters that India is vast and diverse in terms of its physical and socio-cultural attributes. It is largely due to its vast geographical area, environmental diversities and cultural pluralities that scholars often described it using two meaningful adjectives like the 'Indian-subcontinent' and the 'land of unity in diversity'. Its vastness in terms of natural attributes combined with its prolonged colonial past, continuing various forms of social discriminations and also equally large population have enhanced its vulnerability to natural disasters. These observations can also be illustrated by focussing on some of the major natural disasters in India.

### Earthquakes

Earthquakes are by far the most unpredictable and highly destructive of all the natural disasters. You have already learnt the causes of earthquakes in your book *Fundamentals of Physical Geography* (NCERT, 2006). Earthquakes that are of tectonic origin have proved to be the most devastating and their area of influence is also quite large. These earthquakes result from a series of earth movements brought about by a sudden release of energy during the tectonic activities in the earth's crust. As compared to these, the earthquakes associated with volcanic eruption, rock fall, landslides, subsidence, particularly in the mining areas, impounding of dams and reservoirs, etc. have limited area of influence and the scale of damage.

It was mentioned in Chapter 2 of the book that the Indian plate is moving at a speed of one centimetre per year towards the north and northeastern direction and this movement of plates is being constantly obstructed by the Eurasian plate from the north. As a result of this, both the plates are said to be locked with each other resulting in accumulation of energy at different points of time. Excessive accumulation of energy results in building up of stress, which ultimately leads to the breaking up of the lock and the sudden release of energy causes

earthquakes along the Himalayan arch. Some of the most vulnerable states are Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Sikkim, and the Darjiling and subdivision of West Bengal and all the seven states of the northeast.

**Figure 7.1 : A Damaged Building Due to an Earthquake**

Apart from these regions, the central-western parts of India, particularly Gujarat (in 1819, 1956 and 2001) and Maharashtra (in 1967 and 1993) have also experienced some severe earthquakes. Earth scientists have found it difficult to explain the occurrence of earthquakes in one of the oldest, most stable and mature landmass of Peninsular block for a long time. Recently, some earth scientists have come up with a theory of emergence of a fault line and energy build-up along the fault line represented by the river Bhima (Krishna) near Latur and Osmanabad (Maharashtra) and the possible breaking down of the Indian plate (Figure 7.2).

*National Geophysical Laboratory, Geological Survey of India, Department of Meteorology, Government of India*, along with the recently formed *National Institute of Disaster Management*, have made an intensive analysis of more than 1,200 earthquakes that have occurred in India in different years in the past, and based on these, they divided India into the following five earthquake zones:

(i) Very high damage risk zone
(ii) High damage risk zone
(iii) Moderate damage risk zone
(iv) Low damage risk zone
(v) Very low damage risk zone.

Out of these, the first two zones had experienced some of the most devastating earthquakes in India. As shown in the Figure 7.2, areas vulnerable to these earthquakes are the North-east states, areas to the north of Darbhanga and Araria along the Indo-Nepal border in Bihar, Uttaranchal, Western Himachal Pradesh (around Dharamshala) and Kashmir Valley in the Himalayan region and the Kuchchh (Gujarat). These are included in the Very High Damage Risk Zone. Similarly, the remaining parts of Jammu and Kashmir, Himachal Pradesh, Northern parts of Punjab, Eastern parts of Haryana, Delhi, Western Uttar Pradesh, and Northern Bihar fall under the High Damage Risk Zone. Remaining parts of the country fall under moderate to very Low Damage Risk Zone. Most of the areas that can be considered safe are from the stable landmass covered under the Deccan plateau.

### *Socio-Environmental Consequences of Earthquakes*

The idea of an earthquake is often associated with fear and horror due to the scale, magnitude and suddenness at which it spreads disasters on the surface of the earth without discrimination. It becomes a calamity when it strikes the areas of high density of population. It not only damages and destroys the settlements, infrastructure, transport and communication network, industries and other developmental activities but also robs the population of their material and socio-cultural gains that they have preserved over generations. It renders them homeless, which puts an extra-pressure and stress, particularly on the weak economy of the developing countries.

### *Effects of Earthquakes*

Earthquakes have all encompassing disastrous effects on the area of their occurrence. Some of the important ones are listed in Table 7.3.

**Table 7.3 : Effects of Earthquakes**

| *On Ground* | *On Manmade Structures* | *On Water* |
|---|---|---|
| Fissures | Cracking | Waves |
| Settlements | Slidings | Hydro-Dynamic Pressure |
| Landslides | Overturning | Tsunami |
| Liquefaction | Buckling | |
| Earth Pressure | Collapse | |
| Possible Chain-effects | Possible Chain-effects | Possible Chain-effects |

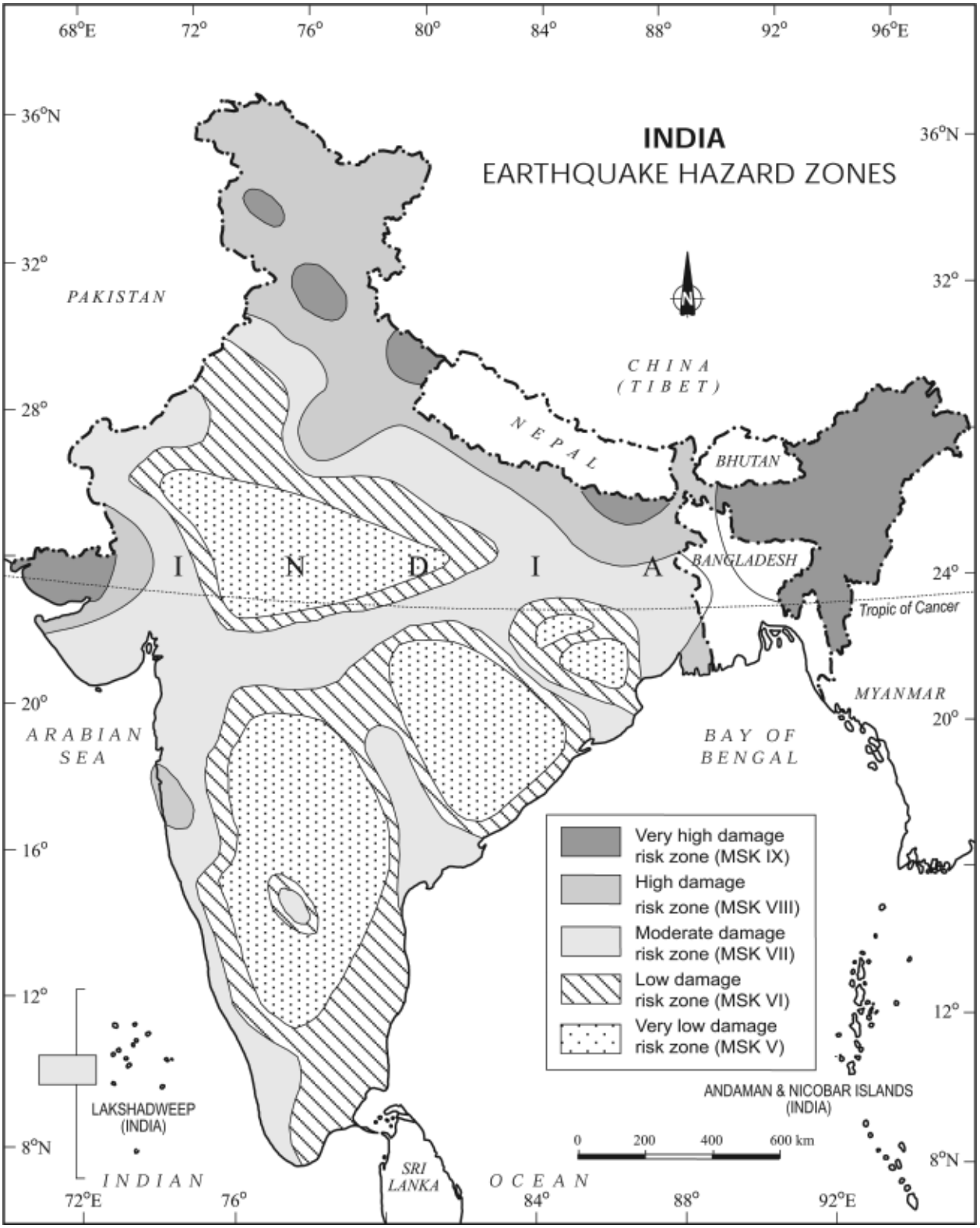


**Figure 7.2 : India: Earthquake Hazard Zones**

Apart from these, earthquakes also have some serious and far-reaching environmental consequences. Surface seismic waves produce fissures on the upper layers of the earth's crust through which water and other volatile materials gush out, inundating the neighbouring areas. Earthquakes are also responsible for landslides and often these cause obstructions in the flow of rivers and channels resulting in the formation of reservoirs. Sometimes, rivers also change their course causing floods and other calamities in the affected areas.

*Earthquake Hazard Mitigation*

Unlike other disasters, the damages caused by earthquakes are more devastating. Since it also destroys most of the transport and communication links, providing timely relief to the victims becomes difficult. It is not possible to prevent the occurrence of an earthquake; hence, the next best option is to emphasis on disaster preparedness and mitigation rather than curative measures such as:

(i) Establishing earthquake monitoring centres (seismological centres) for regular monitoring and fast dissemination of information among the people in the vulnerable areas. Use of Geographical Positioning System (GPS) can be of great help in monitoring the movement of tectonic plates.

(ii) Preparing a vulnerability map of the country and dissemination of vulnerability risk information among the people and educating them about the ways and means minimising the adverse impacts of disasters.

(iii) Modifying the house types and building-designs in the vulnerable areas and discouraging construction of high-rise buildings, large industrial establishments and big urban centres in such areas.

(iv) Finally, making it mandatory to adopt earthquake-resistant designs and use light materials in major construction activities in the vulnerable areas.

**Tsunami**

Earthquakes and volcanic eruptions that cause the sea-floor to move abruptly resulting in sudden displacement of ocean water in the form of high vertical waves are called *tsunamis* (harbour waves) or seismic sea waves. Normally, the seismic waves cause only one instantaneous vertical wave; but, after the initial disturbance, a series of afterwaves are created in the water that oscillate between high crest and low trough in order to restore the water level.

The speed of wave in the ocean depends upon the depth of water. It is more in the shallow water than in the ocean deep. As a result of this, the impact of *tsunami* is less over the ocean and more near the coast where they cause large-scale devastations. Therefore, a ship at sea is not much affected by *tsunami* and it is difficult to detect a tsunami in the deeper parts of sea. It is so because over deep water the tsunami has very long wave-length and limited wave-height. Thus, a tsunami wave raises the ship only a metre or two and each rise and fall takes several minutes. As opposed to this, when a tsunami enters shallow water, its wave-length gets reduced and the period remains unchanged, which increases the wave-height. Sometimes, this height can be up to 15m or more, which causes large-scale destructions along the shores. Thus, these are also called *Shallow Water Waves*. Tsunamis are frequently observed along the Pacific ring of fire, particularly along the coast of Alaska, Japan, Philippines, and other islands of South-east Asia, Indonesia, Malaysia, Myanmar, Sri Lanka, and India etc.

After reaching the coast, the tsunami waves release enormous energy stored in them and water flows turbulently onto the land destroying port-cities and towns, structures, buildings and other settlements. Since the coastal areas are densely populated the world over, and these are also centres of intense human activity, the loss of life and property is likely to be much higher by a tsunami as compared to other natural hazards in the coastal areas. The extent of devastation caused by tsunami can be assessed through the

visuals on Banda Ache (Indonesia) presented in the book *Practical Work in Geography - Part I* (NCERT, 2006).

Unlike other natural hazards, the mitigation of hazards created by tsunami is difficult, mainly because of the fact that losses are on a much larger scale.

**Figure 7.3 : Tsunami Affected Area**

It is beyond the capacity of individual state or government to mitigate the damage. Hence, combined efforts at the international levels are the possible ways of dealing with these disasters as has been in the case of the tsunami that occurred on 26th December 2004 in which more than 300,000 people lost their lives. India has volunteered to join the *International Tsunami Warning System* after the December 2004 tsunami disaster.

## Tropical Cyclone

Tropical cyclones are intense low-pressure areas confined to the area lying between 30° N and 30° S latitudes, in the atmosphere around which high velocity winds blow. Horizontally, it extends up to 500-1,000 km and vertically from surface to 12-14 km. A tropical cyclone or hurricane is like a heat engine that is energised by the release of latent heat on account of the condensation of moisture that the wind gathers after moving over the oceans and seas.

There are differences of opinion among scientists about the exact mechanism of a tropical cyclone. However, some initial conditions for the emergence of a tropical cyclone are:

(i) Large and continuous supply of warm and moist air that can release enormous latent heat.

(ii) Strong Coriolis force that can prevent filling of low pressure at the centre (absence of Coriolis force near the equator prohibits the formation of tropical cyclone between 0°-5° latitude).

(iii) Unstable condition through the troposphere that creates local disturbances around which a cyclone develops.

(iv) Finally, absence of strong vertical wind wedge, which disturbs the vertical transport of latent heat.

### *Structure of Tropical Cyclone*

Tropical cyclones are characterised by large pressure gradients. The centre of the cyclone is mostly a warm and low-pressure, cloudless core known as *eye of the storm*. Generally, the isobars are closely placed to each other showing high-pressure gradients. Normally, it varies between 14-17mb/100 km, but sometimes it can be as high as 60mb/100km. Expansion of the wind belt is about 10-150 km from the centre.

### *Spatio-temporal Distribution of Tropical Cyclone in India*

Owing to its Peninsular shape surrounded by the Bay of Bengal in the east and the Arabian Sea in the west, the tropical cyclones in India also originate in these two important locations. Though most of the cyclones originate between 10°-15° north latitudes during the monsoon season, yet in case of the Bay of Bengal, cyclones mostly develop during the months of October and November. Here, they originate between 16°-2° N latitudes and to the west of 92° E. By July the place of origin of these storms shifts to around 18° N latitude and west of 90°E near the Sunderban Delta. Table 7.4 and Figure 7.4 show the frequency and tracks of time of cyclonic storms in India.

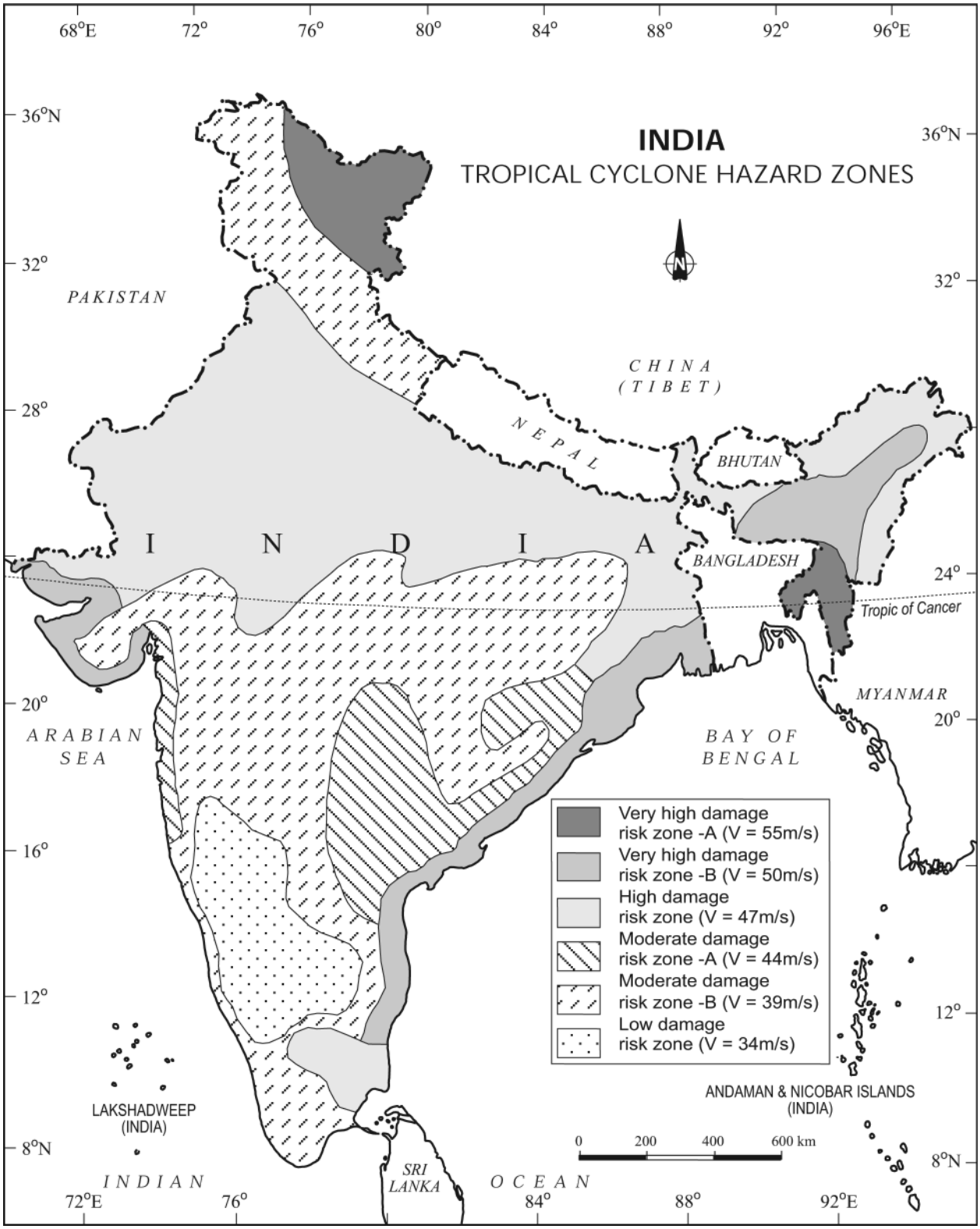


**Figure 7.4 : Tropical Cyclone Hazard Zones**

**Table 7.4 : Frequency of Cyclonic Storms in India**

| *Months* | *Bay of Bengal Sea* | *Arabian* |
|---|---|---|
| January | 4 (1.3) * | 2 (2.4) |
| February | 1 (0.3) | 0 (0.0) |
| March | 4 (1.30) | 0 (0.0) |
| April | 18 (5.7) | 5 (6.1) |
| May | 28 (8.9) | 13 (15.9) |
| June | 34 (10.8) | 13 (15.9) |
| July | 38 (12.1) | 3 (3.7) |
| August | 25 (8.0) | 1 (1.2) |
| September | 27 (8.6) | 4 (4.8) |
| October | 53 (16.9) | 17 (20.7) |
| November | 56 (17.8) | 21 (25.6) |
| December | 26 (8.3) | 3 (3.7) |
| **Total** | **314 (100)** | **82 (100)** |

*Data in the brackets are in percentage to total number of storms taking place in a year

### *Consequences of Tropical Cyclones*

It was mentioned that the energy to the tropical cyclone comes from the latent heat released by the warm moist air. Hence, with the increase in distance from the sea, the force of the cyclone decreases. In India, the force of the cyclone decreases with increase in distance from the Bay of Bengal and the Arabian Sea. So, the coastal areas are often struck by severe cyclonic storms with an average velocity of 180 km/h. Often, this results in abnormal rise in the sea level known as *Storm Surge.*

> A surge is generated due to interaction of air, sea and land. The cyclone provides the driving force in the form of very high horizontal pressure-gradient and very strong surface winds. The sea water flows across the coast along with strong winds and heavy downpour.

This results in inundation of human settlements, agricultural fields, damaging crops and destruction of structures created by human beings.

## Floods

You read in newspapers and watch images of floods on televisions occurring in some regions during rainy seasons. Inundation of land and human settlements by the rise of water in the channels and its spill-over presents the condition of flooding. Unlike other natural disasters, the causes of floods are well-established. Floods are relatively slow in occurrences and often, occur in well-identified regions and within expected time in a year. Floods occur commonly when water in the form of surface run-off exceeds the carrying capacity of the river channels and streams and flows into the neighbouring low-lying flood plains. At times, this even goes beyond the capacity of lakes and other inland water bodies in which they flow. Floods can also be caused due to a storm surge (in the coastal areas), high intensity rainfall for a considerably longer time period, melting of ice and snow, reduction in the infiltration rate and presence of eroded material in the water due to higher rate of soil erosion. Though floods occur frequently over wide geographical area having disasterous ramifications in many parts of the world, floods in the South, Southeast and East Asian countries, particularly in China, India and Bangladesh, are frequent and equally disastrous.

Once again, unlike other natural disasters, human beings play an important role in the genesis as well as spread of floods. Indiscriminate deforestation, unscientific agricultural practices, disturbances along the natural drainage channels and colonisation of flood-plains and river-beds are some of the human activities that play an important role in increasing the intensity, magnitude and gravity of floods.

**Figure 7.5 : Brahmaputra During Flood**

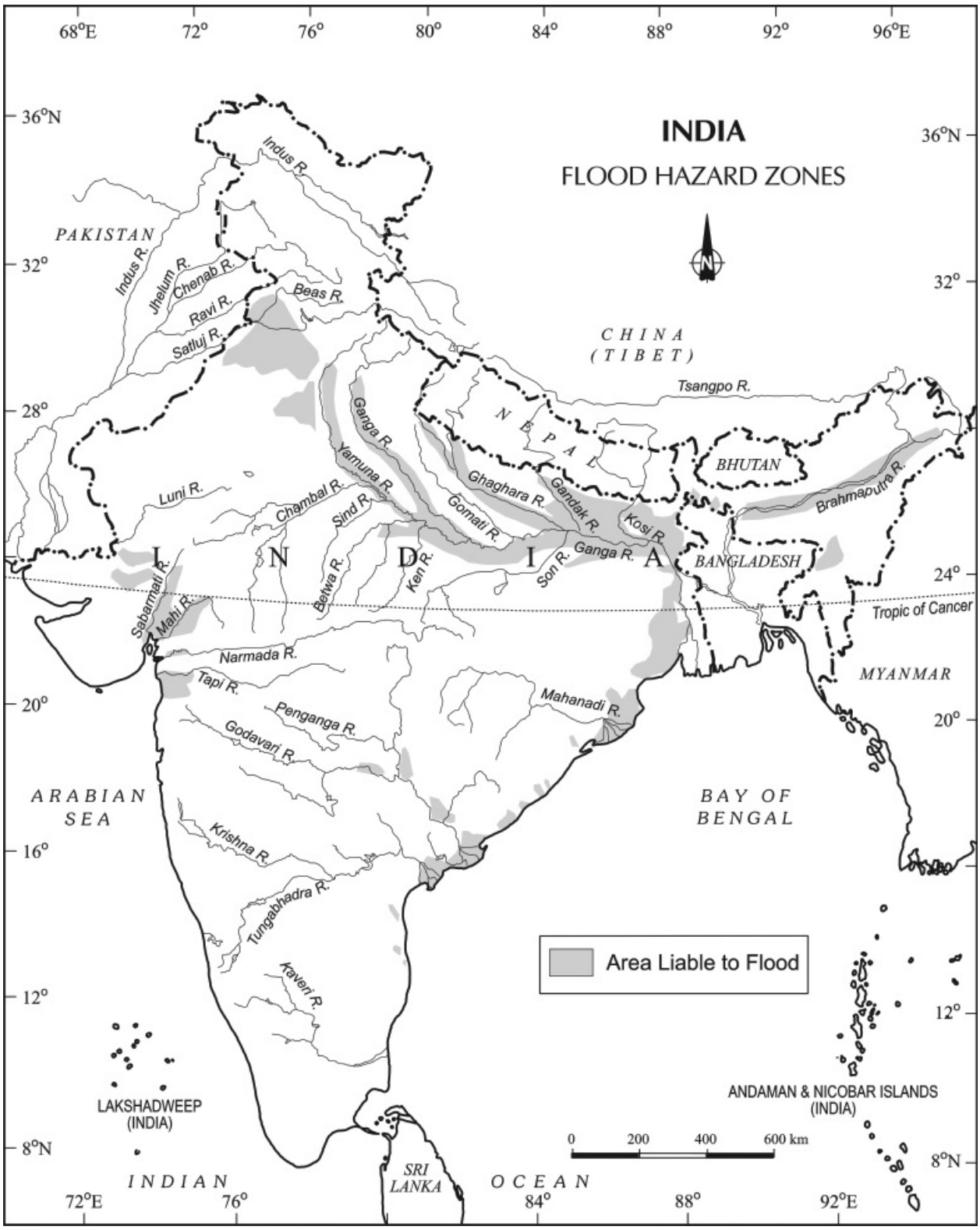


**Figure 7.6 : Flood Hazard Zones**

Various states of India face heavy loss of lives and property due to recurrent floods. *Rashtriya Barh Ayog* (National Flood Commission) identified 40 million hectares of land as flood-prone in India. The Figure 7.6 shows the flood-affected areas in India. Assam, West Bengal and Bihar are among the high flood-prone states of India. Apart from these, most of the rivers in the northern states like Punjab and Uttar Pradesh, are also vulnerable to occasional floods. It has been noticed that states like Rajasthan, Gujarat, Haryana and Punjab are also getting inundated in recent decades due to flash floods. This is partly because of the pattern of the monsoon and partly because of blocking of most of the streams and river channels by human activities. Sometimes, Tamil Nadu experiences flooding during November-January due to the retreating monsoon.

### *Consequence and Control of Floods*

Frequent inundation of agricultural land and human settlement, particularly in Assam, West Bengal, Bihar and Eastern Uttar Pradesh (flooding rivers), coastal areas of Orissa, Andhra Pradesh, Tamil Nadu and Gujarat (cyclone) and Punjab, Rajasthan, Northern Gujarat and Haryana (flash floods) have serious consequences on the national economy and society. Floods do not only destroy valuable crops every year but these also damage physical infrastructure such as roads, rails, bridges and human settlements. Millions of people are rendered homeless and are also washed down along with their cattle in the floods. Spread of diseases like cholera, gastro-enteritis, hepatitis and other water-borne diseases spread in the flood-affected areas. However, floods also make a few positive contributions. Every year, floods deposit fertile silt over agricultural fields which is good for the crops. Majuli (Assam), the largest riverine island in the world, is the best example of good paddy crops after the annual floods in Brahmaputra. But these are insignificant benefits in comparison to the grave losses.

The Government of India as well as the state governments are well aware of the menace created by floods every year. How do these governments generally respond to the floods? Construction of flood protection embankments in the flood-prone areas, construction of dams, afforestation and discouraging major construction activities in the upper reaches of most of the flood-creating rivers, etc. are some steps that need to be taken up on urgent basis. Removal of human encroachment from the river channels and depopulating the flood plains can be the other steps. This is particularly true in western and northern parts of the country which experience *flash-floods*. Cyclone centres may provide relief in coastal areas which are hit by a storm surge.

## Droughts

The term 'drought' is applied to an extended period when there is a shortage of water availability due to inadequate precipitation, excessive rate of evaporation and over-utilisation of water from the reservoirs and other storages, including the ground water.

> Drought is a complex phenomenon as it involves elements of meteorology like precipitation, evaporation, evapo-transpiration, ground water, soil moisture, storage and surface run-off, agricultural practices, particularly the types of crops grown, socio-economic practices and ecological conditions.

### *Types of Droughts*

*Meteorological Drought* : It is a situation when there is a prolonged period of inadequate rainfall marked with mal-distribution of the same over time and space.

*Agricultural Drought* : It is also known as soil moisture drought, characterised by low soil moisture that is necessary to support the crops, thereby resulting in crop failures. Moreover, if an area has more than 30 per cent of its gross cropped area under irrigation, the area is excluded from the drought-prone category.

*Hydrological Drought* : It results when the availability of water in different storages and reservoirs like aquifers, lakes, reservoirs, etc. falls below what the precipitation can replenish.

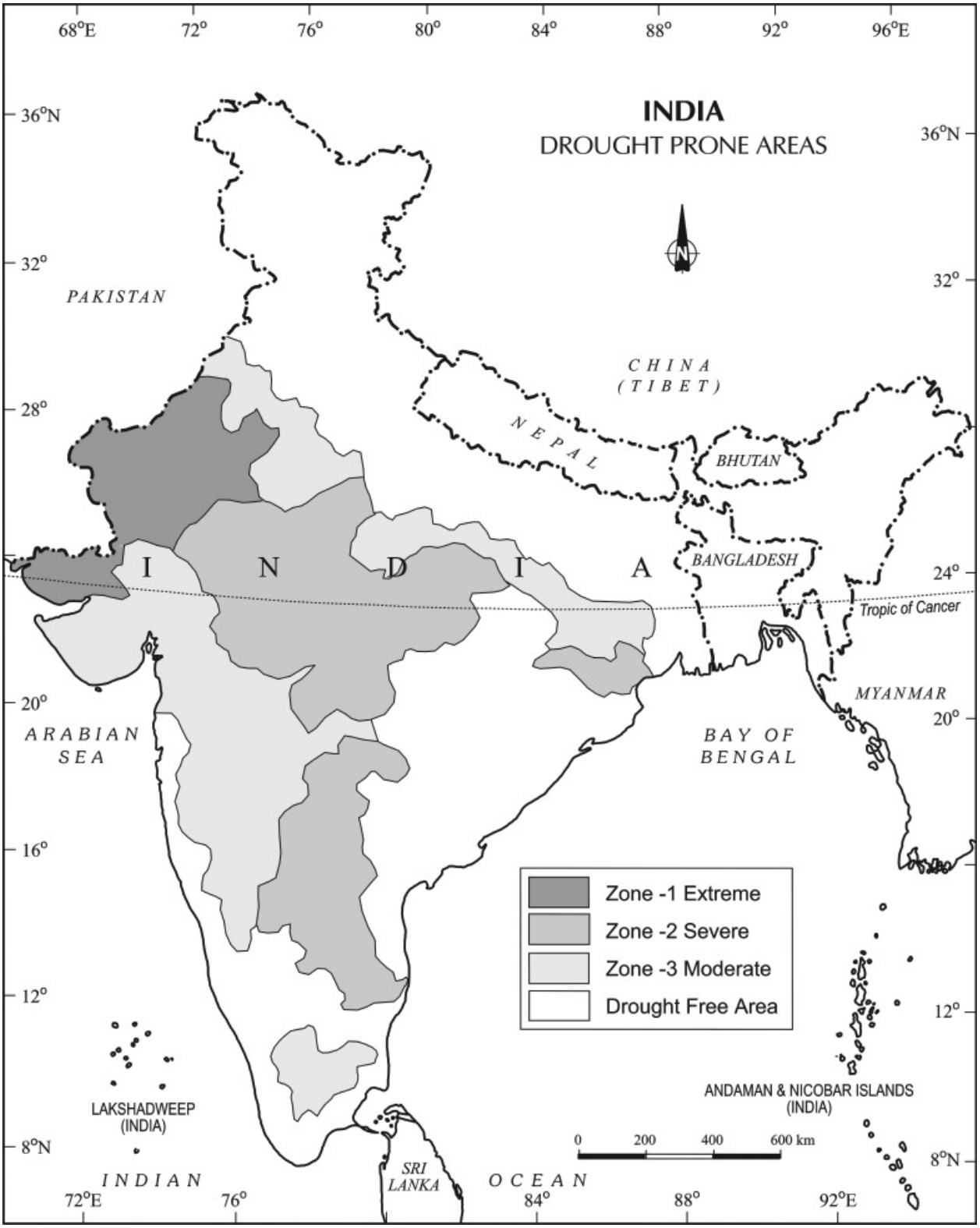


**Figure 7.8 : Drought Prone Areas**

**Figure 7.7 : Drought**

*Ecological Drought :* When the productivity of a natural ecosystem fails due to shortage of water and as a consequence of ecological distress, damages are induced in the ecosystem.

Various parts of India experience these droughts recurrently which result in some serious socio-economic and ecological problems.

*Drought Prone Areas in India*

Indian agriculture has been heavily dependent on the monsoon rainfall. Droughts and floods are the two accompanying features of Indian climate. According to some estimates, nearly 19 per cent of the total geographical area of the country and 12 per cent of its total population suffer due to drought every year. About 30 per cent of the country's total area is identified as drought prone affecting around 50 million people. It is a common experience that while some parts of the country reel under floods, there are regions that face severe drought during the same period. Moreover, it is also a common sight to witness that one region suffers due to floods in one season and experiences drought in the other. This is mainly because of the large-scale variations and unpredictability in the behaviour of the monsoon in India. Thus, droughts are widespread and common phenomena in most parts of the country, but these are most recurrent and severe in some and not so in others. On the basis of severity of droughts, India can be divided into the following regions:

*Extreme Drought Affected Areas :* It is evident from the Figure 7.8 that most parts of Rajasthan, particularly areas to the west of the Aravali hills, i.e. Marusthali and Kachchh regions of Gujarat fall in this category. Included here are also the districts like Jaisalmer and Barmer from the Indian desert that receive less that 90 mm average annual rainfall.

*Severe Drought Prone Area :* Parts of eastern Rajasthan, most parts of Madhya Pradesh, eastern parts of Maharashtra, interior parts of Andhra Pradesh and Karnataka Plateau, northern parts of interior Tamil Nadu and southern parts of Jharkhand and interior Orissa are included in this category.

*Moderate Drought Affected Area :* Northern parts of Rajasthan, Haryana, southern districts of Uttar Pradesh, the remaining parts of Gujarat, Maharashtra except Konkan, Jharkhand and Coimbatore plateau of Tamil Nadu and interior Karnataka are included in this category. The remaining parts of India can be considered either free or less prone to the drought.

*Consequences of Drought*

Droughts have cascading effects on various other aspects of environment and society. Crop failure leading to scarcity of food grains *(akal)*, fodder *(trinkal)*, inadequate rainfall, resulting in shortage of water *(jalkal)*, and often shortage in all the three *(trikal)* is most devastating. Large-scale death of cattle and other animals, migration of humans and livestock are the most common sight to be seen in the drought-affected areas. Scarcity of water compels people to consume contaminated water resulting in spread of many waterborne diseases like gastro-enteritis, cholera, hepatitis, etc.

Droughts have both immediate as well as long-term disastrous consequences on the social and physical environments. Consequently, planning for drought has to take both aspects into consideration. Provision for the distribution of safe drinking water, medicines for the victims and availability of fodder and water for the cattle and shifting of the people and their livestock

to safer places, etc. are some steps that need to be taken immediately. Identification of ground water potential in the form of aquifers, transfer of river water from the surplus to the deficit areas, and particularly planning for inter-linking of rivers and construction of reservoirs and dams, etc. should be given a serious thought. Remote sensing and satellite imageries can be useful in identifying the possible river-basins that can be inter-linked and in identifying the ground water potential.

Dissemination of knowledge about drought-resistant crops and proper training to practise the same can be some of the long-term measures that will be helpful in drought-mitigation. Rainwater harvesting can also be an effective method in minimising the effects of drought.

> Observe the methods adopted for roof-top rainwater harvesting in your locality and suggest measures to make it more effective.

## Landslides

Have you ever read about the blocking of roads to Srinagar or disruption of rail services by stones falling on the Konkan Railway track? It happens due to landslide, which is the rapid sliding of large mass of bedrocks. Disasters due to landslides, are in general, far less dramatic than due to earthquakes, volcanic eruptions, tsunamis and cyclones but their impact on the natural environment and national economy is in no way less severe. Unlike other disasters that are sudden, unpredictable and are largely controlled by macro or regional factors, landslides are largely controlled by highly localised factors. Hence, gathering information and monitoring the possibilities of landslide is not only difficult but also immensely cost-intensive.

It is always difficult to define in a precise statement and generalise the occurrence and behaviour of a landslide. However, on the basis of past experiences, frequency and certain causal relationships with the controlling factors like geology, geomorphic agents, slope, land-use, vegetation cover and human activities, India has been divided into a number of zones.

*Landslide Vulnerability Zones*

*Very High Vulnerability Zone* : Highly unstable, relatively young mountainous areas in the Himalayas and Andaman and Nicobar, high rainfall regions with steep slopes in the Western Ghats and Nilgiris, the north-eastern regions, along with areas that experience frequent ground-shaking due to earthquakes, etc. and areas of intense human activities, particularly those related to construction of roads, dams, etc. are included in this zone.

*High Vulnerability Zone :* Areas that have almost similar conditions to those included in the very high vulnerability zone are also included in this category. The only difference between these two is the combination, intensity and frequency of the controlling factors. All the Himalayan states and the states from the north-eastern regions except the plains of Assam are included in the high vulnerability zones.

*Moderate to Low Vulnerability Zone :* Areas that receive less precipitation such as Trans-Himalayan areas of Ladakh and Spiti (Himachal Pradesh), undulated yet stable relief and low precipitation areas in the Aravali, rain shadow areas in the Western and Eastern Ghats and Deccan plateau also experience occasional landslides. Landslides due to mining and

**Figure 7.9 : Landslide**

subsidence are most common in states like Jharkhand, Orissa, Chhattisgarh, Madhya Pradesh, Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu, Goa and Kerala.

*Other Areas :* The remaining parts of India, particularly states like Rajasthan, Haryana, Uttar Pradesh, Bihar, West Bengal (except district Darjiling), Assam (except district Karbi Anglong) and Coastal regions of the southern States are safe as far as landslides are concerned.

*Consequences of Landslides*

Landslides have relatively small and localised area of direct influence, but roadblock, destruction of railway lines and channel-blocking due to rock-falls have far-reaching consequences. Diversion of river courses due to landslides can also lead to flood and loss of life and property. It also makes spatial interaction difficult, risky as well as a costly affair, which, in turn, adversely affects the developmental activities in these areas.

*Mitigation*

It is always advisable to adopt area-specific measures to deal with landslides. Restriction on the construction and other developmental activities such as roads and dams, limiting agriculture to valleys and areas with moderate slopes, and control on the development of large settlements in the high vulnerability zones, should be enforced. This should be supplemented by some positive actions like promoting large-scale afforestation programmes and construction of bunds to reduce the flow of water. Terrace farming should be encouraged in the northeastern hill states where *Jhumming* (Slash and Burn/Shifting Cultivation) is still prevalent.

## Disaster Management

Disasters due to cyclones, unlike the ones caused by earthquakes, tsunamis and volcanic eruptions are more predictable in terms of the time and place of their occurrences. Moreover, with the help of development of techniques to monitor the behaviour of cyclones, their intensity, direction and magnitude, it has become possible to manage the cyclonic hazard to some extent. Construction of cyclone-shelters, embankments, dykes, reservoirs and afforestation to reduce the speed of the winds are some of the steps that can help in minimising the damages. However, increase in the loss of life and property in countries like India, Bangladesh, Myanmar, etc. in successive storms is largely due to high vulnerability of their population residing in the coastal areas.

**Disaster Management Bill, 2005**

The Disaster Management Bill, 2005, defines disaster as a catastrophe, mishap, calamity or grave occurrence affecting any area, arising from natural or man-made causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, environment, and is of such nature or magnitude as to be beyond the coping capacity of the community of the affected area.

## Conclusion

On the basis of the above discussion, it can be concluded that disasters can be natural or the results of human activities, and all hazards need not turn into disasters since it is difficult to eliminate disasters, particularly natural disasters. Then the next best option is mitigation and preparedness. There are three stages involved in disaster mitigation and management:

(i) Pre-disaster management involves generating data and information about the disasters, preparing vulnerability zoning maps and spreading awareness among the people about these. Apart from these, disaster planning, preparedness and preventive measures are other steps that need to be taken in the vulnerable areas.

(ii) During disasters, rescue and relief operations such as evacuation, construction of shelters and relief camps, supplying of water, food, clothing and medical aids etc. should be done on an emergency basis.

(iii) Post-disaster operations should involve rehabilitation and recovery of victims. It

should also concentrate on capacity-building in order to cope up with future disasters, if any.

These measures have special significance to a country like India, which has about two-third of its geographical area and equal proportion of its population, vulnerable to disasters. Introduction of the Disaster Management Bill, 2005 and establishment of National Institute of Disaster Management are some examples of the positive steps taken by the Government of India.

## EXERCISES

1. Choose the right answer from the four alternatives given below.
   (i) Which one of the following states of India experiences floods frequently?
   (a) Bihar (c) Assam
   (b) West Bengal (d) Uttar Pradesh
   (ii) In which one of the following districts of Uttaranchal did Malpa Landslide disaster take place?
   (a) Bageshwar (c) Almora
   (b) Champawat (d) Pithoragarh
   (iii) Which one of the following states receives floods in the winter months?
   (a) Assam (c) Kerala
   (b) West Bengal (d) Tamil Nadu
   (iv) In which of the following rivers is the Majuli River Island situated?
   (a) Ganga (c) Godavari
   (b) Brahmaputra (d) Indus
   (v) Under which type of natural hazards do blizzards come?
   (a) Atmospheric (c) Terrestrial
   (b) Aquatic (d) Biological
2. Answer the following questions in less than 30 words.
   (i) When can a hazard become a disaster?
   (ii) Why are there more earthquakes in the Himalayas and in the north-eastern region of India?
   (iii) What are the basic requirements for the formation of a cyclone?
   (vi) How are the floods in Eastern India different from the ones in Western India?
   (v) Why are there more droughts in Central and Western India?
3. Answer the following questions in not more than 125 words.
   (i) Identify the Landslide-prone regions of India and suggest some measures to mitigate the disasters caused by these.
   (ii) What is vulnerability? Divide India into natural disaster vulnerability zones based on droughts and suggest some mitigation measures.
   (v) When can developmental activities become the cause of disasters?

**Project/Activity**

Prepare a project report on any one of the topics given below.

(i) Malpa Landslide
(ii) Tsunami
(iii) Orissa and Gujarat Cyclones
(iv) Inter-linking of rivers
(v) Tehri Dam/Sardar Sarovar
(vi) Bhuj/Latur Earthquakes
(vii) Life in a delta/riverine island
(viii) Prepare a model of rooftop rainwater harvesting

## APPENDIX

### States, their Capitals, Number of Districts, Area and Population

| *Sl. No.* | *State* | *Capital* | *No. of Districts* | *Area in sq. km* | *Population* |
|---|---|---|---|---|---|
| 1. | Andhra Pradesh | Hyderabad | 23 | 2,75,060 | 7,57,27,541 |
| 2. | Arunachal Pradesh | Itanagar | 14 | 83,743 | 10,91,117 |
| 3. | Assam | Dispur | 23 | 78,438 | 2,66,38,407 |
| 4. | Bihar | Patna | 37 | 94,163 | 8,28,78,796 |
| 5. | Chhattisgarh | Raipur | 16 | 1,36,034 | 2,07,95,956 |
| 6. | Goa | Panji | 02 | 3,702 | 13,43,998 |
| 7. | Gujarat | Gandhi Nagar | 25 | 1,96,024 | 5,05,96,992 |
| 8. | Haryana | Chandigarh | 19 | 44,212 | 2,10,82,982 |
| 9. | Himachal Pradesh | Shimla | 12 | 55,673 | 60,77,248 |
| 10. | Jammu and Kashmir | Srinagar | 14 | 2,22,236 | 1,00,69,917 |
| 11. | Jharkhand | Ranchi | 18 | 79,714 | 2,69,09,428 |
| 12. | Karnataka | Bangalore | 27 | 1,91,791 | 5,27,83,958 |
| 13. | Kerala | Tiruvanantapuram | 14 | 38,863 | 3,18,38,619 |
| 14. | Madhya Pradesh | Bhopal | 45 | 3,08,000 | 6,03,85,118 |
| 15. | Maharashtra | Mumbai | 35 | 3,07,713 | 9,67,52,247 |
| 16. | Manipur | Imphal | 9 | 22,327 | 23,88,634 |
| 17. | Meghalaya | Shillong | 7 | 22,327 | 23,06,069 |
| 18. | Mizoram | Aizawl | 8 | 21,081 | 8,91,058 |
| 19. | Nagaland | Kohima | 8 | 16,579 | 19,88,636 |
| 20. | Orissa | Bhubaneshwar | 30 | 1,55,707 | 3,67,06,920 |
| 21. | Punjab | Chandigarh | 17 | 50,362 | 2,42,89,296 |
| 22. | Rajasthan | Jaipur | 32 | 3,42,239 | 5,64,73,122 |
| 23. | Sikkim | Gangtok | 04 | 7,096 | 5,40,493 |
| 24. | Tamil Nadu | Chennai | 29 | 1,30,058 | 6,21,10,839 |
| 25. | Tripura | Agartala | 04 | 10,49,169 | 31,91,168 |
| 26. | Uttaranchal | Dehra Dun | 13 | 53,484 | 84,79,562 |
| 27. | Uttar Pradesh | Lucknow | 70 | 2,38,566 | 16,60,52,859 |
| 28. | West Bengal | Kolkata | 18 | 88,752 | 8,02,21,171 |

**APPENDIX**

## UNION TERRITORIES, THEIR CAPITALS, AREA AND POPULATION

| *Sl. No.* | *Union Territories* | *Capital* | *Area* | *Population* |
|---|---|---|---|---|
| 1. | Andaman and Nicobar Islands | Port Blair | 8,249 | 3,56,152 |
| 2. | Chandigarh | Chandigarh | 114 | 9,00,914 |
| 3. | Dadra and Nagar Haveli | Silvassa | 491 | 2,20,490 |
| 4. | Daman and Diu | Daman | 112 | 1,58,204 |
| 5. | NCT Delhi | * Delhi | 1483 | 1,38,00000 |
| 6. | Lakshadweep | Kavaratti | 32 | 60,595 |
| 7. | Pondicherry | **Pondicherry | 492 | 9,73,829 |

*Note* : * Delhi has the status of National Capital Territory with a Legislative Assembly
** Pondicherry also has a Legislative Assembly

*Source* : *India-2005, A Reference Annual*, Publications Division, Ministry of Information and Broadcasting

**APPENDIX**

## IMPORTANT RIVER BASINS

| *Rivers* | *Length (in km)* | *Catchment Area (sq. km) Potential Discharge in the River ($km^3$)* | *Average Annual Flow Excluding the Groundwater ($km^3$)* | *Estimated Utilisable* |
|---|---|---|---|---|
| Indus (in India) | 1,114 | 321,289 | 73.31 | 46.0 |
| Ganga (in India) | 2,525 | 861,452 | 525.02 | 250.0 |
| Brahmaputra (in India) | 916 | 194,413 | | |
| Barak and others Flowing to Meghna | | 41,723 | | |
| Sabarmati | 371 | 21,674 | 3.81 | 1.99 |
| Mahi | 585 | 34,842 | 11.02 | 3.10 |
| Narmada | 1,312 | 98,796 | 45.64 | 34.30 |
| Tapti | 724 | 65,145 | 14.88 | 14.50 |
| Brahmani and Baitarni | 799+365 | 39,033+12,789 | 28.48 | 18.30 |
| Mahanadi | 851 | 141,589 | 66.88 | 49.99 |
| Godavari | 1,465 | 312,812 | 110.54 | 76.30 |
| Krishna | 1,401 | 258,948 | 78.12 | 58.00 |
| Penner | 597 | 55,213 | 6.32 | 6.86 |
| Kaveri | 800 | 81,155 | 21.36 | 19.00 |
| Suvarnarekha | 395 | 19,296 | 12.37 | 6.81 |
| **Total** | | **2,528,084** | **1,869.35** | **690.31** |
| { Medium river basins flowing towards the east and west directions | | 248,505 | 255.02 | 59.03 |
| **Total** | | **2,776,589** | **2,124.37** | **749.34** |

**APPENDIX**


## STATE/UNION TERRITORY WISE FOREST COVER

| *State/UT* | *Geographic Area* | *Forest Cover* | | | |
|---|---|---|---|---|---|
| | | *Dense* | *Open* | *Total* | *Percent* |
| Andhra Pradesh | 275,069 | 25,827 | 18,810 | 44,637 | 16.23 |
| Arunachal Pradesh | 83,743 | 53,932 | 14,113 | 68,045 | 81.25 |
| Assam | 78,438 | 15,830 | 11,884 | 27,714 | 35.33 |
| Bihar | 94,163 | 3,372 | 2,348 | 5,720 | 6.07 |
| Chhattisgarh | 135,191 | 37,880 | 18,568 | 56,448 | 41.75 |
| Delhi | 1,483 | 38 | 73 | 111 | 7.51 |
| Goa | 3,702 | 1,785 | 310 | 2,095 | 56.59 |
| Gujarat | 196,022 | 8,673 | 6,479 | 15,152 | 7.73 |
| Haryana | 44,212 | 1,139 | 615 | 1,754 | 3.97 |
| Himachal Pradesh | 55,673 | 10,429 | 3,931 | 14,360 | 25.79 |
| Jammu & Kashmir | 222,236 | 11,848 | 9,389 | 21,237 | 9.56 |
| Jharkhand | 79,714 | 11,787 | 10,850 | 22,637 | 28.40 |
| Karnataka | 191,791 | 26,156 | 10,835 | 36,991 | 19.29 |
| Kerala | 38,863 | 11,772 | 3,788 | 15,560 | 40.04 |
| Madhya Pradesh | 308,245 | 44,384 | 32,881 | 77,265 | 25.07 |
| Maharashtra | 307,713 | 30,894 | 16,588 | 47,482 | 15.43 |
| Manipur | 22,327 | 5,710 | 11,216 | 16,926 | 75.81 |
| Meghalaya | 22,429 | 5,681 | 9,903 | 15,584 | 69.48 |
| Mizoram | 21,081 | 8,936 | 8,558 | 17,494 | 82.98 |
| Nagaland | 16,579 | 5,393 | 7,952 | 13,345 | 80.49 |
| Orissa | 155,707 | 27,972 | 20,866 | 48,838 | 31.36 |
| Punjab | 50,362 | 1,549 | 883 | 2,432 | 4.83 |
| Rajasthan | 342,239 | 6,322 | 10,045 | 16,367 | 4.78 |
| Sikkim | 7,096 | 2,391 | 802 | 3,193 | 45.00 |
| Tamilnadu | 130,058 | 12,499 | 8,983 | 21,482 | 16.52 |
| Tripura | 10,486 | 3,463 | 3,602 | 7,065 | 67.38 |
| Uttar Pradesh | 240,928 | 8,965 | 4,781 | 13,746 | 5.71 |
| Uttaranchal | 53,483 | 19,023 | 4,915 | 23,938 | 44.76 |
| West Bengal | 88,752 | 6,346 | 4,347 | 10,693 | 12.05 |
| Andaman & Nicobar | 8,249 | 6,593 | 337 | 6,930 | 84.01 |
| Chandigarh | 114 | 5 | 4 | 9 | 7.51 |
| Dadra & Nagar Haveli | 491 | 151 | 68 | 219 | 44.60 |
| Daman & Diu | 112 | 2 | 4 | 6 | 5.53 |
| Lakshadweep | 32 | 27 | 0 | 27 | 85.91 |
| Pondicherry | 480 | 35 | 1 | 36 | 7.45 |
| **Total** | **3,287,263** | **416,809** | **258,729** | **675,538** | **20.55** |

*Source : State Forest Report, 2001*

**APPENDIX**

## NATIONAL PARKS OF INDIA

| *State/UT* | *Area of State* | *National Parks (km²)* | *Area Covered (km²)* | *% of State Area* |
|---|---|---|---|---|
| Andhra Pradesh | 275,068 | 4 | 373.23 | 0.14 |
| Arunachal Pradesh | 83,743 | 2 | 2290.82 | 2.74 |
| Assam | 78,438 | 5 | 1968.60 | 2.51 |
| Bihar | 94,163 | 1 | 335.65 | 0.36 |
| Chhattisgarh | 135,194 | 3 | 2929.50 | 2.17 |
| Goa | 3,702 | 1 | 107.00 | 2.89 |
| Gujarat | 196,024 | 4 | 480.11 | 0.24 |
| Haryana | 442,122 | 2 | 117.13 | 0.26 |
| Himachal Pradesh | 55,673 | 2 | 1429.40 | 2.57 |
| Jammu and Kashmir | 222,235 | 4 | 4680.25 | 2.11 |
| Jharkhand | 79,714 | 1 | 231.67 | 0.29 |
| Karnataka | 191,791 | 5 | 2435.14 | 1.27 |
| Kerala | 38,863 | 4 | 549.34 | 1.41 |
| Madhya Pradesh | 308,252 | 9 | 3656.36 | 1.19 |
| Maharashtra | 307,690 | 5 | 955.93 | 0.31 |
| Manipur | 22,327 | 1 | 40.00 | 0.18 |
| Meghalaya | 22,429 | 2 | 267.48 | 1.19 |
| Mizoram | 21,081 | 2 | 250.00 | 1.19 |
| Nagaland | 16,579 | 1 | 202.02 | 1.22 |
| Orissa | 155,707 | 2 | 990.70 | 0.64 |
| Punjab | 50,362 | 0 | 0.00 | 0.00 |
| Rajasthan | 342,239 | 5 | 4122.33 | 1.20 |
| Sikkim | 7,096 | 1 | 1784.00 | 25.14 |
| Tamil Nadu | 130,058 | 5 | 307.84 | 0.24 |
| Tripura | 10,486 | 0 | 0.00 | 0.00 |
| Uttar Pradesh | 240,926 | 1 | 490.00 | 0.20 |
| Uttaranchal | 53,485 | 6 | 4725.00 | 7.62 |
| West Bengal | 88,752 | 5 | 1693.25 | 1.91 |
| **Union Territories** | | | | |
| Andaman and Nicobar | 8,249 | 9 | 1156.91 | 14.02 |
| Chandigarh | 114 | 0 | 0.00 | 0.00 |
| Dadra and Nagar Haveli | 491 | 0 | 0.00 | 0.00 |
| Daman & Diu | 112 | 0 | 0.00 | 0.00 |
| Delhi | 1,483 | 0 | 0.00 | 0.00 |
| Lakshadweep | 32 | 0 | 0.00 | 0.00 |
| Pondicherry | 493 | 0 | 0.00 | 0.00 |
| India | 3,287,263 | 92 | 38,569.66 | 1.17 |

*Source: State Forest Report, 2001*

# GLOSSARY

**Alluvial Plain** : A level tract of land made up of alluvium or fine rock material brought down by a river.

**Archipelago** : A group of islands that lie in fairly close proximity.

**Arid** : Denoting any climate or region in which the rainfall is insufficient or barely sufficient to support vegetation.

**Backwater** : A stretch of water that has become bypassed by the main flow of a stream, although still joined to it. It has a very low rate of flow.

**Bedrock** : The solid rock lying beneath soil and weathered material.

**Biosphere Reserve** : These are multi-purpose protected areas, where every plant and animal size is to be protected in its natural habitat. Its major objectives are : (i) to conserve and maintain diversity and integrity of the natural heritage in its full form, i.e. physical environment, the flora and the fauna; (ii) to promote research on ecological conservation and other aspects of environment at preservation; (iii) to provide facilities for education, awareness and explaining.

**Bunding** : The practice of constructing embankments of earth or stone for conserving water and soil to increase crop production.

**Calcareous** : Composed of or containing a high proportion of calcium carbonate.

**Catchment Area** : The area drained by a major river and its tributaries.

**Climate** : The average weather conditions of a sizeable area of the earth's surface over a period of time (usually spread over a span of at least 30 years).

**Coast** : The boundary between land and sea. It includes the strip of land that borders the sea shore.

**Coastal Plain** : It is a flat low lying land between the coast and higher ground inland.

**Conservation** : The protection of natural environment and natural resources for the future. It includes the management of minerals, landscape, soil and forests to prevent their destruction and over exploitation.

**Coral** : It is a small calcium secreting marine polyp that occurs in colonies, mainly in warm shallow sea water. It forms the coral reefs.

**Depression** : In meteorology; it denotes an area of relatively low atmospheric pressure, which is found mainly in temperate regions. It is also used as synonym for temperate cyclones.

**Estuary** : The tidal mouth of a river where fresh and saline water get mixed.

**Fauna** : The animal life of a given area or time.

**Fold** : A bend in rock strata resulting from compression of an area of the earth's crust.

**Glacier** : A mass of snow and ice that moves slowly away from its place of accumulation carving gradually a broad and steepsided valley on its way.

**Gneiss** : A coarse grained metamorphic rock with a banded structure. It is formed by the large scale application of heat and pressure associated with mountain building and volcanic activity.

**Gorge** : A deep valley with steep and rocky side walls.

**Gully Erosion** : It is the erosion of the soil and rock by the concentration of runoff into gullies.

**Humus** : The dead organic content of the soil.

**Island** : A mass of land that is surrounded by water and is smaller than a continent.

**Jet Stream** : A very strong and steady westerly wind blowing just below the tropopause.

**Lake** : A body of water that lives in a hollow in the earth's surface and is entirely surrounded by land.

**Landslide** : A form of mass movement in which rock and debris moves rapidly downslope under the influence of gravity as a result of failure along a shear plane.
**Meander** : A pronounced curve or loop in the course of a river channel.

**Monsoon** : A complete reversal of winds over a large area leading to a change of seasons.

**National Park** : A National park is an area which is strictly reserved for the protection of the wildlife and where activities such as forestry, grazing or cultivation are not allowed.

**Pass** : A route through a mountain range which follows the line of a col or a gap.

**Peninsula** : A piece of land jutting out into the sea.

**Plain** : An extensive area of flat or gently undulating land.

**Plateau** : An extensive elevated area of relatively flat land.

**Playa** : The low flat central area of a basin of inland drainage. Playas occur in areas of low rainfall.

**Protected Forest** : An area notified under the provisions of Indian Forest Act or the State Forest Acts having limited degree of protection. In Protected Forests, all activities are permitted unless prohibited.

**Rapids** : A stretch of swift flowing water where a river bed suddenly becomes steeper due to the presence of hard rocks.

**Reserved Forest** : An area notified under the provisions of Indian Forest Act or the State Forest Acts having full degree of protection. In Reserved Forests, all activities are prohibited unless permitted.

**Sanctuary** : A sanctuary is an area, which is reserved for the conservation of animals only and operations such as harvesting of timber, collection of minor forest products are allowed so long as they do not affect the animals adversely.

**Soil Profile** : It is the vertical section of soil from the ground surface to the parent rock.

**Subcontinent** : A big geographical unit which stands out distinctly from the rest of the continent.

**Terai** : A belt of marshy ground and vegetation on the lower parts of the alluvial fans.

**Tectonic** : Forces originating within the earth and responsible for bringing widespread changes in the landform features.

**Unclassed Forest** : An area recorded as forest but not included in reserved or protected forest category. Ownership status of such forests varies from state to state.