

CHAPTER-1-STRUCTURE OF INDIA

1. THE ARCHAEAN FORMATIONS (PRE-CAMBRIAN)

- The Archaean Era is also known as the Precambrian Period.
- the division of geologic time scale from the formation of the Earth (about 4.6 billion years ago) to the beginning of the Cambrian Period of the Paleozoic Era (about 570 million years ago}.
- The Precambrian time constitutes about 86.7% of the Earth's history.
- The term 'Archaean', introduced by J.D. Dana in 1782, refers to the oldest rocks of the Earth's crust.
- The oldest known rocks of the Earth, the evolutionary atmosphere, the first chemosynthesis, the first photosynthesis, the life-supporting atmosphere and the Earth's modern atmosphere, were developed during the Precambrian Era (Archaean and Protozoic).
- Rocks of the Archaean System are devoid of any form of life.
- the Archaean rocks are all azoic or unfossiliferous.
- They are thoroughly crystalline, extremely contorted and faulted, and practically devoid of any sediment.
- They are largely intruded by plutonic intrusions and generally have a well-defined foliated structure.
- These rocks are known as the basement complex or fundamental gneisses.
- cover two-thirds of Peninsular India.
- In the Peninsular region, the Archaean rocks are known to be of three well-defined types:

(i) The Bengal Gneiss

- occurs in the Eastern Ghats, Orissa (known as Khondalites after Khond tribes in Koraput and Bolangir districts), stretching over Manbhum and Hazaribagh districts of Jharkhand, Nellore district of Andhra Pradesh and Salem district of Tamil Nadu.
- occur in the Son Valley, Meghalaya Plateau and Mikir Hills.
- thinly foliated.
- For the first time these rocks were identified in the Midnapur district of West Bengal.

(ii) The Bundelkhand Gneiss

- forms the second group of fundamental gneiss of the Archaean age.
- occurs in Bundelkhand (U.P.), Baghelkhand (M.P.), Maharashtra, Rajasthan, Andhra Pradesh and Tamil Nadu.
- a coarse grained gneiss which looks like granite.
- conspicuously criss-crossed and characterised by quartz veins.

(iii) The Nilgiri Gneiss

- The name being given in honour of John Charnock whose tombstone in Kolkata was made of this rock.
- bluish-grey to dark coloured rock, medium to coarse grained in texture.
- This is plutonic gneiss intruding into the other Archaean rock masses.
- Nilgiri gneiss is popularly recognised as belonging to the Charnockite series.
- widely found in South Arcot, Palni Hills, Shevaroy Hills and Nilgiri in Tamil Nadu, Nellore in Andhra Pradesh, Balasore in Orissa, Karnataka, Kerala, Malabar, Jharkhand, Chhattisgarh and Aravalli (Rajasthan).
- The Archaean rocks are the repositories of the mineral wealth of India.

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- These rocks are rich in ferrous and non-ferrous minerals like iron ore, copper, manganese, mica, dolomite, lead, zinc, silver and gold.

2. DHARWAR SYSTEM (PROTEROZOIC FORMATIONS)

- This geologic time extends from 2500 million years ago to 1800 million years ago.
- the first metamorphosed sedimentary rock systems known as the Dharwar System in the Indian Geological Time Scale.
- In India, these rocks were studied for the first time in the Dharwar district of Karnataka.
- composed largely of igneous debris, schists and gneisses.
- The Dharwar rocks occur in scattered patches in
 - (i) Dharwar and Bellary districts of Karnataka and extend up to the Nilgiris and Madurai districts of Tamil Nadu,
 - (ii) Central and eastern parts of the Chotanagpur Plateau, Meghalaya Plateau and Mikir Hills, and
 - (iii) the Aravallis, Rialo (Delhi series), from Delhi to the south of Alwar and the Himalayan region Nilgiris and Madurai districts of Tamil Nadu,
- Dharwar rocks are highly metalliferous.
- rich in iron ore, manganese, lead, zinc, gold, silver, dolomite, mica, copper, tungsten, nickel, precious stones and building materials.
- Some of the important series of the Dharwar System are:

(a) Champion Series

- Belonging to the Dharwarian System, the series has been named after the Champion reef in the Kolar Gold fields.
- Lying to the north-east of Mysore City and to the east of Bangalore, this series stretches in the Kolar and Raichur districts of Karnataka.
- Its gold mines are one of the deepest in the world, being more than 3.5 km in depth.
- The gold content in this series is about 5.5 grams per tonne of ore.

(b) Champaner Series

- an outlier of the Aravallis system in the vicinity of Vadodra.
- consists of quartzites, conglomerates, phyllites, slates and marbles.
- An attractive green variety of marble is obtained from this series.

(c) Closepet Series

- Stretching over the Balaghat and Chhindwara districts of Madhya Pradesh,
- it is a Dharwarian formation.
- consists of quartzite, copper pyrite, and magniferous rocks.
- The Malanjkhand Copper Plant gets its ore from the Closepet series.

(d) Chilpi Series

- occupies parts of Balaghat and Chhindwara districts of Madhya Pradesh.
- consists of grit, phyllite, quartzites, green stones and magniferous rocks.

(e) Iron-Ore Series

- occurs in Singhbhum, Bonai, Mayurbhanj and Keonjhar in the form of a range.
- is about 65 kilometres in length and reserves about three thousand million tons of iron-ore.

(f) Khondolite Series

- occupies a large area in the Eastern Ghats from the northern extremity to the valley of Krishna.
- The principal rock types in this series are khondolites, kodurites, charnockites and gneisses.

(g) Rialo Series

- known as the Delhi series, it extends from Delhi (Majnu-Ka-Tila) to Alwar, Rajasthan in a north-east to south-west direction.
- rich in marbles.
- The Makrana, and Bhagwanpur known for high quality of marble belong to this series .

(h) Sakoli Series

- Stretching over Jabalpur and Rewa districts, this series belongs to the Dharwarian formation.
- rich in mica, dolomite, schist and marble.
- The marble of this series is of superior quality.

(i) Sausar series

- spreads over Nagpur, Bhandara districts of Maharashtra, and Chindwara district of Madhya Pradesh.
- It belongs to the Dharwarian group and is rich in quartzite, mica chist, marble and magniferous rocks.

3. THE CUDDAPAH SYSTEM (THE PURANA GROUP)

- named after the district of Cuddapah in Andhra Pradesh,
- sedimentary-metamorphic formations.
- The Cuddapah System occurs in the (i) Cuddapah and Kumool districts of Andhra Pradesh, (ii) Chhattisgarh, (iii) Rajasthan-Delhi to the south of Alwar, and (iv) the Lesser Himalayas in the extra-Peninsular region.
- The principle rocks of the Cuddapah System are sandstones, shales, limestone, quartzites slates, inferior quality of iron-ore, manganese ore, asbestos, copper, nickel, cobalt (Delhi System), marble, jasper, building material and stones for interior decoration.
- The metallic contents in the ores of Cuddapah rocks are, however, low and at places uneconomical for extraction.

Papaghani series

- named after the Papaghani river (Andhra Pradesh), in the valley of which these rocks have been exposed.
- consists of quartzites, sandstones, shales, slates, limestones and marbles.
- The series is intruded by magma in the form of dykes and sills which have metamorphosed limestone into marble, talc, slate, and serpentine.

4. THE VINDHYAN SYSTEM

- derives its name from the Vindhyan Mountain.
- This mountain forms a dividing line between the Ganga Plain and the Deccan Plateau.
- The system covers an extensive area of 103,600 sq km from Chittorgarh in Rajasthan to Sasaram in Bihar.
- has enormous sedimentary deposits and at places their depth is more than 4000 metres.
- In some tracts, the Vindhyan rocks are buried under Deccan lava.
- The Great Boundary Fault (GBF) separates the Vindhyan System from the Aravallis for a distance of about eight hundred km
- well known for red-sandstone, sandstone, building material, ornamental stone, conglomerates, diamondiferous and raw materials for cement, lime, glass and chemical industries.
- In certain places these rocks yield inferior, quality of iron ore and manganese.
- The well known diamond mines of Panna and Golconda lie in the Vindhyan System.

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- The historical buildings of Qutab Minar, Humayun's Tomb, Fatehpur Sikri, Agra Fort, Red Fort, Jama-Masjid, Birla Mandir, the Buddhist Stupa of Sanchi, etc. have been constructed from the red-sandstone obtained from the Vindhyan Ranges.
- Coarser sandstones have been used as grindstones and millstones.

Bhander Series

- spreads over the western parts of the Vindhyan formation.
- main rocks are sandstones, shales and limestone.
- provides good quality of building material besides diamonds and precious stones.

Bijwar Series

- Stretching over the districts of Chhatarpur and Panna, this series belongs to the Vindhyan system.
- composed of sandstone, red-sandstone, and quartzite. It has basaltic intrusions whose dykes are rich in diamonds.

Kaimur Series

- This series sprawls over Bundelkhand (U.P.) and Baghelkhand (M.P.).
- The main rocks in this series are sandstone, conglomerate and shale.
- rich in red sandstone used in historical monuments.

5. THE PALAEOZOIC GROUP(CAMBRIAN TO CARBONIFEROUS PERIOD)

- The Palaeozoic Era includes the Ordovician, Silurian, Devonian, Carboniferous and the Permian periods of the Standard Geological Time Scale.
- known as the Dravidian Era in the Indian Geological Time Scale.
- The Palaeozoic Era extends from 570 million years ago to 24.5 million years ago. It marks the beginning of life on the Earth's surface.
- The formations of this period are almost absent in the Peninsular India except near Umaria in Rewa.
- These formations exist in the Pir-Panjal, Handwara, Lidder-Valley, Anantnag of Kashmir Uammu & Kashmir), Spiti, Kangra, Shimla region (Himachal Pradesh), and Garhwal and Kumaun (Uttarakhand).
- It was during this period that the Pangaea was broken and the Tethys Sea came into existence.
- The Cambrian rocks include shales, sandstones, clays, quartzites slates, salts, marble, etc.

Palaeozoic System in the Indian Geologic Time Scale

- The Gondwana formations are fluvial and lacustrine in character.
- They were deposited in the river basins and lakes during the Upper Carboniferous Period.
- These basins later subsided along the trough faults amidst ancient rocks of the great southern continent called the Gondwanaland.
- These rocks were formed during the Upper Carboniferous and the Jurassic Periods (Mesozoic Era).

6. THE MESOZOIC ERA (THE GONDWANA. SYSTEM)

- 'Mesozoic' means middle life.
- The term is used for a period of geologic time in which the presence of fossil invertebrates dominated the rocks.
- includes three periods: Triassic, Jurassic, and Cretaceous.
- In the Indian Geological Time Scale, these periods extend from the Upper Carboniferous up to the beginning of the Cenozoic Era or the Aryan Era.
- The Gondwana group begins with the Permo-Carboniferous period which, in the Standard Geologic Time Scale, is known as a period of coal formation.

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- The Lower Gondwana rocks are found in the Talcher, Panchet and Damuda series.
- Most of the good quality coal deposits (bituminous and anthracite) of India are found in Gondwana formations.
- Moreover, iron ore occurs in the iron-stone shales of Raniganj coal fields.
- In addition to coal and iron, kaolin, fireclay, sandstone and grits are also found in the Gondwana formations.

Talcher Series

- the series of the Gondwana system named after Talcher in Dhankena District of Orissa.
- rich in good quality coal used for smelting and in thermal power plants.

The Damuda series

- The Damuda series belongs to the Middle Gondwana Period which contains enormous deposits of coal seams.
- The coal seams are thicker and more elongated in the eastern coal fields than in the west
- The important coal bearing areas of this period are Raniganj, Jharia, Karanpura and Bokaro of the Damodar basin, Singrauli, Korba, and Pench valley in Chhattisgarh and Madhya Pradesh, Talcher in Mahanadi Basin in Orissa, and Singreni of Satpura Basin in Madhya Pradesh.
- The Jhingurda Coal Seam with a thickness of about 131 metres is the thickest coal seam in India.
- The Gondwana rocks are also found in Himalayas from Kashmir to Arunachal Pradesh and Poorvanchal.
- The coal seams of these areas are metamorphosed. They are also found in Saurashtra, Kachchh, western Rajasthan, Coromandal Coast, and Rajmahal Hills.

Panchet Series

- the youngest series of the Lower Gondwana System, which derives its name from the hill of that name south of Raniganj.
- The series consists of greenish-sandstone and shales.
- It is, however, devoid of coal-seams.
- The iron-ore shales of the Lower Gondwana System are particularly well developed in the Raniganj coalfield of West Bengal.
- they contain inferior quality iron ore, i.e. siderite and limonite.
- Being inferior in quality, they are generally not mined for iron.
- The Gondwana System of rocks provides over 95% of the coal of India.
- Moreover, it provides iron-ore, limestone, sandstone and raw material for ceramic industry.
- India's best and largest coal deposits are found in the Gondwana System-mainly in the Damodar Valley of West Bengal, Jharkhand, the Mahanadi valley of Orissa and Chhattisgarh, the Godavari valley of Andhra Pradesh and the Satpura basin of Madhya Pradesh

The beginning of the Upper Carboniferous Period is known as the Aryan period.

The salient features of the Aryan formations are:

- During the Upper Carboniferous Period, the Himalayan region was occupied by a vast geosyncline which was connected to the Pacific Ocean in the east through China and the Atlantic Ocean in the west through Afghanistan, Iran, Asia Minor and the present Mediterranean Sea. This was called the Tethys Sea.
- The area of the Kashmir Himalayas (from Pir Panjal to Hazara in the north-west and Ladakh in the north-east) witnessed violent volcanic activity.

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- The Upper continent of Gondwanaland developed fissures and its broken parts started drifting away from each other.
- The Subcontinent of India drifted towards north and northeast to collide with the Asian land mass (Eurasian Plate).
- There was large scale eruption of lava in the Deccan Trap.
- The development and expansion of the Arabian Sea and the Bay of Bengal.
- The Tertiary mountain building gave birth to Himalayas.
- The Subcontinent of India assumed its present shape.
- The beginning of Ice Age, belonging to the Pleistocene Period, covering large parts of the earth under ice-sheet.
- Evolution and spread of man in different parts of the world.

7. THE CRETACEOUS SYSTEM (THE DECCAN TRAP)

- The Cretaceous Period extends from about 146 million years ago to 65 million years ago.
- The term 'Cretaceous' has been obtained from the Latin creta, meaning 'chalk'.
- very widely distributed system in the country which has divergent facies of deposits in different parts of India.
- This period is marked by the transgression of the sea (Coromandal coast, Narmada valley) and outpouring of huge quantity of lava (basalt) so as to form the Deccan Trap and intrusion of plutonic rocks such as gabbro and granite.
- Towards the end of the Cretaceous period the Peninsula was affected by intense volcanic activity.
- During this period, enormous quantity of basaltic lava was poured out to the surface assuming a great thickness of over three thousand metres.
- The Lava Plateau (the Deccan Trap) is the result of that lava eruption.
- The Deccan lava covers about five lakh sq km of area in Gujarat (Kachchh, Kathiawad), Maharashtra, Madhya Pradesh (Malwa Plateau), Chhattisgarh, Jharkhand, northern Andhra Pradesh and north-western Karnataka.
- The lava plateau of India (Deccan Trap) has a maximum thickness of about 3000 m along the coast of Mumbai from where it decreases towards south and east
- It is about 800 m in Kachchh, 150 m at Amarkantak and 60 m at Belgaum (Karnataka).
- The individual lava flows, on an average, have a thickness of about 5 m to 29 m.
- Such flows have been identified in a boring near Bhusawal (Maharashtra).
- These are inter-bedded with sedimentary beds called 'inter-trappean beds'.
- The basalt of the Deccan Trap is used for the construction of roads and buildings.
- Moreover, quartz, bauxite, magnetite, agate and semi-precious stones are also found in the trap. It is also rich in magnesium, carbonate, potash and phosphates.

8. THE TERTIARY SYSTEM (THE CENOZOIC ERA)

- Cenozoic means recent life.
- The beginning of the Tertiary Period is about 66 million years ago.
- Fossils in these rocks include many types, closely related to modern forms, including mammals, plants and invertebrates.
- The Cenozoic Era has two periods: The Tertiary and the Quaternary.
- The two great events that occurred during the Tertiary Period include:
- (i) the final beaking-up of the old Gondwana continent, and (ii) the uplift of the Tethys geosyncline in the form of the Himalayas.

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- During the early Tertiary Period, as India collided with Tibet, the sediments which had been accumulating in the Tethys basin had begun to rise by a slow rise of ocean bottom.
- The upheaval of the Himalayas altered the old topography of the subcontinent.

Three phases of the upheaval of the Himalayas have been distinguished:

- ✓ During the first upheaval (Eocene-about 65 million years ago), which culminated in the Oligocene, and resulted in the upheaval of the Greater Himalayas.
- ✓ It was followed by a more intense movement during the mid-Miocene period about 45 million years ago, which resulted in the folding of Lesser Himalayas.
- ✓ The third upheaval took place during the Post-Pliocene period, about 1.4 million years ago which resulted in the folding of Shiwaliks or the Outer Himalayas. There is enough evidence to prove that the Himalayas are still rising.
- ✓ In the Peninsular region, the Tertiary System occurred on the coast of Kachchh, Kathiawar, Konkan, Malabar, Nilgiris, and the Eastern Ghats.

9. THE QUATERNARY PERIOD (THE PLEISTOCENE AND RECENT FORMATIONS)

- ✓ Quaternary is the name proposed for very recent deposits, which contain fossils of species with living representatives.
- ✓ The Northern Plains of India came into existence during the Pleistocene Period.
- ✓ During the Quaternary Period, the ice-sheets descended to as low as 1500 metres in altitude.
- ✓ The third physical division of India which is the Great Indo-Gangetic-Brahmaputra Plain had not formed at all till the Quaternary Period.
- ✓ The bottom configuration of this plain, occupies largely a synclinal basin, called foredeep, which is a downwarp of the Himalayan foreland of variable depth, formed concomitantly with the rise of the Himalayas to the north.
- ✓ The Pleistocene period is marked by Ice Age and glaciation on a large scale in the Northern Hemisphere.
- ✓ The moraine deposits and the boulder formations of Kashmir Valley and the Bhadarwa (Doda District of Jammu Division) are of the Pleistocene period.
- ✓ It forms the terraces of the Jhelum, on the flanks of the Pir-Panjal. The thickness of the karewas at places is up to 1400 metres.
- ✓ The river terraces of the Narmada, Tapi, Godavari, Krishna, and Kaveri, etc. are also of the Pleistocene Period.

Karewas

- ✓ the lacustrine deposits of the Pleistocene period.
- ✓ They consist of sands, clays, loams, silt and boulders.
- ✓ The karewas of Kashmir are generally found along the lower slopes of Pir-Panjal with a dip towards the Kashmir Valley.
- ✓ The Pampore and Pulwama karewas are well known for the cultivation of saffron, almond, and walnut.

CHAPTER-2-PHYSIOGRAPHY

Physiography

- deals with the study of the surface features and landforms of the Earth.
- On the basis of tectonic history, stratigraphy and physiography, India may be divided into the following four physiographic divisions

1. The elevated Peninsular region
2. The mighty Himalayas and their associated young folded mountains
3. The Indo-Gangetic-Brahmaputra Plains
4. The Coastal Plains and Islands.

ORIGIN AND PHYSIOGRAPHY OF THE PENINSULAR INDIA

- The origin of rocks of Peninsular India is more than 3600 million years old.
- Before the Carboniferous period, it was a part of the Gondwanaland.
- the India Peninsula never subsided under the sea permanently.
- more rigid, stable and had remained almost unaffected by the mountain building forces.
- experienced block faulting and displacement during the subsequent periods as evidenced by the Dharwar and Gondwana formations and the fault valleys of the Narmada, Tapi and Son rivers.
- It was during the Carboniferous Period that coal was formed in the Damodar, Son, Mahanadi and Godavari basins.
- During the Cretaceous Period, large scale vulcanicity produced the Deccan Trap (the Lava Plateau of India), comprising lava sheets of several thousand metres in depth.
- The Deccan Trap originated about 146 million years back when the magma flowed from the depth of about 4-0 km below the crust.

Major Geological Formations of the Peninsular India (about 3600 million years ago)

- The plateau of Peninsular India exhibits a complex system of geological structures.
- has some of the oldest rocks of the world from the Precambrian period (Archaean) and the youngest rocks of the Holocene epoch (Quaternary/Recent period).
- major rock systems found in the Peninsular India have been described briefly in the following section:

1. The Archaean Group

- Ancient crystalline and highly metamorphosed gneisses of the Archaean System are found in the plateaus of Tamil Nadu, Nilgiris, Karnataka, Andhra Pradesh, Maharashtra, Chhota Nagpur, West Bengal, Orissa, Jharkhand, Chhattisgarh, Madhya Pradesh, Meghalaya, Mizoram, Bundelkhand (UP.) and the Aravallis (Rajasthan).

- The Bengal gneiss known as Khondolite is found in the Eastern Ghats.
- rich in metallic and non-metallic minerals, precious stones and building materials.

2. The Dharwar System

- the oldest metamorphosed-sedimentary rocks found in narrow geosynclines flanking the Archaean gneiss.
- occur mainly in (i) Dharwar, Bellary and Hospet districts of Karnataka, (ii) the Chhotanagpur Plateau, (iii) the upper reaches of Godavari (Durg, Bastar, Oantewala, Chandrapur, etc.), and (iv) the Aravallis (Delhi, Rajasthan, and Gujarat)
- the majority of the Dharwar rocks had escaped folding completely and had deposited into the hollows and the corrugations of landmasses or were only mildly folded.
- rich in iron ore, manganese, mica, copper, zinc, lead, silver, gold, slate, asbestos, marble, and limestone.

3. The Cuddapah System

- The Cuddapah formations (Andhra Pradesh) occupies the deep basins of: (i) the lower valleys of Penganga and Godavari, (ii) the Talcher Series between Mahanadi and Brahmani (Orissa), the upper courses of the Nannada and Son rivers, and (iii) west of Aravallis near Jodhpur.
- rich in building material, shales, limestone, and sandstone.
- Some inferior quality of iron ore, manganese, copper, and asbestos are also found in these formations.

4. The Vindhyan System

- The Central Indian Highlands known as the Vindhyan Mountains occupy a large basin extending from Chittorgarh (Rajasthan) in the west to Sasaram and Dehri-on-Son (Bihar) in the east.
- One branch of it extends from Sasaram to Hoshingabad (Madhya Pradesh).
- occupies a large contiguous area stretching over one lakh sq km from the Chambal to Son rivers.
- Several isolated exposures of sedimentary rocks occur in the Bastar area of Chhattisgarh.
- In some of the exposures of the Vindhyan System are found the diamond bearing conglomerates.
- The Panna District of Madhya Pradesh and the Kurnool District of Andhra Pradesh are well known for diamond production.
- Elsewhere in the south, the upper Vindhyan are covered by the Deccan Traps.
- The Vindhyan are known for the good quality of building materials. They are rich in ornamental stones, precious stones, diamonds and materials used in ceramics.
- The historical monuments of the Medieval Period and majestic religious places like Stupa of Sanchi, Agra Fort, Fatehpur Sikri, Red Fort, Jama-Masjid, Birla Mandir, etc. have been constructed with the red-sandstones obtained from the Vindhyan Ranges.

5. Gondwana System.

- The coal belts of Peninsular India were developed during the Gondwana {Carboniferous} period.
- The Talcher Series, the Damuda Series and the Panchet Series are the products of this period.
- The rocks of the Upper Carboniferous Period., Permian, Triassic, Jurassic, Cretaceous, Tertiary, etc. are preserved in different parts of the Damodar, Mahanadi, Godavari and Krishna river basins.

6. The Deccan Trap

- The Cretaceous system is a very widely distributed system in the country.
- The Gondwanaland developed fissures and its broken parts started drifting from each other.
- large scale upheaval of lava (basalt) from the interior of the Earth to form the Deccan Trap.
- The eruption of lava was of the Hawaiian or fissure type.
- This period is marked by the transgression of the sea (Narmada valley and Coromandal coast), and outpouring of huge quantity of basalt so as to form the Deccan Trap.
- There had been intrusions of the plutonic rocks such as gabbro and granite.
- The basalt of the Deccan Trap is used for the construction of roads and buildings. Moreover, there are quartzites, agates and carnelians in the lava formations of the Deccan Plateau.

7. The Tertiary System

- The final fragmentation of the Gondwana took place during the Tertiary Period.
- occurred faulting of the Peninsula alongwith the subsidence of the broken blocks beneath the Arabian Sea and the Bay of Bengal.
- rocks are found in Kathiawar, Kachchh (Gujarat), Laki Series (Rajasthan), and along the Coromandal and Malabar coasts.
- In north-east, they are found in the Meghalaya Plateau; the Jaintia Series.

8. The Pleistocene Period

- found in the lower reaches and deltas of Mahanadi, Godavari, Krishna and Kaveri and the western coastal plains of Gujarat, Konkan and Malabar.
- more pronounced along the eastern coast of India.

Physiography and Relief Features of Peninsular India

- Covering an area of about 16 lakh sq km, the peninsular upland forms the largest physiographic division of India.
- With a general elevation between 600-900 metres, the region constitutes an irregular triangle with its base lying between the Delhi Ridge and the Rajmahal Hills and the apex formed by Kanyakumari.

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- It is bounded by the Aravallis in the north-west, Maikala Range in the north, Hazaribagh and Rajmahal Hills in the northeast, the Western Ghats (Sahayadri Mountains.) in the west and the Eastern Ghats in the east.
- The highest peak of Peninsular India-Anai-Mudi (Nilgiris), is 2695 metres above sea level.
- the Peninsular Uplands can be divided into the following eight macro-physiographic units

The Physiographic Regions of Peninsular India

Meso-Regions

1. The North Central Highlands
2. The South Central Highlands
3. The Eastern Plateau
4. The Meghalaya-Mikir Uplands
5. The North Deccan
6. The South Deccan
7. The Western Ghats or Sahayadri
8. The Eastern Ghats

1. The North Central Highlands

- The central highlands of peninsular India include the Aravallis, the Malwa Plateau, and the Vindhyan Range.
- i. **The Aravallis:**
 - runs from north-east to south-west for about 800 km, between Delhi to Palanpur (Gujarat).
 - one of the oldest folded mountains of the world.
 - Being highly denuded its highest peak-Guru-Sikhar-is only 1722 metres in height.
 - composed of quartzites, gneisses and schists of the Precambrian period.
 - Northwest of Udaipur, the Aravallis are called Jarga Hills (1431 m).
 - The Goranghai Pass separates Gurushikar from Mount Abu.
 - The Great Boundary Fault (GBF) separates the Aravallis from the Vindhyan Mountains.
- ii. **The Malwa Plateau:**
 - bordered by the Aravallis in the north, the Vindhyan Range in the south and the Bundelkhand Plateau in the east.
 - two drainage systems, one towards the Arabian Sea (Narmada, and Mahi), and another towards the Bay of Bengal (Charnbal, Sind, Betwa and Ken) joining the Yamuna river.

2. The South Central Highlands

- The Vindhyan Range extends from Jabat (Gujarat) and Chittorgarh (Rajasthan) to Sasaram in Bihar.
- extends for about 1050 km with general elevation between 450 to 600 metres.

- Apart from the Kaimur Hills in the east, the Maikala Range forms a connecting link between the Vindhyan and the Satpura mountains.

(i) The Bundelkhand (Vindhya Plateau):

- It is bounded by the Yamuna river in the north, Vindhyan in the south, the Chambal in the north-west and Panna-Ajigarh Range in the south-east
- The Bundelkhand upland stretches over the districts of Banda, Hamirpur, Jalaun, Jhansi, and Lalitpur (U.P.), and Datia, Tikamgarh, Chhatarpur and Panna (M.P.)
- region is characterized by senile topography.
- rivers like Betwa, Dhasan and Ken have carved out steep gorges, rapids, cataracts and waterfalls.

(ii) The Vindhya-Baghelkhand or Vindhya Plateau:

- includes the plateaux of Satna, Rewa (M.P.) and Mirzapur (U.P.). Its elevation varies between 150 to 1200 metres with uneven relief.
- To the south of this lies the Narmada-Son trough (rift valley) characterized by the Archaean and Bijwar series.
- South of this trough is the eastward extension of the Satpura which is an area of radial drainage.
- Among the basins, Singrauli and Dudhi (150-300 M) are Upper Gondwana basins, which are rich in coal deposits.
- Besides the Narmada and Son, this region is drained by the Karmanasa, Tons, Ken and Belandare rivers.
- Parallel to the Vindhyas between the Narmada and the Tapi rivers is the Satpura Range.
- Satpura consists of Rajpipla Hills, Mahadev Hills and the Maikal Range.
- Dhupgarh (1350 m, near Pachmarhi) is the highest peak of Satpura. Amarkantak (1064 metres) is another important peak of the Satpura mountains.

3. The Chotanagpur Plateau

- sprawls over parts of West Bengal, Jharkhand, Chhattisgarh, Orissa and northeastern part of Andhra Pradesh.
- has a series of the meso and micro plateaux (Ranchi, Hazaribagh, Singhbhum, Dhanbad, Palamu, Santhal-Parganas and Purulia districts of West Bengal).
- composed of Archaean granite and gneiss rocks with patches of Dharwar (micaschists), the Damuda series of the Gondwana Period, and the lava flow of the Cretaceous Period.
- consists of plateaux at different levels of elevation, the highest general elevation of about 1100 m in the mid-western part is known as pat lands.
- The rivers which drain the Chotanagpur Plateau are Barakar, Damodar, Subarnarekha, and Koels.
- These rivers have carved out deep gorges, rapids, cataracts, and waterfalls in the plateau region.

4. The Meghalaya Plateau and the Mikir Hills

- Consisting of the Garo, Khasi, Jaintia hills and the outlying Mikir and Rengma hills,
- it is a plateau which has been detached from the Indian Peninsula by the Malda Gap.
- a chequered evolutionary history of emergence, submergence, planation surface with several phases of erosion, sedimentation, diastrophism and intrusions.
- The Shillong Peak is the highest elevation (1823 m) in the Meghalaya Plateau, while Norkek (1515 m) is the highest peak of the Garo Hills. Mawsynram ($25^{\circ} 15'N$, $91^{\circ} 44'E$) about 16 km west of Cherrapunji records the highest rainfall in the world.
- The Mikir Hills are detached from the Meghalaya Plateau and are surrounded by plains from three sides.
- The southern range of the Mikir Hills is known as the Rengma Hills (900 m).
- The Mikir Hills are characterised by radial drainage with Dhansiri and Jamuna being the main rivers.

5. The North Deccan (Maharashtra Plateau)

- The plateau of Maharashtra includes the entire state of Maharashtra, except the Konkan coast and the Sahyadris.
- mainly covered by the basalt of the Cretaceous Period.
- The basaltic sheet has a thickness of about 3 km in the western parts which diminishes towards the east and south-east.
- The most striking feature of the Maharashtra Plateau is the fault (1000 metres), giving rise to the present shoreline of the Arabian Sea.
- Through the northern part of the Maharashtra Plateau flows the Tapi River from east to west.
- has a gentle slope in the south and steep gradient in the north (towards the Satpura Hills).

(i) The Mahanadi Basin:

- Sprawling over the districts of Raipur, Bilaspur, Durg and Rajgarh, the Mahanadi basin is also known as the Chhattisgarh Plain.
- The region is largely dominated by the Archaean and Cuddapah formations.
- The Mahanadi river and its tributaries like Seonath, Hasdeo and Mana drain this plain.

(ii) The Chhattisgarh Plain:

- bordered by a series of hills and plateaux.
- The northern boundary is formed by the Lomari Plateau, Pendra Plateau, the Chhuri and the Raigarh Hills.
- The Korba coalfields of Chhattisgarh lie in this basin.
- The Gondwana formations are rich in bituminous coal which is supplied to the Bhilai Steel Plant.

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- The western rimland includes the Maikal Range with crest line of 700-900 metres.
- The southern rimland includes the Dhalli-Rajhara Hills in southern Durg district and the Raipur uplands in the south-eastern Raipur district
- The Rajhara Hill contains Dharwarian rocks in which iron ore of haematite type is found.
- The iron ore from the Dhalli-Rajhara mines is supplied to the Bhilai Steel Plant

(iii) Garhjat Hills:

- also known as the Orissa Highlands.
- bordered by the Chotanagpur Plateau in the north, Mahanadi basin in the west, Eastern Ghats in the south and Utkal plains in the east
- mainly composed of Archaean rocks like granite, gneisses and magmatic rocks.
- The Gondwana, Talcher, Barakar and Kamathi series are also located in this region.

(iv) Dandakaranya:

- Sprawling over the Koraput and Kalahandi districts of Orissa, Bastar District of Chhattisgarh and East Godavari, Vishakhapatnam and Srikakulam districts of Andhra Pradesh,
- Dandakaraoya is an undulating plateau.
- Its Abujhmar Hills provide one of the richest iron-ore deposits at Bailadila Range.
- drained by the Tel and Udantj; tributaries of Mahanadi, and the Sabari and Sileru; tributaries of Godavari rivers.

6. The South Deccan

The south Deccan consists of several plateaux:

(i) Karnataka Plateau:

- spans in the slate of Karnataka and the Cannanore and Kozhikode districts of Kerala.
- dominance of Archaean and Dharwar formations.
- has an average elevation of 600-900 metres.
- Mulangiri (1913 metres) is the highest peak in Baba-Budan Hills, followed by the Kudermukh (1892 metres) peak.
- The northern upland of the Karnataka plateau is known as Malnad, while the southern part is called a Maidan.
- drained by the Kaveri and the Tungbhadra rivers.
- The Nandi valley is a summer resort in this region.

(ii) The Telengana Plateau:

- consists of Dharwar and Cuddapah formations.

(iii) **The Tamil Nadu Uplands;**

- lies between the South Sahyadri and Tamil Nadu coastal plains.
- covered by the Archaean rocks.
- The charnockites are found in Javadi and Shevaroy hills.
- Moreover, there are Cuddapah and alluvial formations.
- Between Coimbatore and Anaimalais, there is a broad gap, known as Palakkad Gap (Palghat), about 24 km wide, through which flows the Gayitri river from east to west joining Tamil Nadu with the coast of Kerala.

7. The Western Ghats

- The Western Ghats or Sahyadris run parallel to the western coast for about 1600 km in the north south direction from the mouth of the Tapi river to Kanyakumari (Cape Camorin).
- The western slope of Sahyadri is steep while the eastern slope is gentle.
- These are block mountains formed due to the down warping of a part of land into the Arabian Sea.
- form a watershed of the peninsula.
- All the important rivers of Peninsular India, like the Godavari, Krishna and Kaveri rise from the Western Ghats.
- The western rivers merging into the Arabian Sea are swift
- The Gersoppa (Jog falls) on Sharvati is the highest waterfall in India.
- The average elevation of the Western Ghats varies between 1000 to 1300 metres.
- The important peaks of the Western Ghats are Kudermukh (1892 m), Pushpagiri {1714 m}, KaJsubai (1646 m) and SaJher (1567 m), Mahabaleshwar (1438 m) and Harishchandra (1424 m}.
- In the Nilgiris the Eastern Ghat joins the Western Ghat to form a mountain knot (Nilgiri} whose highest point is Anaimudi (2695 m).
- South of Nilgiri lies the Palghat (Palak.kad Gap). The other important passes of the western Ghat are Thai Ghat and Bhor Ghat.

Bhor Ghat:

- Joins Mumbai with Pune
- about 1000 metres above sea level,
- one of the most busy passes in the Western Ghats.
- The frequency of trains and commercial vehicles is enormous.

Goran Ghat:

- Lying to the south of Mount Abu, it connects the city of Udaipur with Sirohi and Jalore in Rajasthan.
- about 1200 metres above sea level.

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- The surrounding rocks are desolate, characterised by thorny bushes and cacti.

Haldighat:

- a mountain pass in the Aravalli range of Rajasthan.
- Situated about 40 km from Udaipur, it connects Rajsamand and Pali district.
- The name is believed to have come from the turmeric-coloured yellow soil.
- The mountain pass is historically important as the location of the historic battle of Haldighat which took place in 1576 between Rana Pratap Singh of Mewar and Raja Mansingh of Amber, General of the Mughal Emperor-Akbar the Great.

Harishchandra:

- ranges in the southern parts of Maharashtra from north-west to south-east.
- stretches in the districts of Pune and Osmanabad.
- covered by degraded forests.

Jog Falls:

- The short westward flowing Sharavati river pours down the Western Ghats, forming one of the highest waterfalls in the world at 250 m.

Kalsubai:

- Situated in the state of Maharashtra,
- one of the highest peaks of Western Ghats.
- 1646 metres above sea level.
- Inhabited by tribal people, its forest wealth has diminished due to deforestation.

Kudarmukh:

- Situated in the state of Karnataka,
- 1892 m above sea level
- rich in iron ore.
- The iron ore is of haematite and magnetite type.
- Iron ore from here is exported to Iran through the port at Mangalore.

Mahabaleshwar:

- an elevation of 1438 metres,
- one of the important peaks of the Western Ghats.
- a religious and cultural tourist attraction for domestic and international tourists.

The Nilgiri Hills:

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- The Nilgiri Hills in the Western Ghats cover an area of about 2500 sq km and rise over 2500 m.
- Udhagamandalam, one of southern India's most famous hill resorts, is located here.

Palghat (Western Ghats ; joins Coimbarore with Kochi and Kozhikode):

- Also known as the Palakkad Gap,
- lies to the south of Nilgiri Hills.
- an elevation ranging from 75 to 300m above the sea level.
- The width of this gap is about 25 km.
- joins the state of Tamil Nadu with the seaports of Kerala.
- The river Gayitri flows through it from east to west.

Pushpagiri:

- one of the highest peaks of the Western Ghats.
- elevation is 1714 metres above the sea level.
- the abode of Dravidian tribes.
- The forests are however, degraded and soil erosion is the main problem.

Salher:

- an elevation of 1567 metres above sea level,
- the Salher peak lies between Malegaon and Nashik.
- inhabited by tribal people.
- Heavy deforestation has reduced its aesthetic beauty and created numerous ecological problems.

Thal Ghat (Western Ghats; Joins Nasik and Mumbai):

- Located in the Sahyadri Ranges,
- over one thousand metres above sea level.
- The National Highway No. 3 and the Bhopal Indore Railway Line pass through the Thai Ghat.

8. The Eastern Ghats

- form the eastern boundary of the Deccan Plateau.
- a massive outlying block of hills.
- The average height of the Eastern Ghats is about 600 m.
- a series of the detached hills of heterogeneous composition which are called by various local names.
- Between Mahanadi and Godavari, the average elevation of the Eastern Ghats is about 1100 metres
- The peak of Singaraju (Orissa) with an elevation of 1516 metres is the highest peak of the Eastern Ghats.

- Among other peaks Nimalgiri (1515 m) in the Koraput District and Mahendragiri (1501 m) in Ganjam District are the other important peaks.
- The predominant rocks of the Eastern Ghats are khondalites, metamorphosed-sedimentary, and chamokites (intrusive rocks being granite).
- Between the Krishna river and Chinnai are the Kondavidu, Nallarnalai, Velikonds, Palkonda, and Erramala Ranges.
- Their continuation can be seen in the Seshachalam (Cuddapah and Anantapur districts), Javadi, Shevaroy, Panchaimalai, Sirumalai, and Varushnad Hills south west of Madurai (Tamil Nadu).

Significance of the Peninsular Plateau

The importance of Peninsular India is mainly because of the following benefits from its location and rock formations:

(i) The Peninsular region of India is rich in both the metallic and non-metallic minerals. Mineral ores like iron, manganese, copper, bauxite, chromium, mica, gold, silver, zinc, lead, mercury, coal, diamond, precious stones, marble, building materials and decorative stones are found in abundance in this physiographic region. About 98 per cent of the Gondwana coal deposits of India are also found in the Peninsular region.

(ii) A substantial part of the Peninsular India is covered by black earth (Regur soil). The regur soil is conducive for the successful cultivation of cotton, millets, maize, pulses, oranges and citrus fruits. Some areas of south Peninsular India are suitable for the cultivation of tea, coffee, rubber, cashew, spices, tobacco, groundnut and oilseeds.

(iii) On the southern and eastern parts of Peninsular India are large stretches of Archaean, Dharwar, Cuddapah and Vindhyan formations in which red, brown and laterite soils have developed over time. These soils are the bases of rural economy.

(iv) The Western Ghats, Nilgiris and the Eastern Ghats are covered by thick tropical moist deciduous and semi-evergreen forests. These forests provide teak, sal, sandalwood, ebony, mahogany, bamboo, cane, rosewood, iron-wood, and Iogwood as well as a large variety of forest products.

{v} The rivers flowing eastward into the Bay of Bengal make several gorges, waterfalls, rapids and cataracts, which have been harnessed for the generation of hydro-electricity. The rivers originating from the Western Ghats offer great opportunity for the generation of hydel power and irrigation of agricultural crops and orchards.

(vi) There are numerous hill stations and hill resorts, of which Ooty, Udhagamandalam, Kodaikonal, Mahabaleshwar, Khandala, Matheran, Pachmarhi, and Mount Abu are the most important.

{vii} Apart from teak and fuelwood, the forests of Western and Eastern Ghats are rich in medicinal plants.

(viii) The hilly and mountainous areas of the Peninsula are the abodes of many scheduled tribes. South of the Vindhyans is a predominance of Dravidian culture.

THE HIMALAYAS

- consist of four lithotectonic mountain ranges, namely (i) the Trans-Himalaya or the Tethys Himalaya, (ii) the Greater Himalaya, (iii) the Lesser Himalaya, and (iv) the Shiwalik or the Outer Himalaya.
- extend from the eastern boundary of Pakistan to the border of Myanmar for about 2500 km with a varying width of about 500 km in the west and about 320 km in the east.
- lie to the north of the Ganga-Brahmaputra Plains and are separated from the plains by the Himalayan Front Fault (HFF).
- include parts of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Nepal, Sikkim, Bhutan and Arunachal Pradesh.
- Their offshoots run in a north-south direction along the India-Myanmar boundary through Nagaland, Manipur, and Mizoram.

Origin of the Himalayas

- The origin of the Himalayas has been a point of contention among the geologists and geomorphologists.
- It is a complex mountain system having rocks from the Pre-Cambrian and Eocene periods. Mostly formed of sedimentary and metamorphic rocks, it has been subjected to intense folding and faulting. The main theories about the origin of the Himalaya are as under:

(i) The Geosynclinal Origin

- main supporters Argand, Kober and Suess.
- led to the formation of a long Tethys Sea between the Laurasian Shield (Angaraland) of the north and the Gondwanaland of the south.
- This sea was occupying the region of Himalayas during the Mesozoic Era (180 m years ago).
- At the end of the Palaeozoic and beginning of the Mesozoic Eras, the Tethys almost girdled the whole Earth running from Europe in the west to China in the east. Eroded material from the two land masses (Eurasian Shield -Angaraland and Gondwanaland) was deposited in the Tethys Sea and assumed considerable thickness due to the sinking nature of the sea bed.
- During the Cretaceous Period, the bed of the sea started rising which led to the folding of three successive ranges of the Himalayas.
- The first upheaval led to the formation of the Greater Himalayas during the Eocene Period (about 65 m years back). Similarly, the second upheaval took place during the Miocene Period (about 45 million years back) resulting in the formation of the Lesser Himalayas, and the third upheaval

started in the Pliocene period (about 1.4 million years back) resulting in the formation of the Shiwaliks or the Outer Himalayas.

(ii) The Plate Tectonic Origin of the Himalayas

- The theory of Plate Tectonics was put forward by WJ Morgan of Princeton University in 1967.
- based on the concept of 'Sea-Floor Spreading' advocated by H. H. Hess.
- about 70 or 65 million years ago there was an extensive geosyncline, called the Tethys, in place of the Himalayas.
- About 60-30 million years ago the Indian plate came very close to the Asian plate and started subducting under the Asian plate.
- caused lateral compression due to which the sediments of the Tethys were squeezed and folded into three parallel ranges of the Himalayas.
- estimated that this convergence has caused a crustal shortening of about 500 km in the Himalayan region and is compensated by sea floor spreading along the oceanic ridge in the Indian ocean region.
- Since the northward movement of the Indian plate is still continuing, the height of the Himalayan peaks is increasing.
- The Indian Plate is moving northward and the center of rotation is constantly changing.
- The continent-to-continent collision between the Indian and the Asiatic plates started around 65 million years ago and caused the Himalayas to rise from the Tethys geosyncline.
- Thus, the first major phase of uplift in the Himalayas occurred around 65 million years ago.
- This orogenic movement elevated the central axis of ancient crystalline and meta-sedimentary rocks which have been intruded by large masses of granite.
- believed that the first major phase of uplift initially produced the Ladakh and Zaskar ranges of the Trans-Himalayas before the formation of the Great Himalayas.
- Hence, it is to be realized that except the Kashmir part of the Himalayas, the Himalayan ranges have not developed from a geosyncline and are made up of elements formerly connected to the marginal parts of the Indian shield.
- During the main Himalayan orogeny, this continuous geosynclinal sedimentation led to the underthrusting of the Indian shield against the Tibetan Massif which buckled down the geosynclinal deposits, resulting in the outflow of a large amount of ultrabasic rocks known as ophiolites.
- These ophiolites are seen as exotic blocks on the Ladakh and Zaskar Ranges of the Trans-Himalayas.
- The end effect of the buckling of the geosyncline was not only the crustal thrust effect on Ladakh and Zaskar leading to their rise as ranges, but also the creation of the sharp tectonic line of the Indus suture along which large geosynclinal areas disappeared.

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- The intermontane basins in the Indus suture zone of Ladakh continued to receive molasses sedimentation in this period.
- The second major uplift which took place around 45 million years ago, caused the rapid uplift of the southern mountain front of the Lesser Himalayas, giving rise to the extremely rugged and youthful Pir-Panjal, Dhauladhar, Karol, and Mahabharat Ranges abruptly and steeply.
- The Greater Himalayas and the Lesser Himalayas are separated by the Main Central Thrust (MCT).
- These spurs of the Lesser Himalayas again formed, in their turn, the intermontane basins of Kashmir, the Karol-basin, Dun Valley (Uttarakhand) and the Kathmandu Valley of Nepal.
- The foredeep which was formed further away received the thick sequence of terrestrial sediments called Shiwaliks from the middle-Miocene to the middle-Pleistocene periods, covering a span of about 1.4 million years.
- The Lesser Himalayas and the Shiwaliks are separated from each other by the Main Boundary Thrust (MBT).
- The 5000 metres thick Shiwaliks dominated by boulder and conglomerate, reflect the progressive uplift of the Himalayas from which they have been derived as a result of the third major phase of uplift.
- The Shiwaliks are separated from the Northern Plains of India by the Himalayan Front Fault or HFF.
- The Shiwaliks form the normal type of structures with wider basin-like synclines alternating with steep, often faulted, asymmetric anticlines.
- At present, the Himalayan Front Fault (HFF) is quite active recording frequent tremors and earthquakes.

Physiographic Divisions of the Himalayas

- For a systematic study of the physiography and relief, the Himalayas may be divided into the following four divisions from north to south:

- I. The Trans-Himalayas
2. The Greater Himalayas
3. The Lesser Himalayas
4. The Shiwaliks or the Outer Himalayas.

1. The Trans-Himalayas

- about 40 km wide.
- contain the Tethys sediments.
- The rocks of this region contain fossils bearing marine sediments which are underlain by 'Tertiary granite'.
- partly metamorphosed sediments and constitutes the core of the Himalayan axis.

- a great accumulation of debris in the valleys of defeated streams which could not maintain their southerly course across the rising barrier of the Himalayas.

2. The Greater Himalayas

- rise abruptly like a wall north of the Lesser Himalayas.
- The Main Central Thrust separates the Greater Himalayas from the Lesser Himalayas.
- about 25 km wide with an average height above 5000 metres.
- Almost all the lofty peaks of the Himalayas lie in this zone.
- composed of crystalline, igneous or metamorphic rocks (granite, schists, and gneiss).
- The basal complex of the Himalayas is Archaean.
- At places, due to heavy thrust, older rocks are found overlying the newer rocks.
- almost a contiguous range.
- very few gaps mainly provided by the antecedent rivers.
- receive less rainfall as compared to the Lesser Himalayas and the Shiwaliks.
- Physical weathering is pronounced.
- Erosion is, however less effective over the Greater Himalayas as compared to the Lesser Himalayas.
- Being lofty, they have very little forest area.

3. The Lesser Himalayas

- about 80 km with an average height of 1300-5000 m.
- consists, generally, of unfossiliferous sediments or metamorphosed crystalline.
- main rocks are slate, limestone and quartzites.
- Along the southern margin of the Lesser Himalayas lies the autochthonous belt of highly compressed Upper Palaeozoic to Eocene rocks, often containing volcanic material.
- Examples of autochthonous belts are found between Murree and Panjal thrust in Kashmir, Giri thrusts in the Shimla region and Karol and Main Boundary Thrust (MBT) in Garhwal region.
- extensive erosion due to heavy rainfall, deforestation and urbanisation.

4. The Shiwaliks or Outer Himalayas/Sub-Himalayas

- extend from Jammu Division of Jammu and Kashmir State to Assam.
- In width, Shiwaliks vary from 8 km in the east to 45 km in the west with an average elevation of about 1300 m above sea level.
- not a continuous range.
- broader in the west and narrows down in the east.
- Between the Shiwaliks and the Lesser Himalayas are longitudinal valleys called Doons/ Duns.
- important Duns are Dehra Dun, Potli, Kothri, Kathmandu, Chumbi and Kyarda.

- mainly composed of sandstones, sand rocks, clay, conglomerates and limestones, mostly belonging to the Upper Tertiary Period.

Longitudinal Divisions of the Himalayas

- The Himalayas have also been divided by Sir S. Burrard into four divisions, namely (i) The Western Himalayas, (ii) The Kumaun Himalayas, (iii) The Nepal Himalayas, and (iv) The Assam Himalayas. Prof. S.P. Chatterjee (1973), divided the Himalayas into the following six transverse divisions:

1. The Kashmir Himalayas
2. The Himachal Himalayas
3. The Kumaun Himalayas
4. The Sikkim Himalayas
5. The Arunachal Himalayas
6. Purvanchal Himalayas

1. The Kashmir Himalayas

- about 350,000 sq km in the state of jammu and Kashmir, the range stretches about 700 km in length and 500 km in width.
- With an average height of 3000 m, it has the largest number of glaciers in India.
- The Ladakh region of the Kashmir Himalayas is characterised by cold desert conditions. Surrounded by the Greater Himalayas and the Lesser Himalayas is the Kashmir Valley.
- a structural longitudinal 'Doon' (D.N. Wadia).
- A special feature of the Vale of Kashmir is the Karewa (lacustrine) deposits consisting of silt, sand and clay.
- These karewas are mainly devoted to the cultivation of saffron and have orchards of apple, peach, almond, walnut and apricot
- characterised by high snow covered peaks, deep valleys, interlocked spurs and high mountain passes.
- Pir-Panjal, Banihal (Jawahar Tunnel), ZojiLa, Pensi-La, Saser-La, Lanak-La, Jara-La, Taska-La, Chang-La, Umasi-La., and Qara-Tagh-La (Karakoram) are the important passes of the Kashmir Himalayas

The Himadri

- Called the abode of gods, this section of the Himalayas has many snow capped peaks, such as Nanda Devi, Kamet and Trishul.

2. The Himachal Himalayas

- Stretching over Himachal Pradesh, it occupies an area of about 45,000 sq km.

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- All the three ranges (the Greater, the Lesser and the Outer Himalayas) are well represented in this region.
- The northern slopes of the Himachal Himalayas are bare and show plains and lakes, while the southern slopes are rugged and forest clad.
- Rohtang, Bara-Lacha, Imis-La, and Shipki-La are the important passes which join Himachal Pradesh with Tibet (China).
- The beautiful and highly productive valleys of Kangra, Kullu, Manali, Lahul, and Spiti lie in Himachal Pradesh.
- These valleys are well known for orchards and scenic beauty.
- Shimla, Dalhousie, Chamba, Kullu-Manali are the important hill stations of this region.

3. The Kumaun Himalayas

- lie between the Satluj and the Kali rivers, stretching to a length of 320 km and occupying an area of about 38,000 sq km.
- Its highest peak is Nanda Devi (7817 m).
- Among the other peaks Kamet (7756 m), Trisul (7140 m), Badrinath (7138), Kedarnath (6940 m), Dunagiri (7066 m), Jaunli or Shivling (6638 m), Gangotri (6615 m), and Bandarpunch (6320 m) are important. Gangotri, Milam, and Pindari are the main glaciers of Uttarakhand.
- The important hill stations include Mussoorie, Nainital, Ranikhet, Almora, and Bageshwar.
- The Kumaun Himalayas are connected to Tibet by a number of passes namely, Muling-La (5669 m), Mana Pass, Niti Pass, (5068 m), Tunjun-La, Shalsal Pass, Balcha Dhuwa. Kungrinbingri Pass, Lampiya Dhura, Mangsha Dhura, Marhi-La (4993 m), and Lipu Lekh.

4. The Central Himalayas

- stretches from river Kali to river Tista for about 800 km occupying an area of about 116,800 sq km.
- A major part of it lies in Nepal except the extreme eastern part called Sikkim Himalayas and in the Darjeeling District of West Bengal.
- All the three ranges of the Himalayas are represented here.
- The highest peaks of the world like Mt. Everest (8850 m), Kanchenjunga (8598 m), Makalu (8481 m), Dhaulagiri (8168 m), Annapurna (8075 m), and Gosainath (8014 m) are situated in this part of the Himalayas.
- has very few passes.
- The passes of Nathu-La and Jelep-La (4538 m in Sikkim) connect Gangtok (Sikkim) with Lhasa (Tibet, China).

Kanchenjunga:

- Situated on the border of Sikkim and Tibet,

- the third highest mountain peak in the world.
- It is 8,598 metres above sea level and remains snow covered throughout the year.
- Some of the important rivers of India like Kosi and Tista have their origin in this mountain.

5. The Eastern Himalayas

- lie between the Tista and the Brahmaputra rivers, covering a distance of about 720 km with an area of 67,500 sq km.
- The Eastern Himalayas occupy the state of Arunachal Pradesh (India) and Bhutan.
- the Himalayas rise very rapidly from the plains of Assam, and the foothills of Shiwaliks are very narrow.
- The Eastern Himalaya include the Aka Hills, the Daphla Hills, Miri Hills, Abor Hills, Mishmi Hills, and Namcha Barwa.
- has a number of mountain passes among which Bomdi-La, Tse-La, Dihang, Debang (Arunachal Pradesh) are the most important
- In the Eastern Himalayas, due to heavy rainfall, fluvial erosion is quite pronounced.
- On the southern border of Arunachal Pradesh, the Himalayas take a southerly turn and the ranges are arranged in a north-south direction.
- Passing through the states of Arunachal Pradesh (Tirap Division} Nagaland, Manipur, Tripura, and Mizoram, the Himalayas are locally known as Purvachal.
- The main hills of the Eastern Himalayas are Patkai-Bum (Arunachal Pradesh), Naga Hills (Nagaland), Manipur Hills, Blue Mountains (Mizoram), Tripura Range, and Brail range.
- On the border of Nagaland and Myanmar lies the Arakanyoma.
- heavily forested.
- Northern Myanmar is connected through Diphu, Hpungan, Chaukan, Pangsau, and Likhapani (Arunachal Pradesh).
- Southwards, a pass joins Imphal (Manipur) with Mandalay (Myanmar).
- The Purvanchal is joined by the Meghalaya Plateau in the west.
- The extension of the Myanmar mountain chain continues southward up to Andaman and Nicobar Islands and even up to the Archipelago of Indonesia.

The Syntaxial Bends of the Himalayas

- The general east-west trend of the Himalayas terminates suddenly at its western and eastern extremities and the ranges are sharply bent southward in deep knee-bend flexures which are called syntaxial bends.
- The western syntaxial bend is near Nanga Parbat where the Indus has cut a deep gorge.
- The geological formation here takes sharp hairpin bends as if they were bent round pivotal points obstructing them.

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- There is a similar hair-pin bend in Arunachal Pradesh where the mountains take a sharp bend from the eastern to southern direction after crossing the Brahmaputra river.
- The tectonic strike also undergoes a deep k-nee-bend from an easterly to southerly trend.

Main Passes of Himalayas

Aghil Pass (Karakoram-Ladakh):

- Situated to the north of K2 in the Karakoram at an elevation of about 5000 m above the sea level,
- joins Ladakh with the Xinjiang (Sinkiang) Province of China.
- remains closed during the winter season from November to the first week of May

Banihal Pass (Jawahar Tunnel):

- Situated at an elevation of 2832 m in the Pir-Panjal Range,
- it joins Jammu with Srinagar.
- The pass remains snow covered during the winter season.
- The Jawahar Tunnel (named after Pandit Jawaharlal Nehru), inaugurated in December 1956, was constructed for round-the-year surface transport.

Bara Lacha (Himachal Pradesh with Leh-Ladakh):

- Situated in the state of Jammu and Kashmir at an altitude of 5045 m.
- It is on the National Highway connecting Manali and Leh.
- Being a high mountain pass, it remains snow covered from November to mid-May.

Bomdi La (4331 m, Arunachal Pradesh):

- Situated to the east of Bhutan in the Greater Himalayas in Arunachal Pradesh at an altitude of about 2600 m above sea level,
- it connects Arunachal Pradesh with Lhasa, the capital of Tibet.
- It remains closed in the winter season owing to snowfall and adverse weather.

Bunail Pass (Srinagar with Kishan-Ganga Valley):

- Situated at an altitude of more than five thousand feet above sea level
- this pass connects Ladakh with China.
- Being snow covered during the winter season it remains closed for trade and transport.

Chang-La (Ladakh with Tibet):

- Situated at an elevation of over 5270 m, it is a high mountain pass in the Greater Himalayas.
- The road after Chang-La is extremely steep, leading to the small town of Tangtse.
- The pass has a temple dedicated to Chang-la Baba after whom the pass has been named.

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- Being snow-covered, it remains closed during the winter season.

Debsa Pass:

- Situated at an elevation of 5270 m above sea level,
- it is a high mountain pass in Greater Himalayas between the Kullu and Spiti districts of Himachal Pradesh.
- This pass provides an easier and shorter alternative to the traditional Pin-Parbati Pass route between Kullu and Spiti.

Dihang Pass:

- Situated in the state of Arunachal Pradesh at an elevation of about 4000 feet
- this pass connects Arunachal Pradesh with Mandalay (Myanmar).

Diphu Pass (Arunachal Pradesh with Mandalay in Myanmar):

- Situated in the eastern part of Arunachal Pradesh,
- provides an easy and shortest access to Mandalay (Myanmar).
- a traditional pass between India and Myanmar which remains open throughout the year for transportation and trade.

Imis La:

- Situated at an elevation of over 4500 m,
- this pass provides an easy access between Ladakh and Tibet (China).
- It has a difficult terrain, steep slopes, and remains closed during the winter season.

Khardung La:

- Situated at an elevation of more than six thousand m above sea level,
- it is the highest motorable pass in the country.
- The road, however, remains closed during the winter season.

Khunjerab Pass (Karakoram):

- Situated at an altitude of more than five thousand feet in the Karakoram Mountains,
- it is a traditional pass between Ladakh and the Sinkiang Province of China.
- It remains snow covered during the winter season from November to mid-May.

Jelep La (4538 m):

- Situated at an elevation of 4538 m above sea level,
- this pass connects Sikkim with Lhasa.

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- It passes through the Chumbi Valley.

Lanak La:

- Situated at an altitude of about five thousand metres in the Aksai-Chin (Ladakh),
- it connects Ladakh with Lhasa.
- The Chinese have constructed a road to connect the Xinjiang (Sinkiang) Province of China with Tibet.

Likhapani (Arunachal Pradesh):

- Situated at an altitude of more than four thousand metres above sea level,
- the Likhapani Pass joins Arunachal Pradesh with Myanmar.
- For trade and transport, it remains open throughout the year.

Lipu Lakh (Uttarakhand):

- Situated in the Pithoragarh District,
- it connects Uttarakhand with Tibet
- The pilgrims for Mansarovar Lake travel through this pass.
- Landslides in the rainy season and avalanches in winter create great problems for movement and transportation.

Mana Pass:

- Situated at an elevation of 5611 m above sea level in the Greater Himalayas,
- it connects Uttarakhand with Tibet.
- It remains snow covered for about six months during the winter season.

Mangsha Dhura Pass:

- Situated at an elevation of more than five thousand metres in the district of Pithoragarh,
- the Mangsha Dhura Pass connects Uttarakhand with Tibet.
- The pilgrims for Mansarovar cross this pass. Landslides create great problems for tourists and pilgrims ..

Muling La (Uttarakhand):

- Situated north of Gangotri,
- this seasonal pass joins Uttarakhand with Tibet.
- It remains snow covered during the winter season.

Nathu La (Sikkim):

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- Nathu La is located on the Indo-China border.
- The pass, at 4310 m above sea level forms part of an offshoot of the ancient Silk Road.
- one of the three trading border posts between India and China. After the 1962 war it was reopened in 2006 .

Niti Pass:

- Situated at an altitude of 5068 m above sea level,
- the Niti Pass joins Uttarakhand with Tibet
- It remains snow covered during the winter season between November and mid-May.

Pangsan Pass (Arunachal Pradesh):

- Situated at an elevation of more than four thousand metres above sea level,
- this pass connects Arunachal Pradesh with Mandalaya (Myanmar).

Pensi La:

- Situated in the Greater Himalayas at an elevation of more than five thousand metres above sea level to the east of Zoji La,
- this pass connects the Valley of Kashmir with Kargil (Ladakh).
- It remains snow covered from November to mid-May.

Pir-Panjal Pass:

- The traditional pass from jammu to Srinagar, this pass lies on the Mughal Road.
- After partition of the Subcontinent, the pass was closed down.
- provides the shortest and easiest metalled road access from Jammu to the Valley of Kashmir.

Qara Tagh Pass:

- Located in the Karakoram Mountains at an elevation of more than six thousand feet above sea level,
- this pass was an offshoot of the Great Silk Road.
- It remains snow covered during the winter season.

Rohtang Pass:

- Located at an elevation of 3979 m above sea level,
- this pass connects the Kullu, the Lahul and Spiti valleys of Himachal Pradesh.
- It has excellent road access, constructed by the Border Road Organisation (BRO).
- Traffic jams are common occurrences caused by the heavy movement of military vehicles, buses, taxis, trucks and goods carriers.

Shipki La:

- Located at an altitude of more than 6000 m above sea level.
- through the Satluj Gorge, the Shipki-La joins Himachal Pradesh with Tibet.
- It remains snow covered during the winter season.

Thang La (Ladakh):

- Located at an elevation of 5359 m above sea level, i
- a mountain pass in Ladakh (J & K).
- the second highest motorable mountain pass in India after Khardung La.

Trails Pass:

- Located at an elevation of 5212 m above sea level in the Pithoragarh and Bageshwar districts of Uttarakhand,
- it is situated at the end of the Pindari Glacier and links Pindari Valley to Milam Valley.
- Being steep and rugged, this pass is very difficult to cross.

Zoji La:

- Located at an altitude of 3'850 m above sea level,
- it joins Srinagar with Kargil and Leh. Because of heavy snowfall, it remains closed from December to mid-May.
- The Border Road Organisation (BRO) has been trying to keep the road open for most part of the year.
- Beacon Force of Border Road Organisation (BRO) is responsible for clearing and maintenance of the road during the winter season.
- Recently, the Srinagar-Zoji-La Road has been declared a National Highway (NH-1D) by the centre.

Glaciers and Snowline

- The lower limit of perpetual snow is known as 'snowline'.
- The snowline in the Himalayas has different heights in different parts, depending on latitude, altitude, amount of precipitation, moisture, slope and local topography.
- There are about 15,000 glaciers in the Himalayas lying between the two syntaxial bends in the east and the west.
- In the Assam Himalaya, the snowline is about 4400 metres, whereas in the Kashmir Himalayas it varies between 5100 to 5800 metres.
- In the Kumaun Himalaya the snowline is about 5200 metres and about 5500 metres in the Karakoram.

- On the Tibetan side, the altitude of the snowline is about 900 metres higher owing to great desiccation of the region and scarcity of moisture.
- Thus, there is a direct relationship between the presence of moisture and the altitude of the snowline.
- In general, more the moisture in the atmosphere, lower the altitude of the snowline and vice versa.
- The main glaciers in the northern mountains are found in the Greater Himalayas and the Trans-Himalayan mountains (Karakoram, Ladakh and Zaskar).
- The Lesser Himalayas have small glaciers, though traces of large glaciers are found in the Pir-Panjal and Dhauladhar ranges.
- Most of the glaciers of the Lesser Himalayas are smaller in size, ranging from 3 to 5 km in length.
- There are, however, some larger-sized glaciers also in Karakoram and the Greater Himalayas.
- Some of the important glaciers are Siachen (75 km), Sasajni (68 km), Hispara (61 km), Biafo (60 km), Baltora (58 km) (Karakoram mountains).
- The Chogo Lungma Glacier (50 km) terminates at an altitude of 2070 m, the lowest recorded in the Himalayas.
- In Uttarakhand, Gangotri, Milam and Pindari are the main glaciers. The glaciers of Karakoram are the remnants of the Pleistocene Age.
- The diurnal rate of movement of these glaciers is between 8 to 15 cm at the side and 20 to 30 cm in the middle.
- The glaciers of the Pir-Panjal are less numerous and smaller in size as compared to those of the Karakoram and the Greater Himalayan ranges.
- The longest glacier of the Pir-Panjal is Sonapani glacier in the Chandra Valley of Lahul and Spiti region.
- Its length is about 15 km at an altitude of about 4000 m near the Rohtang Pass.
- The largest glacier in the NunKun peak is the Gangri Glacier which is about 13 km in length.
- The glaciers of the Nanga Parbat Massif are small in size and are moving fast due to a steep slope.
- The Chungphar, Rakhiot, Buzhi and Tashan are the other important glaciers of the Pir-Panjal Range.
- The glaciers are not only the source of Himalayan rivers, but also maintain a regular supply of water in these rivers during off monsoon period.
- The Himalayan glaciers are, however, receding.

Ice Ages In India

- The subcontinent of India recorded several ice ages. A brief description of the Indian Ice Ages has been given in the following section:

1. The Dharwar Ice Age

- The moraine deposits and other glaciated topographical features observed in the Dharwar District of Karnataka indicate an ice age during the Dharwadian Period, i.e. about 700 million years ago.

2. The Gondwana Ice Age

- The Talcher Series (Orissa) of the Gondwana System provides a good proof of the glaciation during the Gondwana Period.

3. The Pleistocene Ice Age

- During the Pleistocene Period the effect of ice age was noticed in the Himalayas, especially in the Karakoram and the Greater Himalayan ranges.
- The erratic rocks, boulders, cirques, eskers, rock polishing, buff-coloured sands, and laminated clays inter-stratified among the karewas deposits of Kashmir, Bhadarwa (Doda), and Ladakh give enough proof of the Pleistocene glaciation.
- The Pleistocene glaciation also led to the formation of a number of high altitude glacial lakes of the Himalayas.
- The Kailash-Kund, the Sanasar Lake near Batote, the Gulmarg-basin, the Seshnag, and the Gangabal Lake are some of the examples of this type of lakes.
- The Peninsular part of India has no evidence of Pleistocene glaciation.

The Significance of the Himalayas

- The mighty Himalayas are the most pronounced and dominating physiographic feature of the subcontinent of India. It has often been said that the Himalayas are the body and soul of India. The significance of the Himalayas has been given briefly in the following lines;

1. Climatic Influence
2. Defence
3. Source of Perennial Rivers
4. Source of Fertile Soils
5. Generation of Hydroelectricity
6. Forest Wealth
7. Orchards
8. Minerals
9. Tourism
10. Pilgrimage

THE GREAT PLAINS OF INDIA

- The Great Plains of India lie to the south of the Shiwalik separated by the Himalayan Front Fault (HFF).
- It is a transitional zone between the Himalayas of the north and Peninsular India of the south.

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- It is an aggradational plain formed by the alluvial deposits of the Indus, Ganga, Brahmaputra and their tributaries.
- The plain stretches for about 2400 km from west to east.
- It has varying width; 90-100 km in Assam, 160 km near Rajmahal (Jharkhand), 200 km in Bihar, 280 km near Allahabad and 500 km in Punjab.
- In general, the width of the plain increases from east to west.
- The Great Plains of India consist largely of alluvial deposits brought down by the rivers originating in the Himalayan and the Peninsular region.
- The exact depth of alluvium has not yet been fully determined.
- The average depth of alluvium in the southern side of the plain (south of Bundelkhand) varies between 1300 to 1400 metres, while towards the Shiwaliks, the depth of alluvium increases.
- The maximum depth of over 8000 metres has been reached near Ambala, Yamunanagar and Jalandhar (Haryana).
- The Great plains are remarkably homogeneous with little variation in relief features for hundreds of kilometers.
- The monotony of the physical landscape is broken at micro-level by the river bluffs, mounds, levees, dead-arms of river channels, the ravines and kharis.
- Changing river courses in the areas of frequent floods is a unique geomorphic process in the plains.
- The frequent floods, although a cause of immense damage to life and property, lay down fresh layer of silts in the flood-plains every year, providing rich fertile soils.

Origin of the Great Plains of India

Alluviation of the Foredeep

- According to Edward Suess, an eminent Austrian geologist, a 'foredeep' was formed in front of the high crust-waves of the Himalayas as they were checked in their southward advance by the more

Recession of the Sea

- In the opinion of Blandford, during the Eocene Period, Peninsular India was joined together with Africa.
- During that period, there was one sea extending from Assam Valley to the Irrawaddy river (Myanmar) in the east and another from Iran and Baluchistan to Ladakh (Indus Valley) in the west.
- During the last part of the Eocene Period, arms of the Western Sea extended up to Punjab.
- Due to the rise of the Himalayas during the Miocene Period, these seas started receding by gradual deposits of sediments from the Himalayan rivers.
- After a prolonged period of sedimentation and subsidence, these gulfs (Gulf of Sind in the west and the Eastern Gulf up to the Shillong Plateau) were filled up, resulting in the formation of the Northern Plains of India.

- The evidences cited in favour of the recession of the sea include:
 - (i) the occurrence of limestone rocks in Kumaun-Garhwal region of Uttarakhand,
 - (ii) the presence of saline water lakes in Rajasthan
 - (iii) the joining of the islands of the Gulf of Kachchh with the mainland,
 - (iv) the seaward extension of the Sundarban Delta,
 - (v) the emergence of new islands near Bangladesh coast, and
 - (vi) the presence of marine fossils in the sediments of the Northern Plains of India.
- The theory, however, fails to give convincing arguments so far as the region of the central portion of the plain is concerned.

Remnant of the Tethys

- Some of the geologists and geomorphologists opine that the Great Plains of India are a remnant of the Tethys Sea.
- According to them, after the upheaval of the Shiwaliks, the remaining part of the Tethys was left as a large trough which was joined to the Bay of Bengal in the east and the Arabian Sea in the west. Rivers from the Himalayas deposited their load in the trough.
- Because the Himalayas were rising during that period, rivers experienced rejuvenation and greater quantity of eroded material which increased the thickness of the alluviums.
- Due to infilling of the central part of the trough the seas located in the east and the west started receding, and the Great Plains of India came into existence.

Recent Views

- the Northern Plains of India represent a sag in the crust formed between the northward drifting of the Indian Subcontinent and the comparatively soft sediments accumulated in the Tethyan basin when the latter were crumpled and lifted up into a mountain system.

Physiographic Divisions of the Great Plains of India

- a remarkably homogeneous surface with an imperceptible slope.
- In fact, they are a featureless alluvial fertile plains formed mostly by the depositional process of the Himalayan and Vindhyan rivers.
- deposit enormous quantity of sediments along the foothills. Beyond the foothills, the rivers deposit the alluvium in their flood plains. The Northern

Plains of India may be divided into the following sub-regions:

1. The Bhabar Plain

- It lies to the south of the Shiwalik from west to east (Jammu Division to Assam).
- Its width is however, more in the western plains than in the eastern plains of Assam.

- In width, the Bhabar tract is generally 8 to 15 km, consisting of gravel and unassorted sediments deposited by the rivers

Sunderban:

- The largest mangrove swamp in the world,
- the Sundarbans, or the beautiful forest., gets its name from the Sundari tree which grows well in marshland.
- It is home to the Royal Tiger and crocodiles.

The Brahmaputra Plain

- Stretching over an area of about 56,275 sq km,
- Lie in eastern part of the Great Plains of India.
- It is about 720 km long and about 80 km wide.
- The region is surrounded by high mountains on all sides, except on the west It is a depositional plain.
- The general altitude of the Brahmaputra Plain varies between 130 m in the east to only 30 m in the west.
- The Assam Valley is characterised by a steep slope along its northern margin but the southern side has a gradual fall from the Meghalaya Plateau.
- The whole length of the plain is traversed by the Brahmaputra.
- Due to the low gradient, the Brahmaputra is a highly braided river having numerous islands.
- The Andaman Islands are thickly forested and have a rich marine life among the reefs.
- The islands are a birdwatcher's paradise with 242 species recorded.
- The entire region falls in a major earthquake zone.
- The Barren Island in the Andamans has an active volcano. In the Bay of Bengal, there are two volcanic islands {BaiTen and Narcondam) situated within 80 km east of the Andaman Islands.
- The Andaman Islands have been formed by the extension of the Tertiary mountain chain of Arakanyoma.
- The main rocks of these islands are sandstone, lime· stone and shale.
- The Nicobar group of islands comprise 18 islands of which only 11 are inhabited.
- The physiography of the Nicobar islands is mainly of coral origin.
- Rice is the main crop in Andaman and Nicobar Islands. Coconut and arecanut are the main cash crops of Nicobar.
- Tropical fruits like pineapple, a variety of bananas, sweet papaya and mango grow on a smaller scale in the Andaman an group of islands.
- The Tribal population in the Andaman Islands is fast dwindling.
- Most of its present inhabitants are migrants from Bangladesh, Myanmar, and India and Tamils from Sri Lanka.

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- Some of the well-known surviving tribes of the Andamans and Nicobar are the Onges, Jarawas and Sentinelese.
- One of the largest and also the rarest crabs in the world, the Giant Robber Crab, can be found in the Wandoor Marine Biosphere Reserve in south Andaman and Great Nicobar Islands.
- Its powerful claws help it to climb the coconut tree and break the hard shell of its fruit.

The Arabian Sea Islands

- There are 43 islands in the Arabian Sea, out of which only 10 are inhabited.
- The shortest distance from the mainland {Calicut} is about 109 km.
- Kavaratti, located on the island of this name is the capital of Lakshadweep.
- Lakshadweep islands are separated from the Maldivian Islands by the Eight Degree Channel. Hills and streams are absent on these islands.
- The Minicoy is the largest (4.5 sq km) and has a light house and a weather observatory.
- Fishing is the main occupation of the people of Lakshadweep.
- In Lakshadweep coconut is the only major crop, although pulses and vegetables are also grown.
- The sea around the island is rich in marine life.

Offshore Islands

- There are numerous islands in the delta region of Ganga and in the Gulf of Mannar.
- Among the Western coast islands Piram, Bhaisala (Kathiawar), Diu, Vaidia, Nora, Pirtan, Karunbhar (Kachchh coast), Khadiahet, Aliabet (Narmada-Tapi mouths), Butchers, Elephanta, Karanja, Cross (near Mumbai), Bhalkal, Pegioncock, St. Mary {Mangalore coast}, Arljudiv (Goa coast), Vypin near Kochi, Pam ban, Crocodile, Adunda (Gulf of Mannar), Sri Harikota (mouth of Pulicat Lake, Paikud (mouth of Chilka Lake), Short, Wheeler (Mahanadi-Brahmani mouth), and New Moore, and Ganga-Sagar and Sagar (Ganga Delta).
- Many of these islands are uninhabited and administered by the adjacent states.

EARTHQUAKES IN INDIA

- Earthquakes are vibrations of the Earth caused by ruptures and sudden movements of rocks that have been strained beyond their elastic limits.
- In other words, earthquakes are movements within the earth caused by natural or man-made stresses.
- Earthquakes are caused by (i) volcanic eruptions, (ii) ruptures and sudden movements of rocks (folding and faulting), (iii) movement of plates (plate tectonics), and (iv) anthropogenic factors.

CHAPTER-3-DRAINAGE

THE DRAINAGE SYSTEM

- an integrated system of tributaries and a main stream which collect and funnel surface water to the sea, lake or some other body of water.
- The total area that contributes water to a single drainage system is known as a drainage basin.
- a basic spatial geomorphic unit of a river system, distinguished from a neighboring basin by ridges and highlands that form divides. Thus, river basins are natural units of land. They are regarded as the fundamental geomorphic as well as hydrological units for a systematic study of the river basins, mainly due to the following three reasons:

(i) They can be placed in an orderly hierarchy,

(ii) They are areal units whose geomorphological and hydrological characteristics can be measured quantitatively, and

(iii) They can be treated as working systems with energy inputs of climatological variables like temperature and rainfall and output of river discharge as runoff.

- The Committee on Runoff of the American Geophysical Union treats the micro-unit within a river basin as the watershed, while the sum of all the micro, meso and macro tributaries of a river is known as a river basin.

DRAINAGE PATTERN

- A geometric arrangement of streams in a region; determined by slope, differing rock resistance to weathering and erosion. climate, hydrologic variability, and structural controls of the landscape is known as a drainage pattern.
- In other words, drainage pattern refers to a design which a river and its tributaries form together, from its source to its mouth.
- The factors controlling the pattern of drainage in a region include the topography, slope, structural control, nature of rocks, tectonic activities, supply of water, and above all, the geological history of that region. In India, the following type of drainage patterns are found:

RIVER BASINS OF INDIA

- The area drained by the main river including all its tributaries is known as its drainage basin.
- On the basis of the area drained, the river basins of India have been classified into three categories:
 - (i) river basins with catchment area of more than 20,000 sq km known as large river basins;
 - (ii) river basins having a catchment area between 2000 to 20,000 sq km known as the medium basins, and (iii) the rivers having a catchment area less than 2000 sq km known as minor river basins.
- India has one hundred and thirteen river basins, of which 14 are large, 44 medium and 55 minor river basins.
- The major river basins of India in descending order of area are: the Ganga, Indus, Brahmaputra, Godavari, Krishna, Luni, Mahanadi, Narmada, Kaveri, Tapi, Mahi, Sabarmati, Barak, and Subarnarekha.

- The major river basins form about 84 per cent of the total drainage area of the country
- The three major river systems (Ganga., Indus, and Brahmaputra) are international rivers.
- The Indus and some of its important tributaries traverse Tibet (China), India, and Pakistan while the Ganga and Brahmaputra, and their tributaries cross Tibet, Nepal, Bhutan, and Bangladesh.
- On the basis of mode of origin, the drainage of India may be divided into

{i) Himalayan or the Extra-Peninsular Drainage, and

{ii) the Peninsular Drainage.

- There is no clearcut line of demarcation between these two drainage systems, as many of the Peninsular rivers like the Chambal, Betwa, Sind, Ken, and Son are much older in age and origin than the Himalayan rivers.

RIVER SYSTEMS OF THE HIMALAYAN DRAINAGE

- The rivers originating from the Himalayan and Trans-Himalayan regions consist of three river systems, namely:
 - (i) the Indus System,
 - (ii) the Ganga System, and
 - (iii) the Brahmaputra System

1. The Yamuna River(length "1.380 km.)

- the longest and the western-most tributary of the Ganga.
- source lies in the Yamunotri Glacier on the western slopes of Banderpunch {6316 m}.
- Downwards, it is joined by Tons river behind the Mussoorie Range (Uttarakhand).
- From the Mussoorie Range, it debouches into the plains where it flows in a broad curve.
- Making a boundary between Haryana and Uttar Pradesh, it passes Delhi, Mathura, Agra and flows southward until it joins the Ganga at Allahabad.
- The important tributaries of the Yamuna are mostly the right bank tributaries, originating from the Aravallis (Rajasthan), Vindhyan Range, and the Malwa Plateau of Madhya Pradesh.
- The Chambal, Sind, Behva, Ken and Tons are the main right hand tributaries of the Yamuna River.
- It is believed that during the Vedic period, the River Yamuna might have flowed towards south and southwest through Bikaner in Rajasthan, and shared its water with the legendary River Saraswati.

The Chambal River (Length 960 km)

- The Chambal River rises near Mhow-south-west of Indore in Malwa Plateau from the Vindhyan Range-and flows towards the north in a gorge upto the city of Kota.
- Below Kota, it turns to the north-east, and after passing Bundi, Sawai-Madhopur and Dholpur, it finally joins the Yamuna about 40 km to the west of Etawah.
- The Banas River, rising from the Aravalli Range is its main left bank tributary.

- Kali Sind and Parbati originating from the Malwa Plateau are the right bank tributaries of Chambal.
- The Chambal River is famous for its extensive ravines which it has carved all along in the Lower Chambal Valley-
- The ravines of the Chambal Basin are attributed to a slight uplift during the recent geological times, and they merge into the Yamuna alluvial plain where the landscape is extensively etched out by other tributaries of the Yamuna to the east and west of Chambal.
- Multipurpose projects have been constructed across the river_
- The main dams across the river are Gandhi Sagar, Rana Pratap Sagar (Rawatbhata) and Jawahar Sagar.

Chambal Rivines

- A maze of ravines, valleys and saw-toothed ridges dissect the plateau.
- These ravines are found in Rajasthan, Madhya Pradesh and Uttar Pradesh in the lower course of the Chambal River-Infested with dacoits, the ravines are being reclaimed for agriculture, pastures, and social forestry.

The Ramganga

- This is a comparatively small river which rises in the Kumaun Himalayas.
- The river is deflected to the south-west by the Shiwalik, which it cuts through., before emerging at the Ganga Plain in Najibabad,
- It joins the River Ganga in Hardoi district opposite to Kannauj.

The Sharda

- This river rises from the Milam Glacier in the Nepal Himalayas where it is known as the Goriganga.
- It is known by various names, such as the Kali, when it turns along the Indo-Nepal border, and the Chauka, before it joins the right bank of Ghagra near Barabanki.

The Karnali

- The Karnali is known as Kauriala in the Nepal Himalayas and as Ghagra in the Ganga Plain.

The Narmada (Length 1300 km, drainage basin 98,800 sq km)

- The Narmada River rises from the plateau of Amarkantak of the Maikal Hills of Chhattisgarh.
- Moving north-westward, it passes through a complex course near Jabalpur, through some impressive marble gorges, the most spectacular being Dhunwadhar Waterfalls (10m high) near Jabalpur.
- Moving westward from Jabalpur, it flows through a rift valley between the Vindhyan and the Satpura ranges.
- It has rich alluvial deposits in its valley.
- Finally, it widens below Bharuch and makes a 27 km wide estuary to enter the Gulf of Khambat (Arabian Sea).

Tapi

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- Having a length of 700 km. and a basin area of 66,900 sq km,
- the river Tapi rises from the Satpura Range and flows westward almost parallel to Satpura.
- At Khandwa-Burhanpur Gap, the Narmada and Tapi come close to each other.
- Below Jalgaon, the river, Like the Narmada, flows in a rift valley but in a much constricted form between the Satpura Range to the north and the Ajanta Range to the south.
- Below the city of Surat, it makes an estuary and merges into the Gulf of Khambat.

EASTERLY RIVERS OF THE PENINSULAR REGION

- There are a number of rivers originating from the Chotanagpur Plateau and merging into the Bay of Bengal, of which the Brahmani is the most important.

Subernrekha (length 400 km, basin 28,000 sq km)

- rises a little to the southwest of Ranchi where it has a number of waterfalls.
- In a general easterly direction, it passes through Jamshedpur and flows to the Bay of Bengal near Balasore.

The Brahmani (Length 420 km)

- formed by the confluence of the Kosi and Sankh rivers. They join together at Rourkela and drain the western parts of the Garhjat Hills.
- Floating through Bonai, Talcher and Balsore districts, it merges into the Bay of Bengal above the Paradip-port.
- With the Baitarani river to its north, a delta complex forms below Bhadrak.

The Mahanadi (length 885 km, basin 141,600 sq km)

- most important river of Orissa as well as that of Chhattisgarh.
- rises in the Chhattisgarh basin, draining the western and eastern parts of Raipur.
- In the initial stage, it flows towards the north-east, and after receiving a number of streams such as Seonath and Sandur on both its flanks at heights between 200 m and 700 m, the combined water gets a natural exit towards the east through a gorge which has been impounded to create the Hirakud Dam.
- A little below the dam at Sambalpur, the river turns eastward and flows through the Eastern Ghats

Shifting Courses of Rivers

- River capturing is mainly caused by the headward erosion of the river.
- In the plain areas, generally, the rivers form meanders in their courses. During floods, due to increased quantity of water, the streams try to straighten their courses. Earth movements do have their role in affecting these processes.
- Some of the important river captures are as under: The ancient Saraswati River, which provided an abode for early Aryan settlers, presents a typical example of shifting courses and river capturing.
- Descending from the Himalayan ranges, its initial course during the pre-historic period was passing near Churu (about 2000 to 3000 BC), and the Luni river was one of its tributaries.

- It gradually shifted towards west till it joined the Satluj near Ahmadpur.
- Later on, the water of its upper course was captured by a tributary of the Ganga River as a result of which its lower course became dry.
- This gave birth to Yamuna River, an important tributary of the Ganga System.
- Even today the dry valley of the Saraswati River is found in Rajasthan area in the form of Ghaggar valley.
- Similar shifting has also been observed in the rivers of the Punjab during the historical past
- The records of the third century BC show that the Indus flowed more than 130 km east of its present course, through the now practically dry beds of the deserted channel, to the Rann of Kachchh which was then a gulf of the Arabian Sea.
- Later on, it gradually shifted towards the west and occupied its present position.
- During the reign of Akbar the Great, the Chenab and Jhelum rivers joined the Indus near Uch (Pakistan), but their present confluence lies near Mithankot about 100 km downstream of the old place of confluence.
- Similarly, Multan was formerly located along the Ravi River, but today it is situated about 60 km south of its confluence with the Chenab.
- About 250 years ago the Beas river changed its old course, traces of which are still found between Montgomery and Multan, and joined the Satluj river near Sultanpur.
- In the early part of the Christian Era the Satluj had more easterly course and independently discharged its water into the Arabian Sea.
- About 250 years ago, the Brahmaputra flowing through Mymensingh was discharging its waters into the Meghna River.
- In due course of time, it straightened its course and joined the Ganga (Padma) River forming a new stream called Jamuna.
- A feeble channel of the Brahmaputra is still flowing along the same old course and retains the old name.
- This change in the course was associated with 30 m rise in Madhopur forest area between 1720-1830 A.D.
- Even the entry of the Brahmaputra to the plains of Assam is also the outcome of the process of river capturing.
- According to geologists, during early days, the Tsangpo river of Tibet taking an easterly course used to join the Irrawaddy River (Myanmar) through the Chindwin, which was then a large river, transporting huge quantity of water.
- Later on, a small river flowing along the southern slopes of the Himalayas through its headward erosion captured the water of the Tsangpo River and, thus, helped in the evolution of the stream of Brahmaputra. Similarly, Kapili, a tributary of the Brahmaputra, has captured the waters of the Meghna river of Bangladesh.

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- In old days, the Meghna originated from the Bra.il Ranges (between Meghalaya and Manipur) and flowing southward, emptied its waters in the eastern part of the Bay of Bengal. Rut Kapili, through headward erosion, captured its northern course.
- The Lumding-Halflong Pass is an evidence of this abandoned valley.
- In a similar way, the Dhansiri River capturing the water of a tributary, Kapili River has helped in the formation of a new river called Jumna.
- There can be numerous causes responsible for the shifting of river courses.
- These include the shifting gentle slope of the Great Plains of India, meandering courses of the rivers, straightening of the river courses during floods, upliftment of the Potwar Plateau (Delhi-Sirhind Plateau), down warping of the Maida Gap, rise in the Madhopur forest area and uplift of the Barind areawhen a dam was built across the headwaters of the Luni River.
- Thousands of pilgrims come to bathe in the waters of the lake during the festival of Kartika Poornima in November.

Renuka Lake

- Situated in the Siannaur District of Himachal Pradesh, this lake has been named after the goddess Renuka.
- A Lion Safari and a Zoo are major attractions at Renuka.
- a site for the annual fair in the month of November.

Roopkund

- Situated in Uttarakhand, it is a lake around which 600 skeletons were found at the edge of the Jake. The location is uninhabited and is located at an altitude of about 5010 m.
- The skeletons were discovered in 1942.
- Radio-carbon dating suggest that these people died in an epidemic.

Sambhar Lake

- Situated about 70 km to the west of Jaipur city, it is the largest salt lake of India.
- On the eastern end, the lake is divided by a 5 km long dam made of stones.
- To the east of the dam are salt evaporation ponds where salt is being produced for more than a thousand years.
- The water depth varies from a few cm during the dry season to about 3m after the monsoon rains.
- Sambhar has been designated a Ramsar site (recognised wetland) of international importance. Thousands of Siberian birds reach the lake during the winter season.

Sasthamkotta Lake

- a large fresh water lake in Kerala state.
- located near Sastharnkotta in Kollam District, about 30 km from Kollam. It is a great attraction for the tourists.

Satta or Sat Tal

- the calm, quiet group of seven lakes near Bhimtal town of the Kumaun Division of Uttarakhand.

- These lakes are situated at an altitude of 1370 m above mean sea level. These lakes are a paradise for migratory birds.

Suraj Tal

- Located below the summit of the Bara.lacha Pass, it is a high altitude lake, 4980 m above sea level. This lake is the source of the Bhaga River, one of the main branches of the Chenab River.

Tawa Reservoir

- Located in Hoshingabad on the River Narmada (M.P.), it was created as a result of the Tawa Dam. It forms the western boundary of Satpura National Park and Bori Wild Life Sanctuary.

Tsongmo Lake

- Situated in the state of Sikkim, about 40 km away from Gangtok, it is a glaciated tarn lake. It is oval shaped. Being situated at an altitude of about 3780 m, it remains frozen during the winter season. It is a sacred lake for the Buddhists and the Hindus.

Government Strategy

The total renewable water resources of India are estimated at about 1900 sq km per annum. It is predicted that by 2025 large parts of India will join countries or regions having absolute Water scarcity. The following steps have been taken by the government to implement the water harvesting programme:

1. Since sustainability of drinking water-source is of paramount importance for smooth functioning of rural water supply, 25 per cent out of 20 per cent of the allocation under Accelerated Rural Water Supply Programme (ARWSP) has been earmarked exclusively for water harvesting schemes to make implementation of such schemes mandatory.
2. Similarly, 25 per cent out of the allocation under Prime Minister's Gramodaya Yojana has also been earmarked for funding schemes under submission on sustainability.
3. MPs are requested to utilize Local Area Development Fund in their respective constituencies to take up water harvesting schemes.
4. Preparation of pilot projects on water harvesting in selected states have already been undertaken.
5. Further, preparation of user-friendly atlas type of document on traditional water-harvesting structures in various parts of the country has been initiated for popularizing the concept of water harvesting amongst all concerned, including the community.

By adopting watershed as a unit, different location-specific measures are adopted and executed carefully in each of the topo-sequences according to capability.

- Considering the fact that the rainfed area in India is about 60 per cent of the country's net sown area., and the vast area should not suffer from neglect and poverty, investment in watershed management for water scarce regions (receiving rainfall below 75 cm) of India is an appropriate development intervention which warrants top priority from the point of social justice and containing the widening spatial imbalance between irrigated wet farming and dryland farming systems.
- In brief, watershed development approach being an intensive one, appears to be infinitely expensive in a relative sense over the seed and fertilizer approach, but economic evaluation

conducted at the Central Soil and Water Conservation Research. Institute at Dehradun shows that this is not so.

- On the other hand, the realisation that a crop-based approach, or an approach which treats the country as a single unit, would not address the major issue for agricultural development in different location-specific conditions, watershed management (or alternative drainage, flood control and conjunctive uses of water of different sources, or ag-d.in, a more appropriate management of bill and forest-based agriculture) are alternative regimes, each having a different investment and policy support strategy.
- There are a number of successful watershed management experiences like Sukhomajri near Kalka and Pani-Panchayats {water collectives} at Ralegaon Sidhi in Maharashtra, where the basic problems of food and fuel wood requirements of poor rural communities have been largely solved by water harvesting.
- It is being suggested that in many rural or agricultural situations in our country, we require community participation interfaced with institutional support at the level of, say, 'watershed' land and water managements in difficult ecological regimes to develop the slender resource base of the areas.
- The replication of successes like Sukhomajri would be for the better.
- Studies to develop a baseline data for better understanding of the existing and emerging situations need to be undertaken.
- Recycling of water and water conservation will be a critical component of our daily lives in the new millennium. As far as possible, the technologies should be indigenously developed so as to make them socially acceptable and economically viable.
- Hence, the diversion of excess water from the Brahmaputra to the Ganga may meet this water deficit, which shall help in the economic development of the region.
- The Brahmaputra-Ganga Link Canal Project involves the construction of a diversion barrage at Dhubli (Lower Assam), and a 320 km long feeder canal linking the Dhubri Barrage to the Farakka Ban-age.
- A portion of this feeder canal will lie in Bangladesh for which an international agreement between India and Bangladesh has to be signed. This canal will provide irrigation water to Bangladesh also. The canal may augment the flow of level in the Padma River (Ganga in Bangladesh) during the lean months of the year.
- Besides, the link canal would provide cheap inland navigation facility to both the countries. Due to lack of concurrence from Bangladesh and involvement of huge financial expenditure, the scheme has not yet been started.

The Narmada Link canal to Gujarat and Rajasthan

- Under the Sardar Sarovar Project, there is a proposal to build a terminal storage dam across the Narmada River near Navagaro, and a diversion canal linking the place to regions of Kachchh {Gujarat} and western Rajasthan.

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- This link canal will be of immense help to the drought prone areas of Gujarat and western Rajasthan.

The Chambal link Canal

- A canal of about 500 km connecting the Chambal River with the Indira Gandhi Canal has also been proposed.
- The canal would provide water to the central parts of Rajasthan.
- involve a lift of 200 to 250 m.

Links between the Rivers of the Western Ghats to the East

- The rivers of the Western Ghats carry enormous quantity of water during the rainy season. Due to steep gradient and the narrow coastal plains much of the water goes to the Arabian Sea as waste.
- This water may be diverted to the rain-shadow areas of the Western Ghats through the diversion canals where it can be utilised for irrigation.
- The Periyar Diversion Scheme, constructed several years ago, is such a type of model scheme where the surplus water of the west-flowing Periyar river has been collected in a barrage and diverted through a tunnel across the Sayadri, so as to meet the water needs of the drought prone areas of Tamil Nadu in the east.

GROUND WATER RESOURCES OF INDIA

- India is rich in underground water. Its spatial distribution, however, is most uneven. For example, the average annual rainfall in India is about 110 cm.
- While Mawsynram and Cherrapunji receive more than 1000 cm rainfall annually, the average annual rainfall in Ganganagar is only about 20 cm.
- The underground water resource is a function of geological structure, topography, slope, precipitation, runoff, soils and hydrological conditions of a region.
- In the opinion of Prof. R.L. Singh (1971), India may be divided into eight ground water provinces.

1. Pre-Cambrian Crystalline Province:

- It extends over half of the country's geographical area covering Tamil Nadu, Andhra Pradesh, Karnataka, Maharashtra, Dandakaranya, Bundelkhand and Aravali range. This province is deficient in ground water resources.

2. Pre-Cambrian Sedimentary Province:

- It extends over Cuddapah and Vindhyan basins where the rocks belong to Cuddapah and Vindhyan systems. This province is also not much suitable for ground water development and contains inadequate amount of ground water.

3. Gondwana Sedimentary Province:

- The Gondwana sedimentary rocks of the Barakar and Godavari river basins contain good aquifers of ground water.

4. Deccan Trap Province:

- These are 1,200 metre thick covering of impermeable basalt over the surface which obstructs percolation of water. As such, the whole province is deficient in ground water resources.
- The only aquifers preserved are in the fractures where secondary porosity develops in the weathered moorums at times, in the intertrappean beds sandwiched between two impermeable strata as also in the vesicles and amygdaloids.

5. Cenozoic Sedimentary Province:

- This province includes the Andhra Pradesh, Tamil Nadu, Kerala and Gujarat coasts.
- These areas have tertiary sandstones and the province as a whole has good aquifers.

6. Cenozoic Fault Basin:

- The rift zone of the Narmada, the Purna and the Tapi provides good resource of ground water in their 80-160 metre thick alluvial cover of sand, silt and clay.

7. Ganga-Brahmaputra Alluvial Province:

- This is the richest ground water province of the country.
- The bhabar, tarai and the axial belts are well defined. The streams disappearing in the unsorted materials of the bhabar zone seep out in the tarai belt.
- Moreover, the ground water table is also high.

8. Himalayan Province:

- This complex structural and geographic unit is not very significant with respect to ground water resources.
- Local springs are common but wells are a rare feature.

Siruvani Waterfall

- situated at the Siruvani River at a distance of about 40 km from Coimbatore in the Western Ghats.
- one of the main water sources of Coimbatore city.
- The panoramic view of the dam and the falls is enchanting.

Thalaiyar Waterfall (Rattail)

- Also known as Rat-tail, it is located near Kodaikanal in Tamil Nadu.
- With an elevation of 297 m, it is the highest waterfall in Tamil Nadu State.
- The waterfall is, however, not connected by road and the approach is tiresome.

Vattaparai Waterfall

- Located at the Pazhayar River in the Kanyakumari District of Tamil Nadu, it is a great attraction for tourists. The surrounding area is proposed to be developed into a Wildlife Sanctuary.

Vazhachal Falls

- Located in the Thrissur District of Kerala, these are one of the best waterfalls in India.
- They are a great attraction for the domestic and international tourists.

Some of the other important Waterfalls in India

Chhattisgarh -Teerathgarh. **Madhya Pradesh**-Dhunwadhar {Narmada River, near Jabalpur}.

Himachal Pradesh- Bundla and Palani falls. **Jharkhand**-Ghaghri, Hundru and Johna falls.

Karnataka-Abbey Falls, Arisina Gundi Falls, Hebbe Falls, Irupu Falls, Kalhatti Falls, Keppa Falls, Koosalli Falls, Kudumari Falls Kunchikal Falls, Magod Falls, Mekedaatu Falls, Muthyala Falls, Sathodi Falls, Simsa Falls, Chunchi Falls, Unchalli Falls.

Kerala Athirappilly Falls, Meenmutty Falls, Palilruvi Falls, Soochipara Falls, Thusharagiri Falls.

Maharashtra Clachai Falls, Gatha Falls, Keoti Falls, Raja Pratap Falls (M.P.), Kune Falls, Marleshwar Falls, Pandavgat Fall.

CHAPTER-4-CLIMATE

- Under the extreme low pressure condition on land, the wind from the southern part of the Indian Ocean (south of Equator) is attracted towards the subcontinent of India.
- The air coming from oceans towards land is warm and moist.
- When land barriers like mountain ranges and plateaus come in the way of the moisture-laden winds, they ascend and result into saturation, condensation, and precipitation
- In the Northern Hemisphere during winter season, there develops high pressure areas near Baikal Lake (Siberia), and Peshawar (Pakistan).
- In the Indian Ocean and the Pacific Ocean (south of Japan) remain relatively warm, having low pressure areas.
- There is an outflow of air from the high pressure of the land to the low pressure areas of the oceans.
- The air blowing from high pressure areas of land towards the sea is cold and dry.
- This cold and dry air is incapable of giving precipitation unless it comes into contact with some water body (ocean/sea)
- The thermal concept about the origin of monsoon has, however, not been accepted universally as it fails to explain the intricacies of monsoon.
- Besides differential heating, the origin and development of monsoon are also influenced by the shape of the continents, orography, and the conditions of air circulation in the upper troposphere.

The Halley's concept has been criticised on more than one count as follows:

- The low pressure areas that develop over the continents during the summer season in the Northern Hemisphere are not stationary.
- These low pressure areas change their position suddenly.
- The low pressure areas stabilize in June in the northeastern parts of the subcontinent
- represent the cyclonic lows associated with the dynamic factors, and therefore, these low pressure areas cannot be termed as only thermally induced.
- The Tibetan Plateau acts as a physical barrier.
- At the beginning of June, the subtropical jet stream disappears completely over northern India.
- The plateau of Tibet becomes very cold in winter, and proves to be the most important factor in causing the advance of the jet far to the south in the middle of October.
- The abrupt onset of summer monsoon at the beginning of June is prompted by the hydro-dynamic effect of the Himalayas and not by the thermally induced low pressure centre over northwest India. In the middle of October, the plateau proves to be the most important factor in causing the advance of the jet south of the Himalayas or bifurcate it into two parts.
- The summer-time heating of the Tibetan Plateau makes it a high-level heat source.
- This 'Heat Engine' produces a thermal anticyclone over this region.
- A warm core anticyclone (high pressure) is formed over this plateau during the summer monsoon period.
- The formation of this anticyclone takes place in the middle part of the troposphere at 500mb level. It is the result of a process called anti-cyclogenesis.
- On the southern side of this upper air anticyclone, the direction of air flow is from east to west.
- In fact, these easterly winds blowing in the mid-troposphere are known as tropical easterly jets.

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- The onset of monsoon puts an end to the scorching weather and the local hot winds (loo) in the northern plains of India.
- The relative humidity increases in the atmosphere tremendously.
- The high temperature and high relative humidity are, however, oppressive and injurious to health.
- It is in the season of general rains (July to September) that people suffer from many diseases and epidemics.

BREAKS IN THE MONSOONS

- The migration of the monsoon rainfall zone is one of the major sub-seasonal variations of the summer (or south-westerly) monsoon.
- the monsoon is not a continual deluge of a number of months, duration, but has inter-seasonal variability; being made of a series of discrete events, both pluvial and dry.
- Periods during which there is a rapid succession of weather disturbances or storms lasting a few days are referred to as active periods of the monsoon.
- Periods during which there is no rainfall for few days are the break periods of the monsoon.
- During an active phase, the Tropical Easterly Jet Stream (TEJ) remains very strong in the upper troposphere indicating strong convection and latent heating.
- But, when the maximum cloudiness remains locked up in the foothills of the Himalayas and the monsoon rainfall zone moves in this direction, subsidence occurs to produce a weak easterly flow in the upper troposphere. This creates the condition of break in monsoons.
- In break monsoon condition, there is a general rise of pressure (as well as temperature) over the country and the isobars show marked refraction along the west coast
- Cloudiness decreases and the south-easterlies at the surface levels over northern India are replaced by hot westerly air which blows over the plains, since the broad-scale surface pressure (the monsoon trough) shifts to the Himalayas and the rainfall practically ceases over the country outside the Himalayan regions and the southern slopes of the Himalayas, leading to high floods in the plains of these Himalayan rivers.
- Under weak monsoon conditions and in the years when the eastern end of the axis of the monsoon trough is oriented southward in Orissa, Jharkhand, Chhattisgarh and Madhya Pradesh, a low valley trough develops over the Assam Plain aligned along river Brahmaputra between the eastern Himalayas and the Shillong Plateau.
- The vertical extent of this low valley trough is 2 to 3 kilometers with the south west Monsoon lying to the south of the trough, remaining independent of the main monsoon trough.
- But, when the latter moves northwards and extends to the Himalayas, it joins the trough over the Assam Plain to cause heavy rainfall there.
- The break in monsoon conditions generally occurs in the peak months of July and August, and lasts for at least 3 to 5 days over 500 to 1000 kilometres length in these months.
- The temperature in the eastern states of India and in the hilly regions in the month of May is generally cool and invigorating.
- In the month of April the 30°C isotherm of average temperature encloses a vast area of the country between 10°N and 26°N latitudes (except the west coast and the hilly states of north-east India).
- The diurnal range of temperature ranges between 5°C and 6°C in coastal areas, but reaches 20°C in the interior parts of the country and in the north-west Satluj Ganga Plains.
- the western coast, Sahyadris, Meghalaya, Arunachal Pradesh, Mizoram, Nagaland, Sikkim, and Darjeeling hills get more than 200 cm of rainfall.

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- The remaining parts of north, eastern India, West Bengal, Orissa, Jharkhand, Bihar, Chhattisgarh, the Tarai region and hills of Uttarakhand receive rainfall between 100 to 200 cm.
- the southern and western Uttar Pradesh, northern and western Madhya Pradesh, eastern Maharashtra and Gujarat, and northern Andhra Pradesh experience rainfall between 50 and 100 cm.
- Rajasthan, western Gujarat, southern Andhra Pradesh, Karnataka plateau, Tamil Nadu, plains of Haryana., Punjab, and Jammu and Kashmir receive less than 60 cm of rainfall.
- The lowest rainfall is recorded in the Thar desert along the border of Pakistan, and the Ladakh region of Jammu and Kashmir "state
- the highest variability is found in the areas where the average annual rainfall is the lowest. For example, the desert areas of Bikaner, Ganganagar, Jaisalmer, Jodhpur, etc. have less than 20 cm of average annual rainfall. In these areas the variability of rainfall is around 60 per cent.
- the areas where the average annual rainfall is over 200 cm (Mawsynram and Cherrapunji, Meghalaya Plateau), the annual variability of rainfall is less than 10 per cent.
- The Western slopes of Western Ghats, the Lesser Himalayas, the Shiwaliks and the Tarai belt also record between 100-200 cm of average annual rainfall. The variability of rainfall in these regions is around 10 to 20 per cent.
- an inverse relationship between the average annual rainfall and variability in rainfall.
- The variability of rainfall has a significant role in the agricultural operations and other economic activities of the country.
- The areas showing high variability of rainfall have chronic deficiency of water.
- Such regions are highly prone to droughts, floods and famines, while the areas with high average annual rainfall are less affected by droughts; though flood is a regular feature in flood prone areas.

CLIMATIC REGIONS OF INDIA

- India is often referred to as a country with tropical monsoon type of climate.
- The large size of India, its latitudinal extent, the presence of the Himalayas in the north, and the Indian Ocean, Arabian Sea and Bay of Bengal in the south have resulted in great variations in the distribution of temperature and precipitation in the subcontinent of India.
- A number of attempts have been made by climatologists, geographers and experts of agriculture to divide India into climatic regions.
- While some of these classifications have been suggested for world climates, others are exclusively applied to Indian conditions.

Tropical India

1. Region of Very heavy Rainfall

- stretches over Assam, Meghalaya, Nagaland, Manipur, Tripura and Mizoram.
- The average annual rainfall in these areas is over 200 cm.
- The heaviest rainfall in the world is recorded in this region at the stations of Mawsynram and Cherrapunji.
- Over 90 per cent of the average annual rainfall is recorded during the season of the South-West Monsoon.

- significant variations in the mean monthly temperature of January and July owing to undulating and mountainous topography.

2. Regions of Heavy Rainfall

- covers West-Bengal, Orissa, Jharkhand and eastern parts of Andhra Pradesh.
- The average annual rainfall in this region varies between 100-200 cm.
- a general decrease in the amount of rainfall from east to west
- The mean January temperature is over 18°C, while about 30°C is recorded during the months of June and July.

3. Region of Moderate Rainfall

- lies to the east of the Western Ghats and includes Gujarat, south-western Madhya Pradesh, Maharashtra, Karnataka and greater parts of Andhra Pradesh.
- Being in the rain-shadow area of the Western Ghats, this region receives relatively less rainfall of about 75 cm.
- The average temperature in the months of January and July is about 18°C and 32°C respectively.

4. The Konkan Coast

- It stretches from the mouth of Tapi river to Goa.
- The average annual rainfall is more than 200 cm, of which over 90 per cent is recorded from the Arabian stream of the South-West Monsoon.
- The mean January temperature remains around 24°C while the mean July temperature reads about 27°C.
- The average annual range of temperature varies between 3°C to 6°C depending on the distance from the coast and the equator.
- the annual range of temperature increases from south to north.

5. The Malabar Coast

- lies between Goa and Cape Camorin (Kanniyakumari).
- records over 250 cm of rainfall.
- The average annual temperature reads around 27°C with 3°C being the annual range of temperature.
- Kochi is a typical example of this region.

6. The Tamilnadu Coast

- includes the greater parts of the state of Tamil Nadu and the Coromandal Coast
- The average annual rainfall varies between 100-150 cm.
- Most of the rainfall is recorded during the season of retreating monsoon (October to December).
- The average temperature for the month of January is 24°C, while the July temperature reads around 30°C.

Different Types of Climatic Regions (Climate Group)

The climates of India are mainly divided into four different groups. The classification of these groups is based on the Koppen climate classification system.

Tropical Wet (Humid):

- divided into two sub parts- tropical monsoon climate or the tropical wet climate, and tropical wet and dry climate or savannah climate.
- The Western Ghats, the Malabar Coast, southern Assam, Lakshadweep and Andaman and Nicobar Islands have the tropical monsoon climate.
- It experiences moderate to high temperature with seasonal but heavy rainfall. The months from May to November experience the most rainfall and the rain received during this period is sufficient for vegetation throughout the year.
- Tropical wet and dry climate or the savannah climate is most common in the country and prevails mainly in the inland peninsular region of the country except for some portion of the Western Ghats.
- The summers are extremely hot and the rainy season extends from the month of June to September.

Tropical Dry:

- divided into three subdivisions-(a) tropical semi-arid (steppe) climate, (b) sub-tropical arid (desert) climate and (c) sub-tropical semi-arid (steppe) climate.
- Karnataka, central Maharashtra, some parts of Tamil Nadu and Andhra Pradesh experience the tropical semi-arid (steppe) climate. Rainfall is very unreliable in this type of climate and the hot and dry summers are experienced from March to May.
- With scanty and erratic rainfall and extreme summers, western Rajasthan witnesses the sub-tropical arid (desert) climate.
- The areas of the tropical desert that runs from the regions of Punjab and Haryana to Kathiawar witness the sub-tropical semi-arid (steppe) climate. The maximum temperature in summers goes up to 40°C and the rains are unreliable and generally take place during summer monsoon season in this climate.

Sub-tropical Humid Climate:

- witnessed by most of the North and Northeast India.
- Summers are very hot, while in winters, temperature can plunge to as low as 0°C.
- Rainfall mainly occurs in summers but snowfall or occasional rainfall in winters is also witnessed in some areas.
- The hottest months are May and June and frost also occurs for few months in winters.

Mountain Climate:

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- The temperature falls by 0.6°C for every 100 m rise in altitude in the Himalayas and results in a number of climates from tropical to tundra.
- The trans-Himalayan belt, which is the northern side of the western Himalayas, is cold, arid and windswept.
- There is less rain in the leeward side of the mountains whereas heavy rainfall is received by the well exposed slopes.
- Heaviest snowfall occurs between the months of December to February.

Factors Affecting India's Climate

There are certain factors which affect the climate of India:

Latitude:

- The Tropic of Cancer passes through the middle of India and extends from Mizoram in the east and Rann of Kutch in the west; and considerably affects the climate of the country.
- To the south of the Tropic of Cancer lies the southern part of the country which belongs to the tropical area and to its north lies the northern half of India which belongs to the sub-tropical area.
- Therefore, India experiences both sub-tropical and tropical climates.

Altitude:

- In the north, India is bounded by mountains with an average height of 6,000 metres and in the south, has a vast coastline with maximum elevation of about 30 metres.
- The Himalayas act as a barrier against the cold winds from Central Asia.
- Therefore due to the altitude of these mountains, the Indian subcontinent experiences milder winters than Central Asia.

Monsoon Winds:

- The 'monsoon winds' is the most dominating factor influencing the climate of India. It is often called the monsoon climate.
- A reversal in the monsoon winds can bring a change in the season of the country, for instance the extreme summer season suddenly changing to the rainy or monsoon season.
- The entire country receives rainfall due to the south-west summer monsoons from the Bay of Bengal and Arabian Sea.

Western Disturbances and Tropical Cyclones:

- Large parts of peninsular India get influenced by the tropical cyclones which originate in the Arabian Sea and the Bay of Bengal.
- Most of the cyclones originate in the Bay of Bengal and influence the climatic conditions at the time of the south-west monsoon season.
- The western disturbances originate over the Mediterranean Sea and influence the weather conditions in the Western Himalayan region.

Characteristics of rainfall in India

Name of climatic region	States or territories
Tropical Rainforest	Assam and parts of the Sahyadri Mountain Range
Tropical Savannah	Sahyadri Mountain Range and parts of Maharashtra
Tropical and subtropical steppe	Parts of Punjab and Gujarat
Tropical Desert	Most parts of Rajasthan
Moist subtropical with winter	Parts of Punjab, Assam, and Rajasthan
Mountain climate	Parts of Jammu and Kashmir, Himachal Pradesh, and Uttaranchal
Drought	Rajasthan, Gujarat, and Haryana
Tropical semi-arid steppe	Tamil Nadu, Maharashtra, and other parts of South India

Five major climate groups are designated by capital letters as follows:

A–Tropical Rainy Climate:

- Average temperature of every month is above 64.4oF (18oC).
- These climates have no winter season.
- Annual rainfall is large and exceeds annual evaporation.

B–Dry Climate:

- Potential evaporation exceeds precipitation on the average throughout the year.
- No water surplus; hence no permanent streams originate in B Climate Zones.

C–Mild, Humid (Mesothermal) Climates:

- Coldest month has an average temperature under 64.4oF (18oC), but above 26.6oF (-3oC); at least one month has an average temperature above 50oF (10oC).
- The sea climates have both a summer and a winter season.

D– Snowy Forests (Microthermal) Climates:

- Coldest month has an average temperature under 26.6oF.
- Average temperature of warmest month is above 50oF.

E–Polar Climates:

- The average temperature of warmest month is below 50oF.
- The climates have no true summer.

Sub-Groups:

Sub-groups within the five major groups are designated by a second letter, according to the following codes:-

S – Steppe Climate:

- A semi-arid climate with about 15-30 inches (38-76 cm) of rainfall annually at low latitudes.

W – Desert Climate:

- Arid climate.

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- Most regions included have less than 10 inches (25 cm) of rainfall annually. The letters S and W are applied only to the dry B climates, yielding two combinations – BS and BW.

f:- Moist. Adequate precipitation in all months. No dry season. This modifier is applied to A, C and D groups, yielding combinations – Af, Cf and Df.

w:- Dry season in the winter of the respective hemisphere (low sun season). This modifier is applied to A, C and D groups, yielding combinations – Aw, Cw and Dw.

s:- Dry season in the summer of the respective hemisphere (high sun season).

m:- Rainforest climate. Despite short, dry season in monsoon type of precipitation cycle. Applies to only A climates (Am).

Types of Climates

Tropical Rainforest Climate (Af): Rainfall of the driest month is 6 cm or more.

Monsoon variety of Af (Am): Rainfall of the driest month is less than 6 cm. The dry season is strongly developed.

Tropical Savanna Climate (Aw): At least one month has rainfall less than 6 cm. The dry season is strongly developed.

Steppe Climate (BS): A semi-arid climate characterized by grasslands. It occupies an intermediate position between the desert climate “BW” and the more humid climates of A, C and D groups.

Desert Climate (BW): An arid climate with annual precipitation usually less than 40 cm.

Mild Humid Climate with no dry season (Cf): Temperate rainy climate, moist in all seasons. Precipitation of the driest month averages more than 3 cm.

Mild Humid Climate with a dry winter (Cw): Temperate rainy climate with dry winter. The wettest month of summer has at least 10 times the precipitation of the driest month of winter or 70% or more of the mean annual precipitation falls in the warmer six months.

Mild Humid Climate with a dry summer (Cs): Temperate rainy climate with dry summer. Precipitation of the driest month of summer is less than 3 cm. Precipitation of the wettest month of winter is at least 3 times as much as that of the driest month of summer or 70% or more of the mean annual precipitation falls in the six months of winter.

Snowy Forest Climate with a moist winter (Df): Cold snowy forest climate with moist in all seasons.

Snowy Forest Climate with a dry winter (Dw): Cold snowy forest climate with dry winter.

Tundra Climate (ET): Mean temperature of the warmest month is above 0oC, but below 10oC.

Perpetual Frost Climate (EF):Ice-sheet climate. Mean monthly temperatures of all months are below 0oC.

Further Variations

To differentiate more variations in temperature or weather elements, Koppen added a third letter to the code group. Meanings are as follows:

- a: With hot summer; warmest month over 71.6oF. Used for C and D climates.
- b: With warm summer; warmest month below 71.6oF. Used for C and D climates.
- c: With cold, short summer; less than 4 months over 50oF. Used for C and D climates.
- d: With very cold winter; coldest month below –36.4oF. Used for D climates only.
- h: Dry, hot; mean annual temperature over 64.4oF. Used for B climates only.
- k: Dry, cold; mean annual temperature under 64.4oF. Used for B climates only.

A brief description of some of the important classifications of Indian climate has been given in the following:

KOPPEN'S CLASSIFICATION OF INDIAN CLIMATE

- A Koppen's classification is empirical in nature based on climatic data. Koppen, for the delineation of climatic regions took into consideration (i) the mean monthly temperature, (ii) the mean monthly rainfall, and (iii) the mean annual rainfall. Koppen divided the country into three broad climatic zones:

1. Humid (A) 2. Arid (B) 3. Semi-Arid (C and D). These three broad climatic divisions were sub-divided into sub-types on the basis of seasonal variations in the distribution pattern of precipitation and temperature for which the symbols S, W, m, f, w, s, c, and h have been used

Based on Koppen's climatic scheme, India can be divided into the following nine climatic regions:

1. Aw (Tropical Savanna Type) :

- associated with the tropical savanna grassland and monsoon deciduous vegetation.
- May is the hottest month (the mean maximum reading around 40°C and the mean minimum 27°C) and the temperature of the coldest month is always more than 18°C.
- The annual and diurnal ranges of temperature are high.
- Rainfall occurs mainly during the season of South-West Monsoon (July to September).
- Winters are generally dry.
- Such type of climate is found over major parts of Peninsular India including Jharkhand, Chhattisgarh, Orissa, Andhra Pradesh, Maharashtra, and the Purulia district of West Bengal.

2. Amw (Tropical Monsoon Type):

- This climate has a short dry winter season.
- The rainfall is heavy during the season of South-West monsoon, leading to luxurious growth of evergreen rain forests.
- It occupies parts of Konkan, Malabar Coast and the adjoining areas of the Western Ghats, Plateau of Tamil Nadu, and southern areas of Tripura and Mizoram.

3. As (Tropical Moist Climate):

- It is characterized by dry summer season.
- The mean monthly temperature is more than 18°C in all the months.

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- The average annual rainfall varies between 75-100 cm, and about 75 per cent of the total annual rainfall occurs between September and December.
- It occupies a narrow zone along the Coromandal coast.

4. BShw (Semi-Arid Steppe Climate):

- In this climate the mean annual temperature is above 18°C and the rainfall is seasonal (in summer).
- It stretches over the rain-shadow zone of Karnataka and Tamil Nadu, eastern Rajasthan, Gujarat and some parts of south-western Haryana.

5. BWhw (Hot Desert Type):

- The greater part of Rajasthan lying to the west of the Aravalli has the hot desert type of climate. In fact, it covers the Thar desert of India.
- The mean annual rainfall is below 25 cm.
- The mean maximum summer temperature (May–June) often crosses 45°C at Jodhpur and Ganganagar, while the mean minimum temperature in winter seasons may fall to 0°C in the Bikaner, Ganganagar and Jodhpur districts.

6. Cwg (Mesothermal Climate—Gangetic Plain Type):

- This climate is characterised by dry winter.
- The average temperature of the cold months is less than 18°C and the average temperature of the coldest month is over 15°C.
- The maximum temperature is recorded in the month of May or first half of June.

7. Dfc (Cold Humid Winter Type):

- This climate is characterised by short summer and cold humid winter.
- The winter temperatures are about 10°C and the summer temperature is below 18°C.
- Summers are short and humid. It is found in Sikkim and Arunachal Pradesh.

8. E (Polar Type):

- This type of climate is found in the higher mountainous areas of the Jammu and Kashmir, Himachal Pradesh, and Uttarakhand. In this climate, the temperature of the warmest month is less than 10°C.
- These areas remain under ice during the greater part of the year.

9. ET (Tundra Type):

- In this climate the average temperature of the warmest month is between 0° and 10°C.
- It occupies the higher altitudes of Ladakh, Kashmir, Himachal Pradesh and Uttarakhand.

Flood Control Programme and Strategies

- The National Flood Control Programme was launched in India after the devastating flood of 1954.

The programme consists of three phases which have been briefly described in the following section:

1. **The Immediate Phase:** This phase extends over two years and includes the collection of basic hydrological data and execution of immediate flood protection measures like construction of embankments, improvement of river channels and raising the vulnerable villages above the flood level.
2. **The Short-Term Phase:** This phase lasts for the next five years. In this phase there is emphasis on improvement of surface drainage, establishment of effective flood warning system, shifting or raising of villages above flood level, construction of diversion channels,

construction of embankments and raised platforms to be used during the period of floods.

3. **The Long-Term Phase**: The long-term phase includes construction of dams and storage reservoirs, digging large diversion channels, taking suitable steps for land-use improvement, and soil conservation in the catchment area of the main river and its tributaries.

In order to overcome the problem of floods in the country, the Government of India has set up a National Flood Commission (Rastriya Barh Ayog). This Commission has taken a holistic view of the flood problem. Many multi-purpose projects and large dams have been constructed to overcome this problem. Recently, the Brahmaputra River Board has been constituted to control floods in the Brahmaputra Valley.

CHAPTER-5-NATURAL VEGETATION AND NATIONAL PARKS

FLORISTIC REGIONS OF INDIA

1. The Eastern Himalayan Region

- Stretching over the hilly regions of Sikkim, West Bengal and Arunachal Pradesh,
- an undulating and mountainous region, recording over 200 cm of average annual rainfall.
- has over 4000 species of plants which vary from tropical to temperate and Alpine.
- main trees - sal, oak, chestnut, magnolia, pyrus, bamboo, silver fir, pine, birch, rhododendrons, and alpine grasses.

2.The North-Western Himalayan Region

- stretches over Jammu and Kashmir, Himachal Pradesh and Uttarakhand.
- records relatively less rainfall and temperatures.
- The effect of altitude is quite visible on the vegetation of Western Himalayas.
- one finds the sub-tropical (up to 1525 m), temperate (1525m to 3650 m) and Alpine vegetation from 3650 m to 4575 metres.
- In- the sub-montane region the main vegetation is sal, semul, and savanna type.
- Among the temperate vegetation are chir (pine), oak, deodar, alder, birch, and conifers.
- At higher altitudes, trees are replaced by alpine pastures and trees like juniper, silver fir, birch, and larch are seen.

3. The Assam Region

- The Assam region includes the whole of North-east including Assam, Meghalaya, Nagaland, Manipur, Mizoram and Tripura.
- rich in various types of bamboos and palms with Nilgiri type of grasslands at higher altitudes.

4. The Gangetic Plain

- The flora of the Gangetic plain has been substantially transformed by human activities and cultivation of crops.
- ranges between the semi-arid shrubs of the Aravalli region to evergreen mangroves of the Sundarban Delta.
- Sal and Arjun of the Tarai region of Bihar and West Bengal are the representative species of the primordial vegetation.
- The vegetation of Uttar Pradesh is mainly dry deciduous type which changes to moist deciduous type, in Bihar and West Bengal.
- Sheesham, neem, mahuwa, jamun, acacia, ber, bel, etc. are the examples of this type of vegetation.
- there are numerous types of grasses found in the Gangetic Plain.

5. The Indus Plain

- spreads over Punjab, Haryana, Rajasthan, west of the Aravallis, Kuchchh, and north-western parts of Gujarat.
- the average annual rainfall is less than 75 cm .

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- vegetation is of the type which can bear the arid and severe drought conditions. Acacias, cacti, wild-palms, khejra, and palas, etc. are the main trees of this region.
- During the rainy season, numerous grasses develop which wither during the dry season.

6. The Deccan Region

- covers the greater parts of Peninsular India. This region has teak, tendu, sal, palm, and thorny shrubs.

8. Andaman and Nicobar

- covered by the equatorial evergreen forests of heavy wood.

Forests of India

The Indian forests were also classified by H.G. Champion (1936) into eleven categories.

1. Tropical Evergreen:

- mainly found in the areas recording over 150 cm of average annual rainfall where the temperature varies between 25°C to 27°C.
- North-East India, parts of Western Ghats, the Andaman and Nicobar, upper Assam, lower slopes of Eastern Himalayas, Orissa, along the foot-hills of Himalayas, Bhabhar and Tarai regions
- In the areas where the average annual rainfall is more than 250 cm, the forests are dense; composed of tall trees (45 m) epiphytes, parasites, lianas and rattans so as to look like a green carpet when viewed from above.
- multi-storeyed structures with good canopies.
- trees do not shed their leaves annually and are hence evergreen.
- The floor lacks grasses because of deep shade.
- canes, palms, bamboos, ferns, and climbers.
- important species - white cedar, toon, dhup, palaquinum, mesua, collophyllum, hopea, and canes, gurjan, chaplas, agor, muli, and bamboo.
- Due to poor accessibility these forests have not been properly exploited.
- rainfall varies between 200 to 250 cm and the mean monthly temperature varies between 24°C to 27°C, the evergreen forests degenerate into semi-evergreen forests.
- found along the Western Ghats, upper Assam, slopes of the Himalayas, and Orissa.
- The important varieties include aini, semul, gutel, mundane, hopea, kadam, irul, rosewood, laurel, haldu, kanju, holloch, champa, and mesua.

2. The Tropical Moist Deciduous:

- typical monsoon forests with teak (*Tectona grandis*) and sal (*Shorea robusta*) as the dominant species.
- form the natural vegetation all over the country where the average annual rainfall ranges between 100-200 cm.
- found in Sahyadris, the north-eastern parts of the pen-insula and along the foothills of the Himalayas, have gregarious species.
- The typical landscape consists of tall teak trees with sal, bamboos, and shrubs growing fairly close together to form thickets.

- Both teak and sal are economically important and so are the Sandalwood (*Santalum album*) Shisham (*Dalbergia sissoo*), Hurra (*Terminalia chebula*), and Khair (*Acacia catechu*).

3. The Tropical Thorny Forests:

- degraded version of the moist deciduous forest.
- found in the average annual rainfall varies between 75 and 100 cm and the average annual temperature between 16°C and 22.5°C.
- found in peninsular India, Rajasthan, Haryana, Punjab, western Uttar Pradesh, Kachchh, Madhya Pradesh and the foothills of the Himalayas (Fig. 5.3).
- The important trees -acacia, wild-palms, euphorbias, jhad, tamarix, khair, kokko, dhaman, erunjha, cacti, kanju, and palas.

4. The Subtropical Montane Forests:

- found in areas where the average annual rainfall varies between 100 to 200 cm and the temperature varies between 15° and 22°C.
- found in the north-western Himalayas (except in Ladakh and Kashmir), Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh and on the slopes of north-eastern hill states
- Chir (pine) is the main tree but broad leaved trees are also found in these areas.
- Oak, jamun, and rhododendron are the other varieties in these forests.

5. The Dry Deciduous Forests:

- found in areas where the average annual rainfall ranges between 100-150 cm.
- characterised by closed rather uneven canopies.
- Enough light reaches the ground to permit the growth of grasses and climbers.
- Acacia, jamun, modesta, and pistacia are the main trees. Grasses and shrubs appear during the season of general rains.

6. The Himalayan Moist Forests:

- found in Jammu and Kashmir, Himachal Pradesh, Uttarakhand, and northern hilly parts of North Bengal.
- The wet temperate type is found in a belt where the altitude varies between 1000 and 2000 metres.
- occur largely as bands of crested dark green landscape of coniferous varieties.
- important varieties are oak, chestnut, chir, sal, shrubs, and nutritious grasses.

7. The Himalayan Dry Temperate Forests:

- found in Jammu and Kashmir, Lahul, Chamba, Kinnaur (Himachal Pradesh), and Sikkim.
- These are predominantly coniferous forests with shrubs.
- The important trees -deodar, oak, chilgoza, ash, maple, olive, mulberry, willow, celtis, and parrotia.

8. Montane Wet Temperate Forests:

- found in the entire Himalayas from Jammu and Kashmir to Arunachal Pradesh between the altitudes of 1500 m to 3300 m where the temperature varies between 12°C to 15°C, and the mean annual rainfall is between 100 to 250 cm.

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- Oak, fir, spruce Picea, deodar, (Cedrus deodara), magnolia (Magnolia glandifera) celtis, chestnut, cedar (Chamaecyparis) and maple, spruce, deodar, silver-fir (Abies alba), kail, and yew are found here.
- contain scrubs, creepers, and ferns. The woods of these forests are durable.

9. Alpine and Sub-alpine Forests:

- found all along the Himalayas at altitudes ranging between 2500 to 3500 metres.
- characterised with short dwarf conifers and lush green nutritious grasses during the summer season.
- found in the zone are kail, spruce, yew, firs, birch, honeysuckle, artemesia, potentilla, and small scrubs.

10. Desert Vegetation:

- confined to the west of Aravallis in the states of Rajasthan and northern Gujarat .
- The average annual rainfall in this zone is less than 50 cm, the diurnal and annual range of temperature are high. Acacia, cacti, jhar and khejra, kanju, and wild palms are the main trees of the desert.

11. Tidal (Mangrove):

- These forests are found along the coastal areas of the Bay of Bengal in the states of West Bengal, Orissa, Andhra Pradesh, and Tamil Nadu, and along the coastal areas of Kachchh, Kathiwar, and Gulf of Khambat.
- found in areas where tides are frequent.
- The mangrove which attains a height up to 30 metres is the most important tree.
- utilised for fuel.
- The famous delta of Sundarban is covered by the Sundri (Heritiera minor) trees which supply hard durable timber for construction and boat making.
- Here, higher grounds support screw-pines (Pennanus spp.). Palms occupy creeks, and epiphytes are predominant all over the region.

Percentage Share of Different Types of Forests (2001)

1. Tropical Moist Deciduous -37.0%
2. Tropical Dry Deciduous -28.8%
3. Tropical Evergreen -12.1%
4. Subtropical -9.5%
5. Montane Wet Temperate- 7.0%
6. Alpine and Sub-alpine -2.9%
7. Tropical Thorny -2.6%
8. Mangrove -0.06%

IMPORTANT SPECIES OF TREES AND THEIR UTILITY (INDIA)

On the basis of type of species and utility, the trees of India may be classified under the following categories:

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1. Woods from Evergreen Forests.
2. Woods from Monsoon Forests.
3. Woods from Subtropical (Himalayan Forests).

1. Woods from the Evergreen Forests

(i) Rosewood

- It grows well along the slopes of the Western Ghats (Tamil Nadu, Karnataka, and Kerala) and in some parts of Andhra Pradesh, Orissa, Jharkhand, and Chhattisgarh.
- The wood from these forests is hard and fine-grained, dark purple in colour, widely used in the manufacture of furniture, floor boards, and ornamental playboards.

(ii) Gurjan

- It occurs in the evergreen forests of Assam, West Bengal, and Andaman and Nicobar Islands.
- The wood is dull reddish to brown in colour.
- It is extensively used for internal construction work of houses.
- It is also used for packing cases, tea boxes, flooring, and wagons.

(iii) Telsur or Irupu

- found in West Bengal, Kerala, Karnataka, Maharashtra, and Andaman and Nicobar Islands.
- wood is very hard, strong and durable which are largely used for the manufacturing of boats, bridges, piles, masts, carts, and railway sleepers.

(iv) Toon

- obtained from the foothills of the Himalayas.
- wood is not very hard, it is durable.
- used for making tea boxes, toys and furniture.

(v) Ebony (Diospyros Ebenum)

- found in the dry evergreen forests of Karnataka, Kerala, Tamil Nadu, Malabar Coast, Goa, and Maharashtra.
- wood is lightly yellowish-grey and often streaked with black.
- The heartwood (inner core) is jet black, rarely with brown golden streaks. It has a metallic lustre when smoothed.
- most valuable woods as it is resistant to attack by insects.
- used for ornamental carving and decoration.
- used for veneers, musical instruments, sports goods, piano keys, and caskets.

(vi) Chaplas

- occur in north-east India and the Western Ghats.
- timber is strong and durable and hence, is in great demand for ship-building, furniture-making, and packing boxes.

(vii) Nahar

- found in Assam and the Malabar coast.
- wood is fairly strong and durable. Its wood is used for railway sleepers, piles, and boats.

(viii) Poon

- found in the Western Ghats, Kerala, Nilgiri, and Tamil Nadu.
- wood is very hard, can be easily seasoned and is mainly used as structural timber for house making.

FOREST PRODUCTS AND THEIR UTILITY

1. Bamboo

- found in most of the monsoon regions where the average annual rainfall is more than 150 cm.
- Some of the bamboos may attain a height of 30 m.
- used for a variety of purposes—basket making, roofing, and thatching, construction, paper, and pulp making.
- In India more than 100 varieties of bamboos are found.
- According to the Planning Commission bamboo occupies 100,210 sq km of the forest area of the country with an annual production of four million tonnes.
- Different types of decorative items such as flower pots, trays, vases, caskets, and even ornaments are made of bamboo in states like Mizoram, Nagaland, Meghalaya, Manipur, and Tripura.
- Bamboo also finds a place in cultural activities of the Mizo people, i.e. Cherraw (bamboo) dance.

2. Canes

- Canes grow in moist and wet forests in Assam, Kerala, Karnataka, West Bengal, Gujarat, Uttarakhand, Himachal Pradesh and Jammu and Kashmir states.
- used mainly for making strings, ropes, mats, bags, and baskets.

3. Tendu

- The leaves of tendu are obtained from the forests of Chhattisgarh, Jharkhand, Orissa, Madhya Pradesh, south-east Rajasthan, and Andhra Pradesh.
- Tendu leaves are used for bidi-making.

4. Grasses

- important grasses -Sabai (sub-Himalayan Tarai tracts), elephant-grass (Assam), spear-grass, ulla, and panni grasses, etc. Khus-Khus grass (Bharatpur, and Sawai-Madhopur, Rajasthan) is used for making cooling screens during summer season.
- Rosha, lemon, and ginger-grasses yield medicinal and perfumed oils.

5. Oils

- The raw materials for a number of perfumes and oils are also obtained from the herbs, plants, and trees.
- Like camphor, clove, ylang, cinnamon-oil, cypress-oil, eucalyptus-oil, jasmine-oil, khus-oil, lavender-oil, lemon-grass-oil, mint-oil, sandalwood-oil, patchouli-oil, turpentine oil, nutmeg-oil, and champaca-oil.

6. Medicinal Herbs and Plants

- The leaves, stems, flowers, fruits, barks, roots, and seeds of different plants and scrubs are used as raw materials for the manufacture of a number of medicines.

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- important herbs for medicines are aconite, celery, belladone, colocynth, sarasaparilla, jalap, leadwort, chitraka, serpentine, and liquorice.
- The root of serpentine is an antidote for snake and insect bite.
- Barks of mountain ebony, Indian oak, quinine, Spanish-cherry, bay-berry, lodh-tree, Indian-red-wood, ashoka, arjuna, and Indian barberry have medicinal value.
- The stem of ephedrine, white sandal-wood, catechu, and long needle-pine are also of great medicinal importance.
- Leaves of vasaka, Indian aloe, poison-bulb, fever-nut, life-plant, swallow wart, Indian-penny-word, Tasmanian blue-gum, physic-nut, holy-basil, betel, pepper, and typhlophora yield different drugs.
- Similarly, flowers of saffron, iron-wood, violet and fruits of bel, fish-berry, purging-cassia, coriander, cumin, fennel, emblic, opium, long-pepper, black and white pepper, belleric, myrobalan, ammi and solanum are used in medicine making.

7. Shellac

- secreted by an insect called Kerria lacca which feed on the saps of host trees like palas, peepal, kusum, sissoo, kul, gular, siras, and banyan.
- extensively found in the Gangetic plains, Madhya Pradesh, Chhattisgarh, Jharkhand, Maharashtra and Assam.
- India has a monopoly in lac production in the world.
- used for dyeing silk, making bangles, paints, munitions, fire-works, gramophone records, sealing wax, electrical insulation material, shoe-dressing, plastic-moulding, spirit, baking enamels, and anti-moulding compository for ships.

8. Resins

- exudation of plants belonging to phanerogamic families.
- a yellowish solid, insoluble in water, but soluble in alcohol.
- In the conifer pine forests of the Himalayan region, resin is collected on commercial scale.
- used for soap, and sizing paper and cloth.
- used in the manufacture of sealing wax, linoleum, lubricating compounds, paints, and several kinds of inks.

9. Gums

- obtained from acacia, carob, mesquite, cateera-gum.
- used as adhesives in printing and finishing textiles, in the paint and candy industries, and drugs.

10. Tannins and Dyes

- used for coagulating the protein in hides and skins, so that resistant leather can be produced.
- Lighter vegetable tannins dominate in the production of leather.
- obtained from the bark of mangrove, sundri trees, wattle, avaram, sumac, arjun, Indian almond, jujube, Cuddapah-almond, hog-plum, chestnut, and leaves of smoke trees.
The dyes are coloured compounds.
- On being fixed to fabrics, they do not wash out with soap and water or fade on exposure to light.

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- About 150 dye yielding plants are available in Indian forests, but only a few have been utilised so far.

11. Katha

- extracted from the inner wood of khair tree which is largely grown in Uttarakhand, Uttar Pradesh, Himachal Pradesh, Madhya Pradesh, Chhattisgarh, Jharkhand, Gujarat, and Bihar.
- Its important factories are at Bareilly (U.P.) and Shivpuri (M.P.).

12. Fruits and Vegetables

- obtained from the forests are jamun, bel, ber, gular, jack-fruit, amla, tamarind, khirni, karonda, khajur, and chilgoza.
- Chinch, munga, chkoora, arvi, ratalu, kanhi, akana, kirchi, janningi, sua, saijan, saidu, mushrooms, and guchchhi are obtained as vegetables.

13. Valuable Things

- from forests, the collection of ivory, honey, bees wax, hides, horns, and furs is also done from the forests.

Woods of the Monsoon Forests Of India

(i) Sal (Shorea Robusta)

- occurs in the sub-Himalayan region from Kangra (Himachal Pradesh) to Darrang (Assam), Meghalaya and the northern parts of Tamil Nadu.
- wood is very heavy, hard and durable.
- much in demand for piles, doors, beams, planking and railway sleepers.
- Sal forests occupy 11.6 lakh hectares, accounting for about 16 per cent of the total forest area of the country.

(ii) Teak (Tectona Grandis)

- the most popular tree of the monsoon climate found mainly in Chhattisgarh, Jharkhand, Madhya Pradesh, Orissa, the foothills of Himalayas, Tamil Nadu, Karnataka, Kerala, and the western and eastern Ghats, and Banswara (Rajasthan).
- wood is moderately hard, durable, easy to work and takes a good polish.
- an expensive timber used for doors, cupboards, and furniture.
- cover about 9 million hectares of the total forest area of the country.

(iii) Shisham (Dalbergia Sissoo)

- occurs throughout the Himalayas from Jammu to Assam up to an altitude of 1500 m.
- grows extensively in Punjab, Haryana, Uttarakhand, Uttar Pradesh, Bihar, and West Bengal.
- It is great strength, elasticity and durability, its wood is mainly used in furniture making, musical instruments, and agricultural equipments.

(iv) Haldu

- found all over the monsoon area.
- wood is hard, durable, and light in colour.
- used for toy making and wood carving.

(v) Palas

GEOGRAPHY OF INDIA-MAJID HUSAIN

- occurs mainly in Chotanagpur Plateau, Chhattisgarh, and south-eastern parts of Rajasthan.
- leaves are used for rearing shellac worms.

(vi) Arjun

- an important tree of monsoon forests which is used for the making of agricultural equip-ments and bullock carts.

(vii) Mahua (Madhuca Indica)

- largely found in Madhya Pradesh, Chhattisgarh Bundelkhand (U.P), Jharkhand, Bihar, Gujarat, Maharashtra, Uttarakhand, and south-eastern parts of Rajasthan.
- fruits are used for the extraction of oil and flowers for wine making.

(viii) Semul

- widely found in Assam, Bihar, and Tamil Nadu.
- Its timber is soft and white and is used for toy making, packing cases, match boxes, and plywood.
- fruits yield soft fibre for pillows and lihafs.

(ix) Mulberry

- grows widely in monsoon areas.
- wood is soft and durable, used mainly for the manufacture of sports goods (hockey, cricket bats, tennis rackets, badminton and squash rackets, and cricket stumps).

(x) Jamun (Syzygium cumini)

- a large tree of monsoon region.
- timber is moderately strong and used for the construction of houses and furniture.
- fruits are highly beneficial in controlling diabetes and high blood pressure.

Woods from the High Altitudinal Forests of the Himalayas

(i) Chir (Pinus Longifolia)

- occurs in the Himalayas between 900 m and 1800 m, from Jammu to Arunachal Pradesh.
- wood is light and reddish brown in colour and is moderately hard.
- used for furniture, for making tea-boxes, match industry, and railway sleepers.
- yields resins, gums, and turpentine oils.

(ii) Deodar (Cedrus Deodara)

- grows in the north-western Himalayas in the states of Jammu and Kashmir, Himachal Pradesh, and Uttarakhand, between the heights of 1500 m and 2500 m.
- wood is of light brown to yellow colour.
- wood is very sturdy and durable. It is also an easy timber to saw and work to smooth finish.
- used for construction-work, and for railway sleepers.
- also suitable for beams, floor-boards, ports, doors, window frames, light furniture, and shingles.

(iii) Blue-Pine (Pinus Excelsa)

- grows along the entire length of the Himalayas from Chumbi Valley to Sikkim between the elevation of 1800 m and 3600 m.
- The wood is pink in colour, moderately hard and of good quality.

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- used for making doors, windows, furniture, and railway sleepers. It also yields resins and turpentine.

(iv) Silver-fir (Abies)

- found in the north-western and north-eastern Himalayas between 2200 m and 3000 m.
- The wood is soft but not very durable.
- used for planking, packing boxes, containers, wood-pulp, paper, and match sticks.

(v) Spruce (Picea Mithiana)

- found in the western Himalayas between 2100 m and 3600 m.
- Its soft white wood is used for construction of houses, railway sleepers, cabinets, packing, and pulp making.

(vi) Walnut (Juglans Regia)

- found in Kashmir, Himachal Pradesh, Uttarakhand, and Khasi hills.
- relatively light wood on which work can be done easily and the finish is fine and attractive.
- Once dried it does not shrink, swell or split.
- wood is used for musical instruments, gun-butts, and cabinet works.

(vii) White Willow (Salix Alba)

- a small tree found in north-western Himalayas including the Kashmir Valley.
- Its twigs are used for making baskets.
- The wood is used for making cricket bats and other sports goods.

(viii) Indian Birch

- obtained from the higher slopes of the Himalayas.
- wood is grayish in colour, even textured and straight grained.
- largely used for the making of furniture, plywood, and radio cabinets.

(ix) Cypress

- occurs in Uttarakhand, Himachal Pradesh and Jammu & Kashmir.
- wood is durable and used for making furniture.

Natural Vegetation – Introduction

Types of Natural Vegetation

The following are the principal types of natural vegetation in India: (1) Tropical Evergreen Rain Forests, (2) Deciduous or Monsoon Type of Forests, (3) Dry Deciduous Forests and Scrubs, (4) Semi Desert and Desert Vegetation, (5) Tidal or Mangrove Forests and (6) Mountain Forests.

1. Tropical Evergreen Rain Forests:

- grow in areas where rainfall is more than 200 cm.
- found on the slopes of the Western Ghats and the north-eastern regions of Arunachal Pradesh, Meghalaya, Assam, Nagaland, the Tarai areas of the Himalayas and the Andaman groups of Islands.
- The trees in these forests never shed their leaves all at a time in any part of the year.
- Under humid tropical condition, sub-soil water never dries up completely.

- The trees in these belts have dense growth.
- Important varieties of trees are sishu, chaplash, rosewood, mehogony, bamboos, garjan and sandal wood.

2. Deciduous or Monsoon type of Forests:

- found in areas where the rainfall is between 100 cm and 200 cm.
- grow on the lower slope of the Himalayas, Assam, West Bengal, Bihar, Jharkhand, Orissa, Madhya Pradesh, Chhattishgarh, Maharashtra, Karnataka and the adjoining regions.
- The trees of these forests shed their leaves during dry winter and dry summer.
- The main trees are teak, sal, sandal wood, deodar, bluegum, ebony, sisam, jackfruit, mahua, palash, arjun, khair and bamboo. Teak and sal are valuable trees.
- supply valuable timber.

3. Dry Deciduous Forests and Scrubs:

- grow in areas where the rainfall is between 50 cm and 100 cm.
- found in areas of central Deccan plateau, south-east of Rajasthan, Punjab, Haryana and parts of Uttar Pradesh and Madhya Pradesh. Dwarf deciduous trees and long-grasses grow in these regions.
- used for agriculture.

4. Semi-deserts and Deserts vegetations:

- grow in areas where rainfall is less than 50 cm mostly thorny bushes, acacia, babul and sand binding grasses are found in this vegetation zone.
- The Indian wild date, known as “Khejur” is common in these deserts.
- grow far apart from each other.
- have long roots and thick fleshy stems in which they store water to survive during the long drought.
- found in Rajasthan and parts of Gujarat, Punjab and Karnataka.

5. Tidal or Mangrove Forests:

- grow along the coast and on the edges of the deltas, e.g. the deltas of the Ganga, Mahanadi, Godavari, Krishna and Kaveri.
- They are called ‘Tidal Forests’; because their dense growth depends upon tidal water which submerges the deltaic lands during high tides.
- They are also known as Littoral Forests.
- In West Bengal these forests are known as ‘Sundarbans.’
- The ‘sundri’ is most significant tree in these forests.
- The other notable trees of these forests are hogla, garan, gewa, golpata, pasur etc.
- These forests supply timber and fire wood.
- Palm and coconut trees adorn the coastal strip.

6. Mountain Forests:

- Mountain forests vary considerably according to altitude with varying rainfall and temperature along the slopes of mountain :
1. On the foothills of the Himalayas up to a height of 1500 meters, evergreen trees, such as, sal, teak bamboo and cane grow abundantly.

2. On higher slope between 1,500 meters to 3,500 meters, temperate conifer trees, such as, pine, fir, oak, maple, deodar, laurel, spruce and cedar grow.
 - At the higher altitude of the Himalayas, rhododendrons and junipers are found. Beyond these vegetation belts, alpine grasslands appear up to snowfield.

THE NATIONAL FOREST POLICY OF INDIA

The National Forest Policy 1952 classified the forests of the country into four categories:

- (i) Protected forests essential for physical and climatic needs.
- (ii) National forests to be utilised for the economic needs of the country.
- (iii) Village forests to meet the fuel and domestic needs of villages and neighbouring towns.
- (iv) Tree lands. The policy envisaged the annual organisation of Van-Mahotsava and tree plan-tation week in the month of July/August.

The National Forest Policy 1952 lays emphasis on :

- (i) Weaning the tribal people by persuasion to desist from shifting cultivation.
- (ii) Implementation of forest laws more effectively.
- (iii) To provide adequate facilities for the management of forest resources.
- (iv) To control grazing of cattle, sheep and goats in forest areas.
- (v) Providing fuel-wood to rural areas.
- (vi) To improve the availability of timber wood for industrial purposes.
- (vii) To increase the area under social forestry.
- (viii) To promote research in forestry.

The National Forest Policy 1988

The main emphasis of the National Forest Policy 1988 is on the protection, conservation, regeneration and development of forests. The main points of the National Forest Policy 1988 are:

- (a) Maintenance of environmental stability through the preservation and restoration of ecological balance.
- (b) Conservation of forests as a national heritage with vast varieties of flora and fauna.
- (c) Control of soil erosion and denudation in catchment areas of rivers, lakes and reservoirs.
- (d) Check on the extension of sand-dunes in desert areas of Rajasthan and along sea-coasts.
- (e) Substantial increase in forest cover through massive afforestation and social forestry programmes.
- (f) To meet the needs of fuel-wood, fodder and minor forest products for the rural and tribal people.
- (g) Augment the productivity of the forests to meet national needs.
- (h) Encouragement of efficient utilisation of forest produce and optimum substitution of wood.
- (i) Steps to create massive movement of people with the involvement of women folk to achieve these objectives and to minimise pressure on existing forests.
- (j) Involvement of people in forest management under joint forest management.

SOCIAL FORESTRY

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- refers to the forests (trees) planted by the people of a society.
- defined as 'the forestry of the people, for the people by the people'
- The significance of social forestry has been emphasised in the National Forest Policy 1952 and 1988.
- The main objective is to reduce pressure on traditional forests by plantation of fuel-wood, fodder, timber, and grasses.
- The two types of social forestry include:
- Agro-forestry which includes community forestry and agro-forestry (commercial and non-commercial farm forestry).

Community Forestry

- a part of social forestry.
- It involves the raising of trees on community lands with the set objective to provide benefits to the community as a whole.
- Although the plants and seedlings are provided by the forest departments, the protection of planted trees is primarily the responsibility of the community as a whole.
- India has performed superbly in community forestry and stands only next to China in this respect.
- The states in which community forestry is a big success are Gujarat, Haryana, Himachal Pradesh, Karnataka, Kerala, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttarakhand, and Uttar Pradesh.

Agro-Forestry

- a type of social forestry in which individual farmer undertakes tree-farming and grows fodder plants, grasses and legumes on his own land.
 - trees (forest) are considered as a crop and they (trees) become a part of crop combinations.
 - In fact, in the Northern Plains of India, trees are planted by most of the farmers irrespective of the size of their holdings, but the large farmers and absentee landlords put part of their holdings or total agriculture area under tree crops.
 - a farmer uses his degraded or useful land to plant trees for domestic use or commercial use.
 - Such land may be his own or obtained on lease under social forestry programme.
- Agro-forestry involves both the big and the small farmers.
- It fetches additional income to farm-ers, improves their income and thereby, their standard of living, and provide them employment during lean agricultural seasons.
 - These trees are normally harvested after 6 to 10 years from the date of plantation, depending on the needs and requirements of the farmer.
 - The main advantages of agro-forestry are:
 - (i) The absentee landlords go for agro-forestry to retain title of the land and to increase their income.
 - (ii) To manage the agricultural land even without the availability of family labour.
 - (iii) To ensure better land use.
 - (iv) To generate employment.

- (v) To conserve soil moisture.
- (vi) To meet the needs of fuel-wood, fodder and timber.
- (vii) To protect the arable land from winds and water erosion.
- In brief, it is a system of agricultural land utilisation which not only provides fuel-wood, fodder, and grasses, but helps in the promotion of forests and their conservation.
- The Indian Council of Agricultural Research and the Forestry Department jointly undertake agro-forestry research in order to develop suitable systems of land management which involves integration of silviculture, with horticulture, agriculture and animal husbandry.
- Agro-forestry thus integrates agri-silviculture, silvi-pastoral system, and medicinal plants culture. Under agro-forestry, a farmer generally uses his degraded or useful land to plant trees for his domestic use or for commercial use.
Agro-forestry has become very popular in Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Kerala, Punjab, Rajasthan, Uttarakhand, and Uttar Pradesh.
- The main species of trees planted by farmers in their fields are eucalyptus, poplar and casuarinas.
- The wood of these forests is used mainly for fuel-wood, plywood, paper and pulp manufacturing, and match industries.
- Agro-forestry has benefited the big farmers more than the marginal and small farmers.
- Many of the absentee land-lords plant commercial trees in their agricultural land-holdings to save their land from dispossession.
- Thus, the agricultural labourers are thrown out of employment.
- The diversion of good agricultural land from cereal and commercial crops may create the problem of scarcity of food stuffs and industrial raw material.
- The programme, therefore, needs a new strategy and reorientation to achieve its real objectives.

FOREST CONSERVATION

The conservation of forest resources is imperative for our survival. Some of the steps which can go a long way in making forests healthy and sustainable are as under:

- (i) Afforestation:
- (ii) Plantation of trees along the roads, railway lines, rivers, and canal banks, and along lakes and ponds.
- (iii) Development of Green-belts in the urban areas and plantation of trees on community lands.
- (iv) Plantation of community forests on Gram-Sabha lands.
- (v) Villagers should be given loans at easy interest rates to revive degraded forest.
- (vi) Encroachment of agriculture in forests should be made punishable.
- (vii) like grazing, collection of fuel-wood and fodder from forests by the local people should not be allowed to exceed the carrying capacity of the forests.
- (viii) Rural population should be provided alternate sources of fuel-wood and wood-based products.
- (ix) The development projects including mining and industrial activities should be so planned to cause minimum damage to forest ecosystems.
- (x) Mining contracts should have an obligatory clause of reforestation when the process of mining is

over.

- (xi) Industries should adopt anti-pollution devices and must develop and compensate the forest loss by new plantation.
- (xii) Tribal and local people should be directly involved in the protection, regeneration, and management of forests.
- (xiii) Shifting cultivation should be gradually replaced by terraced farming and orchards development and silviculture.
- (xiv) Scientific methods should be adopted to check and contain forest fires. There should be strict control in issuing license for the establishment of industries in forest areas.
- (xv) There should be more research on forestry in agricultural universities, for which facilities and funds should be provided by the Central and State governments. Forestry should be made an important part of the course structures in schools, colleges and universities.
- (xvi) There should be arrangements to protect the forests from pests and diseases for which trimming and spraying of the trees should be a regular practice.
- (xvii) There should be perfect co-ordination between the forest department and other departments of the government for effective and judicious utilisation of forests and their conservation.
- (xviii) People should be encouraged to participate in the Van-Mahotsav and should be made aware about the Chipko Movement.
- (xix) There is a need to change our outlook towards forests. A forest should not be treated as a perennial resource and a source of revenue only. The planning and conservation of forests is not only the duty of the government, but also all the citizens of the country.
- (xx) There should be special audio-visual programmes, demonstrations, seminars and workshops to develop awareness among the people about the social relevance of forests.

The Indian Council of Forestry Research and Education (ICFRE) was created in 1987 under the Ministry of Environment and Forests. The following forestry research institutes are working under the Indian Council of Forestry Research and education:

- (i) Forest Research Institute, Dehra Dun.
- (ii) The Central Arid Zone Research Institute, Jodhpur.
- (iii) The Institute of Rain and Moist Deciduous Forests, Jorhat.
- (iv) The Institute of Wood Science and Technology, Bangalore.
- (v) The Tropical Forestry Research Institute, Jabalpur.
- (vi) The Institute of Forest Genetics and Tree Breeding, Coimbatore.
- (vii) The Temperate Forest Research Centre, Shimla.
- (viii) The Centre for Forest Productivity, Ranchi.
- (ix) The Centre for Social Forestry and Environment, Allahabad

WILDLIFE OF INDIA

- According to S.H. Prater (1934), India can be divided into six zoo-geographic regions. They are:
 - (i) The Himalayan region (ii) The Northern Plains, (iii) The Thar Desert, (iv) The Peninsular Plateau, (v) The Malabar Coast, and (vi) The Nilgiri.

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- In order to conserve wildlife, the Government of India passed the Wildlife Protection Act in 1972. Large tracts in various parts of the country covering 1.56 lakh sq km-4.75% of the total area of the country—were declared as national parks, sanctuaries and biosphere reserves.
- At present, the number of national parks and sanctuaries has gone up to 89 and 490 respectively.
- To increase the number of animals classified under endangered species, Project Tiger (1973), Crocodile Breeding Project (1975), Rhinoceros Project (1987), Snow-leopard Project, and Project Elephant (1988) have been launched.

Biosphere Reserves

- On the criteria of UNESCO 15 biosphere reserves have been identified in different parts of India
The main objectives of the biosphere reserves are:
 1. to conserve diversity and integrity of plants, animals, birds and micro-organisms,
 2. to promote research on ecological conservation and other environmental aspects, and
 3. to provide facilities for education, awareness and training.

These biosphere reserves include:

1. Nilgiri (Tamil Nadu, Karnataka and Kerala), 2. Namdhapa (Arunachal Pradesh), 3. Nandadevi (Uttarakhand), 4. North Island of Andaman, 5. Gulf of Mannar (Tamil Nadu), 6. Kaziranga (Assam), 7. Sundarban (West Bengal), 8. Thar (Rajasthan), 9. Manas (Assam), 10. Kanha (Madhya Pradesh), 11. Norkek (Meghalaya), 12. Keoladeo Biosphere Reserve (Bharatpur, Rajasthan), 13. Kachchh, 14. Panchmarhi, and 15. Simlipal.

Strategy for the Conservation of Wildlife

The following steps can go a long way in the conservation of wildlife:

- (i) Hunting should be strictly prohibited in the national parks, sanctuaries, tiger reserves and biosphere reserves.
- (ii) Poachers and herdsmen should not be allowed to enter the reserved parks and sanctuaries.
- (iii) More national parks and wildlife sanctuaries should be established.
- (iv) The existing national parks and sanctuaries should be further developed by providing more infrastructural facilities.
- (v) Captive breeding of wildlife should be encouraged.
- (vi) Adequate medical facilities should be provided in the national parks and sanctuaries for the treatment of wildlife.
- (vii) Conducive habitat and environment should be created for living and breeding in the national parks and sanctuaries.
- (viii) Seminars, conferences, workshops and exhibitions should be organised in national parks and sanctuaries to improve general awareness among caretakers about wildlife.
- (ix) All the degraded forest land should be taken up for afforestation.
- (x) The marginal lands that are not suitable for crop production should be brought under social forestry to increase the ecosystems and habitats for wildlife.

CHAPTER-6-SOILS

Soils of India

INTRODUCTION

- The loose material or the upper layer of the mantle rock (regolith—a layer of loose, heterogeneous material covering solid rock) consisting mainly of very small particles and humus which can support the growth of plants is known as soil.
- consists of mineral/rock particles, a certain proportion of decayed organic matter, soil water, soil air, and living organisms.
- influenced by (i) parent material, (ii) relief, (iii) climate, (iv) physical, chemical and biological agents (micro-organisms) in it, (v) land use practices, and (vi) time.
- made up of four elements: (a) inorganic or mineral fraction (derived from the parent material), (b) organic matter (decayed and decomposed plants and animals), (c) air, and (d) water.
- formed under specific natural conditions and each of the elements of the natural environment contributes to this complex process described by soil scientists as the process of pedogenesis or soil formation.
- influenced by the nature of parent rock, surface features of relief, climatic conditions, natural vegetation, land use practices, organisms, insects, micro-organisms (bacteria), and time.
- These factors do not act on soil independently or in isolation, but in close association with each other leading to a whole network of inter-relationships of quite a complex nature.
- The material for soil formation, termed by soil scientists as the parent material, is derived from the rocks exposed on the surface.
- The relief and characteristics of slope along with the work of the various agents of weathering, determine conditions for the disintegration of the rock materials.
- Soils may be transported by running water, wind or other agents of erosion, or may remain in the original position.
- When soil remains in its original position, it is said to be in situ, and in that state it is further modified by the climate, particularly moisture supply, plant growth and bacterial activity dependent on these factors.
- Its nature and fertility determines the agricultural productivity on which depends the carrying capacity of the soil and the level of development of the rural communities.

CLASSIFICATION OF SOILS OF INDIA

- A number of attempts have been made to classify the soils of India during the last century.
- The first scientific classification of Indian soils was made by Voeleker (1893) and Leather (1898).
- According to them the Indian soils may be classified into four categories, namely (i) alluvial, regur (black-earth), (iii) red soil, and (iv) lateritic soil.
- More recently, the Indian Council of Agricultural Research, on the basis of texture, structure, colour, pH value, and porosity has identified the following types of soil groups.
 1. Alluvial soils
 2. Red soils
 3. Regur (Black-earth) soils
 4. Desert soils
 5. Laterite soils

6. Mountain soils
7. Red and Black soils
8. Grey and Brown soils
9. Submontane soils
10. Snowfields

1. Alluvial Soils

- covers about 143.1 million sq km accounting for about 43.4 per cent of the total reporting area.
- occur mainly in the Satluj-Ganga-Brahmaputra Plains.
- found in the valleys of Narmada, Tapi and in the Eastern and Western coastal plains .
- derived from the debris brought down from the Himalayas or from the silt left out by the retreating sea.
- The colour of the alluvial soils varies from light grey to ash grey and the texture is sandy to silty-loam.
- both well drained and poorly drained.
- have an immature profile in undulating areas, while in the leveled areas they have a well developed and mature profile.
- These soils may be divided into the
- (i) **Khadar soil**: low-lying, frequently inundated by floods during the rainy season. occupies the flood plains of the rivers and is enriched by fresh silt deposits every year. The khadar tracts are generally rich in concretions, and nodules of impure calcium carbonate or Kankar.
- In the drier areas, it also exhibits stretches of saline and alkaline efflorescence locally known as reh', kallar or thur,
- (ii) **The Bhangar soil** is above the flood level. well-drained but contains concretion (kankars) of impure calcium carbonate.
- The soil texture varies from loamy soil to clayey-loam.
- well drained and suited to wheat, rice, maize, sugarcane, pulses, oilseeds, barseem (fodder), fruits and vegetables.
- rich in humus, phosphoric acid, lime and organic matter. deficient in potash.

Red Soils

- occupy the second largest area of about 61 million hectares or 18.5 per cent of the total reporting area.
- found mainly over the Peninsula from Tamil Nadu in the south to Bundelkhand in the north, and Rajmahal in the east to Kathiawad and Kachchh in the west .
- found in tracts in western Tamil Nadu, Karnataka, southern Maharashtra, Andhra Pradesh, Chhattisgarh, Jharkhand, Orissa, and in scattered patches in Bundelkhand, Mirzapur, Sonbhadra (Uttar Pradesh), Banswara, Bhilwara, Udaipur, (Rajasthan).
- Developed on Archaean granite, these soils are also known as the omnibus group.
- colour is mainly red because of the presence of ferric oxides. Generally, the top layer is red, while the horizon below is yellowish in colour.
- The texture varies from sand to clay and loam.
- porous and friable structure, absence of lime, kankar and carbonates and small quantity of soluble salts.
- deficient in lime, phosphate, magnesia, nitrogen, humus, and potash.

- Intense leaching is a menace to these soils.
- In the uplands, they are thin, poor, gravelly, sandy, or stony and porous, light-coloured soils, but in the lower plains and valleys, they are rich, deep, dark coloured fertile loams.
- In places where irrigation water is available, they are devoted to wheat, cotton, pulses, tobacco, millets, oilseeds (linseed), potato, and orchards.

Black or Regur Soils

- also known as Regur (cotton-soil) and internationally as 'tropical chernozems', are the third largest soil group in India.
- They sprawl over about 50 million hectares accounting for 15 per cent of the total reporting area of the country.
- stretch over the greater parts of Gujarat, Maharashtra, western Madhya Pradesh, north-western Andhra Pradesh, Karnataka, Tamil Nadu, Rajasthan, Chhattisgarh, and Jharkhand, up to Rajmahal Hills.
- mature soils.
- Over the greater parts of the black earth soil, the average annual rainfall varies between 50 and 75 cm.
- The colour varies from deep black to light black. In general, these soils have clayey texture
- rich in iron, lime, calcium, potash, aluminium and magnesium.
- deficient in nitrogen, phosphorous and organic matter.
- a high water retaining capacity.
- extremely compact and tenacious when wet, and develop wide cracks when dry.
- swell greatly and become sticky when wet in rainy season.
- When wet, it becomes difficult to plough the field as the plough gets stuck in mud.
- In the dry season, the moisture evaporates, the soil shrinks and develops wide cracks, often 10-15 cm deep.
- highly productive, and thus well suited for the cultivation of cotton, pulses, millets, linseed, castor, tobacco, sugarcane, vegetables, and citrus fruits.

Desert Soils

- Sprawling over about 15 million hectares, the desert soils account for over 4.42 per cent of the total reporting area of the country.
- developed under the arid and semi-arid conditions and deposited mainly by wind action.
- found mainly in Rajasthan, west of the Aravallis, northern Gujarat, Saurashtra, Kachchh, western parts of Haryana, and the south-western parts of Punjab.
- sandy to gravelly with low organic matter, low nitrogen and varying percentage of calcium carbonate.
- contain high percentage of soluble salts, but have low moisture content and low water retaining capacity.
- If irrigated, they give high agricultural returns.
- The availability of water from the Indira-Gandhi Canal has transformed the agricultural landscape of the desert soils of western Rajasthan.
- devoted to bajra, pulses, guar, fodder, and less water requiring crops.

Laterite Soils

- studied first by the British geographer F. Buchanan in 1905.
- Their name has been derived from the Latin word 'Later' which means 'brick'.
- These soils, when wet, are as soft as butter, but become quite hard and cloddy on drying.
- the typical soils of the monsoon climate which is characterised by seasonal rainfall.
- The alternating wet and dry seasons lead to the leaching away of the siliceous matter of the rocks leading to the formation of such soils.
- The red colour of the soils is due to the presence of iron-oxide.
- developed mainly in the highland areas of the plateau.
- in the higher areas are generally more acidic than those in the low-lying areas.
- cover an area of about 12.2 million hectares accounting for about 3.7 per cent of the total reporting area of the country.
- found mainly in the hills of Western Ghats, Eastern Ghats, Rajmahal Hills, Satpura, Vindhya, Orissa, Chhattisgarh, Jharkhand, West Bengal, North Cachar Hills of Assam, and the Garo Hills of Meghalaya.
- rich in iron and aluminium, but poor in nitrogen, potash, potassium, lime and organic matter.
- have low fertility, they respond well to manuring.
- devoted to rice, ragi, sugarcane, and cashewnuts.

Other Soils of India

Red and Black Soils

- found in isolated patches in Bundelkhand, and to the east of Aravallis in Rajasthan and Gujarat .
- developed over the granite, gneiss, and quartzite of the Archaean and Pre-Cambrian period.
- relatively less productive, but perform well under irrigation conditions.
- devoted to maize, bajra, millets, pulses, and oilseeds.

Grey and Brown Soils

- formed by the weathering of granite, gneiss, and quartzite.
- These are loose friable soils.
- Due to the presence of iron-oxide (haematite and limonite) these soils vary from red to black and brown in colour.
- found in Rajasthan and Gujarat.

Submontane Soils

- These soils are found in the Tarai region of the sub-montane stretching from Jammu and Kashmir to Assam in the form of a narrow belt.
- These soils have been formed by the deposition of the eroded material from the Shiwaliks and the Lesser Himalayas.
- The soil is fertile and supports luxuriant growth of forests.
- The clearing of forests for agricultural purposes has made this area highly susceptible to soil erosion.

Saline and Alkaline Soils

- characterised by the presence of sodium chloride and sodium sulphate. In these soils, the saline and alkaline efflorescence appears on the surface as a layer of white salt through capillary action.

- known by different names in different parts of the country like reh, kallar, usar, rakar, thur, karl, and chopan.
- found in Rajasthan, Haryana, Punjab, Uttar Pradesh, Bihar, and Maharashtra. Texturally, these soils vary from sandy to sandy-loam.
- deficient in nitrogen, calcium and have very low water bearing capacity.
- reclaimed by improving drainage, by applying gypsum and/or lime and by cultivating salt resistant crops like barseem, dhaincha, and other leguminous crops.

Peaty and Marshy Soils

- originate in the areas of heavy rainfall where adequate drainage is not available.
- submerged during the rainy season and utilised for the cultivation of rice.
- rich in organic matter, highly saline, but deficient in phosphate and potash.
- occur in parts of Kottayam and Alappuzha districts of Kerala and in the Sundarban delta.
- found in the deltas of Mahanadi, Godavari, Krishna, Kaveri, and the Rann of Kachchh.

Karewa Soil

- the lacustrine deposits in the Valley of Kashmir and in Bhadarwah Valley of the Doda District of the Jammu Division.
- the flat topped mounds that border the Kashmir Valley on all sides.
- composed of fine silt, clay, sand, and bouldery-gravel.
- characterised with fossils of mammals and at places by peat.
- Subsequently, due to endogenetic forces, the Baramullah Gorge was created and the lake was drained through this gorge.
- The deposits left in the process are known as karewas
- According to Middlemiss, the thickness of karewas is about 1400 m. In fact, the karewas have been elevated, dissected and in great measure removed by subaerial denudation as well as by the Jhelum river giving them the present position.
- devoted to the cultivation of saffron, almond, walnut, apple and orchards.
- devoted to saffron cultivation are fetching good income to the growers.
- The karewas of Palampur, Pulwama, and Kulgam are well known for their production of superior quality of saffron.

Snowfields

- The area under snow and glaciers is about 4 million hectares.
- The high peaks of the Greater Himalayas, Karakoram, Ladakh, and Zaskar (Zaskar) are covered by ice and glaciers.
- The soils is immature, generally without soil erosion.
- frozen and is unsuitable for the cultivation of crops.

PROBLEMS OF INDIAN SOILS

The main problems of the Indian soils are (i) soil erosion, (ii) declining fertility of soil, (iii) salinity and alkalinity, (iv) water-logging, and (v) desertification.

(i) Soil Erosion

- refers to the removal of top soil.
- a growing menace in many parts of India.
- When the top soil is removed, it is known as sheet erosion, and when the runoff makes gullies, it is known as gully erosion.

- In India, soil erosion is a universal problem. In the areas where rainfall is heavy water is the main agent of soil erosion, while in the arid and semi-arid areas wind is responsible for soil erosion.
 - According to one estimate about 180 million hectare (about 60 per cent of the total area of the country) is adversely affected by soil erosion.
 - The main agents of soil erosion are water, wind, sea-waves, glaciers, and shifting cultivation.
 - The areas adversely affected by the different agents of erosion have been shown in. Out of these, water is the most important agent of erosion. Water erosion may be classified under three categories:
 - (a) surface erosion or the uniform removal of soil from the surface,
 - (b) Rill erosion in which the running water makes finger-shaped grooves in the land, and
 - (c) gully formations, in which the rills are enlarged, making the land bad and unsuitable for cultivation.
 - A typical example of gully erosion is provided in the Chambal valley in Madhya Pradesh. Rajasthan, and Uttar Pradesh also provide typical examples of gully erosion.
 - Gully erosion is also significant in the Shiwalik tracts of Punjab, Haryana, Himachal Pradesh, Jammu and Kashmir, Uttarakhand, Uttar Pradesh and along the southern slopes of Himalayas, and the Western and Eastern Ghats.
 - Wind erosion is significant in the arid and semi-arid areas of Rajasthan, Haryana, Punjab, western Madhya Pradesh and Gujarat. Wind erodes soil along the coastal plains of Peninsular India.
 - Thousands of hectares of fertile lands of Uttar Pradesh, Gujarat, Haryana, Punjab, and western Madhya Pradesh have been adversely affected by this process.
 - The tidal waters of the Arabian Sea and the Bay of Bengal cause considerable damage to the soils along the coastal areas.
 - Severe erosion of beaches along the Kerala, Tamil Nadu, Andhra Pradesh, Orissa, and Gujarat coasts is the example of sea-wave erosion.
- The largest area affected by soil erosion is in the state of Rajasthan, followed by Madhya Pradesh, Maharashtra, Uttar Pradesh, Gujarat, Andhra Pradesh and Karnataka.
- The worst affected areas of soil erosion include: (i) Chambal and Yamuna rivers (Fig. 6.6), (ii) the southern slopes of Shiwaliks, Lesser and Greater Himalayas, (iii) the Western and Eastern Ghats, (iv) the Chotanagpur Plateau, and (v) the arid and semi-arid areas of Rajasthan, Gujarat, Haryana, and Punjab.

(ii) Declining Soil Fertility:

(iii) Water-Logging:

(iv) Saline and Alkaline Soils

- Soil salinity and alkalinity are found in the relatively less rainfall recording areas where the rate of evaporation is generally higher than the rate of precipitation.
- They also develop in the Khadar lands and the canal irrigated areas.
- Under such conditions, the ground water level rises and saline and alkaline efflorescence consisting of salts of sodium, calcium, and manganese appear on the surface as a layer of white salt through capillary action.
- According to one estimate, about 80 lakh hectares (2.4% of the country's reporting area) has been adversely affected by saline and alkaline formations.

(v) Salt Flats

- The soils seriously damaged by the excess of calcium chlorides are found in the Rann of Kachchh.
- These soils are saline, marshy and infested with tall grasses, bushes and scrubs. They are almost useless from agricultural point of view.
- A sound strategy needs to be developed to bring the salt flats under agriculture or pastures.

CONSEQUENCES OF SOIL EROSION

Soil erosion is responsible for the removal of productive nutrients from the soils and causes ecological imbalances. Some of the adverse consequences from soil erosion are:

- (i) Loss of fertile top soil from the top layer leading to gradual loss of soil-fertility and agricultural productivity.
- (ii) Loss of important nutrients from soil through leaching and water-logging.
- (iii) Lowering of the underground water-table and decrease in soil moisture.
- (iv) Drying of vegetation and extension of arid lands.
- (v) Increase in the frequency of droughts and floods.
- (vi) Silting of rivers and canal beds.
- (vii) Recurrence of land slides.
- (viii) Adverse effect on economy which retards cultural development.
- (ix) Increase in crimes and anti-social activities through the formation of natural hideouts for criminals and dacoits.
- (x) Burden on the exchequer to reclaim the bad lands.

There is no uniform strategy to reclaim all the wasteland and degraded soils of different types. Some strategies that might help in the reclamation of wasteland are given below:

- (i) All the degraded forest lands should be planted with trees. Marginal lands which are not suitable for agriculture should be brought under social forestry and agro-forestry.
- (ii) Degraded soils and degraded lands can be reclaimed with the help of watershed programmes.
- (iii) Rainwater harvesting and conservation should be the focus of development planning. A series of small projects of water harvesting in the watershed area should be undertaken to maximise benefits from watershed projects.
- (iv) Soil conservation practices should be adopted which have been briefly described in the following pages.

SOIL CONSERVATION

Some of the important steps which can go a long way in the conservation of soils are as under:

- 1. Afforestation:**
- 2. Restriction on the Felling of Trees:**
- 3. Contour Ploughing and Strip Cultivation**
- 4. Control of Floods**
- 5. Reclamation of Ravine and Badlands:**
- 6. Restriction on Shifting Cultivation**
- 7. Restoration of Long Fallow**
- 8. Reclamation of Saline and Alkaline (usar) Soil**
- 9. Other Measures of Soil Conservation**

- The government of India has been attempting to check the soil erosion throughout the planning period.

- The following steps can go a long way in reducing the rate of soil erosion.
 - (i) Construction of small dams across the tributaries of rivers in their upper reaches to control floods and soil erosion.
 - (ii) Lining of canals to stop seepage of water which leads to waterlogging..
 - (iii) Solving the problem of waterlogging by improving the surface and vertical drainage.
 - (iv) Formation of windbreak and shelter belts in arid and semi-arid regions.
 - vi) Popularising the application of cowdung and green manure.
 - (vii) Conversion of human waste and city garbage into manures.
 - viii) Scientific rotation of crops.
 - (ix) Filling up gullies and forming terraces along the slopes.
 - (x) Levelling of ravines and planting of trees and grasses in the slopes.
 - xi) Check on shifting cultivation and conversion of Jhum lands into sedentary agriculture.
 - (xii) Promotion of afforestation in the degraded soils.
 - xiii) Adopting the techniques of sustainable agriculture.
 - xiv) To educate public about the adverse effects of soil erosion through seminars, conferences, and workshops in the regions of degraded soils. •

CHAPTER-7-RESOURCES

NATURAL RESOURCES

- Any matter or energy derived from the environment (nature) that is used by living things including humans is called a natural resource.
- the basis for the development of any country.
- include air, water, soil, minerals, fossil fuels, plants and wild life.
- classified in many ways. One way is to classify them on the basis of the source of their origin.
- Accordingly, there are land, soil, water, plant, animal, mineral, and energy resources.
- Another method of classification is according to the stage of development of a resource.
- Those resources which are found in the region, but have not been put to proper use are called Potential resources. For example, the state of Assam and the Brahmaputra River have a vast potential of water resources, but all of them have not yet been determined and utilized, fully.
- The resources which have been surveyed and quantified for actual use are called Actual resources.
- The development of the actual resource depends on the technology available and the cost involved.
- That portion of the actual resource which can be developed profitably with available technology is termed a Reserve resource. For example, an increase in the world price of metal such as iron makes it profitable to utilize even low grade ore, thus turning a resource into a reserve.
- Natural resources may also be classified as Renewable and Non-renewable resources.

The main characteristics of these resources are given below:

Renewable Resources:

- Resources which get renewed or replenished fast, are called renewable resources.
- e.g., solar and wind energy.

Non-renewable Resources:

- built over a long geological time span.
- Minerals and fossil fuels are the examples of non-renewable resources.

MINERAL RESOURCES

- A mineral is an aggregate of two or more than two elements.
- has a definite chemical composition, atomic structure and is formed by inorganic processes.
- occur in the earth's crust in the form of ore.
- extracted, processed and utilised for the economic benefits of society.
- The availability and per capita consumption of minerals is taken as an important indicator to assess the economic development of a country.
- India is fairly rich in mineral resources but their distribution is highly uneven.
- The distribution of minerals in India has been described in the following section:

Distribution of Minerals

- The mineral wealth of India is largely confined to the igneous and metamorphic rocks of Peninsular India, while the Great Plains of India and the Himalayan region are almost devoid of the metallic minerals.

- The states which are rich in the metallic and non-metallic minerals are Jharkhand, Chhattisgarh, Orissa, Bihar, West Bengal, Madhya Pradesh, Karnataka, Maharashtra, Tamil Nadu, Gujarat, Uttarakhand, Andhra Pradesh, and Assam.
- The states of Uttar Pradesh, Haryana, Punjab, Himachal Pradesh, Jammu and Kashmir, and Gangetic West Bengal are, however, poor in mineral resources.

Mineral Belts of India

1. The Chotanagpur Belt:

- stretches over, Jharkhand, Chhattisgarh, Orissa, Bihar and West Bengal.
- rich in coal, mica, manganese, chromite, ilmenite, bauxite, iron, uranium phosphate, copper, dolomite, china-clay, and limestone.
- producing districts are Dhanbad, Hazaribagh, Palamu, Ranchi, Santhal-Pargana, and Singhbhum in Jharkhand; Cuttack, Dhankenal, Kendujhar (Keonjhar), Koraput, Mayurbhanj, Sambhalpur, and Sundargarh in Orissa; and Bankura, Birbhum, Medinipur and Purulia in West Bengal.
- contains almost 100% of kyanite reserves, 93% of iron ore, 84% coal, and 70% of chromite of the country.

2. The Midland Belt:

- sprawls over the states of Chhattisgarh, Madhya Pradesh, Andhra Pradesh, and Maharashtra.
- rich in manganese ore, bauxite, mica, copper, graphite, limestone, lignite, marble, and limestone.

3. The Southern Belt :

- stretches over the states of Andhra Pradesh, Karnataka and Tamil Nadu.
- rich in gold, iron ore, chromite, manganese, lignite, mica, bauxite, gypsum, asbestos, dolomite, ilmenite, china-clay, and limestone.

4. The Western Belt:

- stretches over the states of Rajasthan, Gujarat, and Maharashtra.
- rich in non-ferrous metals like copper, lead, zinc, uranium, mica, manganese, salt, asbestos, building stones, precious stones, mineral oil, and natural gas.

5. The South-Western Belt:

- sprawls over Goa, Karnataka, and Kerala.
- contains iron ore, ilmenite, zircon, monazite sands, garnet, china-clay, bauxite, mica, limestone, and soapstone.

6. The Himalayan Belt:

- is poor in metallic minerals.
- valuable pockets of minerals, like copper, lead, zinc, bismuth, bauxite, antimony, nickel, cobalt, tungsten, precious stones, gold, silver, gypsum, limestone, and dolomite in the Himalayas.

7. The Indian Ocean:

- The continental shelf of the Arabian Sea and the Bay of Bengal are rich in mineral oil and natural gas.
- contains high grade nodules of manganese, phosphate, barium, aluminium, silicon, iron, titanium, sodium, potassium, chromium, monazite, limonite, magnetite, and garnet.
- found at a depth of about 4000 metres.

Classification of Mineral Resources:

The minerals may be classified under the following three categories:

- Mineral Fuels (fossil fuels)
- Metallic Minerals
- Non-metallic Minerals

1. Mineral Fuels

- includes energy resources like coal, mineral oil (petroleum), natural gas, and atomic minerals.

2. Metallic Minerals

- constitute the second most important group of minerals after fossil fuels.
- provide a strong base for the development of metallurgical industry, and thereby help the process of industrialisation and urbanisation. India has a substantial reserve of these minerals.

Iron-Ore

- the most important mineral on which hinges the economy of a country.
- not found in pure form in the earth's crust, rather it is often found mixed with lime, magnesium, phosphorus, silica, sulphur, and copper.

Types of Iron Ores

There are four main types of iron ores found in India. They are: (i) Haematite, (ii) Magnetite, (iii) Limonite, and (iv) Siderite.

(i) Haematite ore (red-ochre):

- called 'oxide of iron'.
- metallic content varies between 60 to 70 per cent.
- massive, hard, compact and lumpy ore with reddish or coral-red in colour.
- found in the Dharwarian rocks.
- The main deposits of haematite ore are in Jharkhand (Iron-Series), Orissa (Mayurbhanj), Chhattisgarh (Bailadila Dalli-Rajhara), Madhya Pradesh, Karnataka (Kudermukh, Baba-Budan), Goa, Maharashtra, and Andhra Pradesh.

(ii) Magnetite:

- The magnetite ore is known as 'black ore'.
- The metal content varies between 60 to 65 per cent.
- The ore is either igneous or metamorphic.
- found in the Dharwar and Cuddapah Systems of Karnataka (Dharwar, Shimoga Districts), Andhra Pradesh (Bellary District), Tamil Nadu (Salem, Tiruchirappalli districts), and Kerala states.

(iii) Limonite:

- yellowish in colour and is known as the 'hydrated iron-oxide'.
- inferior and contains 35 to 50 per cent of metal.
- found in the iron-stone shales of the Damuda Series in Raniganj coal fields, Mirzapur District of Uttar Pradesh, Garhwal region of Uttarakhand, and the Kangra Valley of Himachal Pradesh.

(iv) Siderite:

- called as 'iron carbonate'. Its iron content varies between 10 to 40 per cent.
- an inferior variety of iron ore and not economically extractable at most of the places.

Reserves Iron Ore of India

1. Karnataka:

- the leading producer of iron ore accounting for about one-fourth of the total iron ore production of the country.

(i) Bababudan Hills:

- Lying in Chikmagalur District of Karnataka they stretch over 22 km in length and 20 km in width.
- rich in haematite deposits with ferrous content of 60 to 65 per cent.
- exported to Iran through the port of Mangalore.

(ii) Kudermukh Deposits:

- lie in the Chikmagalur District of Karnataka.
- They contain iron ore of the magnetite category with a metal content of 50 to 65 per cent.
- developed under an export agreement with Iran.
- exported through the seaport of Mangalore.

(iii) Sandur Range:

- stretches in the Bellary and Hosapet districts of Karnataka.
- generally hard, compact and steel-grey.
- The ferrous content varies between 50-65 per cent.
- Its ore is supplied to the Vijayanagar Steel Plant.

2. Orissa:

- The contribution of Orissa in the total production of iron ore in the country is about 22 per cent.
- The most important deposits are found at Mayurbhanj (Badampahar), Banspani and Toda in Kendujhar (Keonjhar), Tomka Range in Cuttack, Kandadhar Pahar in Sundergarh, Sambalpur, and Hirapur Hills of Koraput district.

(i) Badampahar:

- Situated in the Mayurbhanj District of Orissa, Badam Pahar has rich deposits of iron ore.
- Its height is about 825 metres above sea level.
- It has 30 million tonnes of iron ore. Iron-ore from Badampahar is supplied to Bokaro, Durgapur, Jamshedpur, and Raurkela.

(ii) Bonaigarh Range:

- Situated in the district of Sundergarh,
- most important iron ore bearing ranges.
- Iron ore is of haematite category which is supplied to Bokaro, Durgapur, Jamshedpur, and Raurkela.

(iii) Mayurbhanj:

- Situated in Orissa, it is well known for the iron ore deposits of haematite type.
- The metal content is more than 65 per cent.
- Iron ore from Mayurbhanj mines is sent to the iron and steel plants of Bokaro, Durgapur, Jamshedpur, and Raurkela.

3. Chhattisgarh:

- This state has about 20 per cent of the total iron ore deposits of the country.
- Bailadila in the Bastar District and Dalli-Rajhara in the Durg district are the main iron ore producing regions of Chhattisgarh state.
- The iron ore belongs to the haematite and magnetite categories in which the metal content varies between 60 to 70 per cent.
- The Bailadila mine is the largest mechanized mine in India.

- A 270-km long slurry pipeline has been constructed to bring the ore from Bailadila to Vishakhapatnam Plant.
- largely exported to Japan through the port of Vishakhapatnam.
- The Dalli Rajhara range is about 32 km long with iron ore reserves of about 125 million tonnes.
- The ferrous content is about 70 per cent.
- worked by the Hindustan Steel Plant of Bhilai. Bilaspur, Jagdalpur, Raigarh, and Surguja are the other iron ore producing districts of Chhattisgarh State.

(i) Dalli Rajhara:

- The Dalli Rajhara Range, well known for the iron ore deposits, lies in the Durg District of Chhattisgarh.
- 32 km long with an estimated iron ore deposit of 120 million tonnes.
- supplied to the Hindustan Steel Plant at Bhilai.

(ii) Bailadila:

- Situated in the Bastar District of the Chhattisgarh state, it is known for the rich deposits of iron ore of the haematite category.
- deposited during the Dharwar Period about 2500 to 1800 million years back.
- exported to Japan through the seaport of Vishakhapatnam.

4. Goa:

- fourth largest producer of iron ore in India.
- Goa produces about 18 per cent of the total iron ore of the country.
- superior quality.
- deposits and mining centres are at Pirna-Adolpale-Asnora, Sanquelim Onda, Kundem-Surla, and Sirigao-Bicholim-Dalda in north Goa.
- The nearby Marmagao seaport is a big advantage to these mines for the export of iron ore.
- exported mainly to Japan and Iran.

5. Jharkhand:

- Jharkhand has 25 per cent of the iron ore reserves and accounts for about 14 per cent of the total production of iron ore of the country.
- Iron ore mining was first of all started at Singhbhum in 1904.
- deposits lie in Bonai Range extending for about 50 km.
- The famous mines are Naomandi, Daltenganj (Palamu District).
- mined at Dhanbad, Hazaribagh, Ranchi, and Santhal Pargana.

Manganese Reserves in India

- India has the second largest reserves of manganese in the world after Zimbabwe, and is the fifth largest producer after Brazil, Gabon, South Africa, and Australia .
- used mainly for the manufacturing of iron and steel, bleaching powder, insecticides, pesticides, paints, dry-batteries, photography, etc

1. Orissa:

- The state of Orissa is the single most important state in the production of manganese accounting for over 38 per cent of the total production.
- The Gondite deposits in Sundargarh and khondolite and kodurite deposits in Kalahandi and Koraput are rich in manganese.
- Manganese is also mined in Bolangir and Sambhalpur districts of Orissa.

2. Maharashtra:

- Maharashtra is the second largest producer of Manganese, accounting for about 23 per cent of the total production.
- In Maharashtra, manganese is found in Bhandara, Nagpur, and Ratnagiri districts.
- The Ratnagiri ore is, however, of superior quality.

3. Madhya Pradesh:

- About 20 per cent of the total manganese production comes from the state of Madhya Pradesh. Balaghat and Chhindwara are the main districts in which it is mined.

4. Karnataka:

- The state of Karnataka produces about 13 per cent of the total production of manganese of the country.
- deposits are in the districts of North Kannada, Shimoga, Bellary, Chitradurga, and Tumkur.

5. Andhra Pradesh:

- About four-and-a-half per cent of the total manganese production of India is done in Andhra Pradesh. Srikakulam and Vishakhapatnam are the leading producer districts of manganese in Andhra Pradesh.
- mined in Cuddapah, Guntur, and Vijayanagram.

Copper Reserves in India

- Copper is highly ductile, strong and good conductor of electricity.
- It is mainly used in electrical machinery, automobile, stainless steel.
- When alloyed with zinc, it is known as 'brass' and with tin as 'bronze'. Rajasthan has the largest deposits of copper-ore followed by Madhya Pradesh, and Jharkhand.
- In the production of copper-ore, however, Madhya Pradesh stands first, followed by Rajasthan and Jharkhand.

1. Madhya Pradesh:

- The state of Madhya Pradesh is the largest producer of copper in India.
- The state has a large deposit of copper in Taregaon in Malanjkhand belt of Balaghat District.
- It is also found in Bargaon of the Betul district.

2. Rajasthan:

- found at Khetri-Singhana belt in Jhunjhunu District.
- It is also mined in Ajmer, Alwar, Bhilwara, Chittorgarh, Dungarpur, Jaipur, Pali, Sikar, and Sirohi districts.
- The Koh-Dariba (mountain), about 48 km to the south-west of Alwar city and Delwara-Kirovli area about 30 km from Udaipur are the other important producers of copper ore.

3. Jharkhand:

- third largest producer state of copper in the country.
- Copper is mined in Hazaribagh, Santhal Pargana (Jharkhand), Gaya, and Palamu districts (Bihar).
- Not being self-sufficient in copper, India is importing substantial quantity of copper from Zimbabwe, Australia, USA, Mexico, and Japan.

Copper plants in India

Chilpi Series:

- It stretches over parts of Balaghat, and Chhindwara districts of Madhya Pradesh.

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- consists of quartzite, copper-pyrite, mica schist, and marble.
- The copper obtained from this series is used in the Malanjkhand Copper Plant.

Ghatsila:

- Located in Jharkhand, it is a copper smelting plant.
- an electrolytic refinery.
- manufactures brass sheets. It also obtains gold, silver, and nickel in the processing of copper.

Khetri:

- an integrated copper mining-cum-ore refining plant in the Jhunjhunu District of Rajasthan.
- obtains copper ore from the Malanjkhand copper mines of Madhya Pradesh.
- has a sulphuric acid plant, and a fertiliser plant.

Korba:

- Bharat Aluminium Company Limited (BALCO) has an aluminium plant located at Korba, Bilaspur District of Chhattisgarh.
- It obtains bauxite deposits from the Amarkantak region and electricity from the Korba Thermal Power Plant.
- The government has disinvested its share to a private company, Sterlite.

Malanjkhand:

- an open cast copper mine in Balaghat District of Madhya Pradesh.
- A copper plant has been established at Malanjkhand.
- sent to the Khetri Copper Plant of Rajasthan.

Rakha Project:

- The Rakha copper Plant is located in the Rakha District of Singhbhum of Jharkhand.
- obtains copper ore from the mines of Rakha.

Tajola:

- The Tajola Copper Plant is located in the Raigadh town in Maharashtra.
- The plant has imported copper cathodes. It manufactures copper rods.

Other minerals found in India

Chromite

- an oxide of iron and chromium.
- used in metallurgical and chemical industries.
- Orissa, accounting for about 99 per cent of the total production, is the largest producer of chromite mined in Cuttack, Dhenkanal and Keonjhar districts.
- Karnataka is the second largest producer mined in Hassan district. Some chromite has been discovered in the Krishna District of Andhra Pradesh and the Tamenglong and Ukhrul districts of Manipur.

Uranium:

- mined at Jaduguda, Bhatin, Narwapahar and Turamdih (Singhbhum East), Jharkhand.

Lead:

- widely used because of its heaviness, malleability, softness and bad conductivity of heat.
- used in alloys, cable cover, lead-sheeting, ammunition, paints, glass making, paints making, automobiles, aeroplanes, type-writers, calculating machines, printing and rubber industry.
- does not occur free in nature.
- obtained from galena which is found in association with limestone, sandstones and calcareous slates.

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- Rajasthan is the leading producer of lead.
- mined in Udaipur (Zawar, Rikhabdeo, and Debari), Dungarpur (Ghugra and Mando), Banswara, and Alwar districts

Zinc:

- found in association with lead and silver.
- used for alloying and for manufacturing galvanised sheets.
- also used for dry-batteries, white pigments, electrodes, textiles, die-casting, rubber industry, and for making collapsible tubes containing drugs, and pastes.
- Rajasthan is the leading producer of zinc accounting for about 99 per cent of the total production.
- Small quantities of zinc are obtained from Sikkim, Jammu and Kashmir (Udhampur District), and South Arcot Vallalar of Tamil Nadu.
- India imports about 80 per cent of its requirements from Australia, Canada, Russia, and Zaire.

Tungsten:

- obtained from the wolfram ore.
- a self hardening mineral and therefore, used in steel industry, manufacturing of ammunition, armour plates, heavy guns, hard-cutting tools, etc.
- found at Degana near Rawat Hills in Rajasthan, Bankura District of West Bengal, Sakoli basin in Bhandara and Nagpur districts of Maharashtra, and Kolar mines in Mysore.
- also found in Chittoor, and East Godavari District of Andhra Pradesh, Ahmedabad District of Gujarat, and Singhbhum District of Jharkhand.

Bauxite in India

- Aluminium is obtained from bauxite.
- Bauxite is an oxide of aluminium.
- not a specific mineral but a rock consisting mainly of hydrated aluminium oxides.
- a clay like substance which is pinkish, whitish or reddish in colour depending on the amount of iron content.
- The total reserves of bauxite are about 3290 million tonnes.

The distribution and production of bauxite in the different states of India has been given below:

1. Orissa:

- Orissa stands first in the production of bauxite, producing more than 50 per cent of the total bauxite.
- The Kalahandi-Koraput belt which extends into Andhra Pradesh is the main bauxite deposit region. In addition to this, bauxite is also obtained from the districts of Bolangir, Sambalpur and Sundargarh.
- The new aluminium plant located at Damanjoli and Doragurha provide a good market for bauxite in this region.

2. Gujarat:

- About 16 per cent of the total bauxite production is from the state of Gujarat.
- In Gujarat, the main bauxite deposits are found between the Gulf of Kachchh and the Gulf of Khambat (Arabian Sea) through the districts of Bhavnagar, Junagarh, and Amreli.
- It is mined in Kheda and Sabarkantha.

3. Jharkhand-Bihar:

- ✓ In Jharkhand, bauxite is obtained from Dumka, Gumla, Lohardaga, Munger, Palamu, and Ranchi districts. The Lohardaga mines are, however, known for high grade bauxite deposits.

4. Maharashtra:

- ✓ About 10 per cent of the total bauxite production comes from Maharashtra. Kolhapur, Pune, Ratnagiri, Satara, and Thane are its main producing centres.

5. Chhattisgarh:

- ✓ In Chhattisgarh, bauxite is obtained from the Maikal Range, Amarkantak Plateau, Bilaspur, Raigarh, and Surguja. Its share in the total production is about 6 per cent.

6. Tamil Nadu:

- ✓ The Madurai, Nilgiri and Salem districts are known for the production of bauxite accounting for about 2.75 per cent of the total production

7. Madhya Pradesh:

- ✓ In Madhya Pradesh, bauxite is mined in the districts of Balaghat, Jabalpur, Katni, Mandla, and Shandol.
- ✓ Nearly 80 per cent of the total bauxite produced is used for the production of aluminium. Italy and UK are the largest importers of Indian bauxite accounting for 60 per cent and 25 per cent of the total export respectively. The remaining is exported to Germany, Belgium, and Japan.

Aluminum Plants In India

Some of the important aluminium plants are as under:

Balco: The Bharat Aluminium Company Limited (BALCO)-Korba (Chhattisgarh).

Renukoot (HINDALCO): The Renukut aluminium plant-Mirzapur (Uttar Pradesh).

Madras Aluminium Company (MALCO):

Koraput Aluminium Plant (NALCO): The Koraput aluminium plant was commissioned in the Koraput District in 1981.

Gold and Silver production in India

- ✓ About 90 per cent of the total gold is produced in the Karnataka state.
- ✓ There are three important gold fields in the country, namely, (i) Kolar Gold Field, Mysore (Karnataka), (ii) Hutti Gold Field in Raichur (Karnataka), and (iii) Ramgiri Gold Field in Anantapur District (Andhra Pradesh).

1. Karnataka: Karnataka stands first in the reserves and production of gold in India.

2. Andhra Pradesh: Andhra Pradesh is the second largest producer of gold in India.

Placer or Alluvial Gold:

- ✓ The gold obtained from the sand and sedimentary deposits of the rivers is known as placer gold.
- ✓ found in the Subarnrekha (Gold Streak) river of Jharkhand.
- ✓ also found near Loha in Singhbhum District and some other parts of the Chotanagpur Plateau.
- ✓ also found in the sand of Dras, and Sum rivers of Kargil (J & K), Shimla and Bilaspur in Himachal Pradesh, Punna-Puzha and Chaiyar Puzha rivers of Kerala, Balaghat and Seoni districts of Madhya Pradesh, Bastar, Raigarh, and Raipur of Chhattisgarh and Purulia District of West Bengal.

Champion Series:

- ✓ named after Champion reef in the Kolar Gold Field. It is the oldest gneiss in Karnataka.
- ✓ one of the oldest metamorphic sedimentary deposits in India.
- ✓ Known for its gold deposits, it has quartz and muscovite.

Silver:

- ✓ a precious metal. India, however, is not very rich in silver deposits.

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- ✓ an important currency metal, and used in the manufacture of chemicals, electroplating, photography, and coloring for glasses.
- ✓ found in association with lead and zinc.
- ✓ Zawar mines of Udaipur (Rajasthan) are the largest producer of silver.

Non-Metallaiic Minerals

Mica (Abhrak)

- ✓ an important non-metallic mineral used mainly in electrical industry as it has great insulating properties, can withstand high voltage and has low power loss factor.
- ✓ obtained from muscovite, biotite and phlogopite ores.
- ✓ Rajasthan accounts for about 51 per cent resources, followed by Andhra Pradesh, Maharashtra and Bihar.

Mica production in India

1. Andhra Pradesh: Andhra Pardesh is the largest producer of mica.

2. Rajasthan:

3. Jharkhand and Bihar:

- ✓ Mica is also found in Gujarat; Tamil Nadu, Chhattisgarh; Madhya Pradesh and Uttar Pradesh. Some deposits are also found in Haryana, Himachal Pradesh, Orissa, and West Bengal.
- ✓ India is the largest producer and exporter of mica in the world. It exports mica to Japan, USA, UK, Norway, Russia, Germany, France, Belgium, Netherlands, Poland, Czech Republic, Slovakia, and Hungary.

Saucer Series:

- ✓ sprawls over Nagpur, Bhandar (Maharashtra), and Chhindwara district (Madhya Pradesh). Saucer series belongs to the Dharwarian Group.
- ✓ consists of quartzite, mica-schist, marble and magniferous rocks.
- ✓ light green colour.

Sakoli Series:

- ✓ spreads over Jabalpur and Rewa districts of Madhya Pradesh.
- ✓ rich in mica schist, quartz, dolomite, and marble.
- ✓ The famous Jabalpur marble is obtained from the Sakoli Series.
- ✓ contains gneisses of the Dharwar period.

Limestone in India

- ✓ an aggregate of calcium carbonate, carbonate of calcium and magnesium or a mixture of the two.
- ✓ contains small quantities of silica, alumina, iron-oxides, phosphorus and sulphur.
- ✓ deposits are of sedimentary origin and exist in almost all the geological formations from the Pre-Cambrian to Recent except in Gondwana.
- ✓ used in cement, iron and steel, and chemical industries.
- ✓ The rapid industrialisation and urbanisation has resulted into heavy demand of this mineral, especially for the manufacturing of cement.
- ✓ produced in almost all the states of India.
- ✓ Its, main producing states are Rajasthan, Madhya Pradesh, Andhra Pradesh, Gujarat, Chhattisgarh, and Tamil Nadu.

Dolomite:

- ✓ a type of limestone which contains more than 10 per cent of magnesium.
- ✓ used mainly in the metallurgical industry, especially in the iron and steel industry.

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- ✓ The total reserves of all grades of dolomites are 7533 million tonnes (India 2010).
- ✓ The states of Orissa, Chhattisgarh, Andhra Pradesh, Jharkhand, Rajasthan, Gujarat, Maharashtra and Karnataka are its main producer.

Orissa

- ✓ is the leading producer of dolomite accounting for about 29 per cent of the total production in the country, followed by Chhattisgarh with over 27 per cent.
- ✓ The share of Andhra Pradesh and Jharkhand is 18.35 per cent and about 8 per cent respectively in the total production. Rajasthan and Karnataka contribute about 6 per cent each.

Other non-metallic minerals in India

Asbestos:

- ✓ great commercial value due to its fibrous structure, and its resistance to fire.
- ✓ used for making fire-proof clothes, rope, paper, sheeting, belt, fireproof safes, insulators, felts, aprons, gloves, curtains, brake linings in automobiles, and insulating mats.
- ✓ Asbestos cement products like sheets, slates, pipes and tiles are used for building purposes.
- ✓ Mixed with magnesia, it is used for making 'magnesia bricks' used for heat insulation. Rajasthan is the leading producer accounting for about 95 per cent of the total asbestos production of India.
- ✓ mined in Ajmer, Alwar, Dungarpur, Pali and Udaipur districts. Andhra Pradesh is the second largest producer.
- ✓ It is produced in Cuddapah District. It is also mined in Karnataka, Jharkhand, Madhya Pradesh, Chhattisgarh, Tamil Nadu, Uttarakhand, and Nagaland.

Magnesite:

- ✓ used for manufacturing refractory bricks, special type of cement, tiles, fire-proof flooring and for extraction of the metal magnesium, and in steel industry.
- ✓ Its major deposits are found in Uttarakhand, Tamil Nadu, and Rajasthan.
- ✓ found in Jammu and Kashmir, Karnataka, Himachal Pradesh, and Kerala.
- ✓ Tamil Nadu is the largest producer accounting for over 74 per cent of the total magnesite production, followed by Uttarakhand (20 per cent) and Karnataka (6 per cent).

Kyanite:

- ✓ Found in the metamorphic rocks, kyanite is used in metallurgical, ceramic, refractory, glass and electrical industries.
- ✓ India is the largest producer of kyanite in the world.
- ✓ located in Jharkhand, Maharashtra, and Karnataka.
- ✓ These three states contribute almost the whole production of kyanite of the country.

Gypsum:

- ✓ a hydrated sulphate of calcium which occurs as a white opaque mineral in beds of bands of sedimentary rocks like limestone, sandstone and shale.
- ✓ used in making ammonia sulphate, fertilisers and in cement industry.
- ✓ also used in making plaster of Paris, ceramic industry, nitrogen-chalk, partition-blocks, sheets, tiles, and plastics.
- ✓ Rajasthan is the leading producer of gypsum accounting for about 99 per cent of the total production of the country.
- ✓ obtained mainly from the districts of Barmer, Bikaner, Chum, Anganagar, Jaisalmer, Jodhpur, Nagaur, and Pali.

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- ✓ The remaining one per cent is mined in Tamil Nadu, Jammu and Kashmir, Gujarat, and Uttarakhand, Andhra Pradesh, Himachal Pradesh, Karnataka, and Madhya Pradesh. The total reserves of gypsum in India were estimated to be about 1237 million tonnes (India 2010)

Sillimanite:

- ✓ used in ceramics, metallurgy, glass, refractory, automobiles and cement manufacturing industries.
- ✓ Its main characteristic is that it can withstand high temperatures. Orissa, contributing about 57 per cent of the total production, is the largest producer of sillimanite in India.
- ✓ Kerala is the second largest producer accounting for about 33 per cent of the total production.
- ✓ produced in Maharashtra, Rajasthan, Meghalaya, Assam (Karbi-Anglong), Madhya Pradesh, (Sidhi), West Bengal (Darjeeling, Bankura and Purulia), and Tamil Nadu (Kanniyakumari, Tirunelveli, and Tiruchirappalli).

Diamond:

- ✓ a precious stone.
- ✓ known for its brilliance, luster, transparency and hardness.
- ✓ found in the Vindhyan formations of Bundelkhand, (M.P.), Andhra Pradesh (Anantapur), and Karnataka (Raichur).
- ✓ Panna District of Madhya Pradesh is the main diamond producing district in India.
- ✓ Cutting and polishing of diamond is mainly carried on in Surat, Ahmedabad, Navasari, Palanpur, Bhavnagar, Mumbai, Khambhat, Jaipur, Trichur, and Goa.

Ajabgarh Series:

- ✓ Lying in the Rajasthan state, the Ajabgarh Series belongs to the Cuddapah and Lower Vindhyan group.
- ✓ rich in biotite-schist, quartzites, and impure limestones. It has inferior quality of iron ore, manganese, asbestos, slate, marble, and jasper.

Bhander Series:

- ✓ belongs to the Vindhyan formation.
- ✓ The main rocks in the Bhandar Series are sandstone, shale and limestone.
- ✓ provides good quality of building material besides diamond mines.
- ✓ The diamonds from the Bhandar series are sent to Surat and Jaipur for polishing and finishing.

Bijwara Series:

- ✓ It occupies parts of Chhatarpur and Panna districts of Madhya Pradesh.
- ✓ It is composed of sandstone, quartzite and limestone. It has basaltic intrusions whose dykes are rich in diamonds.
- ✓ The Panna diamond is famous all over the world for its transparency, brilliance, and hardness.

Rajpura Series:

- ✓ stretches from Delhi to Alwar.
- ✓ It belongs to the Archaean and Dharwarian groups.
- ✓ The famous marbles of Makrana, Rajnagar, and Bhagwanpura belong to this series.
- ✓ Limestone, marble, quartzite, and building material are the main minerals found in this series.

Atomic Minerals In India

Uranium:

- ✓ deposits occur in Singhbhum and Hazaribagh districts of Jharkhand, and Gaya District of Bihar, and in sedimentary rocks of Saharanpur District of Uttar Pradesh.

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- ✓ The largest source of uranium comprise the monazite sands, both beach and alluvial. Monazite sand rich in uranium is found in Kerala. Some uranium is found in the copper and zinc mines of Udaipur (Rajasthan).
- ✓ The total reserves of uranium as estimated by the Department of Atomic Energy, Government of India, are about 31,000 tonnes.

Thorium:

- ✓ derived from monazite. It is produced in Kerala, Jharkhand, Bihar, Tamil Nadu, and Rajasthan.
- ✓ In addition to uranium and thorium, beryllium and lithium are also the atomic minerals found mainly in Jharkhand, Madhya Pradesh, and Rajasthan.

Salt In India

- ✓ used mainly in chemical industry.
- ✓ Common salt (sodium chloride) is used as a food item.
- ✓ Salt is obtained from sea water, brine springs and salt pans in lakes.
- ✓ The main producers of salt are Gujarat, Maharashtra, Tamil Nadu, and Rajasthan. Gujarat coast accounts for about 50 per cent of the total salt production of India.
- ✓ Sambhar lake of Rajasthan contributes about 10 per cent of the total salt production of the country.
- ✓ In addition to this, rock salt is obtained from the Mandi area of Himachal Pradesh.
- ✓ The Mandi salt is hard and massive and has to be blasted.
India exports small quantities of salt to the neighbouring countries like Bangladesh, Bhutan, Indonesia, Japan, Maldives, Nepal, Singapore, South Korea, and Taiwan.

Problems of Mining Industry in India

- 1. Ill-Defined Government Policy:**
- 2. Obsolete Technology:**
- 3. Inadequate Transport Facilities:**
- 4. Inadequate Exploration and Prospecting of Minerals:**
- 5. Inadequacy of Funds:**
- 6. Lack of Awareness about Conservation:**
- 7. Export of Mineral Ores:**
- 8. Strikes and Naxalites:**

Conservation of Minerals:

Some of the steps which can go a long way in the conservation of mineral resources have been given in the following:

- 1. Judicious Use: 2. Efficient Technology: 3. Alternatives to Minerals: 4. Development of Infrastructure: 5. Location of Industries near the Mining Sites: 6. Recycling of Scrap: 7. Sustainable Mining:**

The National New Mineral Policy, 1993:

After liberalisation and globalisation, the mining industry has been opened to the private sector. The main objectives of the New Mineral Policy, 1993, are as under:

- 1. Public Sector Mining:**
- 2. Regular Supply of Minerals to Industries:**
- 3. Foreign Investment:**

4. Check on Adverse Environmental Effect:

5. To Promote Research:

- ✓ The New Mineral Policy, 1993, makes a significant departure from the exclusive control of the Government on the exploration and exploitation of major minerals. The entry of private sector may aggravate the situation by over-exploitation of minerals. Therefore, the government should take adequate and effective measures to overcome such a problem.

BIOTIC RESOURCES IN INDIA

- ✓ The biotic resources include livestock (cattle, buffaloes, goat, and sheep rearing, pig rearing) fisheries, poultry farming.
- ✓ The livestock sector, which contributes about 27 per cent to the GDP from agriculture and allied activities, is of special importance in the arid and semi-arid regions.

Cattle

- India ranks first in respect of buffalo and second in respect of cattle population, second in goat population and third in respect of sheep in the world.
- At the state level, Madhya Pradesh has the largest number of cattle in the country followed by Uttar Pradesh, Bihar, West Bengal, Orissa, and Karnataka. The percentage of cattle in the states of Sikkim, Arunachal Pradesh, Nagaland, Mizoram, and Meghalaya, is less than 0.2 per cent each.

Cattle population in India can be classified into: (i) milch breed, (ii) draught breed, and (iii) mixed or general breed.

Mulch Breeds:

- The cows which give relatively higher quantity of milk are known as mulch breeds.
- The famous mulch breeds in India are Deoni, Gir, Sahiwal, Sindhi, and Tharparkar. The Deoni breed is a native of the north-western parts of Andhra Pradesh which gives about 2000 kg of milk per lactation.
- The Gir breed is a native of Saurashtra which yields over 3000 kg of milk per lactation.
- The Sahiwal breed (formerly known as Montgomery in Pakistan) yields about 3000 to 4500 kg of milk per lactation period.
- The Sindhi breed is red in colour and produces about 5000 kg of milk per lactation.

Draught Breeds:

- The bullocks of the draught breeds are excellent draught animals.
- The main draught breeds in India are: (i) Nagori, and Bachaur, (ii) The Kathiawari, Malvi and Kherigarhi, (iii) the Mysore type characterised by prominent forehead with long pointed horns which are close together, e.g. Hallikar, Amritmahal, Kangyam, and Killari, and (iv) the small black and red coloured breeds of the Himalayan region known as Ponwar and Ski.

Dual Purpose Breed:

- The cows of these breeds give good quantity of milk and bullocks are good quality draught animals.
- Some such important breeds are Haryana (popular in Haryana, Uttar Pradesh, and Punjab), Ongole (belongs to Gantur and Nellore Districts of Andhra Pradesh), Gaolo (Nagpur and Wardha), Rath (Haryana and Mewat), Dangi (Nasik), Kridhna Valley and Nimari.

CHAPTER-8-ENERGY RESOURCES

Energy Resources in India

- classified into two categories, namely:
- (i) conventional (coal, petroleum, natural gas, and electricity), and
- (ii) non-conventional energy (solar, wind, tidal, geothermal, and biogas energy).
- also be classified into non-commercial (fuel-wood, charcoal, dried cow-dung, animal waste and animal power), and
- commercial energy (coal, mineral oil, natural gas, hydro-power, nuclear power wind energy, solar energy).
- It is the commercial energy which plays a vital role in the economic development of a country.

Coal

- main source of energy in the country and accounts for 67% of the commercial requirement of the country.

Classification

- The coal of India may be classified under two categories: (i) Gondwana coal, and (ii) Tertiary coal.

Gondwana Coal

- belongs to the carboniferous period (570 million years to 245 million years back).
- found in the Damodar, Mahanadi, Godavari, and Narmada valleys. Raniganj, Jharia, Bokaro, Ramgarh, Giridih, Chandrapur, Karanpura, Tatajani, Talcher, Himgiri, Korba, Panchghati, Sarguja, Kamthi, Wardha Valley, Singreni (A.P.) and Singrauli.
- The Jharguda coal mine (Chhattisgarh) is the thickest coal seam 132 metres of the Gondwana Period, followed by the Kargali seam near Bokaro coalfield which is about 30 metres in thickness.
- Over 98 per cent of the total coal reserves of India belong to the Gondwana Period.
- mainly bituminous or anthracite in which the carbon content varies between 60 to 90 per cent.
- The bituminous coal is converted into coke before being used in the iron and steel industry.

The Tertiary:

- found in the rocks of the Oligocene period of the Tertiary Era.
- about 15 to 60 million years old.
- also known as the 'brown coal'.
- contributes only about two per cent of the total coal production of the country.
- an inferior type of coal in which the carbon varies between 30 per cent in Gujarat and Rajasthan to 50 per cent in Assam.
- **Lignite coal** is found in Arunachal Pradesh, Assam, Gujarat (Kachchh) Kerala, ammu and Kashmir, Nagaland, Tamil Nadu, Uttar Pradesh, and West Bengal (Darjeeling District).
- The largest lignite deposits of the country are at Neyveli in the state of Tamil Nadu.
- The different types of coal and their characteristics have been given in the following

(i) Peat:

- contains the highest percentage of moisture, gives more smoke, has less than 40 per cent carbon and, therefore, is the lowest and most inferior quality of coal.
- represents the first stage of coal formation.

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(ii) Lignite (Brown-Coal):

- superior to peat. Under the increasing pressure and heat, with the passage of time, peat is converted into lignite.
- contains 40 to 60 per cent carbon. It is mainly found in Neyveli (Tamil Nadu), Palna (Rajasthan), Lakhimpur (Assam), Jaintia Hills (Meghalaya), Nagaland, Kerala, Jammu and Kashmir, Uttar Pradesh, and the union territory of Pondicherry.
- deposits in India estimated around 38930 million tonnes, out of which 4150 million tonnes are in Neyveli area of Tamil Nadu (2010).
- also found in Assam, Gujarat, Jammu & Kashmir, Kerala, Meghalaya, Nagaland, and Rajasthan.

(iii) Bituminous (Black-Coal):

- When coal is buried very deep, the moisture gets expelled.
- The seam subjected to increased temperatures results into the formation of bituminous coal.
- dense, compact and black in colour.
- The traces of original vegetation from which it has been formed are found in this coal.
- Containing 60 to 80 per cent carbon,
- the most popular coal in commercial use.
- The name is derived after a liquid called bitumen released after heating.
- used in making coke (coking coal), gas coal, and steam coal.
- Coking coal results from the heating of coal in the absence of oxygen, which burns off volatile gases and is mainly used in iron and steel industry.
- found in Jharkhand, Orissa, Chhattisgarh, West Bengal and Madhya Pradesh.

(iv) Anthracite (Hard Coal)

- highest quality of coal containing 80 to 90 per cent carbon.
- very little volatile matter and insignificant proportion of moisture.
- short blue flame.
- the most expensive.

Distribution of Coalfields in India:

(i) Jharkhand:

- accounting for about 29 per cent, has the first rank in coal reserves and its production.
- belongs to the Gondwana period.
- The districts of Dhanbad, Dumka, Hazaribagh, and Palamu are very rich in coal deposits.
- Main coal mining centres are Auranga, Bokaro, Daltenganj, Dhanbad, Giridih, Hutar, Jharia, Karanpur, and Ramgarh .

(a) The Jharia:

- Jharia is the largest and most important coal producing mine, which sprawls over an area of about 460 sq km.
- contains the best metallurgical coal (bituminous).
- Nearly 90 per cent of the coking coal is produced from the Jharia mine.
- coal is mainly supplied to the iron and steel plants of Asansol, Bokaro, Durgapur, and Jamshedpur.

(b) The Bokaro Coalfield:

- stretches in the valley of Bokaro river in Hazaribagh district, about 32 km to the west of Jharia.
- The Kargali seam (37 metres) of the Bokaro coalfield is one of the thickest of the Gondwana period in (India).
- mainly supplied to the iron and steel plant of Bokaro.

(c) The Giridih or Karharbari Coalfield:

- stretches in the district of Hazaribagh.
- very close to the surface.
- provides one of the finest quality of bituminous coal used for the metallurgical industry.
- coal is supplied to the Bokaro and Jamshedpur steel plants.

(d) The Karanpur Coalfield:

- divisible into the North and the South Karanpur coalfields.
- lies only about 30 km to the west of Bokaro.
- The thickness of its seam is about 25 metres.
- Much of the coal is, however, non-coking.

(e) The Ramgarh Coalfield:

- Stretching over an area of about 100 sq km, the Ramgarh coalfield is only about 9 km to the west of the Bokaro coalfield.
- relatively inferior quality containing a high proportion of ash (about 30%) and carbon 35 per cent.

(f) The Hutar Coalfield:

- Stretching over about 200 sq km
- lies in the Palamau district.
- thin and the coal is of inferior quality containing about 50 per cent carbon, 30 per cent volatile matter and 20 per cent ash.

(g) The Daltenganj Coalfield;

- Sprawling over 55 sq km,
- lies in the Palamau district.
- either semi-anthracite or non-coking, of inferior quality which can not be used in metallurgical industries.

(h) Deogarh Coalfields:

- lies in the Dumka district and stretches over an area of about 20 sq km.
- inferior quality containing about 40 per cent carbon, 25 per cent volatile matter and 35 per cent ash content.
- mainly used in the brick kilns.

(ii) Orissa:

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- The state of Orissa has more than 24 per cent of the total coal reserves and produces about 15 per cent of the total coal production of the country.
- In Orissa most of the coal deposits are found in Dhenkanal, Sambalpur, and Sundargarh districts.

(a) The Talcher Coalfield:

- Stretching over Dhenkanal and Sambalpur districts, the Talcher coalfield covers an area of about 500 sq km.
- the second largest coal reserves in the country after Raniganj.
- The coal lower grade containing only about 35 per cent of fixed carbon, 40 per cent volatile matter and about 25 per cent ash content.
- mainly utilised in the thermal power and fertiliser plants of Talcher.

(iii) Chhattisgarh and Madhya Pradesh:

- The state of Chhattisgarh has the third largest coal reserves (about 17 per cent of all India) in the country after Jharkhand and Orissa, but it holds the first rank in its production.
- **(a) The Singrauli Coalfield:**
- Stretching over the Sidhi and Shandol districts is the largest coal-field of Madhya Pradesh.
- Its Jhingurda coal seam with a thickness of 132 metres is the thick-est coal-seam of the country.
- belongs to the Gondwana period, which contains 40 to 50 per cent of fixed carbon.
- mainly utilised in the thermal powerplant of Obra.

(b) The Korba Coalfield:

- lies in the Bilaspur district.
- Two of its coal seams are more than 30 metres.
- average quality and is used mainly in the Korba thermal power plant.

(c) The Pech-Kanha-Tawa Coalfield:

- lies in the Chhindwara district.
- coking and semi-coking category.

(d) Umaria Coalfield:

- lies about 60 km south of Katni.
- contains a higher percentage of ash and moisture.
- used mainly in the generation of thermal power.

(iv) West Bengal:

- West Bengal has about 11 per cent of the total coal reserves of India.
- The coal deposits of West Bengal lie in Bankura, Bardhaman, Birbhum, Darjeeling, Jalpaiguri, and Puruliya districts.
- The most important of coal reserves and mining coalfield of West Bengal is Raniganj.

(a) Raniganj Coalfield:

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- Stretching over 185 sq km in the Bardhaman and Birbhum district to the north-west of Kolkata, it is the most important coalfield of West Bengal.
- known for the good quality of coking coal.
- contains 50 to 65 per cent of carbon.
- used in the metallurgical industry, especially in the Durgapur iron and steel plant.

(b) The Darjeeling Coalfield:

- The coal of Darjeeling district belongs to the Tertiary Period.
- exposed in the Mana and Mahanadi valleys.
- powder form with coking quality.

(v) Madhya Pradesh:

- About 8 per cent of the coal reserves of India are found in Madhya Pradesh,
- The main coal deposits lie at Singrauli, Muhpani, Satpura, Sohagpur and Pench-Kanhan.

(vi) Andhra Pradesh:

- About 7 per cent of the coal reserves of India are found in Andhra Pradesh.
- found in the Godavari valley.
- The districts of Adilabad, Khammam, Nellore and Warangal are known for its production.
- used in thermal power plants of Kottagudem, Nellore, Ramagundam, Errazada, Husain-Sagar, and the fertiliser plant at Ramagundam.
- The Singareni coalfield lying about 185 km to the east of Hyderabad is the main mining area of coal in Andhra Pradesh.
- Another important coal producing centre is at Kottagudem.
- Its coal seam is of about 18 metres and the coal is of good quality.

(vi) Maharashtra:

- lie in the Wardha valley, stretching over the Nagpur (Kamptee-coalfield), and Yavatmal districts.
- utilised by the railways and the thermal power stations of Trombay, Chola (Kalyan), Khaperkheda, Paras, Ballarshah, Nasik and Koradi

Coal Deposits of the Tertiary Period

- came into existence during the Eocene, the Oligocene, and Miocene periods.
- found in Arunachal Pradesh, Assam, Meghalaya, Nagaland, and Jammu and Kashmir states.
- also known as brown coal.
- Containing more moisture, it has less carbon content.

Tamil Nadu:

- the largest deposits of lignite at Neyveli in the South Arcot district.
- The seams are 10 to 12 metres in thickness.
- Its carbon and moisture contents are 30-40 per cent and 20 per cent respectively, while the volatile matter varies between 40 to 45 per cent.

Rajasthan:

- Lignite deposits are found in the districts of Bikaner (Palana and Khari mines).
- The thickness of Bikaner seams varies from 5 to 15 metres.
- It is of inferior quality and used mostly in the thermal power plants and railways.

Gujarat:

- Found in Bharauch district and Kachchh.
- poor quality with about 35 per cent carbon and more moisture.

Jammu and Kashmir:

- found at Raithan of the Shaliganga, Handwara, Baramulla, Riasi and Udhampur districts, and the karewas of Badgam and Srinagar.
- inferior quality with less than 30 per cent of carbon, over 15 per cent moisture and 30 per cent volatile matter.

West Bengal:

- lignite deposits of the Tertiary period are found in Burza Hills of Jalpaiguri and Darjeeling districts.
- Scattered deposits of lignite have also been discovered in Pondicherry.

The Talcher Series:

- It is the series of the Gondwana Systems, named after the Talcher and Dhankenal districts of Orissa.
- It rests on the glaciated boulder bed of igneous rocks.
- known for its coal deposits.
- The coal from here is supplied to the Raurkela and Jamshedpur Steel Plants.

The Damuda Series:

- most important series of the Gondwana System.
- well developed in Jharkhand and West Bengal.
- known for good quality coal seams.
- The Raniganj, Jharia coal seams lie in the Damuda series.
- The Superior quality coal (anthracite and bituminous) is obtained from this series.
- The bituminous which has carbon over 60 per cent is used for metallurgy, especiallly the iron and steel plants of Jamshedpur and Bokaro.

The Panchet Series:

- youngest series of the Lower Gondwana System.
- lies to the south of Raniganj.
- consists of greenish sandstone, shales and iron rich rocks, but is devoid of coal-seams.
- An outlier of this series is known as Mangli beds in the Wardha valley of Maharashtra.

Problems of Coal Industry in India

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The main problems of the coal mining industry are as under:

1. Unequal Distribution of Coal
2. Poor Quality of Coal
3. Less Efficient Transport System
4. Obsolete Method of Mining.
5. Shortage of Power Supply
6. Fires and Water-logging

Conservation of Coal

The following steps can go a long way in the conservation of coal in the country.

1. The coking and good quality coal should be reserved only for metallurgical industry.
2. Low grade coal should be washed and impurities removed by modern techniques.
3. Selective mining should be stopped by an act of law. All possible grades of coal should be obtained from all the mines.
4. Environmental safety laws should be effectively implemented.
5. The thermal power plants should be located at the pit-heads to enhance power generation.
6. The pilferages and theft of electricity should be minimised.
7. New reserves should be discovered.
8. The non-conventional sources of energy should be popularised.

Petroleum and Natural gas

- an important source of energy which is much in demand to accelerate the economic development.
- it provides lubricants and raw materials for a number of chemical industries.
- Products include kerosene, diesel, petrol, aviation-fuel, synthetic rubber, synthetic-fibre, thermoplastic resins, benzene-methanol, polystyrene, acrylates, detergents, aromatics, gasoline, carbon-black, dyes, colours, food-colours, pigments, explosives, printing ink, film-photography, greases, cosmetics, paints, lubricant oils, paraffin, and wax.
- **Crude oil is obtained mainly from the sedimentary rocks** of marine origin. In India, crude oil is found in the sedimentary rocks of the Tertiary period .
- does not occur at its place of formation.
- Being lighter than water, crude oil overlain with gas, gets accumulated in the anticlines above the water surface.
- The geologists propounded two theories about the origin of crude oil.

In India, the petroleum and natural gas has been discovered in the following ten basins:

1. The Upper Assam Basin (60,000 sq km)
2. The Western Bengal Basin (60,000 sq km)
3. The Western Himalayan Basin (100,000 sq km)
4. The Rajasthan Saurashtra-Kachchh Basin (95,000 sq km)
5. The Northern Gujarat Basin (140,000 sq km)
6. The Ganga Valley Basin (385,000 sq km)
7. The Coastal Tamil Nadu, Andhra & Kerala Basin (75,000 sq km)
8. The Andaman and Nicobar Coastal Basin (2000 sq km)
9. Offshore of the Khambat, Bombay High & Bassein (2000 sq km)

Crude-Oil Producing Regions in India

The major oilfields of India are as under:

1. The Western Coast Offshore Oilfields

(i) The Bombay High Oilfields :

- largest petroleum production oilfield contributing over 65 per cent of the total production of crude oil.
- lies about 176 km to the south-west of Bombay.
- has about 35 million tonnes of crude oil and about 40,000 million cubic metres of natural gas.
- started in 1976.
- Owing to over exploitation, the production of this oil-field is declining fast.

(ii) Bassein Oilfield:

- lies to the south of Bombay High.
- occurs at a depth of over 1900 metres.
- rich deposits of oil and natural gas.

(iii) Aliabet Oilfield :

- located about 45 km to the south of Bhavnagar.

2. The Gujarat Coast

- This is the second largest oil producing area of the country.
- Its main oilfields are in Ankleshwar, Cambay-Luni area and Ahmadabad-Kalol region.

(i) Ankleshwar:

- Situated in the district of Bharuch, it stretches over an area of about 30 sq km.
- The oil of this region belongs to the Eocene period.
- started in 1961.
- rich in gasoline and kerosene.
- The crude oil from this region is sent to the Koyali petroleum refinery.

(ii) Cambay-Luni Region:

- lies about 60 km to the west of Vadodara.
- started in 1958.
- The estimated reserves of crude-oil are over 30 million tonnes.
- very light with a sulphur content of less than 0.1 per cent.

(iii) The Ahmadabad-Kalol Region:

- lies to the north of Gulf of Khambat (Cambay) around the city of Ahmadabad and extends up to Mehsana. Kalol, situated about 25 km to the north of Ahmadabad is an important oilfield of the region.
- started in 1961.

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- supplied mainly to the Koyali refinery.

3.The Eastern Coast:

- Oil-fields Petroleum and natural gas have been discovered in marine delta regions of Mahanadi, Godavari, Krishna, and Kaveri rivers.
- The Rawa field in the Godavari-Krishna offshore is expected to produce about 3 million tonnes of crude-oil annually.
- Petroleum has also been discovered in the Kaveri delta.
- In addition to these, crude oil has been discovered in the Bilaspur Tehsil of Rampur District of Uttar Pradesh, Jawalamukhi area of Punjab, and in the Barmer District of Rajasthan.
- found on the offshore of Andaman and Nicobar, Gulf of Mannar, Baleshwar coast, Punjab, Haryana and Uttar Pradesh.

4. The Brahmaputra Valley:

- Crude oil was first discovered in the Brahmaputra valley.
- spread from the Dehang Basin up to the Surma valley.
- The main oil producing wells, however, lie in the Dibrugarh and Sibsagar districts of Upper Assam.
- Some of the important oil producing centres of this region are given below:
 - (i) The Digboi Oilfield Stretching over an area of about 15 sq km, the Digboi oilfield is one of the oldest oil-fields of the country.
 - belongs to the Eocene and Miocene periods.
 - There are 85 oil wells in this region.
 - Most of the oil is sent to the refinery of Digboi.
 - Since 1959, the Digboi oilfields are worked by the Oil India Limited (OIL).
 - (ii) The Naharkatiya Oilfield This oil-field lies about 35 km to the south-west of Digboi. Oil production from the Naharkatiya oilfields was started in 1954. Crude oil from this region is supplied to the refineries of Noonmati, New Bongaigaon (Assam), and Barauni (Bihar).

Oil Pipelines in India

Some of the important pipelines are as under:

I. Pipelines of North-East India

(i) **Noonmati-Siliguri-Pipeline** to transport petroleum products from Noonmati to Siliguri. Lakwa-Rudrasagar-Barauni Pipeline, completed in 1968 to transport crude-oil from Lakwa and Rudrasagar (Sibsagar District, Assam) to Barauni Oil Refinery (Bihar). Barauni-Haldia Pipeline: This pipeline was laid down in 1966 to carry refined **petroleum products to Haldia port and bring back imported crude-oil to Barauni refinery.**

(iv) **Barauni-Kanpur Pipeline**: This pipeline was completed in 1966 to transport refined petroleum products to Kanpur city.

(v) **Noonmati-Bongaigaon Pipeline**: This pipeline was constructed to transport crude-oil to Bongaigaon petro-chemical complex.

(vi) **Haldia-Maurigram-Rajbandh Pipeline**: This pipeline was completed in 1998.

2. Pipelines of Western India Bombay-High Mumbai-Ankleshwar-Koyali Pipeline:

- This pipe-line connects the oilfields of Bombay High and Gujarat with the Koyali refinery of Gujarat.
- The city of Mumbai has been connected with a pipe line of 210 km length double pipeline to Bombay High to transport crude oil and natural gas.
- The Ankleshwar-Koyali pipeline was completed in 1965 to transport crude oil to Koyali refinery.

3. The Salaya-Koyali-Mathura Pipeline:

- This pipeline, 1075 km in length was laid down from Salaya (Gulf of Kachchh) to Koyali and Mathura via Viramgram to supply crude oil to the Mathura refinery.
- From Mathura, it has been extended to the oil-refinery at Panipat (Haryana) and Jalandhar in Punjab.
- It has an offshore terminal and the Sayala-Koyali sector of the pipeline was completed in 1978, while the Viramgram-Mathura sector was completed in 1981.

4. The Mathura-Delhi-Ambala-Jalandhar Pipeline:

- This 513 km long pipeline was constructed to transport refinery products of Mathura to the main cities of north and north-west India.

5. Pipelines of Gujarat:

- In Gujarat, there are a number of short distance pipelines to transport crude-oil and natural gas to the refineries and the refined products to the market.
- These include the Kalol-Sabarmati Crude Pipeline, the Nwagam-Kalol-Koyali Pipeline, the Cambay-Dhuravan Gas Pipeline, the Ankleshwar-Uttran Gas Pipeline, the Ankleshwar-Vadodara Gas Pipeline, and the Koyali-Ahmadabad products Pipeline .

6. Mumbai Pipelines:

- From Mumbai, pipelines have been laid up to Pune and Manmad to distribute petroleum products.

7. The Haldia-Kolkata Pipeline:

- Through this pipeline, the Haldia products are sent to Kolkata and neighbouring urban places.

8. The Hajira-Bijaipur-Jagdishpur (HBJ) Gas Pipeline:

- Having a length of 1750 km, this is the longest pipeline of India.
- crosses 75 big and small rivers and 29 railway crossings.
- laid down by the Gas Authority of India.
- connects Kavas (Gujarat), Anta (Rajasthan), Bijaipur (M.P.) and Jagdishpur (U.P.) and Auraiya (U.P.).
- provides gas to the fertiliser plants at Bijaipur, Sawai Madhopur, Jagdishpur, Shahjahanpur, Aonla, and Babrala. Each one of these fertiliser plants has the capacity to produce about 1400 tonnes of ammonia per day.

9. The Kandla-Bhatinda Pipeline:

- This pipeline transports imported crude-oil from the Kandla seaport to the Bhatinda refinery.

Hydro-Electricity in India

Some of the important multipurpose projects have been described in the following:

1. Bhakra Nangal Project:

- a joint venture of the Punjab, Haryana and Rajasthan governments.

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- Constructed across the Satluj river near Bhakra gorge, it is the high-est straightway gravity dam in the world.
- The dam is 518 m long and 226 m high. Its reservoir is known as the Gobind Sagar (named after Sikh Guru Gobind Singh, the tenth Guru of Sikhs).
- multipurpose project funded by the Central Government, built to generate electricity, provide irrigation, flood control, soil conservation, silt control, recreation, navigation; pisci-culture, pre-serving wild-life, and cattle rearing.

2. Damodar Valley Project:

- a tributary of the Hugli River.
- called the 'Sorrow of Bengal'.
- flows through Jharkhand and West Bengal.
- The Damodar Valley Corporation was established on February 18, 1948.
- Under this project, four dams were constructed namely, Tilaiya, Maithon, Konar, and Panchet Dams.

(i) Tilaiya Dam:

- constructed across the Barakar river.
- only concrete dam in the area.
- Two power stations of 2000 kW each have been set-up here.
- provides irrigation to forty thousand hectares of land.
- helped in the reduction of floods.
- completed in 1953.
- underground power station with installed capacity of 60,000 kW provides cheap power to the mica mines of Kodarma and Hazaribagh.

(ii) Konar Dam:

- constructed across the Konar river—a tributary of the Damodar River in the Hazaribagh District.
- completed in 1955.
- an earthen dam with concrete spill-way.
- provides cooling water to the Bokaro Steel Plant.
- The hydel station located near the dam generates about 40,000 kW of electricity.

(iii) Maithon Dam :

- Constructed across the Barakar river near the confluence of Barakar with Damodar river, it is a 56 m high dam.
- completed in 1958, provides irrigation to 50,000 hectares of arable land.
- The underground power station generates 60,000 kW of electricity.

(iv) Panchet Hill Dam:

- constructed across the Damodar river, about 20 km south of the Maithon Dam.
- 45 m high and 2545 m long.
- installed capacity of 40,000 kW.
- irrigates about 3 lakh hectares of agricultural land.

3. Dool Hasti:

- constructed across the Chenab river in the Doda district of the Jammu Division.

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- objective was to harness the water of Chenab river and to generate electricity to be supplied to the main cities of the state including the cities of Srinagar and Jammu.
- It was commissioned in 1986.

4. Gandhi Sagar:

- constructed across the Chambal river.
- The installed capacity of the Gandhi Sagar Dam is 115 MW.
- Five generators have been installed at Gandhi Sagar; four with a capacity of 2300 kW and one with a capacity of 2700 kW.
- providing power and irrigation to the surrounding regions of Rajasthan and Madhya Pradesh.

5. Hirakud Project:

- Constructed across the Mahanadi river, this project was funded by the Central Government.
- 14 km long dam, considered to be the longest in the world.
- involves the construction of three dams across Mahanadi, at Hirakud, Tikrapara, and Naraj.
- The Hirakud Project, according to recent study, has increased floods and droughts in the region.
- Due to increasing siltation, the storage capacity of the reservoir has been reduced, causing floods in the lower catchment area of the Mahanadi.

6. Nangal Project:

- constructed at Nangal, about 13 km downstream of the Bhakra-dam.
- is about 30 metres high, 305 m long, and 121 m wide.
- Its main function is to generate electricity. It also supplies water to the Bhakra canals.

7. Jawahar Sagar Dam:

- constructed to the north of Rana Pratap Dam in the state of Rajasthan.
- about 40 km to the north of the Rana Pratap Sagar.
- a multipurpose project constructed to generate electricity, control floods and provide irrigation water to the catchment area.

8. Kosi Project:

- called 'the 'Sorrow of Bihar', is an outcome of the joint agreement between the Nepali and Indian governments reached in 1954.
- main objective is to construct a barrage near Hanumannagar in Nepal, to built embankments on both the banks of the river to control floods, to construct canals for irrigation and to generate hydro-power.
- Kosi in July, 2008 shifted its course about 100 km towards east and caused great damage to life and property.

9. Koyna Project:

- a multi-purpose project in the Satara District of Maharashtra state.
- installed capacity is 880 MW.
- hydro-electricity is being supplied to the cities of Satara, Sholapur, Sangli, Kolhapur and Pune.

10. Machkund Project :

- a joint venture of the Andhra Pradesh and the Orissa states.
- The Machkund Dam is 54 m high and 410 m long.
- mainly a hydro-electric project which shall generate 115 MW electricity.

11. Mahi Project:

- constructed across the Mahi river which originates from the Vindhyan Hills of Madhya Pradesh.

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- The project on completion will generate 40 MW hydro-power and shall irrigate 80,000 hectares of agricultural land.

12. Mayurakshi Project:

- a tributary of the Hugh.
- rises from the Chotanagpur Plateau and flows through Jharkhand and West Bengal.
- a multipurpose project, generating 4000 kW of electricity and providing irrigation water to 3 lakh hectares.
- Electricity from this project is supplied to Murshidabad, Birbhum (West Bengal), and Santhal Pargana (Jharkhand).

13. Mettur Dam:

- built in 1937 across a tributary of the Kaveri river in the Nilgiris.
- capacity to produce 240 MW of hydro-electricity.
- not only generating electricity and providing irrigation water, but it has also helped in the flood control in the basin.

14. Nagarjun Sagar Project:

- constructed across the Krishna river in Nalgonda District of Andhra Pradesh.
- Its right and left bank canals have been named after Jawaharlal Nehru and Lal Bahadur Shastri respectively.
- generates 210 MW of hydro-electricity.
- supplied to Hyderabad, Khammam, Mahbubnagar, Nalgonda and Vijaiwada.

15. Pochampad Project:

- constructed across the Godavari river in Adilabad District.
- 115 km long canals irrigate about 2.5 lakh hectares in Adilabad, and Karimnagar districts of Andhra Pradesh.

16. The Periyar Project:

- Originating from the Cardamom Hills, Periyar is an important river of Kerala.
- A dam has been constructed across its course in hilly gorge.
- Its installed capacity is 140 MW.
- a multi-purpose project helping in the prevention of floods, soil erosion and generating electricity being supplied to Ernakulam, Kochi and neighbouring cities.

17. Rampad Sagar Dam:

- constructed in the lower reaches of the Godavari river, about 30 km to the north of Rajamundry.
- a multi-purpose project designed to check floods, to provide irrigation in the delta region of the river and to generate electricity.

18. Rana Pratap Sagar Dam:

- constructed across the Chambal river, about 25 km to the north of the Gandhi Sagar Dam in the Kota District of Rajasthan.
- a multipurpose project designed to generate electricity, to control floods and to provide irrigation water to the surrounding agricultural land.
- installed capacity is 99 MW

19. Rihand Project:

- Funded by the Central Government, it is the largest multi-purpose project of Uttar Pradesh.
- constructed across the Rihand river, a tributary of the Son river, near Pipri village in the Sonbhadra District.

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- The reservoir of this dam has been named after Gobind Ballabh Pant.
- connected with the Obra hydro-power station and the Obra thermal power plant located in its vicinity.
- The power generated from this project is supplied to eastern Uttar Pradesh, western Bihar and northern parts of Madhya Pradesh.
- Flood control in Son valley, control of soil erosion in Baghelkhand, tourism and pisci-culture are the other benefits from this project.

20. The Salal Project:

- constructed across the Chenab river in the Riasi District of Jammu Division of Jammu & Kashmir State.
- installed capacity of the project is 750 MW.
- inaugurated in 1986.
- The electricity is supplied to Riasi, Udampur, Jammu, and other neighbouring urban centres.

21. Sardar Sarovar Dam:

- constructed across the Narmada river near Navagaon.
- The project when completed, will generate 1450 MW of hydro-electricity and will irrigate about 18 lakh hectares of agricultural land.
- promote dairy farming, livestock keeping, animal husbandry and allied occupations.

22. Shivasamudram Dam:

- built in 1902 across the Kaveri river in Karnataka.
- The main objective of the project was to supply electricity to the Kolar Gold Mines, the city of Mysore and its neighbouring urban centres.
- helped in flood control and became a centre of tourists attraction.

23. Tawa Dam:

- constructed across the Tawa river; a left bank tributary of the Narmada river.
- a multipurpose project which has been designed to provide irrigation water to more than 50 thousand hectares and has the installed capacity to produce 150 MW hydro-electricity.

24. Tehri Dam:

- constructed across the Bhagirathi river just below the confluence of Bhagirathi and Bhilaganga in the Tehri District of Uttarakhand.
- Conceived by the Planning Commission in 1972, the work on the project was started in 1975.
- implemented with Soviet (Russian) technical and economic aid.
- provide irrigation to 2.74 lakh hectares in Uttarakhand and western Uttar Pradesh and will generate 1000 MW of hydro-electricity.
- Some serious objections were raised about this project as the environment and ecology may be adversely affected by this project which has been constructed in• a highly earthquake prone area of the country.

25. Tungbhadra Project:

- a right hand tributary of the Krishna river which originates from the Western Ghats (Sahayadri Hills) of the Chikmagalur district of Karnataka.
- constructed at Mallapuram near Hosepet in the Bellary District.
- Three power houses have been constructed in this project to generate 126 MW of electricity.
- irrigate more than 4 lakh hectares of arable land.

26. Ukai Dam:

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- a tributary of the Tapi river.
- launched mainly to harness the Tapi water.
- The installed capacity of the Ukai project is 300 MW.
- supplied to Surat and other neighbouring urban centres.

Thermal Electricity in India

Thermal electricity is produced with the help of coal, petroleum, and natural gas. About 65 per cent of the total electricity produced is thermal in character. The main advantages of thermal electricity are as under:

- (i) It can be generated in the areas not suitable for the generation of hydro-electricity.
- (ii) Coal, diesel and natural gas can be transported to the areas of isolation and relative isolation.
- (iii) It can be generated even when the weather is adverse.
- (iv) The gestation period of the thermal power stations is short.

India—Major Thermal Power Stations

1. Badarpur
2. Farakka (West Bengal)
3. Kahalgaon (Bihar)
4. Korba (Chhattisgarh)
5. National Capital Thermal Power Plant Dadri (U.P.)
6. Ramagundum (Andhra Pradesh)
7. Rihand /Obra (Uttar Pradesh)
8. Singrauli (Madhya Pradesh)
9. Talcher (Orissa)
10. Unchahar (Uttar Pradesh)
11. Vindhyachal (Madhya Pradesh)
12. Gas Based Projects:
 - i) Anta (Rajasthan)
 - (ii) Auraiya (Uttar Pradesh)
 - (iii) Kawas (Gujarat)

Nuclear Energy In India

It is produced from uranium and thorium.

India—Atomic Power Stations

Tarapur (Maharashtra), Rawatbhata Kota (Rajasthan), Kalpakkam (Tamil Nadu), Narora (U. P.) Kakrapar (Gujarat), Kaiga(Karnataka), Rawatbhata;Kota (Rajasthan) Tarapur (Maharashtra) Kaiga (Karnataka), Rawatbhata Kota (Rajasthan), Kudankulam (Tamil Nadu), Jaitapur Haripur. Kawada. Kumharia or Gorakhp Maithi-Verdi Bargi-Chutka

- At present, nuclear power constitutes only less than 4 per cent of the total energy production.
- It requires highly sophisticated technology and technical knowhow.
- Moreover, for the cooling of plant there is heavy need of fresh water.
- The Atomic Energy Institution at Trombay was established in 1954. renamed as the Bhabha Atomic Research Centre (BARC), in 1967.
- The first nuclear power station with a capacity of 320 MW was set up at Tarapur near Mumbai in 1969. Subsequently, the Rawatbhata Atomic Plant (300 MW) near Kota was set up in 1969

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which was followed by the establishment of Narora (1989), Kaiga (Karnataka), and Kakrapar in Gujarat in 1993.

NON-CONVENTIONAL ENERGY IN INDIA

- also called as renewable energy.
- include solar energy, wind energy, bio-mass energy, fuel-cells, electric vehicles, tidal energy, hydrogen energy, and geo-thermal energy.

Solar Energy

- most important sources of non-conventional energy.
- non-exhaustible, reliable, and pollution free.
- utilised for water heaters, power generation devices, air-conditioning, space heating, development of pisci-culture, and multifari-ous uses of water and refrigeration.
- average amount of solar energy received in the earth's atmosphere is about 1353 kW per sq metre.
- It is 1000 times the total consumption of the global energy.
- Being situated in the sub-tropical latitudes, India receives higher amount of solar energy.
- The greater part of the country has more than 300 solar days.
- The total amount of energy received from the Sun is about 5000 trillion kWh per year.
- The Solar Photovoltaic (SPV) technology enables the conversion of solar radiation into electricity without involving any moving part like turbine.
- Over 650,000 solar PV systems have been installed in the country.
- example is the Rural Energy Co-operative at Sagar Island in the Sundarban Delta of West Bengal.
- implemented in the other islands in the Bay of Bengal, the desert of Jodhpur (Rajasthan), Kalyanpur (Aligarh), and Coimbatore.

Wind Energy

- an important source of non-conventional energy.
- cheap, pollution free, eco-friendly and can be developed away from the sources of fossil fuels (conventional sources of energy).
- Since ancient times wind energy was utilised in sailing ships and wind mills.
- For the generation of wind energy, a wind speed of more than five km per hour is considered to be suitable.
- Wind speeds above 10 km per hour are prevalent over parts of the coastal regions of Gujarat, Andhra Pradesh, Karnataka, Madhya Pradesh, Rajasthan, Tamil Nadu, Maharashtra, Kerala, Orissa, West Bengal, Uttarakhand, Jammu & Kashmir, and Andaman and Nicobar Islands .
- The state of Rajasthan and Ladakh also record suitable consistency of wind speed.
- Wind mills can be operated there to harness wind energy..
- In India, the total potential of wind energy is estimated to be more than 20,000 MW.
- Wind energy projects have been implemented in 22 states of the country.
- The maximum potential of wind energy lies in the states of Gujarat and Tamil Nadu.
- Asia's largest wind farm of 28 MW capacity is located at Lamba in Gujarat.
- Commercial projects of 1200 MW capacity have been set up in Tamil Nadu, Gujarat, and Andhra Pradesh.

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- Tamil Nadu has the largest installation of wind turbines in the country in the Muppandal Perungudi area near Kanniyakumari. This is one of the largest concentrations of wind farm capacity at a single location anywhere in the world.
- A Centre of Wind Energy Technology has been set up in Chennai.
- The Wind Energy Estates are being set up in the joint sector or in private sector.

Ocean Energy

- The tidal waves and sea-waves are the main sources of ocean energy.
- India has a very long coastline, more than 6100 km, but the ocean energy production is limited. The suitable areas for the generation of tidal and sea-waves energy are:
 - (i) The Gulf of Khambat
 - (ii) The Gulf of Kachchh
 - (iii) The Estuary of Hugli

Geothermal Energy

- India has very limited potential of geothermal energy.
- the total geothermal energy is about 600 MW.
- There are 115 hot water springs in the country and 350 sites from which geothermal energy can be produced.
- The Puga Valley in Jammu and Kashmir, the Manikaran area in Himachal Pradesh, the western slopes of the Western Ghats in Maharashtra and Gujarat, the Narmada-Son Valley, and the Damodar Valley are the main areas which have potential for the generation of thermal energy.

Bio-Energy

- a clean source of energy which improves sanitation, hygiene and the living style of the rural population.
- The technique is based on the decomposition of organic matter in the absence of air to produce gas.
- used for cooking, and lighting fuel in specially designed stove and lamps respectively.
- India has a capacity to produce bio-gas to the extent of 25,000 million cubic metres.
- The left over digested slurry serves as manure.
- meet 50 per cent of the rural domestic fuel requirements.
- produce 7 million tonnes to nitrogen, 3 million tonnes phosphate, 5 million tonnes of potassium, and over 50 million tonnes of compost manure.
- Uttar Pradesh has the highest potential in bio-gas, followed by Madhya Pradesh, Andhra Pradesh, and Bihar.
- The highest production of bio-gas is, however, in the state of Maharashtra (74%) followed by Gujarat (62%) and Karnataka (45%).
- The development of bio-gas is adversely affected because of the non-availability of cattle dung, water, labour, space, and low temperatures in certain parts of the country, especially during the winter season.

Energy Crisis and Energy Conservation

- With the rapid growth of population and increase in the per capita income, there is an increasing demand for energy, especially that of conventional sources of energy.
- The consumption of energy in the country is increasing at the rate of more than 12 per cent per annum.

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- In the absence of energy, there are frequent power failures, load-shedding, closure of factories, etc., resulting in a decrease in industrial and agricultural production.
- In comparison to the developed countries, the per head consumption of electricity in the country is very low.
- For example, the per capita consumption of electricity in India is 350 kWh as against the world average of 1000 kWh and 7000 kWh in U.S.A.
- According to one estimate, the country's peak demand projected for 2010 is 175,500 MW against the actual installed capacity of 90,000 MW.
- This requires an additional installed capacity of 85,500 MW
- Since the coal resources are highly unequally distributed, the transportation cost of coal to the distant thermal power stations is quite expensive.
- Mismanagement of power sector, low efficiency of power houses, power theft, labour problem, pilferage, and power wastage are also aggravating the power crisis in the country.

ENERGY CONSERVATION

- The conventional sources of energy (fossil-fuel) are fixed and exhaustible and the non-conventional sources of energy are not adequately developed. Energy conservation is, how-ever, imperative for our survival and for the survival of the future generations.

Some of the steps which can go a long way in the conservation of energy are as under:

- (i) Emphasis on the development of non-conventional sources of energy. This will conserve the fossil fuels (coal, petroleum and natural gas).
- (ii) Reduction in the consumption of energy.
- (iii) Use of latest technology for cooking stoves and heating lamps.
- (iv) Privatisation of electricity.
- (v) Reduction in pilferages.
- (vi) Severe punishment for power theft.

All these steps, if taken collectively, can ease the power crisis substantially.

CHAPTER-9-AGRICULTURE

- domestication of plants and animals is known as agriculture.
- includes cultivation of crops, animal husbandry, horticulture, pisciculture, sericulture, silviculture, floriculture, etc.
- Being located in tropical and subtropical latitudes, the greater part of the agricultural land of India can produce two or more than two crops in a year.

CHARACTERISTICS AND PROBLEMS OF INDIAN AGRICULTURE

1. Subsistent in Character
2. Heavy Pressure of Population
3. Predominance of Food Grains
4. Mixed Cropping
5. High Percentage of the Reporting Area under Cultivation
6. Small Size of Holdings and Fragmentation of Fields
7. Limited Intensive Agriculture
8. Primitive Technology
9. Indian Agriculture is Labour Intensive
10. Rain-fed Agriculture
11. Less Area under Leguminous and Fodder Crops
12. Tradition Bound
13. Low Productivity
14. Government Policy
15. Lack of Definite Agricultural Land Use Policy
16. Lack of Marketing and Storage Facilities
17. Low Status of Agriculture in the Society
18. Land Tenancy
19. Poverty and Indebtedness of the Farmers
20. Inadequacy of Extension Service
21. Inadequate Agricultural Research and Education, Training, and Extension
22. Soil Erosion and Soil Degradation
23. Other Characteristics and Problems

DETERMINANTS OF AGRICULTURE

1. Physical factors: Terrain, topography, climate, and soil.
2. Institutional factors: Land-tenure, land tenancy, size of holdings, size of fields and land reforms.
3. Infrastructural factors: Irrigation, electricity, roads, credit and marketing, storage facilities, crop insurance and research.
4. Technological factors: High Yielding Varieties (new seeds), chemical fertilisers, insecticides, pesticides, and farm machinery.

Physical Factors:

(a) Terrain, Topography, and Altitude

- dependent on the geo-ecological conditions; terrain, topography, slope and altitude.
- paddy cultivation requires leveled fields, tea plantations perform well in the undulating topography in which water does not remain standing.
- Orchards of coconut are found at low altitudes, preferably closer to the sea level, while the apple orchards in the tropical and sub-tropical conditions perform well above 1500 metres above sea level.
- Cultivation of crops is rarely done 3500 m above sea-level in the tropical and sub-tropical latitudes.

- highly rarified air, low-pressure, low temperature, and shortage of oxygen at high altitudes are the serious impediments not only in the cultivation of crops, but also in keeping dairy cattle.
- soils of high mountainous tracts are generally immature which are also less conducive for agriculture.
- topographical features also affect the distribution of rainfall.
- the windward side gets more rainfall than the leeward side.
- Apart from altitude and aspects of slope, the nature of the surface also affects the agricultural activities.
- gullied land is least conducive for cropping.
- The Chambal ravines in Madhya Pradesh, Rajasthan, and Uttar Pradesh have put over thousands of hectares of good arable land out of agriculture.

(b) Climate

(i) Temperature:

- The crops to be grown, their patterns and combinations controlled by the temperature and precipitation conditions.
- each crop has a specific zero temperature below which it can not be grown.
- also an optimal temperature in which the crop is at its greatest vigour.
- For each stage of crop life, i.e. germination, foliation, blossoming or fructification a specific zero and optimum can be observed in temperature.
- The upper limit of temperature for plants growth is 60°C under high temperature conditions, i.e. at over 40°C, crops dry up, if the moisture supply is inadequate.
- In contrast to this, the chilling and freezing temperatures have a great adverse effect on the germination, growth and ripening of crops.
- Crops like rice, sugarcane, jute, cotton, chilli and tomatoes are killed or damaged at the occurrence of frost.
- minimum temperature for wheat and barley is 5°C, maize 10°C, and rice 20°C.
- impact of temperature on cropping patterns may be seen from the fact that the northern limit of the regions in which date-palm bear ripe fruit coincides almost exactly with the mean annual temperature of 19°C.
- essential factor in the limit of grape orchards seem to be temperature. Grapes ripen only in those countries in which the mean temperature from April to October exceeds 15° C.
- Crops like winter-wheat and barley perform well when the mean daily temperature ranges between 15°C and 25°C.
- tropical crops like cocoa, coffee, spices, squash, rubber and tobacco require over 18° C temperature even in the coldest months, while crops like wheat, gram, peas, lentil, potato, mustard, and rapeseed require a temperature of about 20°C during the growth and development, stage and relatively higher (over 25°C) during the sowing and harvesting periods.

(ii) Moisture:

- All crops need moisture.
- Take water and moisture from the soil.
- Available from the rains or from irrigation systems.
- Within wide temperature limits, moisture is more important than any other climatic factor in crop production.
- There are optimal moisture conditions for crop development just as there are optimal temperature conditions.
- Excessive amount of water in the soil alters various chemical and biological processes, limiting the amount of oxygen and increasing the formation of compounds that are toxic to plant roots.
- Excess of water in the soil, therefore, leads to stunted growth of plants.
- The problem of inadequate oxygen in the soil can be solved by drainage practices in an ill-drained tract. Heavy rainfall may directly damage plants or interfere with flowering and pollination.

- Cereal crops are often lodged by rain and this makes harvest difficult and promotes spoilage and diseases.
- Heavy rainfall at the maturity of wheat, gram, millets, oilseeds, and mustards cause loss of grains and fodder.
- Indian farmers all over the country have often suffered on account of failure of rains or fury of floods.

(iii) Drought:

- Devastating consequences on the crops, their yields and production.
- Soil drought has been described as a condition in which the amount of water needed for transpiration and direct evaporation exceeds the amount of water available in the soil.
- Damages the crops when plants are inadequately supplied with moisture from the soil.
- drought prone areas of India lie in the states of Rajasthan, Gujarat, Madhya Pradesh, Chhattisgarh, Jharkhand, Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu, Orissa, Bundelkhand (U.P.), Uttarakhand, H.P.J&K, south-west Punjab and Haryana.
- Where the average annual rainfall is less than 75 cm, agriculture is considered a gamble on monsoon.
- The incidence of drought and its intensity can be determined from the annual, seasonal and diurnal distribution of rainfall.
- drought prone areas of India, dry farming is practiced, while in the more rainfall recording regions, intensive agriculture of paddy crop is a common practice.

(iv) Snow:

- Occurrence of snow reduces the ground temperature which hinders the germination and growth of crops.
- Land under snow cannot be prepared for sowing because of permafrost.
- Melting of snow may cause hazardous floods in the summer season, affecting the crops, livestock, and land property adversely.

(v) Winds

- Have both, direct and indirect effects on crops.
- Direct winds result in the breaking of plant structure, dislodging of cereals, fodder and cash crops and shattering of seed-heads.
- Fruit and nut crops may be stripped from the trees in high winds.
- Small plants are sometimes completely covered by wind-blown dust or sand.
- The indirect effect of winds are in the form of transport of moisture and heat in the air.

(c) Soils

- Important determining physical factor.
- Determines the cropping patterns, their associations and production.
- Fertility of soil, its texture, structure and humus contents have a direct bearing on crops and their productivity.
- The alluvial soils are considered to be good for wheat, barley, gram, oilseeds, pulses, and sugarcane; while the clayey loam gives good crop of rice.
- Regur soil is known for cotton, and sandy soil for bajra, guar, pulses (green-gram, black-gram, red-gram, etc.).
- The saline and alkaline soils are useless from the agricultural point of view unless they are reclaimed by chemical fertilisers and biological manures and fertilisers.

Institutional Factors of Agriculture

(1) Land Tenure and Land Tenancy

(ii) Land Holding

LAND REFORMS IN INDIA

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- The basic objective of land reform is to do social justice with the tillers, land owners, landless labourers, and rural community with the set objective to provide security to the cultivators, to fix a rational rent, the conferment of title to the tiller and to increase the agricultural productivity.
- The entire concept of land reforms aims at the abolition of intermediaries and bringing the actual cultivator in direct contact with the state.

The scheme of land reforms includes:

- (i) abolition of intermediaries,
- (ii) land tenancy reforms, i.e. regulation of rent, security of tenure for tenants, and confirmation of ownership on them
- (iii) ceiling on land holdings and distribution of surplus land to landless labourers and small farmers,
- (iv) agrarian reorganization including consolidation of holdings and prevention of subdivision and fragmentation,
- (v) organisation of co-operative farms, and
- (vi) improvement in the system of land record keeping.

1. Abolition of Intermediaries

Mahalwari System

Ryotwari System

Tenancy Reforms

Rent Control

Ceiling of Landholdings

Consolidation of Holdings

- Consolidation of holdings means to bring together in compact block, all the fields of land of a farmer which are well scattered in different parts of the village.
- Under the scheme, all land in the village is first pooled into one compact block and it is divided into smaller blocks called chaks, and allotted to individual farmer.
- This is a useful scheme which helped in overcoming the problem of fragmentation of holdings.
- But unfortunately, the scheme has not been implemented in all the states of the country.
- There are many hurdles in the implementation of consolidation of holdings in some of the states.

Computerized Land Records

- The centrally sponsored scheme on computerization of land records was started in 1988-89.
- At present, the scheme has been implemented in 582 districts out of the 640 districts of the country, leaving those districts where there are no proper land records.

Crop Insurance in India

- Crop insurance was introduced by the government of India in 1985.
- It is operated through the General Insurance Corporation of the State Government.
- The Government of India in co-ordination with the General Insurance Corporation of India (GIC), had introduced a scheme called the National Agricultural Insurance Scheme from Rabi-1999-2000 season.

The main objectives of the crop insurance are:

- (i) to provide financial support to farmers in the event of crop failure on account of natural calamities,
- (ii) to enable farmers affected by a crop failure to restore their eligibility for fresh borrowing from the institutional credit institutions,
- (iii) to protect farmers against losses suffered by them due to crop failure on account of natural calamities, such as drought, flood, hailstorm, cyclone, fire, pest/diseases,
- (iv) to stimulate production of cereals, pulses and oilseeds.

Green Revolution in India

- A term coined to describe the emergence and diffusion of new seeds of cereals.

- Norman-e-Borlaug is the Father of Green Revolution in the world, while Dr. M.S. Swami Nathan is known as the Father of Green Revolution in India.
- The new cereals were the product of research work and concentrated plant breeding with the objective of creating High Yielding Varieties (HYVs) of use to the developing countries.
- New varieties of wheat were first bred in Mexico in the 1950s and that of rice, like IR-8 (miracle rice) at the International Rice Research Institute, Manila, (Philippines in the 1960s).
- The increase in the yield from the new seeds has been spectacular as during the last forty years, agricultural production, particularly of wheat and rice, has experienced a great spurt and this has been designated as the Green Revolution.
- The Green Revolution has been used to mean two different things. Some experts of agriculture use it for referring to a broad transformation of agricultural sector in the developing countries to reduce food shortages.
- Others use it when referring to the specific plant improvements, notably the development of HYVs.
- Whatsoever the meaning of Green Revolution may be taken as, the adoption and diffusion of new seeds of wheat and rice has been considered as a significant achievement as it offered great optimism.
- In fact, these varieties of seeds have revolutionised the agricultural landscape of the developing countries and the problem of food shortage has been reduced.
- In India, hybridisation of selected crops, i.e. maize, bajra (bulrush millets), and millets began in 1960.
- The Mexican dwarf varieties of wheat were tried out on a selected scale in 1963-64. Exotic varieties of rice such as Taichung Native I were introduced in India in 1964.
- The diffusion of HYVs, however, became fully operational in the country in the Kharif season of 1965-66.
- The diffusion of the new seeds was mainly in the Satluj-Ganga Plains and the Kaveri Delta.
- Subsequently, a number of varieties of wheat and rice were developed by the Indian scientists and adopted by the Indian farmers.

Merits of the High Yielding Varieties

The High Yielding Varieties have certain advantages over the traditional varieties of cereals which are given as under:

1. Shorter Life Cycle
2. Economize on Irrigation Water
3. Generate more Employment

Geographical Constraints in the Adoption of New Seeds

- The new seeds are less resistant to droughts and floods and need an efficient management of water, chemical fertilisers, insecticides and pesticides.

The conditions required for the good harvest of new seeds have been described below:

1. Irrigation

2. Availability of Chemical Fertilisers

3. Plant Protection Chemicals

- The new seeds are very delicate and highly susceptible to pests and diseases.
- The danger of pests and insects may be reduced by using plant protection chemicals.
- The problems of crop disease and pests may also be tackled by timely application of insecticides and pesticides

4. Capital Constraint

5. Mechanization

6. Marketing and Storage Facilities

7. Extension Service

8. Human Factor

Environmental and Ecological Implications of Green Revolution

- Some of the environmental and ecological problems that emerged out of the cultivation of the High Yielding Varieties are depletion of forests, reduction in pastures, salination, water-logging, depletion of underground water-table, soil erosion, change in the soil chemistry, reduction in bio-diversity, decline in soil fertility, silting of rivers, increase in weeds, emergence of numerous new plant diseases, and health hazards.
- An overview of these environmental and ecological problems has been given here.

1. Salination

- The saline and alkaline affected tracts, locally known as kallar or thur in Punjab and kallar or reh in Uttar Pradesh have expanded and increased in area.
- The problem of salinity and alkalinity can be solved by use of manure (cow dung, compost, and green manure) and by a judicious selection of leguminous crops in the rotation

2. Waterlogging

- Water logging is the other major problem associated with over-irrigation.
- The progressive and ambitious cultivators of the irrigated areas of these districts have changed their cropping patterns and have introduced rice and wheat in place of bajra, pulses, cotton, and fodder.
- Repeated irrigation of these crops in the summer and winter seasons have resulted into waterlogged condition, especially along the canals.

3. Soil erosion

4. Pollution:

5. Lowering of the Underground Water-Table:

6. Deforestation

7. Noise Pollution:

8. Health Hazards:

Green Revolution—Achievements, Problems and Prospects

Green Revolution—Achievements

The main achievements of Green Revolution may be summarized as under:

1. The production and productivity of wheat, rice, maize, and bajra has increased substantially.
2. India has become almost self-sufficient in the matter of staple foods.
3. The double cropped area has increased; thereby intensification of the Indian agriculture has increased.
4. In the areas where Green Revolution is a success, the farmers have moved from subsistent to market oriented economy, especially in Punjab, Haryana, western Uttar Pradesh, and the plain districts of Uttarakhand (Hardwar and Udhamasinghnagar).
5. The adoption of High Yielding Varieties under the Green Revolution has generated more rural and urban employment.
6. Green Revolution has increased the income of farmers and landless labourers, especially that of the big farmers and the semi-skilled rural workers. Thus Green Revolution has increased rural prosperity.
7. Green Revolution has created jobs in the areas of biological (seed fertilisers) innovations, and repair of agricultural equipments and machinery.

Green Revolution—Problems and Prospects

1. Depletion of soil owing to the continuous cultivation of soil exhaustive crops like rice and wheat.
2. Depletion of underground water table due to over-irrigation of more moisture requiring crops like rice and wheat.
3. Green Revolution has increased the income disparity amongst the farmers.
4. Green Revolution led to polarization of the rural society. It has created three types of conflicts in the rural community, namely, between large and small farmers, between owner and tenant farmers, between the employers

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and employees on agricultural farms.

5. Green Revolution has displaced the agricultural labourers, leading to rural unemployment. The mechanical innovations like tractors have displaced the agricultural labour.
6. Agricultural production in the Green Revolution areas is either stationary or has shown declining trend.
7. Some valuable agricultural lands have submerged under water (water-logging) or are adversely affected by salinity and alkalinity.
8. Green Revolution is crop specific. It could not perform well in the case pulses and oil-seeds.
9. The traditional institution of Jijmani system has broken. Consequently, the barbers, carpenters, iron-smith, and watermen have migrated to the urban areas.
10. The soil texture, structure, soil chemistry, and soil fertility have changed.
11. About 60 per cent of agricultural land in the country remains unaffected by Green Revolution.
12. Green Revolution technologies are scale neutral but not resource neutral.
13. Punjab feeds the nation but farmers in the state, especially in the Malwa region fall prey to cancer. The take 'Cancer Train' to Bikaner for cheap treatment.

WHITE REVOLUTION IN INDIA

- The package programme adopted to increase the production of milk is known as White Revolution in India.
- The White Revolution in India occurred in 1970, when the National Dairy Development Board (NDDB) was established to organize the dairy development through the co-operative societies.
- Prof. Varghese Kuerin was the father of White Revolution in India.
- The dairy development programme through co-operative societies was first established in the state of Gujarat.
- The co-operative societies were most successful in the Anand District of Gujarat. The co-operative societies are owned and managed by the milk producers.
- These co-operatives apart from financial help also provide consultancy.
- The increase in milk production has also been termed as Operation Flood.

Objectives

1. The procurement, transportation, storage of milk at the chilling plants.
2. Provide cattle feed.
3. Production of wide varieties of milk products and their marketing management.
4. Provide superior breeds of cattle (cows and buffaloes), health service, veterinary treatment, and artificial insemination facilities.
5. Provide extension service.

Achievements

- Some of the important achievements of the White Revolution are as under:
 1. The White Revolution made a sound impact on rural masses and encouraged them to take up dairying as a subsidiary occupation.
 2. India has become the leading producer of milk in the world.
 4. The import of milk and milk production has been reduced substantially.
 5. The small and marginal farmers and the landless labourers have been especially benefitted from the White Revolution.
 6. To ensure the success of Operation Flood Programme, research centres have been set up at Anand, Mehsana, and Palanpur (Banaskantha). Moreover, three regional centres are functioning at Siliguri, Jalandhar, and Erode. Presently, there are metro dairies in 10 metropolitan cities of the country, beside 40 plants with capacity to handle more than one lakh litres of milk.
 7. Livestock Insurance Scheme was approved in February 2006 and in 2006-07 on a pilot basis in 100 selected districts across the country. The scheme aims at protecting the farmers against losses due to untimely 2. In most of the villages the cattle are kept under unhygienic conditions. death of animals.
 8. To improve the quality of livestock, extensive cross breeding has been launched.

9. For ensuring the maintenance of disease-free status, major health schemes have been initiated.
10. The government implemented livestock insurance on pilot basis in 2005-06.

Problems and Prospects

1. Collection of milk from the remote areas is expensive, time consuming, and not viable economically.
2. In most of the villages the cattle are kept under unhygienic conditions.
3. There are inadequate marketing facilities. The marketing infrastructure needs much improvement.
4. The breeds of cattle is generally inferior.
5. The extension service programme is not effective.

AQUA CULTURE

- the cultivation of aquatic organisms.
- aquaculture, also known as aquafarming, implies the cultivation of aquatic populations under controlled conditions.
- Mariculture refers to aquaculture practiced in marine environments.
- Particular kinds of aquaculture include agriculture (the production of kelp, seaweed, and other algae), fish farming, shrimp farming, shellfish farming, and growing of cultured pearls.

Growth and Development of Aquaculture

- has been used in China since circa 2500 BC.
- practice of aquaculture gained prevalence in Europe during the Middle Ages since fish were scarce and thus expensive.
- Americans were rarely involved in aquaculture until the late 20th century but California residents harvested wild kelp and made legal efforts to manage the supply starting circa 1900, later even producing it as a wartime resource.
- the rise of aquaculture is a contemporary phenomenon.

Types of Aquaculture

1. Algaculture

- A form of aquaculture involving the farming of species of algae.
- Majority of algae are intentionally cultivated fall into the category of microalgae, also referred to as phytoplankton, microphytes, or planktonic algae.
- Macro algae, commonly known as seaweed, also have many commercial and industrial uses, but due to their size and the specific requirements of the environment in which they need to grow, they do not lend themselves as readily to cultivation on a large scale as microalgae and are most often harvested wild from the ocean.

2. Fish Farming

- The principal form of aquaculture, while other methods may fall under mariculture.
- Involves raising fish commercially in tanks or enclosures, usually for food.
- Fish species raised by fish farms include salmon, catfish, tilapia, cod, carp, trout, and others.
- Increasing demands on wild fisheries by commercial fishing operations have caused widespread overfishing.
- Offers an alternative solution to the increasing market demand for fish and fish protein.

3. Freshwater Prawn Farming

- An aquaculture business designed to raise and produce freshwater prawn or shrimp for human consumption.
- Shares many characteristics with, and many of the same problems as, marine shrimp farming.
- Unique problems are introduced by the development life cycle of the main species (the giant river prawn, *Macrobrachium rosenbergi*).

4. Integrated Multi-Trophic Aquaculture

- A practice in which the by- products (wastes) from one species are recycled to become inputs (fertilisers, food) for another.
- Fed aquaculture (e.g. fish, shrimp) is combined with inorganic extractive (e.g. seaweed) and organic extractive (e.g. shellfish) aquaculture to create balanced systems for environmental sustainability (biomitigation), economic stability (product diversification and risk reduction), and social acceptability (better management practices).

5. Mariculture

- a specialised branch of aquaculture involving the cultivation of marine organisms for food and other products in the open ocean, an enclosed section of the ocean, or in tanks, ponds or raceways which are filled with seawater.
- the farming of marine fish, prawns, or oysters in saltwater ponds.
- Non-food products produced by mariculture include fish meal, nutrient agar, jewellerys (e.g. cultured pearls), and cosmetics.

6. Shrimp Farming

- an aquaculture for the cultivation of marine shrimp for human consumption.
- Commercial shrimp farming began in the 1970s, and production grew steeply, particularly to match the market demands of the US, Japan, and Western Europe.
- About 75% of farmed shrimp is produced in Asia, in particular in China and Thailand.
- The other 25% is produced mainly in Latin America, where Brazil is the largest producer.
- The largest exporting nation is Thailand.
- Shrimp farming on modern lines is being done in Andhra Pradesh (Nellore District), a state of India (see Blue Revolution)

Strategies for the Fisheries Development

- Under the Jawahar Rozgar Yojna, village panchayats have been authorised to carry out fisheries development programmes in respective villages.
- Under the programme of Development of Model Fishermen Villages, basic civic amenities such as housing, drinking water and construction of community halls for fishermen villages are provided.
- Brackish Fish Farmers Development Agencies (BFDA) functioning in the coastal areas of the country is providing a package of technical, financial and extension support to shrimp farmers.
- Insurance facilities have been extended to fishermen for the insurance and security of their life.
- The government is collecting data on the micro-climates of various water bodies to promote fisheries in the country.

Problems and Prospects

1. Most of the fishermen are poor. They are not able to purchase good equipment to improve the harvest of fish.
2. The water bodies (rivers, lakes, ponds, and coastal areas of the seas) are increasingly polluted.
3. The area of paddy fields in which fisheries used to be kept is also decreasing under the impact of fast growth of population, industrialisation, and urbanisation.
4. Adequate information about the environment of water-bodies (ponds, lakes, rivers, and sea is not available).
5. Unpredictable nature of monsoon as a result of which the inland fisheries suffer adversely.
6. Problem of marketing, storage, and transportation.

7. Inadequacy of research and extension service facilities.

8. There is need of Pink Revolution (Prawns) in the coastal regions of the country.

BLUE REVOLUTION IN INDIA

- the adoption of a package programme to increase the production of fish and marine products.
- started in 1970 during the Fifth Five-Year Plan when the Central Government sponsored the **Fish Farmers Development Agency (FFDA)**.
- Subsequently, the Brakish Water Fish Farms Development Agency were set up to develop aquaculture.
- brought improvement in aquaculture by adopting new techniques of fish breeding, fish rearing, fish marketing, and fish export.
- tremendous increase in the production of shrimp. Andhra Pradesh and Tamil Nadu have developed shrimp in a big way.
- The Nellore District of Andhra Pradesh is known as the 'Shrimp Capital of India'.
- There are more than 1800 species of fish found in the sea and inland waters of India, of which a very few are commercially important.
- important sea fish include catfish, herring, mackerels, perches, mullets, Indian salmon, shell fish, eels, anchovies, and dorab.
- the main fresh water fish include catfish, loaches, perches, eels, herrings, feather backs, mullets, carps, prawns, murels, and anchovies.
- Marine fisheries contribute about 50 per cent of the total fish production of the country.
- Kerala is the leading producer followed by Maharashtra, Karnataka, Gujarat, and Goa.
- The fishing season extends from September to March.
- The higher fish production in the Arabian Sea is due to the broader continental shelf.
- The important fish varieties include sardines, mackerel and prawn.
- The East Coast contributes about 28 per cent of the total production of marine fish in the country.
- The fishing activity along the East coast is mainly carried on from Rameswaram in the south to Ganjam in the north, with fishing season from September to April along the Coromandal Coast.
- The National Fisheries Development Board has been set up to realize the untapped potential of fishery sector with the application of modern tools of research and development including biotechnology.

SECOND GREEN REVOLUTION

- The main objectives of the second Green Revolution are: (i) To raise agricultural productivity to promote food security (ii) More emphasis on bio-technology (iii) To promote sustainable agriculture (iv) To become self-sufficient in staple food, pulses, oil seeds, and industrial raw material (v) To increase the per capita income of the farmers and to raise their standard of living.

The Eleventh Five-Year Plan has aptly highlighted such a holistic framework and suggested the following strategy to raise agricultural output:

1. Doubling the rate of growth of irrigated area.
2. Improving water management, rainwater harvesting, and watershed development.
3. Reclaiming degraded land and focusing on soil quality.
4. Bridging the knowledge gap through effective extension.
5. Diversifying into high value outputs, e.g. fruits, vegetables, flowers, herbs and spices, medicinal plants, bamboo, bio-diesel, but with adequate measures to ensure food security.
6. Providing easy access to credit at affordable rate of interest.
7. Improving the incentive structure and functioning of markets, and
8. Refocusing on land reforms issues
9. Laying emphasis on the cultivation of pulses. With the limited availability of pulses overseas, development of

hybrid varieties becomes a pre-requisite for increasing domestic production.

10. Focusing on the development of area specific seeds and their application.

11. Attention has to be focused on areas such as rainfed, drought-prone crops, and drought resistant crops, and those amenable to biotechnological application.

- The National Commission on Farmers has already laid the foundation for such a framework.
- Moreover, the National Agricultural Innovation Project initiated in July, 2006, for enhancing livelihood security in partnership mode with farmers' groups, Panchayati-Raj institution and private sector would go a long way in strengthening basic and strategic research in frontier agricultural sciences.

Types of Beekeepers

Beekeepers generally categorize themselves as:

- Commercial beekeeper—Beekeeping is the primary source of income.
- Sideline—Beekeeping is a secondary source of income.
- Hobbyist—Beekeeping is not a significant source of income.

The Colony of Bees

- A colony of bees consists of three classes of bee: a queen, which is normally the only breeding female in the colony; a large number of female worker bees, typically 30,000-50,000 in number; and a large number of male drones—ranging from thousands in a strong hive in spring to very few during death or cold season

SERICULTURE IN INDIA

Production

- Silkworm larvae are fed on mulberry leaves and after the fourth molt, they climb a twig placed near them and spin their silken cocoons.
- The silk is a continuous-filament fibre consisting of fibroin protein, secreted from two salivary glands in the head of each larva, and a gum called sericin, which cements the two filament together.
- The sericin is removed by placing the cocoons in hot water, which frees silk filaments and readies them for reeling.
- The immersion of cocoons in hot water also kills the silkworm larvae.
- In India, silk worms thrive on the leaves of mulberry, mahua, sal, ber, and kusum trees. India ranks third among the silk producing countries of the world.
- Silk production is mainly confined to areas between 15° and 34° N latitudes.
- The state of Karnataka is the largest producer of raw silk (65%) followed by Andhra Pradesh (17%) West Bengal (8%), Tamil Nadu (5%), and Assam (3%).

POULTRY FARMING (SILVER REVOLUTION) IN INDIA

- practice of raising poultry, such as chickens, turkeys, ducks, geese, as a subcategory of animal husbandry, for the purpose of farming meat or eggs for food.
- requires small capital and provides additional income and job opportunities to a large number of rural population in the shortest possible time.
- The vast majority of poultry are farmed using factory farming techniques.
- The contrasting method of poultry farming in free range and friction between the two main methods, has led to long term issues of ethical consumerism.

- Opponents of the factory farming argue that it harms the environment and creates health risks, as well as abuses animals.
- In contrast, proponents of factory farming highlight its increased productivity, stating that the animals are looked after in state-of-the art confinement facilities and are happy; that it is needed to feed the growing global human population; and that it protects the environment.

Poultry Farming in India

- Poultry farming in India is quite old.
- At present, more than three million people are directly or indirectly employed in poultry farming.
- Further, landless labourers derive more than 50 per cent of their income from livestock, especially poultry.
- Uninterrupted supplies of feed as well as avian influenza are critical for the continued robust growth of the poultry sector.
- The first outbreak of avian influenza occurred in India in the state of Maharashtra in the Nandurbar district on 18th Feb. 2006.
- The Central Poultry Development Organisation has been playing a pivotal role in the implementation of the policies of the Government with respect to poultry as a tool for alleviating nutritional hunger and palliating the impecuniosity's of the resource-poor farmers, especially the women.
- The mandate of the Central Poultry Development Organisation has been specifically revised, by restructuring all poultry units of this Department to focus on improved indigenous birds, which lay on an average 180-200 eggs per annum and have a vastly improved FCR ratio in terms of feed consumption and weight gain.
- The Central Poultry Development Organisations have been entrusted with the responsibility of producing excellent germplasm in the form of day-old chicks and hatching eggs of these varieties like Nierbheek, Hitkari, Vanaraja, Shyama, Cari, Chabro, etc.
- Besides, these organisations are also playing a crucial role in analysing feed samples.
- A new Centrally-sponsored scheme called Assistance to State Poultry, is being implemented during the Tenth Plan where one time assistance is provided to suitably strengthen the farms in terms of hatching, brooding, and rearing of birds with provision for feed mill and their quality monitoring and in-house disease diagnostic facilities.
- A new scheme, Dairy/Poultry Venture Capital Fund, has been launched during the 2004-05, wherein there is a provision to grant subsidy on interest payment.
- The nodal agency for the implementation of this scheme is NABARD through nationalized commercial bank.

DRY FARMING IN INDIA

- The spread in the regions where the average annual rainfall is less than 75 cm.
- rainfall is scanty and uncertain, where hot and dry conditions prevail.
- It is not only that the average annual rainfall is low, the variability of rainfall in these areas varies between 25 to 60 per cent.
- Agriculture belongs to fragile, high risking and low productive agricultural ecosystem.
- The areas in which more than 75 cm of average annual rainfall is recorded are known as the areas of rain-fed agriculture.
- In India dry-lands cover about 32 million hectares or about 25 per cent of the total arable land.
- The dry farming areas cover the greater parts of Rajasthan and Gujarat. Moreover, there are small tracts of dry land farming in Punjab, Haryana, Maharashtra, Andhra Pradesh, Karnataka, Himachal Pradesh, Jammu and Kashmir, harkhand, Orissa, Uttarakhand, Uttar Pradesh, West Bengal and Tamil Nadu.
- These areas having scanty rainfall and high variability of rainfall are adversely affected by erratic precipitation, frequent droughts, high temperature, and high wind velocity resulting in soil erosion.

Significant Features of Dry Farming

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- Moisture conservation is basic to dry farming. In order to achieve this objective, the field is ploughed repeatedly, especially during the rainy season.
- Sowing of crops in alternate years or fallowing of land after each harvesting of crop. The fallowing of agricultural land helps in the recuperation of soil fertility.
- Pulverisation of the soil before sowing.
- Regular hoeing and weeding of the crop. Hoeing is generally done before sun-rise so that the night dew may be mixed into the soil to provide moisture to the crops.
- Covering of the land with straw to prevent evaporation of the soil moisture and to control soil erosion.
- Livestock keeping and dairying are also important allied agricultural activities in the dry farming regions.

Crops

- The main crops grown in the dry farming areas are coarse, grains (maize, millets, bajra), pulses, groundnut, oilseeds and fodder.
- Though 75 per cent of the total population of dry-farming regions are directly or indirectly dependent on agriculture, their per capita income, and standard of living are significantly low.

Main Problems of Dry Farming

The main problems of dry farming agriculture are as under:

1. Scarcity of precipitation, erratic occurrence of rains leading to famines, droughts, and floods.
2. The soils, being sandy, lack in humus and organic nutrients.
3. The dry farming areas are highly vulnerable to soil erosion.
4. These are low yields per unit area.
5. In the absence of moisture and irrigation, the use of High Yielding Varieties and new technology is not possible.
6. Most of the farmers in the dry farming regions being poor are not able to apply the new costly inputs.
7. These areas are not having the basic irrigation and other infrastructural facilities, like roads, marketing and storage

Strategy for Development

As stated earlier, agriculture is a highly vulnerable occupation in the scanty rainfall recording areas in which dry farming is practiced.

1. In dry farming areas, water harvesting should be done. The government and other non-government agencies should provide the necessary guidance to the people.
2. Seeds of food crops which are drought resistant should be provided to the farmers at a subsidized rate.
3. Efforts should be made to check soil erosion by adopting soil conservation practices.
4. The farmers should space their crops at a wide gap and there should be regular weeding and hoeing.
5. Seeds of the quick and short duration maturing crops should be developed.
6. Cultivation of crops requiring more moisture should be done in the low lying areas, especially in the lower parts of the catchment.
7. Cotton should be grown only in the areas where rainfall is more dependable or sprinkle irrigation is available.
8. Soil fertility should be enhanced by applying cow dung and compost manures.
9. Repeated tilling of the field is required during the rainy season.
10. Research should be promoted in the dry land farming.

AGRIBUSINESS IN INDIA

- agriculture for commercial purpose.
- Johnston and colleagues have defined agri-business as farming organisation applying modern management techniques and accounting methods with the aim of maximising final profit.
- applied differently in USA and Western Europe.
- In USA, agribusiness has grown as a result of increased involvement by food processing companies in the actual production of their own raw material inputs.

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- Such companies have purchased farms and run them as subsidiary elements within their overall production system, while in Western Europe such integration of farm production with processing is less common.
- In Western Europe and also in some developing countries like India, agribusiness constitutes large farming companies independent of food processors.
- More specifically, that part of modern national economy devoted to production, processing, and distribution of food and fibre products and by-products falls under the category of Agribusiness.

Characteristics of Agribusiness

Agribusiness essentially has the following characteristics:

1. Hierarchical system of management—financial administrators and accountants with farm managers to carry out day-to-day business
2. Large farms
3. Farming operations organized in sizeable production units
4. An extension of the plantation system

NATIONAL COMMISSION ON FARMERS

The National Commission on Farmers (NCF) chaired by Dr. M.S. Swaminathan gave the following recommendations to improve the conditions of farmers. The recommendations include:

1. Assess reforms covering land, water, livestock, and bio-resources
2. Farmer-friendly support services covering extension, training and knowledge
3. Credit and insurance
4. Assured and remunerative marketing
5. Inputs and delivery services
6. Bringing agriculture in Concurrent List of the Constitution
7. Setting up of a National Food Security and Sovereignty Board
8. Universalization of Public Distribution System
9. Setting up of an India Trade Organisation
10. Launch of a Rural-Non-farm Livelihood Initiative (when implemented would be able to absorb higher number of people dependent on agriculture)

INDIAN AGRICULTURE—CHALLENGES AND PROSPECTS

Some of the important challenges Indian agriculture is facing at present are given below:

1. Stunted Yield:
2. Dry Farming:
3. Inadequate Marketing Facilities:
4. Inadequate Formal Sources of Credit:
5. Mismanagement of Public Distribution System:
6. Sustainability of Agriculture:
7. Soil Erosion:

NEW NATIONAL AGRICULTURAL POLICY

The Government of India announced the new agricultural policy on 25th July, 2000. The aim of the new policy is to achieve the target of 4 per cent per annum growth in agriculture. The main features of the policy are as follows:

- (i) Efficient use of resources and technology.
- (ii) Timely and adequate credit is to be provided to farmers.
- (iii) Private sector investment in agriculture would be encouraged.
- (iv) To protect the farmers against the adverse effects of implementation of WTO agreement.
- (v) To protect the farmers against fluctuations in agricultural prices.
- (vi) The restrictions on the movement of agricultural commodities throughout the country would be removed.
- (vii) Excise duties on agricultural machinery, fertilizers, etc. will be reduced.

(viii) Package insurance policy for the farmers.

(ix) Rural electrification, rural roads and development of irrigation to be encouraged.

(X) Strengthening agriculture marketing infrastructure.

(xi) Focus on horticulture, floriculture, animal husbandary and fisheries.

(xi) Remunerative prices for agricultural products.

CHAPTER-10-SPATIAL ORGANISATION OF AGRICULTURE

CROPPING PATTERNS

- means the proportion of area under different crops at a given point of time.
- The crop statistics published by the government are used to denote the cropping patterns.
- however, a dynamic concept as it changes in space and time.
- closely influenced by the geo-climatic, socioeconomic, and political factors.
- The physical environment (physiography, climate, soils, water, etc.) imposes limits on the growth and distribution of plants and animals.
- The cultivation of rice in Punjab, Haryana, and Ganganagar District (Rajasthan) testifies this fact.
- different parts of the world, the physical environment reduces the choice of crops, either by prohibiting the growth of certain crops or by reducing their yield per unit area.
- Depending on the geo-ecological conditions and availability of irrigation, the cropping patterns vary from region to region.
- In those regions where the physical diversity is less, the cropping patterns are less diversified and vice versa.
- For example, in the rainfall deficient areas of Rajasthan (Thar Desert) the farmers grow bajra (bulrush-millet), while in the fertile valley of Brahmaputra, rice has the status of monoculture.
- Contrary to this the soils of the Indo-Gangetic plains are suitable for the cultivation of numerous crops. In addition to physical environment, the land ownership, the land tenancy, land tenure, size of holding and fields also influence the cropping patterns.
- A farmer with small holding prefer the cultivation of labour intensive crop, while a large holding farmer goes for the capital intensive agricultural practices.
- affected by the infrastructural, institutional and technological factors
- determined on the basis of area strength of individual crop.
- The first, second and third ranking crops of an areal unit may be called as the dominant crops of that unit.
- These crops, if occupying more or less the same percentage of the total cropped area, shall be competing with each other and the farmer will decide which crop may fetch him more profit.
- In general, for the demarcation of cropping patterns of a region, the minor crops (crops occupying less than one per cent of the total cropped area) are ignored.

The area under each crop in a given region may be classified under the following four categories:

- (i) High yield, high spread
- (ii) High yield, low spread
- (iii) Low yield, high spread
- (iv) Low yield, low spread
- On the availability of an alternative, more efficient crop than the existing ones is preferred which leads to new cropping patterns.
- The cropping patterns may be intensified with the help of short duration High Yielding Varieties.
- Any cropping sequence to be adopted by the cultivator, however, should be flexible.
- The suitability of a crop and cropping pattern may be judged on the basis of the following:
 1. The crop should not accentuate certain diseases as a result of a fixed continuous rotation.
 2. The crop should not exhaust on some plant specific nutrients from a particular part of the soil.
 3. The crop should be fertility-building and soil-improving.
 4. The crop should fetch handsome return to the cultivator and should provide the cultivator employment all the year round.
 5. The crop should ensure the optimum utilisation of his resources, particularly inputs like irrigation water, chemical fertilisers, insecticides, pesticides, equipments, power and family labour.
- Excluding the areas where Green Revolution is a big success and the areas in which plantation agriculture is being done, Indian farming by and large is subsistence type in character.
- Consequently food crops occupy over 72 per cent of the total cropped area.
- Among the cereals, rice and wheat rank first and second in area respectively.
- The subsistent cropping patterns of India are based on the utilisation of inherent fertility of the soil without much use of modern inputs and technology.
- The importance of adoption of suitable cropping patterns in a developing country like India cannot be over emphasised.

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- The horizontal expansion of agriculture in India is not possible without heavy investment in reclaiming the wasteland for agriculture.
- Only a judicious utilisation of the available agricultural land by adopting more remunerative cropping patterns, scientific rotation of crops and multiple cropping may help in overcoming the problems of shortage of food and agricultural raw materials in the country.
- A change in the cropping pattern and scientific rotation of crops are imperative to make agriculture more remunerative and sustainable.

CROP CONCENTRATION

- the variation in the density of any crop in a region at a given point of time.
- depends on its terrain, climate, and soils and agricultural practices of the farmers.
- Each crop has a maximum, minimum and optimal temperature.
- The crops have a tendency to have high concentration in the areas of ideal agro-climatic conditions and the density declines as the geographical conditions become less conducive.
- It is because of these factors that rice has high concentration in east Indian states, wheat in Punjab and Haryana, cotton in black earth region, and Bajra in Rajasthan.
- A number of statistical techniques have been used by agricultural geographers for the demarcation of crop concentration regions.
- The location quotient method is, however, more reliable as it gives a reliable picture of the relative density of crops.

AGRICULTURAL PRODUCTIVITY

- a synonym for agricultural efficiency.
- The yield per unit area is known as agricultural productivity.
- generally the result of the physical, socio-economic, and cultural factors. It is also affected by the managerial skill of the farmer.
- a dynamic concept which changes in space and time.
- closely influenced by a number of physical (physiography, terrain, climate, soils, and water), socioeconomic, infrastructural institutional, and organisational factors.
- depends on the managerial skill of the farmer, his attitude, and aspirations for the better standard of living.
- The delineation of agricultural productivity has great significance in the planning of agriculture of a region. The main advantages are:
 - (i) It helps in ascertaining the relative productivity of the component areal units of a region.
 - (ii) It helps in identifying the weaker areas which are lagging behind in agricultural productivity.
 - (iii) The existing patterns of agricultural productivity is a reliable index to assess the agricultural development of the past.
 - (iv) It provides a sound base for the agricultural development planning.
- Agricultural geographers and economists have developed a number of methods for the measurement of agricultural productivity. Some of the important methods used by the geographers are given as under:
 1. Output per unit area.
 2. Production per unit of farm labour.
 3. Agricultural production as grain equivalent (Buck, 1967).
 4. Input-output ratio (Khusro, 1964).
 5. Ranking Coefficient Method (Kendall, 1939, Stamp, 1960).
 6. Carrying capacity of land in terms of population (Stamp 1958).
 7. Determining a productivity index on the basis of area and yield (Enyedi, 1964, Shafi 1972).
 8. Determining an index of productivity with the help of area and production under various crops in the areal units and converting them in a uniform scale.
 9. Converting total production in terms of money (Husain, 1976)
 10. To assess the net income in Rupees per hectare of the cropped area (Jasbir Singh, 1985).
 11. Assessing net income (farm business income) in Rupees per hectare of cropped area or per adult male unit of farm work-force (Tiwari, Roy, and Srivastava, 1997).

Each of the methods and techniques adopted by the agricultural geographers has its own merits and demerits. None of the techniques, however, gives satisfactory results at the national and/or global level. Some of the techniques are cumbersome and time-consuming to apply for the delineation of agricultural productivity regions.

High Agricultural Productivity

- found in the Satluj-Ganga Plain, the Brahmaputra Valley, the delta regions of Godavari, Krishna, and Kaveri rivers.
- the irrigation facilities are well developed or there is adequacy of rainfall over greater part of the year.
- Wheat, rice, maize, pulses, sugarcane, and oilseeds are the main crops grown in the high agricultural productivity regions.
- The farmers, especially that of Punjab, Haryana, and western Uttar Pradesh are no longer subsistent as most of them are doing agriculture as agri-business.

Medium Agricultural Productivity

- found in scattered areas and in isolated patches in Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Madhya Pradesh, Orissa, parts of Rajasthan, Tamil Nadu, and West Bengal.
- the irrigation facilities are not well developed and the double cropped area varies between 5 and 20 per cent.
- main crops of the regions in which medium productivity is found are rice, wheat, coarse grains (millets), pulses, and oilseeds.
- The agriculture in these regions is mainly subsistent.
- Non-availability of irrigation is a major barrier in the enhancement of agricultural productivity.

Low Agricultural Productivity

- The state of Jharkhand, Chhattisgarh, parts of Madhya Pradesh, Andhra Pradesh, Gujarat, Maharashtra, Rajasthan, parts of Kerala, Jammu & Kashmir, hilly areas of Uttarakhand, western Rajasthan, northern Gujarat, and the north-eastern hill states have low agricultural productivity.
- deficient in irrigation and characterised with low rainfall conditions.
- areas are susceptible to droughts or floods, and are the less rainfall recording areas.
- main crops of these areas are rice, maize, coarse grains, pulses, and oilseeds.
- The intensification of agriculture in these states is low.
- Agriculture is mainly rain-fed practiced to meet the family requirements.
- It is in these areas where the agrarian community is generally at a low level of subsistence and many of them are committing suicides.
- Special programmes need to be launched to enhance the agricultural productivity of the farmers of these regions.

Very Low Agricultural Productivity

- The areas of very low agricultural productivity sprawl over greater parts of Rajasthan, Jharkhand, and Chhattisgarh.
- The main cause of very low agricultural productivity are either high rainfall variability or poverty and illiteracy of the farmers.

LAND CAPABILITY

- Land capability survey was devised by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) for the demarcation of land capability regions of Australia.
- widely applied in the European and Anglo-American countries and in some of the Third World countries.
- helps in ascertaining the usefulness of land, its utility for agriculture, forest, industry, tourism, and other land use purposes.
- For the delineation of land capability regions, only physical parameters are taken into consideration.
- The demarcation of these regions in fact is on the basis of texture, structure of soil, terrain, slope, run-off, temperature, and precipitation.
- a heavy reliance on the results of soil survey and pedological conditions.
- In general each soil group has its own physical and chemical properties.
- These properties determine the land capability and land suitability.
- For example, the regur soil is good for the cultivation of cotton, sugarcane, and citrus fruits, while the alluvial soil is utilised for wheat, rice, maize, sugarcane, pulses, and oilseeds
- In India, the basic objective of the Soil Survey was to achieve the land capability classification.
- The All India Soil and Land Use Survey Organisation attempted the land capability survey in 1960 which identified eight land use capability classes given below :

Land Suitable for Cultivation

Class I:• Very good arable land with no specific difficulty in farming.

Class II:• Good cultivable land which needs protection from erosion or floods, drainage improvement and conservation of

irrigation water.

Class III: Moderately good cultivable land where special attention has to be paid to erosion control, conservation of irrigation water, intensive drainage, and protection from floods.

Class IV: Fairly good land suited for occasional or limited cultivation. It needs intensive erosion control, intensive drainage and very intensive treatment to overcome the soil limitations.

Land not Suitable for Cultivation

Class V:• Very well suited for grazing and forestry but not for cultivation of crops. It has a very good carrying capacity of livestock but needs protection from gullying.

Class VI:• Well suited for grazing and forestry but not for cultivation of crops. It has a moderate carrying capacity of livestock.

Class VII:• Fairly well suited for grazing or forestry with little carrying capacity of livestock. Class VIII:• Suited only for wildlife.

CONTRACT FARMING

- a method to maximise profit in dealing with agricultural products.
- In this system, a company enters into a written contract with farmer/farmers with the following objectives:

A. To produce a given volume of produce, of specified quality, and that the company will purchase the produce on an agreed price. So briefly, it can be said that marketing enters into contract with production. The company after making the purchase, freezes, dehydrates, and starts canning operation. Sometimes the companies enter into contracts with co-operatives. In contract farming, the major items are fruits, vegetables, flowers and poultry.

B. The farmers gain certain advantages which are briefly given below:

- (i) The sale of their produce is assured.
- (ii) They earn higher price than the price in the open market.
- (iii) The capital requirements of the farmers are reduced as the contract often agreed for advance payment.
- (iv) Very often, the companies also provide specialised knowledge and expertise. Contract farming also leads to certain disadvantages:
 - (i) If a farmer has produced quality products, he could get a higher price than offered by the contracts in the open market.
 - (ii) The farmer acts mechanically and loses his independent status.
 - (iii) The bargaining power is tilted in favour of companies as they are financially more powerful

AGRICULTURAL REGIONALISATION

- Region is one of the basic concepts in geography.
- 'an area that is differentiated from other areas according to a specific criteria.'
- 'region is a differentiated segment of the earth surface. (Whittlesey, 1936)
- an uninterrupted area having some kind of homogeneity with specifically defined outer limit.
- an area which depicts homogeneity in respect of agricultural land use, agricultural practices, and cropping patterns.
- in fact, is a device for selecting and investigating regional groupings of the complex agricultural phenomena found on the earth's surface.
- any segment or portion of the earth surface possessing a distinctive form of agriculture is an agricultural region.
- a dynamic concept which changes in space and time.
- The main characteristics of an agricultural region are: (i) they have location; (ii) they have transitional boundaries; (iii) they may be either formal or functional; and (iv) they may be hierarchically arranged.

Since the boundaries of agricultural regions are transitional and not sharply dividing lines, their precise delineation is a difficult task. Some of the important techniques used for the delineation of agricultural regions by the geographers are:

- (i) Empirical Techniques
- (ii) Single-element Technique
- (iii) Multi-element (Statistical) Technique
- (iv) Quantitative-cum-Qualitative Technique

(i) Empirical Technique:

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- based on the experience of the farmers and the observed facts.
- Von Thunen was the 1st scholar who adopted the empirical technique and prepared the first agricultural land use and crop intensity models.
- gives a generalised picture of the cropping pattern and agricultural regions. By adopting the empirical technique Symons, Munton and Morgan demarcated the agricultural regions of the different parts of the world.
- criticised as it is not objective and scientific.

(ii) Single-Element Technique:

- an arbitrary technique in which only the first ranking crops in respect of area are plotted for the purpose of demarcation of agricultural regions.
- Baker was the first geographer who adopted the single-element technique for the demarcation of agricultural belts of U.S.A.
- criticized as it is not scientific and objective.
- On the basis of this technique, the first ranking crops of India in the different districts in 2005-06 have been plotted which show the rice, wheat, millets, gram, cotton, and oilseeds regions.
- The main weakness of this technique is that it conceals the position and importance of other crops grown in the region.
- In fact, in most of the districts of India, crops are grown in combination and not in isolation.
- A combinational analysis is more important from the agricultural planning point of view than that of the single dominant crop.

(iii) Multi-Element or Statistical Technique:

- more objective and scientific.
- In the statistical techniques more than one elements (crops, etc.) are taken into consideration.
- The crop combination regions demarcated by Weaver, Doi, Coppock, Shafi, Jasbir Singh, Aiyer, Husain, Sapre, and Deshpande, Tiwari etc., were based on the Standard Deviation Technique.
- free from bias and subjectivity
- In the multi-element or statistical techniques, the agricultural regions may be demarcated with the help of the following:
 - (i) Cropping patterns, crop concentration, and crop diversification
 - (ii) Crop combination
 - (iii) Regional patterns of agricultural productivity

(iv) Quantitative-cum-Qualitative:

- The technique in which the physical (geo-climatic factors), socio-economic, cultural, and political factors are taken into consideration for the demarcation of cultural regions is known as the quantitative-cum-qualitative method.
- The factors which are taken into consideration for the delineation of agricultural regions on the basis of quantitative-cum-qualitative techniques are six physical traits: (i) relief, (ii) climate, (iii) surface and subsoil water, (iv) soil, (v) sub-soil, and (vi) natural vegetation; and six functional traits: (i) rural population, (ii) cultural and religious values, (iii) technological, (iv) farming operations, (v) dependent rural population, and (vi) degree of commercialisation.

M. S. Randhawa's Classification of Agriculture (1958)

On the basis of geo-climatic variations, crop characteristics and animals, Randhawa has identified five main agricultural regions of India.

1. The Temperate Himalayan Region

- includes the states of Jammu and Kashmir, Himachal Pradesh, and Uttarakhand in the west, and Arunachal Pradesh and Upper Assam in the east.
- It has two sub-divisions:
 - i) The eastern part comprising Arunachal Pradesh, Sikkim, Nagaland, Tripura, and Upper Assam records heavy rainfall and are covered with thick forests. Here rice and tea are the dominant crops.
 - (ii) The western temperate Himalayan region consists of Jammu and Kashmir, Himachal Pradesh and Uttarakhand.

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This region is characterised by horticulture (apples, cherries, pears, peach, almond, apricot, and walnut). Other crops grown are maize, rice, wheat, and potatoes.

2. The Northern Dry (Wheat) Region:

- stretches over Punjab, Haryana, western Uttar Pradesh, north-western Madhya Pradesh, and irrigated parts of Rajasthan.
- The average annual rainfall in this region is less than 75 cm.
- Parts of it are adequately irrigated by canals and tube wells.
- main crops of this region are wheat, maize, cotton, mustard, gram, rice, sugarcane, and millets.

3. The Eastern Wet (Rice) Region:

- includes the greater parts of the states of Assam, Meghalaya, Manipur, Mizoram, West Bengal, Jharkhand, Bihar, Chhattisgarh, eastern Uttar Pradesh, Orissa, and coastal Andhra Pradesh.
- records more than 150 cm of rainfall.
- Rice, jute, pulses, oil seeds, tea, and sugarcane are the main crops of this region.

4. The Western Wet (Malabar) Region:

- stretches over from Maharashtra to Kerala.
- The average annual rainfall in this region is over 200 cm.
- Rice is the main food crop although coconut and plantation crops (rubber, coffee, spices, cashew nut, etc.) are the main cash crops.

5. The Southern Coarse (Cereals) Region:

- sprawls over Gujarat, Madhya Pradesh, southern Uttar Pradesh (Bundelkhand), eastern Maharashtra, western Andhra Pradesh, Karnataka, and western Tamil Nadu.
- record rainfall between 50 to 100 cm.
- Millets, Bajra, cotton, groundnut, oilseeds, and pulses are the main crops.

AGRO-CLIMATIC REGIONS OF INDIA

- India has great variations in the geo-climatic, socioeconomic, and agricultural practices.
- The variations in the geo-ecological and socioeconomic conditions have closely influenced the agricultural activities.
- For the planning of agriculture, the Planning Commission and the National Remote Sensing Agency (NRSA) have divided the country into 15 agro-climatic regions .
- The main objectives of agro-climatic regions are
 - (i) to optimise agricultural production;
 - (ii) to increase farm income;
 - (iii) to generate more rural employment;
 - (iv) to make a judicious use of the available irrigation water;
 - (v) to reduce the regional inequalities in the development of agriculture.

These agro-climatic regions are as under:

1. The Western Himalayan Region
2. The Eastern Himalayan Region
3. The Satluj-Yamuna Plain
4. The Upper Ganga Plain
5. The Middle Ganga Plain
6. The Lower Ganga Plain
7. The Eastern Plateau and Hills
8. The Aravalli Malwa Upland
9. The Plateau Maharashtra
10. The Deccan Interior
11. The Eastern Coastal Plain
12. The Western Coastal Plain

13. The Gujarat Region
14. The Western Rajasthan
15. The Islands (Andaman and Nicobar and Maldives)

1. The Western Himalayan Region

- stretches over the states of Jammu and Kashmir, Himachal Pradesh, and Uttarakhand.
- great variation in its topography.
- The average temperature of July varies between 5°C and 30°C, while the January temperature reads between 5°C to -5°C.
- mean annual rainfall varies between 75 cm to 150 cm except Ladakh where it is below 20 cm.
- The valley of Kashmir, Kullu, and Dun have thick alluvial soils while the hills and mountains have thin cover of brown soils.
- has perennial rivers, some of which are utilised for irrigation and hydel-power generation.
- Rice, maize, wheat, barley, oilseeds, pulses, potato, and vegetables are the main crops of this region.
- Temperate fruits like apples, peach, pears, almond, apricot, walnut, etc. are the source of cash for the cultivators.
- well suited for orchards and plantation crops, there is a need of improvement in the old less productive varieties of fruits.
- A more judicious land use planning is required for the region.
- Land should be rationally allotted for cultivation of crops, horticulture, pastures, and forestry.
- Better quality of seeds and planting materials should be made available for growing fruits, vegetables, flowers, saffron, ginger, and potato.

2. The Eastern Himalayan Region

- sprawls over Arunachal Pradesh, Hills of Assam, Nagaland, Meghalaya, Manipur, Mizoram, Tripura, Sikkim, and Darjeeling District of West Bengal.
- rugged topography.
- The temperature of July varies between 25°C to 30°C and of January between 10°C and 20°C.
- soil is red-brown and less productive.
- About 33 per cent of the total cultivated area is under Jhuming (shifting cultivation).
- Rice, maize, potato, tea, and orchards (pineapple, lime, litchi, oranges, etc.) are the main crops.
- Shifting cultivation should be controlled by developing terrace farming.
- Soil erosion is another important problem which needs immediate attention of the planners.
- needs marked improvement in infrastructural facilities to accelerate the pace of agricultural development.
- a long term quality seed production suitable for the region needs to be implemented.

3. The Satluj Yamuna Plain

- stretches over Punjab, Haryana, Chandigarh, Delhi, and the Ganganagar District of Rajasthan.
- has the semi-arid characteristics with July's mean monthly temperature between 25°C and 35°C and that of January between 10°C and 20°C.
- The average annual rainfall varies between 65 cm and 125 cm.
- The soil is alluvial which is highly productive.
- Apart from the canals, there are lakhs of tube wells and pumping sets installed by the cultivators and the governments.
- The intensity of agriculture (165 per cent) is the highest in the country.
- Wheat, rice, sugarcane, cotton, maize, gram, millets, pulses, oilseeds, and orchards are the main crops.
- The farmers of this region are most innovative and progressive.
- The High Yielding Varieties of rice and wheat were adopted first by the farmers of this region which led to Green Revolution.
- At present contract farming has been started by the corporate sector in some of the districts of this region. Development of saline and alkaline patches, water-logging, and soil erosion are the main problems of the region.

Agriculturally, this is the most developed part of the country. Agriculture may be made more productive and sustainable if the following steps are taken:

(i) Less area be devoted to rice as it is depleting the underground water table and the fertility of soil. Nearly 5 per cent of the rice and wheat area may be diverted to pulses, oilseeds, maize, fodder, vegetables, flowers, and orchards.

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- (ii) Pests and disease resistant seeds of rice and wheat need to be developed.
- (iii) Horticulture should be promoted.
- (iv) Emphasis should be made on the cultivation of vegetables.
- (v) High quality fodder crops should be developed.
- (vi) Steps should be taken for the diversification of agriculture.

The Ganga Plain

The Upper Ganga Plain

- stretches over the western Uttar Pradesh and the Hardwar and Udham-Singh Nagar districts of Uttarakhand.
- The July temperature varies between 25°C and 35°C and that of January between 10°C and 25°C.
- The soil varies from sandy loam to clayey loam.
- Adequate facilities of irrigation by canals and tube well are available.
- Agriculture is well developed and Green Revolution is a big success in this region also.
- Wheat, rice, sugarcane, maize, millets, pulses, oilseeds, and vegetables are the main crops.
- Mango and guava orchards are also quite significant in the agricultural landscape.
- In order to make agriculture more productive and sustainable there should be emphasis on mixed cropping, horticulture, floriculture, judicious use of irrigation water, lining of canals, reclamation of saline/alkaline soils.

The Middle Ganga Plain

- sprawls over the greater parts of Uttar Pradesh and Bihar.
- The July temperature varies between 25° C and 35° C and that of January between 10° C and 25° C.
- The average annual rainfall varies between 100 cm and 150 cm.
- The soil is alluvial and there is great potential of underground water. Rice, wheat, barley, maize, millets, pulses, mustard, sugarcane and oilseeds, are the main crops.
- Agriculturally, these plains are less developed than the Upper Ganga Plains.
- Agriculture can be made more productive and sustainable to improve the input delivery system and diversification of crops by giving more area to vegetables, fruits, and floriculture.
- Dairying, silviculture, agro-forestry, and pisciculture can also go a long way in improving the income of the farmers.

The Lower Ganga Plains

- stretches over the Brahmaputra Valley, West Bengal (excluding the Darjeeling District) and eastern Bihar.
- The July temperature varies between 25°C and 35°C and that of January between 10°C and 25°C.
- The mean annual rainfall varies between 100 cm and 200 cm.
- The soil is alluvial and highly productive.
- Rice is the main crop.
- From the same field the farmers obtain three successive rice crops (Aman, Aus, and Boro) in a year.
- Jute, maize, pulses, and potato are the other important crops of the region.
- Development of horticulture (banana, mango, and citrus fruits), pisciculture, poultry, and livestock can enhance the income of the cultivators substantially.

The Eastern Plateau and Hills

- The Chotanagpur Plateau, stretching over Jharkhand, Orissa, Chhattisgarh, and Dandakarnaya are included in this agro-climatic region.
- The mean monthly temperature of July ranges between 25°C and 35°C and that of January between 15°C and 25°C.
- The mean annual rainfall ranges between 75 cm and 150 cm.
- Soils are red and yellow.
- The agriculture in this region is mainly rain-fed
- The main crops are rice, maize, millets, ragi, oilseeds, gram, and tobacco.
- The cultivation of high value crops like oilseeds, pulses, vegetables can increase the income of the farmers.
- Water-harvesting and watershed development as well as soil conservation practices can make the agriculture more remunerative.

The Plateau of Maharashtra

- It stretches largely on Deccan Plateau.
- a region of regur soil (black earth soil).

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- The July temperature ranges between 25°C and 35°C, while the mean monthly temperature in January ranges between 15°C and 25° C.
- The average annual rainfall varies between 50 cm and 75 cm.
- Wheat, gram, millets, cotton, pulses, groundnut, and oilseeds are the main crops in the rain-fed areas, while in the irrigated areas, sugarcane, rice, and wheat, are cultivated.
- In place of coarse grains, value crops like pulses and oilseeds need to be cultivated.
- About 5 per cent of the cotton area may be transferred to oilseeds.
- Dairy development, poultry farming, and social forestry are the other aspects of agricultural landscape which deserve immediate attention.

The Deccan Interior

- The Deccan interior sprawls over the greater parts of Karnataka, Andhra Pradesh, and Tamil Nadu uplands from Adilabad District in the north to Madurai District in the south.
- The mean monthly temperature of July varies between 25°C and 35°C, and the mean January temperature reads between 15°C and 20°C.
- records rainfall between 50 cm and 100 cm.
- This is essentially a dry-farming area where millets, pulses, oilseeds, groundnut, coffee, tea, cardamom, and spices are the main crops.
- The area under millets and bajra can be devoted to pulses.
- Development of horticulture, poultry, and dairy-farming can help the farmers in the augmentation of their income.

The Aravalli—Malwa Upland

- includes Bundelkhand, Baghelkhand, Mahabharat Plateau, Malwa Plateau, and Vindhya Hills.
- characterized by semi-arid climatic conditions.
- The mean July temperature reads between 25°C and 35°C, while the mean January temperature ranges between 15°C and 25° C.
- The soil is mixed yellow, red, and black.
- It has scarcity of water, both surface and underground.
- Millets, wheat, gram, pulses, oilseeds, cotton, and sunflower are the main crops.
- Agriculture returns can be improved by farming, sprinkle irrigation, water-harvesting, dairy development, and poultry farming.

THE COASTAL PLAINS

- The Peninsular Plateau of India is flanked by narrow coastal plains of varied width from north to south, known as the West-Coastal Plains and the East Coastal Plains.
- differ from each other.
- formed by the depositional action of the rivers and the erosional and depositional actions of the sea-waves.
- the origin of the western and eastern coasts of India may be attributed to the faulting and subsidence of the Arabian Sea and the Bay of Bengal towards the close of the Eocene Period.
- alluvial deposits along these coasts are of very recent origin, ranging from Pliocene to recent times.
- have the evidence of submergence and emergence.
- The Indian coastal plains may be subdivided into the following three divisions: (i) The Gujarat Coastal Plain, (ii) the West Coastal Plain, and (iii) the East Coastal Plain.

(i) The Gujarat Coastal Plain

- covers almost the entire state of Gujarat, except the districts of Banaskantha and Sabarkantha.
- formed by the alluvial deposits of Sabarmati, Mal* Luni, and numerous tiny parallel consequent streams.
- Part of this plain is the product of depositional activity of the winds and recession of the sea.
- contains the Gondwana rocks (Umia Series), resting over the marine Jurassic rocks and capped by Lower Cretaceous (Apatian) beds.
- The Deccan lava lies over the Umia series.
The eastern section of Gujarat Plain is a projected jet of Sindhu-Ganga alluvial tract in Peninsular India.
- the outcome of an extensive Pleistocene sedimentation.
- Present rivers have further advanced this deposition to the Gulf of Khambat.

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- Among the highlands, mention may be made of the Arasur mountains in eastern Gujarat, the Rajpipla Hills (Satpura)-famous for agate quarries, the Parnera Hills in Bulsar district, Sahyadris in the southern side and igneous complex of the Girnar Hills (Gorakhnath Peak, 1117 m) and Mandav Hills in Kathiawad.

The Rann of Kachchh

- is an extensive tract of naked tidal mudflats transected by abandoned and live creeks.
- The Gulf of Kachchh separates the Rann of Kachchh from the Kathiawar Peninsula.
- The salt in the soil makes this low-lying marshy area almost barren and unproductive.
- The whitish vertebrae of salts appear as white bony structures of the dried creeks.
- Live creeks form dendritic pattern of drainage and there has been accentuation in this pattern due to earthquakes.
- South of the Rann lies Kuchchh, formerly an island, which is almost surrounded by the Rann except in the south-west.

(ii) The West Coastal Plain

- lies between the Sahyadris and the Arabian Sea.
- about 1400 km long and 10 to 80 km wide. It has an elevation up to 150 m above sea level, reaching more than 300 m at places.
- characterised mainly by sandy beaches, coastal sand-dunes, mud-flats, lagoons, alluvial tracts along rivers, estuary, laterite-platforms and residual hills.
- The Sahyadris (elevation 750-1225 m) run parallel to the plain and present their steep face to the low lands with Thalghat and Bhorghat (gaps) in the north and the Palghat (Plakkad Gap) in the south of Nilgiri.
- The northern part of the west coastal plain, known as the Konkan Plain, is about 530 km long and 30 to 50 km wide.
- Southward is the Karnataka coastal plain which is about 525 km long and 8 to 25 km wide.
- the narrowest part of the West coastal plain.
- The southern part is known as the Malabar coast which is about 550 km long and 20-100 km wide.
- The maximum extension of the Malabar coast is found in the valleys of the Beypore, the Ponnani (draining through Palghat), the Periyar and Pamba Achankovil rivers.
- characterised by sand dunes.
- there are numerous shallow lagoons and backwaters
- These lagoons are linked together to facilitate navigation through small country boats.
- Vembanad and Asthamudi are the important lagoons of the Malabar coast.
- The coast shows evidence of emergence.

The Eastern Coastal Plain

- lies between the Eastern Ghats and the Bay of Bengal, and stretches along the coasts of Orissa, Andhra Pradesh and Tamil Nadu.
- formed by the alluvial fillings of the littoral zone comprising some of the largest deltas of the world. The East coastal plains consist mainly of Recent and Tertiary alluvial deposits.
- gentle, monotonous plains rising gently westward to the foot of the Eastern Ghats.
- The monotony of the topography is broken by the presence of numerous hills.
- a straight shoreline with well defined beaches of sand and shingles.
- The most famous is the Marina Beach in Chennai.
- All along the coast, there are several sandbars generally in front of the river mouths.
- There are some of the important lagoons of India along the Eastern coast, of which, Chilka in the south-west of the Mahanadi delta is the biggest lake (65 km x 8 km) in the country.
- The Kulleru lake lies between the deltas of Godavari and Krishna, while the Pulicat lake lies further south on the border of Andhra Pradesh and Tamil Nadu.

The Gujarat Plains and Hills and the Western Region

The Gujarat Plains and Hills

- consists of the hills and plains of Kathiawar, and the fertile valleys of Mahi, and Sabarmati rivers.
- an arid and semi-arid region where the July temperature reads about 30°C and that of January about 25°C.
- The mean annual rainfall varies between 50 cm and 100 cm.
- Groundnut, cotton, rice, maize, millets, oilseeds, wheat, pulses, and tobacco are the main crops.
- an important oilseeds producing area.

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- The major thrust of development in the region should be on canal and ground water management, rain-water harvesting, agro-forestry in the region, and brackish/backwater aquaculture in coastal areas.

The Western Region

- stretches over Rajasthan west of the Aravalli mountains, and northern Gujarat.
- The mean July and January temperatures vary between 40°C and 15°C respectively.
- The mean annual rainfall is less than 25 cm. Bajra, pulses, and fodder are the main crops.
- Livestock contributes greatly to the desert ecology.
- Rain water harvesting horticulture of date-palm, water-melon, and plums deserve more attention.

The Islands Region

- includes Andaman-Nicobar, and Lakshadweep which have marine equatorial climates.
- At Port Blair, the mean July and January temperatures read 30°C and 25°C, respectively.
- Rice, maize, millets, bajra, pulses, arecanut, turmeric, and cassava are the main crops.
- The main thrust in the development of agriculture should be on crop improvement, water management, and fisheries. Brackish water prawn culture should be promoted in the coastal areas.

AGRO-ECOLOGICAL REGIONS OF INDIA

- The concept of 'agro-ecological region' is a modification and improvement on agro climatic regions.
- The concept of agro-ecological region is perhaps hazy to our scientific communities.
- People generally confuse these two terms (agroclimatic and agro-ecological) and use them in more or less the same way. But there is a distinct difference between these two terms.
- According to FAO (1983), agro-climatic region is a land unit in terms of major bio climate and length of growing period and which is climatically suitable for certain range of crop cultivation.
- But agro-ecological region is the land unit carved out of agro-climatic region when superimposed on land form and soil condition that acts as modifier of the length of growing period.
- Therefore, within an agro-climatic region there may be a few agro-ecological regions depending on soil condition. This approach has been used in delineating agro-ecological regions of India.

The agro-ecological regions of India are:

1. Western Himalayas, cold arid eco-region with shallow soil and length of growing period less than 90 days.
2. Western Plain, Kachchh, and part of Kathiawar Peninsula, hot and arid eco region with desert and saline soils and growing period less than 90 days.
3. Deccan Plateau, hot arid region with red and black soils and growing period of less than 90 days.
4. Northern Plain and Central Highlands including Aravallis, hot semi-arid eco region, with alluvium-derived soils and growing period between varying between 90-150 days.
5. Central Malwa Highlands, Gujarat Plains, and Kathiawar Peninsula, hot semi-arid eco region with medium and deep black soils and growing period varying between 90 to 150 days.
6. Deccan Plateau, hot semi-arid eco region, with shallow and medium black soils and growing period varying between 90 to 150 days.
7. Deccan (Telengana) Plateau and Eastern Ghats, hot semi-arid eco region with red and black soil and growing period from 90 to 150 days.
8. Eastern Ghats, Tamil Nadu Plateau and Deccan (Karnataka), hot semi-arid eco region with red-loamy soils, and growing period of 90-150 days.
9. Northern Plain, hot sub-humid (dry) eco region, with alluvium soils, and growing period of 150-180 days.
10. Central Highlands (Malwas, Budelkhand, and Eastern Satpura), hot sub humid eco region, with black and red soils, and growing period 150-189 days.
11. Eastern Plateau (Chattisgarh), hot sub-humid eco region, with red and yellow soils, and growing period of 150-180 days.
12. Eastern (Chotanagpur) Plateau and Eastern Ghats, hot subhumid eco region, with red and lateritic soils, and growing period of 150-180 days.
13. Eastern Plain, hot sub-humid (moist) ecoregion, with alluvium soils, and growing period of 180-210 days.