Gist of NCERT Geography

Download All Subject Free PDF

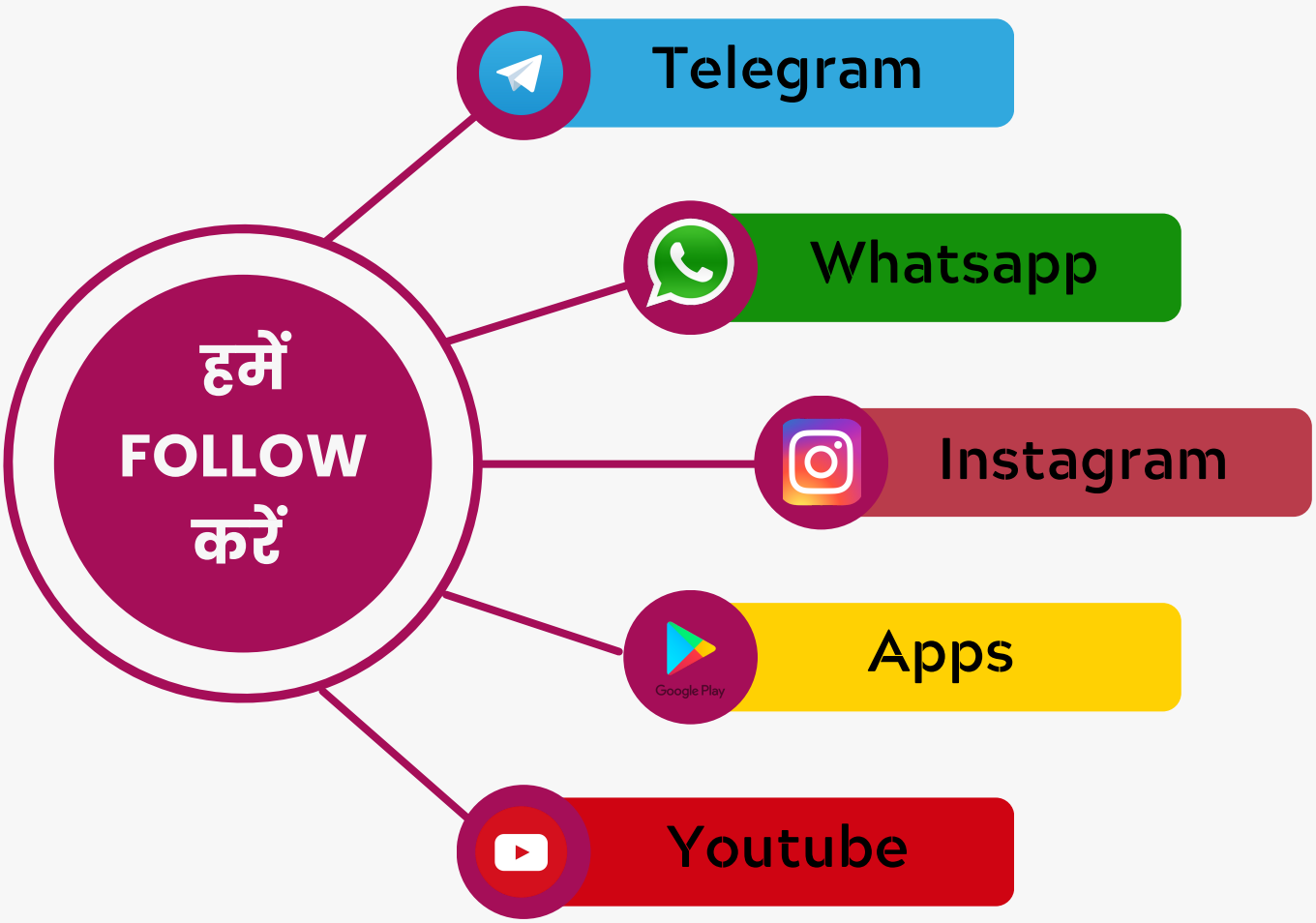
- General Knowledge
- Child Development and Pedagogy
- Current Affairs
- History
- Maths
- Geography
- Reasoning
- Economics
- Science
- Polity
- Computer
- Environment
- General Hindi
- MP GK
- General English
- UP GK

Join Our Best Course

GK Trick By Nitin Gupta

Current Affairs

Daily Current Affairs PDF, Best Test Series, Best GK PDF के लिए हमें Follow करें



GK Trick By Nitin Gupta
The Ultimate Key to Success.

Welcome To

GK TRICK BY NITIN GUPTA APP

यहाँ पर आपको मिलेगा

- Best PDF Notes For All Exams
- Best Test Series For All Exams
- Daily Current Affairs PDF
- सभी Course बहुत ही कम Price पर
- सभी Test Detail Discription के साथ व Analysis करने को सुविधा

CONTENTS

1

INDIA - LOCATION

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

Statute mile= 63,360 inches

Nautical mile= 72,960 inches

1 Statute mile= about 1.6 km (1.584 km)

1 Nautical mile= about 1.8 km (1.852 km)

Our southern boundary extends upto 6°45 N latitude in the Bay of Bengal. If you work out the latitudinal and longitudinal extent of India, they are roughly about 30 degrees, whereas the actual distance measured from north to south extremity is 3,214 km, and that from east to west is only 2,933 km. What is the reason for this difference?

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

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

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

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

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

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.

Structure and Physiography

Current estimation shows that the earth is approximately 4600 million years old.

Based on the variations in its geological structure and formations, Indian 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 may be taken as an irregular the running from Kachchh along the western flank of the Aravali Range near Delhi and then roughly parallel to the Yamuna and the Ganga as far as the Rajmahal Hills and the Ganga delta. Apart from these, the Karbi Anglong and the Meghalaya Plateau the the northeast and Rajasthan in the west are also extensions of this block. The northeastern parts are separated by the Media fault in West Bengal from the Chotanagpur plateau. In Rajasthan, the desert and other desert-like features overlay this block.

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

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

Indo-Ganga-Brahmaputra Plain

The third geological division of India comprises the plains form 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 during the third phase of the Himalayan mountain formation approximately about 64 million years ago. Since then, it has been gradually

filled by the sediments brought by the Himalayan and Peninsular rivers. Average depth of alluvial deposits in these plains ranges from 1,000-2,000 m.

Physiography

'Physiography' of an area is the outcome of structure, process and the stage of development.

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

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

North and North Eastern Himalaya:

Formation of Physical features of north and north-eastern Himalay is a result of "Plate tectonics" According to Plate Tectonic theory earth is divided into several plateau. The formation of Himalaya & north eastern mountain is due to convergent of two plates Eurasia (North of Himalaya) and Gondwana (Indian subcontinents Australia, South Africa, South America). Both the plates came close to each other and tethys sediment called geosynclines was pressed from two sides gave birth to current Himalaya mountains.

The Himalayan uplift out of the Tethys sea and subsidence of the northern flank of the peninsular plateau resulted in the formation of a large basin. In due course of time this depression, gradually got filled with deposition of sediments by the rivers flowing from the mountains in the north and the peninsular plateau in the south. A flat land of extensive alluvial deposits led to the formation of the northern plains of India.

The land of India displays great physical variation. Geologically, the Peninsular Plateau constitutes one of the ancient landmasses on the earth's surface. It was supposed to be one of the most stable land blocks. The Himalayans and the Northern Plains are the most recent landforms. From the view point of geology, Himalayan Mountains form an unstable zone. The whole mountain system of Himalaya represents a very youthful topography with high peaks, deep valleys and fast flowing rivers. The northern plains are formed of alluvial deposits. The peninsular plateau is composed of igneous and metamorphic rocks with gently rising hills and wide valleys.

The Himalayan Mountains

The Himalayas, geologically young and structurally fold mountains stretch over the northern borders of India. These mountain ranges run in a west-east direction from the Indus to the Brahmaputra. The Himalayas represent the loftiest and one of the most rugged mountain barriers of the world. They form an arc, which covers a distance of about 2,400 Km.

Their width varies from 400 Km in Kashmir to 150 Km in Arunachal Pradesh. The altitudinal variations are greater in the eastern half than those in the western half. The Himalaya consists of three parallel ranges in its longitudinal extent. A number of valleys lie between these ranges. The northern most range is known as the Great or Inner Himalayas of the 'Himadri'. It is the most continuous range consisting of the loftiest peaks with an average height of 6,000 metres. It contains all the prominent Himalayan

peaks. The folds of Great Himalayas are asymmetrical in nature. The core of this part of Himalayas is composed of granite. It is perennially snow bound, and a number of glaciers descend from this range.

The range lying to the south of the Himadri forms the most rugged mountain system and is known as Himachal or lesser Himalaya. The ranges are mainly composed of highly compressed and altered rocks. The altitude varies between 3,700 and 4,500 metres and the average width is of 50 Km. While the Pir Panjal range forms the longest and the most important rage, the Dhaula Dhar and the Mahabharat ranges are also prominent ones. This range consists of the famous valley of Kashmir, the Kangra and Kullu Valley in Himachal Pradesh. This region is well known for its hill stations.

Karewas

Karewas are the thick deposits of glacial clay and other materials embedded with moraines. The outer most range of the Himalayas is called the Shiwaliks. They extend over a width of 10.50 Km and have an altitude varying between 900 and 1100 metres. These ranges are composed of unconsolidated sediment brought down by rivers from the main Himalayans ranges located farther north. These valleys are covered with thick gravel and alluvium. The longitudinal valley lying between lesser Himalaya and the Shiwaliks are known as Duns. Dehra Dun, Kotli Dun and Patli Dun are some of the well-known Duns.

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

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

Longitudinal division

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

Kashmir or Northwestern Himalayas

It comprise a series of ranges such as the Karakoram. Ladakh. Zaskar and Pir Panjal. The northeastern part of the Kashmir Himalayas is a cold desert, which lies between the Greater Himalayas and the Karakoram ranges. Between the Great Himalayas and the Pir Panjal range, lies the world famous valley of Kashmir and the famous Dal Lake. Important glaciers of South Asia such as the Baltoro and Siachen are also found in this region. The Kashmir Himalayas are also famous for Karewa formations, which are useful for the cultivation of Zafran, a local variety of saffron. Some of the important passes of the region are Zoji La on the Great Himalayas. Banihal on the 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 Moriri are also in this region. This region is drained by the river Indus, and its tributaries such as the Jhelum and the Chenab. The Kashmir and northwestern Himalayas are well-known for their scenic beauty and picturesque

landscape. The landscape of Himalayas is a major source of attraction for adventure tourists. Some famous places of pilgrimage such as Vaishno Devi, Amarnath Cave, Charar -e-Shariff, etc. are also located here and large number of pilgrims visits these places every year.

Srinagar, capital city of the Jammu and Kashmir is located on the banks of Jhelum river. Dal Lake in Srinagar presents an interesting physical feature. Jhelum in the valley of Kashmir is still in its youth stage and yet forms meanders- a typical feature associated with the mature stage in the evolution of fluvial land form.

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

The Himachal and Uttaranchal Himalays

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

The two distinguishing features of this region from the point of view of physiography are the 'Shiwalik' and 'Dun formations'. Some important duns located in this region are the 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 grasslands in the higher reaches) during summer months and return to the valleys during winters. The famous 'Valley of flowers' is also situated in this region. The places of pilgrimage such as the Gangotri, Yamunotri, Kedarnath, Badrinath and Hemkund Sahib are also situated in this part. The region is also known to have five famous Prayags (river confluences). Can you name some other famous prayags in other parts of the country?

The Darjeeling and Sikkim Himalayas

They are flanked by Nepal Himalayas in the west and Bhutan Himalayas in the east. It is relatively small but is a most significant part of the Himalayas. Known for its fast-flowing rivers such as Tista, it is a region of high mountain peaks like Kanchenjunga (Kanchengiri), and deep valleys. The higher reaches of this region are inhabited by

Lepcha tribes while the southern part, particularly the Darjeeling Himalayas, has a mixed population of Nepalis, Bengalis and tribals from Central India. The British, taking advantage of the physical conditions such as moderate slope, thick soil cover with high organic content, well distributed rainfall throughout the year and mild winters, introduced tea plantations in this region. As compared to the other sections of the Himalayas, these along with the Arunachal Himalayas are conspicuous by the absence of the Shiwalik formations. In place of Shiwaliks here, the 'duar formations' are important, which have also been used for the development of tea gardens. Sikkim and Darjeeling Himalayas are also known for their scenic beauty and rich flora and fauna, particularly various types of orchids.

The Arunachal Himalayas

These extend from the east of the Bhutan Himalayas upto 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 rangers are dissected by fast-flowing rivers from the north to the south, forming deep gorges. Brahmaputra flows through a deep gorge after crossing Namcha Barwa. Some of the important rivers are the Kameng, the Subansiri, the Dihang 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 practice Jhumming. It is also known as shifting or slash and Figure: Eastern Himalayas communities. Due to rugged topography, the inter-valley transportation linkages are nominal. Hence, most of the interactions are carried through the duar region along the Arunachal-Assam border.

The Eastern Hills and Mountains

These are part of the Himalayan mountain system having their general alignment from the north to the south direction. They are known by different local names. In the north, they are known as Patkai Bum, Naga hills, the Manipur hills and in the south as Mizo or Lushai hills. These are low hills, inhabited by numerous tribal groups practicing Jhum cultivation.

Most of these ranges are separated from each other by numerous small rivers. The Barak is an important river in Manipur and Mizoram. The physiography of Manipur is unique by the presence of a large lake known as 'Loktak' lake at the centre, surrounded by mountains from all sides. Mzoram 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 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 Irrawaddy of Myanmar.

The Northern Plains

The northern plains are formed by the alluvial deposits brought by the rivers- the Indus, the Ganga and the Brahmaputra. These plain extend approximately 3,200 km

from the east to the west. The average width of these plains varies between 150-300 km. The maximum depth of alluvium deposits varies between 1,000-2,000 m. From the north to the south, these can be divided into three major zones: the Bhabar, the Tarai and the alluvial plains. The alluvial plains can be further divided into the Khadar and the Bhangar.

Bhabar is a narrow belt ranging between 8-10 km parallel to the Shiwalik foothills at the break-up of the slope. As a result of this, the streams and rivers coming from the mountain 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, oxbow lakes and braided channels. The Brahmaputra plains are known for their riverine islands and sand bars. Most of these areas are subjected to periodic floods and shifting river courses forming braided streams.

The mouths of these mighty rivers also form some of the largest deltas of the world, for example, the famous Sunderbans delta. Otherwise, this is a featureless plain with a general elevation of 50-150 m above the mean sea level. The states of Haryana and Delhi form a water divide between the Indus and the Ganga river systems. As opposed to this, the Brahmaputra river flows from the northeast to the southwest direction before it takes an almost 90° southward turn at Dhubri before it enters into Bangladesh. These river valley plains have a fertile alluvial soil cover which supports a variety of crops like wheat, rice, sugarcane and jute, and hence, supports a large population.

The Peninsular Plateau

Rising from the height of 150 m above the river plains up to an elevation of 600-900 m is the irregular triangle known as the peninsular plateau. Delhi ridge in the northwest, (extension of Aravalis), the Rajmahal hills in the east, Gir range in the west and the Cardamom hills in the south constitute the outer extent of the peninsular plateau. However, an extension of this is also seen in the northeast, in the form of Shillong 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 s also proved by the pattern of the flow of rivers. Name some rivers of the peninsular plateau which have their confluence in the Bay of Bengal and the Arabian sea and mention some landforms which are typical to the east flowing rivers but are absent in the west flowing rivers. Some of the important physiographic features of this region are tors, block mountains, rift valleys, spurs, bare rocky structures, series

of hummocky hills and wall-like quartzite dykes offering natural sites for water storage. The western and northwestern part of the plateau has an emphatic presence of black soil. 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 plateaus is located on the Anaimalai hills of the Western Ghats followed by Dodabetta (2,670 m) on the Nilgiri hills. Most of the Peninsular rivers have their origin in the Western Ghats. Eastern Ghats comprising the discontinuous and low hills are highly eroded by the rivers such as the Mahanadi, the Godavari, the Krishna, the Kaveri, etc. Some of the important ranges include the Javadi hills, the Palconda range, the Nallamala hills, the Mahendragiri hills, etc. The Eastern and the Western Ghats meet each other at the Nilgiri hills.

The Central Highlands

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

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

Chotanagpur plateau.

The Northeastern Plateau

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

The Indian Desert

To the northwest of the Aravali hills lies the Great Indian desert. It is a land of undulating topography dotted with longitudinal dunes and barchans. This region receives low rainfall below 150 mm per year; hence, it has arid climate with low vegetation cover. It is because of these characteristic features that this is also known as Marusthali. It is believed that during the Mesozoic era, this region was under the sea. This can be corroborated by the evidence available at wood fossils park at Aakal and marine deposits around Brahmsar, near Jaisalmer (The approximate age of the wood fossils is estimated to be 180 million years).

Though the underlying rock structure of the desert is an extension of the peninsular plateau, yet, due to extreme arid conditions, its surface features have been carved by physical weathering and wind actions. Some of the well pronounced desert land features present here are mushroom rocks, shifting dunes and oasis (mostly in its southern part). On the basis of the orientation, the desert can be divided into two parts: the northern part is sloping towards Sindh and the southern towards the Rann of Kachchh. Most of the rivers in this region are ephemeral. The Luni river flowing in the southern part of the desert is of some significance. Low precipitation and high evaporation makes it a water deficit region. There are some streams which disappear after flowing for some distance and present a typical case of inland drainage by joining a lake or playa. The lakes and the playas have brackish water which is the main source of obtaining salt.

The Coastal Plains

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

The western coastal plains are an example of submerged coastal plain. It is believed that the city of Dwaraka which was once a part of the Indian mainland situated along the west coast is submerged under water. Because of this submergence it is a narrow belt and provides natural conditions for the development of ports and harbours.

Kandla, Mazagaon, JLN port Navha Sheva, Marmagao. Mangalore, Cochin, etc. are some of the important natural ports located along the west coast. Extending from the Gujarat coast in the north to the Kerala coast in the south, the western coast may be divided into following divisions- the Kachchh and Kathiawar coast in Gujarat, Konkan coast in Maharashtra. Goa coast and Malabar coast in Karnataka and Kerala respectively. The western coastal plains are narrow in the middle and get broader towards north and south. The rivers flowing through this coastal plain do not form any delta. The Malabar coast has got certain distinguishing features in the form of 'Kayals' (backwaters), which are used for fishing, inland navigation and also due to its special attraction for tourists. Every year the famous Nehru Trophy Vallamkali (boat race) is held in Punnamada Kayal in Kerala.

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

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

The Islands

There are two major island groups in India- one in the Bay of Bengal and the other in the Arabian. 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. It s believed that these islands are an elevated portion of submarine mountains. However, some smaller islands are volcanic in origin. Barren island, the only active volcano in India is also situated in the Nicobar islands.

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

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

2

DRAINAGE SYSTEM

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

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

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. There is however, a slight difference between a river basin and a watershed. Watersheds are small in area while the basins cover larger areas.

Indian drainage system may be divided on various bases. On the basis of discharge of water (orientations to the sea), it may be grouped into: (i) the Arabian Sea drainage; and (ii) the Bay of Bengal drainage. They are separated from each other through the Delhi ridge, the Aravalis and the Sahyadris (water divide is shown by a line in Figure. 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.

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

On the basis of the mode of origin, nature and characteristics, the Indian drainage may also be classified into the Himalayan drainage and the peninsular drainage. Although it has the problem of including the Chambal, the Betwa, the Son, etc. which are much older in age and origin

than other rivers that have their origin in the Himalayas, it is the most accepted basis of classification.

Drainage systems of India

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

Important Drainage Patterns

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

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

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

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

The Himalayan Drainage

The Himalayan drainage system has evolved through a long geological history. It mainly includes the Ganga, the Indus and the Brahmaputra rivers basins. Since these are fed both by melting of snow and precipitation, rivers of this system are perennial. These rivers pass through the giant gorges carved out by the erosional activity carried on simultaneously with the uplift of the Himalayas. Besides deep gorges, these rivers also form V-shaped valleys, rapids and waterfalls in their mountainous course. While entering the plains, they form depositional features like flat valleys, ox-bow, lakes, flood plains, braided channels, and deltas near the river mouth. In the Himalayan reaches, the course of these rivers is highly tortuous, but over the plains they display a strong meandering tendency and shift their courses frequently. River Kosi, also know as the 'sorrow of Bihar', has been notorious for frequently changing its course. The Kosi brings huge quantity of sediments from its upper reaches and deposits in the plains. The course gets blocked, and consequently the river changes its course.

Evolution of the Himalayan Drainage

There are difference of opinion about the evolution of the Himalayan rivers. However, geologists believe that a mighty river called Shiwalik or Indo-Brahma traversed the entire longitudinal extent of the Himalaya from Assam to Punjab and onwards to Sind, and finally discharge into the Gulf of Sind near lower Punjab during the Miocene period some 5-24 million years ago. The remarkable continuity of the Shiwalik and its lacustrine origin and alluvial deposits consisting of sands, silt, clay, boulders and conglomerates support this viewpoints.

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 Himalayan, 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, period, diverted the Ganga and the Brahmaputra systems to flow towards the Bay of Bengal.

The river Systems of the Himalayan Drainage

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

The Indus system

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

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

The Jhelum an important tributary of the Indus, rises from a spring at Verinag situated at the foot of the Pir Panjal in the south-eastern part of the valley of Kashmir. It flows through Srinagar and the Wular lake before entering Pakistan through a deep narrow gorge. It joins the Chenab near Jhang in Pakistan. The Chenab is the largest tributary of the Indus. It is formed by two streams, the Chandra and the Bhaga, which join at Tandi near Keylong in Himachal Pradesh. Hence, it is also known as Chandrabhaga. The river flows for 1,180 km before entering into Pakistan.

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

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

enters the Punjab plains where it meets the Satluj near Harike.

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

The Ganga System

The Ganga is the most important river of India both from the point of view of its basin and cultural significance. It rises in the Gangotri glacier near Gaumukh (3,900 m) in the Uttarkashi district of Uttarankhand. Here, it is known as the Bhagirathi. It cuts through the Central and the Lesser Himalayas in narrow gorges. At Devprayag, the Bhagirathi meets the Alaknanda; hereafter, it is known as the Ganga. The Alaknanda has its source in the Satopanth glacier above Badrinath. The Alaknanda consists of the Dhaul and the Vishnu Ganga which meet at Joshimath or Vishnu Prayag. The other tributaries of Alaknanda such as the Pindar join it at Karna Prayag while Mandakini or Kali Ganga meets it at Rudra Prayag. The Ganga enters the plains at Haridwar. From here, it flows first to the south, then to the south-east and east before splitting into two distributaries, namely the Bhagirathi and the Hugli. The river has a length of 2,525 km. It is shared by 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). It is joined by the Chambal, the Sind, the Betwa and the Ken on its right bank which originates from the Peninsular plateau while the Hindan, the Rind, the Sengar, the Varuna, etc. join it on its left water feeds the western and eastern Yamuna and the Agra canals for irrigation purposes.

The Chambal rises near Mhow in the Malwa plateau of Madhya Pradesh northwards through a gorge up wards of Kota in Rajasthan, where the Gandhisagar dam has been constructed. From Kota, it traverses down to Bundi, Sawai Madhopur and Dholpur, and finally joins the Yamuna. The Chambal is famous for its badland topography called the Chambal ravines.

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

The Ghaghara originates in the glaciers of Mapchachungo. After collecting the waters

of its tributaries- Tila, Seti and Beri, it comes out of the mountain, cutting a deep gorge at Shishapani. The river Sarda (Kali or Kali Ganga) joins it in the plain before it finally meets the Ganga at Chhapra.

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

The Ramganga is comparatively a small river rising in the Garhwal hills near Gairsain. It changes its course to the southwest direction after crossing the Shiwalik and enters into the plains of Uttar Pradesh near Najibabad. Finally, it joins the Ganga near Kannauj. The Damodar occupies the eastern margins of the Chotanagpur Plateau where it flows through a rift valley and finally joins the Hugli. The Barakar is its main tributary. Once known as the 'sorrow of Bengal', the Damodar has been now tamed by the Damodar Valley corporation, multipurpose project.

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

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

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

The Brahmaputra System

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

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

The peninsular drainage system

The peninsular drainage system is older than the Himalayan one. This is evident from the broad, largely-graded shallow valleys, and the maturity of the rivers. The Western Ghats running close to the western coast act as the water divide between the major peninsular rivers, discharging their water in the Bay of Bengal and as small rivulets joining the Arabian Sea. Most of the major peninsular rivers except Narmada and Tapi flow from west to east. The Chambal, the Sind, the Betwa, the Ken, the Son, originating in the northern part of the peninsular 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 characterized by fixed course, absence of meanders and no perennial flow of water. The Narmada and the Tapi which flow through the rift valley are, however, exceptions. They meet in Arabian sea.

The Evolution of Peninsular Drainage System

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

River systems of the peninsular drainage

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

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

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

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

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

The Narmada originates on the western flank of the Amarkantak plateau at a height of about 1,057 m. Flowing in a rift valley between the Satpura in the south and the Vindhyan range in the north. It forms a picturesque gorge in marble rocks and Dhuandhar waterfall near Jabalpur. After flowing a distance of about 1,312 km, it meets the Arabian sea south of Bharuch, forming a broad 27 km long estuary. Its catchment area is about 98,796 sq. km. The Sardar Sarovar Project has been constructed on this river.

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

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

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

Smallar Rivers flowing towards the West

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

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

and drains a catchment area of 2,209 sq. km. Goa has two important rivers which can be mentioned here. One is Mandovi and the other is Juari.

River	Catchment area sq. km
Subarnarekha	19.296
Baitarni	12.789
Brahmani	39.033
Penner	55.213
Palar	17.870

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

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

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

3

CLIMATE

Climate refers to the sum total of weather conditions and variations over a large area for a long period of time (more than thirty years). Weather refers to the state of the atmosphere over an area at any point of time.

The elements of weather and climate are the same, i.e. temperature, atmospheric pressure, wind, humidity and precipitation. You may have observed that the weather conditions fluctuate very often even within a day. But there is some common pattern over a few weeks or months, i.e. days are cool or hot, windy or calm, cloudy or bright, and wet or dry. On the basis of the generalized monthly atmospheric conditions, the year is divided into seasons such as winter, summer or rainy seasons.

During the summer season the desert area of Rajasthan witnesses 50° temperature whereas Pahalgam sector of Jammu and Kashmir has 20°C temperature. During winter nights Dras sector of Jammu and Kashmir witnesses– 45°C temperature where as Thiruvananthpuram has 20°C.

Rainfall also varies in terms of quantity and distribution in the regions of Himalaya rainfall is in the from of snowy balls where as in the rest of part of India it is a general rain. Again annual rainfall varies from 400°C in the Meghalya to 10°c in Ladakh and West Rajasthan. In the coastal area the variation of rainfall is less. Whereas in the inner part of country the seasonal variation is more. Accordingly the Indians show their unity in diversity in terms of food, clothing, housing and culture.

Factors determining the climate of India

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

(a) Factors related to Location and Relief

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

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

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

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

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 to its leeward situation along the Western Ghats.

(b) Factors Related to Air Pressure and Wind

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

(i) Distribution of air pressure and winds on the surface of the earth.

(ii) Upper air circulation caused by factors controlling global weather and the inflow of different air masses and jet streams.

(iii) Inflow of western cyclones generally known as disturbances during the winter season and tropical depressions during the south-west monsoon period into India, creating weather conditions favourable to rainfall.

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

Mechanism of Weather in the Winter Season

Surface pressure and winds: In winter months, the weather conditions over India are generally influenced by the distribution of pressure in Central and Western Asia. A high pressure centre in the region lying to the north of the Himalayas during winter. This centre of high pressure gives rise to the flow of air at the low level from the north towards the Indian subcontinent, south of the mountain range. The surface winds blowing out of the high pressure centre over Central Asia reach India in the form of a dry continental air mass. These continental winds come in contact with trade winds over northwestern India. The position of this

contact zone is not, however, stable. Occasionally, it may shift its position as far east as the middle Ganga valley with the result that whole of northwestern and northern India up to the middle Ganga valley comes under the influence of dry northwestern winds.

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

Western Cyclonic Disturbance and Tropical Cyclones: The western cyclone disturbances which enter the Indian subcontinent from the west and the northwest during the winter months originate over the Mediterranean Sea and are brought into India by the westerly jet stream. An increase in the prevailing night temperature generally indicates an advance in the arrival of these cyclones disturbances.

Tropical cyclones originate over the Bay of Bengal and the Indian Ocean. These tropical cyclones have very high wind velocity and heavy rainfall and hit the Tamil Nadu, Andhra Pradesh and Orissa coast. Most of these cyclones are very destructive due to high wind velocity and torrential rain that accompanies it.

Inter Tropical Convergence Zone (ITCZ)

The Inter Tropical Convergence Zone (ITCZ) is a low pressure zone located at the equator where trade winds converge, and so, it is a zone where air tends to ascend. In July, the ITCZ is located around 20°N 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°E 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.

Mechanism of Weather in the Summer Season

Surface Pressure and Winds: As the summer sets in and the sun shifts northwards, the wind circulation over the subcontinent undergoes a complete reversal at both, the lower as well as the upper levels. By the middle of July, the low pressure belt nearer the surface (termed as Inter Tropical

Convergence Zone (ITCZ) shifts northwards, roughly parallel to the Himalayas between 20°N and 25°N. By this time, the westerly jet stream withdraws from the Indian region. In fact, meteorologists have found an interrelationship between the northward shift of the equatorial trough (ITCZ) and the withdrawal of the westerly jet stream from over the North Indian Plain. It is generally believed that there is a cause and effect relationship between the two. The ITCZ being a zone of low pressure attracts inflow of winds from different directions. The maritime tropical air mass (mT) from the southern hemisphere, after crossing the equator, rushes to the low pressure area in the general southwesterly direction. It is this moist air current which is popularly known as the southwest monsoon.

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

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

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

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

Onset of the Monsoon

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

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

The shift in the position of the ITCZ is also related to the phenomenon of the withdrawal of the westerly jet stream from its position over the north Indian plain, south of the Himalayas. The easterly jet stream sets in along 15°N latitude only after the western jet stream has withdrawn itself from the region. This easterly jet stream is held responsible for the burst of the monsoon in India. Entry of Monsoon into India: The southwest monsoon sets in over the Kerala coast by 1st June and moves swiftly to reach Mumbai and Kolkata between 10th and 13th June. By mid- July, southwest monsoon engulfs the entire subcontinent.

Rain-bearing Systems and Rainfall Distribution

There seem to be two rain-bearing systems in India. First originate in the Bay of Bengal causing rainfall over the plains of north India. Second is the Arabian Sea current of the southwest 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.

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

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. 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 even 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, it rain fails to occur for one or more weeks, it is known as break in the monsoon. These dry spells are quite common during the rainy season. These breaks in the different regions are due to different reasons:

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

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

The Rhythm of Seasons

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

(i) The cold weather season

(ii) The hot weather season

(iii) The southwest monsoon season

(iv) The retreating monsoon season.

Some Famous Local Storms of Hot Weather Season

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

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

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

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

The Cold Weather Season

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

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

(ii) The snowfall in the nearby

Himalayan ranges creates cold wave situation; and

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

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

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 characterized by feeble high pressure conditions over the northern plain. In south India, the air pressure is slightly lower. The isobars of 1019 mb and 1013 mb pass through northwest India and far south, respectively.

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

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

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

Role of Westerly Jet Stream

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 meager, it is highly beneficial for rabi crops. The precipitation is in the form of snowfall in the lower Himalayas. It is this snow that sustains the flow of water in the Himalayan Rivers during the summer months. The precipitation goes on decreasing from west to east in the plains and from north to south in the mountains. The average winter rainfall in Delhi is around 53 mm. In Punjab and Bihar, rainfall remains between 25 mm and 18 mm

respectively.

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

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

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

The Hot Weather Season

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

The hot weather season in south India is mild and not so intense as found in north India. The Peninsular situation of south India with moderating effect of the oceans keeps the temperatures lower than that prevailing in north India. So, temperatures remain between 26°C and 32°C. Due to altitude, the temperatures in the hills of Western Ghats remain below 25°C. In the coastal regions, the north-south extent of isotherms parallel to the coast confirms that temperature does not decrease from north to south rather it increases from the coast to the interior. The mean daily minimum temperature during the summer months also remains quite high and rarely goes below 26°C.

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

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

to local storms of great intensity. These local storms are associated with violent winds, torrential rains and even hailstorms.

The Southwest Monsoon Season

As a result of rapid increase of temperature in May over the northwestern plains, the low pressure conditions over there get further intensified. By early June, they are powerful enough to attract the trade winds of Southern Hemisphere coming from the Indian Ocean.

These southeast trade winds cross the equator and enter the Bay of Bengal and the Arabian Sea, only to be caught up in the air circulation over India. Passing over the equatorial warm currents, they bring with them moisture in abundance. After crossing the equator, they follow a southwesterly direction. That is why they are known as southwest monsoons.

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

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

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

(i) The Arabian Sea branch

(ii) The Bay of Bengal branch.

Monsoon Winds of the Arabian Sea

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

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

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

(iii) A third branch of this monsoon wind strikes the Saurashtra Peninsula and the Kachchh. It then passes over west Rajasthan and along the Aravallis, causing only a scanty rainfall. In Punjab and Haryana, it too jokns the Bay of

Bengal branch. These two branches, reinforced by each other, cause rains in the western Himalayas.

Monsoon Winds of the Bay of Bengal

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

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

(i) The Tamil Nadu coast is situated parallel to the Bay of Bengal branch of southwest monsoon.

(ii) It lies in the rain shadow area of the Arabian Sea branch of the south-west monsoon.

Characteristics of Monsoonal Rainfall

(i) Rainfall received from the southwest monsoons is seasonal in character, which occurs between June and September.

(ii) Monsoonal rainfall is largely governed by relief or topography. For instance the windward side of the Western Ghats register a rainfall of over 250 cm. Again, the heavy rainfall in the northeastern states can be attributed to their hill ranges and the Eastern Himalayas.

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

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

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

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

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

(viii) The beginning of the rains

sometimes is considerably delayed over the whole or a part of the country.

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

Season of Retreating Monsoon

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

The retreating southwest monsoon season is marked by clear skies and rise in temperature. The land is still moist. Owing to the conditions of high temperature and humidity, the weather becomes rather oppressive. This is commonly known as the 'October heat'. In the second half of October, the mercury begins to fall rapidly, particularly in northern India. The weather in the retreating monsoon is dry in north India but it is associated with rain in the eastern part of the Peninsula. Here, October and November are the rainiest months of the year. The widespread rain in this season is associated with the passage of cyclonic depressions which originate over the Andaman Sea and manage to cross the eastern coast of the southern Peninsula. These tropical cyclones are very destructive. The thickly populated deltas of the Godavari, Krishna and Kaveri are their preferred targets. Every year cyclones bring disaster here. A few cyclonic storms also strike the coast of West Bengal, Bangladesh and Myanmar. A bulk of the rainfall of the Coromondal coast is derived from these depressions and cyclones. Such cyclonic storms are less frequent in the Arabian Sea.

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 is the northeast and the hills of Meghalaya. Here the rainfall exceeds 200 cm. In some parts of Khasi and Jaintia hills, the rainfall exceeds 1,000 cm. In the Brahmaputra valley and the adjoining hills. The rainfall is less then 200 cm. Areas of Medium Rainfall: Rainfall between 100-200 cm is received in the southern parts of Gujarat, east Tamil Nadu, northeastern Peninsula covering Orissa, Jharkhand, Bihar, eastern Madhya Pradesh, northern Ganga plain along the sub-Himalayas and the Cachar Valley and Manipur.

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

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.

4

NATURAL VEGETATION

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

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

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

Types of Forests

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

Tropical Evergreen and Semi Evergreen Forests

These forests are found in the western slope of the Western Ghats, hills of the northeastern region and the Andaman and Nicobar Islands. They are found in warm and humid areas with an annual precipitation of over 200 cm and mean annual temperature above 22^0C. Tropical evergreen forests are well stratified, with layers closer to the ground and are covered with shrubs and creepers, with short structured trees followed by tall variety of trees. In these forests, trees reach great heights up to 60 m or above. There is no definite time for trees to shed their leaves, flowering and fruition. As such these forests appear green all the year round. Species found in these forests include rosewood, mahogany, aini, ebony, etc.

The semi evergreen forests are found in the less rainy parts of these regions. Such forests have a mixture of evergreen and moist deciduous trees. The under growing climbers provide an evergreen character to these forests. Main species are white cedar, hillock 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 of construction activities as it acts as an insulator of heat. The protectional use of forests was, thus, replaced by commercial use.

Tropical Deciduous Forests

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

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 Odissa. Teak, sal, shisham, hurra, mahua, amla, semul, kusum and sandalwood etc. are the main species of these forests.

Dry deciduous forest covers vast areas of the country, where rainfall ranges between 70-100 cm. On the wetter margins, it has a transition to the moist deciduous, while on the drier margins to thorn forests. These forests are found in rainier areas of the Peninsula and the plains of Uttar Pradesh and Bihar. In the higher rainfall regions of the Peninsular plateau and the northern Indian plain, these forests have a parkland landscape with open stretches in which teak and other trees interspersed with patches of grass are common.

As the dry season begins, the trees shed their leaves completely and the forest appears like a vast grassland with naked trees all around Tendu, palas, amaltas, bel, khair, axlewood, etc. are the common trees of these forests. In the western and southern part of Rajasthan, vegetation cover is very scanty due to low rainfall and overgrazing.

Tropical Thorn Forests

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

Montane Forests

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

The Himalayan ranges show a succession of vegetation from the tropical to the tundra, which change in with the altitude. Deciduous forests are found in the foothills of the Himalayas. It is succeeded by the wet temperate type of forests between an altitudes of 1,000-2,000 m.

In the higher hill ranges of northeastern India, hilly areas of West Bengal and Uttaranchal, evergreen broad leaf trees such as oak and chestnut are predominant. Between 1,500-1,750 m, pine forests are also well-developed in this zone, with Chir Pine as a very useful commercial tree. Deodar, a highly valued endemic species grows mainly in the western part of the Himalayan range. Deodar is a durable wood mainly used in construction activity. Similarly, the chinar

and the walnut, which sustain the famous Kashmir handicrafts, belong to this zone. Blue pine and spruce appear at altitudes of 2,225-3,048 m. At many places in this zone, temperate grasslands are also found.

But in the higher reaches there is a transition to Alpine forests and pastures. Silver firs, junipers, pines, birch and rhododendrons, etc. occur between 3,000-4,000 m. However, these pastures are used extensively for transhumance by tribes like the Gujjars, the Bakarwals, the Bhotiyas and the Gaddis. The southern slopes of the Himalayas carry a thicker vegetation cover because of relatively higher precipitation than the drier north-facing slopes. At higher altitudes, mosses and lichens form part of the tundra vegetation.

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

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

Littoral and Swamp Forests

India has a rich variety of wetland habitats. About 70 per cent of this comprises areas under paddy cultivation. The total area of wetland is 3.9 million hectares. Two sites-Chilika Lake (Odissa) 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 Gujarats through Rajasthan (Keoladeo National Park) and Madhya Pradesh; (iv) the delta wetlands and lagoons of India's east coast (Chilika Lake); (v) the freshwater marshes of the Gangetic Plain; (vi) the floodplains of the Brahmaputra; the marshes and swamps in the hills of northeast India and the Himalayan foothills; (vii) the lakes and rivers of the montane region of Kashmir and Ladakh; and (viii) the mangrove forest and other wetlands of the island arcs of the Andaman and Nicobar Islands Mangroves grow along the coasts in the salt marshes, tidal creeks, mud flats and estuaries.

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

In India, the mangrove forests spread over 6,740 sq. km which is 7 per cent of the

world's mangrove forests. They are highly developed in the Andaman and Nicobar Islands and the Sunderbans of West Bengal. Other areas of significance are the Mahanadi, the Godavari and the Krishna deltas. These forests too, are being encroached upon, and hence, need conservation.

Forest cover in India

According to state records, the forest area covers 23.28 per cent of the total land area of the country. The forest area is the area notified and recorded as the forest land irrespective of the existence of trees, while the actual forest cover is the area occupied by forests with canopy.

The former is based on the records of the State Revenue Department, while the latter is based on aerial photographs and satellite imageries. In 2001, the actual forest cover was only 20.55 per cent. Of the forest cover, the share of dense and open forests was 12.60 per cent and 7.87 per cent respectively.

Both forest area and forest covers vary from state to state. Lakshadweep has zero percent forest area; Andaman and Nicobar Islands have 86.93 per cent. Most of the states with less than 10 per cent of the forest area lie in the north and northwestern part of the country. These are Rajasthan, Gujarat, Punjab, Haryana and Delhi.

Most of the forests in Punjab and Haryana have been cleared for cultivation. States with 10-20 per cent forest area are Tamil Nadu and West Bengal. In Peninsular India, excluding Tamil Nadu, Dadra and Nagar Haveli and Goa, the area under forest cover is 20-30 per cent. The northeastern states have more than 30 per cent of the land under forest. Hilly topography and heavy rainfall are good for forest growth.

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

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

Forest Conservation

Forests have an intricate interrelationship with life and environment. These provide numerous direct and indirect advantages to our economy and society. Hence, conservation of forest is of vital importance to the survival and prosperity of man kind.

Accordingly, the Government of India proposed to have a nation-wide forest conservation policy, and adopted a forest policy in 1952, which was further modified in 1988. According to the new forest policy, the Government will emphasis 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.

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

Social Forestry

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

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

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

Rural forestry lays emphasis on promotion of agro-forestry and community-forestry. Agro-forestry is the raising of trees and agriculture crops on the same land inclusive of the waste patches. It combines forestry with agriculture, thus, altering the simultaneous production of food, fodder, fuel, timber and fruit.

Community forestry involves the raising of trees on public or community land such as the village pasture and temple land, roadside, canal bank, strips along railway lines, and schools etc.

Community forestry programme aims at providing benefits to the community as a whole. Community forestry provides a means under which the people of landless classes can associate themselves in tree raising and thus, get those benefits which otherwise are restricted for landowners.

Farm Forestry

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

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. There are certain species that are at the brink of extinction.

Some estimates suggest that at least 10 per cent of India's recorded wild flora and 20 per cent of its mammals are on the threatened list.

Let us now understand the different categories of existing plants and animal species. Based on the International Union for Conservation of Nature and Natural

Resources (IUCN), we can classify as follows-

Normal Species: Species whose population levels are considered to be normal for their survival, such as cattle, sal, pine, rodents, etc.

Endangered Species: These are species which are in danger of extinction. The survival of such species is difficult if the negative factors that have led to a decline in their population continue to operate. The examples of such species are black buck, crocodile, Indian wild ass, Indian rhino, lion tailed macaque, sangai (brow anter deer in Manipur), etc. Vulnerable Species: These are species whose population has declined to levels from where it is likely to move into the endangered category in the near future if the negative factors continue to operate. The examples of such species are blue sheep, Asiatic elephant, Gangetic dolphin etc. Rare Species:

Species with small population may move into the endangered for vulnerable category if the negative factors affecting them continue to operate. The examples of such species are the Himalayan brown bear, wild Asiatic buffalo, desert fox and hornbill, etc.

Endemic Species: These are species which are only found in some particular areas usually isolated by natural or geographical barriers. Examples of such species are the Andaman teal, Nicobar pigeon, Andaman wild pig, mithun in Arunachal Pradesh. Extinct Species: These are species which are not found after searches of known or likely areas where they may occur. A species may be extinct from a local area, region, country, continent or the entire earth. Examples of such species are the Asiatic cheetah, pink head duck.

Wildlife Conservation in India

The protection of wildlife has a long tradition in India. Many stories of Panchtantra and Jungle Books, etc. have stood the test of time relating to the love for wildlife. These have a profound impact on young minds. In 1972, a comprehensive Wildlife Act was enacted, which provides the main legal framework for conservation and protection of wildlife in India. The two main objectives of the Act are; to provide protection to the endangered species listed in the schedule of the Act and to provide legal support to the conservation areas of the country classified as National parks, sanctuaries and closed areas.

This Act has been comprehensively amended in 1991, making punishments more stringent and has also made provisions for the protection of specified plant species and conservation of endangered species of wild animals. There are 92 National parks and 492 wildlife sanctuaries covering an area of 15.67 million hectares in the country. Wildlife conservation has a very large ambit with unbounded potential for the wellbeing of mankind. However, this can be achieved only when every individual understands its significance and contributes his bit.

For the purpose of effective conservation of flora and fauna, special steps have been initiated by the Government of India in collaboration with UNESCO's 'Man and Biosphere Programme'. Special schemes like Project Tiger (1973) and Project Elephant (1992) have been launched to conserve these species and their habitat in a sustainable manner.

Project Tiger has been implemented since 1973. The main objective of the scheme

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

Project Elephant was launched in 1992 to assist states having free ranging population of wild elephants. It was aimed at ensuring long-term survival of identified viable population of elephants in their natural habitat. The project is being implemented in 13 states. Apart from this, some other projects such as Crocodile Breeding Project, Project Hangul and conservation of Himalayan Musk deer have also been launched by the Government of India.

Biosphere Reserves

A Biosphere Reserve is a unique and representative ecosystem of terrestrial and coastal areas which are internationally recognized within the framework of UNESCO's Man and Biosphere (MAB) Programme. The Biosphere Reserve aims at achieving the three objective as depicted in Figure. There are 16 Biosphere Reserves in India. Four Biosphere Reserves. Namely (i) Nilgiri; (ii) Nanda Devi: (iii) Sunderbans; and (iv) Gulf of Mannar have been recognized by the UNESCO on World Network of Biosphere Reserves.

Nilgiri Biosphere Reserve

The Nilgiri Biosphere Reserve (NBR), the first of the fourteen biosphere reserves of India, was established in September 1986. It embraces the sanctuary complex of Wyanad, Nagarhole, Bandipur and Mudumalai, the entire forested hill slopes of Nilambur, the Upper Nilgiri plateau, Silent Valley and the Siruvani hills. The total area of the biosphere reserve is around 5,520 sq. km. The Nilgiri Biosphere Reserve possesses different habitat types, unspoilt areas of natural vegetation types with several dry scrubs, dry and moist deciduous, semi evergreen and wet evergreen forests, evergreen shoals, grasslands and swamps. It includes the largest known population of two endangered animal species, namely the Nilgiri Tahr and the Lion-tailed macaque. The largest south Indian population of elephant, tiger, gaur, sambar and chital as well as a good number of endemic and endangered plants are also found in this reserve. The habitat of a number of tribal groups remarkable for the traditional modes of harmonious use of the environment are also found here. The topography of the NBR is extremely varied, ranging from an altitude of 250 m to 2,650 m. About 80 per cent of the flowering plants reported from the Western Ghats occur in the Nilgiri Biosphere Reserve.

Nanda Devi Biosphere Reserve

The Nanda Devi Biosphere Reserve situated in Uttarakhand includes parts of Chamoli, Almora, Pithoragarh and Bageshwar districts. The major forest types of the reserve are temperate. A few important species are silver weed and orchids like latifolie and rhododendron. The biosphere reserve has a rich fauna, for example the snow leopard, black bear, brown bear, musk deer, snowcock, golden eagle and black eagle.

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

List of Biosphere Reserves

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

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. Sundarbans is the home of nearly 200 Royal Bengal tigers.The tangled mass of roots of mangrove trees provide safe homes for a large number of species, from fish to shrimp. More than 170 birds species are known to inhabit these mangrove forests.Adapting itself to the saline and fresh water environment, the tigers at the park are good swimmers, and they hunt scarce preys such as chital deer, barking deer, wild pig and even macaques. In the Sunderbans, the mangrove forests are characterized by Heritiera fomes, a species valued for its timber.

Gulf of Mannar Biosphere Reserve

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

5

SOILS

Soil is the most important layer of the earth's crust. It is a valuable resource.

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

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

Classification of Soils

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

On the basis of genesis, colour, composition and location, the soils of India have been classified into: (i) Alluvial soils, (ii) Black soils, (iii) Red and Yellow soils, (iv) Laterite soils, (v) arid soils, (vi) Saline soils, (vii) Peaty soils, (viii) Forest soils.

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

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

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

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.

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

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

Black Soil

Black soil covers most of the Deccan Plateau which includes parts of Maharashtra, Madhya Pradesh, Gujarat, Andhra Pradesh and some parts of Tamil Nadu. In the upper reaches of the Godavari and the Krishna, and the north western part of the Deccan Plateau, the black soil is very deep. These soils are also known as the 'Regur Soil' or the 'Black Cotton Soil'. The black soils are generally clayey, deep and impermeable. They swell and become sticky when wet and shrink when dried. So, during the dry season, these soils develop wide cracks. Thus, there occurs a kind of 'self ploughing'. Because of this character of slow absorption and loss of moisture, the black soil retains the moisture for a very long time, which helps the crops, especially; the rain fed ones, to sustain even during the dry season.

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 Odissa 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 aluminum compound are left behind. Humus content of the soil is removed fast by bacteria that thrives well in high temperature. These soils are poor in organic matter, nitrogen, phosphate and calcium, while iron oxide and potash are in excess. Hence, laterites are not suitable for cultivation; however, application of manures and fertilizers 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 cashew nut.

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

Arid Soils

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

Saline Soils

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

Peaty Soils

They are found in the areas of heavy rainfall and high humidity, where there is a good growth of vegetation. Thus, large

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

Forest Soils

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

Soil Degradation

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

Soil Erosion

The destruction of the soil cover is described as soil erosion. The soil forming processes and the erosional processes of running water and wind go on simultaneously. But generally, there is a balance between these two processes. The rate of removal of fine particles from the surface is the same as the rate of addition of particles to the soil layer. Sometimes, such a balance is disturbed by natural or human factors, leading to a greater rate of removal of soil. Human activities too are responsible for soil erosion to a great extent. As the human population increases, the demand on the land also increases. Forest and other natural vegetation is removed for human settlement, for cultivation, for grazing animal and for various other needs.

Wind and water are powerful agents of soil erosion because of their ability to remove soil and transport it. Wind erosion is significant in arid and semi-arid regions. In regions with heavy rainfall and steep slopes, erosion by running water is more significant. Water erosion which is more serious and occurs extensively in different parts of India, takes place mainly in the form of sheet and gully erosion. Sheet erosion takes place on level lands after a heavy shower and the soil removal is not easily noticeable. But it is harmful since it removes the finer and more fertile top soil. Gully erosion is common steep slopes. Gullies deepen with rainfall, cut the agricultural lands into small fragments and make from 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 hectare of land to ravines every year.

Deforestation is one of the major causes of soil erosion. Plants keep soils bound in locks of roots, and thus, prevent erosion. They also add humus to the soil by shedding

leaves and twigs. Forests have been denuded practically in most parts of India but their effect on soil erosion are more in hilly parts of the country.

A fairly large area of arable land in the irrigated zones of India is becoming saline because of over irrigation. The salt lodged in the lower profiles of the soil comes up to the surface and destroys its fertility. Chemical fertilizers in the absence of organic manures are also harmful to the soil. Unless the soil gets enough humus, chemicals harden it and reduce its fertility in the long run. This problem is common in all the command areas of the river valley projects, which were the first beneficiaries of the Green Revolution. According to estimates, about half of the total land of India is under some degree of degradation. Every year, India loses millions of tones of soil and its nutrients to the agents of its degradation, which adversely affects our national productivity. So, it is imperative to initiate immediate steps to reclaim and conserve soils.

Soil Conservation

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.

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

In arid and semi-arid areas, efforts should be made to protect cultivable lands from encroachment by sand dunes through developing shelter belts of trees and agro-forestry. Lands not suitable for cultivation should be converted into pastures for grazing. Experiments have been made to stabilize sand dunes in western Rajasthan by the Central Arid Zone Research Institute (CAZRI). The Central Soil Conservation Board, set up by the Government of India, has prepared a number of plans for soil conservation in different parts of the country. These plans are based on the climatic conditions, configuration of land and the social behavior of people. Even these plans are fragmental in nature. Integrated land use planning, therefore, seems to be the best technique for proper soil conservation.

Water Resources

Water is a cyclic resource with abundant supplies on the globe. Approximately, 71 per cent of the earth's surface is covered with it but fresh water constitutes only about 3 per cent of the total water. In fact, a very small proportion of fresh water is effectively available for human use. The availability of fresh water varies over space and time.

Water Resources of India

India accounts for about 2.45 per cent of world's surface areas, 4 per cent of the world's water resources and about 16 per cent of world's population. The total water available from precipitation in the country in a year is about 4,000 cubic km. The availability from surface water and replenishable groundwater is 1,869 cubic km. Out of this only 60 per cent can be put to beneficial uses. Thus, the total utilizable water resource in the country is only 1,122 cubic km.

Surface Water Resources

There are four major sources of surface water. These are rivers, lakes, ponds, and tanks. In the country, there are about 10,360 rivers and their tributaries longer than 1.6 km each. The mean annual flow in all the river basins in India is estimated to be 1,869 cubic km. However, due to topographical, hydrological and other constraints, only about 690 cubic km (32 per cent) of the available surface water can be utilized. Water flow in a river depends on size of its catchment area or river basin and rainfall within its catchment area. Given that precipitation is relatively high in the catchment areas of the Ganga, the Brahmaputra and the Barak rivers, these rivers, although account for only about one-third of the total area in the country, have 60 per cent of the total surface water resource. Much of the annual water flow in south Indian rivers like the Godavari, the Krishna, and the Kaveri has been harnessed, but it is yet to be done in the Brahmaputra and the Ganga basins.

Groundwater Resources

The total replenishable groundwater resources in the country are about 432 km. Table shows that the Ganga and the Brahmaputra basins, have about 46 per cent of the total replenishable groundwater resources. The level of groundwater utilization is relatively high in the river basins lying in north-western region and parts of south India.

Basinwise Ground water Potential and Utilization in India (Cubic Km/Year)

S.No.	Name of Basin Ground water Resources	Total Replenishable Utilization (%)	Level of Groundwater
1.	Brahmani with Baltarni	4.05	8.45
2.	Brahmaputra	26.55	3.37
3.	Chambal Composite	7.19	40.09
4.	Kaveri	12.3	55.33
5.	Ganga	170.99	33.52
6.	Godavari	40.65	19.53
7.	Indus	26.49	77.71
8.	Krishna	26.41	30.39
9.	Kuchchh and Saurashtra Including Luni	11.23	51.14
10.	Chennai and South Tamil Nadu	18.22	57.68
11.	Mahanadi	16.46	6.95
12.	Meghna (Barak & Others)	8.52	3.94
13.	Narmada	10.83	21.74
14.	Northeast Composite	18.84	17.2
15.	Pennar	4.93	36.6
16.	Subarnarekha	1.82	9.57
17.	Tapi	8.27	33.05
18.	Western Ghat	17.69	22.88
	Total	**431.42**	**31.97**

The groundwater utilization is very high in the states of Punjab, Haryana, Rajasthan, and Tamil Nadu. However, there are States like Chhatisgarh, Orissa, Kerala, etc., which utilize only a small proportion of their groundwater potentials. States like Gujarat, Uttar Pradesh, Bihar, Tripura and Maharashtra are utilizing their ground water resources at a moderate rate. If the present trend continues, the demands for water would need the supplies. And such situation, will be detrimental to development, and can cause social upheaval and disruptions.

Water Demand and Utilization India has traditionally been an agrarian economy, and about two-third of its population have been dependent on agriculture. Hence, development of irrigation to increase agricultural production has been assigned a very high priority in the Five Year Plans, and multipurpose river valleys projects like the Bhakra-Nangal, Hirakund, Damodar, Valley, Nagarjuna Sagar, Indira Gandhi Canal Project, etc. have been taken up. In fact, India's water demand at present is dominated by irrigational needs.

Agriculture accounts for most the surface and ground water utilization, it accounts for 89 per cent of the surface water and 92 per cent of the groundwater utilization. While the share of industrial sector is limited to 2 per cent of the surface water utilization and 5 per cent of the ground-water, the share of domestic sector is higher (9 per cent) in surface water utilization as compared to groundwater. The share of agricultural sector in total water utilization is much higher than other sectors. However, is future, with development, the shares of industrial and domestic sectors in the country are likely to increase.

Demand of Water for Irrigation

In agriculture, water is mainly used for irrigation. Irrigation is needed because of spatiotemporal variability in rainfall in the country. The large tracts of the country are deficient in rainfall and are drought prone. North-Western India and Deccan plateau constitute such areas. Winter and summer seasons are more or less dry in most part of the country. Provisions of irrigation makes multiple cropping possible. It has also been found that irrigated lands have higher agricultural productivity than un-irrigated land. Further, the high yielding varieties of crops need regular moisture supply, which is made possible only by a developed irrigation systems. In fact, this is why that green revolution strategy of agriculture development in the country has largely been successful in Punjab, Haryana and western Uttar Pradesh.

In Punjab, Haryana and Western Uttar Pradesh more than 85 per cent of their net sown area is under irrigation. Wheat and rice are grown mainly with the help of irrigation in these states. Of the total net irrigated area 76.1 per cent in Punjab and 51.3 per cent in Haryana are irrigated through wells and tube wells. This shows that these states utilize large proportion of their ground water potential which has resulted in ground water depletion in these states. The share of area irrigated through wells and tube wells is also very high in the states given in table.

The over-use of ground water resources has led to decline in ground water table in these states. In fact, over withdrawals in some states like Rajasthan, and Maharashtra has increased fluoride concentration in ground-water, and this practice has led to increase in concentration of arsenic in parts

of West Bengal and Bihar.

Prevention of Water Pollution

Available water resources are degrading rapidly. The major rivers of the country generally retain better water quality in less densely populated upper stretches in hilly areas. In plans, river water is used intensively for irrigation, drinking, domestic and industrial purposes. The drains carrying agricultural (fertilizers and insecticides), domestic (solid and liquid wastes), and industrial effluents join the rivers. The concentration of pollutants in rivers, especially remains very high during the summer season when flow of water is low.

The Central Pollution Control Board (CPCB) in collaboration with State Pollution Control Boards has been monitoring water quality of national aquatic resources at 507 stations. The data obtained from these stations show that organic and bacterial contamination continues to be the main source of pollution in rivers. The Yamuna river is the most polluted river in the country between Delhi and Etawah.

Other severely polluted rivers are: the Sabarmati at Ahmedabad, the Gomti at Lucknow, the Kali, the Adyar, the Cooum (entire stretches), the Vaigai at Madurai and the Musi of Hyderabad and the Ganga at Kanpur and Varanasi. Groundwater pollution has occurred due to high concentrations of heavy/toxic metals, fluoride and nitrates at different parts of the country.

The legislative provisions such as the Water (Prevention and Control of Pollution) Act 1974, and Environment Protection Act 1986 have not been implemented effectively. The result is that in 1997, 251 polluting industries were located along the rivers and lakes.

The Water Cess Act, 1977, meant to reduce pollution has also made marginal impacts. There is a strong need to generate public awareness about importance of water and impacts of water pollution. The public awareness and action can be very effective in reducing the pollutants from agricultural activities, domestic and industrial discharges.

Watershed Management

Watershed management basically refers to efficient management and conservation of surface and groundwater resources. It involves prevention of runoff and storage and recharge of groundwater through various methods like percolation tanks, recharge wells, etc. However, in broad sense watershed management includes conservation, regeneration and judicious use of all resources-natural (like land, water, plants and animals) and human with in a watershed. Watershed management aims at bringing about balance between natural resources on the one hand and society on the other. The success of watershed development largely depends upon community participation.

The Central and State Governments have initiated many watershed development and management programmes in the country. Some of these are being implemented by nongovernmental organizations also. Haryali is a watershed development project sponsored by the Central Government which aims at enabling the rural population to conserve water for drinking, irrigation, fisheries and afforestation. The Project is being executed by Gram Panchayats with people's participation.

Neeru-Meeru (Water and You)

programme (in Andhra Pradesh) and Arvary Pani Sansad (in Alwar, Rajasthan) have taken up constructions of various water harvesting structures such as percolation tanks, dug out ponds (Johad), check dams, etc. through people's participation. Tamil Nadu has made water harvesting structures in the houses compulsory. No building can be constructed without making structures for water harvesting.

Watershed development projects in some areas have been successful in rejuvenating environment and economy. However, are only a few success stories. In majority of cases, the programme is still in its nascent stage. There is a need to generate awareness regarding benefits of watershed development and management among people in the country, and through this integrated water resource management approach water availability can be ensured on sustainable basis.

Rainwater Harvesting

Rain water harvesting is a method to capture and store rainwater for various uses. It is also used to recharge groundwater aquifers. It is a low cost and eco-friendly technique for preserving every drop of water by guiding the rain water to bore well, pits and wells. Rainwater harvesting increases water availability, checks the declining ground water table, improves the quality of groundwater through dilution of contaminants like fluoride and nitrates, prevents soil erosion, and flooding and arrests salt water intrusion in coastal areas if used to recharge aquifers.

Rainwater harvesting has been practiced through various methods by different communities in the country for a long time. Traditional rain water harvesting in rural areas is done by using surface storage bodies like lakes, ponds, irrigation tanks, etc. In Rajasthan, rainwater harvesting structures locally known as Kund or Tanka (a covered underground tank) are constructed near or in the house or village to store harvested rainwater.

There is a wide scope to use rainwater harvesting technique to conserve water resource. It can be done by harvesting rainwater on rooftops and open spaces.

Harvesting rainwater also decreases the community dependence on groundwater for domestic use. Besides bridging the demand supply gap, it can also save energy to pump groundwater as recharge leads to rise in groundwater. These days rainwater harvesting is being taken up on massive scale in many states in the country. Urban areas can specially benefit from rainwater harvesting as water demand has already outstripped supply in most of the cities and towns.

Apart from the above mentioned factors, the issue desalinization of water particularly in coastal areas and brackish water in arid and semi-arid areas, transfer of water from water surplus areas to water deficit areas through inter linking of rivers can be important remedies for solving water problem in India (read more about inter linking of rivers). However, the most important issue from the point of view of individual users, household and communities is pricing of water.

Highlights of India's National Water Policy, 2002

The National Water Policy 2002 stipulates water allocation priorities broadly

in the following order: drinking water; irrigation, hydro-power, navigation, industrial and other uses. The policy stipulates progressive new approaches to water management. Key features include:

- Irrigation and multi-purpose projects should invariably include drinking water component, wherever there is no alternative source of drinking water.
- Providing drinking water to all human beings and animals should be the first priority.
- Measures should be taken to limit and regulate the exploitation of groundwater.
- Both surface and groundwater should be regularly monitored for quality. A phased programme should be undertaken for improving water quality.
- The efficiency of utilization in all the diverse uses of water should be improved.
- Awareness of water as a scarce resource should be fostered.
- Conservation consciousness should be promoted through education, regulation, incentives and disincentives.

6

LAND USE AND AGRICULTURE

Different types of lands are suited to different uses. Human beings thus, use land as a resource for production as well as residence and recreation.

Land-use records maintained by land revenue department. The land use categories add up to reporting area, which is somewhat different from the geographical area. The Survey of India is responsible for measuring geographical area of administrative units in India. The difference between the two concepts are that while the former changes somewhat depending on the estimates of the land revenue records, the latter does not change and stays fixed as per Survey of India measurements.

The land-use categories as maintained in the Land Revenue are as follows:

(i) Forests: It is important to note that area under actual forest cover is different from area classified as forest. The latter is the area which the Government has identified and demarcated for forest growth. The land revenue records are consistent with the latter definition. Thus, there may be an increase in this category without any increase in the actual forest cover.

(ii) Land put to Non-agricultural Uses: Land under settlements (rural and urban), infrastructure (roads, canals, etc.), industries, shops, etc. are included in this category. An expansion in the secondary and tertiary activities would lead to an increase in this category of land-use.

(iii) Barren and Wastelands: The land which may be classified as a wasteland such as barren hilly terrains, desert lands, ravines, etc. normally cannot be brought under cultivation with the available technology.

(iv) Area under Permanent pastures and Grazing Lands: Most of this type land is owned by the village 'Panchayat' or the Government. Only a small proportion of this land is privately owned. The land owned by the village panchayat comes under 'Common Property Resources'.

(v) Area under Miscellaneous Tree Crops and Goves (Not included is Net sown Area): The land under orchards and fruit trees are included in this category. Much of this land is privately owned.

(vi) Culturable Waste-Land: Any land which is left fallow (uncultivated) for more than five years is included in

this category. It can be brought under cultivation after improving it through reclamation practices.

(vii) Current Fallow: This is the land which is left without cultivation for one or less than one agricultural year, Fallowing is a cultural practice adopted for giving the land rest. The land recoups the lost fertility through natural processes.

(viii) Fallow other than Current Fallow: This is also a cultivable land which is left uncultivated for more than five years, it would be categorized as culturable wasteland.

(ix) Net Area Sown: The physical extent of land on which crops are sown and harvested is known as net sown area.

Land-use Changes in India

Land-use in a region, to a large extent, is influenced by the nature of economic activities carried out in the region. However, while economic activities change over time, land, like many other natural resources, is fixed in terms of its area. At this stage, one needs to appreciate three types of changes that an economy undergoes, which affect land-use.

India has undergone major changes within the economy over the past four or five decades, and this has influenced the land-use changes in the country, These changes between 1960-61 and 2002-03 have been shown in Fig. There are two points that you need to remember before you derive some meaning from this figure. Firstly, the percentage shown in the figure have been derived with respect to the reporting area. Secondly, since even the reporting area has been relatively constant over the years, a decline in one category usually leads to an increase in some other category.

Three categories have undergone increases, while four have registered declines. Share of area under forest, are under nonagricultural uses and current fallow lands have shown an increase. The following observations can be made about these increases:

(i) The rate of increase is the highest in case of area under non-agricultural uses. This is due to the changing structure of Indian economy, which is increasingly depending on the contribution from industrial and services sectors and expansion of related infrastructural facilities. Also, an expansion of area under both urban and rural settlements has added to the increase. Thus, the area under non-agricultural uses is increasing at the expense of wastelands and agricultural land.

(ii) The increase in the share under forest, as explained before, can be accounted for by increase in the demarcated area under forest rather than an actual increase in the forest cover in the country.

(iii) The increase in the current fallow cannot be explained from information pertaining to only two points. The trend of current fallow fluctuates a great deal over years, depending on the variability of rainfall and cropping cycles.

The four categories that have registered a decline are barren and wasteland, culturable

wasteland, area under pastures and tree crops and net area sown.

The following explanations can be given for the declining trends:

(i) As the pressure on land increased, both from the agricultural and nonagricultural sectors, the wastelands and culturable wastelands have witnessed decline over time.

(ii) The decline in net area sown is a recent phenomenon that started in the late nineties, before which it was registering a slow increase. There are indications that most of the decline has occurred due to the increases in area under nonagricultural use. (Note: the expansion of building activity on agricultural land in your village and city).

(iii) The decline in land under pastures and grazing lands can be explained by pressure from agricultural land. Illegal encroachment due to expansion of cultivation on common pasture lands is largely responsible for this decline.

Agricultural Land Use in India

Land resource is more crucial to the livelihood of the people depending on agriculture:

(i) Agriculture is a purely land based activity unlike secondary and tertiary activities. In other words, contribution of land in agricultural output is more compared to its contribution in the outputs in the other sectors. Thus, lack of access to land is directly correlated with incidence of poverty in rural areas.

(ii) Quality of land has a direct bearing on the productivity of agriculture, which is not true for other activities.

(iii) In rural areas, aside from its value as a productive factor, land ownership has a social value and serves as a security for credit, natural hazards or life contingencies, and also adds to the social status.

An estimation of the total stock of agricultural land resources (i.e. total cultivable land can be arrived at by adding up net sown area, all fallow lands and culturable wasteland. It may be observed from Table that over the years, there has been a marginal decline in the available total stock of cultivable land as a percentage to total reporting area. There has been a greater decline of cultivated land, in spite of a corresponding decline of cultivable wasteland.

Agricultural land-Use	As a percentage of Reporting Area		As a percentage to Total Cultivated land	
Categories	1960-61	2002-03	1960-61	2002-03
Culturable Wasteland	6.23	4.41	10.61	7.52
Fallow other than current fallow	3.5	3.82	5.96	6.51
Current Fallow	3.73	7.03	6.35	11.98
Net Area Sown	45.26	43.41	77.08	73.99
Total Cultivable Land	58.72	58.67	100.00	100.00

Cropping Seasons in India: There are three distinct crop seasons in the northern and interior parts of country, namely kharif, rabi and zaid. The kharif season largely coincides with Southwest Monsoon under which the cultivation of tropical crops such as rice, cotton, jute, jowar, bajra and tur is possible. The rabi season begin with the onset of winter in October-November and ends in March-April. The low temperature conditions during this season facilitate the cultivation of temperate and subtropical crops such as wheat, gram and mustard. Zaid is a short duration summer cropping season beginning after harvesting of rabi crops. The cultivation of watermelons, cucumbers, vegetables and fodder crops during this season is done on irrigated lands. However, this type of distinction in the cropping season does not exist in southern parts of the country. Here, the temperature is high enough to grow tropical crops during any period in the year provided the soil moisture is available. Therefore, in this region same crops can be grown thrice in an agricultural year provided there is sufficient soil moisture.

Primitive Subsistence Farming

Based upon the characteristics of physical environment technology and socio-cultural practices following farming system can be identified.

This type of farming is still practiced in few pockets of India. Primitive subsistence agriculture is practiced on small patches of land with the help of primitive tools like hoe, dao and digging sticks, and family/ community labour. This type of farming depends upon monsoon, natural fertility of the soil and suitability of other environment conditions to the crops grown.

It is a 'slash and burn' agriculture. Farmers clear a patch of land and produce cereals and other food crops to sustain their family. When the soil fertility decreases, the farmers shift and clear a fresh patch of land for cultivation. This type of shifting allows Nature to replenish the fertility of the soil through natural processes; land productivity in this type of agriculture is low as the farmer does not use fertilizers or other modern inputs. It is known by different names in different parts of the country. It is jhumming in north-eastern states like Assam, Meghalaya, Mizoram and Nagaland; Pamlou in Manipur, Dipa in Bastar district of Chattishgarh, and in Andaman and Nicobar Islands.

Jhumming: The 'slash and burn' agriculture is known as 'Milpa' in Mexico and Central America, 'Conuco' in Venzuela, 'Roca' in Brazil, 'Masole' in Central Africa, 'Ladang' in Indonesia, 'Ray' in Vietnam.

In India, this primitive form of cultivation is called 'Betwar' or 'Dahiya' in Madhya Pradesh, 'Podu' or 'Penda' in Andhra Pradesh, 'Pama Dabi' or 'Koman' or 'Bringa' in Orissa, 'Kumari' in Western Ghats, 'Valre' in South-Eastern Rajasthan, 'Khil' in the Himalayan belt, 'Kuruwa' in Jharkhand, and 'Jhumming' in the North-Eastern region.

Intensive Substance Farming

This type of farming is practiced in areas of high population pressure on land. It is labour intensive farming, where high doses of biochemical inputs and irrigation are used for obtaining higher production.

Though the 'right of inheritance' leading to the divion of land among successive generations has rendered land-holding size uneconomical, the farmers continue to take

maximum output from the limited land in the absence of alternative source of livelihood. Thus, there is enormous pressure on agricultural land.

Commercial Farming

The main characteristic of this type of farming is the use of higher doses of modern inputs, e.g. high yielding variety (HYV) seeds, chemical fertilizers, insecticides and pesticides in order to obtain higher productivity. The degree of commercialization of agriculture varies from one region to another. For example, rice is a commercial crop in Haryana and Punjab, but in Orissa, it is a subsistence crop. Plantation is also a type of commercial farming. In this type of farming, a single crop is grown on a large area. The plantation has an interface of agriculture and industry. Plantations cover large tracts of land, using capital intensive inputs, with the help of migrant laboures. All the produce is used as raw material in respective industries.

Types of Farming

On the basis of main source of moisture for crops, the farming can be classified as irrigated and rainfed (barani). There is difference in the nature of irrigated farming as well based on objective of irrigation, i.e. protective or productive. The objective of protective irrigation is to protect the crops from adverse of soil moisture deficiency which often means that irrigation acts as a supplementary source of water over and above the rainfall. The strategy of this kind of irrigation is to provide soil moisture to maximum possible area. Productive irrigation is meant to provide sufficient soil moisture in the cropping season to achieve high productivity. In such irrigation the water input per unit area of cultivated land is higher than protective irrigation. Rainfed farming is further classified on the basis of adequacy of soil moisture during cropping season into dry land and wetland farming. In India, the dry land farming is largely confined to the regions having annual rainfall less than 75 cm. These regions grow hardy and drought resistant crops such as ragi, bajra, moong, gram and guar (fodder crops) and practice various measures of soil moisture conservation and rain water harvesting. In wetland farming, the rainfall is in excess of soil moisture requirement of plants during rainy season. Such regions may face flood and soil erosion hazards. These areas grow various water intensive crops such as rice, jute and sugarcane and practice aquaculture in the fresh water bodies.

Cropping Pattern

Food grains: The importance of food grains in Indian agricultural economy may be gauged from the fact these crops occupy about two-third of total cropped area in the country. Food grains are dominant crops in all parts of the country whether they have subsistence or commercial agricultural economy. On the basis of the structure of grain the food grains are classified as cereals and pulses.

Cereals: The cereals occupy about 54 per cent of total cropped area in India. The country produces about 11 per cent cereals of the world and ranks third in production after China and U.S.A. India produces a variety of cereals, which are classified as fine grains (rice, wheat) and coarse grains (jowar, maize, ragi) etc. Account of important cereals has been given in the following paragraphs.

Rice: Rice is a staple food for the

overwhelming majority of population in India. Though, it is considered to be a crop of tropical humid areas, it has about 3,000 varieties which are grown in different agro-climatic regions. These are successfully grown from sea level to about 2,000 m altitude and from humid areas in eastern India to dry but irrigated areas of Punjab, Haryana, western U.P. and northern Rajasthan. In southern states and West Bengal the climatic conditions allow the cultivation of two or three crops of rice in an agricultural year. In West Bengal farmers grow three crops of rice called 'aus', 'aman' and 'boro'. But in Himalayas and northwestern parts of the country, it is grown as a Kharif crop during southwest Monsoon season.

India contributes 22 per cent of rice production in the world and ranks second after China. About one-fourth of the total cropped area in the country is under rice cultivation. West Bengal, Punjab, Uttar Pradesh, Andhra Pradesh and Tamil Nadu were five leading rice producing states in the country in 2002-03. The yield level of rice is high in Punjab, Tamil Nadu. Andhra Pradesh, West Bengal and Kerala. In the first four of these states almost the entire land under rice cultivation is irrigated. Punjab and Haryana are not traditional rice growing areas. Rice cultivation in the irrigated areas of Punjab and Haryana was introduced in 1970s following the Green Revolution. Generally improved varieties of seed, relatively high usage of fertilizers and pesticides and lower levels of susceptibility of the crop to pests due to dry climatic conditions are responsible for higher yield of rice in this region. The yield of this crop is very low in rainfed areas of Madhya Pradesh, Chhattisgarh and Orissa.

Wheat: Wheat is the second most important cereal crop in India after rice. India produces about 12 per cent of total wheat production of world. It is primarily a crop of temperate zone. Hence, its cultivation in India is done during winter i.e. rabi season. About 85 per cent of total area under this crop is concentrated in north and central regions of the country i.e. Indo-Gangetic Plain, Malwa Plateau and Himalayas up to 2,700 m altitude. Being a rabi crop, it is mostly grown under irrigated conditions. But it is rainfed crop in Himalayan highlands and parts of Malwa plateau in Madhya Pradesh. About 14 per cent of the total cropped area in the country is under wheat cultivation. Uttar Pradesh, Punjab, Haryana, Rajasthan and Madhya Pradesh are five leading wheat producing states. The yield level of wheat is very high (above 4,000 k.g. per ha) in Punjab and Haryana whereas, Uttar Pradesh, Rajasthan and Bihar have moderate yields. The states like Madhya Pradesh, Himachal Pradesh and Jammu and Kashmir growing wheat under rainfed conditions have low yield.

Jowar: The coarse cereals together occupy about 16.50 per cent of total cropped area in the country. Among these, jowar or sorghum alone accounts for about 5.3 per cent of total cropped area. It is main food crop in semi-arid areas of central and southern India. Maharashtra alone produces more than half of the total jowar production of the country. Other leading producer states of jowar are Karnataka, Madhya Pradesh and Andhra Pradesh. It is sown in both Kharif and rabi seasons in southern states. But it is a Kharif crop in northern India where it is mostly grown as a fodder crop. South of Vindhyachal it is a rainfed crop and its yield level is very low in this region.

Bajra: Bajra is sown in hot and dry climatic conditions in northwestern and western parts of the country. It is a hardy crop which resists frequent dry spells and drought in this region. It is cultivated alone as well as part of mixed cropping. This coarse cereal occupies about 5.2 per cent of total cropped area in the country. Leading producers of bajra are the states of Maharashtra, Gujarat, Uttar Pradesh, Rajasthan and Haryana. Being a rainfed crop, the yield level of this crop is low in Rajasthan and fluctuates a lot from year to year. Yield of this crop has increased during recent years in Haryana and Gujarat due to introduction of drought resistant varieties and expansion of irrigation under it.

Maize: Maize is a food as well as fodder crop grown under semi-arid climatic conditions and over inferior soils. This crop occupies only about 3.6 per cent of total cropped area. Maize cultivation is not concentrated in any specific region. It is sown all over India except eastern and north-eastern regions. The leading producers of maize are the states of Madhya Pradesh, Andhra Pradesh, Karnataka, Rajasthan and Uttar Pradesh. Yield level of maize is higher than other coarse cereals. It is high in southern states and declines towards central parts.

Pulses: Pulses are a very important ingredient of vegetarian food as these are rich sources of proteins. These are legume crops which increase the natural fertility of soils through nitrogen fixation. India is a leading producer of pulses and accounts for about one-fifth of the total production of pulses in the world. The cultivation of pulses in the country is largely concentrated in the dry lands of Deccan and central plateaus and northwestern parts of the country. Pulses occupy about 11 per cent of the total cropped area in the country. Being the rainfed crops of dry lands, the yields of pulses are low and fluctuate from year to year. Grain and tur are the main pulses cultivated in India.

Grain: Grain is cultivated in subtropical areas. It is mostly a rainfed crop cultivated during rabi season in central, western and northwestern parts of the country. Just one or two light showers or irrigations are required to grow this crop successfully. It has been displaced from the cropping pattern by wheat in Haryana, Punjab and northern Rajasthan following the green revolution. At present, grain covers only about 2.8 per cent of the total cropped area in the country. Madhya Pradesh, Uttar Pradesh, Maharashtra, Andhra Pradesh and Rajasthan are the main producers of this pulse crop. The yield of this crop continues to be low and fluctuates from year to year even in irrigated areas.

Tur (Arhar): Tus is the second important pulse crop in the country. It is also known as red grain or pigeon pea. It is cultivated over marginal lands and under rainfed conditions in the dry areas of central and southern states of the country. This crop occupies only about 2 per cent of total cropped area of India. Maharashtra alone contributed about one-third of the total production of tur. Other leading producer states are Uttar Pradesh, Karnataka, Gujarat and Madhya Pradesh. Per hectare output of this crop is very low and its performance is inconsistent.

Oilseeds: The oilseeds are produced for extracting edible oils. Dry lands of Malwa plateau, Marathwada, Gujarat, Rajasthan,

Telangana and Rayalseema region of Andhra Pradesh and Karnataka plateau are oilseeds growing regions of India. These crops together occupy about 14 per cent of total cropped area in the country. Groundnut, rapeseed and mustard, soyabean and sunflower are the main oilseed crops grown in India.

Groundnut: India produces about 17 per cent the total of groundnut production in the world. It is largely a rainfed kharif crop of dry lands. But in southern India, it is cultivated during rabi season as well. It covers about 3.6 per cent of total cropped area in the country. Gujarat, Tamil Nadu, Andhra Pradesh, Karnataka and Maharashtra are the leading producers. Yield of groundnut is comparatively high in Tamil Nadu where it is partly irrigated. But its yield is low in Andhra Pradesh and Karnataka.

Rapeseed and Mustard: Rapeseed and mustard comprise several oilseeds as rai, sarson, toria and taramira. These are subtropical crops cultivated during rabi season in north-western and central parts of India. These are frost sensitive crops and their yields fluctuate from year to year. But with the expansion of irrigation and improvement in seed technology; their yields have improved and stabilized to some extend. About two-third of the cultivated area under these crops is irrigated. These oilseeds together occupy only 2.5 per cent of total cropped area in the country. Rajasthan contributes about one-third production while other leading producers are Uttar Pradesh, Haryana, West Bengal and Madhya Pradesh. Yields of these crops are comparatively high in Haryana and Rajasthan.

Other Oilseeds: Soyabean and sunflowere are other important oilseeds grown in India. Soyabean is mostly grown in Madhya Pradesh and Maharashtra. These two states together produce about 90 per cent of total output of soyabean in the country. Sunflower cultivation is concentrated in Karnataka, Andhra Pradesh and adjoining areas of Maharashtra. It is a minor crop in northern parts of the country where its yield is high due to irrigation.

Fibre Crops: These crops provide us fibre for preparing cloth, bags, sacks and a number of other items. Cotton and jute are two main fibre crops grown in India.

Cotton: Cotton is a tropical crop grown in kharif season in semi-arid areas of the country. India lost a large proportion of cotton growing area to Pakistan during partition. However, its acreage has increased considerably during the last 50 years. India grows both short staple (Indian) cotton as well as long staple (American) cotton called 'narma' in north-western parts of the country. Cotton requires clear sky during flowering stage.

India ranks fourth in the world in the production of cotton after China. U.S.A. and Pakistan and accounts for about 8.3 per cent of production of cotton in the world. Cotton occupies about 4.7 per cent of total cropped area in the country. There are three cotton growing areas, i.e. parts of Punjab, Haryana and northern Rajasthan in north-west, Gujarat and Maharashtra in the west and plateaus of Andhra Pradesh, Karnataka and Tamil Nadu in South. Leading producers of this crop are Maharashtra, Gujarat, Andhra Pradesh, Punjab and Haryana. Per hectare output of cotton is high under irrigated conditions in north-western region of the

country. Its yield is very low in Maharashtra where it is grown under rainfed conditions.

Jute: Jute is used for making coarse cloth, bags, sacks and decorative items. It is a cash crop in West Bengal and adjoining eastern parts of the country. India lost large jute growing areas to East Pakistan (Bangladesh) during partition. At present, India produces about three-fifth of jute production of the world. West Bengal accounts for about three-fourth of the production in the country. Bihar and Assam are other jute growing areas. Being concentrated only in a few states, this crop accounts for only about 0.5 per cent total cropped area in the country.

Other Crops: Sugarcane, tea and coffee are other important crops grown in India.

Sugarcane: Sugarcane is a crop of tropical areas. Under rainfed conditions, it is cultivated in sub-humid and humid climates. But it is largely an irrigated crop in India. In Indo-Gangetic plain, its cultivation is largely concentrated in Uttar Pradesh. Sugarcane growing area in western India is spread over Maharashtra and Gujarat. In southern India, it is cultivated in irrigated tracts of Karnataka, Tamil Nadu and Andhra Pradesh.

India is the second largest producer of sugarcane after Brazil. It accounts for about 23 per cent of the world production of sugarcane. But it occupies only 2.4 per cent of total cropped are in the country. Uttar Pradesh produces about two-fifth of sugarcane of the country. Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh are other leading producers of this crop where yield level of sugarcane is high. Its yield is low in northern India.

Tea: Tea is a plantation crop used as beverage. Black tea leaves are fermented whereas green tea leaves are unfermented. Tea leaves are fermented whereas green tea leaves are unfermented. Tea leaves have rich content of caffeine and tannin. It is an indigenous crop of hills in northern China. It is grown over undulating topography of hilly areas and well drained soils in humid and sub-humid tropics and sub-tropics. In India, tea plantation started in 1840s in Brahmaputra valley of Assam which still is a major tea growing area in the country. Later on, its plantation was introduced in the sub-Himalayan region of West Bengal (Darjeeling, Jalpaiguri and Cooch districts). Tea is also cultivated on the lower slopes of Nilgiri and Cardamom hills in Western Ghats. India is a leading producer of tea and accounts for about 28 per cent of total production in the world. India's share in the international market of tea has declined substantially. At present, it ranks third among tea exporting countries in the world after Sri Lanka and China. Assam accounts for about 53.2 per cent of the total cropped area and contributes more than half of total production of tea in the country. West Bengal and Tamil Nadu are the other leading producers of tea.

Coffee: Coffee is a tropical plantation crop. Its seeds are roasted, ground and are used for preparing a beverage. There are three varieties of coffee i.e. Arabica, robusta and liberica. India mostly grows superior quality coffee, Arabica, which is in great demand in great demand in International market. But India produces only about 4.3 per cent coffee of the world and ranks sixth after Brazil, Vietnam, Colombia, Indonesia and Mexico. Coffee is cultivated in the

highlands of Western Ghats in Karnataka, Kerala and Tamil Nadu. Karnataka alone accounts for more than two third of total production of coffee in the country.

Agricultural Development in India: Agriculture continues to be an important sector Indian economy. In 2001 about 53 per cent population of the country was dependent on it. The importance of agricultural sector in India can be gauged from the fact that about 57 per cent of its land is devoted to crop cultivation, whereas, in the world, the corresponding share is only about 12 per cent. In spite of this, there is tremendous pressure on agricultural land in India, which is reflected from the fact that the land-human ratio in the country is only 0.31 ha which is almost of that of the world as a whole (0.59 ha). Despite various constrains, Indian agriculture has marched a long way since Independence.

Strategy of Development: Indian agricultural economy was largely subsistence in nature before Independence It had dismal performance in the first half of twentieth century. This period witnessed severe droughts and famines. During portion about one-third of the irrigated land in undivided India went to Pakistan. This reduced the proportion of irrigated area in Independent India. After Independence, the immediate goal of the Government was to increase food grains production by (i) switching over from cash crops to food crops; (ii) intensification of cropping over already cultivated land; and (iii) increasing cultivated area by bringing cultivable and fallow land under plough. Initially, this strategy helped in increasing food grains production. But agricultural production stagnated during late 1950s. To overcome this problem, Intensive Agricultural District Programme (IADP) and Intensive Agricultural Area Programme (IAAP) were launched. But two consecutive droughts during mid-1960s resulted in food crisis in the country. Consequently, the food grains were imported from other countries.

New seed varieties of wheat (Mexico) and rice (Philippines) known as high yielding varieties (HYVs) were available for cultivation by mid-1960s. India took advantage of this and introduced package technology comprising HYVs, along with chemical fertilizers in irrigated areas of Punjab, Haryana, Western Uttar Pradesh, Andhra Pradesh and Gujarat. Assured supply of soil moisture through irrigation was a basic pre-requisite for the success of this new agricultural technology. This strategy of agricultural development paid dividends instantly and increased the food grains production at very fast rate. This spurt of agricultural growth came to be known as 'Green Revolution'.

This also gave fillip to the development of a large number of agro-inputs, agro-processing industries and small-scale industries. This strategy of agricultural development made the country self-reliant in food grain production. But green revolution was initially confined to irrigated areas only. This led to regional disparities in agricultural development in the country till the seventies, after which the technology spread to the Eastern and Central parts of the country.

The Planning Commission of India focused its attention on the problems of agriculture in rainfed areas in 1980s. It initiated agro-climatic planning in 1988 to induce regionally balanced agricultural development in the country. It also

emphasized the need for diversification of agriculture and harnessing of resources for development of dairy farming, poultry, horticulture, livestock rearing and aquaculture.

Initiation of the policy of liberalization and free market economy in 1990s is likely to influence the course of development of Indian agriculture. Lack of development of rural infrastructure, withdrawal of subsidies and price support, and impediments in availing of the rural credits may lead to inter-regional and inter-personal disparities in rural areas.

Growth of Agricultural Output and Technology

There has been a significant increase in agricultural output and improvement in technology during the last fifty years.

- Production and yield of many crops such as rice and wheat has increased at an impressive rate. Among the other crops, the production of sugarcane, oilseeds and cotton has also increased appreciably. India ranks first in the production of pulses, tea, jute, cattle and milk. It is the second largest producer of rice, wheat, groundnut, sugarcane and vegetables.
- Expansion of irrigation has played a very crucial role in enhancing agricultural output in the country. It provided basis for introduction of modern agricultural technology such as high yielding varieties of seeds, chemical fertilizers, pesticides and farm machinery. The net irrigated area in the country has increased from 20.85 million ha over the period 1950-51 to 2000-01. Over these 50 years, are irrigated more than once in an agricultural year has increased from 1.71 to 20.46 million ha.
- Modern agricultural technology has diffused very fast in various areas of the country. Consumption of chemical fertilizers has increased by 15 times since mid-sixties. In 2001-02, per hectare consumption of chemical fertilizers in India was 91 kg which was equal to its average consumption in the world (90 kg). But in the irrigated areas of Punjab and Haryana, the consumption of chemical fertilizers per unit area is three to four times higher than that of the national average. Since the high yielding varieties are highly susceptible to pests and diseases, the use of pesticides has increased significantly since 1960s.

Problems of Indian Agriculture: Yet, there are some problems which are common and range from physical constraints to institutional hindrances. A detailed discussion on these problems follows:

Dependence on Erratic Monsoon: Irrigation covers and about 33 per cent of the cultivated area in India. The crop production in rest of the cultivated land directly depends on rainfall.

Low productivity: The yield of the crops in the country is low in comparison to the international level. The vast rainfed areas of the country, particularly drylands which mostly grow coarse cereals, pulses and oilseeds have very low yields.

Constraints of Financial Resources and Indebtedness: The inputs of modern

agriculture are very expensive. Crop failures and low returns from agriculture have forced them to fall in the trap of indebtedness.

Lack of Land Reforms: After independence, land reforms were accorded priority, but these reforms were not implemented effectively due to lack of strong political will.

Small Farm Size and Fragmentation of Landholding: There are a large number of marginal and small farmers in the country. More than 60 per cent of the ownership holdings have a size smaller than one (ha). Furthermore, about 40 per cent of the farmers have operational holding size smaller than 0.5 hectare (ha). The average size of land holding is shrinking further under increasing population pressure.

Lack of Commercialization: Most of the small and marginal farmers grow food grains, which are meant for their own family consumption. Modernization and commercialization of agriculture have however, taken place in the irrigated areas.

Vast Under-employment: In these areas, there is a seasonal unemployment ranging from 4 to 8 months. Even in the cropping season work is not available throughout, as agricultural operations are not labour intensive.

Degradation of Cultivable Land: One of the serious problems that arises out of faulty strategy of irrigation and agricultural development is degradation of land resources.

7

MINERAL AND ENERGY RESOURCES

India is endowed with a rich variety of mineral resources due to its varied geological structure. Bulk of the valuable minerals are products of pre-Paleozoic age mainly associated with metamorphic and igneous rocks of the peninsular India. The vast alluvial plain tract of north India is devoid of minerals of economic use.

The mineral resources provide the country with the necessary base for industrial development. The availability of various types of mineral and energy resources in the country.

Mode of Occurrence of Minerals

Minerals generally occur in these forms:

(i) In igneous and metamorphic rocks minerals may occur in the cracks, crevices, faults or joints. The smaller occurrences are called veins and the larger are called lodes. In most cases, they are formed when minerals in liquid/molten and gaseous forms are forced upward through cavities towards the earth's surface. They cool and solidify as they rise. Major metallic minerals like tin, copper, zinc and lead etc. are obtained from veins and lodes.

(ii) In sedimentary rocks a number of minerals occur in beds or layers. They have been formed as a result of deposition, accumulation and concentration in horizontal strata. Coal and some forms of iron ore have been concentrated as a result of long periods under great heat and pressure. Another group of sedimentary minerals include gypsum. Potash salt and sodium salt. These are formed as a reulst of evaporation especially in arid regions.

(iii) Another mode of formation involves the decomposition of surface rocks, and the removal of soluble constituents, leaving a residual mass of weathered material containing ores. Bauxite is formed this way.

(iv) Certain minerals may occur as alluvial deposits in sands of valley floors and the base of hills. These deposits are called 'placer deposits' and generally contain minerals, which are not corroded by water. Gold, silver, tin and platinum are most important among such minerals.

(v) The ocean waters contain vast quantities of minerals, but most of these are too widely diffused to be of economic significance. However,

common salt, magnesium and bromine are largely derived from ocean waters. The ocean beds, too, are rich in manganese nodules.

Rat-Hole Mining. Do you know that most of the minerals in India are nationalized and their extraction is possible only after obtaining due permission from the government? But in most of the tribal areas of the north-east India, minerals are owned by individuals or communities. In Meghalaya, there are large deposits of coal, iron ore, limestone and dolomite etc. Coal mining in Jowai and Cherapunjee is done by family member in the form of a long narrow tunnel, known as 'Rat hole' mining.

Agencies Involved in the exploration of minerals

In India, systematic surveying, prospecting and exploration for minerals is undertaken by the Geological Survey of India (GSI), Oil and Natural Gas Commission (ONGC), Mineral Exploration Corporation Ltd. (MECL), National Mineral Development Corporation (NMDC), Indian Bureau of Mines (IBM), Bharat Gold Mines Ltd. (BGML), Hindustan Copper Ltd. (HCL), National Aluminum Company Ltd. (NALCO) and the Departments of Mining and Geology in various states.

Distribution of Minerals in India

Most of the metallic minerals in India occur in the peninsular plateau region in the old crystalline rocks. Over 97 percent of coal reserves occur in the valleys of Damodar, Sone, Mahanadi and Godavari. Petroleum reserves are located in the sedimentary basins of Assam, Gujarat and Mumbai High i.e. off-shore region in the Arabian. New reserves have been located in the Krishna-Goadavari and Kaveri basins. Most of the major mineral resources occur to the east of a line linking Mangalore and Kanpur.

Minerals are generally concentrated in three broad belts in India. There may be some sporadic occurrence here and there in isolated pockets. These belts are:

The North-Eastern Plateau Region. This belt covers Chotanagpur (Jharkhand), Orissa Plateau, West Bengal and parts of Chhattsgarh.

The South-Western Plateau Region: This belt extends over Karnataka, Goa and contiguous Tamil Nadu uplands and Kerala. This belt is rich in ferrous metals and bauxite. It also contains high grade iron ore, manganese and limestone. This belt packs in coal deposits except naively lignite.

This belt does not have as diversified mineral deposits as the north-eastern belt. Kerala has deposits of monazite and thorium, bauxite clay. Goa has iron ore deposits.

The North-Western Region: This belt extends along Aravali in Rajasthan and part of Gujarat and minerals are associated with Dharwar system of rocks. Copper, zinc have been major minerals. Rajasthan is rich in building stones i.e. sandstone, granite, marble. Gypsum and Fuller's earth deposits are also extensive. Dolomite and limestone provide raw materials for cement industry. Gujarat is known for its petroleum deposits. Gujarat and Rajasthan both have rich sources of salt.

The Himalayan belt is another mineral belt where copper, lead, zinc, cobalt and tungsten are known to occur. They occur on both the eastern and western parts. Assam valley has mineral oil deposits. Besides oil resources are also found in off-shore-areas near Mumbai Coast (Mumbai High).

Ferrous Mineral: Ferrous minerals such as iron ore, manganese, chromite, etc., provide a strong base for the development of metallurgical industries. Our country is well-placed in respect of ferrous minerals both in reserves and production.

Iron Ore: India is endowed with fairly abundant resources of iron ore. It has the largest reserve of iron ore in Asia. The two main types of ore found in our country are hematite and magnetite. It has great demand in international market due to its superior quality. The iron ore mines occur in close proximity to the coal fields in the north-eastern plateau region of the country which adds to their advantage.

The total reserves of iron ore in the country were about 20 billion tones in the year 2004-05. About 95 per cent of total reserves of iron ore is located in the States of Orissa, Jharkhand, Chhattisgarh, Karnataka Goa, Andhra Pradesh and Tamil Nadu. In Orissa, iron ore occurs in a series of hill ranges in Sundergarh, Mayurbhanj and Jhar. The important mines are Gurumahisani, Sulaipet, Badampahar (Mayurbhaj), Kiruburu (Kendujhar) and Bonai (Sundergarh). Similar hill ranges, Jharkhand has some of the oldest iron ore mines and most of the iron and steel plants are located around them. Most of the important mines such as Noamundi and Gua are located in Poorbi and Pashchimi Singhbhum districts. This belt further extends to Durg, Dantewara and Bailadila. Dalli, Rajhara in Durg are the important mines of iron ore in the country. In Karnataka, iron ore deposits occur in Sandur-Hospet area of Bellary district, Baba Budan hills and Kudremukh in Chikmagalur district and parts of Shimoga, Chitradurg and Tumkur districts. The districts of Chandrapur, Bhandara and Ratnagiri in Maharashtra, Karimnagar, Warangal, Kurnool, Cuddapah and Anantapur districts of Andhra Pradesh, Salem and Nilgiris- districts of Tamil Nadu are other iron mining regions. Goa has also emerged as an important producer of iron ore.

Manganese: Manganese is an important raw material for smelting of iron ore and also used for manufacturing Ferro alloys. Manganese deposits are found in almost all geological formations; however, it is mainly associated with Dharwar system.

Orissa is the leading producer of Manganese. Major mines in Orissa are located in the central part of the iron ore belt of India, particularly in Bonai, Keudujhar, Sundergarh, Gangpur, Koraput, Kalahandi and Bolangir.

Karnataka is another major producer and here the mines are located in Dharwar, Bellary, Belgaum, North Canara, Chikmagalur, Shimoga, Chitradurg and Tumkur. Maharashtra is also an important producer of manganese which is mined in Nagpur Bhandara and Ratnagiri districts. The disadvantage to these mines is that they are located far from steel plants. The manganese belt of Madhya Pradesh extends in a belt in Balaghat-Chhindwara-Nimar-Mandla and Jhabua districts districts. Andhra Pradesh, Goa, and Jharkhand are other minor producers of manganese.

Non-Ferrous Minerals: India is poorly with non-ferrous metallic minerals except bauxite.

Bauxite: Bauxite is the ore which is used in manufacturing of aluminum. Bauxite is found mainly in tertiary deposits and is associated with laterite rocks occurring

extensively either on the plateau or hill ranges of peninsular India and also in the coastal tracts of the country.

Orissa happens to be the largest producer of Bauxite. Kalahandi and Sambalpur are the leading producers. The other two areas which have been increasing their production are Bolangir and Koraput. The patlands of Jharkhand in Lohardaga have rich deposits. Gujarat, Chhattisgarh, Madhya Pradesh and Maharashtra are other major producers. Bhavnagar, Jamnagar in Gujarat have the major deposits. Chhattisgarh has bauxite deposits in Amarkantak plateau while Katni-Jabalpur area and Balaghat in M.P. have important deposits of bauxite. Kolaba, Thane, Ratnagiri, Satara, Pune and Kolhapur in Maharashtra are important producers. Tamil Nadu. Karanataka and Goa are minor producers of bauxite.

Copper: Copper is an indispensable metal in the electrical industry for making wires, electric motors, transformers and generators. It is alloyable. Malleable and ductile. It is also mixed with gold to provide strength to jewellery.

The Copper deposits mainly occur in Singhbhum district in Jharkhand, Balaghat district in Madhya Pradesh and Jhunjhunu and Alwar districts in Rajasthan.

Minor producers of Copper are Agnigundala in Guntur District (Andhra Pradesh), Chitradurg and hasan districts (Karnataka) and South Arcot district (Tamil Nadu).

Non-metallic Minerals: Among the non-metallic minerals produced in India, mica is the important one. The other minerals extracted for local consumption are limestone, dolomite and phosphate.

Mica: Mica is mainly used in the electrical and electronic industries. It can be split into very thin sheets which are tough and flexible. Mica in India is produced in Jharkhand, Andhra Pradesh and Rajasthan followed by Tamil Nadu, West Bengal and Madhya Pradesh. In Jharkhand high quality mica is obtained in a belt extending over a distance of about 150 km, in length and about 22 km, in width in lower Hazaribagh plateau. In Andhra Pradesh. Nellore district produces the best quality mica. In Rajasthan mica belt extends for about 320 kms from Jaipur to Bhilwara and around Udaipur. Mica deposits also occur in Mysore and Hassan districts of Karnataka, Coimbatore. Tiruchirapalli, Madurai and Kanniyakumari in Tamil Nadu, Alleppey in Kerala, Ratnagiri in Maharashtra, Purulia and Bankura in West Bengal.

Energy Resources: Mineral fuels are essential for generation of power, required by agriculture, industry, transport and other sectors of the economy. Mineral fuels like coal, petroleum and natural gas (known as fossil fuels), nuclear energy minerals, are the conventional sources of energy. These conventional sources are exhaustible resources.

Coal: Coal is a one of the important minerals which is mainly used in the generation of thermal power and smelting of iron ore. Coal occurs in rock sequences mainly of two geological ages, namely Gondwana and tertiary deposits.

Lignite is a low grade brown coal, which is soft with high moisture content. The principal lignite reserves are in Neyveli in Tamil Nadu and are used for generation of electricity. Coal that has been buried deep and subjected to increased temperatures is

bituminous coal. It is the most popular coal in commercial use. Metallurgical coal is high grade bituminous coal which has a special value for smelting iron in blast furnaces.

Anthracite is the highest quality hard coal. About 80 per cent of the coal deposits in India is of bituminous type and is of non-coking grade. The most important Gondwana coal fields of India are located in Damodar Valley.

They lie in Jharkhand-Bengal coal belt and the important coal fields in this region are Raniganj, Jharia, Bokaro, Giridih, Karanpura.

Jharia is the largest coal field followed by Raniganj. The other river valleys associated with coal are Godavari, Mahanadi and Sone. The most important coal mining centres are Singrauli in Madhya Pradesh (part of Singrauli coal field lies in Uttar Pradesh), Korba in Chhattisgarh, Talcher and Rampur in Orissa, Chanda-Wardha, Kamptee and Bander in Maharashtra and Singareni and Pandur in Andhra Pradesh.

Tertiary coals occur in Assam, Arunachal Pradesh, Meghalaya and Nagaland. It is extracted from Darangiri, Cherrapunji, Mewlong and Langrin (Meghalaya); Makum, Jaipur and Nazira in upper Assam, Namchik-Namphuk (Arunachal Pradesh) and Kalakot (Jammu and Kashmir). Besides, the brown coal or lignite occur in the coastal areas of Tamil Nadu, Pondicherry, Gujarat and Jammu and Kashmir.

Petroleum: Crude petroleum consists of hydrocarbons of liquid and gaseous states varying in chemical composition, colour and specific gravity. It is an essential source of energy for all internal combustion engines in automobiles, railways and aircraft. Its numerous by-products are processed in petrochemical industries such as fertilizer, synthetic fibre, medicines, Vaseline, lubricants, wax, soap and cosmetics.

Most of the petroleum occurrences in India are associated with anticlines and fault traps in the rock formations of the tertiary age. In regions of folding, anticlines or domes, it occurs where oil is trapped in the crest of the up fold. The oil bearing layer is a porous limestone or sandstone through which oil may flow. The oil is prevented from rising or sinking by intervening non-porous layers.

Petroleum is also found in fault traps between porous and non-porous rocks. Gas, being lighter usually occurs above the oil.

About 63 per cent of India's petroleum production is from Mumbai High, 18 per cent from Gujarat and 16 per cent from Assam.

Crude petroleum occurs in sedimentary rocks of the tertiary period. Oil exploration and production was systematically taken up after the Oil and Natural Gas Commission was set up in 1956. Till then, the Digboi in Assam was the only oil producing region but the scenario has changed after 1956. In recent years, new oil deposits have been found at the extreme western and eastern parts of the country. In Assam, Digboi, Naharkatiya and Moran are important oil producing areas. The major oil fields of Gujarat are Ankaleshwar, Kalol, Mehsana, Nawagam, Kosamba and Lunej. Mumbai High which lies 160 km off Mumbai was discovered in 1973 and production commenced in 1976. Oil and natural gas have been found in exploratory wells in Krishna-Godavari and Kaveri basin on the east coast.

Oil extracted from the well is crude oil

and contains many impurities. It cannot be used directly. It needs to be refined. There are two types of refineries in India: (a) field based and (b) market based. Digboi is an example of field based and Barauni is an example of market based refinery.

Natural Gas: The Gas Authority of India Limited was set up in 1984 as a public sector undertaking to transport and market natural gas. It is obtained alongwith oil in all the oil fields but exclusive reserves have been located along the eastern coast as well as (Tamil Nadu, Orissa and Andhra Pradesh), Tripura, Rajasthan and off-shore wells in Gujarat and Maharashtra.

Nuclear Energy Resources: Nuclear energy as a viable source in recent times. Important minerals used for the generation of nuclear energy are uranium and thorium. Uranium deposits occur in the Dharwar rocks. Geographically, uranium ores are known to occur in several locations along the Singbhum Copper belt. It is also found in Udaipur, Alwar and Jhunjhunu districts of Rajasthan, Durg district of Chhattisgarh, Bhandara district of Maharashtra and Kullu district of Himachal Pradesh. Thorium is mainly obtained from monazite and ilmenite in the beach sands along the coast of Kerala and Tamil Nadu. World's richest monazite deposits occur in Palakkad and Kollam districts of Kerala, near Vishakhapatnam in Andhra Pradesh and Mahanadi river delta in Orissa.

Atomic Energy Commission was established in 1948, progress could be made only after the establishment of the Atomic Energy Institute at Trombay in 1954 which was renamed as the Bhabha Atomic Research Centre in 1967. The important nuclear power projects are Tarapur (Maharashtra), Rawatbhata near Kota (Rajasthan), Kalpakkam (Tamil Nadu), Narora (Uttar Pradesh), Kaiga (Karnataka) and Kakarapara (Gujarat).

Non-Conventional Energy Sources: Fossil fuel sources, such as coal, petroleum, natural gas and nuclear energy use exhaustible raw materials. Sustainable energy resources are only the renewable energy sources like solar, wind, hydro-geothermal and biomass. These energy sources are more equitably distributed and environmental friendly. The non-conventional energy sources will provide more sustained, eco-friendly cheaper energy after the initial cost is taken care of.

Solar Energy: Sun rays tapped in photovoltaic cells can be converted into energy, known as solar energy. The two effective processes considered to be very effective to tap solar energy are photovoltaics and solar thermal technology. Solar thermal technology has some relative advantages over all other non-renewable energy sources. It is cost competitive, environment friendly and easy to construct. Solar energy is 7 per cent more effective than coal or oil based plants and 10 per cent more effective than nuclear plants. It is generally used more in appliances like heaters, crop dryers, cookers, etc. The western part of India has greater potential for the development of solar energy in Gujarat and Rajasthan.

Wind Energy: Wind energy is absolutely pollution free, inexhaustible source of energy. The mechanism of energy conversion from blowing wind is simple. The kinetic energy of wind, through turbines is converted into electrical energy. The

permanent wind systems such the trade winds, westerly's and seasonal wind like monsoon have been used as source of energy. Besides these, local winds, land and sea breezes can also be used to produce electricity.

India, already has started generating wind energy. It has an ambitious programme to install 250 wind-driven turbines with a total capacity of 45 megawatts, spread over 12 suitable locations, specially in coastal areas. According to the estimation by Ministry of Power, India will be able to produce 3,000 megawatts of electric from this source. The Ministry of non-conventional sources of energy is developing wind energy in India to lessen the burden of oil import bill. The country's potential of wind power generation exceeds 50,000 megawatts; of which one fourth can be easily harnessed. In Rajasthan, Gujarat, Maharashtra and Karnataka, favourable conditions for wind energy exist. Wind power plant at Lamba in Gujarat in Kachchh is the largest in Asia. Another, wind power plant is located at Tuticorin in Tamil Nadu.

Tidal and Wave Energy: Ocean currents are the store-house of infinite energy. Since the beginning of seventeenth and eighteenth century, persistent efforts were made to create a more efficient energy system from the ceaseless tidal waves and ocean current.

Large tidal waves are known to occur along the west coast of India. Hence, India has great potential for the development of tidal energy along the coasts but so far these have not yet been utilized.

In India, the Gulf of Kuchchh, provides ideal conditions for utilizing tidal energy. A 900 mw tidal energy power plant is set up here by the National Hydropower Corporation.

Geothermal Energy: When the magma from the interior of earth, comes out on the surface, tremendous heat is released. This heat energy can successfully be tapped and converted to electrical energy. Apart from this, the hot water that gushes out through the gyser well is also used in the generation of thermal energy. It is popularly known as Geothermal energy. This energy is now considered to be one of the key energy sources which can be developed as an alternate source. The hot springs and geysers are being used since medieval period.

The first successful (1890) attempt to tap the underground heat was made in the city of Boise, Idaho (U.S.A.), where a hot water pipe network was built to give heat to the surrounding buildings. This plant is still working.

Bio-energy: Bio-energy refers to energy derived from biological products which includes agricultural residues, municipal, industrial and other wastes.

Establishment of iron and steel industry in Bhilai and Rourkela were based on decision to develop backward tribal areas of the country. At present, government of India provides lots of incentives to industries locating in backward area.

Major Industries

The iron and steel industry is basic to the industrial development of any country. The cotton textile Industry is one of our traditional industries. The sugar Industry is based on local raw materials which prospered even in the British period.

The Iron and Steel Industry

The development of the iron and steel industry opened the doors to rapid industrial

development in India. Almost all sectors of the Indian industry depend heavily on the iron and steel industry for their basic infrastructure.

The other raw materials besides iron ore and coking coal, essential for iron and steel industry are limestone, dolomite, manganese and fire clay. All these raw materials are gross (weight losing), therefore, the best location for the iron and steel plants is near the source of raw materials. In India, there is a crescent shaped region comprising parts of Chhattisgarh, Northern Orissa, Jharkhand and western West Bengal, which is extremely rich in high grade iron ore, good quality coking coal and other supplementing raw materials.

The Indian iron and steel industry consists of large integrated steel plants as well as mini steel mills. It also includes secondary producers, rolling mills and ancillary industries.

Integrated Steel Plants

TISCO: The Tata Iron and Steel plant lies very close to the Mumbai-Kolkata railway line and about 240 km away from Kolkata, which is the nearest port for the export of steel. The rivers Subarnarekha and Kharkai provide water to the plant. The iron ore for the plant is obtained from Noamundi and Badam Pahar and coal is brought from Joda mines in Orissa. Coking coal comes from Jharia and West Bokaro coalfields.

IISCO: The Indian Iron and Steel Company (IISCO) set up its first factory at Hirapur and later on another at Kulti. In 1937, the Steel corporation of Bengal was constituted in association with IISCO and set up another iron and steel producing unit at Burnpur (West Bengal). All the three plants under IISCO are located very close to Damodar valley coal fields (Raniganj), Jharia, and Ramgarh. Iron ore comes from Singhbhum in Jharkhand. Water is obtained from the Barakar River, a tributary of the Damodar. All the plants are located along the Kolkata-Asansol railway line. Unfortunately, steel production from IISCO fell considerably in 1972-73 and the plants were taken over by the government.

Visvesvaraiya Iron and Steel Works Ltd. (VISL)

The third integrated steel plant, the Visvesvaraiya Iron and Steel Works, initially called the Mysore Iron and Steel Works, is located close to an iron ore producing area of Kemangundi in the Bababudan hills. Limestone and manganese are also locally available. But this region has no coal. At the beginning, charcoal obtained by burning wood from nearby forests was used as fuel till 1951. Afterwards, electric furnaces were installed which use hydroelectricity from the Jog Falls-hydel power project. The Bhadravati river supplies water to the plant. This plant produces specialized steels and alloys.

After independence, during the Second Five Year Plan (1956-61), three new integrated steel plants were set up with foreign collaboration: Rourkela in Orissa, Bhilai in Chhattisgarh and Durgapur in West Bengal. These were public sector plants under Hindustan Steel Limited (HSL). In 1973, the Steel Authority of India Limited (SAIL) was created to manage these plants.

Rourkela Steel Plant

The Rourkela Steel plant was set up in 1959 in the Sundargarh district of Orissa in collaboration with Germany. The plant was located on the basis of proximity to raw

materials, thus, minimizing the cost of transporting weight losing raw material. This plant has a unique locational advantage, as it receives coal from Jharia (Jharkhand) and iron ore from Sundargarh and Kendujhar. The Hirakud project supplies power for the electric furnaces and water is obtained from the Koel and Sankh rivers.

Bhilai Steel Plant

The Bhilai Steel Plant was established with Russian collaboration in Durg District of Chhattisgarh and started production in 1959. The iron ore comes from Dalli-Rajhara mine, coal comes from Korba and Kargali coal fields. The water comes from the Tanduladam and the power from the Korba Thermal Power Station. This plant also lies on the Kolkata-Mumbai railway route. The bulk of the steel produced goes to the Hindustan Shipyard at Vishakhapatnam.

Durgapur Steel Plant: Durgapur Steel Plant, in West Bengal, was set up in collaboration with the government of the United Kingdom and started production in 1962. This plant lies in Raniganj and Jharia coal belt and gets iron ore from Noamundi. Durgapur lies on the main Kolkata-Delhi railway route. Hydel power and water is obtained from the Damodar Valley Corporation (DVC).

Bokaro Steel Plant: This steel plant was set up in 1964 at Bokaro with Russian collaboration. This plant was set up on the principle of transportation cost minimization by creating Bokaro-Rourkela combine. It receives iron ore from the Rourkela region and the wagons on return take coal to Rourkela. Other raw materials come to Bokaro from within a radius of about 350 km. Water and Hydel power is supplied by the Damodar Valley Corporation.

Other Steel Plants: New steel plants which were set up in the Fourth Plan period are away from the main raw material sources. All the three plants are located in South India. The Vizag Steel Plant, in Vishakhapatnam in Andhra Pradesh is the first port based plant which started operating in 1992. Its port location is of advantage.

The Vijaynagar Steel Plant at Hospet in Karnataka was developed using indigenous technology. This uses local iron ore and limestone. The Salem Steel Plant in Tamil Nadu was commissioned in 1982.

Apart from these major steel plants, there are more than 206 units located in different parts of country. Most of these use scrap iron as their main raw material, and process it in electric furnaces.

The Cotton Textile Industry

In 1854, the first modern cotton mill was established in Mumbai. This city had several advantages as a cotton textile manufacturing centre. It was very close to the cotton producing areas of Gujarat and Maharashtra. Raw cotton used to be brought to Mumbai port to be transported to England. Therefore, cotton was available in Mumbai city itself, Moreover, Mumbai even then was the financial centre and the capital needed to start an industry was available there. As a large town, providing employment opportunities attracted labour in large numbers. Hence, cheap and abundant labour too was available locally. The machinery required for a cotton textile mill could be directly imported from England. Subsequently, two more mills, the Shahpur Mill and the Calico Mill were established in Ahmedabad. By 1947, the number of mills in

India went up to 423 but the scenario changed after partition, and this industry suffered a major recession. This was due to the fact that the most of the good quality cotton growing areas had gone to West Pakistan and India was left with 409 mills and only 29 per cent of the cotton producing area.

After Independence, this industry gradually recovered and eventually flourished. In 1998, India had 1782 mills; of which, 192 mills were in the public sector and 151 mills in the cooperative sector. The largest number, that is, 1,439 mills were in the private sector.

The cotton textile industry in India can be broadly divided into two sectors, the organized sector and the decentralized sector. The decentralized sector includes cloth produced in handlooms (including Khadi) and power looms. The production of the organized sector has drastically fallen from 81 per cent in the mid-twentieth century to only about 6 per cent in 2000. At present, the power looms on the decentralized sector produce more than 59 per cent and the hand loom sector produces about 19 per cent of all cotton cloth produced in the country.

Cotton is a "pure" raw material which does not lose weight in the manufacturing process, so other factors, like, power to drive the looms, labour, capital or market may determine the location of the industry. At present the trend is to locate the industry at or close to markets, as it is the market that decides what kind of cloth is to be produced. Also the market for the finished produces is extremely variable, therefore, it becomes important to locate the mills close to the market.

After the first mills were set up in Mumbai and Ahmedabad in the second half of the nineteenth century, the cotton textile industry expanded very rapidly. The number of units increased dramatically. The Swadeshi movement gave a major impetus to the industry as there was a call for boycotting all British made goods in favour of Indian goods. After 1921, with the development of the railway network other cotton textile centres expanded rapidly. In southern India, mills were set up at Coimbatore, Madurai and Bangalore. In central India, Nagpur, Indore, Solapur and Vadodra became cotton textile centres. Cotton textile mills were set up at Kanpur based on local investment. Mills were also set up at Kolkata due to its port facilities. The development of hydro-electricity also favoured the location of the cotton textile mills away from the cotton producing areas. The rapid development of this industry in Tamil Nadu is the result of the abundant availability of hydel power for the mills. Lower labour costs at centres like Ujjain, Bharuch, Agra, Hathras, Coimbatore and Tirunelveli also caused industries to be located away from cotton producing areas.

Thus, the cotton textile industry is located in almost every state in India, where one or more of the locational factors have been favourable. The importance of raw materials has given way to market or to a cheaper local labour force or it may be the availability of power.

Presently, the major centres of the cotton textile industry are Ahmedabad, Bhiwandi, Solapur, Kolhapur, Nagpur, Indore and Ujjain. All these centres are the traditional centres and are located close to the cotton producing regions. Maharashtra, Gujarat and Tamil Nadu are the leading cotton producing

states. West Bengal, Uttar Pradesh, Karnataka, and Punjab are the other important cotton textile producers.

Tamil Nadu has the largest number of mills and most of them produce yarn rather than cloth. Coimbatore has emerged as the most important centre with nearly half the mills located there. Chennai, Madurai, Tirunelveli, Tuticorin, Thanjavur, Ramanathapuram and Salem are the other important centres. In Karnataka, the cotton textile industry has developed in the cotton producing areas in the north-eastern part of the state. Davangere, Hubli, Bellary, Mysore and Bangalore are important centres. In Andhra Pradesh, the cotton textile industry is located in the cotton producing Telengana region, where most of the mills are spinning mills producing yarn. The important centres are Hyderabad, Secundrabad, Warangal and Guntur.

In Uttar Pradesh, Kanpur is the largest centre. Some of the other important centres are Modinagar, Hathras, Saharanpur, Agra and Lucknow. In West Bengal, the cotton mills are located in the Hugli region. Howrah, Serampur, Kolkata and Shyamnagar are the important centres. Production of cotton cloth increased almost five times from 1950-51 to 1999-2000. Cotton textile has been facing tough competition from synthetic cloth.

8

SUGAR INDUSTRY

The sugar industry is the second most important agro-based industry in the country. India is the largest producer of both sugarcane and cane sugar and contributes about 8 per cent of the total sugar production in the world. Besides, khandasari and gur or jaggery are also prepared from sugarcane. This industry provides employment for more than 4 lakh persons directly and a large number of farmers indirectly. Sugar industry is a seasonal industry because of the seasonality of raw materials.

Development of the industry on modern lines dates back to 1903, when a sugar mill was started in Bihar. Subsequently, sugar mills were started in other parts of Bihar and Uttar Pradesh. In 1950-51, 139 factories were in operation producing 11.34 lakh tones of sugar. The number of sugar factories rose to 506 and production to 176,99 lakh tones in 2000-01.

Location of the Sugar Industry

Sugarcane is a weight-losing crop. The ratio of sugar to sugarcane varies between 9 to 12 per cent depending on its variety. Its sucrose content begins to dry during haulage after it has been harvested from the field. Better recovery of sugar is dependent upon its being crushed within 24 hours of its harvesting. Sugar factories hence, are located within the cane producing regions.

Maharashtra has emerged as a leading sugar producer in the country and produces more than one-third of the total production of the sugar in the country. There are 119 sugar mills in the state in a narrow belt extending from Manmad in the north to Kolhapur in the south. There are 87 mills in the cooperative sector.

Uttar Pradesh is the second largest producer of sugar. The sugar factories are concentrated in two belts- the Ganga-Yamuna doab and the taria region. The major sugar producing centres in the Ganga- Yamuna doab are Saharanpur, Muzaffarnagar, Meerut, Ghaziabad, Baghpat and Bulandshehr districts; while Kheri Lakhimpur, Basti, Gonda, Gorakhpur, Bahraich are important sugar producing districts in the Tarai region.

In Tamil Nadu, sugar factories are located in Coimbatore, Vellore, Tiruvanamalai, Villupuram and Tiruchchirappalli districts. Belgaum, Bellary, Mandya, Shimoga, Bijapur, and Chitradurg districts are the major producers in Karnataka. The industry is distributed in the coastal regions i.e. East Godawari, West Godavari, Vishakhapatnam districts and Nizamabad, and Medak districts of Telangana alongwith Chittoor district of Rayalseema.

The other States which produce sugar

are Bihar, Punjab, Haryana, Madhya Pradesh and Gujarat. Saran, Champaran, Muzaffarnagar, Siwan, Darbhanga, and Gaya are the important sugarcane producing districts in Bihar. The relative significance of Punjab has declined, although Gurdaspur, Jalandhar, Sangarur, Patiala and Amrtisar are major sugar producers. In Haryana, sugar factories are located in Yamuna Nagar, Rohtak, Hissar and Faridabad districts. Sugar industry is comparatively new in Gujarat. Sugar mills are located in the cane growing tracts of Surat, Junagarh, Rajkot, Amreli, Valsad and Bhavnagar districts.

Petrochemical Industries

This group of industries has been growing very fast in India. A variety of products come under this category of industries. In 1960s, demand for organic chemicals increased so fast that it became difficult to meet this demand. At that time. Petroleum refining industry expanded rapidly. Many items are derived from crude petroleum, which provide raw materials for many new industries; these are collectively known as petrochemical industries. This group of industries is divided into four subgroups; (i) polymers, (ii) synthetic fibres, (iii) elastomers, and (iv) surfactant intermediate. Mumbai is the hub of the petrochemical industries. Cracker units are also located in Auraiya (Uttar Pradesh), Jamnagar, Gandhinagar, and Hajira (Gujarat), Nagothane, Ratnagiri (Maharashtra), Haldia (West Bengal) and Vishakhapatnam (Andha Pradesh).

Three organizations are working in the petrochemical sector under the administrative control of the Department of Chemicals and Petrochemicals. First is the Indian Petrochemical Corporation Limited (IPCL), a public sector undertaking. It is responsible for the manufacture and distribution of the various petrochemicals like polymers, chemicals, fibres and fibre intermediates. Second is the Petrofils Cooperative Limited (PCL), a joint venture of the Government of India and Weaver's Cooperative Societies. It produces polyester filament yarn and nylon chips at its two plants located at Vadodara and Naldhari in Gujarat. Third is the Central Institute of Plastic Engineering and Technology (CIPET), involved in imparting training in petrochemical industry.

Polymers are made from ethylene and propylene. These materials are obtained in the process of refining crude oil. Polymers are used as raw materials in the plastic industry. Among polymers, polyethylene is a widely used thermoplastic. Plastic is first covered into sheets, power, resin and pellets, and then used in manufacturing plastic products. Plastic products are preferred because of their strength, water and chemical resistance and low prices. Production of plastic polymers started in India in the late fifties and the early sixties using other organic chemicals. The National Organic Chemicals Industries Limited (NOCIL), established in private sector in 1961, started the first naphtha based chemical industry in Mumbai. Later, several other companies were formed. The plants located at Mumbai, Barauni, Mettur, Pimpri and Rishra are major producers of plastic materials.

About 75 per cent of these units are in small scale sector. The industry also uses recycled plastics, which constitutes about 30 per cent of the total production.

Synthetic fibres are widely used in the

manufacturing of fabrics because of their inherent strength, durability, wash ability, and resistance to shrinkage. Industries manufacturing nylon and polyester yarns are located at Kota, Pimpri, Mumbai, Modinagar, Pune, Ujjain, Nagpur and Udhna. Acrylic staple fibre is manufactured at Kota and Vadodara.

Though plastics have becomes inseparable items in our daily use and they have affected our life style. But due to its non-biodegradable quality it has emerged as the greatest threat to our environment. Hence, use of plastic is being discouraged in different states of India.

Knowledge based Industries

The advancement in information technology has had a profound influence on the country's economy. The Information Technology (IT) revolution opened up new possibilities of economic and social transformation. The IT and IT enabled business process outsourcing (ITESBPO) services continue to be on a robust growth path. Indian software industry has emerged as one of the fastest growing sectors in the economy. Exports of the Indian software and services sector were Rs. 78,230 crore in 2004-05 which is approximately 30-32 per cent increase from the previous year. The software industry has surpassed electronic hardware production. The Indian government has created a number of software parks in the country.

The IT software and services industry account for almost 2 per cent of India's GDP. India's software industry has achieved a remarkable distinction for providing quality products. A large number of Indian software companies have acquired international quality certification. A majority of the multinational companies operating in the area of information technology have either software development centres or research development centres in India. However, in the hardware development sector, India is yet to make any remarkable achievements.

A major impact of this growth has been on employment creation, which is almost doubled every year.

Liberalization, Privatization, Globalization (LPG) and Industrial Development in India

The new Industrial Policy was announced in 1991. The major objectives of this policy were to build on the gains already made, correct the distortions or weaknesses that have crept in, maintain a sustained growth in productivity and gainful employment and attain international competitiveness.

Within this policy, measures initiated are: (1) abolition of industrial licensing, (2) free entry to foreign (technology, (3) foreign investment policy, (4) access to capital market, (5) open trade, (6) abolition of phased manufacturing programme, and (7) liberalized industrial location programme. The policy has three main dimensions: privatization and globalization.

The industrial licensing system has been abolished for all except six industries related to security, strategic or environmental concerns. At the same time, the number of industries reserved for public sector since 1956 have been reduced from 17 to 4. Industries related to atomic energy substances specified in the schedule of the Department of Atomic Energy as well as Railways have remained under the public sector. The government also have decided

to offer a part of the shareholdings in the public enterprises to financial institutions, general public and workers. The threshold limits of assets have been scrapped and no industry required prior approval for investing in the delicensed sector. They only need to submit a memorandum in the prescribed format.

In the new industrial policy, Foreign Direct Investment (FDI) has been seen as a supplement to the domestic investment for achieving a higher level of economic development. FDI benefits the domestic industry as well as the consumers by providing technological upgradation, access to global managerial skills and practices, optimum use of natural and human resources, etc. Keeping all this in mind, foreign investment has been liberalized and the government has permitted access to an automic route for Foreign Direct Investment. The government has also announced changes in the industrial location policies. Industries are discouraged in or very close to large cities due to environmental reasons.

The industrial policy has been liberalized to attract private investor both domestic and multinationals. New sectors like, mining, telecommunication, highway construction and management have been thrown open to private companies. In spite of all these concessions, Foreign Direct Investment has not been up to the expectation. There has been a big gap between approved and actual foreign direct investment, even though the numbers of foreign collaborations are increasing. Larger parts of this investment have gone to domestic appliances, finance, services, electronics and electrical equipment, and food and dairy products.

Globalization means integrating the economy of the country with the world economy. Under this process, goods and services along with capital, labour and resources can move freely from one nation to another. The thrust of globalization has been to increase the domestic and external competition through extensive application of market mechanism and facilitating dynamic relationship with the foreign investors and suppliers of technology. In Indian context, this implies: (1) opening of the economy to foreign direct investment by providing facilities to foreign companies to invest in different fields of economies activity in India; (2) removing restrictions and obstacles to the entry of multinational companies in India; (3) allowing Indian companies to enter into foreign collaboration in India and also encouraging them to set up joint ventures abroad; (4) carrying out massive import liberalization programs by switching over from quantitative restrictions to tariffs in the first place and then bringing down the level of import duties considerably; and (5) instead of a set of export in incentives, opting for exchange rate adjustments for promoting export.

Industrial Region and Districts

Major Industrial Regions (8)

1. Mumbai-Pune Region,
2. Hugli Region,
3. Bangalore-Tamil Nadu Region,
4. Gujarat Region,
5. Chotanagpur Region,
6. Vishakhapatnam-Guntur Region,
7. Gurgaon-Delhi-Meerut Region and
8. Kollam-Tiruvantapuram Region.

Minor Industrial Regions (13)

1. Ambala-Amritsar,
2. Saharanpur-Muzaffarnagar-Bijnor,
3. Indore-Dewas-Ujjain,
4. Jaipur-Ajmer,
5. Molhapur-South Kannada,
6. Northern Malabar,
7. Middle Malabar,
8. Adilabad-Nizamabad,
9. Allahabad-Varanasi-Mirzapur,
10. Bhojpur-Munger,
11. Durg-Raipur,
12. Bilaspur-Korba, and
13. Brahmaputra valley.

Industrial Districts (15)

1. Kanpur,
2. Hyderabad,
3. Agra,
4. Nagpur,
5. Gwalior,
6. Bhopal,
7. Lucknow,
8. Jalpaiguri,
9. Cuttak,
10. Gorakhpur,
11. Aligarh,
12. Kota,
13. Purnia,
14. Jabalpur, and
15. Bareilly.

A breakup of foreign collaboration approval reveals that the major share went to core, priority sectors while infrastructural sector was untouched. Further, gap between developed and developing states has become wider. Major share of both domestic investment as well as foreign direct investment went to already developed states. For example, out of the total proposed investment by the industrial entrepreneurs during 1991-2000 nearly one fourth (23 per cent) was for industrially developed Maharashtra, 17 per cent for Gujarat, 7 per cent for Andhra Pradesh, and about 6 per cent for Tamil Nadu while Uttar Pradesh, the state with the largest population has only 8 per cent. In spite of several concessions, seven north-eastern states could get less than 1 per cent of the proposed investment. In fact, economically weaker states could not compete with the developed states in open market in attracting industrial investment proposals and hence they are likely to suffer from these processes.

Industrial Regions in India

Industries are not evenly distributed in the country. They tend to concentrate on certain locations because of the favourable locations factors.

Several indices are used to identify the clustering of industries, important among them are: (i) the number of industrial units, (ii) number of industrial workers, (iii) quantum of power used for industrial purposes, (iv) total industrial output, and (v) value added by manufacturing etc.

Major industrial regions of the country are given below in some details.

Mumbai-Pune Industrial Region

It extends from Mumbai-Thane to Pune and in adjoining districts of Nasik and Solapur. Besides, industrial development has been rapid in Kolaba, Ahmednagar, Satara, Sangli and Jalgaon districts. Development of this region started with the location of cotton

textile industry in Mumbai. Mumbai, with cotton hinterland and moist climate favoured the location of cotton textile industry. Opening of the Suez Canal in 1869 provided impetus to the growth of Mumbai port. Machineries were imported through this port. Hydro-electricity was developed in the Western Ghat region to meet requirements of this industry.

With the development of cotton textile industry, chemical industry also developed. Opening of the Mumbai High petroleum field and erection of nuclear energy plants added additional pull to this region.

Besides, engineering goods, petroleum refining, petrochemicals, leather, synthetic and plastic goods, drugs, fertilizers, electrical, shipbuilding, electronics, software, transport equipments and food industries also developed. Important industrial centres are Mumbai, Kolaba, Kalyan, Thane, Trombay, Pune, Pimpri, Nasik, Manmad, Solapur, Kolhapur, Ahmednagar, Satara and Sangli.

Hugli Industrial Region

Located along the Hugli river, this region extends from Bansberia in the north to Birlanagar in the south for a distance of about 100 km. Industries also have developed in Mednipur in the west. Kolkata- Howrah from the nucleus of this industrial region. Historical, geographical, economic and political factor have contributed much to its development. It developed with the opening of river port on Hugli. Kolkata, emerged as a leading centre of the country, Later, Kolkata was connected with interior parts by railway lines and road routes. Development of tea plantations in Assam and northern hills of West Bengal, the processing of indigo earlier and jute later coupled with the opening of coalfields of the Damodar Valley and iron ore deposits of the Chotanagpur plateau, contributed to the industrial development of the region. Cheap labour available from thickly populated part of Bihar, eastern Uttar Pradesh and Orissa also contributed to its development. Kolkata, being the capital city of British India (1773-1911), attracted the British capital. The establishment of first jute mill at Rishra in 1855 ushered in the era of modern industrial clustering in this region.

The major concentration of jute industry is at Howrah and Bhatapara. The partition of the country in 1947 adversely affected this industrial region. Cotton textile industry also grew along with jute industry, paper, engineering, textile machinery, electrical, chemical, pharmaceuticals, fertilizer and petrochemical industries have also developed within this region. Factory of the Hindustan Motors Limited at Konnagar and diesel engine factory at Chittaranjan are landmarks of this region. Location of petroleum refinery at Haldia has facilitated the development of a variety of industries. Important, industrial centres of this region are Kolkata, Haora, Haldia, Serampur, Rishra, Shibpur, Nahati, Kakinara, Shamnagar, Titagarh, Sodepur, Budge Budge, Birlanagar, Bansberia, Belgurriah, Triveni, Hugli, Belur, etc. However, industrial growth of this region has slowed down in comparison to other regions. Decline of the jute industry is one of the reasons.

Bangalore-Chennai Industrial Region

This region witnessed most rapid industrial growth in post-Independence period. Till 1960, industries were confined to Bangalore, Salem and Madurai districts but now they have spread over all the districts

of Tamil Nadu except Viluppuram. Since, this region is away from the coalfields, its development is dependent on the Pykara hydroelectric plant, which was built in 1932. Cotton textile industry was the first to take roots due to the presence of cotton growing areas. Along with cotton mills, loom industry spread very rapidly. Several heavy engineering industries converged at Bangalore. Aircraft (HAL), machine tools, telephone (HTL) and Bharat Electronics are industrial landmarks of this region. Important industries are textiles rail wagons, diesel engines, radio, light engineering goods, rubber goods, medicines, aluminum, sugar, cement, glass, paper, chemicals, film, cigarette, match box, leather goods, etc. Petroleum refinery at Chennai, iron and steel plant at Salem and fertilizer plants are recent developments.

Gujarat Industrial Region

The nucleus of this region lies between Ahmedabad and Vadodara but this region extends upto Valsad and Surat in the south and to Jamnagar in the west. Development of this region is also associated with the location of the cotton textile industry since 1860s. This region became an important textile region with the decline of the cotton textile industry at Mumbai.

Located in cotton growing area, this region has double advantage of the proximity of raw materials as well as of market. The discovery of oil fields led to the establishment of petrochemical industries around Ankleshwar, Vadodara and Jamnagar. The port at Kandla helped in the rapid growth of this region. Petroleum refinery at Koyali provided raw materials to a host of petrochemical industries.

The industrial structure is now diversified. Besides, textiles (cotton, silk and synthetic fabrics) and petrochemical industries, other industries are heavy and basic chemicals, motor, tractor, diesel engines, textile machinery, engineering, pharmaceuticals. Dyes, pesticides, sugar, dairy products and food processing. Recently, largest petroleum refinery has been set up at Jamnagar. Important industrial centres of this region are Ahmedabad, Vadodara, Bharuch, Koyali, Anand, Khera, Surendranagar, Rajkot, Valsad and Jamnagar.

Chotanagpur Region

This region extends over Jharkhand, northern Orissa and western West Bengal and is known for the heavy metallurgical industries. This region owes its development to the discovery of coal in the Damodar Valley and metallic and non-metallic in Jharkhand and northern Orissa. Proximity of coal, iron ore and other minerals facilitated the location of heavy industries in this region. Six large integrated iron and steel plants at Jamshedpur, Burnpur-Kulti, Durgapur, Bokaro and Rourkela are located within this region. To meet the power requirement, thermal and hydroelectric plants have been constructed in the Damodar Valley. Densely populated surrounding regions provide cheap labour and Hugli region provides vast market for its industries. Heavy engineering, machine tools, fertilizers, cement, paper, locomotives and heavy electrical are some of the important industries in this region. Important centres are Ranchi, Dhanbad, Chaibasa, Sindri, Hazaribag, Jamshedpur, Bokaro, Rourkela, Durgapur, Asansol and Dalmianagar.

Vishakhapatnam-Guntur Region

This industrial region extends from Vishakhapatnam district to Kurnool and Prakasam districts in the south. Industrial development of this region hinges upon Vishakhapatnam and districts in the south. Industrial development of this region hinges upon Vishakhapatnam and Machilipatnam ports and developed agriculture and rich reserves of minerals in their inter lands. Coalfields of the Godavari basin provide energy. Ship building industry was started at Vishakhapatnam in 1941. Petroleum refinery based on imported petroleum facilitated the growth of several petrochemical industries. Sugar, textile, jute, paper, fertilizer, cement, aluminum and light engineering are principal industries of this region. One lead-zinc smelter is functioning in Guntur district. Iron and steel plant at Vishakhapatnam uses the Bailadila iron ore. Vishakhapatnam, Vijayawada, Vijaynagar, Rajahmundry, Guntur, Eluru and Kurnool are important industrial centres.

Gurgaon-Delhi-Merrut Region

Industries located in this region have shown very fast growth in the recent past. This region is located far away from the mineral and power resources, and therefore, the industries are light and market-oriented. Electronics, light engineering and electrical goods are major industries of this region. Besides, there are cotton, woolen and synthetic fabrics, hosiery, sugar, cement, machine tools, tractor, cycle, agricultural implements, chemical and vanaspati industries which have developed on large scale. Software industry is a recent addition. To the south lies the Agra-Mathura industrial area which specializes in glass leather goods. Mathura with an oil refinery is a petrochemical complex. Among industrial centres, mention be made Gurgaon, Delhi, Shahdara, Faridabad, Meerut, Modinagar, Ghaziabad, Ambala, Agra and Mathura.

Kollam-Tiruvanantapuram Region

The industrial region is spread over Tiruvanantapuram, Kollam, Alwaye, Ernakulam and Alappuzha districts. Plantation agriculture and hydropower provide industrial base to this region. Located far away from the mineral belt of the country, agricultural products processing and market oriented light industries predominate the region.

Among them, cotton textile, sugar, rubber, matchbox, glass, chemical fertilizer and fish-based industries are important. Food processing, paper, coconut coir products, aluminum and cement industries are also significant. Location of petroleum refinery at Kochi has added a vista of new industries to this region. Important of petroleum centres are Kollam, Tiruvanantapuram, Alluva, Kochi, Alappuzha, and Punalur.

9

TRANSPORT AND COMMUNICATION

The use of transport and communication depends upon our need to move things from place of their availability to the place of their use.

Land Transport

Road Transport: India has one of the largest road networks in the world with a total length of 33.1 lakh km (2005). About 85 per cent of passenger and 70 per cent of freight traffic are carried by roads every year. Road transport is relatively suitable for shorter distance travel.

Road transport in modern sense was very limited in India before World War-II. The first serious attempt was made in 1943 when 'Nagpur Plan' was drawn. This plan could not be implemented due to lack of coordination among the princely states and British India. After Independence, twenty-year road plan (1961) was introduced to improve the conditions of roads in India. However, roads continue to concentrate in and around urban centres. Rural and remote areas had the least connectivity by road.

For the purpose of construction and maintenance, roads are classified as National Highways (NH), State Highways (SH), Major District Roads and Rural Roads.

National Highways: The main roads which are constructed and maintained by the Central Government are known as the National Highways. These roads are meant for inter-state transport and movement of defence men and material in strategic areas. These also connect the state capitals, major cities, important ports, railway junctions, etc. The length of the National Highways has increased from 19,700 km in 1951 to 65,769 km in 2005. The National Highways constitute only two per cent of the total road length but carry 40 per cent of the road traffic.

The National Highways Authority of India (NHAI) was operationalized in 1995. It is an autonomous body under the Ministry of Surface Transport. It is entrusted with the responsibility of development, maintenance and operation of National Highways. This is also the apex body to improve the quality of the roads designated as National Highways.

Indian Road Network (2005)

Sl. No.	Road Category	Length in Km	% of total road length
1.	National Highways	65,769	2
2.	State Highways	1,28,000	4
3.	Major District Roads	4,70,000	14
4.	Rural Rods	2,65,000	80
	Total	**33,13,769**	**100**

State Highways: These are constructed and maintained by state governments. They join the state capitals with district headquarters and other important towns. These roads are connected to the National Highways. These constitute 4 per cent of total road length in the country.

In order to consolidate his empire Shershah Suri built the road from Indus Valley (Pakistan) to Soner Valley in Bangal. This was coordinating Kolkata to Peshawar later on named as Grand Trunk Road during the British period. In the present time it has been divided into two part between Amritsar to Kolkata. (a) National Highway (NH-I) from Delhi to Amritsar. (b) National Highway (NH-2) Delhi to Kolkata.

District Roads: These roads are the connecting link between District Headquarters and the other important nodes in the district. They account for 14 per cent of the total road length of the country.

Rural Roads

These roads are vital for providing links in the rural areas. About 80 per cent of the total road length in India are categorized as rural roads. There is regional variation in the density of rural because these are influenced by the nature of the terrain.

Other Roads

Other roads include Border Roads and International Highways. The Border Road Organization (BRO) was established in May 1960 for accelerating economic development and strengthening defence preparedness through rapid and coordinated improvement of strategically important roads along the northern and north-eastern boundary of the country. It is a premier multifaceted construction agency. It has constructed roads in high altitude mountainous terrain joining Chandigarh with Manali (Himachal Pradesh) and Leh (Ladakh). This road runs at an average altitude of 4,270 metres above the mean sea level.

This organization has completed over 40,450 km of roads by March 2005. Apart from the construction and maintenance of roads in strategically sensitive areas, the BRO also undertakes snow clearance in high altitude areas. The international highways are meant to promote the harmonious relationship with the neighbouring countries by providing effective links with India.

The distribution of roads is not uniform in the country. Density of roads (length of roads per 100 square km of area) varies from only 10.48 km in Jammu and Kashmir to 387.24 km in Kerala with a national average of 75.42 km. The density of road is high in most of the northern states and major southern states. It is low in the Himalayan region, Madhya Pradesh and Rajasthan. Why does this variation occur? Nature of terrain and the level of economic development are the main determinants of density of roads. Construction of roads is easy and cheaper in the plain areas while it is difficult and costly in hilly and plateau areas. Therefore, not only the density but also the quality of roads is relatively better in plains as compared to roads in high altitude areas, rainy and forested regions.

National Highways Development Projects

NHAI has taken up some major projects in the country under different phases:

Golden Quadrilateral: It comprises construction of 5,846 km long 4/6 lane, high density traffic corridor, to connect India's four big metro cities of Delhi-Mumbai-

Chennai-Kolkata. With the construction of Golden Quadrilateral, the time-distance and cost of movement among the mega cities of India will be considerably minimized.

North-South and East-West Corridors: North-South corridor aims at connecting Srinagar in Jammu and Kashmir and Kaniyakumari in Tamil Nadu (including Kochi-Salempur) with 4,076 km long road. The East-West Corridor has been planned to connect Silchar in Assam with the port town of Porbandar in Gujarat with 3,640 km of road length.

Rail Transport

Indian Railway was introduced in 1853, when a line was constructed from Bombay to Thane covering a distance of 34 km.

Indian Railways is the largest government undertaking in the country. The length of Indian Railways network is 63,221 km. Its very large size puts lots of pressure on a centralized railway management system. Thus, in India, the railway system has been divided into sixteen zones. Table shows the zone-wise performance of Indian Railways.

Areas around towns, raw material producing areas and of plantations and other commercial crops, hill stations and cantonment towns were well-connected by railways from the British colonial era. These were mostly developed for the exploitation of resources. After the Independence of the country, railway routes have been extended to other areas too. The most significant development has been the development of Konkan Railway along the western coast providing a direct link between Mumbai and Mangalore. Railway continuous to remain the main means of transport for the masses. Railway network is relatively less dense in the hill states, north eastern states, central parts of India and Rajasthan.

Rural Roads: These roads received special impetus under the Pradhan Mantri Grameen Sadak Yojana. Under this scheme special provisions are made so that every village in the country is linked to a major town in the country by an all season motorable road.

Konkan Railway: Konkan Railway was a great achievement of Indian railway in 1998. It is 760 km long track extending from Roha in Karnataka to Mangalore. This railway crosses 146 rivers, 2000 bridges and 91 tunnels, has longest tunnels of the Asia having 6.5 km in length. It is joint enterprise of Karnataka, Goa and Maharashtra government.

Indian Railways Zone

Railway Zone	Headquarters
Central	Mumbai CST
Eastern	Kolkata
East Central	Hajipur
East Coast	Bhubaneshwar
Northern	New Delhi
North Central	Allahabad
North Eastern	Gorakhpur
North East Frontier	Maligaon (Guwahati)
North Western	Jaipur
Southern	Chennai
South Central	Secundrabad
South Eastern	Kolkata
South East Central	Bilaspur
South Western	Hubli
Western	Mumbai (Church Gate)
West Central	Jabalpur

Water Transport

Waterways is an important mode of transport for both passenger and cargo traffic in India. It is the cheapest means of transport and is most suitable for carrying heavy and bulky material. It is a fuel-efficient and eco-friendly mode of transport. The water transport is of two types-(a) inland waterways, and (b) oceanic waterways.

Inland Waterways

It was the chief mode of transport before the advent of railways. It, however, faced tough competition from road and railway transport. Moreover, diversion of river water for irrigation purposes made them non navigable in large parts of their courses. India has 14,500 km of navigable waterways, contributing about 1% to the country's transportation. It comprises rivers, canals, backwaters, creeks, etc. At present, 3,700 km of major rivers are navigable by mechanized flat bottom vessels, out of which only 2,000 km are actually used. Similarly, out of 4,300 km of the network of navigable canal, only 900 km is navigable by mechanized vessels.

For the development, maintenance and regulation of national waterways in the country, the Inland Waterways Authority was set up in 1986. The authority has declared three inland waterways as National Waterways as given in the table.

Inland Waterways Authority has also identified ten other inland waterways, which could be upgraded. The backwaters (Kadal) of Kerala has special significance in Inland Waterway. Apart from providing cheap means of transport, they are also attracting large number of tourists in Kerala. The famous Nehru Trophy Boat Race (VALLANKALI) is also held in the backwaters.

National Highway-7 is the longest and traverses 2,369 km between Varanasi and Kanyakumari via Jabalpur, Nagpur, Hyderabad, Bangalore and Madurai. Delhi and Mumbai are connected by National Highway-8, while National Highway-15 covers most of Rajasthan.

Oceanic Routes

India has a vast coastline of approximate 7,517 km, including islands. Twelve major and 185 minor ports provide infrastructural support to these routes. Oceanic routes play an important role in the transport sector of India's economy. Approximately 95 per cent of India's foreign trade by volume and 70 per cent by value moves through ocean routes. Apart from international trade, these also used for the purpose of transportation between the islands and the rest of the country.

Air Transportation

Air Transport is the fastest means of movement from one place to the other. It has reduced distances by minimizing the travel time. It is very essential for a vast country like India, where distances are large and the terrain and climatic conditions are diverse.

Air transport in India made a beginning in 1911 when airmail operation commenced over a little distance of 10 km between Allahabad and Naini. But its real development took place in post-Independent period. The Airport Authority of India is responsible for providing safe, efficient air traffic and aeronautical communication services in the Indian Air Space. The authority manages 126

airports including 11 international, 86 domestic and 29 civil enclaves at defence air fields.

The air transport in India is managed by two corporations, Air India and Indian Airlines after nationalization. Now many private companies have also started passenger services.

History of Indian Airlines

1911 - Air transport in India was launched between Allahabad and Naini.

1947 - Air transport was provided by four major companies namely Indian National Airways. Tata Sons Limited, Air Services of India and Deccan Airways.

1951 - Four more companies joined the services, Bharat Airways, Himalayan Aviation Limited, Airways India and Kalinga Airlines.

1953 - Air transport was nationalized and two Corporations. Air India International and Indian Airlines were formed. Now Indian Airlines is known as 'Indian'.

Air India: Air India provides International Air Services for both passengers and cargo traffic. It connects all the continents of the world through its services. In 2005, it carried 12.2 million passengers and 4.8 lakh metric tonnes of cargo. About 52 per cent of the total air traffic was handled only at Mumbai and Delhi airports. In 2005, domestic movement involved 24.3 million passengers and 20 lakh metric tonnes of cargo. Pawan Hans is the helicopter service operating in hilly areas and is widely used by tourists in north-eastern sector.

In addition, Pawan Hans Limited mainly provides helicopter services to petroleum sector and for tourism.

Oil and Gas Pipelines: Pipelines are the most convenient and efficient mode of transporting liquids and gasses over long distances. Even solids can also be transported by pipelines after converting them into slurry. Oil India Limited (OIL) under the administrative set up of the Ministry of Petroleum and Natural Gas is engaged in the exploration, production and transportation of crude oil and natural gas. It was incorporated in 1959 as a company. Asia's first cross country pipeline covering a distance of 1,157 km was constructed by OIL from Naharkatiya oilfield in Assam to Barauni refinery to Bihar. It was further extended up to Kanpur in 1966. Another extensive network of pipeline has been constructed in the western region of India of which Ankleshwar-Koyali, Mumbai High-Koyali and Hazira-Vijapur-Jagdishpur (HVJ) are most important. Recently, a 1256 km long pipeline connecting Salaya (Gujarat) with Mathura (U.P.) has been constructed. It supplies crude oil from Gujarat to Punjab (Jalandhar) via Mathura. OIL is in the process of constructing of 660 km long pipeline from Numaligarh to Siliguri.

Communication Networks: Human beings have evolved different methods of communication over time. In earlier times, the messages were delivered by beating the drum or hollow tree trunks, giving indications through smoke or fire or with the help of fast runners. Horses, camels, dogs, birds and other animals were also used to send messages. Initially, the means of communication were also the means of

transportation. Invention of post office, telegraph, printing press, telephone, satellite, etc. has made the communication much faster and easier. Development in the field of science and technology has significantly contributed in bringing about revolution in the field of communication.

People use different modes of communication to convey the messages. On the basis of scale and quality, the mode of communication can be divided into following categories:

Personal Communication System: Among all the personal communication system internet is the most effective and advanced one. It is widely used in urban areas. It enables the user to establish direct contact through e-mail to get access to the world of knowledge and information. It is increasingly used for e-commerce and carrying out money transactions. The internet is like a huge central warehouse of data, with detailed information on various items. The network through internet and e-mail provides an efficient access to information at a comparatively low cost. It enables us with the basic facilities of direct communication.

Three types of Indian Railway on the basis of breadth of Rails

1. Broad guage- distance --- two rails 1.616 mts total length of Broad guage in India.
2. Meter guage- Distance between two rail in one meter. Total length of meter ganage in India is 13,290 km, account 21.02% of total length of country.
3. Narrow gauge- Distance between two rail is 0.762 mts/0.610 mts. Total length is 3,124 km, accounts 4,49% of total length.

Mass Communication System

Radio: Radio broadcasting started in India in 1923 by the Radio Club of Bombay. Since then, it gained immense popularity and changed the socio cultural the life of people. Within no time, it made a place in every household of the country. Government took this opportunity and brought this popular mode of communication under its control in 1930 under the Indian Broadcasting System. It was changed to All India Radio in 1936 and to Akashwani in 1957.

All India Radio broadcasts a variety of programmes related to information, education and entertainment. Special news bulletins are also broadcast at specific occasions like session of parliament and state legislatures.

Television (T.V.): Television broadcasting has emerged as the most effective audio-visual medium for disseminating information and educating masses. Initially, the T.V. services were limited only to the National Capital where it began in 1959. After 1972, several other centres became operational. In 1976, TV was delinked from All India Radio (AIR) and got a separate identity as Doordarshan (DD). After INSAT-IA (National Television- DD1) became operational, Common National Programmes (CNP) were started for the entire network and its services were extended to the backward and remote rural areas.

Satellite Communication: Satellites are mode of communication in themselves as well as they regulate the use of other means of communication. However, use of satellite in getting a continuous and synoptic view of larger area has made satellite communication

very vital for the country, due to the economic and strategic reasons. Satellite images can be used for the weather forecast, monitoring of natural calamities, surveillance of border areas, etc. On the basis of configuration and purposes, satellite system in India can be grouped into two: Indian National Satellite System (INSAT) and Indian Remote Sensing Satellite System (IRS).

The INSAT, which was established in 1983, is a multipurpose satellite system for telecommunication, meteorological observation and for various other data and programmes.

The IRS satellite system became operational with the launching of IRS-IA in March 1988 from Vaikanour in Russia. India has also developed her own Launching Vehicle PSLV (Polar Satellite Launch Vehicle). These satellites collect data in several spectral bands and transmit them to the ground stations for various uses. The National Remote Sensing Agency (NRSA) at Hyderabad provides facilities for acquisition of data and its processing. These are very useful in the management of natural resources.

Region	Imports	
	2003-04	2004-05
West Europe	85,88	1,08,71
East Europe	43	85
CIS and Baltic states	5,79	8,32
Asia and Oceania	1,24,76	1,70,28
Africa	14,69	16,80
America	31,82	40,20
Latin American Countries	5,35	8,55

Source : India 2006

International Trade

The exchange of goods among people, states and countries is referred to as trade. The market is the place where such exchanges take place. Trade between two countries is called international trade. It may take place through sea, air or land routes. While local trade is carried in cities, towns and villages, state level trade is carried between two or more states. Advancement of international trade of a country is an index to its economic prosperity. It is, therefore, considered the economic barometer for a country.

As the resources are space bound, no country can survive without international trade. Export and import are the components of trade. The balance of trade of a country is the difference between its export and import. When the value of export exceeds the value of imports, it is called a favourable balance of trade. On the contrary, if the value of imports exceeds the value of exports, it is termed as unvfavourable balance of trade.

India has trade relations with all the major trading blocks and all geographical regions of the world. Among the commodities of export, whose share has been increasing over the last few year till 2004-05 are agriculture and allied products (2.53 per cent), ores and minerals (9.12 per cent), gems and jewellery (26.75 per cent) and chemical and allied products (24.45 per cent), engineering goods (35.63 per cent) and petroleum products (86.12 per cent).

Table: India'sMajor Trading Partner's Percentage share in total trade (Export + Import)

Country	2000-01	2003-04
U.S.A.	13.0	10.3
U.K.	5.7	3.7

Belgium	4.6	3.7
Germany	3.9	3.5
Japan	3.8	2.7
Switzerland	3.8	3.3
Hong Kong	3.7	2.8
U.A.E.	3.4	6.2
China	2.5	6.4
Singapore	2.5	3.4
Malaysia	1.9	1.7
Total	48.6	47.7

Source : Economic Survey 2005-06

The commodities imported to India include petroleum and petroleum products (41.87 per cent), pearls and precious stones (29.26 per cent), inorganic chemicals (29.39 per cent), coal, coke and briquettes (94.17 per cent), machinery (12.56 per cent). Bulk imports as a group registered a growth accounting for 39.09 per cent of total imports. This group includes fertilizers (67.01 per cent), cereals (25.23 per cent), edible oils (7.94 per cent) and newsprint (5.51 per cent). International trade has under gone a sea change in the last fifteen years. Exchange of commodities and goods have been superseded by the exchange of information and knowledge. India has emerged as a software giant at the international level and it is earning large foreign exchange through the export of information technology.

Direction of Trade

India has trade relations with most of the countries and major trading blocks of the world.

India aims to double its share in the international trade within the next five years. It has already started adopting suitable measures such as import liberalization, reduction in import duties, de-licensing and change from process to product patents.

Asia and Oceania accounted for 47.41 per cent of India's export followed by West Europe (23.80 per cent) and America (20.42). Similarly, India's imports were highest from Asia and Oceania (35.40 per cent) followed by West Europe (22.60 per cent) and America (8.36 per cent) in 2004-05.

The U.S.A. is India's largest trading partner and the most trading partner and the most important destination of India's export. Other countries in order of significance include the U.K., Belgium, Germany, Japan, Switzerland, Hong Kong, the U.A.E., China, Singapore and Malaysia.

Most of India's foreign trade is carried through sea and air routes. However, a small portion is also carried through land route to neighbouring countries like Nepal, Bhutan, Bangladesh and Pakistan.

Ports

Today Indian ports are handling large volumes of domestic as well as overseas trade. Most of the ports are equipped with modern infrastructure. Previously the development and modernization was the responsibility of the government agencies, but considering the increase in function and need to bring these ports at par with the international ports, private entrepreneurs have been invited for the modernization of ports in India. The capacity of Indian ports increased from 20 million tonnes of cargo handling in 1951 to more than 500 million tonnes at present.

Kandla Port situated at the head of Gulf of Kuchchh has been developed as a major port to cater to the needs of western and north western parts of the country and also

to reduce the pressure at Mumbai port. The port is specially designed to receive large quantities of petroleum and petroleum products and fertilizer. The offshore terminal at Vadinar has been developed to reduce the pressure at Kandla port.

Demarcation of the boundary of the hinterland would be difficult as it is not fixed over space. In most of the cases, hinterland of one port may overlap with that of the other.

Mumbai is a natural harbor and the biggest port of the country. The port is situated closer to the general routes from the countries of Middle East, Mediterranean countries, North Africa, North America and Europe where the major share of country's overseas trade is carried out. The port is 20 km long and 6-10 km wide with 54 berths and has the country's largest oil terminal. M.P., Maharashtra, Gujarat, U.P. and parts of Rajasthan constitute the main hinterlands of Mumbai ports.

Jawaharlal Nehru Port at Nhava Sheva was developed as a satellite port to relieve the pressure at the Mumbai port. It is the largest container port in India.

Marmagao Port, situated at the entrance of the Zuari estuary, is a natural harbor in Goa. It gained significance after its remodeling in 1961 to handle iron-ore exports to Japan. Construction of Konkan railway has considerably extended the hinterland of this port. Karnataka, Goa, Southern Maharashtra constitutes its hinterland.

New Mangalore Port is located in the state of Karnataka and caters to the needs of the export of iron-ore and iron-concentrates. It also handles fertilizers, petroleum products, edible oils, coffee, tea, wood pulp, yarn, granite stone, molasses, etc. Karnataka is the major hinterland for this port.

Kochchi Port situated at the head of Vembanad Kayal, popularly known as the "Queen of the Arabian Sea," is also a natural harbor. This port has an advantageous location being close to the Suez-Colombo route. It caters to the needs of Kerala, southern- Karnataka and south western Tamil Nadu.

Kolkata Port is located on the Hulgi river, 128 km inland from the Bay of Bengal. Like the Mumbai port, this port was also developed by the British. Kolkata had the initial advantage of being the capital of British India. The port has lost its significance considerably on account of the diversion of exports to the other ports such as Vishakhapatnam, Paradwip and its satellite port, Haldia.

Kolkata port is also confronted with the problem of silt accumulation in the Hugli river which provides a link to the sea. Its hinterland covers U.P, Bihar, Jharkhand, West Bengal, Sikkim and the north-eastern states. Apart from this, it also extends ports facilities to our neighbouring land-locked countries such as Nepal and Bhutan.

Haldia Port is located 105 km downstream from Kolkata. It has been constructed to reduce the congestion at Kolkata port. It handles bulk cargo like iron ore, coal, petroleum, petroleum products and fertilizers, jute, jute products, cotton and cotton yarn, etc.

Paradwip Port is situated in the Mahanadi delta, about 100 km from Cuttack. It has the deepest harbor specially suited to handle very large vessels. It has been developed mainly to handle large-scale

export of iron-ore. Orissa, Chhattisgarh and Jharkhand are the parts of its hinterland.

Visakhapatnam Port in Andhra Pradesh is a land-locked harbor, connected to the sea by a channel cut through solid rock and sand. An outer harbor has been developed for handling iron-ore, petroleum and general cargo. Andhra Pradesh is the main hinterland for this port.

Chennai Port is one of the oldest ports on the eastern coast. It is an artificial harbor built in 1859. It is not much suitable for large ships because of the shallow waters near the coast. Tamil Nadu and Pondicherry are its hinterland. Ennore, a newly developed port in Tamil Nadu, has been constructed 25 km north of Chennai to relieve the pressure at Chennai port. Tuticorin Port was also developed to relieve the pressure of Chennai port. It deals with a variety of cargo including coal, salt, food grains, edible oils, sugar, chemical and petroleum products.

Tourism as a Trade

Tourism in India has grown substantially over the last three decades. Foreign tourist's arrivals in the country witnessed an increase of 23.5 per cent during the year 2004 as against the year 2003, thus contributing Rs. 21,828 crore of foreign exchange. Over 2.6 million foreign tourists visit India every year. More than 15 million people are directly engaged in the tourism industry. Tourism also promotes national integration, provides support to local handicrafts and cultural pursuits. It also helps in the development of international understanding about our culture and heritage. Foreign tourists visit India for heritage tourism, eco tourism, adventure tourism, cultural tourism, medical tourism and business tourism.

Rajasthan, Goa, Jammu and Kashmir and temple towns of south India are important destinations of foreign tourists in India. There is vast potential of tourism development in the north-eastern states and the interior parts of Himalayas, but due to strategic reasons these have not been encouraged so far. However, there lies a bright future ahead for this upcoming industry.

10

OUR SOLAR SYSTEM

Our Solar system consists of eight planets. The nine planet 2003 UB313 has also been recently sighted. The nebula from which our Solar system is supposed to have been formed, started its collapse and core formation some time 5-5.6 billion ago and the planets formed about 4.6 billion years ago. Our solar system consists of the sun (the star), 8 planets, 63 moons, millions of smaller bodies like asteroids and comets and huge quantity of dust-grains and gases.

A light year is a measure of distance and not of time. Light travels at a speed of 300,00 km/second. Considering this, the distances the light will travel in one year is taken to be one light year. This equals to 9.461x1012 km. The mean distance between the sun and the earth is 149,598,000 km. In terms of light years, it is 8.311 minutes of a year. Out of the eight planets, mercury, venus, earth and mars are called as the inner planets as the lie between the sun and the belt of asteroids the other five planets are called the outer planets. Alternatively, the first four are called Terrestrial, meaning earth-like as they are made up of rock and metals, and have relatively high densities. The rest five are called Jovian or Gas Giant planets. Jovian means Jupiter-like. Most of them are much larger than the terrestrial planets and have thick atmosphere, mostly of helium and hydrogen. All the planets were formed in the same period sometime about 4.6 billion years ago. Some data regarding our solar system are given in the box below.

The Solar System

	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
Distance	0.387	0.723	1.000	1.524	5.203	9.539	19.182	30.058
Density	5.44	5.245	5.517	3.945	1.33	0.70	1.17	1.66
Radius#	0.383	0.949	1.000	0.533	11.19	9.460	4.11	3.88
Satellites	0	0	1	2	16	about 18	about 17	8

* Distance from the sun is astronomical unit i.e. average mean distance of the earth is 149,598,000 km = 1

@ Density in gm / cm^3

Radius : Equatorial radius 6378.137 km = 1

The Moon

The moon is the only natural satellite of the earth. Like the origin of the earth, there have been attempts to explain how the moon was formed. In 1838, Sir George Darwin suggested that initially, the earth and the moon formed a single rapidly rotating body. The whole mass became a dumb-bell-shaped body and eventually it broke. It was also suggested that the material forming the moon was separated from what we have at present the depression occupied by the Pacific Ocean. However, the present scientists do not accept either of the explanations. It is now generally believed that the formation of moon, as a satellite of the earth, is an outcome of 'giant impact' or what is described as "the big splat". A body of the size of one to three times that of mars collided into the earth sometime shortly after the earth was formed. It blasted a large part of the earth into space. This portion of blasted material then continued to orbit the earth and eventually formed into the present moon about 4.44 billion years ago.

Development of Lithosphere

The earth was mostly in a volatile state during its primordial stage. Due to gradual increase in density the temperature inside has increased. As a result the material inside started getting separated depending on their densities. This allowed heavier materials (like iron) to sink towards the centre of the earth and the lighter ones to move towards the surface. With passage of time it cooled further and solidified and condensed into a smaller size. This later led to the development of the outer surface in the form of a crust. During the formation of the moon, due to the giant impact, the earth was further heated up. It is through the process of differentiation that the earth forming material got separated into

Geological Time Scale

Eons	Era	Period Quaternary	Epoch Holocene Plestocene	Are/Years 0 - 10.000 10.000-2 million	Life/Major Extents Modern Man Home Saptens
	Catnozoic (From 65 million years to the present times)	Tertiary	Pitocene Miocene Oligocene Eocene Palaeocene	2 -5 million 5 - 24 million and Trees 24 - 37 Ma 37 - 68 million 57 - 65 million	Early Human Ancestor Ape : Flowering Plants Anthropoid Ape Rabbits and Hare Small Mammals: Rats - Mice
	Mesozoic 65-245 million Mammals	Cretaceous Jurassic Triassic		65 - 144 million 144-208 million 208 - 245 million	Extinction of Dinosaurs Age of Dinosaurs Frogs and turtles
	Palaeozotc 245-570 million	Permtan Carboniferous Devonian Stlurtan Ordovtctan Cambrtan		245 - 286 million 286-360 million 360-408 million 408-438 million 438-505 million 505-570 million	Repttle dominate-replace amphibtans First Reptiles: Vertebrates: Coal beds Amphibtans First trace of life on land: Plants first Fish No terrestrial Life: Marine Invertebrate
	Proterozoic Archean Pre Cambratan Hadean -4,800 million			 3,800-4,800 million 570 million -	570-2,500 million Soft-bodied arthropods 2,500-3,800 million Blue green Algae: Untcellular bacteria Oceans and Continents form-Ocean and Atmosphere are rich in Carbon dioxide
the	Origin of				5,000 million Origin of sun

different layers. Starting from the surface to the central parts, we have layers like the crust, mantle, outer core and inner core. From the crust to the core, the density of the material increases.

Minerals & Rocks

The earth is composed of various kinds of elements. These elements are in solid form in the outer layer of the earth and in hot and molten form in the interior. About 98 per cent of the total crust of the earth is composed of eight elements like oxygen, silicon, aluminum, iron, calcium, sodium, potassium and magnesium, and the rest is constituted by titanium hydrogen, phosphorus, manganese, sulphur, carbon, nickel and other elements.

These substances are recognized as minerals. Thus, a mineral is a naturally occurring inorganic substance, having an orderly atomic structure and a definite chemical composition and physical properties. A mineral is composed of two or more elements. But, sometimes single element minerals like sulphur, copper, silver, gold, graphite etc. are found.

The elements in the earth's crust are rarely found exclusively but are usually combined with other elements to make various substances.

Though the number of elements making up the lithosphere are limited they are combined in many different ways to make up many varieties of minerals. There are at least 2,000 minerals that have been named and identified in the earth crust; but almost all the commonly occurring ones are related to six major mineral groups that are known as major rock forming minerals.

The basic source of all minerals is the hot magma in the interior of the earth. When magma cools, crystals of minerals appear and a systematic series of minerals are formed in seq-uence to solidify so as to form rocks.

Minerals such as coal, petro-leum and natu-ral gas are orga-nic substances found in solid, liquid and gaseous forms respectively.

Besides these main minerals, other minerals like chlorite, calcite, magne-tic, haematite, bauxite and barite are also present in some quantities in the rocks.

The Major Elements of the Earth's Crust

Sl. No.	Elements	By Weight (%)
1.	Oxygen	46.60
2.	Silicon	27.72
3.	Aluminum	8.13
4.	Iron	5.00
5.	Calcium	3.63
6.	Sodium	2.83
7.	Potassium	2.59
8.	Magnesium	2.09
9.	Others	1.41

Metallic Minerals

These minerals contain metal content and can be sub-divided into three types:

(i) Precious metals: gold, silver, platinum etc.

(ii) Ferrous metals: iron and other metals often mixed with iron to form various kinds of steel.

(iii) Non-ferrous metals: include metals like copper, lead, zinc, tin, aluminum etc.

Hardness- relative resistance being scratched; ten minerals are selected to measure the degree of hardness from 1-10. They are: 1. talc; 2. Gypsum; 3. calcite; 4.

fluorite; 5. apatite; 6. felspar; 7. quartz; 8. topaz; 9. corundum; 10. Diamond. Compared to this for example, a fingernail is 2.5 and glass or knife blade is 5.5.

Non-Metallic Minerals

These minerals do not contain metal content. Sulphur, phosphates and nitrates are examples of non-metallic minerals. Cement is a mixture of non-metallic minerals.

Rocks

The earth's crust is composed for rocks. A rock is an aggregate of one or more minerals. Rock may be hard or soft and in varied colours. For example, granite is hard, soapstone is soft. Gabbro is black and quartzite can be milky white. Rocks do not have definite composition of mineral constituents. Feldspar and quartz are the most common minerals found in rocks.

As there is a close relation between rocks and landforms, rocks and soils, a geographer requires basic knowledge of rocks. There are many different kinds of rocks which are grouped under three families on the basis of their mode of formation. They are: (i) Igneous Rocks- solidified from magma and lava; (ii) Sedimentary Rocks- the result of deposition of fragments of rocks by exogenous processes; (iii) Metamorphic Rocks- formed out of existing rocks undergoing recrystallisation.

Igneous Rocks

As igneous rocks form out of magma and lava from the interior of the earth, they are known as primary rocks. The igneous rocks (Ignis- in Latin means 'Fire') are formed when magma cools and solidifies. You already know that magma is. When magma in its upward movement cools and turns into solid form it is igneous rock. The process of cooling and solidification can happen in the earth's crust or on the surface of the earth.

Igneous rocks are classified based on texture. Texture depends upon size and arrangement of grains or other physical conditions of the materials. If molten material is cooled slowly at great depths, mineral grains may be very large. Sudden cooling (at the surface) results in small and smooth grains. Intermediate conditions of cooling would result in intermediate sizes of grains making up igneous rocks. Granite, gabbro, pegmatite, basalt, volcanic breccias and tuff are some of the examples of igneous rocks.

Sedimentary Rocks

The word 'sedimentary' is derived from the Latin word sedimentum, which means settling. Rocks (igneous, sedimentary and metamorphic) of the earth's surface are exposed to denudational agents, and are broken up into various sizes of fragments. Such fragments are transported by different exogenous agencies and deposited. These deposits through compaction turn into rocks. This process is called lithification. In many sedimentary rocks, the layers of deposits retain their characteristics even after lithification. Hence, we see a number of layers of varying thickness in sedimentary rocks like sandstone, shale etc.

Depending upon the mode of formation, sedimentary rocks are into three major groups: (i) mechanically formed- sandstone, conglomerate, limestone, shale, loess etc. are examples; (ii) organically formed- geyserites, chalk, limestone, coal etc. are some examples; (iii) chemically formed- chert, limestone, halite, potash etc. are some examples.

Metamorphic Rocks

The word metamorphic means 'change of form'. These rocks form under the action of pressure, volume and temperature (PVT) changes. Metamorphism occurs when rocks are forced down to lower levels by tectonic processes or when molten magma rising through the crust comes in contact with the crustal rocks or the underlying rocks are subjected to great amounts of pressure by overlying rocks. Metamorphism is a process by which already consolidated rocks undergo recrystallisation and reorganization of materials within original rocks.

Interior of the Earth

The earth's radius is 6,370 km. No one can reach the center of the earth and make observations or collect samples of material. Under such conditions, you may wonder how scientists tell us about the earth's interior and the type of materials that exist at such depths. Most of our knowledge about the interior of the earth is largely based on estimates and inferences. Yet, a part of the information is obtained through direct observations and analysis of materials.

Direct Sources

The most easily available solid earth material is surface rock or the rocks we get from mining areas. Gold mines in South Africa are as deep as 3-4 km. Going beyond this depth is not possible as it is very hot at this depth. Besides mining, scientists have taken up a number of projects to penetrate deeper depths to explore the conditions in the crustal portions. Scientists world over are working on two major projects such as "Deep Ocean Drilling Project" and "integrated Ocean Drilling Project". The deepest drill at Kola, in Arctic Ocean, has so far reached a depth of 12 km. This and many deep drilling projects have provided large volume of information through the analysis of materials collected at different depths.

Volcanic eruption forms another source of obtaining direct information. As and when the molten material (magma) is thrown onto the surface of the earth, during volcanic eruption it becomes available for laboratory analysis. However, it is difficult to ascertain the depth of the source of such magma.

Indirect Sources

Analysis of properties of matter indirectly provides information about the interior. We know through the mining activity that temperature and pressure increase with the increasing distance from the surface towards the interior in deeper depths. Another source of information are the meteors that at time reach the earth. The other indirect sources include gravitation, magnetic field, and seismic activity.

Earthquake

The study of seismic waves provides a complete picture of the layered interior. An earthquake in simple words in shaking of the earth. This is a natural event. It is caused due to release of energy, which generates waves that ravel in all directions.

Why does the earth shake?

The release of energy occurs along a fault. A fault is a sharp break in the crustal rocks. Rocks along a fault tend to move in opposite directions. As the overlying rock strata press them, the friction locks them together. However, their tendency to move apart at some point of time overcomes the friction. As a result, the blocks get deformed and eventually, they slide past one another

abruptly. This causes a release of energy, and the energy waves travel in all directions. The point where the energy is released is called the focus of an earthquake, alternatively, it is called the hypocenter. The energy waves travelling in different directions reach the surface. The point on the surface, nearest to the focus, is called epicenter. It is the first one to experience the waves. It is a point directly above the focus.

Earthquake Waves

All natural earthquakes take place in the lithosphere. It is sufficient to note here that the lithosphere refers to the portion of depth up to 200 km from the surface of the earth. An instrument called 'seismograph' records the waves reaching the surface. Note that the curve shows three distinct sections each representing different types of wave patterns. Earthquake waves are basically of two types- body waves and surface waves. Body waves are generated due to the release of energy at the focus and move in all directions travelling through the body of the earth. Hence, the name body waves. The body waves interact with the surface rocks and generate new set of waves called surface waves. These waves move along the surface. The velocity of waves changes as they travel through materials with different densities. The denser the material, the higher is the velocity. Their direction also changes as they reflect or refract when coming across materials with different densities.

There are two types of body waves. They are called P and S-waves. P-waves move faster and are the first to arrive at the surface. These are also called 'primary waves'. The P-waves are similar to sound waves. They travel through gaseous, liquid and solid materials. S-waves arrive at the surface with some time lag.

These are called secondary waves. An important fact about S-waves is that they can travel only through solid materials. This characteristic of the S-waves is quite important.

It has helped scientists to understand the structure of the interior of the earth. Reflection causes waves to rebound whereas refraction makes waves move in different directions. The variations in the direction of waves are inferred with the help of their record on seismograph. The surface waves are the last to report on seismograph. These waves are more destructive. They cause displacement of rocks, and hence, the collapse of structures occurs.

Propagation of Earthquake Waves

Different types of earthquake waves travel in different manners. As they move or propagate, they cause vibration in the body of the rocks through which they pass. P-waves vibrate parallel to the direction of the wave.

This exerts pressure on the material in the direction of the propagation. As a result, it creates density differences in the material leading to stretching and squeezing of the material. Other three waves vibrate perpendicular to the direction of propagation. The direction of vibrations of S-waves is perpendicular to the wave direction in the vertical plane. Hence, they create troughs and crests in the material through which they pass. Surface waves are considered to be the most damaging waves.

Emergence of Shadow Zone

Earthquake waves get recorded in seismographs located at far off locations.

However, there exist some specific areas where the waves are not reported. Such a zone is called the 'shadow zone'. The study of different events reveals that for each earthquake, there exists an altogether different shadow zone.

It was observed that seismographs located at any distance within 105° from the epicenter, recorded the arrival of both P and S-waves. However, the seismographs located beyond 145° from epicenter, record the arrival of P-waves, but not that of S-waves. Thus, a zone between 105° and 145° from epicenter was identified as the shadow zone for both the types of waves. The entire zone beyond 105° does not receive S-waves. The shadow zone of S-wave is much larger than that of the P-waves. The shadow zone of P-waves appears as a band around the earth between 105° and 145° away from the epicenter. The shadow zone of S-waves is not only larger in extent but it is also a little over 40 per cent of the earth surface.

Measuring Earthquakes

The earthquake events are scaled either according to the magnitude or intensity of the shock. The magnitude scale is known as the Richter scale. The magnitude relates to the energy released during the quake. The magnitude is expressed in absolute numbers, 0-10. The intensity scale is named after Mercalli, an Italian seismologist. The intensity scale takes into account the visible damage caused by the event. The range of intensity scale is from 1-12.

Though the actual quake activity lasts for a few seconds, its effects are devastating provided the magnitude of the quake is more than 5 on the Richter scale.

Structure of the Earth

The Crust

It is the outermost solid part of the earth. It is brittle in nature. The thickness of the crust varies under the oceanic and continental areas. Oceanic crust is thinner as compared to the continental crust. The mean thickness of oceanic crust is 5 km whereas that of the continental is around 30 km. The continental crust is thicker in the areas of major mountain systems. It is as much as 70 km thick in the Himalayan region.

It is made up of heavier rocks having density of 3 g/cm3. This type of rock found in the oceanic crust is basalt. The mean density of material in oceanic crust is 2.7 g/cm3.

The Mantle

The portion of the interior beyond the crust s called the mantle. The mantle extends from Moho's discontinuity to a depth of 2,900 km. The upper portion of the mantle is called asthenosphere. The word astheno means weak. It is considered to be extending upto 400 km. It is the main source of magma that finds its way to the surface during volcanic eruptions. It has s density higher than the crust's (3.4 g/cm3). The crust and the uppermost part of the mantle are called lithosphere. Its thickness ranges from 10-200 km. The lower mantle extends beyond the asthenosphere. It is in solid state.

The Core

As indicated earlier, the earthquake wave velocities helped in understanding the existence of the core of the earth. The core mantle boundary is located at the depth of 2,900 km. The outer core is in liquid state while the inner core is in solid state. The desnity of material at the mantle core bound-

ary is around 5 g/cm3 and at the centre of the earth at 6,300 km. the density value is around 13 g/cm3. The core is made up of very heavy material mostly constituted by nickel and iron. It is sometimes referred to as the knife layer.

Volcanoes and Volcanic landforms

A volcano is a place where gases, ashes and/or molten rock material- lava- escape to the ground. A volcano is called an active volcano if the materials mentioned are being released or have been released out in the recent past. The layer below the solid crust is mantle. It has higher density than that of the crust. The mantle contains a weaker zone called asthenosphere. It is from this that the molten rock materials find their way to the surface. The material in the upper mantle portion is called magma. Once it starts moving towards the crust or it reaches the surface, it is referred to as lava. The material that reaches the ground includes lava flows, pyroclastic debris, volcanic bombs, ash and dust and gases such as nitrogen compounds, sulphur compounds and minor amounts of chlorine, hydrogen and argon.

Volcanoes

Volcanoes are classified on the basis of nature of eruption and the form developed at the surface. Major types of volcanoes are as follows:

Shield Volcanoes

Barring the basalt flows, the shield volcanoes the largest of all the volcanoes on the earth, The Hawaiian volcanoes are the most famous examples. These volcanoes are mostly made up of basalt, a type of lava that is very fluid when erupted. For this reason, these volcanoes are not steep. They become explosive if somehow water gets into the vent; otherwise, they are characterized by low-explosivity. The upcoming lava moves in the form of a fountain and throws out the cone at the top of the vent and develops into cinder cone.

Composite Volcanoes

These volcanoes are characterized by eruptions of cooler and mokre viscous lavas than basalt. These volcanoes often result in explosive eruptions. Along with lava, large quantities of pyroclastic material and ashes find their way to the ground. This material accumulates in the vicinity of the vent openings leading to formation of layers, and this makes the mounts appear as composite volcanoes.

Caldera

These are the most explosive of the earth's volcanoes. They are usually so explosive that when they erupt they tend to collapse on themselves rather than building any tall structure. The collapsed depressions are called calderas. Their explosiveness indicates that the magma chamber supplying the lava is not only huge but is also in close vicinity.

Flood Basalt Provinces

These volcanoes outpour highly fluid lava that flows for long distances. Some parts of the world are covered by thousands of sq. km. of thick basalt lava flows. There can be a series of flows with some flows attaining thickness of more than 50 m. Individual flows may extend for hundreds of km. The Deccan Traps from India, presently covering most of the Maharashtra plateau, are a much large flood basalt province. It is believed that initially the trap formations covered a much larger area than the present. Mid-Ocean Ridge Volcanoes: These volcanoes occur in

the oceanic areas. There is a system of mid-ocean ridges more than 70,000 km long that stretches through all the ocean basins. The central portion of this ridge experiences frequent eruptions.

Volcanic Landforms

Intrusive Forms: The lava that is released during volcanic eruptions on cooling develops into igneous rocks. The cooling may take place either on reaching the surface or also while the lava is still in the crustal portion. Depending on the location of the cooling of the lava, igneous rocks are classified as volcanic rocks (cooling at the surface) and plutonic rocks (cooling in the crust). The lava that cools within the crustal portions assumes different forms. These forms are called intrusive forms.

Batholiths: A large body of magmatic material that cools in the deeper depth of the crust develops in the form of large domes. They appear on the surface only after the denudational processes remove the overlying materials. They cover large areas, and at times, assume depth that may be several km. These are granitic bodies. Batholiths are the cooled portion of magma chambers.

Laccoliths: These are large dome-shaped intrusive bodies with a level base and connected by a pipe-like conduit from below. It resembles the surface volcanic domes of composite volcano, only these are located at deeper depths. It can be regarded as the localized source of lava that finds its way to the surface. The Karnataka plateau is spotted with domal hills of granite rocks. Most of these, now exfoliated, are examples of laccoliths or batholiths.

Lapolith, Phacolith and Sills

As and when the lava moves upwards, a portion of the same may tend to move in a horizontal direction wherever it finds a weak plane. It may get rested in different forms. In case it develops into a saucer shape, concave to the sky body, it is called lapolith. A wavy mass of intrusive rocks, at times, is found at the base of synclines or at the top of anticline in folded igneous country. Such wavy materials have a definite conduit to source beneath in the form of magma chambers (subsequently developed as batholiths). These are called the phacoliths.

The near horizontal bodies of the intrusive igneous rocks are called sill or sheet, depending on the thickness of the material. The thinner ones are called sheets while the thick horizontal deposits are called sills.

Dykes: When the lava makes its way through cracks and the fissures developed in the land, it solidifies almost perpendicular to the ground. It gets cooled in the same position to develop a wall-like structure. Such structures are called dykes. These are the most commonly found intrusive forms in the western Maharashtra area. These are considered the feeders for the eruptions that led to the development of the Deccan traps.

11

LAND FORMS

After weathering processes have had their actions on the earth materials making up the surface of the earth, the geomorphic agents like running water, ground water, wind, glaciers, waves perform erosion. Erosion causes changes on the surface of the earth. Deposition follows erosion and because of deposition too, changes occur on the surface of the earth.

A landmass passes through stages of development somewhat comparable to the stages of life- youth, mature and old age.

Running Water

In humid regions, which receive heavy rainfall running water is considered the most important of the geomorphic agents in bringing about the degradation of the land surface. There are two components of running water. One is overland flow in general land surface as a sheet. Another is linear flow as streams and rivers in valleys. Most of the erosional landforms made by running water are associated with vigorous and youthful rivers flowing along gradients. With time, stream channels over steep gradients turn gentler due to continued erosion, and as a consequence, lose their velocity, facilitating active deposition.

In the early stages, down-cutting dominates during which irregularities such as waterfalls and cascades will be removed. In the middle stages, streams cut their beds slower, and lateral erosion of valley sides becomes severe. Gradually, the valley sides are reduced to lower and lower slopes. The divides between drainage basins are likewise lowered until they are almost completely flattened leaving finally, a lowland of faint relief with some low resistant remnants called monad nocks standing out here and there. This type of plain forming as a result of stream erosion is called a peneplain (an almost plain). The characteristics of each of the stages of landscapes developing in running water regimes may be summarized as follows:

Youth

Streams are few during this stage with poor integration and flow over original slopes showing shallow V-shaped valleys with no floodplains or with very narrow floodplains along trunk streams. Streams divides are broad and flat with marshes, swamp and lakes. Meanders if present develop over these broad upland surfaces. These meanders may eventually entrench themselves into the uplands. Waterfalls and rapids may exist where local hard rock bodies are exposed.

Mature

During this stage streams are plenty with good integration. The valleys are still V-shaped but deep; trunk streams are broad

enough to have wider floodplains within which streams may flow in meanders confined within the valley. The flat and broad inter stream areas and swamps and marshes of youth disappear and the stream divides turn sharp. Waterfalls and rapids disappear.

Old

Smaller tributaries during old age are few with gentle gradients. Streams meander freely over vast floodplains showing natural levees, oxbow lakes, etc. Divides are broad and flat with lakes, swamps and marshes. Most of the landscape is at or slightly above sea level.

EROSIONAL LANDFORMS

Vallyes

Valleys start as small and narrow rills; the rills will gradually develop into long and wide gullies; the gullies will further deepen, widen and lengthen to give rise to valleys. Depending upon dimensions and shape, many types of valleys like V-shaped valley, gorge, canyon, etc. can be recognized. A gorge is a deep valley with very steep to straight sides and a canyon is characterized by steep step-like side slopes and may be as deep as a gorge. A gorge is almost equal in width at its top as well as its bottom. In contrast, a canyon is wider at its top than at its bottom. In fact, a canyon is a variant of gorge. Valley types depend upon the type and structure of rocks in which they form. For example, canyons commonly form in horizontal bedded sedimentary rocks and gorges form in hard rocks.

Potholes and Pluge Pools

Over the rocky beds of hill-streams more or less circular depressions called potholes form because of stream erosion aided by the abrasion of rock fragments. Such large and deep holes at the base of waterfalls are called plunge pools. These pools also help in the deepening of valleys. Waterfalls are also transitory like any other landform and will recede gradually and bring the floor of the valley above waterfalls to the level below.

Incised or Entrenched Meanders

But very deep and wide meanders found cut in hard rocks. Such meanders are called incised or entrenched meanders.

River Terraces

River terraces are surfaces marking old valley floor or floodplain levels. River terraces are basically products of erosion as they result due to vertical erosion by the stream into its own depositional floodplain.

DEPOSITIONAL LANDFORMS

Alluvial Fans

Alluvial fans are formed when streams flowing from higher levels break into foot slope plains of low gradient. Alluvial fans in humid areas show normally low cones with gentle slope from head to toe and they appear as high cones with steep slope in arid and semi-arid climates.

Deltas

Deltas are like alluvial fans but develop at a different location. The load carried by the rivers is dumped and spread into the sea. It this load is not carried away far into the sea or distributed along the coast, it spreads and accumulates as a low cone.

Floodplains, Natural Levees and Point Bars

Floodplain is a major landform of river deposition. The flood plains in a delta are called delta plains.

Natural levees are found along the

banks of large rivers. They are low, linear and parallel ridges of coarse deposits along the banks of rivers, quite often cut into individual mounds. During flooding as the water spills over the bank, the velocity of the water comes down and large sized and high specific gravity materials get dumped in the immediate vicinity of the bank as ridges. They are nearer the banks and slope gently away from the river. The levee deposits are coarser than the deposits spread by flood waters away from the river. When rivers shift laterally, a series of natural levees can form.

Point bars are also known as meander bars. They are found on the convex side of meanders of large rivers and are sediments deposited in a linear fashion by flowing waters along the bank.

Meanders

In large flood and delta plains, rivers rarely flow in straight courses. Loop-like channel patterns called meanders develop over flood and delta plains.

As meanders grow into deep loops, the same may get cut-off due to erosion at the inflection points and are left as ox-bow lakes.

Braided Channels: When rivers carry coarse material, there can be selective deposition of coarser materials causing formation of a central bar which diverts the flow towards the banks; and this flow increases lateral erosion on the banks. As the valley widens, the water column is reduced and more and more materials get deposited as islands and lateral bars developing a number of separate channels of water flow. Deposition and lateral erosion of banks are essential for the formation of braided pattern. Or, alternatively, when discharge is less and load is more in the valley, channel bars and islands of sand, gravel and pebbles develop on the floor of the channel and the water flow is divided into multiple threads. These thread-like streams of water rejoin and subdivide repeatedly to give a typical braided pattern.

Groundwater

Here the interest is not on groundwater as a resource. Our focus is on the work of groundwater in the erosion of landmasses and evolution of landforms. The surface water percolates well when the rocks are permeable, thinly bedded and highly jointed and cracked. After vertically going down to some depth, the water under the ground flows horizontally through the bedding planes, joints or through the materials themselves. It is this downward and horizontal movement of water which causes the rocks to erode. Physical or mechanical removal of materials by moving groundwater is insignificant in developing landforms. That is why; the results of the work of groundwater cannot be seen in all types of rocks. But in rocks like limestone or dolomites rich in calcium carbonate, the surface water as well as groundwater through the chemical process of solution and precipitation deposition develop varieties of landforms. These two processes of solution and precipitation are active in limestone's or dolomites occurring either exclusively or inter-bedded with other rocks. Any limestone or dolomite region showing typical landforms produced by the action of groundwater through the processes of solution and deposition is called Karst topography after the typical topography developed in limestone rocks of Karst region in the Balkans adjacent to Adriatic sea.

The karst topography is also characterized be erosional and depositional landforms. Indian subcontinent is full of example of glaciers. It can be seen in mountainous area of Uttaranchal, Himachal Pradesh, Jammu Kashmir. The source of Bhagirathi river is Gangotri glacier called 'Gaumukh'. The source of Alakananda river is Alkapuri glacier. Where Alakhanda joins Bhagirathi at Devprayag it ows nomenclature as "The Ganga".

EROSIONAL LANDFORMS

Pools, Sinkholes, Lapies and Limestone Pavements

Small to medium sized round to sub-rounded shallow depressions called swallow holes form on the surface of limestone's through solution. It might collapse leaving a large hole opening into a cave or a void below (collapse sinks). The term do line is sometimes used to refer the collapse sinks. Solution sinks are more common than collapse sinks. Quite often the surface run-off simply goes down swallow and sink holes and flow as underground streams and re-emerge at a distance downstream through a cave opening. When sink holes and do-lines join together because of slumping of materials along their margins or due to roof collapse of caves, long, narrow to wide tranches called valley sinks or Uvalas form. Gradually, most of the surface of the limestone is eaten away by these pits and trenches, leaving it extremely irregular with a maze of points, grooves and ridges or lapis. Especially, these ridges or lapis form due to differential solution activity along parallel to sub-parallel joints. The lapie field may eventually turn into somewhat smooth limestone pavements.

Caves: In areas where there are alternating beds of rocks (shales, sandstones, quartzite's) with limestones or dolomites in between or in areas where limestone's are dense, massive and occurring as thick beds, cave formation is prominent.

Stalactites, Stalagmites and Pillars: Stalactites hang as icicles of different diameters. Normally they are broad at their bases and taper towards the free ends showing up in variety of forms. Stalagmites rise up from the floor of the caves. In fact, stalagmites form due to dripping water from the surface or through the thin pipe, of the stalactite, immediately below it. Stalagmites may take the shape of a column, a disc, with either a smooth, rounded bulging end or a miniature crater like depression. The stalagmite and stalactites eventually fuse to give rise to columns and pillars of different diameters.

Glaciers

Masses of ice moving as sheets over the land (continental glacier or piedmont glacier if a vast sheet of ice is spread over the plains at the foot of mountains) or as linear flows down the slopes of mountains in broad trough-like valleys (mountain and valley glaciers) are called glaciers. The movement of glaciers is slow unlike water flow. The movement could be a few centimeters to a few meters a day or even less or more. Glaciers move basically because of the force of gravity.

We have many glaciers in our country moving down the slopes and valleys in Himalayas. Higher reaches of Uttaranchal, Himachal Pradesh and Jammu and Kashmir, are places to see some of them. River Bhagirathi is basically fed by melt waters from under the snout (Gaumukh) of the

Gangotri glacier. In fact, Alkapuri glacier feeds waters to Alakananda river. Rivers Alkananda and Bhagirathi join to make river Ganga near Deoprayag.

Erosion by glaciers is tremendous because of friction caused by sheer weight of the ice. The material plucked from the land by glaciers (usually large-sized angular blocks and fragments) get dragged along the floors or sides of the valleys and cause great damage through abrasion and plucking. Glaciers can cause significant damage to even un-weathered rocks and can reduce high mountains into low hills and plains.

As glaciers continue to move, debris gets removed, divides get lowered and eventually the slope is reduced to such an extent that glaciers will stop moving leaving only a mass of low hills and vast outwash plains along with other depositional features. The highest peak in the Alps, Matterhorn and the highest peak in the Himalayas, Everest are in fact horns formed through headword erosion of radiating cirques.

Erosional Landforms

Cirque: The cirques quite often are found at the heads of glacial valleys. The accumulated ice cuts these cirques while moving down the mountain tops. They are deep, long and wide troughs or basins with very steep concave to vertically dropping high walls at its head as well as sides. A lake of water can be seen quite often within the cirques after the glacier disappears. Such lakes are called cirque or tarn lakes. There can be two or more cirques one leading into another down below in a stepped sequence.

Horns and Serrated Ridges

Horns form through head ward erosion of the cirque walls. It three or more radiating glaciers cut head ward until their cirques meet, high, sharp pointed and steep sided peaks called horns form. The divides between cirque side walls or head walls get narrow because of progressive erosion and turn into serrated or saw- toothed ridges sometimes referred to as arêtes with very sharp crest and a zigzag outline.

Glacial Valleys/Troughs

Glaciated valleys are trough-like and U-shaped with broad floors and relatively smooth, and steep sides. The valleys may contain littered debris or debris shaped as moraines with swampy appearance. There may be lakes gouged out of rocky floor or formed by debris within the valleys. There can be hanging valleys at an elevation on one or both sides of the main glacial valleys are quite often truncated to give them an appearance like triangular facets. Very deep glacial troughs filled with sea water and making up shorelines (in high latitudes) are called fjords/fiords.

Depositional Landforms

The unasserted coarse and fine debris dropped by the melting glaciers is called glacial till.

Moraines: They are long ridges of deposits of glacial till. Terminal moraines are long ridges of debris deposited at the end (toe) of the glaciers. Lateral moraines form along the sides parallel to the glacial valleys. The moraine in the centre of the glacial valley flanked by lateral moraines is called medial moraine.

Eskers

When glaciers melt in summer, the water flows on the surface of the ice or seeps down along the margins or even moves through holes in the ice. These waters accumulate

beneath the glacier and flow like streams in a channel beneath the ice. Such streams flow over the ground (not in a valley cut in the ground) with ice forming its banks. Very coarse materials like boulders and blocks along with some minor fractions of rock debris carried into this stream settle in the valley of ice beneath the glacier and after the ice melts can be found as a sinuous ridge called esker.

Outwash Plains

The plains at the foot of the glacial mountains or beyond the limits of continental ice sheets are covered with glacio-fluvial deposits in the form of broad flat alluvial fans which may join to form outwash plains of gravel, silt, sand and clay.

Drumlins

Drumlins are smooth oval shaped ridge-like features composed mainly of glacial till with some masses of gravel and sand. The long axes of drumlins are parallel to the direction of ice movement. They may measure up to 1 km in length and 30 m or so in height. One end of the drumlins facing the glacier called the stoss end is blunter and steeper than the other end called tail. The drumlins form due to dumping of rock debris beneath heavily loaded ice through fissures in the glacier. The stoss end gets blunted due to pushing by moving ice. Drumlins give an indication of glacier movement.

Waves and Currents

Coastal processes are the most dynamic and hence most destructive.

Some of the changes along the coast take place very fast. At one place, there can be erosion in one season and deposition in another. Most of the changes along the coast are accomplished by waves. When waves break, the water is thrown with great force onto the shore, and simultaneously, there is a great churning of sediments on the sea bottom. Constant impact of breaking waves drastically affects the coasts. Storm waves and tsunami waves can cause far-reaching changes in a short period of time than normal breaking waves. As wave environment changes, the intensity of the force of breaking waves changes.

Other than the action of waves, the coastal landforms depend upon (i) the configuration of land and sea floor; (ii) whether the coast is advancing (emerging) seaward or retreating (submerging) landward. Assuming sea level to be constant, two types of coasts are considered to explain the concept of coastal landforms: (i) high, rocky coasts (submerged coasts); (ii) low, smooth and gently sloping sedimentary coasts (emerged coasts).

High Rocky Coasts

Along the high rocky coasts, the rivers appear to have been drowned with highly irregular coastline. The coastline appears highly indented with extension of water into the land where glacial valleys (fjords) are present. The hill sides drop off sharply into the water. Shores do not show any depositional landforms initially. Erosion features dominate.

Along with rocky coasts, waves break with great force against the land shaping the hill sides into cliffs. With constant pounding by waves, the cliffs recede leaving a wave-cut platform in front of the sea cliff. Waves gradually minimize the irregularities along the shore. The materials which fall off, and removed from the sea cliffs, gradually break

into smaller fragments and roll to roundness, will get deposited in the offshore. After a considerable period of cliff development and retreat when coastline turns somewhat smooth, with the addition of some more material to this deposit in the offshore, a wave-built terrace would develop in front of wave-cut terrace. As the erosion along the coast takes place a good supply material becomes available to long shore currents and waves to deposit them as beaches along the shore and as bars (long ridges of sand and/ or shingle parallel to the coast) in the near shore zone. Bars are submerged features and when bars show up above water, they are called barrier bars. Barrier bar which get keyed up to the headland of a bay is called a spit. When barrier bars and spits form at the mouth of a bay and block it, a lagoon forms. The lagoons would gradually get filled up by sediments from the land giving rise to a coastal plain.

Low sedimentary coasts

Along low sedimentary coasts the rivers appear to extend their length by building coastal plains and deltas. The coastline appears smooth with occasional incursions of water in the form of lagoons and tidal creeks. The land slopes gently into the water. Marshes and swamps may abound along the coasts. Depositional features dominate.

When waves break over a gently sloping sedimentary coast, the bottom sediments get churned and move readily building bars, barrier bars, spits and lagoons. Lagoons would eventually turn into a swamp which would subsequently turn into a coastal plain. The maintenance of these depositional features depends upon the steady supply of materials.

Storm and tsunami waves cause drastic changes irrespective of supply of sediments. Large rivers which bring lots of sediments build deltas along low sedimentary coasts.

Erosional Landforms

Cliffs, Terraces, Caves and Stacks Wave-cut cliffs and terraces are two forms usually found where erosion is the dominant shore process. Almost all sea cliffs are steep and may range from a few m to 30 m or even more. At the foot of such cliffs there may be a flat or gently sloping platform covered by rock debris derived from the sea cliff behind. Such platforms occurring at elevations above the average height of waves is called a wave-cut terrace. The lashing of waves against the base of the cliff and the rock debris that gets smashed against the cliff along with lashing waves create hollows and these hollows get widened and deepened to form sea caves. The roofs of caves collapse and the sea cliffs recede further inland. Retreat of the cliff may leave some remnants of rock standing isolated as small islands just off the shore. Such resistant masses of rock, originally parts of a cliff or hill are called sea stacks. Like all other features, sea stacks are also temporary and eventually coastal hills and cliffs will disappear because of wave erosion giving rise to narrow coastal plains, and with onrush of deposits from over the land behind may get covered up by alluvium or may get covered up by shingle or sand to form a wide beach.

Depositional landforms

Beaches and Dunes

Beaches are characteristic of shorelines that are dominated by deposition, but may occur as patches along even the rugged shores. Most of the sediment making up the

beaches comes from land carried by the streams and rivers or from wave erosion. Beaches are temporary features. The sandy beach which appears so permanent may be reduced to a very narrow strip of coarse pebbles in some other season. Most of the beaches are made up of sand sized materials. Beaches called shingle beaches contain excessively small pebbles and even cobbles.

Just behind the beach, the sands lifted and winnowed from over the beach surfaces will be deposited as sand dunes. Sand dunes forming long ridges parallel to the coastline are very common along low sedimentary coasts.

Bars, Barriers and Spits

A ridge of sand and shingle formed in the sea in the off-shore zone (from the position of low tide waterline to seaward) lying approximately parallel to the coast is called an off-shore bar. An off-shore bar which is exposed due to further addition of sand is termed a barrier bar. The off-shore bars and barriers commonly from across the mouth of a river or at the entrance of a bay. Sometimes such bars get keyed up to one end of the bay when they are called spits. Spits may also develop attached to headlands/hills. The barriers, bars and spits at the mouth of the bay gradually extend leaving only a small opening of the bay into the sea and the bay will eventually develop into a lagoon. The lagoons get filled up gradually by sediment coming from the land or from the beach itself (aided by wind) and a broad and wide coastal plain may develop replacing a lagoon.

Winds

Wind is one of the two dominant agents in hot deserts. Winds cause deflation, abrasion and impact. Deflation includes lifting and removal of dust and smaller particles from the surface of rocks. In the transportation process sand and silt act as effective tools to abrade the land surface. The impact is simply sheer force of momentum which occurs when sand is blown into or against a rock surface. It is similar to sandblasting operation. The wind action creates a number of interesting erosional and depositional features in the deserts.

Erosional Landforms

Pediments and Pedi plains

Landscape evolution in deserts is primarily concerned with the formation and extension of pediments. Gently inclined rocky floors close to the mountains at their foot with or without a thin cover of debris, are called pediments. Such rocky floors from through the erosion of mountain front through a combination of lateral erosion by streams and sheet flooding.

Erosion starts along the steep margins of the landmass or the steep sides of the tectonically controlled steep incision features over the landmass. Once, pediments are formed with a steep wash slope followed by cliff or free face above it, the steep wash slope and free face retreat backwards. This method of erosion is termed as parallel retreat of slopes through back wasting.

So, through parallel retreat of slopes, the pediments extend backwards at the expense of mountain front, and gradually, the mountain gets reduced leaving an inselberg which is a remnant of the mountain. That's how the high relief in desert areas is reduced to low featureless plains called Pedi plains.

Playas: Plains are by far the most prominent landforms in the deserts. In basins with mountains and hills around and along,

the drainage's towards the center of the basin and due to gradual deposition of sediment from basin margins, a nearly level plain forms at the centre of the basin. In times of sufficient water, this plain is covered up by a shallow water body.

Such types of shallow lakes are called as playas where water is retained only for short duration due to evaporation and quite often the playas contain good deposition of salts. The playa plain covered up by salts is called alkali flats.

Deflation Hollows and Caves

Weathered mantle from over the rocks or bare soil, gets blown out by persistent movement of wind currents in one direction. This process may create shallow depressions called deflation hollows. Deflation also creates numerous small pits or cavities over rock surfaces.

The rock faces suffer impact and abrasion of wind-borne sand and first shallow depressions called blow outs are created, and some of the blow outs become deeper and wider fit to be called caves.

Many rock-outcrops in the deserts easily susceptible to wind deflation and abrasion are worn out quickly leaving some remnants of resistant rocks polished beautifully in the shape of mushroom with a slender stalk and a broad and rounded pear shaped cap above. Sometimes, the top surface is broad like a table top and quite often, the remnants stand out like pedestals.

Depositional Landforms

Wind is a good sorting agent. Depending upon the velocity of wind, different sizes of grains are moved along the floors by rolling or saltation and carried in suspension and in this process of transportation itself, the materials get sorted. When the wind slows or begins to die down, depending upon sizes of grains and their critical velocities, the grains will begin to settle.

So, in depositional landforms made by wind, good sorting of grains can be found. Since wind is there everywhere and wherever there is good source of sand and with constant wind directions, depositional features in arid regions can develop anywhere.

Sand Dunes

Dry hot deserts are good places for sand dune formation. Obstacles to initiate dune formation are equally important. There can be a great variety of dune forms.

Barchans

Crescent shaped dunes called barchans with the points or wings directed away from wind direction i.e., downwind, form where the wind direction is constant and moderate and where the original surface over which sand is moving is almost uniform. Parabolic dunes form when sandy surfaces are partially covered with vegetation. That means parabolic dunes are reversed barchans with wind direction being the same. Seif is similar to barchans with a small differences. Seif has only one wing or point. This happens when there is shift in wind conditions. The long wings of seifs can grow very long and high. Longitudinal dunes form when supply of sand is poor and wind direction is constant. They appear as long ridges of considerable length but low in height. Transverse dunes are aligned perpendicular to wind direction. These dunes form when the wind direction is constant and the source of sand is an elongated feature at right angles to the wind

direction. They may be very long and low in height. When sand is plenty, quite often, the regular shaped dunes coalesce and lose their individual characteristics. Most of the dunes in the deserts shift and a few of them will get stabilized especially near human habitations.

12

COMPOSITION AND STRUCTURE OF ATMOSPHERE

Composition and Structure of Atmosphere

Atmosphere is a mixture of different gases and it envelopes the earth all round. It contains life-giving gases like oxygen for humans and animals and carbon dioxide for plants. The air is an integral part of the earth's mass and 99 per cent of the total mass of the atmosphere is confined to the height of 32 km from the earth's surface. The air is colourless and odourless and can be felt only when it blows as wind.

Composition of the Atmosphere

The atmosphere is composed of gases, water vapour and dust particles. Table shows details of various gases in the air, particularly in the lower atmosphere. The proportion of gases changes in the higher layers of the atmosphere in such a way that oxygen will be almost in negligible quantity at the height of 120 kin. Similarly, carbon dioxide and water vapour are found only up to 90 km from the surface of the earth.

Constituent	Formula	Percentage by Volume
Nitrogen	N_2	78.08
Oxygen	O_2	20.95
Argon	Ar	0.93
Carbond dioxide	Co_2	0.93
Neon	Ne	0.002
Helium	He	0.0005
Krypto	Kr	0.001
Xenon	Xe	0.00009
Hydrogen	H_2	0.00005

Gases: Carbon dioxide is meteorologically a very important gas as it is transparent to the incoming solar radiation but opaque to the outgoing terrestrial radiation. It absorbs a part of terrestrial radiation and reflects back some part of it towards the earth's surface. It is largely responsible for the green house effect. The volume of other gases is constant but the volume of carbon dioxide has been rising in the past few decades mainly because of the burning of fossil fuels. This has also increased the temperature of the air. Ozone is another important component of the atmosphere found between 10 and 50 km above the earth's surface and acts as a filter and absorbs the ultra-violet rays radiating from the sun and prevents them from reaching the surface of the earth.

Water Vapour: Water vapour is also a variable gas in the atmosphere, which decreases with altitude. In the warm and wet tropics, it 'may account for four percent of the air by volume, while in the dry and cold areas of desert and polar regions, it may be less than one percent of the air. Water vapour also decreases from the equator, towards the poles. It also absorbs parts of the

insolation from the sun and preserves the earth's radiated heat. It thus, acts like a blanket allowing the earth neither to become 'too cold nor too hot. Water vapour also contributes to the stability and instability in the air.

Dust Particles: Atmosphere has a sufficient capacity to keep small solid particles, which may originate from different sources and include sea salts, fine soil, smoke-soot, ash, pollen, dust and disintegrated particles of meteors. Dust particles are generally concentrated in the lower layers of the atmosphere; yet, convectional air currents may transport them to great heights. The higher concentration of dust particles is found in subtropical and temperate regions due to dry winds in comparison to equatorial and polar regions. Dust and salt particles act as hygroscopic nuclei around which water vapour condenses to produce clouds.

Structure of the Atmosphere

The atmosphere consists of different layers with varying density and temperature. Density is highest near the surface of the earth and decreases with increasing altitude. The column of atmosphere is divided into five different layers depending upon the temperature condition. They are: troposphere, stratosphere, mesosphere, ionosphere and exosphere.

The troposphere is the lowermost layer of the atmosphere. Its average height is 13 km and extends roughly to a height of 8 km near the poles and about 18 km at the equator. Thickness of the troposphere is greatest at the equator because heat is transported to great heights by strong convectional currents. This layer contains dust particles and water vapour. All changes in climate and weather take place in this layer. The temperature in this layer decreases at the rate of 1°C for every 165m of height. This is the most important layer for all biological activity.

The zone separating the tropsophere from stratosphere is known as the tropopause. The air temperature at the tropopause is about minus 80°C over the equator and about minus 45°C over the poles. The temperature here is nearly constant, and hence, it is called the tropopause. The stratosphere is found above the tropopause and extends up to a height of 50 km. One important feature of the stratosphere is that it contains the ozone layer. This layer absorbs ultraviolet radiation and shields life on the earth from intense, harmful form of energy.

The mesosphere lies above the stratosphere, which extends up to a height-of 80 km. In this layer, once again, temperature starts decreasing with the increase in altitude and reaches up to minus 100°C at the height of 80 km. The upper limit of mesosphere is known as the mesopause. The ionosphere is located between 80 and 400 km above the mesopause. It contains electrically charged particles known as ions, and hence, it is known as ionosphere. Radio waves transmitted from the earth are reflected back to the earth by this layer. Temperature here starts increasing with height. The uppermost layer of the atmosphere above the 'ionosphere is known as the exosphere. This is the highest layer but very little is known about it. Whatever contents are there, these are extremely rarefied in this layer, and it gradually merges with the outer space. Although all layers of the atmosphere must be exercising influence on us, geographers are concerned with the first two layers of the atmosphere.

Water in the Atmosphere: The air contains water vapour. It varies from zero to four percent by volume of the atmosphere and plays an important, role in the weather phenomena. Water is present in the atmosphere in three forms namely — gaseous, liquid and solid. The moisture in the atmosphere is derived from water bodies through evaporation and from plants through transpiration. Thus, there is a continuous exchange of water between the atmosphere, the oceans and the continents through the processes of evaporation, transpiration; condensation and precipitation.

Water vapour present in the air is known as humidity. It is express equantitatively in different ways. The actual amount of the water vapour present in the atmosphere is known as the absolute humidity. It is the weight of water vapour per unit volume of air and is expressed in terms of grams per cubic metre. The ability of the air to hold water vapor depends entirely on its temperature. The absolute humidity differs from place to place on the surface of the earth. The percentage of moisture present in the atmosphere as compared to its full capacity at a given temperature is known as the relative humidity. With the change of air temperature, the capacity to retain moisture increases or decreases and the relative humidity is also affected. It is greater over the oceans and least over the continents.The air containing moisture to its full capacity at a given temperature is said to be saturated. It means that the air at the given temperature Is incapable of holding any additional amount of moisture at that stage. The temperature at which saturation occurs in a given sample of air is known as dew point.

Evaporation and Condensation

The amount of water vapour in the atmosphere is added or withdrawn due to evaporation and condensation respectively. Evaporation is a process by which water is transformed from liquid to gaseous state. Heat is the main cause for evaporation. The temperature at which the water starts evaporating is referred to as the latent heat of vapourisation.Increase in temperature increases water absorption and retention capacity of the given parcel of air. Similarly, if the moisture content is low, air has a potentiality of absorbing and retaining moisture. Movement of air replaces the saturated layer with the unsaturated layer. Hence, the greater the movement of air, the greater is the evaporation.

The transformation of water vapour into water is called condensation. Condensation is caused b the loss of heat. When moist air is cooled, it may reach a level when its capacity to hold water vapour ceases. Then, the excess water vapour condenses into liquid form. If it directly condenses into solid form, it is known as sublimation. In free air, condensation results from cooling around very small particles termed as hygroscopic condensation nuclei. Particles of dust, smoke and salt from the ocean are particularly good nuclei because they absorb water. Condensation also takes place when the moist air comes in contact with some colder object and it may also take place when the temperature is close to the dew point. Condensation, therefore, depends upon the amount of cooling and the relative humidity of the air. Condensation is influenced by the volume of air, temperature, pressure and humidity.

Download All Subject Free PDF

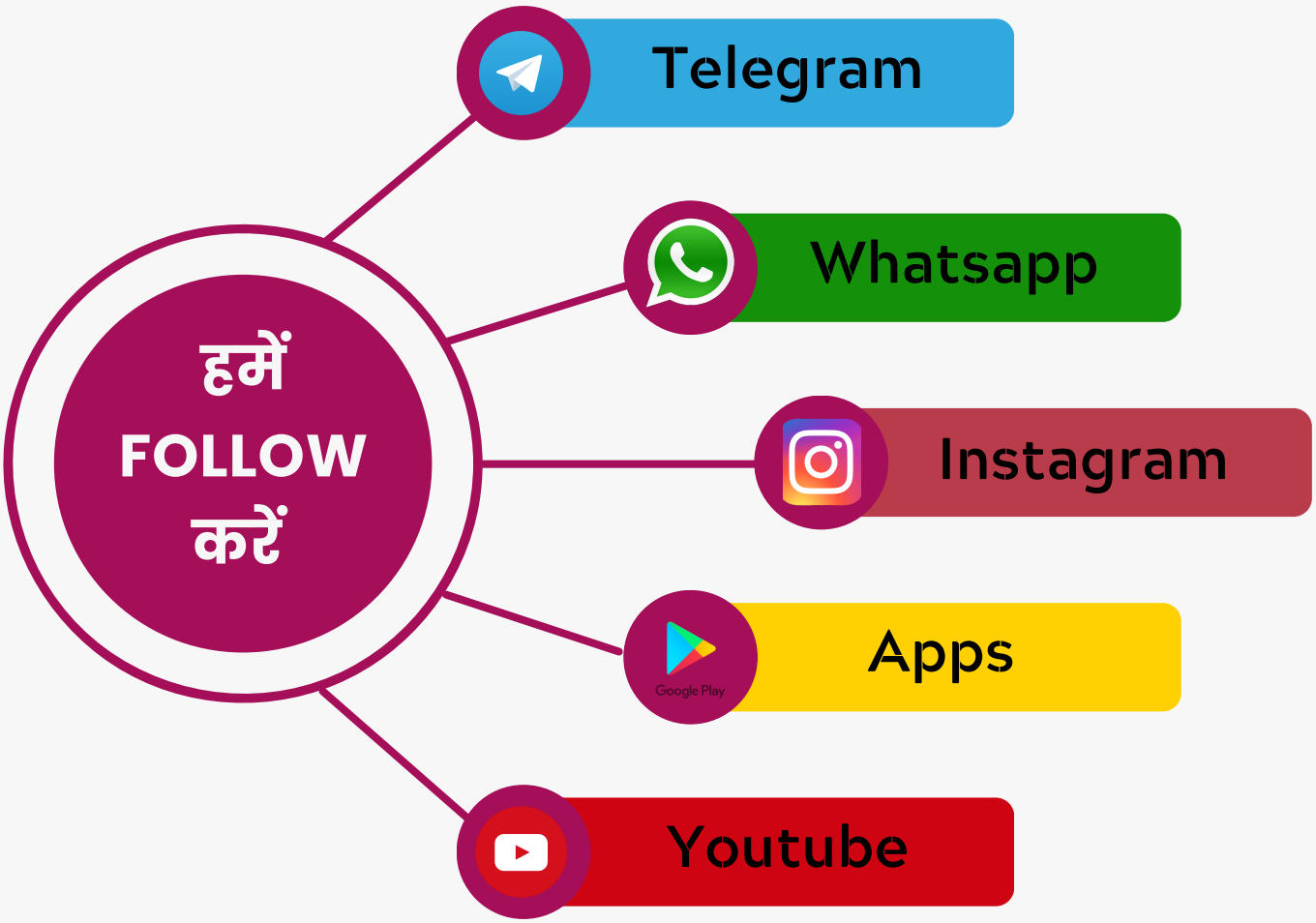
- General Knowledge
- Child Development and Pedagogy
- Current Affairs
- History
- Maths
- Geography
- Reasoning
- Economics
- Science
- Polity
- Computer
- Environment
- General Hindi
- MP GK
- General English
- UP GK

Join Our Best Course

GK Trick By Nitin Gupta

Current Affairs

Daily Current Affairs PDF, Best Test Series, Best GK PDF के लिए हमें Follow करें



GK Trick By Nitin Gupta
The Ultimate Key to Success.

Welcome To

GK TRICK BY NITIN GUPTA APP

यहाँ पर आपको मिलेगा

- Best PDF Notes For All Exams
- Best Test Series For All Exams
- Daily Current Affairs PDF
- सभी Course बहुत ही कम Price पर
- सभी Test Detail Discription के साथ व Analysis करने को सुविधा