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India Physical Environment

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UNIT I

CHAPTER

1

INDIA– LOCATION

- 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.

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)

- Southern boundary extends upto 6°45' N latitude in the Bay of Bengal.
- 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.
- distance between two longitudes decreases towards the poles whereas the distance between two latitudes remains the same everywhere.
- 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.
- 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
- 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.

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.

SIZE

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.

Rajeshra

- 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.
- contributed towards the evolving of a unique regional identity of the Indian subcontinent.
- **Peninsular part of India extends towards the Indian Ocean.**
- 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.

INDIA AND ITS NEIGHBOURS

- 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.
- **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.**

UNIT II-PHYSIOGRAPHY

CHAPTER 2 STRUCTURE AND PHYSIOGRAPH

- 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.
- **the Indian plate was to the south of the equator millions of years ago**
- 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 south eastern direction and the Indian plate to the north.
- This northward movement of the Indian plate is still continuing and it has significant consequences on the physical environment of the Indian subcontinent.
- 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 Peninsular Block
- (ii) The Himalayas and other Peninsular Mountains
- (iii) Indo-Ganga-Brahmaputra Plain.

THE PENINSULAR BLOCK

- The northern boundary of the Peninsular Block - 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.
- 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 by a great complex of very ancient gneisses and granites, which constitutes a major part of it.
- 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.

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

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

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 1,000-2,000m.
- 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 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:

- (1) The Northern and North- eastern Mountains
- (2) The Northern Plain
- (3) The Peninsular Plateau
- (4) The Indian Desert
- (5) The Coastal Plains
- (6) 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 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 north south 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.
- the Himalayas stand almost like a strong and long wall between the Indian subcontinent and the Central and East Asian countries.
- Himalayas are not only the physical barrier, they are also a climatic, drainage and cultural divide.

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.

i. Kashmir or Northwestern Himalayas

- 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.
- 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

ii. The Himachal and Uttarakhand Himalayas

- lies approximately between the Ravi in the west and the Kali (a tributary of Ghaghara) in the east.
- 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 Dhauladhar in Himachal Pradesh and Nagtibhain Uttarakhand) and the Shiwalik range from the North to the South.
- 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 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

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.
- 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.

iii. The Darjiling and Sikkim Himalayas

- Bordered 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.

- 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.

iv. **The Arunachal Himalayas**

- 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.
- the Bhramaputa 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.

v. **The Eastern Hills and Mountains**

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

Jhum cultivation.

- 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.

The Northern Plains

- Formed by the alluvial deposits brought by the rivers – the Indus, the Ganga and the Brahmaputra.
- extend approximately 3,200 km from the east to the west.
- average width of these plains varies between 150-300 km.
- maximum depth of alluvium deposits varies between 1,000-2,000m.
- 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.
- 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 600-900m 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.
- 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.
- 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 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 southwest 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.
- 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

- 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 Dwarka 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.

- western coast may be divided into following divisions –1- the Kachchh and Kathiawar coast in Gujarat, 2- Konkan coast in Maharashtra, 3- Goan coast and Malabar coast in Karnataka and Kerala respectively.
- 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.

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.

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 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 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.
- 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 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 Cannanore Island.
- The Islands of this archipelago have storm beaches consisting of unconsolidated pebbles, shingles, cobbles and boulders on the eastern seaboard

3.DRAINAGE SYSTEM

- flow of water through well-defined channels is known as ‘drainage’ and the network of such channels is called a ‘drainage system’.
- 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.
- perennial (always with water)
- ephemeral (water during rainy season, and dry, otherwise)
- 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 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.
- difference between a river basin and a watershed- Watersheds are small in area while the basins cover larger areas
- The drainage pattern resembling the branches of a tree is known as “dendritic” the examples of which are the rivers of northern plain.
- 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.
- 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’.
- When the rivers discharge their waters from all directions in a lake or depression, the pattern is known as ‘centripetal’.
- the basis of discharge of water (orientations to the sea), it may be grouped into:
1-the Arabian Sea drainage; (ii) the Bay of Bengal drainage.
- They are separated from each other through the Delhi ridge, the Aravalis and the Sahyadris .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.
 - (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
- 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

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. 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.
- the course of these rivers is highly tortuous, but over the plains they display a strong meandering tendency and shift their courses frequently.

River Kosi, also known 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.
- 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 Indus System

- 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 total length of 2,880 km (in India 1,114 km).
- 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.
- enters into Pakistan near Chillar in the Dardistan region
- 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. 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.
- 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

- 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 Uttarakhand. Here, it is known as the Bhagirathi.

- 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 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 Uttarakhand (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 Mahananda. 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).
- 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 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 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.
- 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.
- 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 and Dhansari (South) 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

- older than the Himalayan one.
- Evident from the broad, largely-graded shallow valleys, and 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:

- 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.
- 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

- The Mahanadi rises near Sihawa in Raipur district of Chhattisgarh and runs through Odisha 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 Odisha.
- 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, Odisha 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 ,...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.

Sl. No.	Aspects	Himalayan River	Peninsular River
1.	Place of origin	Himalayan mountain covered glaciers	Peninsular plateau and central
2.	Nature of flow	Perennial; receive water from and rainfall	Seasonal; dependent on Rainfall

3.	Type of	Antecedent and consequent dendritic pattern in plains	Super imposed, rejuvenated in trellis, radial and Patterns
4.	Nature of river	Long course, flowing rugged mountains headward erosion and river In plains meandering and course	Smaller, fixed course with well-Valleys
5.	Catchment area	Very large basins	Relatively smaller basin
6.	Age of the river	Young and youthful, active deepening in the valleys	Old rivers with graded profile, almost reached their base levels

- The pattern of flow of water in a river channel over a year is known as its regime.
- 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
- 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 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.

4. CLIMATE

- 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
- 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.

FACTORS DETERMINING THE CLIMATE OF INDIA

- 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-

1- Latitude -

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.

2- 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. The Himalayas also trap the monsoon winds, forcing them to shed their moisture within the subcontinent

3- **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.**

4- **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.

5- **Altitude** : Temperature decreases with height. Due to thin air, places in the mountains are cooler than places on the plains.

6- **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

1-Distribution of air pressure and winds on the surface of the earth

2- Upper air circulation caused by factors controlling global weather and the inflow of different air masses and jet streams

3 - 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.

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.
- **Jet Stream and Upper Air Circulation** : 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. A 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.

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.

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, By this time, the westerly jet stream withdraws from the Indian region.

It is generally believed that there is a cause and effect relationship between the ITCZ and jet stream. 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** : An easterly jet stream flows over the southern part of the Peninsula in June, and has a maximum speed of 90 km per hour. 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.
- **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 Inter Tropical Convergence Zone (ITCZ)

- 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 NATURE OF INDIAN Monsoon

Onset of the Monsoon

- 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 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.
- Entry of Monsoon into India : The southwest monsoon sets in over the Kerala coast

Rain-bearing Systems and Rainfall Distribution

There seem to be two rain-bearing systems in India.

1-in the Bay of Bengal causing rainfall over the plains of north India.

2- 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.

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. 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

1-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.

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;
- (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

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.

2- 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.

3-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.
- (ii) 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

1. **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 the coastal regions, the north-south extent of isotherms parallel to the coast confirms that temperature does not decrease from north to south rather it increases from the coast to the interior.

2. **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 centered at 25°N in July. .

THE SOUTHWEST MONSOON SEASON

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, . 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 monsoons.

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.
- (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 Aravalis, causing only a scanty rainfall.

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 Khasihills, 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.
- (iii) The monsoon rainfall has a declining trend with increasing distance from the sea.
- (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.
- (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 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.
- 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.

Distribution of Rainfall

The average annual rainfall in India is about 125 cm, but it has great spatial variations

- **Areas of High Rainfall** : The highest rainfall occurs along the west coast, on the **Western Ghats**, as well as in the sub-Himalayan areas in 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 than 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 Odisha, 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.

Climatic Regions of India

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

- Tropical climates**, where **mean monthly temperature throughout the year is over 18°C.**
- 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).
- Warm temperate climates**, where **mean temperature of the coldest month is between 18°C and minus 3°C.**
- 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.**
- Ice climates**, where mean temperature **of the warmest month is under 10°C.**

5. 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.
- 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

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

- found in the **western slope of the Western Ghats, hills of the northeastern region and the Andaman and Nicobar Islands**
- found in warm and humid areas with an annual precipitation of over 200 cm and mean annual temperature above 22°C.
- 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.
- trees reach great heights upto 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, mahogany, aini, ebony, etc.**

The semi evergreen

- 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**

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, 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**

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 Odisha.**
- **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.** found in rainier areas of the Peninsula and the plains of Uttar Pradesh and Bihar.
- **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.

Tropical Thorn Forests

- 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.
- , plants remain leafless for most part of the year and give an expression of scrub vegetation.
- babool, ber, and wild date palm, khair, neem, khejri, palas, etc. Tussocky grass grows upto a height of 2 m as the under growth.

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.

The southern mountain 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.
- Two sites — Chilika Lake (Odisha) and Keoladeo National Park (Bharatpur) are protected as water-fowl habitats under the Convention of Wetlands of International Importance (Ramsar Convention).
- 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

FOREST COVER IN INDIA

- 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.
- According to India State of Forest Report 2011, the actual forest **cover in India is only 21.05 per cent.**
- 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.
- 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
(i) The region of high	> 40
(ii) The region of medium	20-40
(iii) The region of low	10-20
(iv) The region of very low	< 10

FOREST CONSERVATION

➤ 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**

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
- 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.

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

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.

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

WILDLIFE CONSERVATION IN INDIA

- **In 1972, a comprehensive Wildlife Act was enacted**, which provides the main legal framework for conservation and protection of wildlife in India. two main objectives of the-
1-to provide protection to the endangered species listed in the schedule of the Act and 2-to provide legal support to the conservation areas of the country classified as National parks, sanctuaries and closed areas
- 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 102 National parks and 515 wildlife sanctuaries
- Government of **India in collaboration with UNESCO's 'Man and Biosphere Programme' MAB**
- **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 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.** The tiger population in the country has registered an increase from 1,411 in 2006 to 1,706 in 2010.
- **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

BIOSPHERE RESERVES

- A Biosphere Reserve **is a unique and representative ecosystem of terrestrial and coastal areas which are internationally recognised within the framework of UNESCOK Man and Biosphere (MAB) Programme.** The Biosphere Reserve aims at achieving the three objectives-
- There are 14 Biosphere Reserves in India . Four Biosphere Reserves, namely (i) Nilgiri; (ii) Nanda Devi (iii) Sunderbans; and (iv) Gulf of Mannar have been recognised by the UNESCO on World Network of Biosphere Reserves.

Nilgiri Biosphere Reserve

- **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.**
- good number of endemic and endangered plants are also found in this 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 latifolia 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.

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. I

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 e.g. sea cow (*Dugong dugon*). Besides six mangrove species, endemic to Peninsular India are also endangered.

6.SOILS

- 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
- human activities also influence it to a large extent.
- Components of the soil are mineral particles, humus, water and air.
- 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.

CLASSIFICATION OF SOILS

- In ancient times, soils used to be **classified into two main groups – Urvara and Usara**, which were fertile and sterile, respectively.
 - Soil Survey of India, established in 1956, made comprehensive studies of soils in selected areas like in the Damodar Valley
 - Indian Council of Agricultural Research (ICAR) did a lot of studies on Indian soils
- 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

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

1. Alluvial soils
2. Black soils
3. Red and Yellow soils
4. Laterite soils
5. Arid soils
6. Saline soils
7. Peaty soils
8. 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.
- vary in nature from sandy loam to clay
- rich in potash but poor in phosphorous.
- 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).
- 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 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’.
- 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 ‘selfploughing’. 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
- 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 Odisha 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.
- 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.
- The laterite soils are commonly found in Karnataka, Kerala, Tamil Nadu, Madhya Pradesh and the hilly areas of Odisha and Assam.

Arid Soils

- Arid soils range from red to brown in colour.
- They are generally sandy in structure and saline in nature. , they lack moisture and humus. Nitrogen is insufficient and the phosphate 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

- 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 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.

- 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

- 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.
- soils are normally heavy and black in colour.
- 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

- , 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.
- 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.

SOIL DEGRADATION

- 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.
 - 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.

- Deforestation is one of the major causes of soil erosion. They also add humus to the soil by shedding leaves and twigs.
- 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.

Soil Conservation

- 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
- 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

7. NATURAL HAZARDS AND DISASTERS

DISASTERS- 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”

- Natural Hazards are elements of circumstances in the Natural environment that have the potential to cause harm to people or property or both.
- 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.

CLASSIFICATION OF NATURAL DISASTERS

Classification of Natural Disasters			
Atmospheric	Terrestrial	Aquatic	Biological
Blizzards	Earthquakes	Floods	Plants and Animals as

Thunderstorms	Volcanic Eruptions	Tidal Waves	colonisers (Locusts, etc.).
Lightning	Landslides	Ocean Currents	Insects infestation—fungal,
Tornadoes	Avalanches	Storm Surge	bacterial and viral diseases
Tropical Cyclone	Subsidence	Tsunami	such as bird flu, dengue,
Drought	Soil Erosion		etc.
Hailstorm			
Frost, Heat Wave or			
Loo.Cold Waves, etc.			

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.

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

NATURAL DISASTERS AND HAZARDS IN INDIA

Earthquakes

- Earthquakes are by far the most unpredictable and highly destructive of all the natural disasters.
- 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.
- 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, Uttarakhand, Sikkim, and the Darjiling and subdivision of West Bengal and all the seven states of the northeast
- 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
- National Geophysical Laboratory, Geological Survey of India, Department of Meteorology, Government of India, along with the recently formed National Institute of Disaster Management, following five earthquake zones:
 - **Very high damage risk zone**- North-east states, areas to the north of Darbhanga and Araria along the Indo-Nepal border in Bihar, Uttarakhand, Western Himachal Pradesh (around Dharamshala
 - **High damage risk zone**- 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
 - **Moderate damage risk zone**
 - **Low damage risk zone**
 - **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

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.

Table 7.3 : Effects of Earthquakes

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

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

Rajeshra

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 area

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

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.**

some initial conditions for the emergence of a tropical cyclone are:

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

- Unstable condition through the troposphere that creates local disturbances around which a cyclone develops.
- Finally, absence of strong vertical wind wedge, which disturbs the vertical transport of latent heat.

Structure of Tropical Cyclone

- The centre of the cyclone is mostly a warm and low-pressure, cloudless core known as eye of the storm.
- 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.
- 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.

- 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.

Floods

- the causes of floods are well- established. 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.

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 disastrous 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.

- **Rashtriya Barh Ayog (National Flood Commission) identified 40 million hectares of land as flood-prone 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.

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 soilmoisture 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 grosscropped area under irrigation, the area isexcluded from the drought-prone category.

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

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.

Drought Prone Areas in India

Extreme Drought Affected Areas :

- 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 than 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.

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

Landslides

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.