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INDIAN GEOGRAPHY

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INTRODUCTION

The largest democracy in the world, the land also known as Bharat or Hindustan is unique with its incredible diversity, both culturally and physically. The second largest populous country, India is home to around 17.5 per cent of world's population. The country, however, accounts for 2.42 per cent of the total world area.

GEOGRAPHICAL POSITION

India lies entirely on the Indian Plate in the northern portion of the Indo-Australian Plate. The country lies to the north of the equator between 8°4' and 37°6' North latitude and 68°7' and 97°25' East longitude. It is the seventh-largest country in the world, with a total land area of 3,287,263 square kilometres (1,269,219 sq miles). India measures 3,214 km (1,997 miles) from North to South and 2,993 km (1,860 mi) from East to west. It has a land frontier of 15,200 km (9,445 miles) and a coastline of 7,517 km (4,671 miles).

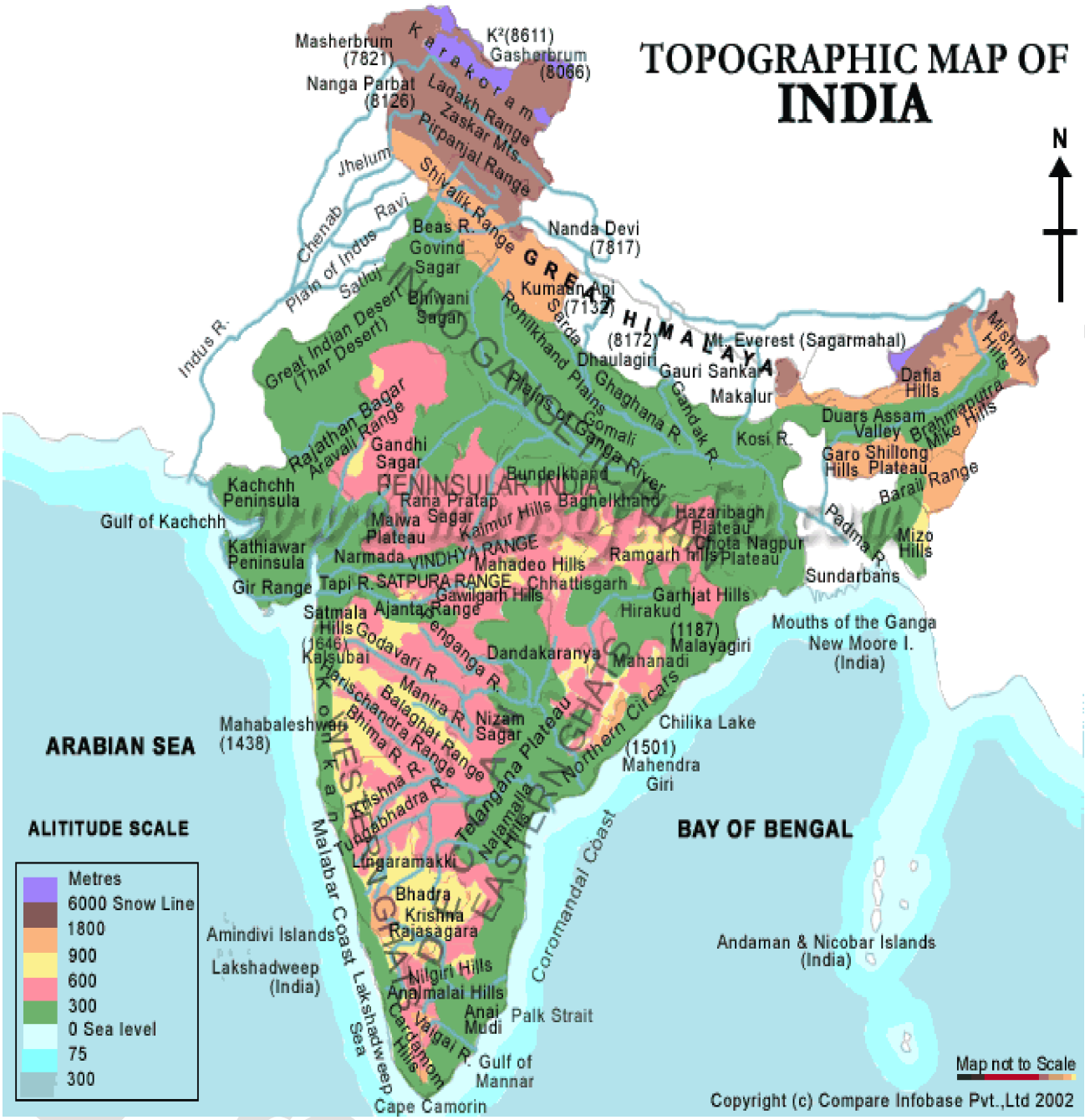
India is bounded in the southwest by the Arabian Sea, in the southeast by the Bay of Bengal and by the Indian Ocean in the south. Cape Comorin constitutes the southern tip of the Indian peninsula, which narrows before ending in the Indian Ocean. The southernmost part of India is Indira Point in the Andaman and Nicobar Islands. The Maldives, Sri Lanka and Indonesia are island nations to the south of India with Sri Lanka separated from India by a narrow channel of sea formed by Palk Strait and the Gulf of Mannar. The territorial waters of India extend into the sea to a distance of 12 nautical miles (13.8 miles; 22.2 km) measured from the appropriate baseline.

The northern frontiers of India are defined largely by the Himalayan mountain range where its political boundaries with China, Bhutan, and Nepal lie. Its western borders with Pakistan lie in the Punjab Plain and the Thar Desert. In the far northeast, the Chin Hills and Kachin Hills, deeply forested mountainous regions, separate India from Burma while its political border with Bangladesh is defined by the watershed region of the Indo-Gangetic Plain, the Khasi hills and Mizo Hills.

The Ganges is the longest river originating in India and forms the Indo-Gangetic Plain. The Ganges-Brahmaputra system occupies most of northern, central and eastern India, while the Deccan Plateau occupies most of southern India. Along its western frontier is the Thar Desert, which is the seventh-largest desert in the world.

Officially, India's highest point is K-2 at 8,611 m (28,251 ft), though it lies in Gilgit-Baltistan, part of the disputed Kashmir region. Kanchanjunga in Sikkim at 8,598 m (28,209 ft) is the highest point within India's current geographic boundaries. Climate across India ranges from equatorial in the far south, to Alpine in the upper reaches of the Himalayas.

The country's land is flanked by the Bay of Bengal and the Arabian Sea, along the southeast and along the southwest respectively. On the western border is situated Pakistan and in the east, Bangladesh and Burma. Along her northern boundary are Bhutan, Nepal, and Tibet and Sinkiang region of China. The Gulf of Mannar and the Palk Strait separate India from Sri Lanka. The Andaman and Nicobar Islands in the Bay of Bengal and Lakshadweep in the Arabian Sea are parts of the Indian Territory.



BOUNDARIES

The Indian peninsula in the south is bounded on the west by the Arabian Sea, on the east by the Bay of Bengal and on the south by the Indian Ocean. Sri Lanka lies off the southeast coast, and the Maldives off the southwest coast. In the North, North East and North West of the subcontinent lies the Himalayan ranges. India shares borders to the northwest with Afghanistan (106 km) and Pakistan, to the north with China, Nepal and Bhutan, and to the east with Bangladesh and Myanmar.

India's borders run a total length of 15,106.70 km (9,387 miles). Its borders with Pakistan and Bangladesh were delineated according to the Radcliff Line, which was created in 1947 during Partition of India. Its western border with Pakistan extends up to 3,323 km (2,065 miles), dividing the Punjab region and running along the boundaries of the Thar Desert and the Rann

of Kutch. Both nations delineated a Line of Control (LoC) to serve as the informal boundary between the Indian and Pakistan-administered areas of Kashmir. According to India's claim, it shares a 106 km border with Afghanistan in northwestern Kashmir, which is under Pakistani control.

India's border with Bangladesh runs 4,096.70 km (2,546 miles). There are 92 enclaves of Bangladesh on Indian soil and 106 enclaves of India are on Bangladeshi soil. The Teen Bigha Corridor is a strip of land formerly belonging to India on the West Bengal-Bangladesh border which has been leased indefinitely to Bangladesh so that it can access its Dehgram-Angalpota enclaves.

The Line of Actual Control (LAC) is the effective border between India and the People's Republic of China. It traverses 4,057 km along the Indian states of Jammu and Kashmir, Uttarakhand, Himachal Pradesh, Sikkim and Arunachal Pradesh. Both nations lay claim to the Aksai Chin region of northeastern Kashmir, which fell into Chinese control during the Sino-Indian War of 1962.The border with Burma (Myanmar) extends up to 1,643 km (1,021 miles) along the southern borders of India's northeastern states. Located amidst the Himalayan range, India's border with Bhutan runs 699 km (434 miles). The border with Nepal runs 1,751 km (1,088 miles) along the foothills of the Himalayas in northern India. The Siliguri Corridor, narrowed sharply by the borders of Bhutan, Nepal and Bangladesh, connects peninsular India with the northeastern states.

GEOLOGY

The Indian craton was once part of the Supercontinent of Pangaea. At that time, it was attached to Madagascar and southern Africa on the south west coast, and Australia along the east coast. During the Jurassic Period, rifting caused Pangaea to break apart into two supercontinents namely, Gondwana (to the south) and Laurasia (to the north). The Indian craton remained attached to Gondwana, until the Supercontinent began to rift apart about in the early Cretaceous, around 125 Ma. The Indian Plate then drifted northward toward the Eurasian Plate. It is generally believed that the Indian plate separated from Madagascar about 90 Ma. This orogeny, which is continuing today, is related to closure of the Tethys Ocean. The closure of this ocean, which created the Alps in Europe, and the Caucasus, range in western Asia, created Himalaya Mountains and the Tibetan Plateau in South Asia. The current orogenic event is causing parts of the Asian continent to deform westward

Greater/Inner Himalayas	Lesser/Middle Himalayas	Outer/Lower Himalayas
The highest mountain range of the Himalayas.	Situated to the south of the Himadri.	This is the outer most range to the south of the Lesser Himalayas.
These ranges have an average height of about 6000 m.	Average height is above 3000 m	These discontinuous ranges join the lesser Himalayas in the extreme east.
Highest Mountain peaks are situated in this range. (e.g.Kanchanjunga - 8595m, Nangaparbat- 8126m)	Many health resorts are situated on the southern slope of the mountain range, e.g.: Shimla, Darjeeling	Its average height is about 1200m
The source of Ganges and Yamuna	----	There are several elongated and flat valleys running parallel to the moun tain ranges. They are called "duns". (e.g.: Dehradun)

and eastward on either side of the orogeny. Concurrently with this collision, the Indian Plate sutured on to the adjacent Australian Plate, forming a new larger plate, the Indo-Australian Plate.

Evolution of India

The cooling and solidification of the upper crust of the earth surface marked the earliest phase of tectonic evolution in the Archaean era (prior to 2.5 billion years) which is represented by the exposure of gneisses and granites especially on the Peninsula. These form the core of the Indian craton. The Aravalli Range is the remnant of an early Proterozoic orogeny called the Aravalli-Delhi orogeny that joined the two older segments that make up the Indian craton. It extends approximately 500 kilometers from its northern end to isolated hills and rocky ridges into Haryana, ending near Delhi. Minor igneous intrusions, deformation (folding and faulting) and subsequent metamorphism of the Aravalli Mountains represent the main phase of orogenesis. The erosion of the mountains and further deformation of the sediments of the Dharwarian group marks the second phase. The volcanic activities and intrusions, associated with this second phase are recorded in composition of these sediments.

Early to Late Proterozoic calcareous and arenaceous deposits, which correspond to humid and semi-arid climatic regimes, were, deposited the Cuddapah and Vindhyan basins. These basins, which border or lie within the existing crystalline basement, were uplifted during the Cambrian (500 Ma). The Vindhyans are believed to have been deposited between around 1700 and 650 Ma.

Early Palaeozoic rocks are found in the Himalayas and consist of southerly-derived sediments eroded from the crystalline craton and deposited on the Indian platform.

In the Late Paleozoic, Permo-Carboniferous glaciations left extensive glacio-fluvial deposits across central India, in new basins created by sag/normal faulting. These tillites and glacially derived sediments are designated the Gondwana series. The sediments are overlain by rocks resulting from a Permian marine transgression (270 Ma)

The late Paleozoic coincided with the deformation and drift of the Gondwana super-continent. To this drift, the uplift of the Vindhyan sediments and the deposition of northern peripheral sediments in the Himalayan Sea can be attributed.

During the Jurassic, as Pangaea began to rift apart, large grabens formed in central India filling with Upper Jurassic and Lower Cretaceous sandstones and conglomerates.

By the Late Cretaceous India had separated from Australia and Africa and was moving northward towards Asia. At this time, prior to the Deccan eruptions, uplift in southern India resulted in sedimentation in the adjacent nascent Indian Ocean. Exposures of these rocks occur along the south Indian coast at Pondicherry and in Tamil Nadu.

At the close of the Mesozoic era, one of the greatest volcanic eruptions in earth's history occurred, the Deccan lava flows. Covering more than 500,000 square kilometers area, these mark the final break from Gondwana. In the early Tertiary, the first phase of the Himalayan orogeny, the Karakoram phase occurred. The Himalayan orogeny has continued to the present day.

PHYSIOGRAPHIC DIVISION

The four major geographical regions of India are:

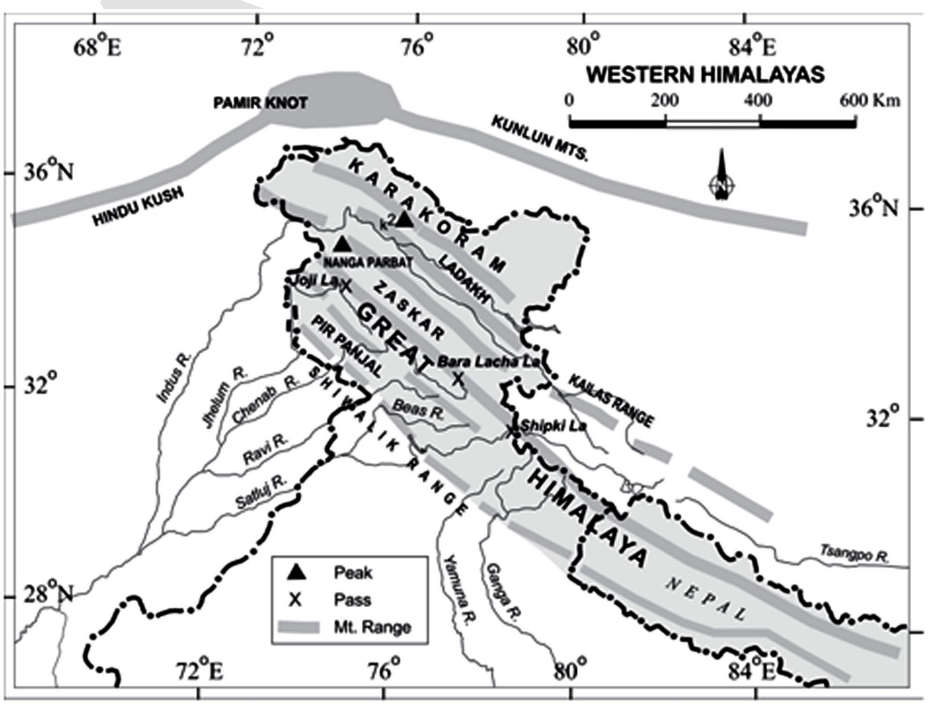
1. The Great Himalayan range,
2. The Indo Gangetic Plain,
3. The Deccan Plateau and Peninsula
4. The Coastal plains
5. The Islands

HIMALAYAN MOUNTAIN SYSTEM

This is the great wall like physiographic unit, which stretches from Kashmir in the North West to the Indian border in the east. This region is formed by the Karakoram, Ladakh, Zaskar and the Himalayan range of mountains and the eastern highlands. These mountain ranges are subdivided into three divisions namely, Trans Himalayas, Himalayas and the Eastern himalayas. The Trans Himalayas comprises the Karakoram, Ladakh and Zaskar ranges that originate from the Pamir Knot. The highest peak in India, 'Mount K2' (Mt. Godwin Austin, 8611m) is in the Karakoram Range. The Himalayas can be divided into - (i) The Himalayan ranges (ii) The Trans-Himalayas (iii) The Eastern Hills.

The height of the mountain ranges gradually decreases as they approach the eastern parts of the Northern mountainous regions. This region with an average height of 500m to 3000m above MSL is known as the Eastern highlands (Purvanchal).

1. **Duns:** The longitudinal valley lying between Lesser Himalaya and Shiwaliks are known as duns
2. The Himalayan Mountains are also known as the Himadri, Himaven or Himachal.
3. It consists of the youngest and the loftiest, rugged tertiary mountain chains of the World.
4. It is characterized by youthfulness, great deal of folding and deformation tectonic origin and great erosive power of rivers.
5. It stretches for a distance of over 2400 km (over 22° longitude) from Indus gorge in the west to the Brahmaputra gorge (Dihang gorge) in the east.
6. The width of the Himalayas varies from 500 km in Kashmir to 200 km in Arunachal



Pradesh, i.e., it becomes narrower from west to east.

7. It extends from west to east in arcate shape which is convex to the south.

Origin of Himalayas

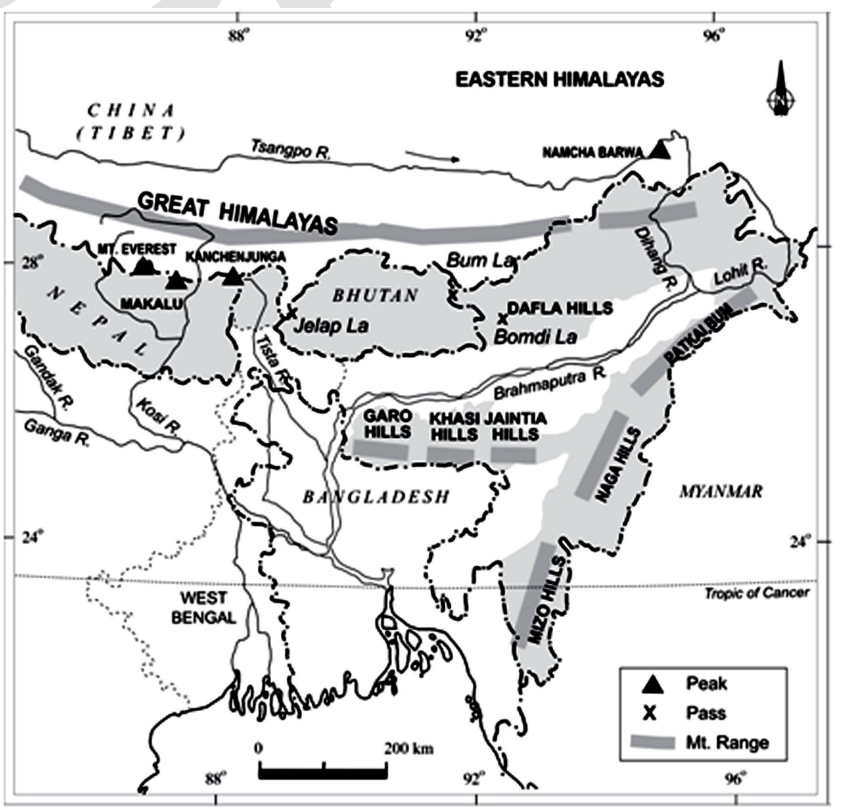
Plate tectonics is the most recent and widely acclaimed theory for the origin of Himalayas. Plate is a broad segment of lithosphere that floats on the underlying asthenosphere and moves independently of other plates. When two plates move towards each other, converge and in the process one plate overrides the other. The overridden plate is sub ducted and goes under the asthenosphere and is lost or consumed. It is the converging boundary of plates where folded mountains like the Himalayas build up. When two convergent plates composed of continental crusts collide against each other, the denser plate is sub ducted under the lighter plate. The resultant lateral compression squeezes and folds the sediments deposited on either side of the continental plate margins. Himalayas are the product of such a process on the conveyance zone of the Asiatic plate in north and the Indian plate in the south.

Some 70 million years ago, the Indian plate started moving towards the Asian plate and the Tethys Sea began to contract. The sediment got folded in three successive phases giving rise to three ranges of Himalayas explained below.

Cross-Sectional view of Himalayas

1. **The Great Himalaya:** This is also known as inner Himalaya, Central Himalaya or Himadri. It is mainly formed of central crystallines (granites and gneisses) overlain by metamorphosed sedimentary races. It is the most continuous range consisting of loftiest peaks with an average height of 6000 meters. The core of these mountains is composed of Archaean rocks like granite, gneisses and the schists. The folds in this range are asymmetrical with steep south slope and gentle North Slope. It extends in arcate shape, from Nanga Parbat in north-west and Namcha Barwa in the north-east, which is convex to the south. Average elevation is 6100 in and average width is about 25km.

2. **The Middle or the Lesser Himalaya:** It is also called the Himachal or Lower Himalaya. It is mainly composed of metamorphic rocks and unfossiliferous sedimentary rocks. The southern slopes are bare and rugged while the northern slopes are thickly forested. The Pir Panjal, the Dhauladhar, the Musoorie range, Nag Tibba and the Mahabharata are the important ranges. The Pir Panjal in Kashmir is the longest and the most important range. Banihal pass situated in the Pir Panjal range is used by the Jammu-Srinagar national highway. The valley of Kashmir lies between the Pir Panjal and the Zaskar range. Most of the hill stations (Shimla, Musoorie, Ranikhet, Nainital, Almora and Darjeeling etc.) lie in this section. Average



elevation in 3500 to 5000 m and average width is 60-80 km.

Mountain Peaks in the Himalaya	
Mt Everest	8848 M
Mt K2	8611 M
Kanchanjunga	8598 M
Makalu	8481 M
Dhaulagiri	8172 M
Annapurna	8078 M

3. **The Shiwaliks or the Outer Himalaya:** Consists of foothills which non almost from Potwar plateau to Brahmaputra valley. These ranges are mainly made up of fluvial deposits like sand, clay, Rounded stones, gravels, slates etc. This section is characterized by poor drainage, which is move pronounced in Terai region. Its eastern part upto Nepal is thickly forested but the forest cover becomes thin in the west. Average elevation is 1000 - 1500m while average width is 15-50 km. The gorges of Tista and raidak have jointly formed a gap 80-90 km wide in the Shiwalik range. Shiwalik are known by different names in different areas. They are called Dafla, Miri, Abor and Mishmi hills in Arunachal Pradesh, and Jammu hills in Jammu

Regional Division of Himalayas

On the basis of river valleys Himalayas can be longitudinally divided into the following sections:

(I) Kashmir Himalaya

1. Average elevation is about 3000m.
2. This section has the largest share of shows and glaciers
3. **Two important passes**: Pir Panjal and Banihal - lie in Pir Panjal range.
4. The Valley of Kashmir lies in this section.

(II) Punjab Himalaya

1. Stretches eastward upto Satluj for about 570km.
2. High Peaks are rare.
3. **Main ranges:** Karakoram, Ladakh, Pir Panjal, Zaskar and Dhauladhar
4. **Important Passes:** Zojila, Rohtang and Bara Lacha la.
5. **Important Valleys:** Kangra, Lahul and Spiti.
6. This section is important for fruit cultivation (horticulture) and scenic beauty.

(III) Kumaon Himalaya

1. Stretches from Satluj to Kali River for about 320km and the general elevation is higher than Punjab Himalayas.
2. Its western part is called Garhwal Himalaya while eastern part is known as Kumaon Himalaya proper.
3. **Important peaks:** Nanda Devi, Kamet, Trishul, Badrinath, and Kedarnath
4. Nanda Devi is the highest peak in this section.
5. **Important lakes:** Nainital and Bhimtal
6. Several duns lie between Middle Himalayas and Shiwaliks.

(IV) Central Himalaya

1. Extends from river Kali to Tista for about 800km.
2. Most of it lies in Nepal and hence it is also called as Nepal Himalaya.
3. This section has some of the world's highest peaks, such as, Mt. Everest, Makalu, Kanchanjunga, Dhaulagiri, Annapurna, and Gosainthan.
4. This section is known as Sikkim Himalaya in Sikkim, Darjeeling Himalaya in West Bengal and Bhutan Himalaya in Bhutan.
5. Bilafond la also known as "pass of the butterflies".
6. Saltoro pass is a mountain pass situated in Saltoro ridge on the west of siachen glacier.
7. Chang la is the main gateway for the chang tang plateau, situated in the Himalayas.
8. The Debsa pass provides an easier and shorter alternative to the traditional Pin-Parbati pass route between Kullu and Spiti.

(V) Assam Himalaya

1. Stretches from river Tista to Brahmaputra for about 720km.

2. Pauhunri and Kulakangri are important peaks.
3. The Naga hills and Patkai Bum hills of this section form the watershed between India and Myanmar.

(VI) Trans Himalayas

1. It immediately lies north of the Great Himalayan range.
2. It is also called the Tibetan Himalaya because most of it lies in Tibet.
3. The Zaskar, the Ladakh, the Kailash and the Karakoram are the main ranges of this system.
4. Mt. K-2(Godwin Austin), Nanga Parbat, Rakaposhi, Haramosh, Gasherbrum-I (Hidden Peak), Gasherbrum-II etc. are important peaks.
5. This section has some of the world's largest glaciers - Siachen, Hispar, Biafo, Batura and Baltoro.
6. Ladakh Plateau (5000m), the highest plateau of the Indian Union, lies to the north-east of the Karakoram range. It has been dissected into a number of plains and mountains. The most outstanding among them are Aksai Chin, Soda Plains, Lingzi Tang, Depsang Plains, and Chang Chenmo.

(VII) Eastern Hills or the Purvanchal Hills

After crossing the Dihang gorge (Brahmaputra gorge), the Himalayas suddenly turn southward and form a series of comparatively low hills running in the shape of a crescent with its convex side pointing towards the west. These hills are collectively called the Purvanchal because they are located in the eastern part of the country. It extends from Arunachal Pradesh in the north to Mizoram in the south and form boundary between India and Myanmar. The Indo-Burma hill range is a part of the Arakan Yoma Suture zone that stretches south through Andaman - Nicobar island chain to Sunda. The elevation of the Eastern Hills (Purvanchal) decreases from north to south and it is characterized by rough terrain, dense forests and swift streams. All these Ranges are generally 2,000m or less in height but are rather forbidding because of dense forests, very rough terrace and inhospitable tribe.

It comprises of the following hills -

a) **Mishmi hills:** Contains the loftiest range of the Purvanchal. Dapha Bum is its highest peak.
b) **Patkai Bum Range:** It is the northernmost range forming the easternmost limit of the Great Himalaya Mountains, has synclinal structure and is made up of Tipam sandstone.
c) **Naga Hills:** It lies south to the Patkai Bum and Saramati (3826m) is its highest peak. Patkai Bum and Naga hills form the watershed between India and Myanmar.
d) **Manipur Hills:** It is south to Naga hills and form boundary between Manipur and Myanmar. Its central part is a large basin which appears to be bed of an old lake, a remnant of which occupies the south-east corner of the basin and is known as Loktak Lake. The Barail Range separates Naga Hills from Manipur hills.
e) **Mizo Hills (Lushai Hills):** It lies south to the Manipur hills and its highest point is the Blue Mountain (2157m) in the south.

Significance of the Himalayas

The Himalayas comprise the most dominating geographical feature of India. No other mountain range anywhere in world has affected the life of people and shaped the destiny of a nation as the Himalayas have in respect of India. The Himalayas are the body and soul of India. In a very special measure, the Himalayas constitute India's national mountain system. The following fe3w points will bring out the significance of the Himalayan Mountains to India.

1. **Climatic Influence.** The Himalayas play a very significant role in influencing the climate of India By virtue of their high altitude, length and direction; they effectively intercept the summer monsoons coming from the Bay of Bengal and Arabian Sea and cause precipitation in the form of rain or snow. Besides, they prevent the cold continental air masses of central Asia from entering into India. Had there been no Himalayas, the whole of Indian would have been a desert

in the absence of precipitation and its winters would have been very severe under the influence of cold airmasses coming from Central Asia. According to the latest meteorological studies, the Himalayas are responsible for splitting the jet stream into two branches and these in turn play and extremely important role in bring monsoons in India.

2. **Defence.** The Himalayas have been protecting Indian from outside invaders since the early times thus serving as a defence barrier. But the Chinese aggression on India in October, 1962 has reduced the defence significance of the Himalayas to a considerable extent. In spite of advancement in modern warfare technology, the defence significance of the Himalayas cannot be ignored altogether.
3. **Source of Rivers.** Almost all the great rivers of India have their sources in the Himalayas ranges. Abundant rainfall and vast snowfields as well as large glaciers are the feeding grounds of the mighty rivers of India. Snow melt in summer provides water to these rivers even during dry season and these are perennial rivers. The Himalayan Rivers, along with hundreds of their tributaries, form the very basis of life in the whole of north India.
4. **Fertile Soil.** The great rivers and their tributaries carry enormous quantities of alluvium while descending from the Himalayas. This is deposited in the Great Plain of North India in the form of fertile soil. Making the plain one of the most fertile lands of the world. It has been estimated that the Ganga and the Indus carry 19 and 10 lakh tones of silt, per day respectively and the silt carried by the Brahmaputra is even more. It is, therefore often said that the great plain of north India is a Gift of the Himalayas.
5. **Hydroelectricity.** The Himalayan region offers several sites which can be used for producing hydroelectricity. There are natural waterfalls at certain places while dams can be constructed across rivers at some other places. The vast power potential of the Himalayan Rivers still awaits proper utilization.
6. **Forest Wealth.** The Himalayan ranges are very rich in forest resources. In their altitude, the Himalayan ranges show a succession of vegetal cover from the tropical to the Alpine. The Himalayan forests provide fuel wood and a large variety of raw materials for forest based industries. Besides many medicinal plants grow in the Himalayan region. Several patches are covered with grass offering rich pastures for grazing animals.
7. **Agriculture.** The Himalayas do not offer extensive flat lands for agriculture but some of the slopes are terraced for cultivation. Rice is the main crop on the terraced slopes. The other crops are wheat, maize, potatoes, tobacco and ginger. Tea is a unique crop which can be grown on the hill slopes only. A wide variety of fruits such as apples, pears, grapes, mulberry, walnut, cherries, peaches, apricot, etc. are also grown in the Himalayan region.
8. T**ourism.** By virtue of their scenic beauty and healthy environment, the Himalayan ranges have developed a large number of tourist spots. The hilly areas in the Himalayas offer cool and comfortable climate when the neighbouring plains are reeling under the scorching heat of the summer season. Millions of tourists from different parts of the country as well as from abroad throng the Himalayas tourist centres to enjoy their natural beauty and to escape from the summer heat of the plains. The increasing popularity of winter sports and the craze to enjoy snowfall has increased the rust of tourists in winters also. Srinagar, Dalhousie, Dharmashala, Chamba, Shimla, Kulu, Manali, Mussoorie, Nainital, Ranikhet, Almora, Darjeeling, Mirik, Gangtok etc. are important tourist centres in the Himalayas.
9. **Pilgrimage.** Apart from places of tourists interest, the Himalayas are proud of being studded with sanctified shrines which are considered to be abodes of the Gods. Large number of pilgrims trek through difficult

terrain to pay their reverence to these sacred shrines. Kailas, Amarnath, Badrinath, Kedarnath, Vaishnu Devi, Jwalaji, Uttrkasi, Gangotri, Yamunotri, etc. are important places of pilgrimage.

10. **Minerals.** The Himalayan region contains many valuable minerals. There are vast potentialities of mineral oil in the tertiary ricks. Coal is found in Kashmir. Copper, lead, zinc, nickel, cobalt, antimony, tungsten, gold, silver, limestone, semi-precious and precious stones, gypsum and magnetite are known to occur at more than 100 localities in the Himalayas. Unfortunately manly of the mineral resources cannot be exploited at the present level of technological advancement due to adverse geographical conditions. Further advancements in modern technology may help in exploiting these resources, so the future possibilities of mineral exploitation in the Himalayas are great.

THE NORTHERN PLAINS

Lying between the Himalayas in the north and the stable peninsula in the south, it stretches from the arid and semi-arid plains of Rajasthan in the west to the Ganga delta in the east. It is drained by three major river systems; the Ganga system, the Indus system, the Brahmaputra system. The plain is believed to be formed from infilling of a marine depression or fore deep, that formed dome to Himalayan uplift and subsidence of the northern blank of the plateau, by alluvial deposits brought by both rivers Himalayan Rivers and Peninsular Rivers.

Origin of the Plain

It is almost universally accepted that this vast plain has been formed as a result of filling of a deep depression lying between the Peninsular and the Himalayan region by the depositional work of the rivers coming from these two landmasses. However, divergent views have been expressed regarding originally a deep depression or furrow lying between the Peninsula and the mountain region. The great Austrian geologist Edward Suess has suggested that "foredeep" was formed in front of high crust waves of the Himalayas as they were checked in their southward advance by inflexible solid landmass of the Peninsula. This foredeep was like a large syncline in which alluvium brought by the Himalayan and the Peninsular Rivers was deposited. In due course of time, this was filled with alluvium and the Great Plain of North India was formed. It rests on the hard and crystalline rocks through which the region is connected to the Himalayan and the Peninsular blocks. Sir Sydney Burrard, on the other hand, thinks that the Indo-Gangetic alluvium conceals a great deep rift, or fracture, in the earth's sub-crust, several thousand metres deep, the hollow being subsequently filled up by detrital. He ascribes to such sub-crustal cracks or rifts a fundamental importance in geotectonic and attributes the elevation of the Himalayan chain to an incidental bending or curbing movement of the northern wall to the fissure. Such sunken tracts between parallel, vertical dislocations are called 'Rift Valleys'. The rift valley between the Himalayan ranges and the Peninsula which gave birth to this plain was about 2,400 km long and hundreds of metres deep. His findings were based on some anomalies in the observations of the deflections of the plumb line and other geodetic considerations. He described some other rift valleys of the Himalayan region as well as the rift valleys of Narmada and Tapi in the Peninsular India. Scholars like Hayden and R.D. Oldham as well as other geologists of the Geological Survey of India have not accepted Burrard's view of the Indo-Gangetic depression. The main objection to Burrard's views is that there is no trace of rift valley at the northern edge of the peninsula and that such vast rift valley is not possible.

According to the recent views expressed by many geologists and geographers, sediment deposited at the bed of the Tethys Sea was folded and warped due to northward drift of the Peninsula. Consequently the Himalayas and a trough to the south were formed. The origin of this depression or trough, lying at the foot of the mountain, is doubtless intimately connected with the later. The Great plain represents the infilling of the foredeep warped down between

the advancing Peninsular Block and the Himalayas. The infilling has been done by the deposition of the detritus of the mountains brought by the numerous rivers emerging from them during the period of great gradational activity. Geologically most parts of this plain are of the Pleistocene and Recent formations.

Characteristic & Geo-morphological Features From North to South

1. **Bhabar:** It is a narrow belt of about 8-16km width running in east-west direction along the foot of the Shiwaliks with a remarkable continuity from the Indus to the Tista, where rivers descending from the Himalayas deposit their load along the foothills in the form of alluvial fans. These are porous, gravel-ridden plain and due to high porosity the streams in this zone get lost in the ground except during the rainy season. It is comparatively narrow in the east and extensive in the western and northwestern hill of region. This area is not suitable for agriculture and only big trees with large Roots thrive in this belt.
2. **Tarai**: The streams that disappear in Bhabar belt reappear in Terai region. It is 10-20 km wide, ill drained, marshy, thickly forested area having a variety of wildlife. Most of the Terai land, especially in Punjab, Uttar Pradesh and Uttaranchal, has been reclaimed and turned into agricultural land which gives good crops of sugarcane, rice and wheat. Dudhwa national park is situated in this region.
3. **Bhangar (Bengha):** It is composed of old alluvium in the form of terrace above the level of flood plains. These terraces are often impregnated with calcareous concretions known as Kankar.
4. **Khadar:** It is composed of newer alluvium and forms the flood plains along the river banks, which is liable to inundations during flooding and rainy season.
5. **Reh or Kallar:** It comprises barren saline efflorescence's of drier areas in Uttar Pradesh and Haryana.
6. **Bhur:** It represents aeolian deposits during Pleistocene in the middle Ganga - Yamuna Doab.

Region-wise Division

a) **Western Plains:** These plains extend over Rajasthan desert, Rann of Kuchchh and drier parts of Punjab and Haryana, where wind action predominates over water action. This area was under sea from Permo-Carboniferous to Pleistocene It is dotted with salt Lakes, such as Sambhar, Didwana, Degana, Pachpadra, Kuchaman,etc. Dhrian (shifting sandiness), Raun (Playa Lakes), Rohi (fertile plains west of Aravallis) are important geomorphological features of this plain.

b) **Punjab - Haryana Plain:** This plain is drained by five important rivers namely. Jhelum, Chenab, Ravi, Beas and Satluj, and the Panjdoabs (Doabs - the land between two rivers) are the most important feature of this section, which are as follows:-

(a) **Bist:** (Jalandhar Doab) between Beas and Satluj
(b) **Bari** -between Beas and Ravi
(c) **Rachna** - between Ravi and Chenab
(d) **Chaj** -between Chenab and Jhelum
(e) **Sind Sagar** - between Jhelum and Indus

The only river between the Yamuna and Satluj is the Ghaggar, which is considered to be the present day successor of the legendary Saraswati river.

The Khadar belt liable to flooding but agriculturally important is known as 'Bets'. These Khadar belts are flanked by heavily gullied bluffs locally known as 'Dhayas'. The northern part of this plain adjoining the Shiwaliks has been intensively eroded by numerous streams called Chos.

c) **Ganga Plain:** This is the largest unit of the Great plain of India stretching from Delhi to Kolkata in the static of U.P., Bihar and West-Bengal. The general slope of the entire plain is east - and south - east. These plains can be divided into following: distinct cultural - geographical divisions.

- **Ganga - Yamuna Doab:** It is the largest doab between Ganga and Yamuna. The Bhangar uplands along the Yamuna and Chambal courses have been broken into intricate maze of ravines and gullies giving rise to the badland topography. Bhabar plains, Terai, Bhangar, Khadar are striking features of this section. Khots are intervening slopes between Bhangar and Khadar. Another unusual topographic feature of the upper doab is Bhur which is formed of aeolian deposits during Pleistocene period.
- **Rohilkhand Plains:** To the east of Ganga-Yamuna doab it stretches from the foothills of Himalayas to the Ganga. Lying entirely in U.P. it is drained by Ramganga, Gomati and Sarda rivers. The Bhabar and Terai plains are well developed in the north. The general slope is towards south - east.
- **Awadh Plains:** The major portion of lowland north of the Ganga, gently sloping eastwards, comes within this physiographic region. Strips of Khadar and Bhangar are very conspicuous in this section; the Ghaghra is the master - stream traversing the whole length of the Awadh plains.
- **Bihar Plains:** After the end of Awadh plains in U.P., the next stretch of the Great Plains in the Bihar Plains, which is narrowed eastwards by the prolongation of the Rajmahal hills. On the basis of differing Relief and river conditions it can further be subdivided into two parts.

  North Bihar Plain - Lying north of Ganga and drained by it's tributaries Ghaghra, Gandak, Kosi it slopes towards the south - east in the western part and south in the eastern part. A long live of marshes extends parallel to the Ganga; locally known as CHAURS. Some of them are deep enough to contain water throughout the years e.g. the Kabar Tal.

  South Bihar Plain - lies west of Rajmahal hills and eastward side of southern bank of Ganga occur vast depression known as Jala near Patna and Tal hear Mokama.
- **North Bengal Plains:** Extending from the foot of the Eastern Himalaya to the northern limit of the Bengal basin it's eastern part is drained by the rivers joining the Brahmaputra and western part by the tributaries of the Ganga. Powerful streams like Tista, Jaldhaka and Torsa drain it. Its northern fringe, known as the western Dhar, is well drained and is the ideal home of tea plantations. Farther south of Dhars lies the Bhangar land of Barind plain, which is the older delta of Ganga, formed during the Pleistocene period and subsequently up-warped and eroded into terraces.
- **Bengal Basin:** It comprises of most of the alluvial plains of West Bengal and East Pakistan. The Ganga delta occupies the major portion of the Bengal Basin. The thickly forested Sunderbans in the south and the east Bhagirathi plains is the north, with its dead and dieing rivers, offer contracting features.
- **Rarh Plain:** Though it is not a part of the delta proper, it is equally flat lowland to the west of the Bhagirathi. The natural levees of the Damodar and other rivers of this area are characteristic feature. The prolonged weathering has given rise to Lateritic silks. Damodar River is accused to be the sorrow of Bengal due to its devastating nature.

PENINSULAR PLATEAU REGION

It is roughly triangular in shape whose base lies in the north coinciding with the southern edge of the great plain and apex in south is formed by Kanyakumari. It is surrounded by the hill ranges on all the three sides- to its north is the Aravali range, The Vindhyas, the Satpura the Bharmer and the Rajmahal hills while Western Ghats (Sahyadris) and Eastern Ghats forms its western and eastern boundaries respectively. It covers a total area of about 16 lakh sq km which is about half of the total land area

of the country, and thus it is the largest physiographic unit of India. The general slope of the plateau is from west to east with the exception of Narmada-Tapi rift which slopes westwards. Following are important plateau and hill ranges of the peninsular plateau -

1. **Aravali range -** extends in north - east to south - west direction for about 800 km from Delhi to Ahmedabad. It is one of the world's oldest mountains formed as a Result of folding during Archaean era. The general elevation is 400- 800 m; Mt. Abu (1158m) lies in this range. Guru Shikhar (1722m), the highest peak, is situated in Mt Abu.
2. **Marwar Upland -** To the east of the Aravali Range also called upland of eastern Rajasthan. It is made up of sandstone, shales and limestones of the Vindhyan Period. Banas river drains this region.
3. **The Central Highland -** lying to the east of Marwar upland, also called Madhya Bharat Pathar. Most of it is thickly forested and in its northern part are the ravines or badlands of the Chambal river.
4. **Bundelkhand Upland -** It lies between Yamuna and Vindhyan scarpland. It is carved only of granite, known in Indian geology as 'Bundelkhand Gneiss'.
5. **Malwa Plateau -** It lies north of Vindhyan range in M.P. it is composed of extensive lava flow and is covered with black soils. It is drained by Chambal, Parbati, Sindh, Kali, Betwa and Mahi.
6. **Baghelkhand-** Lying east of Maikal range, it is made of limestone and sandstone on the west and granite in the east. The central part of the plateau act as water divide between the son drainage system in the north and Mahanadi river system in the south. The scarps of Vindhyan sandstone between the Ganga plain and the Narmada - Son trough is the main physiographic element.
7. **Chotanagpur Plateau -** The north - eastern projection of the Indian Peninsula, east of Baghelkhand, lies mostly in Jharkhand, northern part of Chhattisgarh and Purulia district of West Bengal. It is composed mainly of Gondwana Rocks with patches of Archaean granite and gneisses and Deccan Lavas. Pat lands (high level laterite plateau) are the highest points of this region. The Damodar River flows through the middle of this region in a rift valley from west to east where Gondwana Coal fields are found.
   a) **Hazaribagh Plateau -** A Peneplain to the north of Damodar River having average elevation of 600m. Parasnath (1366m) denotes the highest hill. It is made of granites and gneisses.
   b) **Ranchi Plateau -** Lying south of Damodar. Its average elevation is about 600 m. Pats, Netarhat Pat (1119m), Goru rise (1142m) are the highest points.
   c) **Rajmahal Hills -** forming the north - eastward edge of Chhotanagpur plateau are mostly made of basalt and are covered by lava flows.
8. **Meghalaya Plateau (Shillong Plateau) -** It is north-eastward extension of peninsular plateau which is separated from the main block by Garo Rajmahal Gap. It is largely formed of Archaean quartzites, shales and schists with granite intersections. Garo (900m), Khasi - Jaintia (1500m) and Mikir (700m) are important hills lying in western, central and eastern parts of the plateau respectively. Shillong (1961m) is the highest point.
9. **Deccan Plateau -** The largest unit of peninsular plateau (5 lakh sq. km), it is a triangular plateau bounded in north by Vindhyas , Satpura, Mahadev and Maikal ranges, Western Ghats in the west and Eastern Ghats in the east. Average elevation is about 600m (more in south then north) and general slope in from west to east It is subdivided points.
   a) **Maharashtra Plateau:** Looking like a rolling plain, done to weathering, most of the region in underlain by basaltic rocks of lava origin. The horizontal lava sheets have led to the formation of typical Deccan Trap. The entire area is covered by black cotton soil known as Regur soil.

b) **Karnataka Plateau (Mysore Plateau)** - Made up primarily of Archaean rocks. The highest peak is at Mulangiri (1918m) in Baba budan Hills. Divided into two parts -

i) **Malnad -** hilly region with dense forest.
ii) **Maidan -** rolling plain with low granite hills.
iii) **Telangana Plateau** - In Andhra Pradesh consists of Archaean Gneisses, drained by Godavari, Krishna and Penneru.

10. **Chhattisgarh Plain -** A saucer shaped depression drained by the upper basin of Mahanadi, lying between Maikal range and Orissa hills. The basin is laid with nearly horizontal beds of limestone and shales deposited during the Cuddapah age.
11. **Vindhyan Range -** Acting as watershed between the Ganga system and the river systems of south India, it is an escarpment flanking the northern edge of Narmada - Son Trough. Most parts are composed of sedimentary rocks. Western part is covered with lava.
12. **Satpura Range -** A series of seven mountains running in the east - west direction between Narmada and Tapi, have three distinct parts -

a) **Western part** - locally known as Rajpipla hills and formed of basalt.
b) **Central part -** bordered on north by Mahadev hills and on the south by Gawligarh hills. Dhaupgarh is the highest peak near Pachmarhi hill station.
c) **Eastern part -** is Maikal Plateau.

Eastern Ghats

The elevation of the Eastern Ghats is lower than that of the Western Ghats. They have an average height of 450 metres and rarely exceed 1200 metres. To the southernmost part of the Eastern Ghats are the low Sirumalai and Karanthamalai hills of southern Tamil Nadu. To the north of the Kaveri River are comparatively higher hills like Kollimalai, Pachaimalai, Shevroy (Servaroyan), Kalrayan Hills, Chitteri, Palamalai, and Mettur hills. The higher hill ranges experience a generally cooler and wetter type of climate than the surrounding plains. These hills harbour many coffee plantations and dry forests. The hill station of Yercaud is located in the Shevroy Hills.

In the Nilgiri Hills, which run east from the Western Ghats to the Kaveri River, there is a wooded ecological strip that connects the Eastern and Western Ghats. This region has the second-largest wild elephant population in India. The Ponnaiyar and Palar rivers flowing through gaps in the Ghats drain into the Bay of Bengal. These two rivers are separated by the Javadi Hills. Some isolated areas have waterfalls. The Kiliyur Falls is one of them .To the north of the Palar River in Andhra Pradesh, the central portion of the Eastern Ghats consist of two parallel ranges running approximately north-south; the lower Velikonda range lies to the east, and the higher Palikonda-Lankamalla-Nallamalla ranges lie to the west. The Velikonda range ultimately descends to the coastal plains in the northern Nellore district, while the Nallamalla Range continues to the Krishna River.

The Krishna and the Godavari are separated by a range of low hills. To the north of the Godavari river the Eastern Ghats record an abrupt increase in height, acting as the boundary between Andhra Pradesh and Orissa. The region possesses fertile soil. The Eastern Ghats are elder than the Western Ghats. The history of its origin is much complicated and takes off from the congregation and fragmentation of the ancient supercontinent of Rodinia and the assembly of the Gondwana supercontinent.

A chain of highly broken and detached hills starting from Mahanadi in Orissa to the Vagai River in Tamilnadu is known as Eastern Ghats. The Eastern Ghats are a series of discontinuous low ranges along the Bay of Bengal coast running from the Mahanadi river valley for about 500 metres up to the Nilgiris in the south and forms the eastern edge of the dissected Deccan plateau .The Eastern Ghats start from the state of West Bengal in the north and culminates in

the state of Tamil Nadu in the south. On the way they cover the states of Orissa and Andhra Pradesh. They are swept by the four chief rivers of southern India, the Godavari, Mahanadi, Krishna, and Kaveri. The Eastern Ghats are cut into various discontinuous hills by these rivers. They are separated from the Bay of Bengal by the coastal plains.

Characteristics of Eastern Ghats:

Eastern Ghats are older than Western Ghats. The elevation of Eastern Ghats is lower than the Western Ghats. It covers a total area of around 75,000 sq. km. Sirumalai and Karanthamalai hills of Tamil Nadu lies in the southern most part of the Eastern Ghats. North of Kaveri River is higher Kollimalai, Pachaimalai, Shevroy, Kalrayan Hills, Palamalai and Mettur hills in north Tamil Nadu.

One of the biggest characteristics of Eastern Ghats lies in its being extremely fertile. In fact, the Ghat is said to be the watershed of many rivers as the Ghat gets higher average waterfall. Due to higher rainfall, the fertile land results into better crops. Often referred as "Estuaries of India", Eastern Ghats gift its inhabitant the popular profession of fisheries as its coastal area is full of fishing opportunity. Like Western Ghats, thus, Eastern Ghats also carry a heap of ecological importance.

(a) Northern section -

1. Between Mahanadi and Godavari, only in this part it exhibits the true mountaineer character.
2. Composed of khondalites & Charnokites, it is locally known as Maliyas.

(b) Southern Section -

1. Dissected due to large numbers of rivers.
2. Biligiri Rangan Hills are famous for Sandalwood and Teak forests.
3. Malagiri range is famous for Sandalwood and other valuable timbers.
4. Shevroy hills and Javadi hills are composed of Charnokite rocks.
5. Nallamalla range in the most prominent range of this section whose southern part, the Palkonda range is higher.
6. The Nilgiri (Blue mountain) - It is the nodal point of three mountain systems- The Western Ghats, The Eastern Ghats and the southern hills. They are composed of strong Charnokites. Doda Beta (2637m), Makurti (2554m) and Wambadi Shola (2470 m) are three highest peaks. This belt is famous for rubber, tea and coffee plantation. Ooty, the most popular hill-station in South India is located in a broad undulating valley at the foot of Doda Beta.

Eastern Ghats Flora and Fauna:

The diversified ecological niches and environmental situation provide habitat for rich fauna. Eastern Ghats is home to largest number of Asiatic elephants in the world. Other large animals such as Nilgiri Tahr, Leopards, Gaurs, Sambar, and tigers abound the landscape. Apart from this, these Ghats are known for the wide variety of bird species. Eastern Ghats also holds the rich floral system. It is region where you may find large number of medicinal plants.

Eastern Ghats Tribal Population:

The land is also occupied by quite a few tribes which include Savara, Jatapu, Konda Dora, Gadaba, Khond, etc. These indigenous people have their own unique cultural heritage. These people follow the age old customs and traditions. They are still dependent on the forest produce and hunting for their livelihood. These tribes have good knowledge about the region and its produce and thereby make a good use of its medicinal plants.

Western Ghats

The Western Ghats along the western coast of India separates the Deccan Plateau from a narrow coastal strip along the Arabian Sea. The range starts from the southern part of the Tapi River near the border area of Gujarat and Maharashtra. It covers a length of around 1600 km running through the states of Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala finally culminating at Kanyakumari, in the southernmost tip of the peninsula.

Mountains, Gaps and Passes

The Western Ghats have an average elevation of 1200 metres. However, in certain places they rise abruptly to a height of over 2440 metres. The Western Ghats of Maharashtra, extending from the Satpura Range to the north, travels south past Goa to Karnataka. The chief hill range of the segment is the Sahyadri range. Here we have two high peaks, Kalsubai, having a height of 1646 metres and Salher having a height of 1567 metres.

The Western Ghats are home to a number of gaps and passes, notable among them being the Thal Ghat and the Bhor Ghat. They link the interior of the Deccan with Mumbai. The southern part of the Western Ghats harbour the Nilgiri which serve as the meeting point o the Western and Eastern Ghats. The Nilgiris show a steep rise from the plains and enclose between them the Karnataka Plateau. The Nilgiri Hills are home to two of the highest peaks of the Western Ghats: Dodabeta (2637 m) and Makurti (2554 m). To the south of the Nilgiri Hills is located the Palghat gap, extending from the east to the west of the Ghats. With a width of 24 km, the Palghat gap is an easy passageway across the Western Ghats. To the south of the Nilgiris are the Annamalai, Cardamom and Palni hills. The Anaimudi is the highest peak in Peninsular India. It is situated in the Annamalai hills and has a height of 2695 metres.

The narrow coastal plain between the Western Ghats and the Arabian Sea is known as the Konkan Coast in the north and the Malabar Coast in the south. The largest city amidst these mountains is Pune.

Climate and Rainfall

The lower parts of the Western Ghats record humid and tropical type of climate. The elevated regions (1,500 m and above in the north and 2,000 m and above in the south) have a more temperate climate. Mean temperature varies from 24°C in the north to 20°C in the south. In the Western Ghats the climate is largely modified by the winds as they play a major role in the seasonal cycle. In summer they are responsible for ushering the monsoons while in the winter these winds provide a soothing effect. During the monsoon season between June and September, the path of the heavy, eastward-moving rain-bearing clouds is intercepted by the Western Ghats. This results in more rain on the windward side, an average of about 3,000 to 4,000 mm with occasional extremes of 9,000 mm. On the other hand the eastern region of the Western Ghats, which is the rain-shadow region, records a meagre average of 1000 mm. The Coromandel Coast falls in the rain shadow of the Western Ghats, and receives a good deal less rainfall during the summer southwest monsoon, which contributes heavily to rainfall in the rest of India.

Significance of peninsular plateau: Peninsular area is the oldest and the most stable landmass of the Indian sub continent. It contains rich variety of minerals which occur in large quantities as copper, mica, iron; coal etc. a large part of North West plateau is covered with fertile black soil that is useful for growing cotton. Some other areas are suitable for cultivation of tea, coffee, rubber, millets, spices etc. the rivers originating in Western Ghats offer great opportunity for developing hydroelectricity and provide irrigation facilities to the agricultural crops.

COASTAL PLAINS

The plateau is flanked by coastal plains of varied width extending from Kutch to Orissa. There are striking difference between the eastern and the western coastal plains; with notable exception of Gujarat the west coast has narrow alluvial margin interspersed by hilly terrain .It has indentation except in the south where the beautiful Lagoons introduce an element of diversity. The eastern coast on the other hand has a wide plain with well developed deltas of the major rivers. The climatic transition between the south west monsoon regime of the north and the north -east monsoon regime of the south has given rise to interesting differences in the alluvial features in the two different stretches of the east coastal plain.

Eastern Coastal Plains

The eastern coastal plains are located on a wide stretch of land between the Eastern Ghats of India and the Bay of Bengal. This stretch of land stretches to 120 km in width at parts. The eastern coastal plains extend from Tamil Nadu in the south to West Bengal in the north. The eastern coastal plains have rivers draining into them and river deltas also occupy the valleys.

The region of the eastern coastal plains is an expansive area and is divided into six regions. The six regions of the eastern coastal plains of India are the Mahanadi Delta, the Southern Andhra Pradesh Plain, the Krishna Godavari deltas, the Kanyakumari Coast, the Coromandel and the Sandy Coastal regions.

Deltas of many of India's rivers form a major portion of these plains. The Mahanadi, Godavari, Kaveri and Krishna rivers drain these plains. The region receives both the Northeast and Southwest monsoon rains with its annual rainfall averaging between 1,000 mm and 3,000 mm. The width of the plains varies from 100 to 130 km. It is locally known as Northern Circars between Mahanadi and Krishna rivers and Carnatic between Krishna and Kaveri rivers.

The eastern coastal plains are characterized by a temperature that exceeds 30 degrees Celsius and also experiences high levels of humidity. The rainfall of the region is also abundant in the region with rainfall amounts in excess of 1000mm annually with the amount usually approaching 3000mm. It is also of note that this region of the eastern coastal plains is subject to both northeast and southwest monsoon rains when these storms are in season.

It has three broad divisions:-

(i) **Utkal Plains:** - It is the coastal track of Orissa including Mahanadi delta. Most prominent feature is Chilka Lake which is the largest lake in India.

(ii) **Andhra Plains:** - It extends from Utkal Plains in the North of the Pulicat Lake in south (Sriharikota Island is in this lake). Its most important feature is the delta formation of River Godavari and River Kaveri. It also has Lakana Lake.

(iii) **Tamil Nadu Plains:** - It extends from Pulicat Lake to Kanyakumari. Most important feature is Kaveri delta whose fertile soil and irrigation facilities make it a granary of South India where rice is the major crop.

Its characteristics are-

1. Wider and drier (receives less rainfall) than the west coast plain.
2. Contains shifting sand-dunes and stretches of saline soil.
3. Deficient in rainfall.
4. In Madras and Andhra Pradesh, it is called PYAN GHAT.
5. Pulicat Lake near Madras, is a typical lagoon which is now separated from the sea by the Sriharikota island (an old beach ridge).
6. Chilka Lake, Lying south of Mahanadi delta, originated due to the formation of a bay-mouth bar. Two river, Bhargavi and Daya, drain into the Lake, making the water sweet in the rainy season.

Western Coastal Plains

The Western Coastal Plains is a thin strip of coastal plain 50 kilometres (31 miles) in width between the west coast of India and the Western Ghats hills. The plains begin at Gujarat in the north and end at Kerala in the south. It also includes the states of Maharashtra, Goa and Karnataka. The western coastal plain of India in contrast to the eastern coastal plain is located on a narrow strip of land. They extend from Gujarat in the north down 50 km to the south in Kerala and are characterized by numerous backwaters and rivers that flow into the region. These rivers that flow into the region lead to the forming of estuaries that are found in the western coastal plains of India. The western coastal plains are smaller than their eastern counterpart and the region is divided into three parts. The western coastal plains are divided into the regions of Konkan, Kanara, and the Malabar Coast.

Some important facts

North Circars: Between the Mahanadi and the Krishna River.

Carnatic: Between the Krishna and the Cauvery river

Coromandel: Between the Cauvery river and Kanyakumari.

Sub-divisions of the Coastal Plains:

(i) **Kutch Peninsula -**

1. It was an island surrounded by seas and Lagoons, Later it became a part of mainland and developed as a broad plain by the sediments deposited by Indus river system.
2. It is made of tertiary rock system.
3. Due to the scarcity of rain and flowing surface water it has been developed as arid and semi-arid Landscape and, thus, the work of wind is predominant.

(ii) Kathiawar Peninsula -

1. It is made of Deccan Lava.
2. In central part, Mandav hills lies from which small streams radiates in all direction.
3. Mt. Girnar, (of volcanic origin) is the highest point.
4. The Gir range having dense forest and famous as the home of Gir lion, is located in the southern part.
5. Most of hills like Osem hills, Barda hills, etc. are of volcanic origin.

(iii) **Gujarat Plain -**

1. Lying east of Kathiawar; slopes westwards.
2. The eastern part is made of alluvium and in fertile enough to support agriculture while western part is mostly covered by wind blown loess which after weathering has given rise to semi-arid Landscape.

(iv) **Konkan Plain -**

1. Lies south of Gujarat plain; stretches from Daman to Goa.
2. It is characterised by cliffs of basaltic rocks.
3. The submerged forests near the Bombay city suggest that the sea level rose on the Konkan coast in the past.

(v) **Karnataka Coastal Plains -**

1. Stretches from Goa to Mangalore.
2. Maximum width is found near Mangalore.
3. Sharavati is the chief river, which makes Gersoppa (Jog) falls before entering the plain.

(vi) **Kerala Plain (Malabar Plain) -**

1. Stretches from Mangalore to Kanyakumari.
2. Much wider & less hilly than Karnataka plain and other plain.
3. Presence of Lakes, Lagoons, Backwaters, spits etc. is a significant characteristic of Kerala coast.
4. Rivers are short and many of them dry up in summer.

Significance of coastal plains

Large parts of the coastal plains of India are covered by fertile soils on which different crops are grown. Rice is the main crop of these areas. Coconut trees grow along the coast. About 98% of the trade is carried out by the ports. Low lying areas of Gujarat are famous for producing salt whereas fishing is the main occupation of the people living in coastal areas.

THE INDIAN ISLANDS

Apart from the large number of islands in the near proximity of the Indian coast, there are two main groups of islands in the Indian Ocean far away from the coast. One of them is the Andaman and Nicobar Archipelago in the Bay of Bengal and the other is a group of tiny islands known as the Lakshadweep Islands in Arabian Sea. These islands have gained much importance and their study has become almost indispensable in view of the increasing interest of super powers in the geopolitics of the Indian Ocean.

The Andaman and Nicobar group of islands form and arcuate chain, convex to the west, extending from 6° 45′ – 13° 45′ N and 92° 10′

– 94° 15′ E for a distance of about 590 km with a maximum width of about 58 km. This archipelago is composed of 265 big and small islands covering a cumulative area of about 8249 sq km. The entire chain consists of two distinct groups of islands. The Great Andaman group of islands in the north is separated by the north is separated by the Ten Degree Channel from the Nicobar group in the south. The Andaman is a closely knit group of about 203 islands. It is 260 km long and 30 km wide with a total area of 6596 sq km. This group of islands is divided into three major groups viz. North Andaman, Middle Andaman and South Andaman. Little Andaman is separated from the Great Anadmans by 50 km wide Duncan Passage.

The Nicobar group of islands consists of 7 big and 12 small islands together with several tiny islands. They are scattered over a length of 262 km with maximum width of 58 km covering an area of 1,653 sq km. The Great Nicobar, as its name suggests, is the largest island measuring 50 × 25 km. It is the southernmost island and is only 147 km away from Sumatra island of Indonesia.

Most of these islands are made of tertiary sandstone, limestone and shale resting on basic and ultrabasic volcanoes. The Barren and Narcondam islands, north of Port Blair, are volcanic islands. Some of the islands are fringed with coral reefs. Many of them are covered with thick forests and some are highly dissected. Most of the islands are mountainous and reach considerable heights. Saddle peak (737 m) in North Andaman is the highest peak.

The Lakshadweep Islands in the Arabian Sea, though literally mean one lakh islands is only a group of 25 small islands. They are widely scattered over and area of 108.78 sq kms extending from 8° – 12° 20′ N – 71° 45′ 74° E about 200-500 km south-west of the Kerala coast. The islands north of 110 N are known as Amendivi Islands while those south of this latitude are called Cannanore Islands. In the extreme south is the Minicoy island. All are tiny islands of coral origin and are surrounded by fringing reefs. The largest and the most advanced is the Minicoy island with and are of 4.53 sq km. Betra has and area of only 0.12 sq km. Most of the islands have low elevation and do not rise more than five metre above sea level. Their topography is flat and relief features such as hills, streams, valleys, etc. are conspicuous by their absence. Shallow lagoons are seen their western side, while on the eastern seaboard the slopes are steeper. ■■■

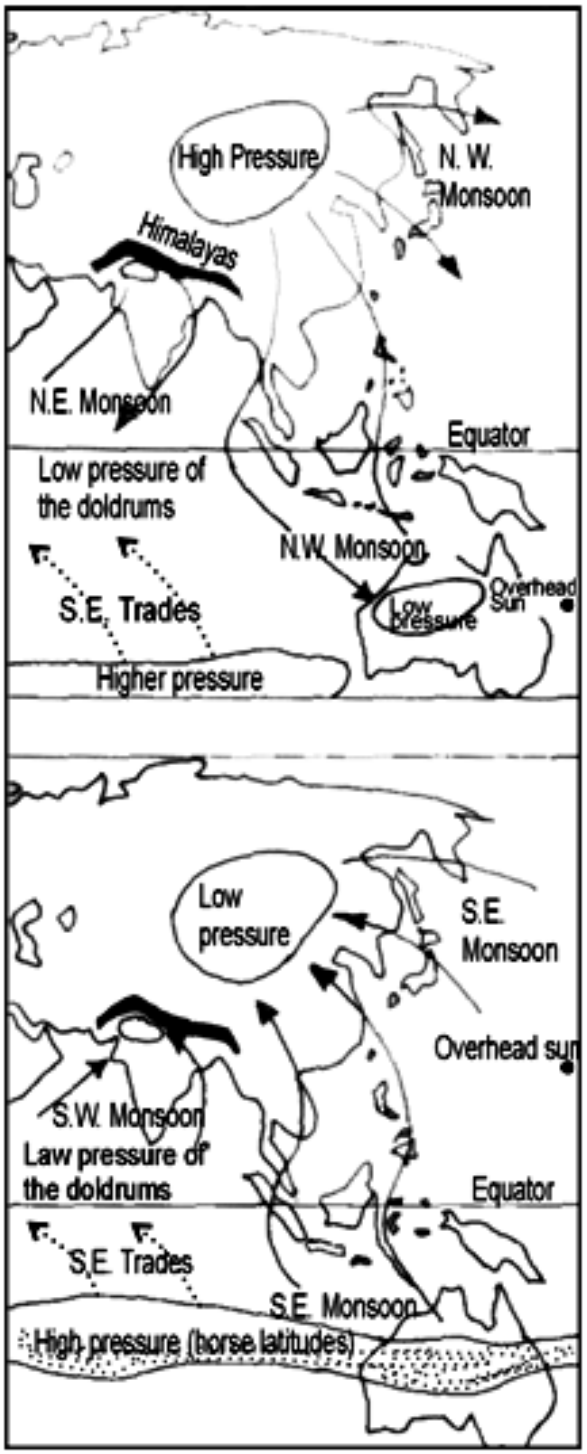
2 CLIMATE OF INDIA

India is a land of contrast of relief and climate. Geographically India is a peninsular extension of the great Eurasian landmass. Climatologically India comes in tropical, sub tropic and temperate regimes.

India is basically a tropical country although its northern part is situated in the temperate belt. In the south, the Indian coasts are washed by the Arabian Sea and the Bay of Bengal branches of the Indian Ocean which give it a typical tropical monsoon climate.

FACTORS DETERMINING THE CLIMATE OF INDIA

1. **Location and Latitudinal Extent:** The Tropic of Cancer passes through the central part of India in east-west direction. Thus, northern part of India lies in sub-tropical and temperate zone and the southern part falls in the tropical zone. The tropical zone being nearer to the equator, experiences high temperatures throughout the year with small daily and annual range. Area north to the Tropic of Cancer being away from the equator, experiences extreme climate with high daily and annual range of temperature.
2. **Distance from the Sea:** Arabian Sea and Bay of Bengal surround the Indian peninsula and make climatic conditions mild along the coastal areas. Areas in the interior of India are far away from the moderating influence of the sea thus having extremes of climate. That is why the annual range of temperature at Kochi does not exceed 3°C whereas it is as high as 20°C at Delhi.
3. **The Himalayas:** The Himalayan Ranges protect India from the bitterly cold and dry winds of Central Asia during winter. Further, these ranges act as an effective physical barrier for rain-bearing south-west monsoon winds to cross the northern frontiers of India. Thus, the Himalayas act as a climatic divide between the Indian Subcontinent and Central Asia.
4. **Physiography:** Physical map of India is very closely related to the climatic conditions of the country. Places located at higher altitude have cool climate even though they are located in the southern India, i.e., Ooty. Similarly, though Agra and Darjeeling are located on the same latitude, the temperature of Agra in January is 16°C whereas it is only 4°C in Darjeeling. The physiography of India also affects the direction and speed of wind and the amount and distribution of rainfall. The windward sides of the Western Ghats and Assam receive high rainfall during June-September whereas the southern plateau remains dry due to its leeward situation along the Western Ghats. It is due to physiography that the funnel shaped Cherrapunji valley is the wettest place on Earth.
5. **Monsoon Winds:** The most dominating factor of the Indian climate is the 'Monsoon winds' as a result of which it is often called the Monsoon Climate. The south-west summer monsoons from the Arabian sea and the Bay of Bengal bring rainfall to the entire country. The north-eastern winter monsoons travel from land to sea and do not cause much rainfall except along the Coromandel coast after getting moisture from the Bay of



Bengal.

6. **Upper Air Circulations:** The changes in the upper air circulation over Indian landmass influence the climate of India to a great extent.

   (i) **Westerly Jet Stream:** All of Western and Central Asia remains under the influence of westerly winds along the altitude of 9-13 km from west to east. These are known as Jet Streams. Tibetan highlands act as a barrier in the path of these jet streams. As a result, jet streams get bifurcated. One of its branches blows to the north of the Tibetan highlands, while the southern branch blows in an eastward direction, south of the Himalayas. It is believed that this southern branch of the jet stream exercises an important influence on the winter weather in India as they bring western disturbances from the Mediterranean region to India.

   (ii) **Easterly Jet:** Reversal in upper air circulation takes place in summer due to the apparent shift of the sun's vertical rays in the northern hemisphere. The westerly jet is replaced by the easterly jet stream which owes its origin to the heating of the Tibetan plateau. This leads to the development of an easterly cold jet stream centered around 15°N latitude and blowing over peninsular India. This helps in the sudden onset of the southwest monsoons.

   The easterly jet stream steers the tropical depressions into India. These depressions play a significant role in the distribution of monsoon rainfall over the Indian subcontinent.

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

8. **Western Disturbance:** The western disturbances, which enter the Indian subcontinent from the west and the northwest during the winter months, originate over the Mediterranean Sea and are brought into India by the westerly jet stream. They influence the winter weather conditions over most of the Northern plains and Western Himalayan region.

9. **El-Nino Effect:** El-Nino is a narrow warm current which occasionally replaces the cold Peru current. This is responsible for wide spread floods and droughts in the tropical regions of the world. It is believed that the severe drought of 1987 in India was caused by El-Nino.
10. **La Nina:** The returning of the weather conditions to normal after an El-Nino is called La Nina. The presence of La Nina is the harbinger of heavy monsoon showers in India.

INDIAN MONSOON

Monsoon comes from an Arabic word 'MAUSAM' which means season. Thus monsoon are seasonal winds which reverse their direction of flow with the change of season. They flow from sea to land during the summer and from land to sea during winter.

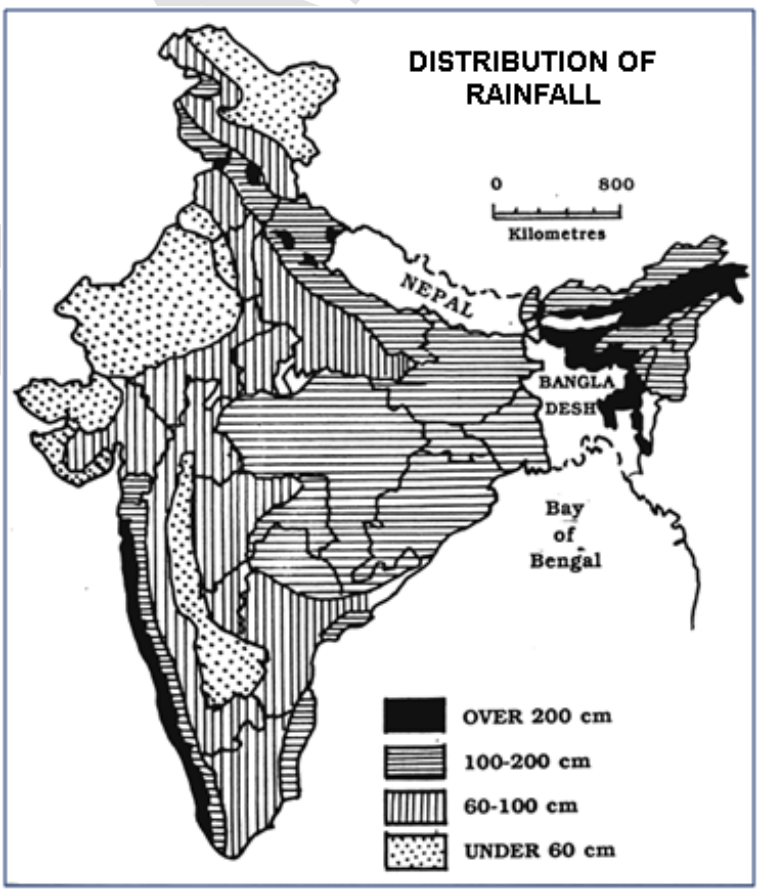
The theories regarding the monsoons are generally divided into following two broad categories:

1. **Classical theory:** Halley explained the monsoon as resulting from thermal contrasts between continents and oceans due to their differential heating.
   In summer the sun shines vertically over the tropic of cancer resulting in high temperature and low pressure in central Asia while the pressure is still sufficiently high over Arabian Sea and Bay of Bengal. This induces air flow from sea to land and brings heavy rainfall to India and her neighbouring countries.
   In winter the sun shines vertically over the tropic of Capricorn. The north western part of India grows colder than Arabian Sea and Bay of Bengal and the flow of the monsoon is reversed.
   It was lacking in the physical ingredient of the effect of rotation of the earth.
2. **Modern theory:**

a) Role of ITCZ; according of FEOHN monsoon is only the normal seasonal migration of planetary winds following the sun. According to him the existence of Asian monsoon is not due to contrast between land and sea but mainly due to the annual migration of thermally produced planetary winds and pressure belts under continental influence. The southeast trade winds of the southern hemisphere cross the equator and start flowing from southwest to northeast direction under the effect of Coriolis force. These displaced trade winds are called south west monsoon and bring monsoon to the region.

b) Role of jet streams; M.T.Yin had given this concept stating that the burst of monsoon depends upon the upper air circulation. Two prominent jet streams effect the monsoon winds

- The sub tropical westerly jet stream, this jet stream dominates in winter time in



upper troposphere circulation of the northern latitudes. It has a global extent between latitudes 25-32 ° N and can be located over south Asia at an elevation of about 12 km. the jet stream is split owing to the 0presence of Himalayan mountain system in its path.

The winds tend to descend over north-western part of India resulting in atmospheric stability.

- Equatorial easterly jet stream, this jet is a prominent feature of the upper air circulation during the Indian monsoon season appearing as a band of strong easterlies extending from south East Asia across the Indian Ocean and Africa to the Atlantic.

  The western and eastern jet streams flow in the north and south of the Himalayas respectively. The eastern jet becomes powerful and stationed and this results in more active south west monsoon.

c) Role of Tibetan plateau, the Tibetan plateau is located more than 4500 km above sea level with a length of 2000 km and with a width of 600 km in the west and 1000 in the east.

This plateau is considered to be one of the key factors in the development of monsoon. The Tibetan plateau exerts its influence as a mechanical barrier as well as high heat plateau. An anticyclone appears in upper troposphere due to latent heating over the Tibetan plateau. It generates an area of rising air, during its ascent the air spreads outwards and gradually sinks over the equatorial part of the Indian Ocean. It picks up moisture from the Indian Ocean and causes rainfall in India and adjoining countries.

Characteristics of Monsoonal Rainfall

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

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

(iii) The monsoon rainfall has a declining trend with increasing distance from the sea. Kolkata receives 119 cm during the southwest monsoon period,

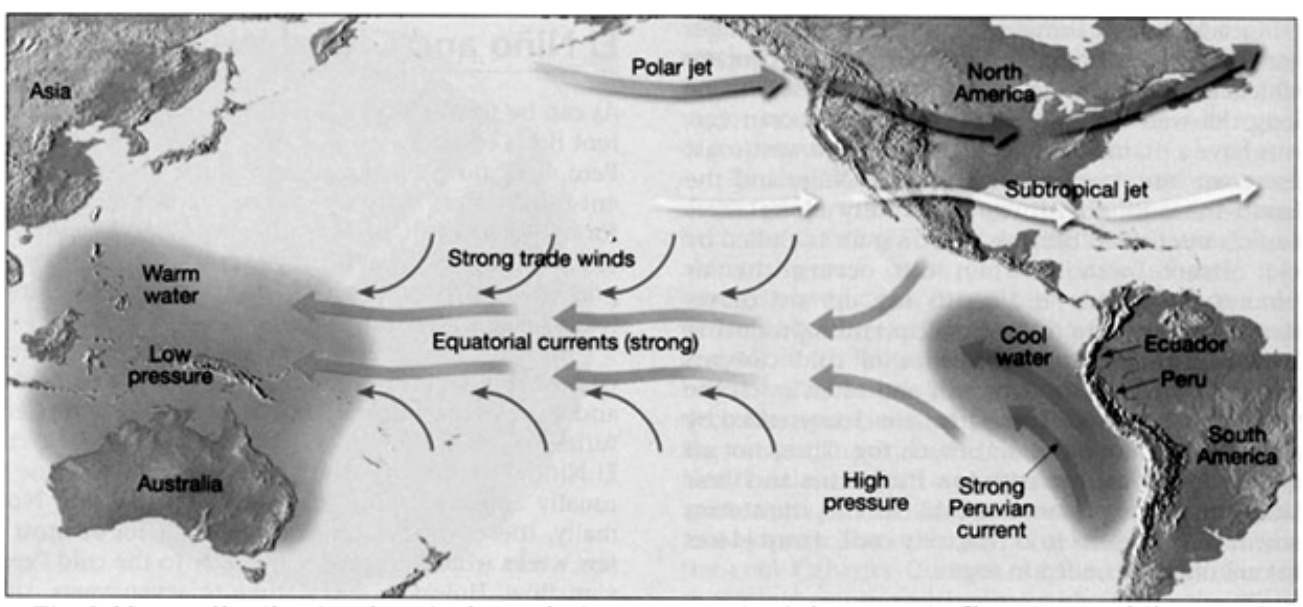


Fig.6 Normally, the trade winds and strong equatorial currents flow toward the west. At the same time, an intense Peruvian current causes upwelling of cold water along the west coast of South America.

Patna 105 cm, Allahabad 76 cm, Delhi 56 cm and Bikaner 24 cm.

(iv) The monsoon rains are characterized by 'Breaks'. These breaks in rainfall are related to the cyclonic depressions formed at the head of the Bay of Bengal, and their crossing into the mainland. The frequency of such depressions is 2 to 4 per months, from June to September. Besides the frequency and intensity of these depressions, the passage followed by them determines the spatial distribution of rainfall.

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

(vi) Monsoon is the pivot of the agrarian economy of India because over three-fourths of the total rain in the country is received during the southwest monsoon season.

(vii) Its spatial distribution is quite uneven ranging from 12 cm in western Rajasthan to more than 400 cm in Meghalaya.

(viii) The beginning of the rains sometimes is considerably delayed over the whole or a part of the country. The rains sometimes end considerably earlier than usual, causing great damage to standing crops and making the sowing of winter crops difficult. This is why monsoons are extremely unpredictive and uncertain.

Rainfall Distribution

1. **Areas of very high rainfall (annual rainfall of 200cm and above)**
   These include the west coast from Thiruvananthapuram in the South to Mumbai in the North (Avg. annual rainfall 200 - 400 cm). Almost the whole of Assam, Nagaland, Meghalaya, Mizoram, Arunachal Pradesh, Sikkim, parts of Manipur, Tripura and northeastern tip of West Bengal also receive 200cm or more, with isolated pockets receiving over 400 cm. Meghalaya (The abode of clouds) is the wettest part of the country with Mawsynram and Cherrapunji getting 1221cm and 1102 cm of annual rainfall respectively.
2. **Areas of High rainfall (100-200cm annual rainfall)**These include eastern slopes of the Western Ghats, major part of the northern plain, Orissa, M.P. Andhra Pradesh, and Tamil Nadu.
3. **Areas of Low rainfall (50 - 100 cm annual rainfall)**
   Include large parts of Gujarat, Maharashtra, Western M.P., Andhra Pradesh, Karnataka, eastern Rajasthan, Punjab, Haryana and parts of Uttar Pradesh.
4. **Areas of very Low rainfall (Less than 50 cm of annual rainfall)**
   These are desert and semi-deserts areas. They include large parts of Western Rajasthan, Kuchchh, and most of Ladakh region of Jammu and Kashmir.

WESTERN DISTURBANCES

With the southward shift of the polar front in winter, the tracks of middle latitude cyclones pass across the northern portion of the Indian subcontinent during the period October to June. In the other months the tracks shift far to pole ward and do not usually affect the Indian region.

The temperate cyclones originates in western Asia and Mediterranean Sea and reach the Indian area in the course of their eastward passage from west India and refer to as western disturbances. These western disturbances causes

- ✓ Snowfall in higher reaches of Himalayas
- ✓ Rainfall in north west plains which are beneficial for rabi crop
- ✓ The sudden cold wave that decreases the temperature of that area and hail also takes place.

LOCAL WINDS

During summers the atmospheric pressure is low all over the country. In the months of May

and June high temperature in North West India builds up steep pressure gradient and under such conditions dust laden and strong winds blows.

a) **LOO:** it is hot dust laden winds that usually starts in the morning and reaches its peak at afternoon. This increases the temperature of the area and causes high humidity.

b) **AANDHIS:** these are basically thunder-storms which move like a solid wall of dust and sand. The winds velocity is high and visibility reduces to few meters only. Such dust storms are common in Rajasthan, Haryana, Delhi, Uttar Pradesh etc.

In West Bengal and adjoining areas of Jharkhand, Orissa the direction of storm is mainly from the North West and are called NORWESTERS.

c) **KAL BAISAKHIS:** these are violent storms causes heavy damage to standing crops, livestock and human beings. Maximum occurs in month of March and April.

■■■

3 WATER RESOURCES AND DRAINAGE PATTERN

Water is essential for human civilization, living organisms, and natural habitat. It is used for drinking, cleaning, agriculture, transportation, industry, recreation, and animal husbandry, producing electricity for domestic, industrial and commercial use. Due to its multiple benefits and the problems created by its excesses, shortages and quality deterioration, water as a resource requires special attention.

WATER RESOURCES OF INDIA

Rivers, estuaries, groundwater and other water bodies constitute the water resource of India.

Water resources of a country constitute one of its vital assets. India receives annual precipitation of about 4000 km^3 .The rainfall in India shows very high spatial and temporal variability and paradox of the situation is that Mousinram near Cherrapunji, which receives the highest rainfall in the world, also suffers from a shortage of water during the non-rainy season, almost every year. The total average annual flow per year for the Indian rivers is estimated as 1953 km^3 .The total annual replenishable groundwater resources are assessed as 432 km^3 .

The annual utilizable surface water and groundwater resources of India are estimated as 690 km^3 and 396 km^3 per year, respectively. With rapid growing population and improving living standards the pressure on our water resources is increasing and per capita availability of water resources is reducing day by day. Due to spatial and temporal variability in precipitation the country faces the problem of flood and drought syndrome. Overexploitation of groundwater is leading to reduction of low flows in the rivers, declining of the groundwater resources, and salt water intrusion in aquifers of the coastal areas. Over canal-irrigation in some of the command areas has resulted in water logging and salinity. The quality of surface and groundwater resources is also deteriorating because of increasing pollutant loads from point and non-point sources. The climate change is expected to affect precipitation and water availability.

India is gifted with a river system comprising more than 20 major rivers with several tributaries. Many of these rivers are perennial and some of these are seasonal. The rivers like Ganges, Brahmaputra and Indus originate from the Himalayas and carry water throughout the year. The snow and ice melt of the Himalayas and the base flow contribute the flows during the lean season. More than 50% of water resources of India are located in various tributaries of these river systems. Average water yield per unit area of the Himalayan rivers is almost double that of the south peninsular rivers system, indicating the importance of snow and glacier melt contribution from the high mountains.

Apart from the water available in the various rivers of the country, the groundwater is also an important source of water for drinking, irrigation, industrial uses, etc. It accounts for about 80% of domestic water requirement and more than 45% of the total irrigation in the country. As per the international norms, if per-capita water availability is less than 1700 m^3 per year then the country is categorized as water stressed and if it is less than 1000 m^3 per capita

per year then the country is classified as water scarce.

WATER CONSERVATION

Our country being a monsoon land is having a short period of about three to four months of rainfall. Thus, water conservation in India is must to complete the scarce surface water supply for the greater part of the year. This process of water conservation in our country is done because of less water resources which include rainy, ground, sea, pond and river water in it. Thus, to improve and to make better water facilities for water supply, government issued numerous of soil and water conservation plans for it.

Groundwater and Surface water management

To protect the aquifers from overexploitation, an effective groundwater management policy oriented towards promotion of efficiency, equity and sustainability is required.

Agricultural holdings in India are highly fragmented and the rural population density is large. The exploitation of groundwater resources should be regulated so as not to exceed the recharging possibilities, as well as to ensure social equity. The detrimental environmental consequences of over-exploitation of groundwater need to be effectively prevented by the Central and State Governments. Overexploitation of groundwater should be avoided, especially near the coasts to prevent ingress of seawater into freshwater aquifers. Clearly, a joint management approach combining government administration with active people participation is a promising solution. In critically overexploited areas, bore-well drilling should be regulated till the water table attains the desired elevation. Artificial recharge measures need to be urgently implemented in these areas. Amongst the various recharge techniques, percolation tanks are least expensive in terms of initial construction costs. Many such tanks already exist but a vast majority of these structures have silted up. In such cases, cleaning of the bed of the tank will make them reusable. Promotion of participatory action in rehabilitating tanks for recharging would go a long way in augmenting groundwater supply. Due to declining water table, the cost of extraction of groundwater has been increasing over time and wells often go dry. This posses serious financial burden on farmers. Hence, special programmes need to be designed to support these farmers. Finally, the role of government will have to switch from that of a controller of groundwater development to that of a facilitator of equitable and sustainable development.

Large canal infrastructure network for providing irrigation has been the prime goal of the Government of India, since the first five-year plan, which continued up to seventh five-year plan. In some of the irrigation project commands such as Sarda Sahayak in UP, Gandak in Bihar, Chambal in Rajasthan, Nagarjuna Sagar in Andhra Pradesh, Ghataprabha and Malaprabha in Karnataka etc , problems of water logging are being faced. The main reason for excessive use of surface water as compared to groundwater is it's much lower price for irrigation as compared to the cost incurred in using groundwater. Water logging problems could be overcome if conjunctive use of surface and groundwater is made. Groundwater utilization for irrigation in waterlogged areas can help to lower the groundwater table and reclaim the affected soil. Over exploitation of groundwater in areas like Mehsana, in Gujarat; parts of Meerut and Varanasi districts in Uttar Pradesh, Coimbatore in Tamil Nadu and Karnal district in Haryana etc. have resulted in mining of groundwater. Many research workers have focused the causes of water logging. Several groundwater flow modelling studies have focused on assessing the waterlogged areas and measures to control problems of water logging and salinization

It is desirable that the irrigation needs for fulfilling crop water requirements should be satisfied by judicious judicious utilization of available canal water in conjunction with groundwater so as to keep the water table within the acceptable range.

Thus, the optimal conjunctive use of the region's surface and groundwater resources

would help in minimizing the problems of water logging and groundwater mining.

Rain water harvesting

Rainwater harvesting is the process to capture and store rainfall for its efficient utilization and conservation to control its runoff, evaporation and seepage. Some of the benefits of rainwater harvesting are:

- It increases water availability
- It checks the declining water table
- It is environmentally friendly
- It improves the quality of groundwater through dilution, mainly of fluoride, nitrate, and salinity, and
- It prevents soil erosion and flooding, especially in the urban areas.

Recycle and reuse of water

Another way through which we can improve freshwater availability is by recycle and reuse of water. It is said that in the city of Frankfurt, Germany, every drop of water is recycled eight times. Use of water of lesser quality, such as reclaimed wastewater, for cooling and fire fighting is an attractive option for large and complex industries to reduce their water costs, increase production and decrease the consumption of energy. This conserves better quality waters for potable uses. Currently, recycling of water is not practiced on a large scale in India and there is considerable scope and incentive to use this alternative

Drip irrigation

Drip irrigation consists of a network of porous or perforated piping, usually installed on the surface or below ground, which delivers water directly to the root zones of the crops. These techniques keep evaporation losses at a very low level (about 5%). Hence, this system cuts water use upto 60% as compared with gravity systems.

LEPA

The LEPA method delivers water to the crops from drop tubes that extend from the sprinkler's arm. When applied with appropriate water saving techniques, this method also can achieve efficiencies as high as 95%. Since this method operates at low pressure, energy costs are reduced by 20 percent to 5 percent compared with conventional systems.

DRAINAGE SYSTEMS OF INDIA

India is blessed with hundreds of large and small rivers, which drain the length and breadth of the country. The annual yield of water in the rivers of the country is 18, 58,100 million cubic meters, 1/3rd (33.8%) of which is contributed by the Brahmaputra followed by the Ganga (25.2%), the Godavari (6.4%), the Indus (4.3%), the Mahanadi (3.6%), the Krishna (3.4%), and the Narmada (2.9%).

On the basis of the origin of rivers, the Indian drainage system can broadly be divided into–

(1) The Himalayan river system including Indus, Brahmaputra, Ganga and their tributaries, and

(2) The Peninsular river system which include Mahanadi, Godavari, Krishna, Cauvery, Narmada, Tapi and their tributaries.

Similarly on the basis of orientation to the sea, the Indian drainage system can be divided into -

(A) The Bay of Bengal drainage

(B) The Arabian sea drainage.

About 77% of the drainage area of the country is oriented towards the Bay is Bengal and it consists of large numbers of rivers like Ganga, Brahmaputra, Mahanadi, Godavari, Krishna, Cauvery, Penneru, Vaigai etc. while 23% of the country's drainage area is oriented towards the Arabian sea including the Indus, Narmada, Tapi, Sabarmati, Mahi and large number of swift flowing western coast rivers descending from the Sahyadris. Over 90% of the water carried by the Indian rivers is drained into the Bay of Bengal and rest into the Arabian Sea or forms inland drainage. Water-divide plays an important role in deciding the direction of the river flow.

HIMALAYAN RIVER SYSTEMS

Important features:-

- Himalayan rivers are typical example of antecedent drainage, i.e. they were in existence before the uplift of the Himalayas. It is evident from the deep gorges of the rivers like Indus, Satluj, Alaknanda, Bhagirathi, Brahmaputra and Kosi. Also, most of them are not consequent to the Himalayan relief.
- Because these rivers are fed by extensive snow cover of the Himalayas, they are perennial in nature. During the monsoon season they receive heavy Rainfall and reach to their maximum discharge.
- The geologically unstable condition and friable nature of the terrain cause considerable meandering or drastic changes in their courses and uncertainty and capriciousness in their behaviour.
- The valleys are in immature stage of development and, therefore, they are characterized by a number of rapids, waterfalls, and cascades.

Evolution of the Himalayan drainage

Geologists believe that a mighty river called Shiwalik or Indo-Brahma traversed the entire longitudinal extent of the Himalayas from Assam to Punjab and onwards to Sind, and finally discharged into the Gulf of Sind near lower Punjab during the Miocene period. The remarkable continuity of the Shiwalik and its lacustrine origin and alluvial deposits consisting of sands, silt, clay, boulders and conglomerates support this viewpoint. It is opined that in due course of time Indo-Brahma river was dismembered into three main drainage systems:

(i) the Indus and its five tributaries in the western part;
(ii) the Ganga and its Himalayan tributaries in the central part; and
(iii) the stretch of the Brahmaputra in Assam and its Himalayan tributaries in the eastern part.

The dismemberment was probably due to the Pleistocene upheaval in the western Himalayas, including the uplift of the Potwar Plateau (Delhi Ridge), which acted as the water divide between the Indus and Ganga drainage systems. Likewise, the downthrusting of the Malda gap area between the Rajmahal hills and the Meghalaya plateau during the mid-Pleistocene period, diverted the Ganga and the Brahmaputra systems to flow towards the Bay of Bengal.

The Indus System

This is one of the largest river basins of the world, covering an area of 1,178,440 sq. km (in India 321,290 sq. km) and a total length of 2,880 km (in India 709 km). The Indus, also known as the Sindhu, is the westernmost of the Himalayan rivers in India.

The Indus originates from a glacier near Bokhar Chu (31°15' N latitude and 81°40' E longitude) in the Tibetan region at an altitude of 5,182 m in the Kailash Mountain range. In Tibet, it is known as 'Singe Khamban' or Lion's mouth until it is joined by the Dhar. It enters India and continues to flow in the northwest direction between Ladakh and Jaskar ranges. In India, the Indus flows only through the Leh district in Jammu and Kashmir. The gradient of the river is very gentle (30 cm per km). It receives a number of tributaries such as the Shyok, the Gilgit, the Gortang, the Zaskar, the Hunza, the Nubra, the Shigar, the Gasting and the Dras.

Indus enters Pakistan near Chillar in the Dardistan region and finally emerges out of the hills near Attock where it receives the Kabul river on its right bank. The other important tributaries joining the right bank of the Indus are the Khurram, the Tochi, the Gomal, the Viboa and the Sangar. They all originate in the Sulaiman ranges. The river flows southwards and receives 'Panjnad' a little north of Mithankot. The Panjnad is the name given to the accumulated water of the five rivers of Punjab namely the Jhelum, the Chenab, the Ravi, the Beas and the Satluj. Indus finally discharges into the

Arabian Sea, east of Karachi. The average annual flow of water in the Indus river is 110,450 million cubic meters at Kalabagh.

The Jhelum, an important tributary of the Indus, rises from a spring at Verinag situated at an altitude of 4900m in the south-eastern part of the valley of Kashmir. It flows northward through Srinagar and the Wular lake. At Muzaffarabad, the river takes a hairpin bend southwards and receives river Kishenganga on its right bank. Thereafter, it forms the India-Pakistan boundary for 170km and emerges at Potwar plateau near Mirpur. Its main tributaries are the Lidar, the Sind, and the Pohru from Kashmir Himalayas. The average annual flow of water in the Jhelum river is 27,890 million cubic meters at Mangala. It joins the Chenab at Trimmu near Jhang in Pakistan.

The Chenab, the largest tributary of the Indus, originates near Bara Lacha Pass and is formed by two streams, the Chandra and the Bhaga, which join at Tandi near Keylong in Himachal Pradesh. Here, it is also known as Chandrabhaga. It flows towards northwest through Pangi valley and enters Jammu and Kashmir. At Akhnur, the Chenab enters the plain. The river flows for 1,180 km before entering into Pakistan. The average annual flow of water in the Chenab river is 29,000 million cubic meters at Marala. It joins the Satluj at Panchnad in Pakistan.

The Ravi has its source in the Kullu hills near Rohtang Pass in Himachal Pradesh. Flowing in the northwest direction, it drains the area lying between the Pir Panjal and the Dhauladhar ranges. It enters Punjab plains near Madhopur and enters Pakistan 26km south of Amritsar. It debouches into Chenab at Sarai Sindhu near Rangpur. Its annual flow at Madhopur is 8,000 million cubic meters.

The Beas originates from the Beas Kund near the Rohtang Pass at an elevation of 4,000 m above the mean sea level. The river flows through the Kullu valley and forms gorges at Kati and Lorji in the Dhauladhar range. It enters the Punjab plains near Pong. Then it takes south-westerly direction and meets the Satluj near Harike. The average annual flow of the Beas at Mandi is 15,800 million cubic meters.

The Satluj, an antecedent river, originates from the Mansarovar-Rakas Lake near Darma Pass at an altitude of 4,570 m in Tibet where it is known as Langchen Khamban. It flows almost parallel to the Indus for about 400 km before entering India through the Shipki La Pass. It has created a 900 m deep gorge in Nari Khorsan province of Tibet. Its main tributary Spiti joins it at Namgia. It is a very important river as it feeds the canal system of the Bhakra Nangal project. After entering the plains at Rupar, it turns westward and is joined by the Beas at Harike. From Ferozepur to Fazilka, it forms the boundary between India and Pakistan for 120 km. Out of its total length of 1,450 km, it flows for 1,050 km in India. Its average annual flow at Rupnagar (Rupar) is 16,600 million cubic meters.

The Ganga River System

The Ganga originates as the Bhagirathi from the Gangotri glacier at Gaumukh, at an elevation of 7,010 m. Alaknanda, the other headstream of Ganga, has its source in the Satopanth glacier near Badrinath. The Alaknanda consists of the Dhauli and the Vishnu Ganga which meet at Joshimath. The Alaknanda river meets-

- The Dhauliganga river at Vishnuprayag,
- The Pindar river at Karnaprayag,
- The Mandakini or Kali Ganga at Rudraprayag and finally
- The Bhagirathi river at Devprayag.

At Devprayag Ganga gets its name. After traversing 280km from its source, Ganga debouches on the Gangetic Plain at the pilgrimage town of Haridwar. Here, some of its waters is diverted to the Ganges Canal, which irrigates the Doab region of Uttar Pradesh. The Ganges, whose course has been roughly southwestern until this point, now begins to flow southeast through the plains of northern India. The river follows a 770 km curving course passing through the city of Kanpur before being joined from the southwest by the Yamuna at Allahabad. Joined by numerous rivers such as the Kosi, Son, Gandak and Ghaghra, the Ganges forms a

formidable current in the stretch between Allahabad and Malda in West Bengal. On its way it passes the towns of Varanasi, Buxar, Patna and Bhagalpur. At Bhagalpur, the river meanders past the Rajmahal Hills, and begins to run south.

At Pakur, the river begins its attrition with the branching away of its first distributary, the Bhagirathi-Hooghly, which goes on to form the Hooghly River. Near the border with Bangladesh the Farakka Barrage, built in 1974, controls the flow of the Ganges, diverting some of the water into a feeder canal linking the Hooghly to keep it relatively silt-free. The Farakka barrage project consists of a barrage across the Ganga at Farakka and another across the Bhagirathi at Jangipur.

After entering Bangladesh, the main branch of the Ganges is known as the Padma River until it is joined by the largest distributary of the Brahmaputra- the Jamuna River at Goalundo. Further downstream, it is fed by the Meghna River, the second largest tributary of the Brahmaputra, and flows as Meghna to enter the Meghna Estuary near Sagar island.

The total length of Ganga is 2525 km, of which 310 km is in Uttarakhand, 1140 km in Uttar Pradesh, 445 km in Bihar, and 520 km in west Bengal. The remaining 110 km stretch of the Ganga forms the boundary between Bihar and Uttar Pradesh. The Yamuna and the Son are its major right bank tributaries. The important left bank tributaries are the

Ramganga, the Gomati, the Ghaghara, the Gandak, the Kosi and the Mahananda in the order from west to east.

The Yamuna, the western most and the longest tributary of the Ganga, has its source in the Yamnotri glacier on the western slopes of Banderpunch range (6,330 m). Small streams like Rishiganga, Uma, and Hanuman Ganga join it in the mountains. Tons joins it near Kalsi. It enters plains at Tajewala. It is joined by the Chambal, the Sind, the Betwa and the Ken on its right bank which originates from the Peninsular plateau while the Hindon, the Rind, the Sengar, the Varuna, join it on its left bank. It joins the Ganga at Prayag (Allahabad). The total length of Yamuna from its origin to Prayag is 1,376 km. Much of its water feeds the western and eastern Yamuna and the Agra canals for irrigation purposes.

The Chambal rises from Janapao hills near Mhow in the Malwa plateau of Madhya Pradesh and flows northwards through a gorge upwards of Kota in Rajasthan, where the Gandhisagar dam has been constructed. From Kota, it traverses down to Bundi, Sawai Madhopur and Dholpur, and finally joins the Yamuna in Etawah district of U.P. The Chambal is famous for its badland topography called the Chambal ravines. The total length of the river is 1,050 km. The Banas joins it at Sawai Madhopur.

The Sind originates in Vidisha plateau of Madhya Pradesh. It flows for a distance of 415 km before joining Yamuna.

The Betwa rises in the Bhopal district and joins Yamuna near Hamirpur after traversing a distance of 590 km. The Dhasan is its important tributary.

The Ken is 360 km long river rising from the Barner Range of Madhya Pradesh. It joins Yamuna near Chila.

The Son is a large south bank tributary of the Ganga, originating in the Amarkantak

plateau. After forming a series of waterfalls at the edge of the plateau, it turns northeastward. It reaches Arrah, west of Patna, to join the Ganga. The important tributaries of the Son are the Johilla, the Gopat, the Rihand, the Kanhar and the North Koel.

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

The Ramganga is a small river rising in the Garhwal hills near Kalagarh.

It changes its course to the southwest direction after crossing the Shiwalik and enters into the plains of Uttar Pradesh near Najibabad.

Finally, it joins the Ganga near Kannauj. Its main tributaries are the Khoh, the Gangan, the Aril, the Kosi, and the Deoha (Gorra).

The Ghaghara originates in the glaciers of Mapchachungo near Gurla Mandhata peak south of Mansarovar. It is known as Karnali in western Nepal. After collecting the waters of its tributaries - Tila, Seti and Beri, it comes out of the mountain, cutting a deep gorge at Shishapani. The river Sarda (Kali or Kali Ganga) joins it in the plain before it finally meets the Ganga at Chhapra. Its other tributaries are the Sarju and the Rapti. Its average annual flow is 94,000 million cubic meter.

The Sarda or Saryu river rises in the Milan glacier in the Nepal Himalayas where it is known as the Goriganga. Along the Indo-Nepal border, it is called Kali. After reaching the plain near Tanakpur, it is called as Chauka. Then it takes southeasterly course to join the Ghaghara.

The Gandak comprises two streams, namely Kaligandak and Trishul Ganga. It rises in the Nepal Himalayas between the Dhaulagiri and Mount Everest and drains the central part of Nepal. Gandak is known as narayani in Nepal. It enters the Ganga plain in Champaran district of Bihar and joins the Ganga at Sonpur near Patna. The average annual flow is 52,200 million cubic meters. Its main tributaries are the Mayangadi and the Bari.

The Burhi Gandak originates from the western slopes of Sumesar hills near Indo-Nepal border and flows in south-east direction. It joins Ganga opposite Monghyr. Its length is 610 km.

The Kosi is an antecedent river with its source to the north of Mount Everest in Tibet, where its main stream Arun rises. After crossing the Central Himalayas in Nepal, it is joined by the Sun Kosi from the West and the Tamur Kosi from the east. It forms Sapt Kosi after uniting with the river Arun at Triveni. Soon after debouching onto the plain the river becomes sluggish due to heavy load. The river channel is braided and it shifts its course frequently. This causes devastating floods. Thus the Kosi is known as 'the Sorrow of Bihar'. Hanuman Nagar barrage has been constructed in 1965 to tame the river. The Kosi joins Ganga near Kursala.

The Brahmaputra River System

The Brahmaputra, one of the largest rivers of the world, has its origin in the Chemayungdung glacier of the Kailash range. Mariam La separates its source from the Mansarovar lake. From here, it traverses eastward longitudinally for a distance of nearly 1,200 km in a dry and flat region of southern Tibet, where it is known as the Tsangpo, which means 'the purifier.' The Rango Tsangpo is the major tributary of this river from the north in Tibet. It emerges as a turbulent and dynamic river after carving out a deep gorge in the Central Himalayas near Namcha Barwa (7,756 m). The river emerges from the foothills under the name of Siang or Dihang. It enters India west of Sadiya town in Arunachal Pradesh. Flowing southwest, it receives its main left bank tributaries, viz., Dibang or Sikang and Lohit; thereafter, it is known as the Brahmaputra.

The Brahmaputra receives numerous tributaries in its 750 km long journey through the Assam valley. Its major left bank tributaries are the Burhi Dihing, Noa Dihing, Dhansiri (South), Dibru, Dikhu, and Kalang whereas the important right bank tributaries are the Subansiri, Kameng, Dhansiri (north), Manas, and Sankosh. The Subansiri, which has its origin in Tibet, is an antecedent river. The Brahmaputra enters Bangladesh near Dhubri and flows southward. In Bangladesh, the Tista joins it on its right bank from where the river is known as the Jamuna. It finally merges with the river Padma, which falls in the Bay of Bengal.

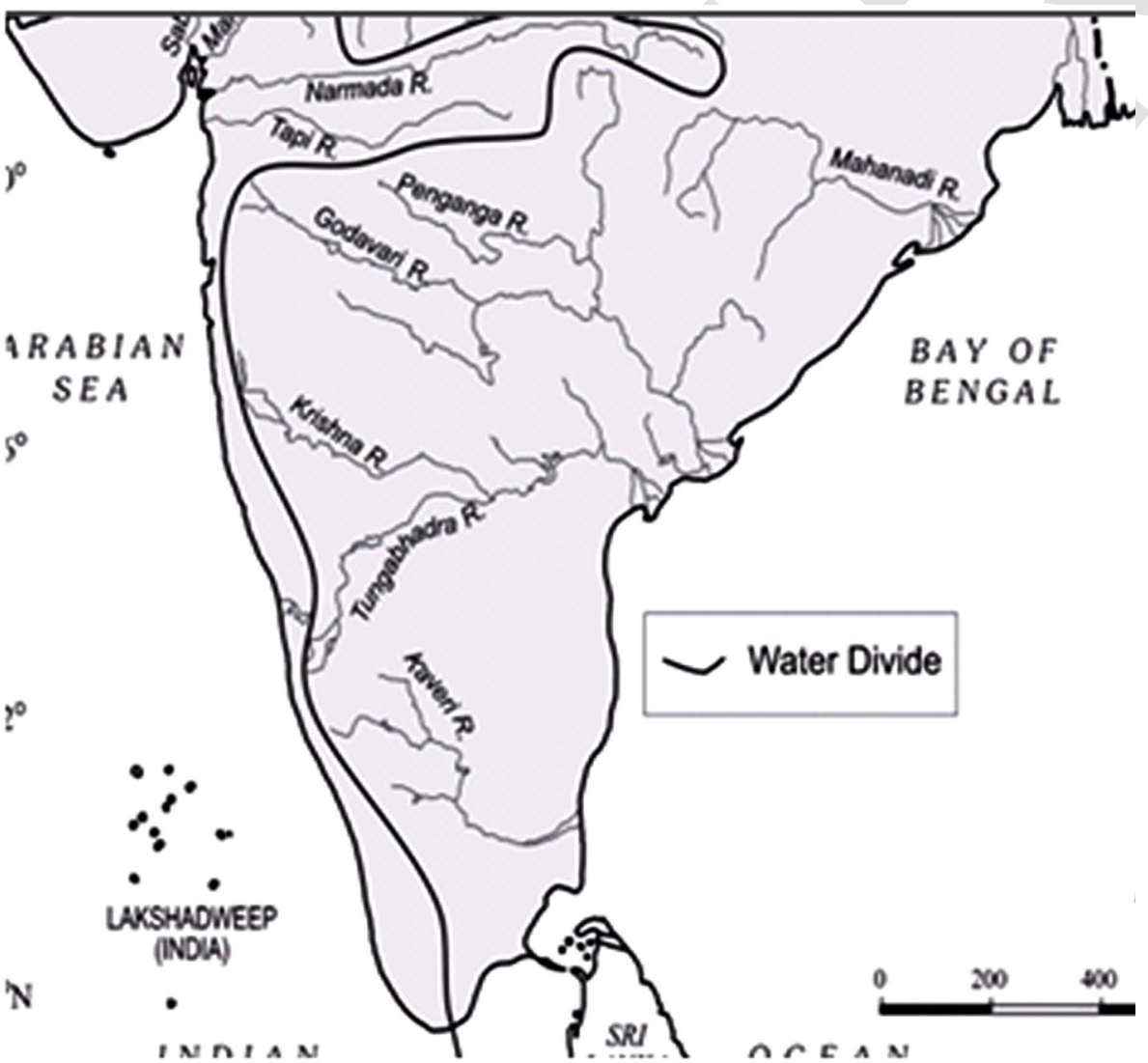
The Brahmaputra is well-known for floods, channel shifting and bank erosion. This is due to the fact that most of its tributaries are large, and bring large quantity of sediments owing to heavy rainfall in its catchment area. It has a braided channel for most of its course in Assam and forms the worlds largest river island 'Majuli'.

THE PENINSULAR DRAINAGE SYSTEM

The Peninsular drainage system is older than the Himalayan one. This is evident from the broad, largely-graded shallow valleys and the maturity of the rivers. The Western Ghats running close to the western coast act as the water divide between the major Peninsular rivers, discharging their water in the Bay of Bengal and small rivulets joining the Arabian Sea. Most of the major Peninsular Rivers except Narmada and Tapi flow from west to east. The major river systems of the peninsular drainage are - the Mahanadi the Godavari, the Krishna and the Cauvery. Peninsular rivers are characterized by fixed course, absence of meanders and non perennial flow of water. The Narmada and the Tapi which flow through the rift valley are, however, exceptions.

Evolution of the peninsular drainage

Three major geological events in the distant past have shaped the present drainage systems of Peninsular India:



(i) Subsidence of the western flank of the Peninsula leading to its submergence below the sea during the early tertiary period. Generally, it has disturbed the symmetrical plan of the river on either side of the original watershed.

(ii) Upheaval of the Himalayas when the northern flank of the peninsular block was

subjected to subsidence and the consequent trough faulting. The Narmada and the Tapi flow in trough faults and fill the original cracks with their detritus materials. Hence there is a lack of alluvial and deltaic deposits in these rivers.

(iii) Slight tilting of the Peninsular block from northwest to the southeastern direction gave orientation to the entire drainage system towards the Bay of Bengal during the same period.

The Peninsular River Systems

Important features of the Peninsular River system:

- The peninsular rivers originate at lower altitudes and drain areas which are geologically more stable and, therefore, are devoid of meanders.
- The river Channels have reached the base levels and have low gradients.
- Larger deltas are formed by larger rivers at their mouth (except those flowing towards west).
- The broad, largely graded and shallow valleys of the peninsular rivers indicate that they have existed for a much longer period than the Himalayan rivers.
- Most of the peninsular river flow towards the east because the main watershed lies in Western Ghats in close proximity to the west coast. Notable exceptions are Narmada and Tapi, which flows in a direction opposed to this general trend.
- There are a large number of river systems in the peninsular drainage. There are three main directions of flow of peninsular rivers-
  (i) The Mahanadi, the Godavari, the Krishna, the Cauvery and several small rivers draining south-east into the Bay of Bengal.
  (ii) The Narmada and the Tapi flowing west as well as several small streams originating from the Western Ghats flow westward into the Arabean sea.
  (iii) The tributaries of Ganga and Yamuna such as Chambal, Sind, Betwa, Ken, Son and Damodar flow in north-easterly direction.

The East Flowing Rivers of the Peninsula

The Mahanadi rises near Sihawa in Raipur district of Chhattisgarh and runs through Orissa to discharge its water into the Bay of Bengal. It is 851 km long and its catchment area spreads over 1.42 lakh sq. km. Some navigation is carried on in the lower course of this river. 53 per cent of the drainage basin of this river lies in Madhya Pradesh and Chhattisgarh, while 47 per cent lies in Orissa. The main tributaries are the Ib, the Mand, the Hasdo and the Sheonath on the left bank and the Ong, the Jonk, and the Tel on the right bank. World's longest dam Hirakud is situated on this river.

The Godavari is the largest peninsular river. It is also called the Vridha Ganga or the Dakshin Ganga. It rises from the Triambak plateau in the Nasik district of Maharashtra and discharges its water into the Bay of Bengal. Its tributaries run through the states of Maharashtra, Madhya Pradesh, Chhattisgarh, Orissa and Andhra Pradesh. It is 1,465 km long with a catchment area spreading over 3.13 lakh sq. km, 49 per cent of which lies in Maharashtra, 21 per cent in Madhya Pradesh and Chhattisgarh, 24 percent in Andhra Pradesh and the rest in Orissa. The Manjra is the only important right bank tributary which passes through Nizam Sagar dam. The Penganga, the Wardha, the Wainganga, the Indravati, the Pranhita, and the Sabari are its principal left bank tributaries. The Penganga joins the Wardha which in turn joins the Wainganga to become short-span Pranhita which merges with the Godavari. The Indravati rises from Kondhan hills of Eastern Ghats. The Godavari is subjected to heavy floods in its lower reaches to the south of Polavaram, where it forms a picturesque gorge. It is navigable for only 300 km in the deltaic stretch. After Rajamundri, the river splits into Gautami Godavari in the east and Vashishtha Godavari in the west forming a large Lobate type delta.

The Krishna is the second largest east-flowing peninsular river which rises near Mahabaleshwar in the Sahyadris. Its total length is 1,400 km. The Koyna, the Muneru, the Ghatprabha, the Malprabha, the Tungbhadra, the Musi, and the Bhima are its major tributaries. Of the total catchment area of the Krishna, 27 per cent lies in Maharashtra, 44 per cent in Karnataka and 29 per cent in Andhra Pradesh.

The Kaveri rises from Taal Kaveri in Brahmagiri hills in Karnataka. Its length is 800 km and it drains an area of 81,155 sq. km. Since the upper catchment area receives rainfall during the southwest monsoon season (summer) and the lower part during the northeast monsoon season (winter), the river carries water throughout the year with comparatively less fluctuation than the other peninsular rivers. The river descends from the South Karnataka Plateau to the Tamilnadu Plains through the Sivasamudram Falls. The river island Srirangam is in its middle course. About 3 per cent of the Kaveri basin falls in Kerala, 41 per cent in Karnataka and 56 per cent in Tamil Nadu. Its important tributaries are the Herangi, the Hemavati, the Lokpavani, the Shimsha and the Arkavati from the north and the Lakshamantirtha, the Kabini, the Suvarnavati, the Bhavani and the Amravati from south.The other east flowing rivers of the peninsular India are, from north to south, the Subarnarekha, the Brahmani, the Penneru, the Ponnaiyar, and the Vaigai. The Brahmani forms after the confluence of the Koel and the Sankh near Rourkela. Its tributaries are the Kura, the Sankhad and the Tikra. The tributaries of the Penneru are the Jayamangli, the Kunderu, the Saigileru, the Chitravati, the Papagni and the Cheyyeru. The Baitarni, the Vamsadhara and the Palar are other important rivers.

The West Flowing Rivers of the Peninsula

The Narmada, the largest west flowing river of the peninsula, originates on the western flank of the Amarkantak plateau at a height of about 1,057 m. Flowing in a rift valley between the Satpura in the south and the Vindhyan range in the north, it forms a picturesque gorge in Marble Rocks and Dhuandhar waterfall near Jabalpur. It makes other waterfalls at Mandhar, Dardi and Maheshwar (Sahasradhara Falls). After flowing a distance of about 1,310 km, it meets the Arabian sea south of Bharuch, forming a broad 27 km long estuary in the Gulf of Khambhat. Its catchment area is about 98,796 sq. km. The Sardar Sarovar Project has been constructed on this river. The Hiran, the Orsang, the Barna and the Kolar are its major right bank tributaries. The major left bank tributaries are the Burhner, the Banjar, the Shar, the Shakkar, the Kundi and the Tawa.

The Tapi or the Tapti is the second largest westward flowing river. It is also known as 'The Twin' and 'The Handmaid' of the Narmada. It originates from Multai in the Betul district of Madhya Pradesh. It is 730 km long and drains an area of 65,145 sq. km. Nearly 79 per cent of its basin lies in Maharashtra, 15 per cent in Madhya Pradesh and the remaining 6 per cent in Gujarat. Its main tributary is the Purna joining it near Bhusawal. Other tributaries are the Betul, the Patki, the Aner, and Gomai on the right bank and the Khursi, the Girna, the Bori and the Panjhara on the left bank.

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

The Sabarmati is the name given to the combined streams of the Sabar and the Hathmati. It rises from Mewar in Aravali range and falls into the Gulf of Khambhat. Its tributaries are the Sedhi, the Meshwa, etc.

The Mahi rises in the Vindhyas and falls into the Gulf of Khambhat. Its drainage area is shared by Madhya Pradesh (19%), Rajasthan (47%), and Gujarat (34%). Its tributaries are the Som, the Anas and the Panam.

The West Flowing Rivers of the Sahyadris

The rivers flowing towards the Arabian sea have short courses. These drain 3% of India's

land area but carry 18% of country's water resources. In Karnataka, the Kalinadi rises from Belgaum district and falls in the Karwar Bay. The source of Bedti river lies in Hubli Dharwar and traverses a course of 161 km. The Sharavati is another important river in Karnataka flowing towards the west. It originates in Shimoga district and drains a catchment area of 2,209 sq. km. The famous Jog or Gersoppa Falls made by the Sharavati is the highest in India. The Bhadra originates near Aniali village in Rajkot district in Gujrat. The Vaitarna rises from the Triambak in Nasik district at an elevation of 670 m.

Goa has a few rivers which can be mentioned here. They are Mandovi, Rachol and Juari.

Kerala has a narrow coastline. The longest river of Kerala, Bharathapuzha rises near Annamalai hills. It is also known as Ponnani. It drains an area of 5,397 sq. km. The Periyar is the second largest river of Kerala. Its catchment area is 5,243 sq. km. Other rivers of Kerala worth mentioning are the Pamba river which falls in the Vembanad lake after traversing a course of 177 km, the Beypore and the Pannam.

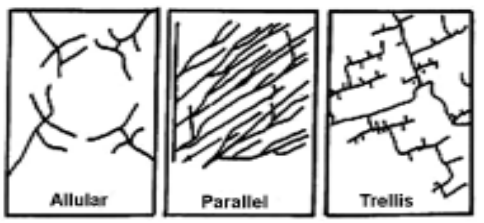
DRAINAGE PATTERNS

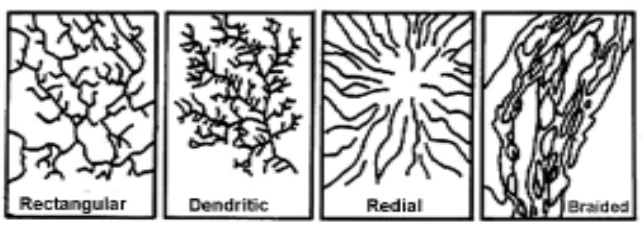
A drainage system is the pattern formed by the streams, rivers, and lakes in a particular drainage basin. They are governed by the topography of the land, whether a particular region is dominated by hard or soft rocks, and the gradient of the land.

Types of drainage system

1. **Dendritic drainage system:** Dendritic drainage systems are the most common form of drainage system. In a dendritic system, there are many contributing streams (analogous to the twigs of a tree), which are then joined together into the tributaries of the main river (the branches and the trunk of the tree, respectively). They develop where the river channel follows the slope of the terrain. Dendritic systems form in V-shaped valleys; as a result, the rock types must be impervious and non-porous.

2. **Parallel drainage system:** A parallel drainage system is a pattern of rivers caused by steep slopes with some relief. Because of the steep slopes, the streams are swift and straight, with very few tributaries, and all flow in the same direction. This system forms on uniformly sloping surfaces, for example, rivers flowing southeast from the Aberdare Mountains in Kenya.





3. **Trellis drainage system**: The geometry of a trellis drainage system is similar to that of a common garden trellis used to grow vines. As the river flows along a strike valley, smaller tributaries feed into it from the steep slopes on the sides of mountains. These tributaries enter the main river at approximately 90 degree angles, causing a trellis-like appearance of the drainage system. Trellis drainage is characteristic of folded mountains, such as the Appalachian Mountains in North America.

4. **Rectangular drainage system**: Rectangular drainage develops on rocks that are of approximately uniform resistance to erosion, but which have two directions of jointing at approximately right angles. The joints are usually less resistant to erosion than the bulk rock so erosion tends to preferentially open the joints and streams eventually develop along the joints. The result is a stream system in which streams consist mainly of straight line segments with right angle bends, and tributaries join larger streams at right angles.

5. **Radial drainage system:** In a radial drainage system the streams radiate outwards from a central high point. Volcanos usually display excellent radial drainage. Other geological features on which radial drainage commonly develops are domes and laccoliths. On these features the drainage may exhibit a combination of radial and annular patterns.
6. **Deranged drainage system:** A deranged drainage system is a drainage system in drainage basins where there is no coherent pattern to the rivers and lakes. It happens in areas where there has been much geological disruption. The classic example is the Canadian Shield. During the last ice age, the topsoil was scraped off, leaving mostly bare rock. The melting of the glaciers left land with many irregularities of elevation, and a great deal of water to collect in the low points, explaining the large number of lakes which are found in Canada. The watersheds are young and are still sorting themselves out. Eventually the system will stabilize.
7. **Annular drainage pattern:** In an annular drainage pattern streams follow a roughly circular or concentric path along a belt of weak rock, resembling in plan a ring like pattern. It is best displayed by streams draining a maturely dissected structural dome or basin where erosion has exposed rimming sedimentary strata of greatly varying degrees of hardness, as in the Red Valley, which nearly encircles the domal structure of the Black Hills of South Dakota.

NATIONAL WATER POLICY 2012

Water is a natural resource, fundamental to life, livelihood, food security and sustainable development. It is also a scarce resource. India has more than 17 percent of the world's population, but has only 4% of world's renewable water resources with 2.6% of world's land area. There are further limits on utilizable quantities of water owing to uneven distribution over time and space. Precipitation is confined to only about three or four months in a year and varies from 100 mm in the western parts of Rajasthan to over 10000 mm at Cherrapunji in Meghalaya. Rivers and underground aquifers often cut across state boundaries. Water, as a resource is one and indivisible: rainfall, river waters, surface ponds and lakes and ground water are all part of one system.

In addition, there are challenges of frequent floods and droughts in one or the other part of the country. With a growing population and rising needs of a fast developing nation as well as the given indications of the impact of climate change, availability of utilizable water will be under further strains in future with the possibility of deepening water conflicts among different user groups. Low public consciousness about the overall scarcity and economic value of water results in its wastage and inefficient use. In addition, there are inequitious distribution and lack of a unified perspective in planning, management and use of water resources.

The objective of the National Water Policy is to take cognizance of the existing situation and to propose a framework for creation of an overarching system of laws and institutions and for a plan of action with a unified national perspective.

National Water Policy was adopted in September, 1987. Since then, a number of issues and challenges have emerged in the development and management of the water resources. Therefore, the National Water Policy (1987) has been reviewed and updated in 2012.

The salient features of new National Water Policy (2012) are:

a) Constitutionally the States have the right to frame suitable policies, laws and regulations on water, the draft NWP, 2012 lays emphasis on the need for a national water framework law, comprehensive legislation for optimum development of inter-State rivers and river valleys, public trust doctrine, amendment of the Indian Easements Act, 1882, etc.

b) The draft NWP, 2012 presents a holistic picture of ecological need of the river rather than restricting it to only mini-

mum flow requirement. It states that the ecological needs of the river should be determined recognizing that river flows are characterized by low or no flows, small floods (freshets), large floods and flow variability and should accommodate development needs. A portion of river flows should be kept aside to meet ecological needs ensuring that the proportional low and high flow releases correspond in time closely to the natural flow regime.

c) It recognizes the need to adapt to climate change scenario in planning and implementation of water resources projects. Coping strategies for designing and management of water resources structures and review of acceptability criteria has been emphasized.

d) Need and approaches towards enhancing water availability have been stipulated. Direct use of rainfall and avoidance of inadvertent evapo-transpiration have been proposed as the new additional strategies for augmenting utilizable water resources.

e) Draft proposes the mapping of the aquifers to know the quantum and quality of ground water resources in the country has been proposed with provision of periodic updation.

f) A system to evolve benchmarks for water uses for different purposes, i.e., water footprints, and water auditing should be developed to ensure efficient use of water.

g) Water Users Associations should be given statutory powers to collect and retain a portion of water charges, manage the volumetric quantum of water allotted to them and maintain the distribution system in their jurisdiction.

h) All water resources projects, including hydro power projects, should be planned to the extent feasible as multi-purpose projects with provision of storage to derive maximum benefit from available topology and water resources.

i) The draft NWP, 2012 lays emphasis on preparedness for flood / drought with coping up mechanisms as an option. Frequency based flood inundation maps should be prepared to evolve coping strategies

j) Appropriate institutional arrangements for each river basin should be developed to collect and collate all data on regular basis with regard to rainfall, river flows, area irrigated by crops and by source, utilizations for various uses by both surface and ground water and to publish water accounts on ten daily basis every year for each river basin with appropriate water budgets and water accounts based on the hydrologic balances.

Planning and implementation of water resources projects involve a number of socio-economic aspects and issues such as environmental sustainability, appropriate resettlement and rehabilitation of project-affected people and livestock, public health concerns of water impoundment, dam safety, etc. ■■■

4 SOIL AND VEGETATION

SOIL

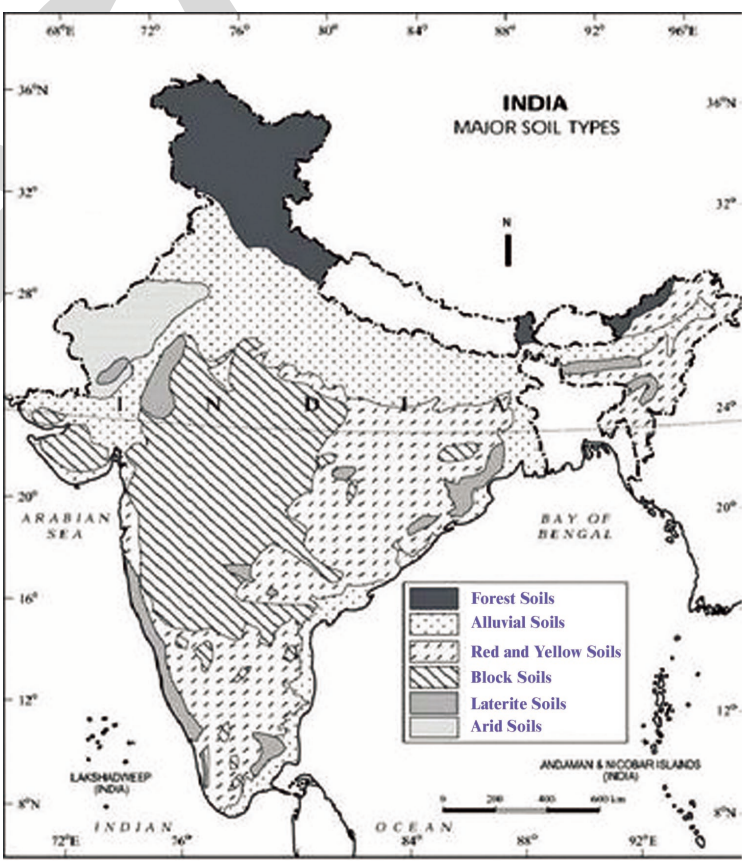
Soil is the topmost layer of the earth's surface. It consists of a mixture of minute particles of disintegrated rocks, minerals, organic matter and bacteria. Soil is formed when forces of nature such as temperature, rain, wind, waves, animals and plants act on rocks and break them into tiny pieces over a long period of time.

Soil consists of four layers. The first or topmost layer of soil is made up of minute soil particles and decayed plant and animal matter. This layer is vital for the cultivation of crops. The second layer is made up of fine particles like clay; the third layer is a combination of weathered basic rock materials and soil while the fourth layer consists of un-weathered hard rocks.

Each type of soil benefits different types of crops through their unique physical, chemical and biological properties. Alluvial soil is a fertile soil rich in potassium. It is highly suitable for agriculture, especially for crops such as paddy, sugarcane and plantain. Red soil has high iron content and is fit for crops like red gram, Bengal gram, green gram, groundnut and castor seed. Black soil is rich in calcium, potassium and magnesium but has poor nitrogen content. Crops like cotton, tobacco, chilly, oil seeds, jowar, ragi and maize grow well in it. Sandy soil is low in nutrient content but is useful for growing trees such as coconut, cashew and casuarinas in areas with high rainfall.

SOIL TYPES AND DISTRIBUTION

There are different types of soils in India and climate, altitude and composition of bedrock are the major factors that control the soil formation in India. Disproportion in the annual distribution of rainfall in the country and excessive heat contribute characteristics to the soils of the country. Seven major types of soils in India are Alluvial soils, Black soils, Desert soils, Red and yellow soils, Saline soils, Lateritic soils and mountain soils.



1. **Alluvial Soil:** This is the most crucial and pervasive kind. It covers forty per cent of land area. In fact the complete Northern Plains are made up of these soils. They have been brought down and deposited by three enormous Himalayan rivers- Satluj, Ganga and Brahmaputra-and their tributaries. Through a tapered outlet in Rajasthan, they continue into the plains of Gujarat. They are common in eastern coastal plains, in the deltas of Mahanadi, Godavari, Krishna and Kaveri.

   The river deposits extremely refined particles of soil, called alluvium in their plains during the path of their long travail, spread over hundreds of kilometres and thousands of years. These soils consist of diverse ratios of sand, silt and clay. They are prevalent in the coastal plains and deltas. As one moves further inland in the river valleys, the soil particles appear pretty heavier in size. In the upper reaches of the river Valleys, i.e. near the place of their origin, the soils are coarser. Such soils are more familiar in piedmont plains, i.e. those that are near the foot of mountains.

   Soils are distinguished according to their age also. They are grouped in old alluvium and new alluvium types. The so called new alluvium may be even ten thousand years old. The old alluvium is called `Bhangar`, and the new alluvium is called `khadar`. The old alluvium often contains kankar nodules, with calcium carbonates in subsoil. The new alluvium is richer compared to the old.

   Alluvial soils all together are exceptionally prolific. In general, they carry ample potash, phosphoric acid and lime. However, they are lacking in organic and nitrogenous substance. Soils in the drier areas are more alkaline. Alluvial soils sustain over half the Indian population.

2. **Regur Soil/Black soil:** Regur soils are black in colour and are also known as `black soils`. Since they are perfect for growing cotton, they are also called cotton soils, in addition to their local terminology of 'regur soils`. These soils are most characteristic of the Deccan trap (Basalt) region, spread over the north-west Deccan plateau and are made up of lava flows. They cover the plateaus of Maharashtra, Saurashtra, Malwa and southern Madhya Pradesh and continue eastwards in the south, along the Godavari and Krishna Valleys.

   Black soils are made of exceptionally delicate that is clayey material. Owing to the high proportion of clay, Regur soils are sticky when wet and consequently, it becomes difficult to plough. They are well-known for their ability to retain moisture. In addition, they are prosperous in soil nutrients, like calcium carbonate, magnesium carbonate, potash and lime. They are usually poor in phosphoric content. They develop thick fissures in the field during hot weather. This helps in their ventilation; hence their self-ploughing eminence. This soil is viscous and unmanageable to work, unless tilled without delay, after the first or pre-monsoon showers.

   Regur soils develop under semi-arid conditions specifically in the areas that are covered with basalt. In the southern region of Tamil Nadu, granites and gneisses with iron content also form black soils under the required semi-arid climatic conditions. Regur soils are formed in Surat and Broach districts and also in the Narmada Valley and Tapti Valley. In these regions, humus is almost absent in the soil and black colour of the soil is because of the presence of certain salts. In the hilly region of the country, Black soils are usually thin, poor and sandy.

   Black soils or Regur soils are rich in lime and it is not unusual to find lime nodules deposition under the layer of this type of soil. Moreover, this soil is highly retentive of moisture and is highly productive particularly in the plains and along the river valleys where it is clayey and deep. It is said that the feature of retaining moisture in the soil is extremely useful. Thus, the deeper

the soil, the larger is the amount of moisture held. However, nitrogen which is considered as useful for the growth of plants is not sufficiently found in the Regur soil.

3. **Laterite Soil:** Laterite soils are generally found capping the Indian flat uplands, and are spread in the western coastal region, getting incredibly heavy rain. Lateritic soils are also found in areas along the edge of the plateau in the east, covering small parts of Tamil Nadu and Orissa and a small part of Chhotanagpur Plateau in the north and Meghalaya in north-east. The soils are habitually poor and can hold only pastures and scrub forests. Among the mixed types of soils, two groups are more substantial. They include the desert soils of west Rajasthan and mountain soils of the Himalayas.

   Laterite soil is mainly found in the tropical regions that receive heavy seasonal rainfall. High rainfall promotes leaching of the soil where silica and lime are leached away and a soil rich in oxides of aluminium predominate and are in abundance laterite is called bauxite. Due to the presence of iron oxides the colour of laterite soil is basically red. This soil is poor in lime content and hence it is acidic. Laterite soils are found on the high level plateau and hilly areas that receive high rainfall and are specifically well developed on the Eastern Ghats in Orissa. It is also found in the southern part of the Western Ghats including the adjoining coastal regions in Ratnagiri District and Malabar.

   Humus is almost absent in this type of soil. However, in the laterite soil developed in the forested areas in the western part of Karnataka, humus is present. Further, laterite soils of high level areas are very poor and least retentive of moisture and at times barren. But, in the low lying areas, regular addition of soils that are washed down from the adjacent higher areas affects lateritization. In those areas, the lateritic soil being either loam or mud is useful and is regularly ploughed. For the continuous cultivation of crops, regular application of fertilizers is required.

4. **Red Soil:** Red soils are also known as yellow soils. Like laterite soil, red soils are heavily leached and they contain a considerable concentration of iron oxides. The presence of iron oxides is responsible for giving this soil its reddish or yellowish shade. Red soils are sandier and less clayey comparatively. Moreover, these soils are formed in those areas which receive relatively low rainfall and thus they are less leached as compared with laterite soils. Further, red or yellow soils develop usually on metamorphic rocks.

   Red soils do not contain any essential nutrient. Like for instance, they are poor in nitrogen, lime and phosphorous contents. Red soils are acidic in nature. This is one similarity between laterite soils and red soils. Red soils are not retentive of moisture and hence, they are cultivated mostly during the rainy season. For higher yield in this type of soil, constant application of manures is required. Red soils mostly develop in the Indian peninsular plateau. Interestingly, in the lowlands and valleys, red soils are fertile and deep. On the other hand, on the hill slopes, they are basically poor and thin.

   The northwestern half of the peninsular block is covered by black soil and the remaining southeastern half is covered by red soil of various shades of red and yellow. They basically surround the whole black soil region on all sides, and cover the eastern part of the peninsula, comprising Chhotanagpur Plateau, Orissa, eastern parts of Madhya Pradesh, Nilgiris and Tamil Nadu plateau. They continue northwards in the west, along the Konkan coast of Maharashtra. They also develop in the Eastern Ghats, Bihar plateau, and Shillong plateau. It is found in states like Mizoram and Manipur. Soils are loamy in deep depressions and in uplands they consist of gravel. They function well with dosage of fertilizers and irrigation waters.

5. **Forest and Mountain Soil:** Generally, there is a huge variety of soils in the Himalaya Mountain ranges. Mountain soils are found in the dry and cold districts like Ladakh, Lahul-Spiti, Kinnaur District, etc. Further, in the river valleys as well as on the river terraces, alluvial soils are found but across the slopes, one generally comes across soils of different textures. It varies from silty loam to rock fragments. Fine textured soils are mainly found in the river valleys or in the outwash plains. In other parts of these hilly districts, soils are in general stony and shallow but are poor in organic matter.

   The basic character of the mountain soils depend on the climate and are mainly found in the warm temperate belt or the cool temperate belt of the Himalaya Mountains. Brown forest soil is mainly found in the warm temperate belt lying at heights ranging from 900 to 1800 metres, which has deciduous forests. This belt comprises enough warmth for decomposition of vegetation. The typical brown forest soil of this zone is rich in humus and is deep. They are slightly acidic and are fertile largely used for raising different varieties of crops.

6. **Desert soils:** A large part of the arid region belonging to the western Rajasthan, Haryana, Punjab, lying between the Indus River and the Aravalli range is affected by the desert conditions of geologically recent origin. This part is covered under a mantle of brown sand which, when combined with the arid climate results in poor soil development. The most predominant component of the desert sand is quartz but feldspar and hornblende grains also occur with a fair proportion of calcareous grains. It receives little monsoon rain. The sands which cover the area are partly derived from the disintegration of the subjacent rocks, but are largely blown in from the coastal regions and the Indus Valley. Some of these soils contain high percentages of soluble salts, high pH, a varying percentage of calcium carbonate and are poor in organic matter.

   The Rajasthan desert is a vast sandy plain, including isolated hills or out crops at places. Though on the whole the tract is sandy, the soil improves in fertility from west and north-west to east and north-east. In many parts, the soils are saline or alkaline, with unfavorable physical conditions and high pH.

7. **Peaty and marshy soil:** Peaty soil originates in humid regions as a result of accumulation of large amount of organic matter in the soils. These soils contain considerable amount of soluble salts and 10-40 per cent of organic matter. Soils belonging to this group are found in Kottayam and Alappuzha districts of Kerala where it is called KARI. Marshy soil with high proportion of vegetable matter also occurs in the coastal areas of Orissa and Tamil Nadu. The peaty soils are black, heavy and highly acidic. They are deficient in potash and phosphate.

8. **Saline and alkaline soils:** These soils are found in Andhra Pradesh and Karnataka. These soils are liable to saline and alkaline efflorescences and are known as reh, kallar, usar, rakar and chopan. These soils contain toxic concentrations of soluble salts in the root zone. Electrical conductivity in the saturation extract of such soils taken as a measure of salts is greater than 4.0 mmhos/cm. Exchangeable sodium percentage is less than 15 and pH is less than 8.5. The soluble salts mainly consist of chlorides and sulphates of sodium, calcium and magnesium. Because of the white encrustation due to salts, the soil is called white alkali.

   The soil salinity or alkalinity or both have many adverse effects, summarized below:

   1. Causing low yield of crops or crop failure in extreme cases.
   2. The limiting of the choice of crops because some crops are sensitive to salinity or alkalinity or both.
   3. Rendering the quality of fodder as poor, as at times the fodder grown on alkali soils may contain a high amount of

molybdenum and a low amount of zinc, causing nutritional imbalance and disesses among live-stock.

4. Creating difficulties in the construction of buildings and roads and their maintenance.
5. Causing excessive run offs and floods due to low infiltration resulting in damage to crops.

SOIL EROSION AND CONSERVATION

Soil erosion in India is a major cause of concern. Almost 130 million hectares of land i.e. approx 45% of total land is affected by serious soil erosion through gorge and gully, shifting cultivation, water logging etc.

Soil erosion is the gradual removal of the top soil cover by natural agencies like water, wind etc or by manmade activities as alkanisation, salinization of soil, deforestation etc.

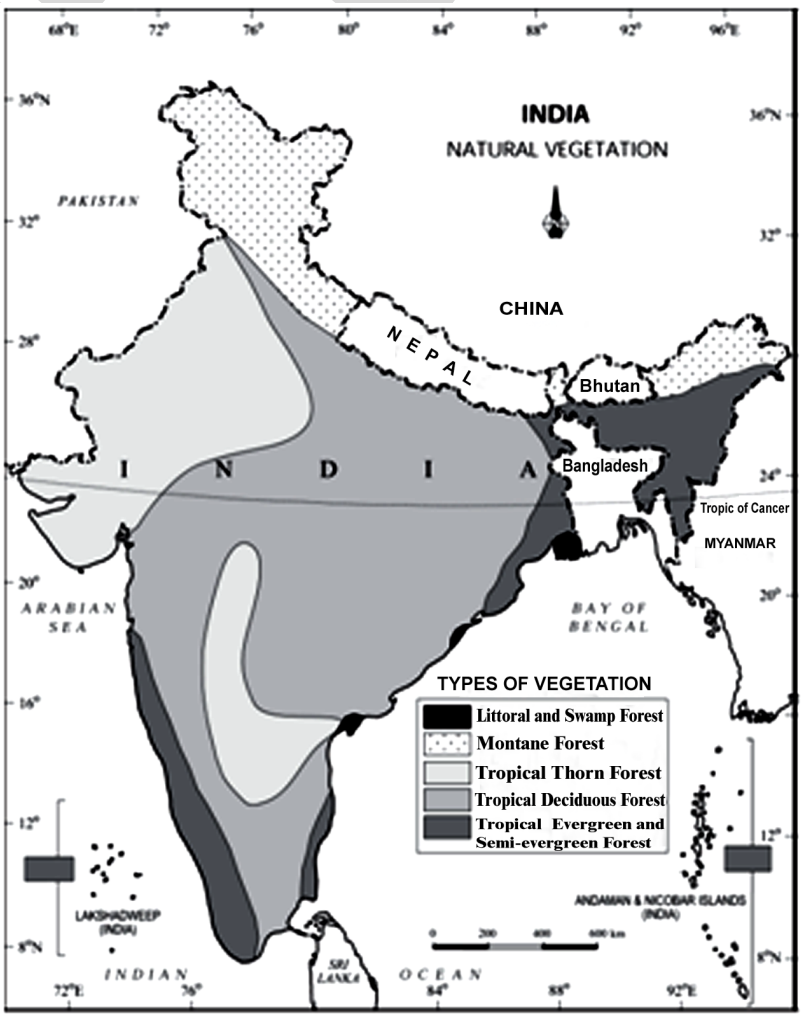
Soil erosion is almost universally reorganized as a serious threat to man's well-being. The two main agents of erosion are wind and water. In the case of erosion by water, the major erosive agents are impacting raindrops and run-off water flowing over the soil surface. Erosion and sedimentation embody the processes of detachment, transportation and deposition of soil particles. Detachments are the dislodging of soil particles from the soil mass by erosive agents.

Most of the land area in the country shows evidence of degradation thus affecting the productive base of economy. Out of the total geographical area of 329 million hectares, 175 million hectares are considered degraded.

Although soil-erosion is frequent throughout the country, it operates most intensely in the hilly regions. The precipitation often occurs in torrents which instead of sinking into the ground as the light drizzles, wash away the top layers of the soil. The steep slopes of the hills further stimulate the eroding power of the rain water. The soils are very thin and all exposed slopes are susceptible to serious sheet erosion or gullying.

Erosion may be of little consequence for hilly tracts, but is of great significance to the plains. The whole basin of Kosi river is threatened by this erosion, as a result of which the rivers bring with them millions of tonnes of sand and debris annually. When the rivers reach the plains and below and the stream flow slackens the load is dropped and gets deposited in their beds. This leads to choking of river channels, which in turn increase the flood danger and induces shifting of the course which brings disaster in train to the whole country-side.

Both surface erosion and deep gullying are considerably influenced by the type of soil in



India, although a given soil type may not behave consistently under all conditions and no type of soil is entirely safe from erosion. Thus, sandy porous soil in the country are in general least subject to gradual weathering down by water action, since they are capable of absorbing a great amount of water in ordinary rains. On the other hand, if the rate of percolation is prevented by frost or by even thin strata of clay, the very lack of "binding" qualities in the sandy soils permit them to be moved at a very rapid pace. Again, however, the coarseness of the material may cause it to be deposited before it has been carried to any great distance.

The most potent and common causes for erosion in India are deforestation and overgrazing. Throughout the country, as population has increased, more and more forests have been destroyed mainly by grazing cattle feeding on grass and herbs and green bushes.

Effects of soil erosion

a) Loss of fertile top soil leading to gradual loss of soil fertility and agricultural productivity.
b) Loss of mineral nutrients from soil through leaching and flooding
c) Lowering of the underground water table and decrease in the percentage of soil moisture
d) Drying of vegetation and extension of arid lands
e) Increase in frequency of droughts and floods
f) Silting of river and canal belts
g) Recurrence of landslides
h) Adverse effect on economic prosperity and cultural development

Soil conservation

Soil conservation is maintaining good soil health, by various practices. The aim of soil conservation methods is to prevent soil erosion, prevent soil's overuse and prevent soil contamination from chemicals. There are various measures that are used to maintain soil health, and prevent the above harms to soil. Here are the soil conservation methods which are practiced for soil management.

Strategies

There are many ways to conserve soil, some are suited to those areas where farming is done, and some are according to soil needs. Here are the various soil conservation methods that are practiced.

a) **Planting Vegetation:** This is one of the most effective and cost saving soil conservation methods. By planting trees, grass, plants, soil erosion can be greatly prevented. Plants help to stabilize the properties of soil and trees also act as a wind barrier and prevent soil from being blown away.

   This is also among strategies used for soil conservation methods in urban areas, one can plant trees and plants in the landscape areas of the residential places. The best choices for vegetation are herbs, small trees, plants with wild flowers, and creepers which provide a ground cover.

b) **Contour Ploughing:** Contour farming or ploughing is used by farmers, wherein they plough across a slope and follow the elevation contour lines. This method prevents water runoff, and thus prevents soil erosion by allowing water to slowly penetrate the soil.

c) **Maintaining the Soil pH:** The measurement of soil's acidity or alkalinity is done by measuring the soil pH levels. Soil gets polluted due to the addition of basic or acidic pollutants which can be countered by maintaining the desirable pH of soil.

d) **Soil Organisms:** Without the activities performed by soil organisms, the organic material required by plants will litter and won't be available for plant growth. Using beneficial soil organisms like earthworms, helps in aeration of soil and makes the macro-nutrients available for the plants. Thus, the soil becomes more fertile and porous.

e) **Crop Rotation Practice:** Crop rotation is the soil conservation method where a series of different crops are planted one after the other in the same soil area, and

is used greatly in organic farming. This is done to prevent the accumulation of pathogens, which occur if the same plants are grown in the soil, and also depletion of nutrients.

f) **Watering the Soil:** We water plants and trees, but it is equally important to water soil to maintain its health. Soil erosion occurs if the soil is blown away by wind. By watering and settling the soil, one can prevent soil erosion from the blowing away of soil by wind. One of the effective soil conservation methods in India is the drip irrigation system which provides water to the soil without the water running off.

g) **Salinity Management:** Excessive collection of salts in the soil has harmful effects on the metabolism of plants. Salinity can lead to death of the vegetation and thus cause soil erosion, which is why salinity management is important.

h) **Terracing:** Terracing is among one of the best soil conservation methods, where cultivation is done on a terrace leveled section of land. In terracing, farming is done on a unique step like structure and the possibility of water running off is slowed down.

i) **Bordering from Indigenous Crops:** It is preferable to plant native plants, but when native plants are not planted then bordering the crops with indigenous crops is necessary. This helps to prevent soil erosion, and this measure is greatly opted in poor rural areas.

j) **No-tilling Farming Method:** The process of soil being ploughed for farming is called tilling, wherein the fertilizers get mixed and the rows for plantation are created. However, this method leads to death of beneficial soil organisms, loss of organic matter and compaction of soil. Due to these side effects, the no-tilling strategy is used to conserve soil health.

k) **Increased use of organic manure:** Through manuring, the Indian farmers can check the deflection of soil nutrients, which takes place with continuous cropping. Manures can be animal and plant residues. They ensure yet another aspect of soil conservation viz, the building up of soil productivity.

l) **Keeping the soil covered:** Grasses are even more firm protectors of soil than the trees.

m) **River embankments:** By making river embankments, soil erosion can be reduced along the bank of the rivers.

VEGETATION

Located at tropical latitudes, the beautiful land of India is characterized by rainfall regimes and diverse temperature and climate. **India's** climate helps in the growth of forests in the country. However, in the past thousand years, various types of human activities have altered the climatic formations in the country to a large extent. The **natural vegetation in India** primarily comprise of forests.

Vegetation growing in correspondence with different environmental conditions is the natural vegetation of a particular place. Several major factors such as soil, topography, temperature and rainfall have influenced the **natural vegetation of India** to a large extent. Depending on the atmosphere, weather, position and other factors, there can be several classification of **India's natural vegetation**. The many features that characterize the natural vegetation of India are the tropical deciduous forests, the tropical rain forests, the alpine and tundra vegetation, rain forests of Southern India, Himalayan vegetation, the desert region, the temperature forests and grasslands and many more.

(A) MOIST TROPICAL FORESTS

These forests are found in the areas of quite high temperature and rainfall. The forests are dense, multi-layered and have many types of trees, shrubs and lians. These forests are further categorized into 4 types depending on the degree of wetness in the area and the dominant life form in the forest.

(1) **Tropical moist evergreen forests:** These are climatic climax forests found commonly

in areas having annual rainfall above 250 cm and temperature 25-30°C. These forests are chiefly distributed on the western face of Western Ghats, Assam, Cachar, parts of West Bengal, northern Canara, Annamalai Hills and Coorg in Meysore and Andman Islands.

The **characteristic feature** of these forests is dense growth of very tall trees having height of more than 45 m. Climbers, lians, epiphytes and shrubs are abundant but herbs and grasses are rare in these forests. The carpet layer of herbs and grasses cannot grow because very dense layer of leaf canopy of trees does not allow enough light to reach to the ground.

Dominant trees in forests of west coast are *Dipterocarpus indica, Palaquim and Cellenia* while in forests of Assam are Diptercarpus macrocarpus, D. turbinatus, Shorea assamica, Mesua ferrea andKayea

(2) **Tropical moist semi-evergreen forests:** These are also climatic climax forests found commonly in areas of annual rainfall 200-250 cm and temperature 25-32°C.These forests are chiefly distributed along the Western Ghats, in upper parts of Assam and Orissa and in Andman Islands. These forests are more developed in the northern India than in southern India.

Characteristic feature of these forests is dense growth of evergreen trees intermixed with deciduous trees that shed their leaves for very brief period of relative dryness. Average height of trees in these forests is 25-35 m and shrubs are common. Forests have rich carpet layer of herbs, grasses ferns and orchids.

Dominant trees in these forests are *Dipterocarpus alatus, Hopea, Terminalia and Salmalia* **in Andman Island;** Artocarpus, Micheliaand Mangifera **in Orissa;** Schima wallichii, Bauhinia, Phobe and Ammora in **Assam.**

(3) **Tropical moist deciduous forests:** These forests are found in the area having temperature of 25-30°C and quite high annual rainfall of 150-200 cm spread over most of the year but periods of rain alternating with very short periods of dryness. In several areas, the forests have been converted into open savannahs due to intensive biotic factors. These forests are chiefly distributed in a narrow belt along Himalayan foothills, on the eastern side of Western Ghats, Chota Nagpur, Khasi hills, in moist areas of Kerala, Karnataka, sothern Madhya Pradesh, parts of northern Uttar Pradesh, Bihar and West Bengal.

Chief characteristic of these forests is dominance of deciduous trees that remain leafless for one or two months only along with lower story of smaller trees and evergreen shrubs.

Dominant trees of these forests in north India are Tectona grandis, Shorea robusta, Salmella andDalbergia while in south India are Tectona grandis and Shorea sp. .

(4) **Littoral and swamp forests:** These forests are found in wet marshy areas, in river deltas, in saline or other swampy areas and along the sea coasts. They are chiefly distributed in deltas of large rivers on the eastern coast and in pockets on the western coast (Tidal forests), in saline swamps of Sundarban in West Bengal, coastal areas of Andhra and Orissa (Mangrove forests) and in less saline or non-saline swampy pockets throughout the India.

Chief characteristic of these forests is dominance of halophytic evergreen plants of varying height with varying density of plants in different area.

Dominant plants of tidal and mangrove forests are Rhizophora, Bruguiera, Ceriops, Horitora, Avicennia, Nipa, Sonneratia and Acanthus. In less saline swamps, dominant plants are Ipomea, Phoenix, Phragmitis, Casuarina, Manilkara and Calophyllum. In other swamps, the dominant plants areBarringtonia, Syzygium, Myristica, Bischofia, Trowia, Lagerstroemia, Sophora, Pandanus, Entada andPremna.

(B) DRY TROPICAL FORESTS

These forests are found in the areas where wet season is followed by a relatively long period of dryness during which trees remain leafless. These forests are dominated by smaller trees and shrubs and have abundance of shrubs or sometimes grasses. This category includes three types of forests.

(1) **Tropical dry deciduous forests:** These forests are found in areas having temperature of 25-32°C and annual rainfall of 75-125 cm along with a dry season of about six months. Distribution of these forests in northern India is in areas of Punjab, Haryana, Uttar Pradesh, Bihar and Orissa. In the southern and central India, these forests are distributed in dry areas of Maharashtra, Tamilnadu, Karnataka and Madhya Pradesh.

Chief characteristic feature of the forests is open canopy of small (10-15 m high) trees and abundance of shrubs.

Dominant species of the forests in north India are Shorea robusta, anogeissus, Terminalia, Buchnnania, Somocarpus, Carissa, Emblica, Madhuca, Acacia, Aegle, Diospyros, Bauhinia, Eugenia, Zyzyphus, Lannea, Sterculia, Dendrocalamus, Salmelia, Adina, Grewia, Adathoda and Helicteres. In south India, dominant plants are Tectona grandis, Dalbergia, Kydia, Terminalia, Pterospermum, Dillenia, Acacia, Diospyros, Anogeissus, Boswellia, Bauhinia, Chloroxylon, Hardwickia, Soymida, Gymnosporia, Zyzyphus, Dendrocalamus and Holorrhena.

(2) **Tropical thorn forests:** These forests are found in the areas of high temperature of 27-30°C and very low annual rainfall of 20-60 cm with long periods of dryness. These forests are distributed in western Rajasthan, parts of Maharashtra, Madhya Pradesh and Tamilnadu.

Chief charateristic of such forests is sparse distribution of small (8-10 m high) mostly thorny trees with shrubs being more common than trees. The plants in these forests remain leafless for most of the year. They develop leaves only during the brief rainy season when grasses and herbs also become abundant.

Dominant plants in these forests are Acacia nilotica, A. leucophloea, A. senegal, Prosopis spicigera, P. juliflora, Albizzia and Capparis.

(3) **Tropical dry evergreen forests:** These forests are found in the areas of relatively high temperature and small rainfall available only during summers. The forests are distributed in some parts of Tamilnadu and Karnataka.

Chief characteristic features of the forests are dense distribution of mixed small evergreen and deciduous trees of 10-15 m height, absence of bamboos and abundance of grasses.

Dominant plants in the forests are Memecylon, Maba, Pavetta, Foronia, Terminalia, Ixora, Sterculia, Mesua and Schleichora.

(C) MONTANE SUBTROPICAL FORESTS

These forests occur in the areas where climate is cooler than tropical but warmer than temperate areas i.e. on the hills between the altitudes of 1000 m and 2000 m. The forests are dominated by semi-xerophytic evergreen plants. This category includes three types of forests.

(1) **Sub-tropical broad-leaved hill forests:** These forests occur in relatively moist areas at lower altitudes on mountain ranges. Their chief distribution is in eastern Himalayas of West Bengal and Assam , hills of Khasi, Nilgiri and Mahabaleshwar.

Chief characteristic feature of the forests is dense growth of evergreen browd-leaved trees with abundant growth of climbers and epiphytic ferns and orchids.

Dominant trees in the forests of north are *Quercus, Schima* and *Castanopsis* with some temperate species. **In the southern areas, dominants are** *Eugenia* and members of family Lauraceae.

(2) **Sub-tropical dry evergreen forests:** These forests occur in areas having quite low temperature and rainfall. The forests are distributed in the lower altitudes of eastern and western Himalayas.

Chief characteristic feature of the forests is presence of thorny xerophytes and small-leaved evergreen plants.

Dominant plants in the forests are Acacia modesta, Dodonea viscosa and Olea cuspidata.

(3) **Sub-tropical pine forests:** These forests occur at middle altitudes between 1500-2000 m in Himalayas. They are distributed in western Himalayas from Kashmir to Uttar Pradesh. In eastern Himalayas, the forests occur in Khasi Jayantia Hills of Assam.

Chief characteristics of the forests are open formations of pine trees.

Dominant trees in the forests are P. roxburghii and Pinus khasiana.

(D) TEMPERATE FORESTS

These forests are found in the areas having quite low temperature along with comparatively high humidity than the comparable areas of higher latitudes. The cause of high humidity is greater rainfall in Himalayas except in parts of Uttar Pradesh, Punjab, Himachal Pradesh and Kashmir where humidity is lower. The forests occur mainly in the Himalayas at altitudes 2000-4000 m. The forests are generally dominated by tall conifers or angiospermic evergreen trees with abundance of epiphytic mosses, lichens and ferns. The category includes three types of forests.

(1) **Wet temperate forests:** These forests are found at altitudes of 1800-3000 m in the cooler and humid mountains. They are distributed in the eastern Himalayas from eastern Nepal to Assam, in the western Himalayas from Kashmir to western Nepal and in Nilgiri Hills of south Indian.

Chief characteristic feature of the forests in the Himalayas is dense formation of evergreen, semievergreen broad-leaved and coniferous trees of up to 25 m height. In south India, these forests are termed Shola forests and mostly have 15-20 m high broad-leaved trees with dense leaf canopy, abundant epiphytic flora and rich herbaceous undergrowth.

Dominant trees in the forests of western Himalayas are angiosperms like Quercus, Betula, Acer, Ulmus, Populus, Corylus, Caprinus etc. and conifers like Abies, Picea, Cedrus etc..

(2) **Himalayan moist temperate forests:** These forests are found at 1700-3500 m altitude in eastern and western Himalayas. These occur in areas having annual rainfall above 100 cm but relatively less than that in areas of wet temperate forests.

Chief characteristic feature of the forests is presence of tall (up to 45 m high) conifers, oaks or their mixture along with thin partly deciduous undergrowth.

Dominant trees in the eastern Himalayas are Tsuga dumosa, Quercus lineata, Picea spinulosa, Abies densa and Quercus pachyphylla. In the western Himalayas, dominants in lower zones are Quercus incana, dialata, Cedrus deodara, Pinus wallichiana, Picea smithiana, Abies pindrew, Cotoneaster, Berberis and Spire while in the higher zones the dominants are Quercus semicarpifolia and Abies pindrew.

(3) **Himalayan dry temperate forests:** These forests occur in the regions of Himalayas having very low rainfall. They are distributed in both eastern and western Himalayas. Chief characteristic feature of the forests is dominance of evergreen oaks and conifers. Undergrowth is formed by scrubs.

Dominant trees in the forests of comparatively drier western Himalayas are Pinus gerardiana andQuercus ilex. In the comparatively wetter western Himalayan region, the dominants are Abies, Picea, Larix griffithia and Juniperus wallichiana.

(E) ALPINE FORESTS

These forests are found in the regions of Himalayas having extremely low temperature and humidity. The forests are dominated by perennial and annual herbs and grasses though some trees may also be present in areas of relatively high humidity. Abundant lichen flora is characteristic feature of these forests. This category includes three types of forests.

(1) **Sub-alpine forests:** These forests are found in open strands throughout the Himalayas between the altitude 3500 m and the tree tine.

Chief characteristic feature of the forests is presence of some evergreen conifers and broad-leaved trees along with prominent shrub layer.

Dominant trees in the forests are Abies spectabilis, Rhododendron and Betula. Prominent shrubs in the forests are Coto-neaster, Rosa, Smilax, Lonicera and Strobilanthus.

(2) **Moist alpine scrub forests:** These forests are found in the Himalayas above the tree line up to 5500 m altitude in somewhat moist areas.

Chief characteristic feature of the forests is dominance of dwarf, evergreen shrubby conifers and broad-leaved trees along with prominent shrub layer under them.

Dominant trees in the forests are Juniperus and Rhododendron

(3) **Dry alpine forests:** These forests are found in comparatively more dry areas of Himalaya's upto 5500 m altitude.

Chief characteristic feature of the forests is open formation of xerophytic scrubs with many herbs and grasses.

Dominant plants in the forests are Juniperus, Caragana, Eurctia, Salix and Myricaria. ■■■

5 AGRICULTURE

Agriculture has been a way of life and continues to be the single most important livelihood of the masses. Agricultural policy focus in India across decades has been on self-sufficiency and self-reliance in foodgrains production. Considerable progress has been made on this front. Foodgrains production rose from 52 million tonnes in 1951-52 to 244.78 million tonnes in 2010-11. The share of agriculture in real GDP has fallen given its lower growth rate relative to industry and services. However, what is of concern is that growth in the agricultural sector has quite often fallen short of the Plan targets. During the period 1960-61 to 2010-11, foodgrains production grew at a compounded annual growth rate (CAGR) of around 2 per cent. In fact, the Ninth and Tenth Five Year Plans witnessed agricultural sectoral growth rate of 2.44 per cent and 2.30 per cent respectively compared to 4.72 per cent during Eighth Five Year Plan. During the XI Five Year plan, agriculture growth is estimated at 3.28 per cent against a target of 4 per cent.

India is the largest producer in the world of milk, cashew nuts, coconuts, tea, ginger, turmeric and black pepper, and has the world•fs largest cattle population (281 million).It is the second largest producer of wheat, rice, sugar, groundnut and inland fish. It is the third largest producer of tobacco. India accounts for 10% of the world fruit production with first rank in the production of banana and sapota. India•fs population is growing faster than its ability to produce rice and wheat.

GREEN REVOLUTION

The introduction of high-yielding varieties of seeds after 1965 and the increased use of fertilizers and irrigation are known collectively as the Green Revolution, which provided the increase in production needed to make India self-sufficient in food grains, thus improving agriculture in India.

The adoption of HYVs occurred quickly. By 1970, about 20 percent of the wheat area and 30 percent of the rice area in country was planted to HYVs, and by 1990, the share had increased to about 70 percent for both crops.

Yields of rice and wheat virtually doubled. Higher yields and profitability also led farmers to increase the area of rice and wheat they grew at the expense of other crops. And with faster-growing varieties and irrigation, they grew more crops on their land each year. These changes more than doubled cereal production in India between 1970 and 1995.

Poor infrastructure, high transport costs, limited investment in irrigation, and pricing and marketing policies that penalized farmers made the Green Revolution technologies too expensive or inappropriate for much of the country masses.

Impact of Green Revolution

Like other developing countries, Green Revolution has influenced the economy and way of life in India to a great extent as is evident as is from the following points:

1. **Increase in agricultureal Production:** The introduction of Green Revolution in 1967-68 has resulted in phenomenal increase in the production of agricultural crops especially in foodgrains. From 1967 onwards, the Green Revolution aimed at bringing

about a Grain Revolution. The production wheat increased by more than three times between 1967-68 and 2003-04 while the overall increase in the production of cereals was only two times. On account of this reason, it is said that the Green Revolution in India is largely the Wheat Revolution.

2. **Prosperity of Farmers:** With the increase in farm production the earnings of the farmers also increased and they became prosperous. This has, especially, been the case with big farmers having more than 10 land.

3. **Reduction in import of foodrgrains:** The main benefit of Green Revolution was the increase in the production of foodgrains, as a result of which there was a drastic reduction in their imports. We are not self sufficient in foodgrains and have sufficient stock in the central pool. Sometimes we are in a position to export foodgrains also. The per capita net availability of foodgrains has also increased from 395 grams per day in early 1950s to the level of 436 grams in 2003, this inspite of the rapid increase in population. In the words of Dantwala, Green Revolution had given a breathing time. As a result, there will be relief from anxiety of food shortage and the planners will concentrate more on Indian planning.

4. **Capital Farming:** Big farmers having more than100 hectares of land have tended to get the maximum benefit from Green Revolution technology by investing large amount of money in various inputs like HYV seeds, fertilizers, machine, etc. This has encouraged capitalistic farming.

5. **Ploughing back of profit:** The introduction of Green Revolution helped the farmers in raising their level of income. Wiser farmers ploughed back their surplus income improving agrucultural productivity. This led to further improvement in agriculture. According to a study conducted by Punjab Agriculture University, Ludhiana farmers plough back about 55 per cent of their income for agricultural progress.

6. **Industrial Growth:** Green Revolution brought about large scale farm mechanisation which created demand for different types of machines like tractors, harvestors, threshers, combines, diesel engines, electric motors, pumping sets, etc. Besides, demand for chemical fertilizers, pesticides, insectivides, weedicides, etc. also increased considerably. Consequently, industries producing these items progessed by leaps and bounds. Moreover, seceral agricultural products are used as raw materials in various industries. These industries are known as agro based industries. Textile, sugar, vanaspati, etc. are some outstanding examples of agro based industries.

7. **Rural Employment:** While on one hand, large scale unemployment was feared due to mechanization of farming with the introduction of Green Revolution technology in India, there was an appreciable increase in the demand for labour force due to multiple cropping and use of fertilizers. According to Gobind Thukral, "Green Revolution has generated lakhs of new jobs in Punjab. Almost 15 lakh poor people from the impoverished regions of Bihar eastern Uttar Pradesh and Orissa work here they not only earn their bread and butter, but take back home new ideas and technology". As per findings of Bhalla and Chadha in respect of Punjab, " The drive towards mechanization was caused mainly by the scarcity of labour and relatively high wage rate especially during peak agricultural operations." During the last few years, a large number of farm labours have migrated from Bihar and eastern Uttar Pradesh to Punjab where they find better opportunities of earning a livelihood.

8. **Change in the Attitude of Farmers:** The Indian farmer had remained illiterate, backward and traditional and had been using conventional methods of cultivation since the early times. But Green Revolution has brought about a basic change in his attitude towards farming. The way he has

readily adopted the Green Revolution technology are available, no farmer denies their effectiveness. The desire for better farming methods nad a better standerd of living is growing not only among the relatively small number of affluent farmers using the new technology, but also among countless farmers still from outside looking in."

Demerits or Problems of Green Revolution

Green Revolution is a unique event in the agricultural history of Independent India. This has saved us from the disasters of hunger and starvation and made our peasants more confident than ever before. But it has its own inherent deficiency segments. Ever since its inception, the income gap between large, marginal and small farmers has increased, gap between irrigated and rainfed areas has widened and some crops have benefited more than the others, sometimes even at the cost of other crops. It is neither product-neutral nor region-neutral and leaves uneven effects of growth on products, regions and classes of people. This has given birth to a plethora of socio-economic problems. According to Radha Krishna Rao. "The spiraling prices of fertilizers, the tendency to use them frequently and the stagnant wheatand rice yields in Punjab and Haryana have combined to confirm that Green Revolution has reached ripened old age". The fatigue of the Green Revolution is already visible. Still the man lacuna in the Green Revolution is that up till now it is an unfinished task. Some of the demerits or problems of Green Revolution are briefly discussed as under :

1. **Inter-Crop Imbalances:** The effect of Green Revolutions primarily felt on foodgrains. Although all foodgrains including wheat, rice, jowar, bajra and maize have gained from the Green Revolution, it is wheat which has benefited the most. It has areas from coarse cereals, pulses and oilseeds. The HYV seeds in latter crops have either not been developed so far at all, or they are not good enough for farmers to risk their adoption. Consequently, their cultivation is fast becoming uneconomic and they are often given up in favour of wheat or even rice. The result is that an excess of production in two main foodgrains (wheat and rice) and shortages in most others today prevail side by side. Major commercial crops like cotton, jute, tea and sugarcane are also slmost untouched by the Green Revolution. The rate of growth in production of pulses has declined from 1.39 per cent per annum in the pre-Green Revolution period to only 0.79 per cent annum during the period from 1967-68 to 1994-95. This is not good for a balanced growth on Indian agriculture. Central Government has taken some steps to remove these imbalances.
2. **Regional Disparties:** Green Revolution technology has given birth to growing disparties in economic development at inter and intra regional levels. It has so far affected only 40 per cent of the total cropped area and 60 per cent is still untouched by it. The most affected areas are Punjab, Haryana and Western Uttar Pradesh in the north and Andhra Pradesh and Tamil Nadu in the south. It has hardly touched the Eastern region, including Assam, Bihar, West Bengal and Orissa and arid and semi-arid areas of Western and Southern India. In short, Green Revolution affected only those areas which were already better placed from agricultural point of view. Thus the problem of regional disparities has further aggravated as a result of Green Revolution.The ratio between the lowest and highest yield-rates among the states for the 1975-78 period amounted to 1 : 3.2 in paddy, 1 : 3.7 in wheat, 1 : 3.4 in cereals, 1 : 3.2 in pulses, 1 : 3.2 in food grains, 1 : 3.0 in oilseeds, 1 : 3.2 in sugarcane, 1 : 4.9 in cotton and 1 : 1.6 in jute. Studyof some sample surveys recently conducted by the Indian Agricultural Statistics Research Institute (IASRI) revealed that the single most important factor is the 'input differential' which alone can explain extreme yield variation seven under similar physical and

cultural conditions. According to a study by Bhalla and Alagh, 69 districts with a relatively high productivity levels account for 20 per cent of the cultivated area and 36 per cent of output, consume 44 per cent of fertilizers, employ 50 per cent of tractors and 45 per cent of irrigation pumps and have 38 per cent of India's gross irrigated are.

Regional disparties in crop yields can be reduced by evolving suitable disease resistant high-yield strains of paddy for most eastern parts and by developing irrigation facilities and a suitable dry farming technology for the arid and semi-arid western and southern regions.

3. **Increase in Inter-Personal Inequalities:** It has been observed that it is the big farmer having 10 hectares or more land. Who is benefited the most from Green Revolution because he has the financial resources to purchase farm implements, better seeds, fertilizers and can arrange for regular supply of irrigation water to the crops. As against this, the small and marginal farmers do not have the financial resources to purchase these farm inputs and are depreived of the benefits of Green Revolution Technology. There were about 1,053 lakh holdings in Indian in 1990-91 out of which only 1.6 per cent exceeded 10 hectares n size. Francine R. Rankel has concluded from his study of Ludhiana (Paunjab), West Godavari (Andhra Pradesh, Thanjavur (Tamil Nadu), Palghat (Kerala) and Bardhaman (West Bengal) that the greater beneficiaries are those farmers who own 10 to 12 hectares of land. Similar conclusion was drawn by G.R. Saini from his study of Ferozepur (Punjab) and Muzaffarnagar (U.P.). G.S. Bhallal and G.K. Chadha have found out that Green Revolution has benefited the farmers in general but one-third of them are small farmers with 2.5 acres of land and are living below poverty line. Another 24.0 per cent of the farmers own 2.5 to 5.0 acres of land and they are also lining below poverty line. The land holdings are generally small in rice producing areas and the economic position of the farmers living in those areas is extremely miserable. In short, Green Revolution has made the rich richer and rendered the poor poorer resulting in widespread social and economic tensions.

4. **Unemployment.** Except in Punjab, and to some extent in Haryana, farm mechanization under Green Revolution has created widespread unemployment among agricultural labourers in the rural areas. The worst hit are the poor and the landless people.

5. **Other Problem.** Agriculture under Green Revolution has not grown at a rate which was expected in the beginning. The differential rates of growth of different crops and their regional variations have already been discussed. Some scholars have expressed serious doubts about the capability of HYV seeds itself. Analysing the role played by miracle seeds in the Green Revolution, Vandana Shiva says that the term HYV is a misomer. In acutality, these seeds are highly responsive to certain key inputs such as fertilizer and irrigation and as such they should have been called highly resonsive varieties. Shiva says that there is increasing evidence that the indigenous varieties could also be high yielding given the required doses of inputs. According to Shiva, "the inevitability of the Green Revolution option was built on neglecting the other avenues for increasing production that is more important such as improving mixed cropping systems, improving indigenous seeds and improving the effiency of use of local resources." Vandana Shiva further comments that "having destroyed nature's mechanisms for controling pests through the destruction of diversity, the 'miracle seeds' of the Green Revolution became mechanisms for breeding new pests and creating new diseases". In a case study of Punjab, M.K. Sekhon and Manjeet Kaur of P.A.U. Ludhiana have warned against the excessive use of groundwater, chemical

fertilizers and pesticide. This will lead to large scale depletion of groundwater and will adversely affect the health of soil.

Suggestions for Strengthening of Green Revolution

Following suggestions are put forward for sustainability of Indian Agriculture and for the stability of Green Revolution in India.

1. **Wider Area**. So far Green Revolution has affected only 40 per cent of the culturable area in India. The remaining parts especially the eastern region and larger parts of peninsular India (except Andhra Pradesh and Tamil Nadu) are still unaffected by Green Revolution. These areas need to be covered by Green Revolution Technology so that agricultural production in India as a whole is increased and at the same time regional disparties are removed.
2. **More Crops:** The greatest benefit drawn from the Green Revolution is that by wheat, although rice is also benefited to some extent. Other crops such as cotton, jute, tea and sugarcane are not affected by it and pulses and oilseeds have suffered at the hands of Green Revolution. These crops should also be brought under the canvas of Green Revolution. A greater input of research and development is required in this connection.
3. **Irrigation:** Green Revolution has left greater impact in areas which were better served by irrigation facilities. About 2/3rd of the total cropped area is still without proper irrigation. There is an urgent need to extend irrigation facilities to these areas for the success of Green Revolution. Minor irrigation schemes especially tube-wells can play an important role in this direction.
4. **Small Farmers:** About 85 per cent are small farmers in Indian who are almost entirely deprived of the benefits of Green Revolution. Rather they have suffered a lot because they lost employment opportunities dut to mechanisation of farming. These poor farmers should be helped in all possible ways if we want Indian agricultural development to really become a mass movement.
5. **High Yields:** Though there has been a tremendous increase in yields of some crops as a result of introduction of HYV seeds and other farm inputs; they are still much less when compared with the world's best. Therefore, there is still a large scope of increasing the yields. Moreover, the possibility of increasing area under cultivation has been almost exhausted and the only way to increase production is to lay more stress on increasing yields.
6. **Intensity of cropping:** Intensity of cropping is the ratio of gross croppped area to the net sown area. It is expressed on percentages and it calculated with the help of the following formula:

$$\text{Intensity of cropping} = \frac{\text{Total cropped area}}{\text{Net sown area}} \times 100$$

In 1999-2000, total cropped area was 189.7 million hectares and net sown area was 142.2 million hectares. Thus the intensity of cropping comes out to 134.3. Cropping intensity varies from 100 per cent in Mizoram to 194.43 per cent in Punjab (1991-2000). Next to Punjab is West Bengal (174%), Himachal Pradesh (173%), followed by Haryana (169%), and Uttar Pradesh (151%). It is higher than the national average in Jammu and Kashmir, Assam, and Manipur, Sikkim, Bihar and Orissa (Fig. 23.1). It is low and very low in the states of peninsular plateaus. The densely populated northern plains. Coastal plains and deltas, which are irrigated or are favoured by sufficient rainfall, are marked with high intensity of cropping. Very low and low intensities predominate in the hilly, arid, semi-arid and semi-humid lands of Rajasthan, Gujarat, Maharashtra, Andhra Pradesh, Karnataka, and north eastern hilly states where soils are light or heavy and irrigation facilities are absent or negligible.

The index of the intensity of cropping depends upon the extent of area sown more than once. Higher the extent of area sown more than once higher will be the intensity of cropping, In other words, intensity of cropping is the indicator of the efficiency of land use. Higher the

index of intensity of cropping higher is the efficiency of land use. The main factors influencing intensity of cropping are irrigation, fertilizer, early-maturing high-yielding varieties of seeds, mechanization of agriculture and plant protection measures through the use of insecticides, pesticides and weedicides. The availability of water for irrigation ensures the use of higher doses of fertilizers which, in turn, reduces the extent of fallow land. The quick-ripening varieties of seeds help in taking more than one crop from the same field in one agricultural year.

Intensity of cropping increased from 110 per cent in 1950-51 to 134.3 per cent in 1999-2000. This means that even now only 34.3 per cent of the net sown area is used for raising more than one crop in a year. This is too small compared to 90 per cent in China and 40 per cent in Bangladesh. Therefore, there is much scope for increasing the intensity of cropping.

WHITE REVOLUTION

Operation Flood was a rural development programme started by India's National Dairy Development Board (NDDB) in 1970. One of the largest of its kind, the programme objective was to create a nationwide milk grid.

It resulted in making India the largest producer of milk and milk products, and hence is also called the White Revolution of India. It also helped reduce malpractices by milk traders and merchants. This revolution followed the Indian Green Revolution and helped in alleviating poverty and famine levels from their dangerous proportions in India during the era.

Operation Flood's objectives included:

- Increase milk production ("a flood of milk")
- Augment rural incomes
- Fair prices for consumers

List of other agricultural revolution

Black Revolution	Petroleum production
Blue Revolution	Fish production
Golden Fiber Revolution	Jute Production
Grey Revolution	Fertilizer production
Pink Revolution	Onion production/ Pharmaceutical (India)/Prawn production
Red Revolution	Meat & Tomato production
Round Revolution	Potato production
Silver Fiber Revolution	Cotton production
Silver Revolution	Egg/Poultry production
White Revolution	Milk/Dairy production (In India - Operation Flood)
Yellow Revolution	Oil Seeds production
Evergreen Revolution	Overall development of Agriculture

SOCIAL FORESTRY

India's population has crossed the figure of 1000 million. Cultivable land per capita has declined significantly. With the present rate of deforestation, there would be hardly any forest cover in the coming fifty years. Already there are acute shortages of fuel wood and fodder. Even to sustain present demand, fuel wood production must be increased. Survival for the poor is becoming precarious. Women are forced to walk miles in search of fuel wood, fodder and water. Scant supply of forest-based raw materials has devastated the livelihood of millions of tribals and others dependent on forests, as also their culture and way of life. India's future is hinged to the revival of its degraded forests and different cultivable and non-cultivable land resources.

One of the most serious problems threatening the country today is its population growth. Although the foodgrain production in the last few years has kept pace with the population increase, the daunting task of feeding each and everyone in the next century is the biggest challenge before us. In our attempts to meet such increasing demands, the improper and over-use of chemical inputs had deteriorated

the agro-ecosystems to a considerable extent. Moreover, the pressure due to growing human and cattle population on the land has added to the deterioration of land status of the country. The increasing deterioration of land due to soil-erosion, injudicious use of chemical fertilizers, water logging, salinity / alkalinity, shifting cultivation etc. necessitates a more scientific approach towards the utilization of these lands, often termed as degraded or waste-lands. The growing awareness in the world on the environment conservation and the emphasis on the concept of sustainability has focused on the area of 'wasteland utilization' as an important component of sustainable development.

Why Social Forestry?

Social forestry is seen as an instrument of sustainable development. This is due to its potential of resolving the three basic issues of rural poor simultaneously. It has a capacity to provide food security, fuel security and livelihood security with eco-friendly approach to development thus leading to sustainable development.

As a source for meeting the daily needs of public requirements viz., timber, fuel, fodder, industrial and medicinal products, forests are quite significant. In view of the various developmental schemes, the pressure on forest resources to cope up with the increasing demand has become much more severe. As such, the gap between the demand and supply is on the increase. To bridge this gap to a certain extent, it is inevitable to raise forests on all available government and private lands.

Social forestry assumes an important role in removing the regional imbalances which occur in vegetation. Since there is no chance of increasing the area under forests, the only alternative is to bring as much private land under forests as may be possible. Hence the need to have a vigorous social forestry programme is realised.

Government for social forestry

In 1976, the National Commission on Agriculture in its review of the forestry sector sugggested two new directions. A greater emphasis on production forestry by establishing Forest Development Corporations and a programme on Social Forestry to deal primarily with fuelwood and fodder production for the rural poor.

Social forestry was to be a programme of the people for the people, and by the people. Because social forestry is labour intensive, it was also hoped that it would contribute significantly to rural employment. Social forestry, with its village woodlots, farm forestry and other afforestation activities seemed to promise the greening of the country. And, in the long run, this would have meant halting deforestation and significant contribution to the ecological regeneration of the country.

Social forestry was maintained by government and significant funds set apart for its progress, particularly from the Sixth Plan onwards. Centrally sponsored schemes were accepted for increasing fuel-wood in the fuelwood deficient districts. International agencies gave generous support for social forestry not only to increase the supply of fuel-wood and fodder, but also to ensure the participation of the rural poor so that the control of these resources would be in the hands of the poor.

It may be recalled that the National Commission on Agriculture (1976) spelt out the objectives of social forestry as:

(1) fuelwood supply to replace cowdung
(2) small timber supply
(3) fodder supply
(4) protection of agricultural fields against winds, and
(5) recreational needs.

Local Organization efforts

Significance of local organization is broad in achieving the prospect of social forestry. Voluntary agencies can set up a model after carefully studying the local needs. They have to identify the areas and species suitable for a specific type of land to meet the needs. The achievement of the programmes rest on association of the people. People should involve themselves in planning, execution and management of resources meant

for them. One suggestion that could be given for this is forming a village council for planning and implementing various activities at the village level. Grass roots level planning is the strength of voluntary agencies. They should have credibility and it is reinforced by the enthusiasm of the local people. A village should have a dynamic local leader who can motivate people for the cause.

The main role of local agencies involved in the cause of forest development is regeneration of forests and rebuilding the tribal community. The voluntary sector is not homogenous but has a great variety. Some voluntary agencies view afforestation as a source of income generation, some as regeneration of environment and others as part of community building. So the success also depends on the approach of the local agencies.

In West Bengal, social forestry has been more successful because the village panchayats were actively involved in identifying land beneficiaries. The revitalisation of village panchayats in West Bengal was based on implementation of land reforms and distribution of surplus lands. The protection of forests by village communities has been so successful that the West Bengal Government has extended the scheme to other parts in the state as well. Without a local organisation, active participation and involvement of people is difficult to achieve.

In many successful projects of afforestation and the sustainable use of forests, the principle of equity in distribution of local resources has contributed significantly to the success of the project. In the Chipko village in the Himalayas, the women in the villages have organised themselves for safeguarding their ecosystems and in developing fuelwood and fodder resources in their common lands. They identified fragile slopes and planted them to prevent landslides.

Another successful example of a local organisation based on equitable sharing of resources is the Sukhomajri project in the Shivalik hills. The Sukhomajri village has been able to protect its watershed, save the village from falling into a widening gorge because of massive erosion and has been able to increase the social and economic well-being of the village community in a span of three to four years. Sukhomajri has established a Water Users Association, which provides an equal share of the rain- water collected by building a small dam. Even the landless are entitled to an equal share, which they can barter for share-cropping, money etc. Everyone in the village has a vested interest in safeguarding the watershed, so that the dam does not get silted.

Earlier the trees were planted in the watershed by the Forestry Department to stop soil erosion, but the villagers did not cooperate. The forest officials threatened the villagers and imposed heavy fines when caught with their cattle grazing in the watershed. But these mechanisms, as we know from experience elsewhere, did not work. Only when the community established its own organisation and assured equitable distribution of benefits that every member of the community endeavored to safeguard the afforestation in the watershed.

With the building of the check-dam, with availability of harvested rain-water, with the consensus on equitable sharing of water, the economy of the village boomed.

Selecting suitable Species

To meet the needs, proper species should be identified specific to the land capabilities and environmental conditions. Voluntary agencies can select the species which can meet the local demand for fuel, fodder and timber. Sometimes, despite firewood shortage people do not show any preference for better varieties. This is perhaps due to the perception of the farmers that they will not be profitable. A multipurpose indigenous tree would assume greater importance which has quick growing provenance. Acute fodder shortage is a major problem that is faced by the farmers. So, due importance should be given to the fodder species.

Any of the following species combination can be planted by an individual to meet his requirement: Artocarpus for fruit, fuel and foldder, Tectona grandis for timber, Eucalyptus, Neem etc. for medicinal value, bamboo for timber, etc.

Barriers blocking the Success

Despite reasonable development in the right direction further acceleration in social forestry calls for identification of major barriers blocking the success of the programme. On the basis of several studies and reports they can be listed as follows:

1) Critical analysis of objectives of social forestry and actual outcome show that there is a priority over fodder and fuel wood tree plantation which has resulted into insignificant contribution to improving the consumption of poor families. As a result, the pressure on forest land has not significantly reduced. Block plantation on degraded waste land has remained much less than strip plantation.
2) Bureaucratic and departmental imperatives are more powerful than poor people's interests which reflect in the decision regarding choice of plantation. Consequently projects that given the government help, people would be willing to invest their labour and capital has failed to a larger extent.
3) One of the observations of a social forestry evaluation report notes that ever increasing targets and complex and intensified administration provide little time for extension or seeking the 'participation' which remained 'an ideology without a methodolgy.'
4) People's participation is not forthcoming as species selection and spacing are left to the forestry sector which emphasize on revenue generating plants and environmentally significant plants but not people's current needs oriented plants. In the name of next generation the needs of present generation is neglected. Benefits which could flow to the poor from species yielding intermediate products were not properly appreciated. Thus, productions of grasses, legumes, fodder, fruit and minor forest products are neglected.
5) The structure of marketing arrangements and pricing of minor forest produce are totally ignored in comparison to production efforts under the social forestry programmes. Forest co-operatives which had once played very significant role have almost disappeared now.
6) People's participation in social forestry projects is much less than desired. Staffs engaged on project implementation have different approach. 'I manage, you participate' has been a dominant underlying principle behind government projects. However, the FAO defines people's participation "as the process by which the rural people are able to organize themselves and through their own organization are able to identify their needs, share in design, implementation and evaluation of the participatory action."
7) The role of NGOs is very significant in developing non-forest area through social forestry, besides promoting people's participation in the social forestry. National Waste Land Development Board has developed specific guidelines for participation of NGOs. However, recent project report of the department on "Integrated Forest Development" has made sad remarks about the performance of NGOs.'
8) Small and marginal farmers, despite the recognition of Tree as a ready saving bank, do not show enthusiasm to plant trees. The response is poor because of problems of security, ownership, pricing, marketing and even benefits.
9) It is notable that employment programmes under Anti-Poverty schemes have specific target provision to cover forest development work which could be easily linked up to social forestry programmes. Such linkage is missing due to lack of co-ordination among government departments.

Thus, critical review of social forestry programmes help us to identify specific issues to promote them with accelerated momentum through participation of people and active support of Government and non-government organizations.

Suggested Policy Actions

The specific and pragmatic policy actions are not easy to suggest. However, a modest effort could be made to point out broad policy actions:

A) Specific measures are needed to be taken up to reach the poor. Now that forest personnel have developed friendly image through social forestry programmes, people will be approachable through Panchayats and NGOs.

B) Educating people for understanding the importance of ongoing social forestry programmes. However, apart from dissemination of information and knowledge of social forestry, it should be "one facility centre" for adoption of social forestry by the people.

C) Aghakhan Rural Development support Programme (AKRSO) has not only received due recognition by the department as the model of NGO participation but it has also shown an approach to deal with afforestration through landless laboures. Efforts could be made to replicate such models.

D) Decision making process of the programme must be highly decentralized with adequate participation of the beneficiaries which would help balancing the needs of the poor and society and economy at large. A balance between ecological stability and economic progress will be achievable only by this way.

School Nursery Programme

Nursery establishment is the foremost important activity in the social forestry programme. The nurseries should be easily accessible to the farmers; that means, decentralised nurseries should be established so that the enthusiasm and interest of the people in planting trees can be boosted. A classic example of the nursery establishment by the Tarabalu Rural Development Foundation in Chitradurga district of Karnataka can be quoted. It runs 157 educational instiutions which is a tremendous development resource for social action. It started a project, viz Tarabalu Seedlings (TS), in 1985 with the assistance of the society for the Promotion of the Wasteland Development and the Social Forestry Department of Karnataka. The objectives include rising of experimental nurseries in 60 schools involving students and teachers, developing scientific afforestation of degraded land and initiating social forestry.

The School Nursery Development Programme has evoked good response from students and teachers. Kisan nurseries that are developed by the Social Forestry Department of Karnataka also supply seedlings to farmers. But people would like to go in for seedlings from TS because there they have a sense of belonging. They think that the seedlings are grown by their own children. So they prefer these seedlings to those supplied by Kisan nurseries, since an element of attachment is present there. If social forestry has to become a social movement, it has to take roots in the minds of the people and not just in the minds of the foresters and bureaucrats. The School Nursery Development Programme has to clearly focus on nutrition habits among school children.

Tree Patta Scheme

As part of social forestry and rural development a 'tree patta' scheme was jointly evolved by the National Wastelands Development Board (NWDB) and the Ministry of Rural Development. The scheme involved access to common land for afforestation purposes. The patta holder was given access to land with usurer rights of trees and grasses grown on the land. The scheme did not take off primarily because land was not available for the purpose. Only very rocky and degraded land was offered and even that meant various political and bureaucratic hurdles. The policy in terms of treeless forest land-about 35 to 40 m ha has been that it is to be safeguarded and not allowed to be used even for afforestation purposes under the guidance of the Forestry Department. Without access to land, social forestry and other afforestation schemes can only be on paper and rhetoric for the birds.

Conclusion

Social Forestry was conceived as people-centred programme, a programme to empower the rural poor for their fuelwood, fodder and other timber needs. In time, social forestry became a government programme, a programme of the Forest Department. Major funds of social forestry were used in protected and reserved forests, and the only benefit to the poor was in terms of employment; it is sad to observe that even here, in some instance it was found that minimum wages were not paid.

Lack of appropriate policies regarding access of land to the poor for afforestation purposes, defunct Acts and laws, which hinder rather than motivate people, resulted in vested interests controlling the social forestry programme. Instead of fuelwood and fodder, social forestry has largely provided raw materials to paper, pulp and building industry, bypassing the rural poor.

New programmes require new strategies and new structure. Social Forestry too needs to be doused in an appropriate organisation structure which encourages and promotes people's participation. One such structure promoted was the Rashtriya Virkshamitra Sahyog Mandal (RVSM), an agency jointly sponsored by the National Wastelands Development Board, and the National Dairy Development Board (NDDB). The RVSM has promoted tree growers cooperatives for fuelwood and fodder in several states.

Social forestry and massive afforestation by the people cannot be a programme of a single government department. Social forestry must be a people's movement. Schools, colleges, municipalities, government departments, and other identified institutions should share the responsibility to plant trees and maintain them either directly or through a contract system with local people.

AGROFORESTRY

The land management patterns in India vary from area to area depending upon land characteristics and the climate. The land has a limited-population supporting capacity, beyond that there will be degradation and irreversible loss of productivity because of improper and excessive use.

Agroforestry systems hold promise to provide such sustainable land management. The production of food grains, fruits, fodder, fuelwood, timber etc. can be obtained simultaneously through these systems. The total production-mix can be selected depending upon the area, climate, demand etc.

Agroforestry is a way to reduce the existing pressure on the forest. The practice is very old, but the term is definitely new and for the last one decade it has taken a scientific approach. The need is for diversification of agriculture to reduce the risk of crop failure due to uncertainty of weather conditions and erosion hazards. People raise trees, crops and animals traditionally on the same farm. This practice of mixed farming has developed over centuries for meeting most of the requirements of family.

Agroforestry is a collective name for land use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same piece of land management unit as agricultural crops and/or animals in some form of spatial arrangement or temporal sequence.

In agro forestry, there are both ecological and economical interactions between the different components. In simple terms, agriculture is a land use system where agricultural crops are grown for the production of food grains, fodder, etc. Forestry, on the other hand, is land use system where forest trees, shrubs etc. are grown for the production of wood, fodder and other benefits. Agroforestry is a hybrid of both land use systems where the object is to obtain yield of grains, fodder, fuelwood, fruit, wood and other benefits.

Advantages of Agro-forestry

There is serious concern over degradation of environment. Serious adverse ecological manifestation, increase of carbon-dioxide (CO_2) in the atmosphere, global warming, serious soil losses, repeated droughts, floods and serious

pollution, etc. are the results of dwindling forest resources. An agroforestry system helps to increase the tree cover. It also makes available to people the required quantity of timber, fruit, fuel-wood, fodder etc. for which they traditionally depend on forests. Thus, this system helps in reducing the pressure on forests and helps in conservation and development.

Different areas are gravely under the threat of pollution. Air, water and noise pollution are common. Trees guard from distinct kinds of pollutants. The best safeguard against landslides is through agroforestry i.e. mixed forests and grasses. This requires careful selection of tree species, grasses etc. Agroforestry systems maintain soil fertility through recycling of nutrients and prevent soil erosion and loss of nutrients through leaching and runoff. Reduction in erosion and surface run off helps in reducing flood damage. Many leguminous tree species fix nitrogen from the atmosphere and return much more in leaf-fall than they take from the soil. Leaves of the trees could be used as green manure and help the farmer in increasing soil fertility.

Agroforestry system is therefore helpful in maintaining land productivity at optimum levels over a long period of time. These systems constitute sustainable land management.

These systems are capable of meeting the demands of raw materials of several agricultural and forest based industries. Some of the industries e.g. paper and pulp mills, sports goods, furniture, saw mills, etc. are meeting requirements from forestry and agroforestation produce. Poplar has been widely cultivated in the Tarai area of Uttar Pradesh and Haryana and is being used by several industries, e.g., match splints, plywood, packing cases etc.

Such systems improve the productivity of plants and animals since they are based on sustainable land management and maximum utilisation of natural resources, to increase the ecological and economic benefits.

Various Forms of Agroforestry

- **Silvipastoral System:** In this system of sustainable land management, improved pasture crops are grown along with tree species.
- **Agri-Silvipastoral System:** This system is the result of the union between silvipastoral and agri-silvicultural systems. Under this system, the same unit of land is managed to get agricultural and forest crops where farmers can also rear animals.
- **Agri-Horticultural System:** If agricultural crops are grown along with fruit trees, the system is referred to as agri-horticultural system.
- **Silvi-Horticultural System:** In this system, tree species are managed to get timber, fuel wood etc. and horticultural crops are grown in the interspace.
- **Silvi-Horti pastoral System:** A combination of tree species, horticultural crops and grasses are practiced in this system. The three combinations are based on the principle that each of its components draws nutrients from different layers of soil.
- **Silvi-Agri-Sericultural System:** This is a very complex system of agro-forestry. In this system, crops/vegetables are grown along with tree species (silk host plants). The larval excreta are good manure for the crops/vegetables.
- **Silvi-Agri-Lac Cultural System:** In this system, crops are grown along with lac host plants. It is very common in Chota Nagpur plateau of Jharkhand.
- **Horti-Silvi-Agri-Apicultural System:** The land is managed for concurrent production of flowers, crops and honey. Flowering plants often favour increases of parasites and predators of crop pests and thus an antiregulatory bio-control system operates here.
- **Multi-Storeyed Agroforestry System:** This system is managed by the combination between cultural practices and the natural processes of vegetation production and reproduction. It represents a profitable production system and constitutes an efficient buffer between villages and forests. This is common in coastal parts of Southern India

where coconut is grown with black pepper and tapioca (cassava).

- **Aqua-Agri-Hortipastoral System:** In this system, fruit trees are planted on the terraced land around the water tanks, ponds, etc. and crops (agricultural and pastoral) are grown in the interspace. The fallen leaves of trees enrich the pond nutrients for fish.

SERICULTURE

Sericulture is an agro-based industry. It involves rearing of silkworms for the production of raw silk, which is the yarn obtained out of cocoons spun by certain species of insects. The major activities of sericulture comprises of food-plant cultivation to feed the silkworms which spin silk cocoons and reeling the cocoons for unwinding the silk filament for value added benefits such as processing and weaving.

India has the unique distinction of being the only country producing all the five kinds of silk - Mulberry, Eri, Muga, Tropical Tasar and Temperate Tasar.

Sericulture Activities

- **Moriculture:** Cultivation of mulberry plants is referred to as Moriculture. It is an agricultural activity. In Tamil Nadu, mulberry cultivation is mainly taken up in irrigated condition. Flat, deep, fertile, well drained loamy and clay loamy with good moisture holding capacity soil is ideal for mulberry cultivation.
- **Silkworm Rearing:** Silkworm Rearing is considered to be an agro based cottage industry since it involves mulberry cultivation. Silkworms are reared for the production of "cocoons" which is the raw material for silk production. The farmers rear silkworms and produce cocoons. By marketing the cocoons the farmers earn money. It is ideally suited for the rural areas of Sericulture States. Silkworms are reared in well ventilated rearing shed following shoot rearing method
- **Silk Reeling:** Extraction of silk filament from cocoons by employing a set of processes is known as silk reeling. Presently silk reeling is done using three types of reeling devices viz. Charka, Cottage basins and Multi-end basins. Poor quality cocoons can be reeled economically on charka. About 50% of silk produced is of charka and about 35 - 40% is at cottage basins and a small quantity of silk is from multiend reeling. The silk obtained out of the reeling process is referred to as "Raw Silk".
- **Silk Weaving:** The raw silk cannot be directly used for weaving. The raw silk is to be twisted before they are fed into looms. The operation of conversion of raw silk into twisted silk, is termed as twisting. The twisted silk is referred to as Ready Silk. Twisting is undertaken either by separate entrepreneurs or by the weavers themselves. The silk weaving is done either on handlooms or power looms. The traditional silk sarees and dhoties are made on handlooms whereas the printed sarees, dress materials, etc., are made on power looms.

Eco- friendly activity

- As a perennial crop with good foliage and root-spread, mulberry contributes to soil conservation and provides green cover.
- Waste from silkworm rearing can be recycled as inputs to garden.
- Dried mulberry twigs and branches are used as fuel in place of firewood and therefore reduce the pressure on vegetation / forest.
- Being a labour intensive and predominantly agro-based activity, involvement of smoke-emitting machinery is minimal.
- Developmental programmes initiated for mulberry plantation are mainly in upland areas where un-used cultivable land is made productive.
- Mulberry can also be cultivated as intercrop with numerous plantations.
- Mulberry being a deep-rooted perennial plant can be raised in vacant lands, hill slopes and watershed areas.

- Currently, only about 0.1 % of the arable land in the country is under mulberry cultivation.

DRY ZONE FARMING

Dry zone agriculture basically belongs to fragile, high risking and low productive agricultural eco-system. This spreads over those areas of country where annual amount of rainfall is less than 75cm. dry lands cover about 22%of country's area. More than three-fifth of Rajasthan and one - fifth of Gujarat and some areas of Punjab, Haryana, Maharashtra, Andhra Pradesh and Karnataka come under dry lands.

Due to low productivity it grows jowar, bajra, maize, cotton, groundnut, pulses and oilseeds.

Problems of dry zone agriculture:

- Here rainfall is scarce and uncertain which makes the region susceptible to draughts and famines
- Here soil is sandy which lacks nutrient materials for soil fertility
- The area is prone to problem of soil erosion
- Low yield and more susceptible to pests and diseases
- Fields are scattered and the use of new farm machineries lacking
- These areas lack infrastructural facilities as transport, market, storage etc.

With the growing emphasis on food security of the masses need of the hour is to launch second green revolution related to coarse grains and oilseeds which should be based on organic farming methods to counter the drawbacks of first green revolution.

LAND RESOURCES OF INDIA

Major Land Forms of India		
1.	Plain	43%
2.	Mountain & hills	30%
3.	Plateau	27%

The utilization of land depends upon physical factors like topography, soil and climate as well as upon human factors such as the density of population duration of occupation of the area, land tenure and technical levels o the people.

Net sown Area

1. Agriculture land means cultivated area it includes net cropped area and fallow lands. Cropped area in the year under consideration in called net sown area.
2. India stands seventh in the world in terms of total geographical area but second in terms of cultivated land.
3. Net sown area to total geographical area varies from state to state.
4. Net shown Area is 46%
5. Percentage wise Punjab and Haryana are highest and Arunachal Pradesh is Lowest (3.2%)
6. Area wise largest Net shown area- Madhya Pradesh- Maharashtra-U.P- Rajasthan-Andhra Pradesh- Karnataka.

Culturable Waste

Culturable Waste' is the land available for cultivation but not used for cultivation for one reason or the other.

1. It is not being used at present due to such constraints as lack of water, salinity or alkalinity of soil.
2. $\frac{1}{6}$ of total area of Goa is Culturable waste.
3. Rajasthan has maximum culturable waste-land about 36% followed by Gujarat M.P, U.P., and Maharashtra.

Land not available for cultivation

This can be classified in two types:
a) Land put to non-agricultural use.
b) Barren and uncultivable land.

These areas cannot be brought under plough except at high input cost with possible Low returns. In India land not available for cultivation is 13.8 percent. The largest areas in this category Andhra Pradesh, Rajasthan. M.P, Gujarat, U.P. Bihar.

Permanent Pastures and other grazing land

1. About 4 percent of total area, Grazing takes place mostly in forest and other uncultivated land where pastures are available.
2. Permanent pastures land- Himachal Pradesh, M.P. Karnataka, Gujarat, and Rajasthan.

Land under tree crops and groves

1. Land under tree crops and groves include all cultivable land which are not included in net shown area, but have been put to some aquaculture use.
2. Land State wise tree crops- Orissa, Uttar Pradesh, Bihar, Karnataka. ■■■

6 MINERALS

Minerals are valuable natural resources being finite and non-renewable. They constitute the vital raw materials for many basic industries and are a major resource for development. The history of mineral extraction in India dates back to the days of the Harappan civilization. The wide availability of the minerals in the form of abundant rich reserves made it very conducive for the growth and development of the mining sector in India.

The country is endowed with huge resources of many metallic and non-metallic minerals. Mining sector is an important segment of the Indian economy. Since independence, there has been a pronounced growth in the mineral production both in terms of quantity and value.

India continued to be wholly or largely self-sufficient in minerals which constitute primary mineral raw materials to industries, such as, thermal power generation, iron & steel, ferro-alloys, aluminium, cement, various types of refractories, china clay-based ceramics, glass, chemicals like caustic soda, soda ash, calcium carbide, titania white pigment, etc. India is, by and large, self-sufficient in coal (with the exception of very low ash coking coal required by the steel plants) and lignite among mineral fuels, bauxite, chromite, iron, manganese ores, and rutile among metallic minerals; and almost all the industrial minerals with the exception of chrysotile asbestos, borax, fluorite, kyanite, potash, rock phosphate and elemental sulphur. Despite high degree of self-sufficiency, some quantities of flaky and amorphous graphite of high fixed carbon, kaolin and ball clay for special applications, very low silica limestone, dead-burnt magnesite and sea water magnesia, battery grade manganese dioxide, etc. were imported to meet the demand for either blending with locally available mineral raw materials and/or for manufacturing special qualities of mineral-based products. To meet the increasing demand of uncut diamonds, emerald and other precious and semi- precious stones by the domestic cutting and polishing industry, India continued to depend on imports of raw uncut stones for their value-added re-exports.

MINERAL BELTS OF INDIA

(1) North-Eastern Peninsular Belt:

1. It is the richest mineral belt of India.
2. Comprises of Chotanagpur plateau and Orissa plateau in Jharkhand, W. Bengal and Orissa.
3. The Chhotanagpur plateau is known as the mineral heart land of India, also Ruhr of India.
4. It contains large quantities of coal, iron, manganese, mica, bauxite, Copper, Chromites, and Kyanite.

(2) Central Belt:

1. It is the 2nd largest mineral belt of India.
2. Comprises of Chhattisgarh, M.P, Andhra Pradesh and Maharashtra.
3. It has large deposits of Manganese, bauxite, limestone, marble, coal, gems (Panna), mica, iron ore, graphite etc.

(3) Southern Belt:

1. It comprises mostly of Karnataka plateau and contiguous T.N. upland.
2. It lacks coal deposits except lignite at Neyveli (T.N.).
3. It is more or less similar to northeastern peninsular belt as far as deposits of ferrous minerals and bauxite is concerned.

(4) South-Western Belt:

1. Southern Karnataka & Goa are included.
2. It has deposits of iron-ore, garnet and clay.

(5) North-West Belt:

1. Extends along the Aravallis in Rajasthan and in adjoining parts of Gujarat.
2. Important minerals - Copper, lead, zinc, Uranium, mica, bauxite, gypsum, manganese, salt.

(6) The Indian Ocean

1. Along with availability of petroleum and natural gas in the off shore areas the sea bed contains manganese nodules, phosphorite nodules and barium sulphate concentration
2. The best quality nodules are found in water depths of more than 4000m.
3. Phosphate nodules are mainly found near Andaman Islands.

DISTRIBUTION OF MINERALS

IRON ORE:

Types of iron-ore:

(A) Magnetite - contains 72% pure iron.
(B) Hematite - contains 60-70% pure iron.
(C) Limonite - contains 40-60% pure iron.
(D) Siderite - contains 40-50% pure iron.

(A) Magnetite ores:

- This type of ore in India is either of igneous origin or metamorphosed banded magnetic silica formations probably of sedimentary type.
- It occurs in Dharwar and Cuddapah system of the peninsula.

(i) **Karnataka:** Kudremukh deposits.
(ii) **Tamil Nadu:** Salem, Nilgiri, and Dharampuri.
(iii) **Andhra Pradesh:** at the trijunction of Adilabad, Karimnagar and Nizamabad dist. and Khammam and Warangal dist.
(iv) **Kerala:** Kozhikode dist.

(B) Hematite Ores: It also occurs in Dharwar & Cuddapah system of the peninsula.

(i) **Jharkhand & Orissa:** Gurumahisani-Badampahar belt

(ii) **M.P. and Eastern Maharashtra region:**

(a) Bailadila, Raoghat (Bastar dist.)
(b) Dalli-Rajhara group (Durg dist.)
(c) Lohara-piplagaoh and surajgarh deposits (Eastern Maharashtra).

(iii) **Karnataka:**

(a) Sandur range (Bellary dist.)
(b) Bababudan Hills (Chikmanglur dist.)
(c) Tumkur, Shimoga & Chitradurg dist.
(d) North Kanara deposit.

(iv) **Goa-Ratnagiri area:**

(a) **Goa:** North (rich), Central (medium), South (poor
(b) Ratnagiri dist.

(v) **Rajasthan:** Bhilwara & Udaipur dist.

(C) Limonite & Siderite: Damuda series (Raniganj coal field), Garhwal (Uttaranchal) and Mirzapur dist. of U.P. and Kangra Valley (H.P.)

- **Largest reserves:** (i) Karnataka (ii) Orissa (iii) Chhattisgarh (iv) Andhra Pradesh
- **Largest producers:** (i) Orissa (ii) Karnataka (iii) Chhattisgarh (iv) Goa

MANGANESE ORE:

- India has the 2nd largest manganese ore reserves in the world after Zimbabwe.
- India is its 5th largest producer after Brazil, Gabon, S.Africa and Australia.
- Orissa, Maharashtra, M.P, Karnataka and Andhra Pradesh produce more than 99% of it.
- Manganese Ores Occurs in Dharwar sedimentary socks.

Production centres:

1. **Orissa** - Sundergarh, Kalahandi, Koraput, Keonjhar, & Mayurbhanj
2. **Karnataka** - Sandur, N.Kanara, Tumkur, Shimoga
3. **M.P.** - Balaghat, Chhindwara, Jabalpur, Jhabna
4. **Maharashtra** - Nagpur, Bhandara, South Ratnagiri
5. **Jharkhand** - Singhbhum

6. **Rajasthan** - Udaipur, Banswara
7. **Andhra Pradesh** - Vishakhapatnam, Srikakulam.

- Largest reserves - (i) Orissa (ii) Karnataka (iii) M.P.
- Largest producers - (i) Orissa (ii) Maharashtra (iii) M.P.

COPPER:

- Important ores - cuprite, Malachite, chlcocite, Bronite, Chalcopyrite, and Azurite.
- **Production centres:**

  Rajasthan - Khetri copper belt - (a) Mandan Kaddhan section (b) Kolihan section (c) Dariba.
  Jharkhand - Singhbhum copper belt
  M.P. - Balaghat
- Largest reserves: - (i) Rajasthan (ii) M.P. (iii) Jharkhand
- Largest producers: - (i) M.P. (ii) Rajasthan (iii) Jharkhand

LEAD:

- Galena (lead sulphide) is the chief ore.
- It is found in the reins of limestone, sandstone & slates.
- Major deposits are in Precambrian series. Production center: - Zawar mines (Udaipur dist.) in Rajasthan
- Largest reserves: - Rajasthan
- Largest producers: - Rajasthan

GOLD:

- It is found in quartz veins or reefs of quartz (Lead-gold), occasionally associated with iron and copper sulphide.
- Three important gold fields of India:

  (i) Kolar gold field - Kolar dist. (Karnataka)
  (ii) Hutti gold field - Raichur dist. (Karnataka)
  (iii) Ratnagiri gold field - Anantpur dist. (Andhra Pradesh)
- **Alluvial gold** - Gold is also found in the alluvial sand and gravels of many streams and rivers.
- Important mines are:

  Jharkhand - Subarnarekha, Sona nadi, streams draining Sonapat Valley.
- **Kerala** - River terraces along Panna Puzha & Chakiye Puzha.
- Largest producers - (i) Karnataka (ii) Andhra Pradesh (iii) Jharkhand.

SILVER:

- Chief ores: Argentine, Stephanite, Pyrogyrite and Pronstite
- It occurs in mixed form with Zinc, Copper, Lead and Gold.
- Silver is also found in lead-Zinc ores of Zawar mines (Rajasthan), Kolar gold fields and Hutti gold mines of Karnataka.
  Largest producer - (i) Rajasthan (ii) Jharkhand (iii) Karnataka.

ZINC:

- Main Ore: Zinc-blend.
- It is a mixed ore containing lead and zinc (Pb+Zn).
- More than 99% of the total zinc of India is produced in Zawar area in Udaipur dist. of Rajasthan.
- Small quantity of this Ore is also produced in Sikkim.
- Some deposits have been found in Udhampur dist. (J&K) and South Arcot dist. (Tamil Nadu)

BAUXITE:

- An important ore of Aluminium.
- The deposits were formed mainly in tertiary period.
- It is associated with Laterite rocks.
- Largest reserves: (i) Orissa (ii) Andhra Pradesh (iii) Gujarat
- Largest Producers: (i) Orissa (ii) Gujarat (iii) Jharkhand.

MICA:

- Three major types of mica found in India are: (i) Muscovite (Potash mica) (ii) Biotite (Iron-magnesium mica) (iii) Phlogopite.
- About 95% of India's mica is found in three states of Andhra Pradesh, Rajasthan and Jharkhand

- Productions areas:

Rajasthan:

- ❖ Mica belt from Jaipur in NE to Udaipur in SW Rajasthan.
- ❖ Bhilwara is the most important centre.
- ❖ Light green or pink colour, high quality mica.

Andhra Pradesh:

- ❖ Nellore mica belt between Guntur and Sangam (100 km long and 25 km wide.)
- ❖ Nellore mica is generally light green in colour.

Jharkhand & Bihar:

- ❖ A belt of 150 km length and 20 km width runs from Gaya to Bhagalpur through Hazaribagh, Giridih and Munger.
- ❖ Kodarma is the most important centre and world's largest mica market.
- ❖ This belt contains the richest deposits of high quality Ruby-mica & Bengal-mica.
- ❖ Largest producers: (i) Andhra Pradesh (ii) Rajasthan (iii) Jharkhand.

FOSSILS FUEL MINERALS:

COAL:

- Coal is the primary source of energy accounting for about 68% of the total commercial energy consumption in the country.
- There are two main categories of the coal bearing strata in the country:-

(i) **Gondwana Coalfields:** It accounts for 98% of the total reserves and 99% of the total production of coal in India. Of the 113 major coalfields found all over the India, 80 are located in the rock system of lower Gondwana age. There are about 75 separate basins, mainly confined to peninsular India, in the valleys of certain rivers viz. Damodar (Jharkhand-West Bengal), Mahanadi (Chhattisgarh-Orissa), Son (M.P.-Jharkhand), Godavari & Wardha (Maharashtra-Andhra), Indravati, Narmada, Pench and Kanha.

(ii) Tertiary Coalfields:

- Contains the coal of younger age.
- Primarily confined to extra peninsular region, viz. Assam, Meghalaya, Arunachal Pradesh, Nagaland, Himalayan foothills of Darjeeling in W.Bengal, J&K, U.P. Rajasthan, Kerala, T.N. and U.T. of Pondicherry.
- Assam coal is of high grade as fuel while coals of Kashmir and T.N. have a lower percentage of fixed carbon.

Types of Indian Coal:

1. **Anthracite** - (80-95% carbon) it is found only in J&K and that too in small quantity.
2. **Bituminous** - (40-80% carbon) most of it is found in Jharkhand, Orissa, W.Bengal, Chhattisgarh and M.P.
3. **Lignite (Brown Coal)** - (40-55% carbon) it is found in Palan (Rajasthan), Neyveli (T.N), Lakhimpur (Assam) Karewa (J&K).

Distribution:

Most of the coalfields are found in the eastern part of India particularly to the east of 78° E longitude. Maximum concentration is in the north-eastern part of the peninsular plateau comprising parts of Jharkhand, Chhattisgarh, Orissa and eastern M.P. and western part of W. Bengal adjoining parts of Maharashtra also have large deposits of coal.

Gondwana Coal:

- **Jharkhand:** Jharia, Bokaro, Giridih, Dhanbad, Karnapura, and Ramgarh (most of the coal fields are located in a narrow belt in east west direction almost along 24°N latitude).
- **Orissa:** Dhenkanal, Sambalpur and Sundergarh dist. (Talcher coalfield is the most important.
- **Andhra Pradesh:** Singrauni, Tandur, Kathagudam (Godavari Valley has the largest reserves)
- **Maharashtra:** Kamptee, Wardha Valley, Ballarpur and Warora (Chandrapura dist.)
- **W. Bengal:** Raniganj, Burdawan, Purulia, Virbhum, Jalpaiguri and Darjeeling. (Raniganj is the largest coalfield).

- **U.P:** Singrauli coal fields (Mirzapur dist.)

Tertiary Coal:

- **Assam:** Makum, Nazira, Mikir hills, and Dilli-Jeypore (Makum coalfield in Sibsagar dist. is most developed)
- **Rajasthan:** Palan-Bikaner.
- **Meghalaya:** Garo, Khasi and Jaintia hills.
- **Arunachal Pradesh:** Namchick-Namrup coalfield (Tirap dist.)
- **Largest coal reserves:** (i) Jharkhand (ii) Orissa (iii) Chhattisgarh (iv) W. Bengal
- **Largest coal producers:** (i) Jharkhand (ii) Chhattisgarh (iii) Orissa (iv) M.P

PETROLEUM:

In India petroleum resources are confined to the sedimentary rocks Mesozoic and tertiary periods. However, most of the areas are of pre-Cambrian age, which are regarded as highly unfavorable regions for oil fields.

Important Potential Basins:

Upper Assam, Southern Assam-Surma Valley, Tripura, Sunderbans (W. Bengal), coastal region of Orissa, Andhra Pradesh, T.N. Kerala, Kutch region, Saurashtra, Southern Gujarat (Ankleshwar), Narmada valley (M.P.) Western Himalaya and Ganga basin. The only off-shore basin is Bombay High.

Important Oil fields:

(i) **Assam:** Digboi, Naharkatiya, Hagrijan-Moran, Surma valley, Rudrasagar and Lakwa are new areas.

(ii) **Gujarat:** Cambay, Ankleshwar, Kabul, Nawgam, Kosamba, Dholka, Sanand.

(iii) **Bombay High (Mumbai High):** It is an offshore structure in 2500 km2, 176 km off Mumbai coast, where production started in 1976.

Produces about 2/3 of the total production of India.

(iv) **Bassein:** Newly discovered off shore region south of Mumbai High.

(v) **Aliabet:** Located at Aliabet Island in the Gulf of Cambay. Commercial production is expected to start soon.

(vi) **Krishna-Godavari Basin:** Ravva field

- Largest producers -

(i) Mumbai High
(ii) Gujarat
(iii) Assam
(iv) T.N.
(v) Andhra Pradesh

- The first boring was made at Nahar Pung in 1866 in Makum area of Assam.

Oil Refineries:

At present there are 18 refineries in the country, of which 16 are in Public sector, one is joint sector and one in private sector.

Public Sector Refineries: Digboi, Nunmati, Bongaigaon and Numaligarh in Assam, Barauni (Bihar), Haldia (W. Bengal), Vishakhapatnam (Andhra Pradesh), Chennai & Narimanam (T.N), Kochin (Kerala) Trombay (Maharashtra), Koyali (Gujarat), Karnal, Panipat (Haryana), Mathura (U.P.)

- **Joint sector Refineries:** Mangalore (Karnataka).
- **Private sector Refinery:** Jamnagar (Gujarat).
- The first refinery was established at Digboi is 1901.
- Jamnagar (Gujarat) refinery has the largest capacity followed by Koyali

Natural Gas:

It is available both alone and in association with crude oil but most of the output comes from associated sources. The associated gas fields are Ankleshwar and Cambay in Gujarat, Mumbai High and in Assam. Petroleum refineries also produce fuel gas as by product.

Recent findings:

- Largest producers - (i) Mumbai High (ii) Gujarat (iii) Andhra (iv) Assam, and (v) Tripura.
- Krishna-Godavari basin, Ravva field, Barmer (Rajasthan).

ATOMIC MINERALS

THORIUM:

- Main Ores - Thorianite (38-80% of thorium), Monazite (upto 18% thorium).
- Monazite deposits of commercial value are found in about 160 km belt between cape Comorin and Quilon (in Kerala)
- India possesses the largest reserves of Monazite known in the world.

URANIUM:

- **Main ores**: Pitch blend (50-50% uranium), Uranite (65-80% uranium)
  Production: Jharkhand - Jadugoda mines (Singhbhum)
  Rajasthan: Bissundi (Ajmer), Umra (Udaipur)
  Andhra Pradesh: Sankara mines (Nellore)

ZIRCONIUM & ILMENITE:

Deposits of commercial value occur is the beach sands of Kerala coast.

PROBLEMS POSED BY MINERAL RESOURCES

a) Depletion of mineral resources: Due to excessive exploitation many minerals are going to be depleted in near future. Thus proper mineral policy for scientific conservation of minerals is needed.

b) Ecological problems: Mineral extractions have lead to serious environmental problems. Rapidly growing mining activities has rendered large agricultural tracts almost barren. Natural vegetation has been removed from vast tracks. In hilly mining areas landslides are frequent phenomena causing loss of human beings and property.

c) Pollution: Mining extraction process causes air pollution, water pollution, soil pollution, noise pollution and radioactive pollution.

d) Social problems: New discoveries of mines or establishment of new mining industry large amount of local masses has to be displaced. This simply converts them to refugees. The pollution by mining extraction makes them more prone to diseases.

CONSERVATION OF RESOURCES

In world of diminishing resources, it becomes essential that the mineral resources should be judiciously used by the present generation to ensure a resource base for future generations.

The strategies include:

a) New researches should be undertaken to find out and develop replacement minerals for use in place of scarce minerals which are in short supply and are going to be depleted soon.

b) Researches should be carried on to develop new technology which should avoid wast-

age and promote maximum utilization of by- products

c) There should be curbing on wastage mining methods that deplete the environment too.

d) Use of alternate sources of energy like solar energy, hydroelectric energy etc.

e) Walking on a path that leads to sustainable development.

f) Use of renewable sources of energy.

g) Avoid over-exploitation of the mineral resources.

h) Use of biogas as a fuel for cooking instead of the non-renewable sources of energy.

■■■

7 INDUSTRIES OF INDIA

India started her quest for industrial development after independence in 1947.There has been many industrial policies in the country since that time, the latest being the New Industrial Policy of 1991. With three-fourths of India's population residing in rural areas, 60% of the labour force constitutes agricultural industry. The remaining 23% is in services and 17% is in industry.

Some of the important industries are textiles, steel, food processing, cement, fertilizer and machinery.

TEXTILE INDUSTRY

1. Cotton-Textile Industry

It in the largest organized modern industry of the country and provides 2nd largest employment after Railways. Though the first modern textile mill was started at Fort Gloster (Howrah) in 1818 but it could not survive. The real beginning of the industry goes back to 1854 in Mumbai. Earlier it was heavily concentrated in cotton growing region due to infrastructural facilities but later it started to disperse to the market region since the raw cotton is neither weight losing nor weight gaining. Still it is mostly concentrated in the cotton providing region.

On modern pattern, first mill come up in 1854 in Mumbai and later on in Ahmedabad. These two centers are virtually having one-fifth of total cotton mills even today the underlying factors are:-

1. Mumbai, being a port facility was connected with the hinterland and as well as world market.
2. Located in the heartland of cotton growing area,
3. Cheap labour in nearby Konkan belt
4. Natural humid climate of Mumbai has been of special advantage.
5. Local Parsi and Bhatia merchant's financial condition and their considerable experience in business matters.

Maharashtra, Gujarat, M.P., U.P., West Bengal and Tamil Nadu are leading in cotton textile production.

Maharashtra is the largest producing state - 122 mills in the organized sector out of which 59 are only in Mumbai. Mumbai is known as cottonpolis of India or Manchester of India.. The factories have the advantage of local cotton, cheap and easily available hydel power, nearness of Mumbai ports help in import of raw materials and machines and simultaneously in export of finished products. Mumbai, Akola, Amravati, Sholapur, Kolhapur, Jalgaon, Hubli, Pune, Nagpur, Billmiori are notable centres.

Gujarat ranks second in production. There are the numbers of mills, 130 out of which 70 lies only in the Ahmedabad. Surat, Bhavnagar, Rajkot and Vadodara are other notable centers. Location in the cotton belt, cheap labour, and capital availability are main factors of location of a number of cotton textile industries.

West Bengal: Kolkata is the most important center. There are 45 mills in the districts of Chaubis Pargana, Hooghly and Howrah districts. Howrah has 14 and Srirampore has 10 mills. Port facility, cheap labour, availability of coal and vast market are main factors of location of a large number of cotton textile industries.

Uttar Pradesh- There are 41 mills out of which 14 are located in Kanpur. Kanpur is known as Manchester of North India. Varanasi, Agra, Moradabad, Aligarh, Modinagar, Bareli and Saharanpur are other centers.

Tamil Nadu- The numbers of mills are highest in India - 208 mills. Chennai, Coimbatore, Madurai are main centers of productions. Coimbatore in known as Manchester of South India. Main factors of localization are local cotton, power facility from Pykara projects, cheap and abundant labour, and lignite coal from Neyveli coal mines. Tamil Nadu ranks first in the production of cotton yarn in the country followed by Maharashtra.

2. Woollen Textile

First woolen textile mill came up in 1876 at Kanpur and second one at Dhariwal in 1883. These are mainly concentrated in Punjab, Maharashtra and U.P. which account for about ¾ of the total spindlage capacity.

1. **Punjab:** Largest producer of Woolen textile. New Isserton Mill at Dhariwal is the largest center of hosiery in India. Other centers are -Amritsar, Ludhiana, and Kharar.
2. **Maharashtra:** 2nd largest producer. There are two centers of production in Maharashtra-Mumbai and Thane. Mumbai is the most important center. Two units in Mumbai are Modella textile Industries and the Raymond Woolen mills.
3. **U.P.:** Kanpur is the largest center in the state. Other centres are - Mirzapur, Varanasi, Shahjahanpur, Agra, and Modinagar. Kanpur is the main center where woolen mills are famous by the name of Lal Imli Mills.
4. **Gujarat:** Jamnagar, Ahmedabad, Kalol and Vadodara.
5. **Haryana:** Panipat is other center of production in Haryana.
6. **Jammu & Kashmir:** Srinagar is important center where Pashmina and Namda are famous wool.

3. Silk Textile

India is the only country in the world which produces all the four silk varieties - Mulberry, Eri, Tasar and Muga. India produced 15% of the world's silk. It is the second largest producer of natural silk after China. 95% of Indian silk comprises of Mulberry category. It gives employment to more than 6 million people. Only 15% of the total output is exported because remaining part is consumed in sari.

1. **Karnataka** is the largest producer with 60% of mulberry silk. 5% of its population is engaged in silk industry especially in south Karnataka, Bangalore, Raidurg, Belgaum, Harihar, and Hubli.
2. **West Bengal** stands second with 13% of total silk. Murshidabad and Bankura are main centres.
3. In **Jammu & Kashmir** 3.6 lakh persons are engaged in this industry. Udhampur, Jammu, Srinagar, Baramula and Anantnag are main centers of production.
4. **Assam** is the largest producer of muga silk in the country.
5. In **Madhya Pradesh** and **Chhattisgarh** production is concentrated in Bilaspur, Bastar, Mandla, Balaghat, Shahdol, Sarguja, Raipur and Raigarh. Bastar produces 15% of national and 50% of state silk. There are 215 centers of production in the State.
6. **Punjab, Tamil Nadu and Andhra Pradesh** are other states of mulberry silk production. In Punjab Amritsar, Ludhiana, Hoshiarpur, Gurdaspur are important centers.
7. **Bihar, Orissa, U.P. and Maharashtra** are Tasar silk producers. Bhagalpur is famous for Tasar silk. In U.P. Mirzapur, Varanasi, Shahjahanpur, Pratapgarh are important centers.

4. Jute Textile

Known as 'Golden Fiber' - The first mill was established at Srirampore in 1855 which rose to 26 mills till 1895 and 111 in 1945-46. The partition had most severe impact on this indus-

try as three fourth production areas lies in Bangladesh. About 8 lakh hectares land was devoted to jute cultivation and production was 10 million tones. West Bengal is the largest producer followed by Bihar, Assam and Orissa.

Presently there are 73 mills in India out of which 40 are on the bank of the Hooghly from Bansberia to Birlapur in a length of 90 kms. The following factors are responsible for unusual concentration in this belt (i) the natural humid climate, availability of clean water from the Hooghly, nearby availability of coal from Raniganj mines and the dense population provides cheap and abundant supply of labour. (ii) The beginning was made from the export point of view; hence nearby port location was highly beneficial (iii) the cheapest mode of transportation for moving the jute from field to factories.

Chandernagar, Noakhali, Chandrahati, Bansberia, Titagarh, Agarpara, Rishra, Salika Howrah, Behighat are main centers. In Bihar the units are located at Katihar, Purnea and Darbhanga. In A.P. jute industries are at Vishakhapatnam, Ellury, and Guntur.

METALLURGICAL INDUSTRY

1. Iron and Steel Industries

For the first time pig iron was produced in 1874 at Burnpur by Bengal Iron Works but financial crunch forced to down the shutter in 1877. It was in 1907 at Sakchi (now Jamshedpur) where first successful attempt was made by J.N. Tata by establishing Tata Iron and Steel Company. In TISCO pig iron was produced in 1911 and steel in 1913. The Indian Iron & Steel Company (IISCO) was set up in 1919 at Burnpur followed by the setting up of Mysore Steel Works at Bhadravati (now Visveshwaraya Iron and Steel Works) in 1923. After independence development of iron and steel industries was envisaged in 2nd Five Year Plan.

Tata Iron and Steel Company (TISCO): It is the largest steel plant in private sector. It enjoys the following facilities -

(a) Coal form Jharia and Raniganj coalfields (only 60 kms. away);
(b) Iron-ore from Noamundi (Singhbhum distt of Jharkhand) and Gurumahisani (Mayurbhanj dist. Of Orissa);
(c) Manganese from Joda mines (Keonjhar, Orissa)
(d) Limestone and dolomite form Sundergarh and Birmitrapur, Orissa
(e) Cheap electricity form Damodar Valley Corporation;
(f) Industrial region around Kolkata serves as a valuable outlet for the disposal of finished products;

Indian Iron and Steel Company (IISCO): IISCO has three plants in Kulti, Hirapur and Burnpur in West Bengal. IISCO enjoys the following facilities:-

(a) Iron ore from Guna mines (Singhbhum)
(b) Coal from Raniganj and Jharia
(c) Manganese from Keonjhar
(d) Limestone from Birmitrapur
(e) Hydel power from DVC

Visveshwaraya Iron and Steel Works (VISL): Formerly known as Mysore Iron and Steel Company, it was set up in 1923 at Bhadravati on the Bank of River Bhadra on the Dirur-Shimoga branch of Southern railway. All raw materials are available within the radius of 50 kilometers.

(a) Iron ore from Kemangundi mine of Bababudan hills (40 kms.);
(b) Limestone is obtained form the distance of 20 kms;
(c) Manganese from Shimoga and Chitradurg (98 km);
(d) Adjacent reserve fulfils the need of coal;

Hindustan Steel Limited (HSL): Government of India established the HSL in order to increase the production of iron and steel. Consequently, three plants under the public sector i.e. Bhilai, Rourkela and Durgapur came into existence during the 2nd Five Year Plan. During 3rd Five Year Plan a steel plant at Bokaro was also proposed.

Rourkela Steel Plant: Rourkela Steel Plant was established in 1954 with the help of German technology (Krupps Demag) 431 km south of Kolkata on Kolkata- Bombay railway line.

The capacity is of 1.8 million tonnes of steel. This unit enjoys the following facilities -

(a) Iron-ore from mines in Keonjhar and Sundergarh Dist.;
(b) Good quality coal from Jharia, Bokaro (240 km), Talcher;
(c) Limestone form Hathibari and Birmitrapur lying only 25 kms away;
(d) Manganese form nearby Baspam and Bolani mines;
(e) Hydel power from Hirakud Project;

Bhilai Steel Plant: It lies in Durg district of Chhattisgarh. It is the largest steel Plant in India. The plant has installed capacity of 4.0 million tonnes of steel, which is to be enhanced upto 6.0 million tones. It receives:-

(a) Iron ore from Dalli-Rajhara which is only 32 kms form the plant;
(b) Coking coal from Jharia and Bokaro (225 km) and low quality coal form Korba;
(c) Limestone form Nandi mine, (24 km) and dolomite form Hirni mine of Bilaspur.
(d) Manganese form Balaghat district-220 km;
(e) Water from Tandulla and Gandhi Canals;

Durgapur Steel Plant: It lies 175 km west of Kolkata in Bardhaman district. The capacity is 1.6 million tonnes of ingots steel. The facilities available to this unit are:-

(a) Iron-ore from Gua and Noamundi (190 km);
(b) Coal from Raniganj and Jharia - 70 kms;
(c) Limestone form Birmitrapur, Bhawanathpur and Hathibari mines of Orissa;
(d) Hydel power form DVC; Water form Durgapur dam;
(e) Nearness form Kolkata provides market facility;

Bokaro Steel Plant: Established at Bokaro on Bokaro River in Hazaribagh district of Jharkhand. The capacity is of 4.0 million tonnes of steel. The unit enjoys the following facilities:-

(a) Coal form Jharia coalfield and local mines;
(b) Availability of cheap power form DVC;
(c) Iron-core form Kiriburu mine in Keonjhar district and limestone form Palamau district;

Vijayanagar Steel Plant: It lies near Hospet in Bellary district of Karnataka. The capacity is of 3.0 million tonnes of steel ingots. The Units enjoys these facilities

(a) Iron ore from local mines (Hospet region);
(b) Coking coal form Kanhan valley (C.G) and Singareni (A.P.);
(c) Water from Tungbhadra dam (32 km);
(d) Dolomite and limestone form nearby mine (200 km);

Salem Steel Plant: It is in Salem district of Tamilnadu. The magnetic iron-ore, limestone and dolomite are available in nearby mines. Lignite coal is obtained from nearby mines.

Vishakhapatnam Steel Plant: This is first and only shore-based steel plant in India. The unit has installed capacity of 3.0 million tonnes of ingots steel. The production began in 1992. It receives

(a) Coals form Jharkhand;
(b) Iron-ore from Bailadila mines;
(c) The port facility;

Mini Steel Plants: Presently there are 199 mini steel plants with the installed capacity of 6.2 million tonnes. In private sector Lloyds Steel Industries, Nippon Denro in Maharashtra. Eicher Steel in Gujarat, Jindal Strips in M.P. and Malvika Steel in U.P. are fast emerging. There are several units of sponge iron in India. India is ninth largest producer of steel in the world but per capita consumption is very low, 32 kg against the world average of 150 kg a person. Now India is exporting iron and steel.

2. Aluminium Industry

The availability of raw material (Bauxite) and power is the most important factors for the location of this industry. Since the raw material is weight loosing, the industries are mostly located in areas producing bauxite and where cheap hydro-electricity in available.

The first aluminum plant of the country was established in 1937 at Jaykaynagar (W. Bengal), which was primarily a coal region. The 2nd plant was established in 1938 at Muri (Jharkhand), which was bauxite producing region. Presently there are six units in India two in public sector and four in private sector.

Aluminum Company	Cooperation of Countries Electricity	Important Centers	Resource Availabilities	
			Bauxite	Electricity
BALCO	Russia	Korba (Chhattisgarh)	Amarkantak Plateau	Thermal
		Ratnagiri (Maharashtra)	Amarkantak Plateau	Hydel
NALCO	France	Damanjodi (Orissa)	Eastern Ghat	Hirakud Hydel Plant
HINDALCO	U.S.A.	Renukut (U.P)	Jharkhand	Rihand Project
INDALCO	Canada	Jaykaynagar (W. Bengal)	Jharkhand	Thermal
		Muri (Jharkhand)	Local	Thermal
		Hirakud (Orissa)	Eastern Ghat	Hirakud Hydel Plant
		Alwaye (Kerala)	Belgaum (Karnataka)	Hydel
MALCO	Italy	Chennai, Mettur,Salem (T.N.)	Shevroy & Javadi Hills	Hydel

Bharat Aluminium Co. Ltd. (BALCO): It is a public sector company having two units: **Korba** (Chhattisgarh) and **Ratnagiri** (Maharashtra). The annual capacities of these two units are 40000 and 50,000 tonnes a year respectively.

National Aluminium Co. Ltd. (NALCO): It is the largest unit in India and lowest cost producer in the world, established in 1981 in Orissa with installed capacity of 2.18 lakh tonnes. The plant is at Damanjodi and the smelter is at Angul.

Hindustan Aluminum Corporation Ltd. (HINDALCO): This was set up in 1958 having its main factory at Renukut in Mirzapur district of U.P. Its capability is 1.75 lakh tonnes.

Indian Aluminum Co. Ltd. Kerala (IANDALCO): It is an integrated plant having units at different places. The first plant in the devices is located at Muri (Jharkhand) second at Alwaye (Kerala) and third at Belur (W.Bengal). New Plant has been established at Belgaum in Maharashtra.

Madras Aluminium Company (MALCO): It was established in 1965 at Mettur.

3. Copper Smelting Industry

Hindustan Copper Ltd. (HCL), estd. in 1967 is the sole producer of primary copper in the country. It has 6 plant complexes.

1. Khetri copper complex (Rajasthan)
2. Indian Copper complex (Maubhandar near Ghatsila)
3. Malanjhkhand copper project (M.P.)
4. Rakha copper project (Singhbhum)
5. Dariba copper project (Alwar)
6. Chandmari copper project (Jhunjhuna)

Agnigundala Copper-Lead project in Guntur **district** of Andhra is coming up at fast rate. Sterlite Industries is a private sector which has commissioned its copper smelter at Tuticorin. Birla Copper Ltd. Has set up a copper project at Dahej in Gujarat. Swil Copper Ltd. is setting up a plant at Bharuch in Gujarat.

4. Lead Industry

1. The first Lead smelting plant was set up at Tundoo near Dhanbad by Metal Corporation of India. It was taken over by Hindustan Zinc Ltd. The ore is supplied from Zawar and Dariba mines of Rajasthan.
2. Another plant has been established at Vishakhapatnam based on the ore supply from Agnigundala.
3. The Lead-Zinc Complex was constructed at Chanderia in 1991 under the British aid programme.

5. Zinc Industry

At present there are 4 zinc smelters in the country, one each at Alwaye (Kerala), Debari and Chanderia (Raj) and Vishakhapatnam.

Alwaye Plant: The Alwaye plant is totally dependent upon imported supplies of zinc concentrates. It started production in 1967.

Debari Plant: It started production in 1968. Besides, it also produces Sulphuric acid, Cadmium, Phosphoric acid and Super Phos-

phate. Half of ore is supplied by Balaria and Rajpur-Dariba mines and rest is imported.

Chanderia Plant: It was set up in 1991 based on the supplies from Bhilwara and Chittorgarh. It also produces lead and silver.

Vishakhapatnam Plant: It receives ore from Agnigundala mines and gives a production of 40000 tonnes per annum.

FERTILIZERS INDUSTRY

There are three types of chemical fertilizers, viz.

(i) Nitrogenous fertilizers (67%)
(ii) Phosphatic fertilizers (21%) and
(iii) Potash fertilizer (12%).

The first fertilizer (Nitrogen based) plant was established in 1906 at Ranipet (T.N.). India is the third largest producer and consumer of fertilizer in the world. It produces mainly two types of fertilizers: (1) Nitrogenous (2) Phosphate. Potash based fertilizer is produced in very limited quantity due to lack of raw material and is completely dependent on import of potash. Majority of chemical fertilizer factories are located near oil refineries.

Gujarat and Tamil Nadu lead in production followed U.P., Punjab, Maharashtra, Jharkhand, Kerala, Haryana, A.P., Assam and West Bengal. Gujarat is the largest producer of nitrogenous fertilizer (14.7%) and second largest producer of phosphate fertilizer (30.6%). Units at Bharuch and Kandla produce phosphate fertilizer. Nitrogenous fertilizer is produced at Vadodara and Kalol. Tamil Nadu is the largest producer of phosphate fertilizer (37%) and second largest of nitrogenous fertilizer. Four units are located at Tuticorin, Neyveli, Chennai and Ellore. Tuticorin is the largest unit.

In U.P. 95% of nitrogenous fertilizer is produced from four units at Kanpur, Gorakhpur, Phulpur and Varanasi. In Punjab two units are at Nangal and Bhatinda. In Maharashtra nitrogenous fertilizer and phosphate fertilizer is produced. Trombay has the largest nitrogenous fertilizer factory in the country. Andhra Pradesh contributes phosphate and nitrogenous fertilizer. Ramagudam and Vishakhapatnam are two important centers. Kerala, Orissa, Haryana, Rajasthan, West Bengal and Assam are other producing states. Per hectare consumption of fertilizer is highest in Punjab. High domestic consumption force India to import fertilizers.

Public Sector:

(1) Fertilizer Corporation of India - Sindri, Gorakhpur, Talcher and Ramagundam.
(2) National Fertilizer Ltd. - Nangal, Bhatinda, Panipat, Vijaipur, Durgapur, Barauni, Namrup and Trombay.
(3) National Chemical & Fertilizer ltd. - Trombay
(4) Madras Fertilizer ltd. - Always, Cochin
(5) Fertilizers and Chemicals Travancore Ltd. - Udyogmandal and Kochi.
(6) Rashtriya Chemicals and Fertilizers Ltd. - Trombay and Thal.
(7) Hindustan Fertilizer Corporation Ltd.- Namrup, Durgapur and Barauni.

Joint Sector: Madras Fertilizer ltd.

Under the Ministry of Mines: Rourkela, Neyveli, Khetri

Co-operative sector: IFFCO (Kalol, Kandla, Phulpur and Aonla)

Gas based plant along HBJ pipeline: Vijaipur, Aonla, Hazira, Jagdishpur, and Babrala.

CEMENT INDUSTRY

Manufacturing of cement started at Ranipet (Chennai) in 1904. But this attempt proved abortive and the successful attempt was made in 1912 when Indian Cement Co. Ltd. set up a plant at Porbandar. India is the 2nd largest producer of cement in the world after China. All the raw materials (limestone, dolomites coal, gypsum etc.) are heavy and weight losing, therefore, the industry is concentrated in the source region of these raw materials, mainly in limestone producing region, and is influenced by the minimization of transportation cost. There are 103 large and 252 small cement factories in India with installed capacity of 740.7 lakh tones a year. Madhya Pradesh,

Andhra Pradesh, Rajasthan, Gujarat, Karnataka and Maharashtra produce 80% of total national production of cement.

1. **Madhya Pradesh & Chhattisgarh** is the largest producer of cement of India producing one fifth of total production. 14 large and 15 small factories are located here. Satna, Katni, Durg, Kymore, Maihar, Mandhar, Damoh, Bilaspur and Raipur are important centers.
2. **Andhra Pradesh** is the second largest producer (10.7%). There are 10 factories in the state of Karimnagar, Adilabad, Cementnagar, Vijayawada, Vijayanagar, Mancherla, Vishakhapatnam and Krishna. Pedapalli is the biggest plant.
3. **Rajasthan** produces 11% cement- Chittorgarh, Udaipur, Sirohi, Nimbaheda, Sawai Madhopur and Lakheri are main centers of production.
4. **Gujarat** produces 9% of cement - Sika, Ahmedabad, Dwarka, Porbandar, Sevolia, Ramarao, Bhavnagar and Okha are main centers.
5. **Tamil Nadu** produces 8.7% of cements. Nine factories are there at Shankridurga, Talaiyathu, Dalmiapuram, Talukkapatti, Alangulam and Salem.
6. **Jharkhand, Karnataka, U.P. and Orissa** are other cement producing states in India. The highest consumption is in the state of Maharashtra followed by Uttar Pradesh.
7. **Sea-conch based cement industry:** Dwarka (Gujarat), Thiruvanantapuram (Kerala), Chennai (T.N.)
8. **Sludge based cement factories:** Sindri (Jharkhand), Talcher (Orissa)
9. **Other Important Centers:** Sindri, Jhinupani, Khalari, Chaibasa, Kalyanpur (all in Jharkhand); Dalmia Nagar, Japla (Bihar)

LEATHER INDUSTRY

Tamil Nadu is the largest producer of leather in the country, contributing 65% followed by Kolkata, Kanpur, Bombay, Aurangabad, Kolhapur, Dewar, Jalandhar and Agra. Kanpur is the largest market of hides in the country. Only 10% of the total production comes from organized sector. Though India is the largest country in animal wealth its share in the leather market is only of 3.0%. Germany is the largest importer of India leather goods.

Tanning

The first tannery was set up at Kanpur in 1867. At present Kanpur, Chennai and Kolkata are the largest tanning centres. Other centers are Agra, Bangalore, Belgaum, Bhopal, Mokama (Bihar), Phulbani (Orissa), Sherbaug (Guj), Kapurthala, etc. Central Leather Research Institute is at Chennai.

Leather Goods

The main centres are Chennai, Ranipet, Ambur, Vaniambadi, Mumbai, Kolkata, Kanpur, Agra, Kolhapur, Jalandhar, Delhi, Batanagar, Faridabad and Jaipur.

Sugar Industry

It is the 2nd largest agro-based industry after cotton textile. India is the 2nd largest producer of sugar after Cuba but if Gur & Khandsari are taken into account it is the largest. In 1950-51 the production was 11.4 lakh tones, which increased 280 lakh tones in 2006-07. The number of sugar mills was 139 in 1950-51 rose to 530 in 2007-08. Since sugarcane in a heavy, weight losing and perishable raw material, most of the industries are located in the region of sugar cultivation. More than 85% sugar is produced in the states of Uttar Pradesh, Maharashtra, Bihar, Tamil Nadu, Andhra Pradesh and Karnataka.

Maharashtra is the largest producer of sugar in India with 90 sugar mills. It produces 40% of total sugar production in India. Ahmednagar, Nasik, Kolhapur, Sholapur, Pune, Satara, Sangli and Aurangabad are main producing districts.

Uttar Pradesh is the second largest producer; number of sugar mills are 103 - produces 28% of sugar. In western U.P. Saharanpur, Meerut, Muzaffarnagar, Ghaziabad and

Bulandshahar and in Terai belt - Deoria, Gonda, Basti, Pilibhit, Bahraich and Gorakhpur are main producing districts.

Tamil Nadu is the third largest producer with 32 sugar mills. Coimbatore, Arcot, Tiruchirapalli and Madurai are main producing district. Per hectare production is highest in this state.

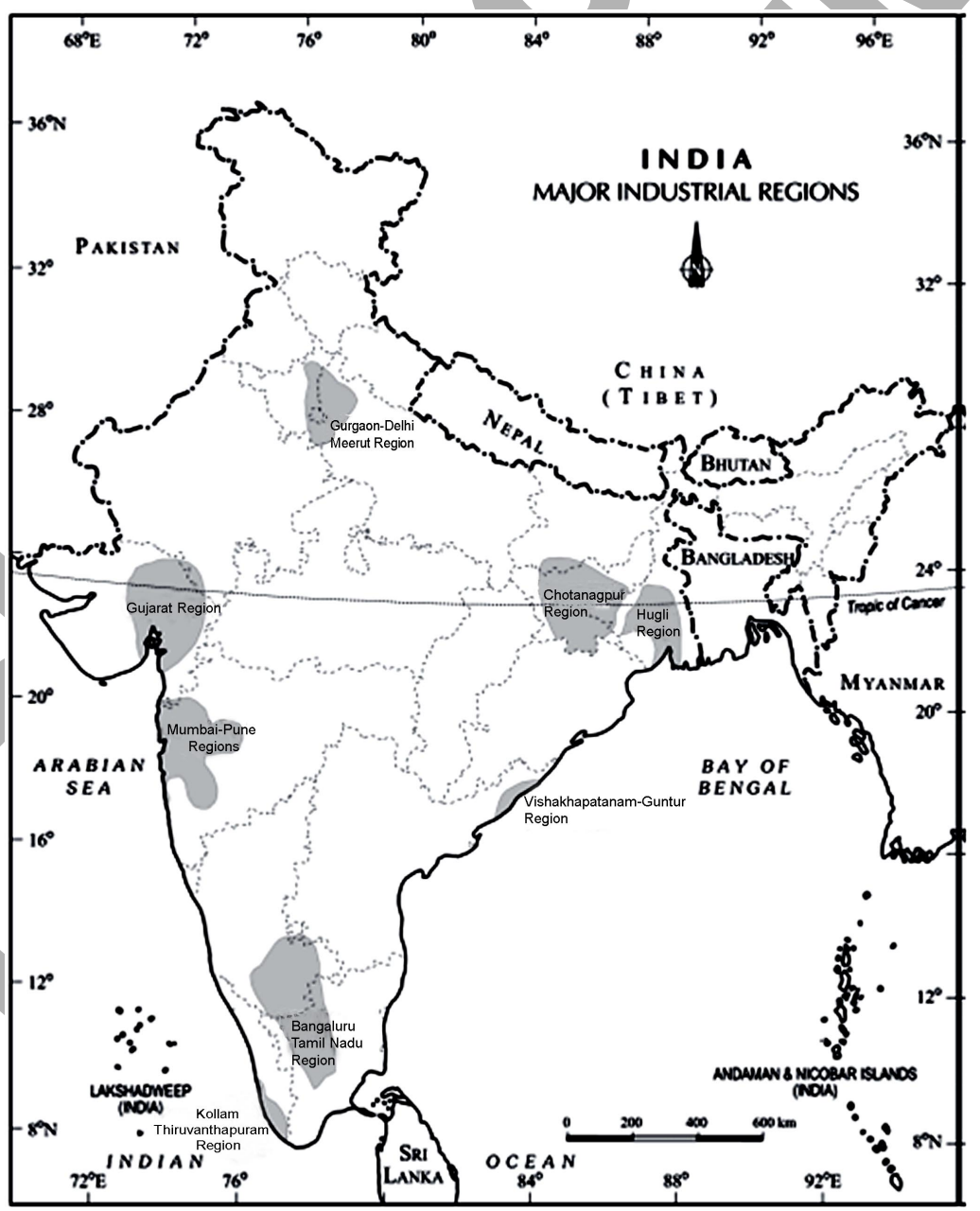
Karnataka has 30 mills located at Belgaum, Mandya, Bijapur, Bellary, Shimoga and Chitradurg.

Gujarat - 16 mills mainly in, Bhavnagar, Jamnagar, Amreli, Banaskantha, Junagarh Surat and Rajkot.

Andhra Pradesh - 35 mills mainly in Krishna, Nazimabad, Medak, Chittur, East and West Godavari.

Haryana (Rohtak, Ambala), Punjab (Amritsar, Jalandhar) and Bihar (Darbhanga, Saran, Champaran and Muzzafarpur) are other main producers.

INDUSTRIAL REGIONS



Industrial region refers to the continuous development of industrial landscape over a large area by the concentration of a number of factories of different industries.

Industrial region has following characteristics:

a) Predominance of industries and concentration of factories.
b) Emergence of many big and small towns supporting residential colonies of industrial workers and markets for industrial goods and raw materials.
c) Dense network of transport and communication lines.
d) Sparse rural population
e) Emphasis on the production of consumer goods.

On the basis of workers employed, B.N. Sinha classified industrial regions into three categories.

1) **Major Region:** Those employing a minimum daily number of 1.5 lakh workers are major industrial regions.
2) **Minor Region:** Those employing 25000 workers daily as minor industrial regions and
3) **Industrial Districts:** Those employing less than 25000 workers are industrial districts.

Major industrial regions are:--

1. **Kolkata - Hooghly Belt:** It is an old and important region of the country stretching along the either side of the river - from Naihati to Budge- Budge along the left Bank and from Tribeni to Nalpur in the right bank. Cotton textile, silks, jute engineering chemical and pharmaceuticals, leather and foot-wears industries are located here. The region is facilitated with rich hinterland of Ganga, Brahmaputra Plain, and the enough availability of good coal, cheap local labour and the port facility of Kolkata.

   The region is experiencing stagnation and relative decline in industrial growth in recent years.

The main problems are: -

- High degree of congestion.
  lGradual filling of Kolkata port making the shipping facilities somewhat difficult.
- Bottle-neck in South-East and Eastern rainy-days.
- Paucity of space.
- Shortage of drinking water and civic amenities.
- Environmental pollution.
- The state government is pursuing the policy of liberalization but problem of land acquisition is acting as a main obstacle for redevelopment of the region.

2. **Mumbai-Poona Belt:** It is the most important industrial region of the country. It has a heavy concentration of cotton textile, engineering, oil refiners, fertilizers and chemical industries. The belt consists of Mumbai, Kurla, Ghatkopar, Andheri, Jogeshwari, Thane, Bhandrup, Kalyan, Pimpri and Poona.

   Cheap labour, easy availability of hydro-electricity, raw cotton along with the port facilities; act as the main assets of this area.

   The industrial development of this region has almost reached its saturation stage. After partition cotton producing area reduced thus effected the raw material supply and high transport cost of coal and other minerals effected the growth. But now it has developed as an economic hub.

3. **Ahmedabad-Vadodara-Surat Belt:** It is the third largest industrial region comprising within its fold the centers of Kalol, Ahmedabad, Nadiad, and Vadodara, Surat, Nava sari and Ankleshwar, leather goods and a wide variety of engineering units are established here. The initial advantage was the availability of raw cotton from the hinterland and the transport network along with the Kandla port.

4. **Madurai-Coimbatore-Bangalore Region:** Cheap and skilled labour, large market were the chief factors, which attracted a number of industries. Availability of cheap hydel power helped in various ways.

Cotton textile, sugar plants, leather goods, chemicals, H.M.T. Bharat Electricals, Iron and Steel, Hindustan Aeronautics have assisted the development of this area.

5. **Chotanagpur Plateau Region:** Locally available coal, iron-ore mica, bauxite copper, limestone, manganese have given rise to heavy industries like iron and steel at Jamshedpur, Durgapur, Kulti, Burnpur, Bokaro along with many associated industries. Proximity to Kolkata port, vast network of railways, cheap labour supply from the tribal areas and the development of DVC and numerous thermal power stations helped the area to develop as a major industrial region on the map of India. Besides, many more mini industrial regions and industrial districts are fast emerging in different parts of the country in recent times.

6. **Mathura-Delhi-Saharanpur Ambala belt:** It has the advantage of the proximity of the national capital; availability of cheap raw materials; nearness of large market and regular supply of power. This region spreads in two separate belts running in north-south direction between Faridabad and Ambala in Haryana and Mathura and Saharanpur in Uttar Pradesh.

   The capital city has predominance of engineering, electronic, chemical, glass and consumer industries. ■■■

8 TRANSPORT

INTRODUCTION

A well-knit and coordinated system of transport plays an important role in the sustained economic development of a country. Development being a multi dimensional process; rests upon the resources of the region and infrastructural facilities like transport and communication. It is the transport which helps in movement of goods and materials from producer to consumer ends. The transport facility increases the linkage between backward and developed regions of the country thus reducing regional disparity among regions. The transport also helps in maintaining the uniformity in the prices, remove scarcity of goods during time of crisis, promotes national integration and cohesiveness.

India's transport sector is large and diverse; it caters to the needs of 1.2 billion people.

The present transport system of the country comprises several modes of transport including rail, road, coastal shipping, air transport, pipelines etc. Transport has recorded a substantial growth over the years both in spread of network and in output of the system. The Ministry of Shipping, Ministry of Road Transport and Highways, Ministry of railways and civil aviation is responsible for the formation and implementation of policies and programmes for the development of various modes of transport.

However, the sector has not been able to keep pace with rising demand and is proving to be a drag on the economy. Major improvements in the sector are required to support the country's continued economic growth and to reduce poverty.

Each transport sector is discussed below in detail with recent developments and problems and solution of present era.

RAIL TRANSPORT

The Indian railway system is the second largest system in the world under the single management. Railways virtually forms the lifeline of the country, catering to its needs for large scale movement of traffic, both freight and passenger, thereby contributing to economic growth as well as promoting national integration. It is a multi gauge system operating on three gauges - the broad, the metre and the narrow.

The Indian railway had a modest beginning in 1853 when first train flagged off from Mumbai to Thane. The detailed railway expansion plan was chalked out under Lord Dalhousie. During the post independence era the new strategy was chalked out that included expansion of the route length, gauge conversion, electrification on tracks, modernizing the signaling system, improvement in passenger safety and amenities, better management of freight and passenger traffic, Introducing high speed passenger trains etc.

Factors effecting distribution pattern of Railways

1. Geographical factors; this includes the profile of terrain. As northern plain with level topography, high population density and rich agricultural presence have attracted high level of railway network. There are practically no railways in the flood plains of many rivers in Bihar and Assam. The plateau region of south

India sometimes hinders railway development. The Himalayan region in the north is almost devoid of railways due to rugged topography but by using new technologies new railway network has been established in Jammu and Kashmir. Similarly Konkan railway acts as a masterpiece of engineering passing through rugged Western Ghat. But the density of railway network decreases in sandy areas, hilly areas where cost of installation exceeds the profit dimension.

2. Economic factors; as railways develop more in economically advanced areas where the need for railway network is felt more. This is because of the economic linkages we find the highest density of railways near big urban and industrial centres and in areas rich in mineral and agricultural resources. The rich coal, iron ore deposits of Chotanagpur region created high demand for rail network. The cotton growing tract of Deccan favoured rail development despite physical constraints arising out of western ghat topography.

3. Political and administrative factors; British administration developed railway network to enhance their penetration to interior India as well as to provide better connectivity to major ports. After independence the government followed this only policy but for uniform inclusive growth the rail network has been enhanced to all over country with passage of time.

Trains as a Social Campaigner

1. SANSKRITI EXPRESS

Indian Railways will run an exhibition train **Sanskriti Express** to celebrate Nobel laureate **Rabindranath Tagore's** 150th birth anniversary and showcase his life and philosophy.

The train, to be flagged off by Railway Minister Mamata Banerjee May 9, 2011 will touch important stations in various parts of the country before returning to Kolkata May 8 next year.

Five air-conditioned coaches have been modified at the **LILUAH RAILWAY WORKSHOP** in **Howrah** to **depict Tagore's achievements and thoughts.**

The first coach, named 'JIBON SMRITI', will depict the life of Tagore through photographs, while the second **'GITANJALI'** will exhibit his poems and songs. **'JOGAJOG' 'MUKTODHARA'** will exhibit his literature; the fourth **'CHITRAREKHA'** will depict paintings of Tagore and other eminent artists. The last **'SMARANIKA'** will exhibit and sell handicraft and other items from **SANTINIKETAN,** founded by the poet.

Tagore, who was born in 1861 and died in 1941, is among the most revered writers in the world who churned out poems, plays, songs, novels and short stories. He was the first Indian to win the **Nobel Prize** in 1913.

2. MOTHER EXPRESS:

Mother Express', an exhibition train to commemorate **the birth centenary of Mother Teresa,** was launched by railway ministry.

The train focuses on **the life, work and message of Mother Teresa,** would travel all over the country in the six months. The train comprises **three air-conditioned coaches,** in which **photographs, write-ups on the life and message of Mother Teresa have been kept for public viewing.** The Missionaries of Charity helped the railways by supplying photographs and various materials.

Mother Teresa loved the poor and served them and was the **embodiment** of peace. Mother Teresa saw Christ in the poorest of the poor, the lepers, the homeless, the HIV and AIDS patients in the slums of Calcutta and also those suffering from Poverty of Loneliness and Abandonment in the Western World

3. RED RIBBON EXPRESS:

Red Ribbon Express is an **AIDS/HIV awareness campaign train** by the Indian Railways. The **motto of the Red Ribbon Express is "Embarking on the journey of life"**

To provide awareness among the people both urban & rural population of our country, the Red Ribbon Express project was developed. The concept of the project was to **provide knowledge, precautions to the public to fight against the dreadful disease "AIDS"**

On-platform and off-site communication activities such as **exhibits, street plays** and **demonstrations** are used. Treatment and counseling services were also available on the coach.

The projects target audience was broad, including youth groups, women's groups, student communities, urban slum dwellers and farmers.

In its first phase the train was expected to travel 27,000km, reaching 180 stations and holding programmes in over 50,000 villages. To reach outer districts, buses and bicycles are used.

The Red Ribbon Express, in its second phase, also devotes information to **general health, hygiene and communicable diseases such as swine influenza, tuberculosis and reproductive and child health services.**

Ongoing Developments

1. DEDICATED FREIGHT CORRIDOR PROJECT (DFC)

The DFC project was first proposed in April 2005 to address the needs of the rapidly developing Indian economy. The existing quadrilateral railway network, also known as the Golden quadrilateral, which links the major metropolitan cities of Delhi, Mumbai, Chennai and Kolkata, is unable to support the growing demand due to capacity constraints. A dedicated freight corridor was, hence, required to address these concerns.

Ministry of Railways, under the direction of the Indian Government, has taken up the dedicated freight corridor (DFC) project. The project involves the construction of six freight corridors traversing the entire country. The purpose of the project is to provide a safe and efficient freight transportation system.

The DFC project envisaging a **Western DFC (1534 km) from Mumbai to Rewari** to cater largely to the container transport requirement and an **Eastern DFC (1839 km) from Ludhiana to Dankuni** largely to serve coal and steel traffic is being implemented by the Dedicated Freight Corridor Corporation of India Ltd. (DFCCIL). Delhi-Mumbai industrial corridor is also coming up. Considering the need for DFCs on other important routes, a preliminary engineering cum traffic survey (PETS) is being undertaken on the following routes---north-south (Delhi to Chennai), east-west (Kolkata to Mumbai), east-south (Kharagpur to Vijayawada), and south (Goa to Chennai)

The DFC project is expected to reduce congestion at various terminals and junctions. It will provide the efficient and fast movement of freight along the corridor. The project is currently facing land acquisition problems.

2. MONO RAIL IN MUMBAI

Considering the increase in population, increased travel demand and narrow road networks running through congested structures, there is a need of a system which will occupy less space as well as reduce travel time.

With the objective, to support public rapid transit system such as suburban rail system and metro rail system and where public rapid transit system is not available or impossible to provide such system and where widening of roads is not possible due to structures on either sides, Mono Rail system is proposed to be implemented in " city of dreams" MUMBAI. Once completed it will be world's second longest Monorail corridor.

Larsen and Toubro along with Scomi has received the contract to build and operate the monorail.

Salient features of Monorail system:

1. In Monorail System train runs on a narrow Guide way Beam, wheels of which are gripped laterally on either side of the beam.
2. Monorail is a Light Weight System and its cost of execution is less compared to heavy rail systems and it takes approximately 1.5 to 2 years for execution.
3. Mono rail System requires 1.00 m wide space (Column Size 0.8 m × 1.5 m) the space of a footpath or a divider and it rests on a single pillar of height 6.5 m without disturbing the existing traffic.
4. As compared to other systems Monorail produces less noise and is eco-friendly and

hence easily acceptable in dense residential locale.

5. Monorail System is in use in Tokyo (Japan) from 1963, in Kuala-Lumpur (Malaysia) for last 5 years and in china for last 3 years.
6. Monorail System is Safe and reliable system.

Effect on Indian Economy

- The construction and expansion of the railways have been proved to be beneficial for the economic and inclusive growth of the economy. It provides a better linkage between producer, retailer and consumer.
- It has played a significant role in the development of cotton textile industry, jute industry as it provides free flow of raw materials with proper penetration to market areas.
- Railways have been very helpful in the development of Indian agriculture. Now farmers can send their agricultural goods to distant places and can fetch good incomes.
- Railways also help in maintaining uniform price level for agricultural products through better movement.
- New industrials hubs have been emerged as higher mobility of raw materials reduced the concentration of industries mainly around raw material centres. As Kanpur is known for cotton garments whereas the raw materials are present in Maharashtra and Gujarat.
- Railways are playing significant role in running country's administration and safeguarding its freedom and integrity, as it provides easy movement of police, troops, defence equipments etc.

Environmental side Effects

The penetration of railway networks in every nook and corner of the country; on one hand enhancing the economy, cultural linkages, and national integration but on the other hand leading to environment depletion. The laying of new tracks requires clearance of forests that affects the biodiversity and forest dwellers both.

Recently we have seen in news that due to presence of railway track in elephant corridor accidents and death of around five elephants took place. Similarly for the establishment of railway tracks in hilly areas dynamites are used to break hills which in turn cause air pollution as well as lead to frequent landslides.

Thus environmental angle has to be included along with economic and cultural angle while developing railway networks.

Problems and Solutions

Indian railway have progressed a lot, both quantitatively and qualitatively but this system is still plagued by a number of problems which require immediate attention.

1. **SAFETY:** Safety has become a prime concern for railways after frequent accidents occurred recently killing about hundreds of passengers. There are several factors which are responsible for increasing number of accidents as over raged tracks, wagons, coaches, bridges and signaling system. The tracks suffer from fatigue and wear and tear in due course of time. The railway zones should monitor safety measures and implement them on priority basis in the larger interest of passengers. All vacancies related to safety should be filled soon. Proper training to railway personnel, particularly in safety segments needed to reduce the implementation time after accidents.
2. **COST AND REVENUE PROBLEMS:** Railways used to face the problem of financial crisis. The annual rate of increase in cost has overtaken that of revenue. New trains have been launched and frequency of mobility have too increased a lot thus up gradation of tracks, amenities, safety measures causes a heavy burden on exchequer of railway. The solution can be allowing PPP model in railways for up gradation of infrastructure.
3. **SOCIAL BURDEN:** A railway has a dual role of being commercial organization along with social organization .it has to provide facilities at low cost. Suburban passenger

services, concessionary travel to certain section of society, being a social campaigner etc creates the financial crisis on railways.

ROAD TRANSPORT

Road is the indigenous mode of transport .Roads offer door to door services and construction can be undertaken even in areas of difficult terrain. In developing country like India road is a harbinger of economic development and prosperity.

Importance of Roads

1. Roads play a very important role in the transportation of goods and passengers for short and medium distances.
2. It helps farmers to move their perishable agricultural products soon to markets and mandis. Thus encourage farmers to switch to more commercially viable agricultural products.
3. Road transport system establishes easy contact between farms, fields, factories and markets, thus leading to better linkage between consumer and producer.
4. Mobility is one of the most fundamental and important characteristics of economic activity as it satisfies the basic need of going from one location to the other, a need shared by passengers, freight and information. Road transport provides a better mobility that leads to economic development.
5. It is suitable for transportation of both perishable and non perishable goods controlling the price in the economy.

Urban Transport

India is transiting from a developing to developed country with high pace of economic development. Urbanization is too increasing at high pace as mega cities, cities and towns are providing better economic opportunities. Fast-growing cities have nurtured business and industry and have provided jobs and higher incomes to many migrants from rural areas. Thus, it is important that cities function efficiently - that their resources are used to maximize the cities' contribution to national income.

City efficiency largely depends upon the effectiveness of its transport systems, i.e., efficacy with which people and goods are moved throughout the city. Poor transport systems hampers economic growth and development, and the net effect may be a loss of competitiveness in both domestic as well as international markets

Thus proper development of urban transport to meet the needs of growing population is urgently needed in country like INDIA. The public transport system helps in improving urban-rural linkage and improves access of the rural/semi-urban population in the periphery to city centres for the purpose of

labour supply without proliferation of slums within and around cities.

The major objective of urban transport initiative is to provide efficient and affordable public transport. A National Urban Transport Policy (NUTP) was laid down in 2006, with the objective of ensuring easy, accessible, safe, affordable, quick, comfortable, reliable, and sustainable mobility for all. In order to provide better transport, proposals for bus rapid transit system (BRTS) were approved.

The quality and quantity of roads had been improved by providing better signaling system, foot over bridges for pedestrians, over bridges and flyovers to decrease travelling time, diverging heavy vehicles directly to highways without accessibility to city roads etc.The new concept of low floor buses has been introduced in capital cities to control pollution as well as for improving the conditions of local government buses.

Metro rail projects as already present in Delhi/NCR has been further sanctioned for new cities as Chennai, Bangalore, Mumbai as (monorail) to decrease the travelling time and environmental effects of vehicular emissions.

Urban Transport Problems

- Traffic injuries and fatalities pose a serious threat to the urban population. The causes can be poor conditions of roads, burgeon-

ing fleet of motor vehicles, unsafe drinking behaviour, overcrowding of buses, autos etc.

- Environmental pollution as Noise, air both are contributed by vehicles. BHARAT STAGE EMISSION NORMS have been launched by government to decrease air pollution from vehicles. Switching public transport to CNG has reduced the pollution content drastically.
- Roadway congestion is probably the most visible, most pervasive, and most immediate transport problem plaguing India's cities on a daily basis. It affects all modes of transportation and all socioeconomic groups.
- Vast improvements are needed in India's public transport systems, but the necessary funding is not available Most buses and trains in small and medium size Indian cities are old and poorly designed, inadequately maintained, dangerously overcrowded, undependable, and slow.

Grameen Sadak Yojana: Enhancing Rural Development

Pradhan Mantri Gram Sadak Yojana (PMGSY) was launched on 25th December 2000 by the Government of India as a 100% Centrally Sponsored Scheme to provide road connectivity in rural areas of the country. The programme envisages connecting all habitations with a population of 500 persons and above (250 persons and above in respect of hill States, the tribal and the desert areas) through good all-weather roads

This will enhance the pace of rural development as follows:

- New business opportunities will emerge due to better transport.
- Transportation cost of agricultural goods will get reduce.
- This will increase connectivity to schools and hospitals.
- This will provide employment to poor and unemployed people.
- This will increase penetration of government assistance in inaccessible areas too.
- This will enhance the better implementation of government schemes

Ultimately till will help in better connectivity to nearby cities that will lead to rural development economically as well as socially

Public Private Partnership Model in Road Transport

Traditionally, the road projects were fully financed and controlled/ supervised by the Government. The implementation of road projects was purely dependent on the availability/allocation of funds out of the budget of the Government. It was assessed, at the time of the preparation of the Tenth Plan that for National Highways alone, Rs. 1, 65,000 crore is required for removal of the deficiencies. . It was in this context that the necessity for exploring the innovative means of financing the highly capital intensive road projects was felt. Thus government has to switch to PPP model of working so that the burden of cost of labour and resources can be divided between government and private sector.

Highways are a critically important infrastructure for an emerging nation. And the design of appropriate contracts is the critical instrument for meeting the challenge of highways. What are these challenges? To put it in one sentence, the challenge is to maximize the difference between:

(a) The additional welfare that our citizens get from having more and better roads and,
(b) The present value of the cost of building (henceforth, building should be taken to mean building or renovating) those roads.

The involvement of private sector will bring 3's to the system: Efficiency, **Economy** and **Effectiveness** thus in present scenario where fast pace economic development is transiting from a developing world to emerging world; slow pace of transport sector can act as obstacle. So PPP model is need of the hour.

While there are a number of forms of Public Private Partnership, the common forms that are popular in India and have been used for development of National Highways are -

- **Build Operate and Transfer (BOT) Toll basis:** The concessionaire (private sector) is required to meet the upfront cost and the expenditure on annual maintenance. The concessionaire recovers the entire upfront cost along with the interest and a return on investment out of the future toll collection.
- **Build Operate and Transfer (BOT) Annuity basis:** In an BOT (Annuity) Model, the Concessionaire (private sector) is required to meet the entire upfront/construction cost (no grant is paid by the client) and the expenditure on annual maintenance

The Concessionaire recovers the entire investment and a pre-determined cost of return out of the annuities payable by the client every year. The selection is made based on the least annuity quoted by the bidders (the concession period being fixed).The client (Government/ NHAI) retains the risk with respect to traffic (toll), since the client collects the toll.

Central Road Fund

The Central Government has created a dedicated fund, called Central Road Fund by collection of cess from petrol & diesel. Presently, Rs. 2/- per litre is collected as cess on petrol and High Speed Diesel (HSD) Oil. The fund is distributed for development and maintenance of National Highways, State Roads, and Rural Roads and for provision of road over bridges/ under bridges and other safety features at unmanned Railway Crossings as provided in Central Road Fund Act, 2000. Fifty percent of the cess levy on diesel will be used to improve rural connectivity whereas remaining for the development of state roads and national highways

Major National Highways

- NH 1- Delhi - Ambala - Jalandhar - Ludhiana - Amritsar - Wagah Border.
- NH 1A- Jalandhar - Jammu - Udhampur - Banihal - Srinagar - Baramula - Uri
- NH 1D- Srinagar - Kargil - Leh
- NH 2 - Delhi-Agra-Allahabad-Kolkata
- NH 3 - Agra-Gwalior-Indore-Dhule-Nasik-Mumbai
- NH 4 - Thane-Pune-Bangalore-Chennai. (Mumbai-Pune-1st 6 lane express highway)
- NH 5 - Baharagora - Cuttack - Bhuvaneshwar - Vishakhapatnam - Chennai
- NH 6 - Hazira - Surat - Dhule - Nagpur - Raipur - Baharagora - Kolkata
- NH 7 - Varanasi-Nagpur-Hyderabad-Bangalore- Kanyakumari (Longest Highway)
- NH 8 - Delhi-Jaipur-Ajmer-Udaipur-Ahmedabad-Vadodara-Surat-Mumbai
- NH 24 - Delhi - Moradabad - Bareilly - Lucknow
- NH 47A-Kundannur-Willington Island in Kochi (Shortest NH-6 km)

Golden Quadrilateral Project

The Golden Quadrilateral is a highway network connecting India's four largest metropolises: Delhi, Mumbai, Chennai and Kolkata, thus forming a quadrilateral of sorts. Four other top ten metropolises: Bangalore, Pune, Ahmadabad, and Surat, are also served by the network. It is the first phase of the National Highways Development Project (NHDP), and consists of building 5,846 km (3,633 mi) of four/ six lane express highways.

The GQ project establishes better and faster transport networks between many major cities and ports. It provides an impetus to smoother movement of products and people within India. It enables industrial and job development in smaller towns through access to markets. It provides opportunities for farmers through better transportation of produce from the agricultural hinterland to major cities and ports for export, through lesser wastage and spoils. Finally, it drives economic growth directly through construction as well as through indirect demand for cement, steel and other construction materials. It gives an impetus to Truck transport throughout India

Organisations Related to Road Transport

1. THE NATIONAL HIGHWAYS AUTHORITY OF INDIA

The National Highways Authority of India was constituted by an act of Parliament, the

National Highways Authority of India Act, 1988. It is responsible for the development, maintenance and management of National Highways entrusted to it and for matters connected or incidental thereto. The Authority was operationalised in February, 1995 with the appointment of full time Chairman and other Members.

It aims at meeting the nation's need for the provision and maintenance of National Highways network to global standards and to meeting user's expectations in the most time bound and cost effective manner, within the strategic policy framework set by the Government of India and thus promote economic well being as quality of life of the people."

2. CENTRAL PUBLIC WORKS DEPARTMENT

The Central Public Works Department of India is a central government owned authority that is in charge of public sector works in the country. Central Public Works Department (CPWD) under Ministry of Urban Development is entrusted with construction and maintenance of buildings for most of the Central Government Departments, Public undertakings and Autonomous bodies

3. BORDER ROAD ORGANISATION

The Border Roads Organization [BRO] plays a very vital role in connecting the inaccessible border areas. BRO was raised on May 7, 1960 with the mission of developing communication in hither to forlorn areas of the north and North-East states of India and also fortification of the turbulent borders. BRO, the brain child of first Prime Minister Pandit Jawaharlal Nehru came into existence on May 7, 1960 as a pioneer road construction agency. Border Roads Organization, popularly known as BRO, is a civil engineering institution responsible to provide civil (construction) engineering cover to the Armed Forces of India, during war and peace.

Environmental Effects

Road transport no doubt has increased the accessibility of people to interiors of the nation but the environmental effects are increasing day by day with the development of roads.

The major environmental effect is air pollution. The burning of petrol and diesel releases many harmful gases as sulphur, lead, carbon monoxide that causes respiratory diseases in human beings.

As the four lane highways and six lane highways are coming up for which the clearance of the roadside trees are required thus depleting the biodiversity at large.

The construction of roads in hilly areas affects the topography, biodiversity of that area and leads to frequent landslides

Problems and Solutions

1. **INADEQUACY OF ROAD NETWORK:** despite the large progress in road network of the nation road length of 75.01km per 100 sq km of area is present whereas in other nations as Japan (294.6km), France (147.2km) etc. Lakhs of villages are still not connected by surface roads.

   Government is implementing schemes for up gradation of roads but poor implementation effects the whole scenario.PPP model should also be used in village road contracting.

2. **LOW SURFACED ROADS:** around 40% of roads are unsurfaced. They can be only used in fair weather and become muddy and unfit for transportation in rainy season. Government should concentrate on increasing area of surfaced roads as it is implementing Grameen Sadak Yojana.

3. **POOR INFRASTRUCTURE:** national highway network will have to be improved to meet the growing traffic of men and materials. A large section has insufficient road pavement thickness, weak and distressed bridges, congested city sections and weak road safety measures.

4. **POOR FINANCIAL STRUCTURE OF STATE ROAD TRANSPORT UNDERTAKINGS:** these are facing financial constraints due to social commitment to operate at low cost and even on uneconomic routes, absence of rationalized cost based fare structures and overstaffing. Private

parties should be allowed to enter in road transport sector to increase the efficiency and effectiveness of road transport but with regulations.

AIR TRANSPORT

Air transport is the fastest and modern means of transportation that has lead to shrinking of the world. Air transport plays a vital role in times of emergencies and calamities as floods, famines, epidemics for transportation of men and materials.

Air transport in India begins in 1911 when air mail operation commenced between Naini and Allahabad. In 1953 air transport was nationalized and two corporations were formed: Air India Internationals and Indian Airlines. Further the two airlines officially merged in each other on 27 February 2011. As part of the merger process, a new company called the National Aviation Company of India Limited (now called Air India Limited) was established, into which both Air India (along with Air India Express) and Indian Airlines (along with Alliance Air) had merged. There are many private players also as jet airways, kingfisher, spice jet, indigo etc.

International Airports

International Airports are located at Mumbai, Delhi, Kolkata, Chennai, Bangalore, Jaipur, Panaji, Amritsar, Guwahati, Kochi, Hyderabad, Ahmedabad, Thiruvananthapuram and Goa.

1. INDIRA GANDHI INTERNATIONAL AIRPORT, DELHI

a) It is the busiest airport in South Asia handling the most traffic movements and passengers on the subcontinent.
b) The airport was previously operated by the Indian Air Force and was a part of the Palam Airport until its management was transferred to the Airport Authority of India.

2. CHHATRAPATI SHIVAJI INTERNATIONAL AIRPORT, MUMBAI

a) Formerly called SAHAR (international) Airport and SANTA CRUZ (domestic) Airport. The two airports were merged and renamed as Chhatrapati Shivaji International Airport.
b) India's and South Asia's largest air port.
c) Country's second busiest airport. It, along with Delhi's Indira Gandhi International Airport, handles more than half of the air traffic in South Asia.

3. NETAJI SUBHASH CHANDRA BOSE INTERNATIONAL AIRPORT, KOLKATA

a) It is located at Dum-Dum near Kolkata, West Bengal.
b) The airport was originally known as Dum-Dum Airport.
c) The airport is the largest in eastern India.

4. MEENAMBAKAM INTERNATIONAL AIRPORT, CHENNAI

a) It is located in Tirusulam, 7 km south of Chennai.
b) This is the third-busiest airport in India (after Delhi and Mumbai).
c) It is the second-largest cargo hub in the country, after Mumbai.

5. BENGALURU INTERNATIONAL AIRPORT, BENGALURU

a) The airport is located 4 km south of Devanahalli in Bengaluru covering 4,000 acres.
b) It replaced the old HAL Bangalore International Airport.

6. RAJIV GANDHI INTERNATIONAL AIRPORT, HYDERABAD

a) Earlier it was known as Begumpet airport.
b) It is the second public-private partnership venture in the Indian airports, the first being the Cochin International Airport.

7. **SARDAR VALLABHBHAI PATEL INTERNATIONAL AIRPORT, AHMEDABAD**

a) It is India's eighth busiest airport with an average of 150 aircraft movements a day.

8. NEDUMBASSERY AIRPORT INTERNATIONAL AIRPORT, KOCHI

a) It is the fourth busiest airport in India in terms of international traffic & is the busiest airport in Kerala in terms of domestic and international traffic.
b) The airport is the first international airport in India incorporated as a public limited company.

9. RAJA SANSI INTERNATIONAL AIRPORT, AMRITSAR

a) It is also known as Guru Ram Das International Airport.
b) It handles about 90 commercial flights a week, both international and domestic.

10. TRIVANDRUM INTERNATIONAL AIRPORT, THIRUVANANTHAPURAM

a) It is the first International airport in a non-metro city in India.
b) It is considered as an "all weather" airport in the country and is ISO 9001-2000 certified.
c) It is the 8th busiest airport in the country in terms of international passenger traffic and 10th busiest in terms of overall passenger traffic.

11. DABOLIM AIRPORT INTERNATIONAL AIRPORT, GOA

a) It is the only airport in the state and operates as a civil enclave in a military airbase named INS Hansa.

12. LOKPRIYA GOPINATH BORDOLOI INTERNATIONAL AIRPORT, GUWAHATI

a) Known as Guwahati International Airport and formerly as Borjhar Airport.
b) The airport is managed by Airports Authority of India and also serves as Indian Air Force base.
c) It is named after Gopinath Bordoloi who was a freedom fighter and also the first CM of Assam after independence.

Air Ambulance

An air ambulance is an aircraft used for emergency medical assistance in situations where either a traditional ambulance cannot reach the scene easily or quickly enough, or the patient needs to be transported over a distance or terrain that makes air transportation the most practical transport. These and related operations are referred to as Aero medical. Air ambulance crews are supplied with equipment that enables them to provide medical treatment to a critically injured or ill patient. Common equipment for air ambulances includes ventilators, medication, an ECG and stretchers

The air crash in Faridabad of air ambulance has pointed on its safety provisions. Government has set up Accident Investigation Committee (AIC) to work under supervision of the Civil Aviation Ministry. It would identify the causes of accident in an independent manner and assist the formal probe panels like courts or committees of inquiry. It would also coordinate and provide support for the probe panels and follow up and monitor the compliance of the recommendations made in the Accident and Serious Incident Investigation Reports.

Pawan hans Helicopters Limited (PHHL)

Pawan Hans Helicopters Ltd. (PHHL) an ISO 9001:2000 certified company, is one of India's leading helicopter companies and is known for its reliable helicopter operations. The company was incorporated in 1985 with the objective of providing helicopter services to the petroleum sector, linking inaccessible areas of the country and operating charters for promotion of tourism.

Pawan Hans is a leader in providing offshore helicopter support in India. Its helicopters fly under a variety of conditions for carrying out ONGC tasks at Bombay High. The Company has a strong presence in the North-East having its helicopters deployed in the States of Arunachal Pradesh, Meghalaya, Sikkim and Tripura. Regular passenger services are being run under the aegis of these State Governments. Helicopter has also been provided to Ministry of Home Affairs in the North-East for VIP transportation. PHHL runs the helicopter services from Agustmuni and Phata to the Holy shrine of Kedarnath in the months of May-June and

September-October every year. The Company has also deployed two Bell 407 helicopters for operations at Katra (for Mata Vaishno Devi) from April 2008 onwards.

The company has provided helicopters to Andaman & Nicobar Islands and Lakshadweep Islands for inter-island helicopter services. It also meets the requirements of Government of Punjab (VIP transportation) and PSUs such as GAIL for pipelines surveillance.Pawan Hans is the largest helicopter Company in India and it's operating and maintenance standards are of a high order with in-house workshops and maintenance facilities.

Jal Hans

It is a commercial seaplane facility to Andaman and Nicobar Islands. "The launch of the sea plane service is a step towards faster promotion of the tourism sector in the islands". Besides developing tourism infrastructure, the plane service will also help improve connectivity between different islands of the Union territory. The sea plane service, a joint venture between Pawan Hans Helicopter and Andaman and Nicobar administration will be used to connect Port Blair with Havelock Island and subsequently others islands in the North and Middle Andaman. The sea plane is a Cessna Caravan 208 Amphibian and has a seating capacity of nine passengers and can land on water.

Gagan Project: Enhancing Safety

GPS Aided Geo Augmented Navigation "Gagan" is an augmentation system to enhance the accuracy and integrity of GPS signals to meet precision approach requirements in Civil Aviation and is being implemented jointly by AAI and ISRO. The goal is to provide navigation system for all phases of flight over the Indian airspace and in the adjoining area. It is applicable to safety-to-life operations, and meets the performance requirements of international civil aviation regulatory bodies.

GSAT IV being fabricated by ISRO will carry GAGAN payload. The footprint of this satellite will cover a vast geographical area from Africa to Australia and hence would facilitate expansion of the service area of "Gagan" far beyond Indian airspace. When implemented this would replace most of the ground based navigational aids and it would be possible to provide precision approach and landing guidance up to category I to aircraft hitherto not available due to terrain conditions precluding the provision of Instrument Landing System.

Flight Management System based on GAGAN will then be poised to save operators time and money by managing climb, descent and engine performance profiles. The FMS will improve the efficiency and flexibility by increasing the use of operator-preferred trajectories. It will improve airport and airspace access in all weather conditions, and the ability to meet the environmental and obstacle clearance constraints. It will also enhance reliability and reduce delays by defining more precise terminal area procedures that feature parallel routes and environmentally optimized airspace corridors.

GAGAN will increase safety by using a three-dimensional approach operation with course guidance to the runway, which will reduce the risk of controlled flight into terrain i.e., an accident whereby an airworthy aircraft, under pilot control, inadvertently flies into terrain, an obstacle, or water.

GAGAN will also offer high position accuracies over a wide geographical area like the Indian airspace. These positions accuracies will be simultaneously available to 80 civilian and more than 200 non-civilian airports and airfields and will facilitate an increase in the number of airports to 500 as planned. These position accuracies can be further enhanced with ground based augmentation system

Problems and Solutions

AIR TRANSPORT industry of India is facing a number of problems. AIR INDIA is facing stiff competition from the private players in terms of facilities and fare charges. These airlines suffer from mismanagement as frequent pilot strikes, political interference occurs.

The primary step would be to enlarge and upgrade airports and allied infrastructural facilities to meet the growing traffic. For these private players should be welcomed as in Greenfield airport of Hyderabad.

The recent fraud pilots' cases have minimized the credibility of airlines. Government should take strict action against the culprits and proper regulations should be made to curb this practice in future.

WATER TRANSPORT

Water transport is the cheapest means of transport and is therefore suitable for carrying heavy and bulky materials. It is a fuel-efficient and eco-friendly mode of transport. According to one estimate the construction of each kilometer of railway and road needs an investment of around 1 crores whereas only 0.10 crores is required to develop same length of waterways. The salient features of India's shipping policy are the promotion of national shipping to increase self-reliance in the carriage of the country's overseas trade and protection of stakeholders' interest in EXIM trade. National shipping makes significant contribution to the foreign exchange earnings of the country. Their development is faster and maintenance cost is much lower. Water transport in India has been divided into:

1. Inland Waterways
2. Seaways.

Inland Waterways

Inland waterways refer to using inland water bodies like rivers, canals, backwaters, creeks etc. for transporting goods and people from one place to another. Inland Waterways Authority of India was set up in 1986 for the development, maintenance and regulation of national waterways in the country. In other to increase the significance of inland waterways and to improve their efficiency, the government has identified important waterways and designated them as national waterways of India.

- **National Waterway No 1 (NW-1) - The Ganga (North India)**

The Ganga-Bhagirathi-Hooghly River System connecting Haldia-Kolkata (Calcutta) - Farakka - Munger - Patna - Varanasi - Allahabad is navigable by mechanized boats up to Patna and by ordinary boats up to Haridwar.

The NW-1 stretches to more than 1620 Kms of potentially navigable waterways. Night navigational facilities are in the process of implementation.

- **National Waterway No 2 (NW-II) - The Brahmaputra (North-East India)**

The river Brahmaputra connecting Dhubri-Pandu (Guwahati)-Tezpur-Neamati-Dibrugarh-Sadiya stretching to about 891 Kms was declared a National Waterway in 1988. Provisions for 2-meter depth channels, night navigational facilities are under consideration.

An inland Water Transport transit and trade protocol exists between India and Bangladesh. The NW-2 connects the North East region with Calcutta and Haldia ports through Bangladesh and Sunderbans waterways.

- **National Waterway No 3 (NW-III) - The West Coast Canal (South West India)**

The West Coast Canal located in Gods Own Country - Kerala runs from Kollam to Kottapuram and was declared a National Waterway in 1993.The NW-3 is one of the most navigable and tourism potential area in India and has much to offer to the potential tourist.

- **National Waterway 4 (NW 4)**

The Kakinada-Puducherry stretch of Canals and the Kaluvelly Tank, Bhadrachalam - Rajahmundry stretch of River Godavari and Wazirabad - Vijayawada stretch of River Krishna has been declared as national waterways No. 4.

- **National Waterway 5 (NW 5)**

The Talcher-Dhamra stretch of river Brahmani, Geonkhali - Charbatia stretch of East Coast Canal, Charbatia- Dhamra stretch of Matai River and Mangalgadi-Paradip stretch of Mahanadi delta rivers has been declared as national waterway No. 5.

Factors affecting Inland waterways:

1. Diversion of river water for irrigation canals has reduced the flow of water and declined the navigation capacity of the rivers.

2. The presence of waterfalls, cataracts and sharp bends hinders the development of waterways.
3. Silting of river bed reduces the depth of water and creates problem for navigation.
4. Lack of funds.

The government is promoting Inland Water transport in the form of interest subsidies and inducing private investment. For promoting the use of this mode by private operators, they are encouraged to use Central Inland Water Transport Corporation vessels free of hire charges.

Inland water transport has a good potential to be exploited and efforts should be made in this direction. Passenger transport should be encouraged. Intermodal connections with shipping, railways and roadways can improve the performance of Inland Water transport.

For overall development of IWT sector in the country it is necessary that national waterways as well as other waterways are developed side by side. A large number of smaller rivers from tributaries of National Waterways Rivers if developed with IWT infrastructure, many of these smaller rivers can become suitable for navigation by smaller/medium size inland vessels and can act as feeder routes to the main waterways. While the development and regulation of National Waterways is the responsibility of Central Govt./IWAI, the respective State Governments should develop other waterways. However, due to fund constraint, it has not been possible for the States to provide adequate funds for IWT development. Therefore, to encourage the States for IWT development, there was a Centrally Sponsored Scheme (CSS) for IWT sector. Under the CSS, 100 per cent grant is provided for the projects of North-Eastern States including Sikkim and 90 per cent grant to other States. The Planning Commission has discontinued the scheme for areas other than North East Region from the year 2007-08. The scheme has been continued for the North-Eastern regional and classified as a Central Sector Scheme

SEAWAYS

Shipping plays an important role in the transport sector of India's economy. Almost 98% of India's overseas trade in terms of volume is moved by sea. Coal and petroleum products constitute the bulk of the cargo.

India has a vast coastline of about 7,516 km and over two million square kilometers of Exclusive Economic Zone. The entire coastline is studded with 12 major and 185 minor ports. India has the largest merchant shipping fleet among the developing countries and ranks 20th amongst the countries with the largest cargo carrying fleet with 8.83 million GT.

Major Sea Ports in India

The coastline of India is dotted with 12 Major Ports and about 200 Non-major Ports. The Major Ports are under the purview of the central government while the Non-major Ports come under the jurisdiction of the respective State Governments. On the western coast the major ports are: Mumbai, Marmagao, Kandla, New Mangalore, Nhava Sheva (Jawaharlal Nehru Port) and Kochin. Whereas on the eastern coast are Madras, Kolkata- Haldia, Vishakhapatnam, Tuticorin, Paradeep and Ennore.

1. **Kandla -** It is a tidal port located at the eastern end of Gulf of Kuchchh about 48 km away from Bhuj. It has been developed after independence to relieve congestion on Mumbai port and to compensate for the loss of Karachi port to Pakistan after partition. It is a port with natural sheltered harbour in Kandla creek. Leather, petroleum products, chemicals, salt, cement, cotton and silk textile, edible oils are main items of export. Crude oil, good quality coffee, potash, and machines are main items of import.
2. **Mumbai -** It is situated on SALSETTE ISLAND on the western coast. It is a natural harbour and the largest port of India handling about 1/5th of India's foreign trade. Oilseeds, groundnut, raw leather and leather-wears, tobacco, cotton textile and engineering goods are the main items of exports. High quality cotton, chemicals and chemical fertilizer, petroleum, machineries and paper are main import items.

It handles foreign trade with Western and East African countries and Gulf countries. Opening of the Suez Canal in 1869 brought it much closer to the European countries

3. **Jawaharlal Nehru port -** It has been built at Nhava Sheva Island across the Elephanta caves, about 10 km from Mumbai. Main objective is to relieve the pressure on the Mumbai Port. It is equipped with most modern facilities having mechanized container berth for handling dry bulk cargo and service berth etc. It is the largest man-made and most modernized port of India. It handles 55-60% of the country's containerized cargo.

4. **Marmagao -** It is a natural port located at the entrance of Zuvari estuary in Goa. It handles the export of iron-ore from Goa. Iron ore, manganese, coconut, coffee, cotton, etc. are the main items of export. Petroleum, fertilizer, chemicals, machines and food-grains are the main import items.

5. **New Mangalore -** Located at the southern tip of Karnataka coast north of Gurpur River. Iron ore, tea, rice, cashew nut, granite, coffee, rubber, fruits and fishes are the main export items. Fertilizer, edible oils, petroleum and machines are import items. It has facilities for export of iron-ore from Kudremukh mines. It is well connected through broad gauge rail lines and NH-17 with Mumbai & Kanyakumari. The ship beyond 6000 tones cannot stay here.

6. **Kochi -** A natural harbour on the western coast of Kerala (in Vembanad Lake), 320 kilometers north of Kanyakumari. It is located close to Suez-Colombo sea route. The port has sheltered backwater bay. This port handles 5% of the total trade. Tea, Coffee, Copper, Rubber, Rice, Sea products and Spices are main export items whereas coal, iron and steel, zinc, petrol, fertilizers cotton, wheat, rice and bauxite are main import items.

7. **Tuticorin -** It is an artificial deep sea harbour in Tamil Nadu, north of Adam Bridge and east of Sri Lanka. Its main purpose is to carry on trade with Sri Lanka as it is very near to that country. Spices, tea, salt, sugar, copra, cotton textile, leather and banana are main export items whereas coal, fertilizer and machines are main import items.

8. **Chennai -** It is the oldest artificial port on the eastern coast of India. At a time 16 ships can stay in this artificial harbor. Tamil Nadu, eastern Karnataka and southern Andhra Pradesh fall under its hinterland. Cotton and silks textile, coffee, fertilizer, rubber, tobacco, oilseeds, rice, leather and fishes are main export items. Coal, petroleum, paper, sugar, vehicles, medicines, machines and chemicals are main import items. Due to lesser depth near coast, it is ill-suited for large ships.

9. **Ennore:** Recently developed to reduce pressure of traffic on Chennai port. It is located slightly north of Chennai on T.N. coast. It is country's first corporate port. The major items of traffic are coal, iron ore, petroleum, chemicals, etc.

10. **Vishakhapatnam -** It is the deepest land-locked and protected port at the coast of Andhra Pradesh. Manganese, spices, wood, coal and iron ore are main export items. Steel, oil, coal, machines and luxury items are the main imports. An outer harbour has been developed to handle the export of iron-ore. Iron-ore from Bailadila mines is exported to Japan from this port. It also has ship-building and ship-repairing industry.

11. **Paradeep -** It is a deep-water & all weather port on Orissa coast in Mahanadi delta region. This port has been developed with a view to export raw materials mainly iron ore to Japan. Iron- ore, chromites, fishes, manganese are main items of export where as chemical, fertilizer potash and food grains are main import items. It is being developed as a free port where iron-steel industry in proposed to be established.

12. **Kolkata-Haldia -** It is a river rine port located on the west bank of the Hooghly River. Tea, sugar, jute, iron and steel goods, coal, textiles, oilseeds, leather, mica and manganese are main items of export. Paper, petrol, fertilizers, chemical goods, rub-

ber, machines medicine are main import items. It handles goods coming from South-East Asian Countries, Australia and New Zealand. It is called "Gateway to Eastern India". Haldia port has recently been developed on the confluence of rivers Hooghly & Haldi, about 105 km downstream from Kolkata. Its main purpose is to release congestion at Kolkata.

Passenger Ferry service between India and Sri Lanka

Ferry service has been resumed between Sri Lanka and India after being halted for more than 25 years because of the island's civil war. The ferry will carry the passengers from both the countries in economical and efficient. This will enhance the relations between two countries both economically and culturally as tourist flow will increase. The ferry service will connect Tuticorin port in India and Colombo in Sri Lanka.

Problems and Solutions

The Indian water transport system is confronted with problems as inadequacy of tonnage capacity, shortage of container fleet, over raged vessels resulting into high operational costs, stiff competition from foreign shipping companies, congestion at the major ports and inadequate infrastructural support like ship repair facility, dry docking, cargo handling and lack of proper coordination in entire logistics chain.

In the eighth plan the basic thrusts were towards the replacement of aged and uneconomic ships, diversification of fleet through the acquisition of container ships and specialized containers, achievement of self sufficiency in tankers and improvement of infrastructural facilities at the port.

Requirement is to make the ports more autonomous and reduce existing legal formalities. Autonomous ports can raise resources from the primary market by way of equity.

In order to improve efficiency productivity and quality of services as well as to bring in competitiveness in port services, the port sector has been thrown open to private sector participation. The Major Port Trust Act, 1963 permits private sector participation in major ports invites Foreign Direct Investment (FDI) up to 100% under the automatic route is permitted for construction and maintenance of ports and harbours. Private sector participation has been allowed in a variety of ports services which includes construction and operation of terminals, warehousing/storage facility, dry docking and ship repair facilities.

PIPELINE

Pipelines are the most convenient mode of transporting liquids and gases over long distances. Even solids can also be transported by pipelines after converting them into slurry. The country had a network of about 5,035 km long pipelines in 1980 which has increased to over 7,000 km now.

India is not self sufficient in crude oil and petroleum based products. Hence every year it has to import around 70% of these products from abroad. While giant tanker ships import it from foreign country but to transport the crude to refineries and petroleum products from refinery to consumer markets needs widespread branches of pipelines. India has developed an indigenous network of pipeline for easy and economical transfer of oil from one place to another.

Advantages of Pipeline:

a) They are ideally suited to transport the liquid and gases.
b) They can be laid over difficult terrain as well as under water.
c) It involves very low energy consumption.
d) Their operation and maintenance cost is low.
e) They are safe, accident-free and environmental friendly.

Disadvantages of Pipeline:

a) It is not flexible i.e. it can be used only for a few fixed points.
b) Its capacity cannot be increased once it is laid.
c) It is difficult to make security arrangements for pipelines.

d) Underground pipelines cannot be easily repaired and detection of leakage is also difficult.

Major Pipelines of India

1. NAHORKATIYA-NOONMATI-BARAUNI PIPELINE

This is the first pipeline of the country constructed by OIL for transporting crude oil from Nahorkatiya oilfield in Assam to Barauni in Bihar via Noonmati. It is now extended to Kanpur in Uttar Pradesh

2. BOMBAY HIGH-MUMBAIANKLE-SHWAR-KOYALI PIPELINE

This line connects the oil fields of Mumbai high and Gujarat with oil refinery at Koyali. It provides facilities for transporting crude oil and natural gas.

3. SALAYA-KOYALI-MATHURA PIPELINE

This has been laid down from Salaya to Koyali and Mathura via Viramgram to supply crude oil to the extended Koyali and Mathura refinery. It has an offshore terminal for imported crude oil. Now it has been further extended to Panipat and Jalandhar.

4. HAJIRA-BIJAPUR-JAGDISHPUR GAS PIPELINE

This has been constructed by Gas Authority of India to transport gas. It connects Hajira in Maharashtra to Bijapur in M.P and Jagdishpur in U.P. It carries 18 million cubic metres of gas everyday to three power houses of Gujarat, Rajasthan and U.P. and to six fertilizer plants. This is the world's largest underground pipeline and brought economic boost to economy of Gujarat, Madhya Pradesh, Rajasthan and Uttar Pradesh.

5. JAMNAGAR-LONI LPG PIPELINE

This has been constructed by Gas Authority of India connecting Jamnagar in Gujarat to Loni near Delhi. This is the longest pipeline of the world. This is the first time that cross country pipeline has been used to transport LPG adding to availability of supplies, safety in transportation and wider distribution.

Issue of Pipeline Safety

Aging infrastructure, lack of safety standards, and weak oversight and enforcement are the key elements leading to pipeline accidents. The following are the recommendations for improved pipeline safety and accountability.

1. Prevent Pipeline Disasters

- **Require Better Monitoring**
  a) Require regular integrity testing of pipelines.
  b) Require better training and oversight of staff.
  c) Require pipeline companies to provide pipeline mapping data with the possible exception of gathering lines.
- **Require Safer Pipelines**
  a) Require double-walled pipelines especially in high consequence areas.
  b) Require state of the art leak detection system and automatic shut off valves.
  c) Dig up and inspect pipelines more than 20 years old.
  d) Require setbacks of at least 1,000 feet for high-risk areas for pipelines larger than 8 inches.

2. Hold Pipeline Companies Responsible for Accidents

a) Establish mandatory fines.
b) Require strict and thorough reporting.

As India is entering in agreement with Tajikistan and Iran for the supply of natural gas so agenda of pipeline safety comes at forefront.

Effect on Economy

Pipelines play a major role in economic development of the country as

(i) It provides easy transportation of petroleum products from refineries to consumer market maintaining a balance between demand and supply. Thus keeping the cost of petroleum products at desired point.

(ii) It helps in transfer of petroleum products to fertilizer plants thus effects the agricultural production of the country.
(iii) LPG is now transferred by pipelines thus decreasing the transportation cost and making it easily available to the masses.
(iv) Refineries can be set up at far distance from the raw material source thus helps in reducing regional disparity.

TRANSPORT PLANNING COMMITTEE

The above description of the transport sector of India reveals that there is a lack of proper coordination between different modes of transport and despite ongoing developments it is not able to meet the growing demands of the nation. There exists neck to neck competition between road and railway transport that diminishes the ultimate goal of whole transport industry. Different transport sectors should coordinate to complement each other in different regions.

India that aspires to be an economic superpower is visibly in need of a transport policy that is in tune with the times. The constitution of a high level Transport Policy Development Committee, headed by the former deputy governor of the Reserve Bank of India, Rakesh Mohan, reflects this. The last time a comprehensive view of transport was taken at the national level was in 1980 when the B.D. Pande committee submitted its report. Much has happened since then. India's economic transformation from a near-closed economy to a fast liberalizer led to a significant stepping up of economic activity, particularly by the private sector, and resulted in higher individual spending capacity. While the former meant increased flow of goods and services, calling for better freight facilities, the latter translated into both higher purchasing power for personal transportation modes and higher effective demand for better public transport. Liberalization has also spawned its own huge inequities. A fresh policy has to factor in the harsh reality that the overwhelming majority, in the region of 800 million Indians, live in poverty. This calls for a more active state role as a provider of subsidized transport and as an effective regulator, particularly since the trend is to move towards a system that facilitates private players.

The terms of reference of the Rakesh Mohan committee are wide: they range from "assessing the transport requirements for the next two decades" to "assessing the investment requirements" of the sector. Although there are several issues that jostle for attention, there is an urgent need to develop a comprehensive policy for road transport as this mode carries 87 per cent of India's passengers, moves 60 per cent of its freight, and is in serious disarray. Efficient inter-State, intra-city, and rural transport systems will reduce losses, improve connectivity, and open up more economic opportunities. The most shocking lapse of state policy is the decline of public transport. As a Parliamentary Standing Committee rightly pointed out, the decline of buses in the total fleet of vehicles from 11 per cent in 1951 to a paltry 1.1 per cent in 2004 has meant an increase in personalized transport. This leads to avoidable economic losses due to higher fuel expenditure, apart from widening inequalities. The retrogressive trend needs urgent reversal. A policy that accords primacy of space to an affordable, efficient, and integrated public transport system will be a key to fixing India's transport troubles. ■■■

9 POPULATION

Population is the basic element of the state. With 1,210,000,000 (1.21 billion) people, India is currently the world's second largest country in terms of population representing a full 17.5% of the earth's population. India's 2011 census showed that the country's population had grown by 181 million people in the prior decade.

When India gained independence from the United Kingdom sixty years ago, the country's population was a mere 350 million. Since 1947, the population of India has more than tripled.

1ndia's high population growth results in increasingly impoverished and sub-standard conditions for growing segments of the Indian population. Population plays an important role in economic development of the country. The human resource of the country if skilled and trained contribute to the growth whereas on the other hand illiterate and unskilled population full of ethnic and linguistic diversities acts as havoc for the nation. It may pose serious threat to the survival of mankind.

Some of the reasons for this population explosion are poverty, better medical facilities, and immigration from the neighboring countries of Bangladesh and Nepal. Several solutions to decrease the rate of population increase have been tried by the government, some successful, some unsuccessful. Although the rate of increase has decreased, the rate has not reached the satisfactory level yet. The population in India continues to increase at an alarming rate. The effects of this population increase are evident in the increasing poverty, unemployment, air and water pollution, and shortage of food, health resources.

POPULATION GROWTH SINCE 1901

The demographic history of India during the twentieth century can be charted and classified into following four distinct phases.

1. Period of Stagnant Population (1901-1921)
2. Period of Steady Growth (1921-1951)
3. Period of Rapid High Growth (1951-1981)
4. Period of High Growth with Definite Signs of Slowing Down (1981-2001)

1. Period of Stagnant Population (1901-1921)

During most of the 19th century India witnessed sporadic, irregular and slow growth of population which drifted into twentieth centuary until 1921. Thus the population growth during this period can be termed more or less stagnant when compared to the growth rates observed during the consequent periods. The high birth rate was counter balanced by high death rate. The progressive growth rate in 1921 over 1901 was only 5.42 per cent. In fact, the census year 1921 registered a negatigve growth rate of -0.31 per cent which happened only once throughout the demographic history of India. It is because of this decline in place of rise in populaion that the year 1921 is called as the '**demographic divide**' in the demographic history of India. The high mortality during this period was the product of large scale abnormal deaths due to epidemics of influenza, plague, small pox, cholera, etc. Influenzia alone claimed 12 million lives in1918. Food shortages caused by severe droughts in 1911, 1913, 1915, 1918 and 1920 claimed their own toll. In addition, thousands of Indian solidiers lost their liives during the World War-I (1914-18).

2. Period of Steady Growth (1921-51)

During 1921-51, the population of Indian increased from 251 million to 361 million. This duration of 30 years has thus registered a growth of 47.3 per cent. Therefore, this period is called the period of steady growth rate.The mortality rate started showing downward trend as a result of improvement in general health and sanitation conditions after 1921. These developments helped in controlling epidemics like plague, cholera and malaria. The crude death rate which stood at a high of 47 per thousand in 1921 declined to 27 per thousand in 1951 .On the contray, the crude birth rate continued to stay at an abnormally high level and decline only to 40 per thousand in 1951 as against 48 per thousand in 1921. Decline in death rate was also achieved partly though the improvement in the distribution system as a result of improved transportation so that timely supplies of food could be made available to drought and famine stricken areas. The combined effect of these factors was that the population started increasing steadily. Since crude death rate declined considerly and crude birth rate remained very high. The population growth during this period is called mortality induced growth.

3. Period of Rapid High Growth (1951-81)

After 1951, there was a steep fall in the mortality rate but the fertility remained stubornly high. Therefore, this period experienced very high rate of population growth and is often referred to as the period of population explosion. As a matter of fact, the birth rate increased from 40 per thousand in 1951 to 42 per thousand in 1961 and stayed at 34 per thousand in1981. However, it fell to 36 per thousand in 2001. In contrast, death rate fell rapidly from 27 per thousand in 1951 to 9 per thousand in 2001. Consequently the natural rate of growth, which fell slightly from 14.0 per thousand in 1941 to 13 per thousand in 1951 rose steeply to 22 per thousand in 1971 and remained at the same level in 1981 also. The total population of the country increased from 361.09 million in 1951 to 683.3 million in 1981 recording an increase of 89.36 per cent in a short span of thirty years. This unprecedented growth rate was due to the accelerated developmental activities and further improvement in health facilities. The living conditions of the people improved enormously. Death rates declined much faster than the birth rates. This situation resulted in high natural increase. Thus, it was fertility induced growth.

4. Period of High Growth Rate with Definite Signs of Slowing Down (1981-2001)

The last phase of 20th century, i.e., the period between census years 1981 and 2001 is known as the period of high growth with definite signs of slowing down. Although the rate of growth was still very high, it started declining after 1981. The highest growth rate of 2.22 per cent was recorded in 1971 which continued in 1981 also. It declined to 2.14 per cent in 1991 and further to 1.95 per cent in 2001.This declining trend marks the beginning of the new era in the country's demographic history. During this period, birth rate declined rapidly, from 34 per thousand in 1981 to 26 per thousand in 2001.Declining trend of death rate continued but at a slower rate. The difference between birth and death rates narrowed to 17. This declining trend is a positive indicatior of the official efforts of birth control and people's own inclination to opt for smaller families. It seems that the country has now reached a take-off stage in its demographic evolution.

The Demographic Transition

The demographic transition is the process of change in population of a society. It consists of the following four stages:

(a) Stage 1. High death and birth rates, low growth rate.

(b) Stage 2. Rapid decline in death rate, continued high birth rate, very high growth rate.

(c) Stage 3. Rapid decline in birth rate, continued decline in death rate, growth rate begins to decline.

(d) Stage 4. Low death and birth rates, low growth rate.

The story of population growth in India is fairly in tune with the classical theory of demographic transition. During most of the nine-

teenth century India witnessed a fluctuating but ultimately more or less a stagnant growth of population, which drifted into the twentieth century until 1921. Thereafter, country passed through successively all the phases of demographic transition and is now widely believed to have entered the final phase which is normally characterised by rapidly declining fertility. However, it is yet to be seen as to how long will this phase extend and when India will achieve a stable population.

The National Population Policy (NPP) adopted by the Government of India in 2000 states that 'the long-term objective is to achieve a stable population by 2045;that changed to 2070 at a level consistent with the requirement of sustainable economic growth, social development and environment protection.

REASONS FOR INCREASE IN POPULATION

I. BIRTH RATE

a) Poverty

According to ABC News, India currently faces approximately "... 33 births a minute, 2,000 an hour, 48,000 a day, which calculates to nearly 12 million a year". Unfortunately, the resources do not increase as the population increases. Instead the resources keep decreasing, leading to making survival for a human being more and more competitive even for the basic necessities of life like food, clothing and shelter.

India currently faces a vicious cycle of population explosion and poverty. One of the most important reasons for this population increase in India is poverty. According to Geography.com, "More than 300 million Indians earn less than US $1 everyday and about 130 million people are jobless." The people, who have to struggle to make two ends meet, produce more children because more children mean more earning hands. Also, due to poverty, the infant mortality rate among such families is higher due to the lack of facilities like food and medical resources. Thus, they produce more children assuming that not all of them would be able to survive. The end result is a mounting increase in the population size of India. Due to the increase in population, the problems of scarce resources, jobs, and poverty increases. Thus the cycle continues leading to an ever increasing population. This cycle in fact might be considered as a positive feedback, in that the increase in one result in the increase of the other factor. As the poverty and the population both increase, the development of the country and the society seems even more far-fetched.

b) Religious beliefs, Traditions and Cultural Norms

India's culture runs very deep and far back in history. Due to the increased population, the educational facilities are very scarce. As a result, most people still strictly follow ancient beliefs. In addition, a lot of families prefer having a son rather than a daughter. As a result, a lot of families have more children than they actually want or can afford, resulting in increased poverty, lack of resources, and most importantly, an increased population.

Another one of India's cultural norms is for a girl to get married at an early age. In most of the rural areas and in some urban areas as well, families prefer to get their girls married at the age of 14 or 15. Although child marriage is illegal in India, the culture and the society surrounding the girls in India does not allow them to oppose such decisions taken by their family. For many, giving a girl child in marriage is done not by choice, but rather out of compulsion. The poor economic status of tribal villagers is attributed as one of the primary factors responsible for the prevalence of child marriages in India. Due to the young age of these girls, they have more potential of bearing children, and that is, since they start bearing children at a very early age, they can have more children throughout their lifetime. This results in the increase of the global fertility rate. Since these girls get married at a very early age, they do not have the opportunity to get educated. Therefore, they remain uneducated and teach

the same norms to their own children, and the tradition goes on from one generation to the other.

II. DEATH RATE:

Although poverty has increased and the development of the country continues to be hampered, the improvements in medical facilities have been tremendous. This improvement might be considered positive, but as far as population increase is considered, it has only been positive in terms of increasing the population further. The crude death rate in India in 1981 was approximately 12.5, and that decreased to approximately 8.7 in 1999. Also, the infant mortality rate in India decreased from 129 in 1981 to approximately 72 in 1999 .These numbers are clear indications of the improvements in the medical field. This development is good for the economy and society of India, but strictly in terms of population, this advancement has further enhanced the increase in population.

The average life expectancy of people in India has increased from 52.9 in 1975-80 to 62.4 in 1995-00. Although our near and dear ones would live longer, due to the increase in the population, the resources available per person would be much less, leading to a decrease in the curvature of the slope of development instead of a higher gradient. In addition, abortion is not allowed by several religions that are followed in India. In fact, in Islam, one of the leading religions of India, children are considered to be gifts of God, and so the more children a woman has, the more she is respected in her family and society. As a result, although the measures to control birth are either not available or known to the public, the facilities to increase birth through medical facilities are available.

III. MIGRATION:

In countries like the United States (U.S.), immigration plays an important role in the population increase. However, in countries like India, immigration plays a very small role in the population change. Although people from neighboring countries like Bangladesh, Pakistan and Nepal, migrate to India; at the same time Indians migrate to other countries like the U.S., Australia, and the U.K. During the 1971 war between India and Pakistan over Bangladesh, the immigration rate increased tremendously. However, currently the migration in India is -0.08 migrants per 1000 population and is decreasing further. This is definitely good for India. This way, the population might eventually come close to being under control and more people may get better job opportunities and further education. For example, the students in my university from India, like myself, have better chances for job opportunities and better education outside India than we would have had in India.

POPULATION DISTRIBUTION IN INDIA (FACTORS AFFECTING)

One of the most important aspects of India's population is its uneven distribution. The factors that affect the distribution of population includes geographical, social,demographic, political and historic angles.Some are discussed below:

a) **Terrain:** Terrain of land is a potent factor which influences the concentration and growth of population. Normally plain areas encourage higher density as it offers great opportunities for the growth of agriculture, transport and industries. Whereas due to technological developments the human interference is increasing in all the areas even of difficult terrain as deserts, mountains, snow areas, etc.

b) **Climate:** Of all the climatic factors,twin elements of rainfall and temperature play an important role in determining population density.It is generally said that "the population map of india follows its rainfall map".As we move from GANGA BRAHMAPUTRA DELTA in the east towards the THAR DESERT in the west,the density of population decreases consequently.But sometimes the adverse factors as steep slope, infertile land, frequent floods counterbalance the positive effects of rain-

fall. But alarming increment in population forces people to live at vulnerable places.

c) **Soil and water availaibility:** Soil plays an important role in determining the population distribution in agricultural country like INDIA. Fertile soil supports high population as it provides food security and employement whereas dry zone area with poor soil quality requires high input whereas in turn yeild lower gains. Water acts as a basic need for human survival. The areas with easy availability of water resources attract more population. It plays a significant role in irrigation, industries and transportation too.

d) **Mineral resources:** minerals act as a great source of attraction as it provides easy establishments of industries around it which further improves the living conditions of the masses. The industries provide living support and employment and leads to overall development of the region reducing disparity.

e) **Transport:** The northern plain of India has a dense network of transport route and is densely populated whereas the Himalayan region lacks transport facilities and is scarcely populated.

All the above factors defined, plays an important role in determination of population density of the region with all working simultaneously at a point.

HUMAN DEVELOPMENT INDICATORS

SEX RATIO

Sex ratio is defined as the number of females per thousand males. The primary sex ratio is the ratio at the time of conception, secondary sex ratio is the ratio at time of birth, and tertiary sex ratio is the ratio of mature organisms.

Sex ratio is an important parameter that reflects the status of woman in a society. Census 2011 shows the sex ratio at 940females / 1000 males that are high from 2001 census but when compared to different countries it is still low.

Sex ratio at birth has emerged as an indicator of certain kinds of sex discrimination in some countries. For instance, low female to male ratios at birth in these states can be attributed to sex-selective abortion and infanticide due to a strong preference for sons. This will affect future marriage patterns and fertility patterns.

In India there is a great variation in sex ratio data of different states. Kerala has highest sex ratio whereas Haryana and Punjab has the lowest. The northern India and the southern India shows a regional divide, one showcasing the developed countries data whereas other showcasing a traditional feudal society. Unfortunately, women in this country are mostly unaware of their rights because of illiteracy and the oppressive tradition.

LITERACY

Literacy is an index of human development and quality of human life. Literacy in India is key for socio-economic progress and the Indian literacy rate grew to 74.04% in 2011 from 12% at the end of British rule in 1947.Although this is greater than six fold improvement, the level is well below the world average literacy rate of 84% and India currently has the largest illiterate population of any nation on earth.

There is a wide gender disparity in the literacy rate in India: effective literacy rates (age 7 and above) in 2011 were 82.14% for men and 65.46% for women. The low female literacy rate has had a dramatically negative impact on family planning and population stabilization efforts in India. Studies have indicated that female literacy is a strong predictor of the use of contraception among married Indian couples, even when women do not otherwise have economic independence. The census provided a positive indication that growth in female literacy rates (11.8%) was substantially faster than in male literacy rates (6.9%) in the 2001-2011 decadal period, which means the gender gap appears to be narrowing.

There is wide variation in the spatial pattern of literacy in the country. Kerala has the highest literacy rate followed by Mizoram. More than 94% of the rural population has access to

primary school within 1 km, while 98% of population benefits one school within a distance of 2 km. An upper primary school within a distance of 3 km is available for more than 96% of the people, whose 98% benefit the facility for secondary education within 8 km. The access for rural students to higher educational institutions in cities is facilitated by widely subsidized transport fares.

Bihar has the lowest literacy rate of 63.8% but it has showed a significant increment in last decade as it was just 47% in 2001. The Government of Bihar has launched several programs to boost literacy, and its Department of Adult Education even won a UNESCO award in 1981. Extensive impoverishment, entrenched hierarchical social divisions and the lack of correlation between educational attainment and job opportunities are often cited in studies of the hurdles literacy programs face in Bihar. Children from "lower castes" are frequently denied school attendance and harassed when they do attend. In areas where there is no discrimination, poor funding and impoverished families means that children often cannot afford textbooks and stationery. To incentivize students to attend, the government announced a Rupee 1 per school day grant to poor children who show-up to school.

Literacy rates also differ due to religious, social, and traditional aspects.

AGE STRUCTURE/PYRAMID

It is a graphical illustration that shows the distribution of various age groups in a human population (typically that of a country or region of the world), which ideally forms the shape of a pyramid when the region is healthy.

Population pyramids can be used to find the number of economic dependents being supported in a particular population. Economic dependents are defined as those under 15 (children who are in full time education and therefore unable to work) and those over 65 (those who have the option of being retired). It also helps us in understanding about the longetivity and aged population.

India has one of the largest proportions of population in the younger age groups in the world. 35.3% of the population of the country has been in the age group 0-14 years at the Census 2001. 41% of the population account for less than 18 years of age.

The Indian age pyramid is upright having large base but it will transits to contracting pyramid as of developed ones; having low birth rate and lower death rate.The inverted pyramid creates a problem of shortage of labour and increases the burden of care of large old aged people. Government has to redesign its policies according to needs.

Countries with a favorable age structure as those with a large proportion of working-age adults and relatively few dependents are generally more peaceful and democratic, allowing governments to better meet the needs of their people. An adverse age structure is more challenging to governments, particularly when national resources are insufficient to improve economic and social welfare.

ETHNIC COMPOSITION

Our present day population is a conglomeration of people belonging to different racial groups with different ethnic backgrounds. These people entered India from different parts of the world at different points of time adopting different land and water routes. In fact India has been a melting pot of various races and tribes from times immemorial. Almost all the major races of the world are visible in India as a result of which the country is said to have a varied and diverse ethnic composition. The present by population of the country has been derived mainly from the following racial groups:

1. The Negritos

According to Hutton, the earliest occupants of India were the people of Negrito race.S.K. Chatterjee and S.M. Katre have expressed the view that Negroid people migrated to India from Africa and established their language on the soil of India. A.C. Haddon opines that Negrito features are met with particularly amongst the Andaman islanders and most prob-

ably the Uralis Nilgiri hills, Kadors of Kochi, Pullayans of Palni hills, etc. Besides some tribes like the Angami Nagas in the north-east and the Badgis in the Rajmahal hills in Jharkhand etc. possessing some physical traits reminiscent of the Negrito are seen. The Negrito race is characterised by short stature, dark chocolate brown skin, wooly hair, bulbous forehead, broad flat nose and slightly protruding jaws.

2. The Proto-Australoids

Hutton is of the opinion that the Proto-Australoids came to India from the East Mediterranean are (Palestine). They came soon after the Negritos. Today they constitute the bulk of population in many isolated and semi-isolated parts of central land southern India. The Veddahs, Malavedahs, Irulas and Sholagas are the true representatives of Proto-Australoids. The Bhils, Kols, Badagas, Korwas, Kharwars, Mundas, Bhumjis and Malpaharis of the highlands of Central India and the Chenchus, Kurumbas, Malayans and Yeruvas of South India may all be treated as Proto- Australoids. Some anthropologists believe that the Proto-Australoids pushed, pressed, displaced and supplanted the negritos and forced them to shift to more inaccessible, remote and less hospitable areas, where they are found even today. In the process, there was some admixture of the two races, perhaps more so in the south than in the north. In physical appearance the Proto-Australoids more or less resemble the Negritors with the main exception that they do not have wooly hair like the Negritos. Their other Physical characterstics are bulbous forehead, broad flat nose and slightly protruding jaws.

3. The Mongoloid

According to Risley, "On its northern and eastern frontier. India marches with the great Mongoloid region of the earth".Most of the anthropolists believe China to be the homeland of the Monogoloid race from where they were pushed southward into the Mallaya penisula and Indonesia. They entered India through the passess in the northern or eastern mountains. Huttopn is of the Opinion that the bulk of Burma (Myammar) in any case is primarily Mongoloid, and any non-Mongoloid streams of migration that may reached India through Myammar have absorbed a vast quantity of Mongolian blood. There is also some evidence of a Mongloid Melansian intrusion from Oceania to Tamil Nadu and Kerala and probably that accounts for the occasional Mongoloid element noticed among the people of these states. Presently, they occupy large areas in Ladakh, Sikkim, Arunchal Pradeshand some other parts of east India. Some of the basic physical characteristics of the Mongloid race include a round and broad head, face with very high cheek bones and a long flat nose, with little or no hair on the face and the body. The tribes of Garo, Khasi, Jaintia, Lipchas, Chakmas, Murnis, Naga and Daffla belong to the Mongloid race.

The Mongoloid racial stock of India can be divided into two sub-groups as follows:

(i) Palaeo-Mongloids
(ii) Tibeto-Mongloids.

(i) Palaeo-Mongloids are further divided into broad headed and long headed sub-types. They settled mainly along the fringes of the Himalayas in Assam and the Myammar border.

(ii) Tibeto-Mongloids have come from Tibet as their name suggests. They are mostly living in Bhutan and Sikkim, as well as in the north-western Himalayas and Trans Himalayan regions.

4. The Mediterrraneans

The Mediterranean racial stock came to India from eastern Mediterranean region or South West Asia. They are believed to have migrated during the third and the second millennium B.C. This race has contributed much to the physical composition of peoples of India and also to it culture. They brought earlier forms of Austro-Asiatic languages and are believed to be the bearers of the earliest form of Hindustan into India. Palaeo-Mediterraneans are considered to be the first and the most ancient of all the Mediterranean races to enter India. Their physical chracterstics include medium stature, dark skin and long head. In all probability, They firsts settled in north-west India and started practising agriculture there. However, they were

pushed into central and southern India by subsequent immigrants. Today the Paleo- Mediterranean stock forms the bulk of population of south India and a considerable proportion of population in northern India. The Mediterraneans were the chief architects of the Indus Valley Civilization as is evident from the excavations of Mohanjo Daro and Harappa.

5. Brachyephals

Brachycephal groups of races of India are characterised by broad heads. Coorgis and Parsis are representatives of the Brachycephals in India. These are sub-divided into three major groups.

(i) Alpinoids. Alpinoids came to India along the route passing through Baluchistan, Sind, Kathiawar, Gujarat, Maharashtra, Karnataka and Tamil Nadu.

(i) Dinarics. Dinarics followed the Ganga vallely and its delta as their route to enter India.

(ii) Armenoids. Chitral, Gilgit, Kashmir and Nepal formed the third route for the Amenoids of the Brachycephal group of races to enter India.

6. The Nordics

The Nordics constitute the last wave of migration into India. They spoke Aryan language and migrated to India some time during the second millennium B.C. The main concentration of these people is in the north-western part of the country. They are a predominat type in Punjab, Haryana and Rajasthan. They are mostly represented among the upper castes of North India particularly in Punjab. The main characterstics of this race are long head, fair complexion, well developed nose and a well built, strong body.

TRIBAL POPULATION

The tribes are the autochthonous people of the land who are believed to be the earliest settlers in the Indian Peninsula. They are generally called adivasis, implying original inhabitants. The ancient and medieval literature mention a large number of tribes living in India. Before the introduction of the caste system during the Brahminic Age, people were divided into various tribes. A tribe was a homogenoeous and self contained unit without any hierachical discrimination.

The study of tribal population suffers from serious anomalies as there is no clear cut and scientific criteria for this purpose. For example, the Gonds are a Scheduled Tribe in Madhya Pradesh, but a Scheduled Caste in Uttar Pradesh. This problem of anomalies is further aggravated in the case of transhumance groups like the Gujjars of north-western India. A Gujjar Bakarwal Kafila when pasturing in Himachal Pradesh during summer belongs to the scheduled category and the same group loses this status in its winter pastures on the Jammu plains.

The growth of Scheduled Tribes population are due to following two reasons:

(i) There has been a rapid natural growth of tribal population and

(ii) Additions have been made to the list Scheduled Tribes time and again

An appraisal of the distribution pattern of the tribal communities shows that their spatial distribution is characterised by a striking tendency of clustering and concentrating in pockets,which have suffered from isolation are are situated in areas where environmental setting is, by and large, not suitable for settled agriculture. Thus, most of the tribal communities live in hilly and forested tracts and other remote areas of the country. Constrained by rigors of environment, which fostered physical and social isolation for ages, the tribal communities have developed their own traditional mode of living. However, the interaction between tribal and non-tribal people after Independence has changed the scenario to some extent.

Further, it is intersting to note that while no caste has been scheduled in Nagaland, Andaman and Nicobar Islands and Ladehhadeep, no tribe has been scheduled in the states of Haryana and Punjab and the Union Territories of Chandigarh, Delhi and Pondicherry.

Components of the Tribal Action Plan:

Tribal Action Plans may include but not be limited to the following elements:

- Profile population needs
- Mobilize/build capacity to address needs
- Develop Comprehensive Strategic Plan
- Implement infrastructure development and evidence based prevention and/or treatment programs
- Monitor, evaluate, sustain, and improve processes

1987, the Tribal Cooperative Marketing Development Federation of India Limited was set up with an aim to serve the interest of the tribal community and work for their socio economic development by conducting its affairs in a professional, democratic and autonomous manner for undertaking marketing of tribal products.

Further to achieve the aim of accelerating the economic development of tribal people by providing wider exposure to their art and crafts, TRIBES INDIA, the exclusive shops of tribal artifacts were set up all over India by TRIFED. They showcase and market the art and craft items produced by the tribal people and thus demonstrate the magical mystique of tribal India espousing tribal cause.

MIGRATION

The term migration refers to the movement of population from one place to another. It may be temporary or permanent. Migration has three fold impacts

a) On the area experiencing immigration
b) On the area experiencing out migration
c) On the migrants themselves

The purpose of migration may be employment, business, education, family movement, marriage, calamity etc.

In India the rural areas suffering from poverty, unemployment produce push effects from where rural youths in large number, migrate to mega cities and industrial towns which have pulling effects due to better job prospects and better living conditions. This type of migration forms the largest share of percentage of migration in India whereas other types are urban to urban, rural to rural, urban to rural.

OPTIMUM POPULATION CONCEPT

Optimum population denotes the maximum population a country can sustain if it uses its resources at its fullest. Optimum population may be defined as the type of population which when combined with the available resources and the given level of existing technology secure a maximum return per head. Optimum population is neither too small nor too large. In other words, optimum population stands in between the two other extremes of over population and under population. It is the best type of population and it differs from country to country and from time to time. Optimum population is dynamic; hence it changes according to the changing quantity and quality of a country's available resources.

Implications:

1. At a given level of technology, it balances population with available resources.
2. The management or control of economy that has optimum population is very easy.
3. An optimum population ensures or secures a maximum return per head.
4. An optimum population is the population that produces full employment.
5. Optimum population is a dynamic population that changes with the changing quantity and quality of a country's available resources.
6. Optimum population also ensures the highest standard of living in a country.

This concept is not as futile for developing country India as for other developed countries. India is said to be overpopulated but if concept of optimum population is applied might be Indian resources can support more population, if used properly with new and innovative technologies.

Thus optimum population is a dynamic and theoretical concept.

As in India if yield of wheat in one hectare is 25 tonnes (superficial) whereas if better seeds, new technologies, organic fertilizers etc are be

used it might reach 50 tonnes. Now it can support more people thus optimum population differs with the proper utilization of technologies done. It is based on economic concept.

EFFECTS OF POPULATION EXPLOSION

The current rate of population growth in India is 1.58% and the total fertility rate is 2.62. Although the total fertility rate has decreased, due to the increase in the total number of women between the ages of 15 and 44 (reproductive ages), the total number of births has increased. This has lead to the current enormous population size of approximately 1 billion. This has greatly hampered the development of the Indian economy. The amount of resources that could have been available to one person a few years ago now need to be shared between two people, which are not sufficient for either of them. The population increase has lead to air and water pollution, unemployment, poverty, lack of educational resources, and even malnourished women and children.

I. Air pollution:

The technological development of India has lead not only to medical advancements, but also to an increase in the number of factories. That has lead to air and water pollution. More energy needs to be produced to power these factories. When fossil fuels - the world's major source of energy - are burnt, gases are added to the atmosphere. Many cities in India have crossed the limits of suspended particulate matter, sulfur dioxide, and other pollutants due to vehicular and industrial emissions

As the population grows, more and more forests are cleared. The two most common reasons for deforestation are to make houses for increased number of people to live in, and to use wood as a fuel in the industries. As a result, the trees that help us in reducing the air pollution through the process of photosynthesis are not able to do so any more.Some of the diseases caused by air pollution are "respiratory diseases, asthma, chronic obstructive pulmonary disease, cardiovascular disease and cancer of the lung". Due to the tropical climate of India, air pollution also causes smog which may result in headaches, dizziness, breathing difficulties, or even mass illness due to carbon monoxide. This slow murder goes unnoticed because people die of diseases like cancer, asthma, and heart problems after long exposures to deadly air pollutants.

Besides the untimely deaths of several thousands of people every year due to air pollution, the pollutants also have a deadly impact on our national heritage - the historical monuments that have made India proud for centuries. A classic example of the air pollution effect is the TAJ MAHAL in India. The sulfur dioxide in the air because of the pollution caused by the neighboring industries mixes with atmospheric moisture and settles as sulfuric acid on the surface of the tomb, making the smooth white marble yellow and flaky, and forming a subtle fungus that experts have named "marble cancer". Trying to save the monument might mean closing down several industries in the neighborhood. However, this means that several thousands of people would lose their jobs, resulting in eventual poverty. This again brings us to the same problem that is the root of all the problems - population increase.

One of the major issues that have lately been bothering environmentalists all over the world is global warming. Like glass in a greenhouse, gases like carbon monoxide admit the sun's light but tend to reflect back downward the heat that is radiated from the ground below, trapping heat in the earth's atmosphere. This is called the greenhouse effect. However, due to the increase in pollution, especially due to carbon dioxide and chlorofluorocarbons, the ozone layer is getting depleted. This layer plays the major role in controlling the temperature of earth, saving it from the harmful effect of the ultraviolet radiation of the sun. However, with the depletion of the ozone layer on the rise, the temperature of the earth is increasing. This is global warming. As we know that India is mainly an agrarian country, temperature and climate plays an important role in the economy of the country. Global warming affects the main crops in India in following ways:

1. Researchers have estimated that only a 2° C increase in mean air temperatures will be enough to decrease the rice yield by 0.75 ton / hectare in high-yield areas like Punjab, Haryana and Uttar Pradesh.
2. It is also estimated that a drastic increase in greenhouse gases like carbon dioxide may cause wheat production to fall as much as 68%.
3. Additionally, the changing climatic conditions have the potential to significantly increase tropical disturbances like cyclones and storms in coastal regions.

The effect on crops greatly hampers the economy of the country, especially for those farmers who solely depend on agriculture for their survival. For them, the loss of one crop would lead to a plunge into absolute poverty, and thus, the vicious cycle of poverty and population explosion continues. The effect of air pollution on the climatic conditions reveals that air pollution not only affects our environment, but it also greatly endangers the lives of everybody. This means that if the number of people increases the carrying capacity, the mere survival of human beings poses a threat to the lives of all human beings.

II. Water Pollution:

Air pollution is not the only environmental damage being done by the increasing population. Nowadays water pollution is also one of the increasing problems due to the population explosion. Water is considered the essence of life. There is no life without water. One might think that 70% of the earth is covered with water, so, why worry about the water problem? In fact, 3 sides of the Indian subcontinent are surrounded by water. And there are several rivers, lakes, and other sources of water within the country as well. However the fact is that less than 3 percent of that water we see can be used for human consumption and industrial uses. Nearly 10 percent of the world's population faces chronic freshwater shortage. This figure may rise if the population growth is uncontrolled. As in the case of air pollution, the increasing population calls for increasing numbers of factories. These factories lead to various kinds of pollution, including water pollution. Also, India being an agrarian country, the water pollution also comes from pesticides used for agriculture. Some of the major types of pollutants are:

1. Petroleum products required for automobiles, cooking, and other such human activities.
2. Pesticides and herbicides used for agriculture by the Indian farmers.
3. Heavy metals from industries, automobiles' exhausts and mines.
4. Hazardous wastes.
5. Excessive organic matter like fertilizers and other organic matter used by farmers.
6. Sediments caused by soil erosion produced by strip mines, agriculture and roads.
7. Thermal pollution caused by deforestation.

One of the classic examples of water pollution in India is the RIVER GANGA. This river is considered sacred and incorruptible. People bathe in it for spiritual renewal and drink water from it. But people do not realize that along with washing off their sins in the river, they are also washing off their body wastes, leading to polluting the holy water of the river. Also, cremated and partially cremated bodies are dumped into the river. Although, dumping these bodies is a religious act in India among the Hindus, but at what cost? Thus, with the increasing population, the number of people dying is also increasing, and so is the pollution in the river Ganga. In addition, the nearby factories and human colonies dump sewage directly into the river. Recent studies show that there are more than 25,000 small-scale industries in just one of the states sharing the river and dispose off their waste in the river.

As we can observe, the increased population size is leading to increased pollution, which in turn is leading to a more hostile environment for human beings themselves.

III. Unemployment and Illiteracy:

With the increasing number of people, we have to share our resources with even more people. Resources of all types are limited, even employment, especially in India. India, being a

developing country, has a limited number of jobs available. Due to the increasing number of people, the competition for the most menial jobs is also tremendous. Several highly educated people with Bachelor's and Master's degrees in India sit at home, because they cannot find jobs.

Such unemployment and underemployment leads to corruption and exploitation of people by the richer classes of the society. This lack of resources further leads to lack of educational resources. Due to the unavailability of resources, parents cannot afford to educate their children to higher levels. Some parents simply cannot afford to teach their children further, and in some families, children need to work along with their parents in order to bring food to the table. According to the World Bank Group, "about 32 million primary school-age children, mostly girls or those from the poorest households and disadvantaged groups are not in school; more than half of rural students drop out before completing the primary cycle, and only one-third of females make it to the secondary level." In addition, "nearly half the population over 15 years old and about 60 percent of all women over 15 years old is illiterate." Also, basic education has become a commodity that acts on the basis of supply and demand. Basic education has become too expensive in India for a commoner to afford for his/her children. Lack of education further leads to even more unemployment. Due to these reasons, a major part of the population is either illiterate or has the most minimum education leading them to accept minimal work in which they cannot even support themselves.

Unemployment, or underemployment, further leads to poverty. This again starts the vicious cycle of poverty and population explosion discussed above. Poverty leads to an increase in the population, because poverty leads people to produce more children to increase the earning members of the family. This increases the population size of India, which further increases the unemployment rate and lack of educational facilities leading to poverty that started this whole cycle.

IV. Food Resources

Resources are always limited. And in a developing and highly populous country like India, resources are even scarcer. Population explosion results in the shortage of even the most basic resources like food. According to an article by World Bank Group, "...more than half of all children under the age of four are malnourished, 30 percent of newborns are significantly underweight, and 60 percent of women are anemic." Resources are limited everywhere. India spends approximately $10 billion each year on malnutrition and even then the government of India cannot provide the everyday nutritional requirements to everybody in India.

URBANISATION IN INDIA

Urbanization is a socio-economic process by which an increasing proportion of the population of an area becomes concentrated into towns and cities. It includes two things - an increase in the number of people living in urban settlements and an increase in the percentage of the population engaged in non agricultural activities.

Problem of Urbanisation in India

Although India is one of the less urbanized country of the world with only 27.78 per cent of her population living in urban agglomerations/towns, this country is facing a serious crisis of urban growth at the present time. Whereas urbanisation has been an instrument of economic, social and political progress, it has led to serious socio-economic problems. The sheer magnitude of the urban population, haphazard and unplanned growth of urban areas, and a desperate lack of infrastructure are the main causes of such a situation. The rapid growth of urban areas, and a desperate lack of infrastructure are the main causes of such a situation. The rapid growth of urban population both natural and through migration, has put heavy pressure on public utilities like housing, sanitation, transport, water, electricity, health, education and so on. Poverty, unemployment and under employment among the rural immigrants, beggary, thefts, dacoities, bur-

glaries and other social evils are on rampage, Urban sprawl is rapidly encroaching the precious agricultural land. The urban population of Indian had already crossed the 285 million mark by 2001. By 2030, more than 50 per cent of India's population is expected to live in urban areas. Following problems need to be highlighted:

1. Urban Sprawl

Urban sprawl or real expansion of the cities, both in population and geographical area, of rapidly growning cities is the root cause of urban problems. In most cities the economic base is incapable of dealing with the problems created by their excessive size. Massive immigration from rural areas as well as from small towns into big cities has taken place almost consistently; thereby adding to the size of cities.Such hyperubanissation leads to projected cities sizes of which defies imagination. Delhi, Mumbai, Kolkata, Chennai, Banglore, etc. are examples of urban sprawl due to large scale migraion of people from the surrounding areas.

In several big cities wealthy people are constantly moving from the crowded centres of the cities to the more pleasant suburbs where they can build larger houses and enjoy the space and privacy of a garden around the house. In some cities, the outskirts are also added to by squatters who build makeshift shacks of unused land although they have no legal right to the land. The difficulty of restricting town growth in either case is immense and most towns and cities are surrounded by wide rings of suburbs.

2. Overcrowding

Overcrowding is a situation in which too many people live in too little space. Overcrowding is a logical consequence of over-population in urban areas. It is naturally expected that cities having a large size of population squeezed in a small space must suffer from overcrowding. This is well exhibited by almost all the big cities of India. For example, Mumbai has one-sixth of an acre open space per thousand population though four acre is suggested standard by the Master Plan of Greater Mumbai. Metropolitan cities of India are overcrowded both in 'absolute' and 'relative' terms. Absolute in the sense that these cities have a real high density of population; relative in the sense that even if the densities are not very high the problem of providing services and other facilities to the city dwellers makes it so. Delhi has a population density of 9,340 persons per sq km (Census 2001) which is the highest in India. This is the overall population density for the Union territory of Delhi. Population demsity in central part of Delhi could be much higher. This leads to tremendous perssure on infrastructural facilities like housing, electricity, water, transport, employment, etc. Efforts to decongest Delhi by deveoping ring towns has not met with the required success.

3. Housing

Overcrowding leads to a chronic problem of shortage of houses in urban areas. This problem is specifically more acute in those urban areas where there is large influx of unemployed or underemployed immigrants who have no place to live in when they enter cities/towns from the sourrounding areas. Moreover, the current rate of housing construction is very slow which makes the problem further complicated. Indian cities require annually about 2.5 million new dwellings but less than 15 per cent of the requirement is being constructed.

Several factors are responsible for the sad state of affairs with respect to housing problems faced by the urban people. The major factors are shortage of building materials and financial resources, inadequate expansion of public utilities into sub-urban areas, poverty and unemployment of urban immigrants, strong caste and family ties and lack of adequate transporation to sub-urban areas where most of the vacant land for new construction is located.

4. Unemployment

The problem of unemployment is no less serious than the problem of housing mentioned above. Urban unemployment in India is estimated at 15 to 25 per cent of the labour force. This percentage is even higher among the edu-

cated people. It is estimated that about half of all educated urban unemployed are concentrated in four metropolitan cities (Delhi, Mumbai, Kolkata, Chennai). Furthermore, although urban incomes are higher than the rural incomes, they are appallingly low in view of high cost of living in urban areas.

One of the major causes of urban unemployment is the large scale migration of people from rural to urban areas. Rural-urban migration has been continuing for a pretty long time but it has not always been as great a problem as it is today. The general poverty among the rural people pushes them out to urban areas to migrate in search of livelihood and in the hope ofa better living. But the growth of economic opportunities fail to keep pace with the quantum of immigraration. The limited capacity of urban areas could not create enough employment opportunities and absorb the rapid growth of urban labour force.

5. Slums and Squatter Settlements

The natural sequel of unchecked, unplanned and haphazard growth of urban areas is the growth and spread of slums and squatter settlements which present a striking feature in the ecological structure of Indian cities, especially of metropolitian centres.

The rapid urbanisation in conjuction with industrialisation has resulted in the growth of slums. The proliferation of slums occurs due to many factors; the shortage of developed land for housing, the high prices of land beyond the reach of urban poor, a large influx of rural migrants to the cities in search of jobs etc. In spite of several efforts by the Central and State Government to contain the number of slum dwellers, their growth has been increasing sharply exerting tremendous pressure on the existing civic amenities and social infrastructure.

New Definition of Slums: Any compact housing cluster or settlement of at least 20 households with a collection of poorly built tenements which are, mostly temporary in nature with inadequate sanitary, drinking water facilities and unhygienic conditions will be termed as slums.

Slums are known by different names in different cities. They are called bustees in Kolkata, jhuggijhoparies in Delhi, Jhorparpattis or Chawl in Mumbai and Cheri in Chennai.

6. Transport

With traffic bottleneck and traffic congestion, almost all cities and towns of India are suffering from acute form of trasport problem. Transport problems increase and become more complex as the town grows in size. With its growth, the town performs varied and complex functions and more people travel to work or shop. As the town becomes larger, even people living within the built-up area have to travel by car or bus to cross the town and outsiders naturally bring their cars or travel by public transport. Wherever, trade is important, commercial vehicle such as vans and trucks will make problem of traffic more complicated.

Since most of the commercial activities of the towns are concenttated in the Central Business District (C.B.D.). the centres are areas of greatest congesion. However, other parts of the town are not free from traffic congestion. Such areas include the roads leading to factories, offices, schools, etc., which will be thronged with people in morning and evening; minor shopping centres which grow up in the suburbs; sporting arenas, entertainment districts which will be busy at night, roads leading to residential and dormitory towns which will be busy when commuters flock to the cities in the morning to work and return home in the evenings. Such congestion becomes greater when the centre is built up in tall skyscraper blocks whose offices sometimes employ thousands of workers, because at the end of the office hours everyone leaves the building within a short space of time to make their way home. This puts tremendous pressure on public transport and causes journeys to take much longer period than they normally would.In most cities the rush hour or peak traffic hour lasts for about two hours and during that period buses and trains are crammed

to capacity, roads are overcrowded with vehichles and the movement of traffic becomes very slow.

7. Water

What is one of the most esssential of nature to sustain life and right from the beginning of urban civilisation, sites for settlements have always been chosen keeping in view the availability of water to the inhabitants of the settlements. However, supply of water started falling short of demand as the cities grew in size and number. Today we have reached a stage where practically no city in India gets sufficient water to meet the needs of city dwellers. In many cities people get water from the municipal sources for less than half an hour every alternate day. In dry summer season, taps remain dry for days together and people are denied water supply at a time when they need it the most. The individual towns require water in larger quantities, Many small towns have no main water suppply at all and depend on such sources as individual tubewells, household open wells or even rivers. Acclerated Urban Water Supply Programme (AUWSP) was launched to provide water to towns with population of less than 20,000. Keeping in view the increased demarks for water by the urban population, Central Public Health and Environmental Engineering Organisation (CPGEEI) fixed 125-200 litres oif water per head per day for cities with a population of more than 50,000, 100-125 litres for population between 10,000 and 50,000 and 70-100 litres for towns with a popultion below 10,000 cities and towns. To meet the growing demand for water, many cities are trying to tap external sources of water supply. Mumbai draws water from neighbouring areas and from sources located as far as 125 km in the Western Ghats. Chennai uses water express trains to meets its growing demand for water. Bangalore is located on the plateau and draws water from Cauvery river at a distance of 100 km. Water for Bangalore has to be lifted about 700 metres with help of lifting pumps. Hyderabad depends on Nagarjuna Sagar located 137 km away. Delhi meets large part of its water requirements from Tajiwala in Haryana. Water is also drawn from Ramganga as far as 180 km.

8. Sewarage Problems

Urban areas in India are almost invariably plagued with insufficient and inefficient sewage facilities. Not a single city in India is fully sewered. Resources crunch faced by the municipalities and unauthorised growth of the cities are two major causes of this pathetic state opf affairs. Most of the cities have old sewerage lines which are not looked after properly. Often sewerage lines break down or they are overflowing. Most cities do not have proper arrangements for treating the sewerage waste and it is drained into a nearby river (as in Delhi) or in sea (as in Mumbai, Kolkata and Chennai), thereby polluting the water bodies.

In most cities, water pipes run in close proximity to sewer lines. Any leakage leads to contamination of water which results in the spread of several water borne diseases.

9. Trash Disposal

As Indian cities grow in number and size the problem of trash disposal is assuming alarming proportions. Huge quantities of garbage produced by our cities pose a serious health problem. Most cities do not have proper arrangements for garbage disposal and the existing landfills are full to the brim. These landfills are hotbeds of disease and innumerable poisons leaking into their surroundings. Wastes putrefy in the open inviting disease carrying files and rats and a filthy, poisonous liquid, called leachate, which leaks out from below and contaninates ground water. People who live near the rotting garbage and raw sewage fall easy victims to several diseases like dysentery, malaria plague, jaundice, diarrhoea, typhoid, etc.

10. Problem of Urban Pollution

With rapid pace of urbanisation, industries and transport systems grow rather out of pro-

portions. These developments are primarly responsibe for pollution of environment, particularly the urban environment.

SATELLITE TOWN

A satellite town or satellite city is a concept in urban planning that refers essentially to smaller metropolitan areas which are located somewhat near to, but are mostly independent of, larger metropolitan areas.

Satellite cities are small or medium-sized cities near a large metropolis, that:

a) predate that metropolis' suburban expansion.
b) are at least partially independent from that metropolis economically and socially.
c) are physically separated from the metropolis by rural territory or by a major geographic barrier such as a large river; satellite cities should have their own independent urbanized area, or equivalent.
d) have a traditional downtown surrounded by traditional "inner city" neighborhoods.
e) May or may not be counted as part of the large metropolis' Combined Statistical Area.

RURAL-URBAN FRINGE

The rural-urban fringe is the zone of transition in land use, social and demographic characteristics, lying between (a) the continuously built- up urban and suburban areas of the central city, and (b) the rural hinterland, characterized by the almost complete absence of non farm dwellings, occupations and land use, and of semi-urban and rural social orientation; an incomplete range and penetration of urban utility services; uncoordinated zoning or planning regulations; a real extension beyond although contiguous with the political boundary of the central city; and an actual and potential increase in population density, with the current density above that of surrounding rural districts but lower than the central city.

These lands are basically used for housing, instituitional settings, hyper markets and super store etc. These are also used for growing perishable items as vegetables for easy transportation to city centres.now a days rural urban fringe is facing problems of land degradation, air pollution, traffic congestion, illegal land acquisition etc. ■■■

10 REGIONAL PLANNING

Planning is a method of achieving economic prosperity by the optimum utilization of the resources of a region or country. Also it is an effort towards attaining self sufficiency and narrowing the inter and intra regional disparities and preparing ideal conditions for development.

SOME AREA SPECIFIC DEVELOPMENT PROGRAMMES

1. Command area Development Programme

During the post independence period high priority was accorded to increase agricultural production and productivity for providing food security to the people thus a number of irrigation projects were constructed. The surface irrigation potential, which stood at 22.6 m.ha till 1950-51, had increased to 33.6 m.ha. by mid-sixties. In the later years, it was realized that the irrigation potential created was not being fully utilized and substantial gap existed due to which the purpose of irrigation projects was not fully met. The gap between irrigation potential created and irrigation potential utilized prompted the Irrigation Commission in 1972 to make specific recommendations for systematic and integrated development of commands of irrigation projects.

Thus centrally sponsored Command Area Development (CAD) Programme was launched in 1974-75 with the main objectives of improving the utilization of created irrigation potential and optimizing agriculture production and productivity from irrigated agriculture through a multi-disciplinary team under an Area Development Authority.

Components of the Programme

- On-Farm Development (OFD) works i.e. Development of field channels and field drains within the command of each Outlet; Land levelling on an outlet command basis; Reclamation of waterlogged areas; Enforcement of a proper system of "WARABANDI" and fair distribution of water to individual fields; Realignment of field boundaries, wherever necessary (where possible, consolidation of holding should also to be combined); Supply of all inputs and services - including credit; Strengthening of extension services; and, Encouraging farmers for Participatory Irrigation Management (PIM).
- Selection and introduction of suitable cropping pattern.
- Development of ground water to supplement surface irrigation (conjunctive use under Minor Irrigation sector).
- Development and maintenance of the main and intermediate drainage system (irrigation sector).
- Modernization, maintenance and efficient operation of the irrigation system up to the outlet of one-cusec capacity (irrigation sector)

Implementation of this programme has helped in bringing the land under irrigation rapidly, increase in water use efficiency, agricultural production and productivity, changes in the cropping pattern of the area.

But it has posed the environmental problems as water logging and soil salinity due to lack of

proper drainage and overuse of irrigation facility.

2. Hill Area Development Programme

The hill area of a country due to their difficult terrain, variable agro-climatic conditions and distinct socio-cultural features, face problems inhibiting their process of development. Thus, it was realized that adequate steps are needed for proper and efficient utilization of the resources of the hilly areas. Hence Hill Area Development Programme was introduced in the fifth year plan to initiate the socio-economic development of the hilly areas of the country.

The objectives of the program include eco-preservation and eco-restoration with the focus on sustainable use biodiversity, ensuring community participation in the design and implementation of the strategies for the biodiversity and sustainable livelihood.

Areas of Concern

- **Land Use Pattern:** The current land-use pattern either in the form of jhuming in the eastern Himalayan region or in the form of indiscriminate deforestation for a variety of purposes in the Western region is leading to eco-catastrophes of various kinds. It is widely accepted that in the hills and in undulating terrain, it would be wise to grow perennial plants and to promote scientific animal husbandry. Horticulture, particularly apple cultivation, has received widespread interest not only in Jammu and Kashmir, Himachal Pradesh and Uttarakhand but also in Arunachal Pradesh and parts of eastern Himalayan region. Proper land use patterns should be laid for conservation of biodiversity.
- **Soil Erosion:** The damage that soil erosion causes to the hill areas, including its impact on irrigation projects is well known. In this context, it is necessary to evolve; in integrated strategy in the hill areas of mini-watershed management. Besides the technology as applied to these areas in fields like road construction, power, irrigation and industrial projects would need constant review to avoid unfavourable consequences like landslides and erosion.
- **Forestry:** Forestry is essential not only for eco-preservation but also for fuel, human and animal nutrition, limber and raw-material for industry. It also provides wind barrier to agriculture and shade for plantations of coffee, tea, spices, etc. Preventing further deforestation and promoting extensive planting of these are both necessary. Afforestation of catchment areas is of very high priority for preventing soil erosion as well as regulating water supply. Suitable agro-forestry techniques would be fostered in such areas.
- **Animal Husbandry:** In spite of the opportunities offered by favourable climate, the economic potential offered for dairying, sheep and other animal husbandry in the hill areas has not been fully tapped. In many hill regions the problem, is of over-grazing due to uncontrolled animal population and poor management. The scientific management of these lands can increase the yield of fodder and support effectively a large animal population. The animal husbandry programme will need a strong preventive and curative animal health programme, together with processing and marketing of the produce.
- **Conservation and Environment:** The hill areas, particularly, the Himalayan region is rich in genetic material of medicinal and food plants, fruits, including citrus and a wide range of other economic plants, orchids and other flowers. Some rare wild life still occurs in these areas. It would be important to have an integrated strategy for the preservation of the valuable flora and fauna through a chain of biosphere reserves, national parks and gene-sanctuaries.

For the scientific planning of the hill areas in the country, vital information on resources e.g., occurrence of minerals, soil characteristics, vegetation types and characteristics, estimation of the volume of surface and sub-surface flow

in watersheds, etc., is required. Such information also needs to be constantly updated. Remote-sensing techniques and air-photo interpretation combined with ground truth studies hold great possibilities for this purpose. A perspective plan spelling out the long-term and short-term developments in the area need to be drawn up. Plans also need to be drawn up for the regional, sub-regional, taluka (block) and settlement levels.

While the use of legal and executive powers to provide necessary protection to the environment should be made effective, far more reliance should be placed on people's action to achieve the desired results. The need for increasing public awareness about the environmental issues and public participation is required.

3. Desert Area Development Programme

The desert development programme aimed at checking further desertification of the desert areas and raising productivity of the local resources to raise the income and employment levels of local inhabitants.

The programme had been implemented both in the hot and cold desert. The programme put emphasis on arresting desertification through activities which restore ecological balance, stabilize sand dunes and facilitate soil and water conservation. Plantation of shelter belts, adaptation of water harvesting techniques and development of pastures to sustain the livestock economy were some of the strategies followed under the scheme.

The major elements of the new strategy are:

- Area development under the programme to be taken up on watershed basis only and a watershed development project of about 500 hectares would be the field unit for implementation over a period of four to five years. A watershed development project should cover a village, as far as possible.
- However, in some sandy areas where it is not physically feasible to demarcate a watershed, programme is to be implemented by adopting either a cluster of villages or an Index Catchment as the unit of planning.
- Direct participation of the local people in planning and development of watershed project areas as well as in the maintenance of assets after the project is completed.
- The Panchayati Raj Institutions were responsible for monitoring and reviewing the programme at district, block and village levels up to 2002-03. Under new HARYALI Guidelines the Panchayati Raj Institutions would function as Project Implementation Agencies(PIA) for the Watershed Development Projects
- Keeping in view the problem of sand dune stabilization in 10 districts of Rajasthan, special projects would be taken up for three activities namely sand dune stabilization, shelter belt plantation and afforestation.

4. Drought Prone Area Programmes (DPAP)

This programme was initiated in 1974. The intent was to change DPAP from a relief and employment oriented programme into one aimed at 'drought proofing' through adoption of an inegrated area development approach which sought to mitigate the impact of future droughts by stabilizing both production and employment. The programme was conceived as a long term measure for resoration of ecological balance by conserving, developing and harvesting land, water, livestock and human resources. The objectives of the programme are:

(i) To minimise the adverse effects of drought on production of crops and livestock and productivity of land, water and human resources through intergrated development of the natural resource base of the area and adoption of approproate technologies.

(ii) To conserve, develop and harness land, water and other natural resources including rainfall for restoration of ecological balance in the long run.

DPAP is under implementation in 629 blocks of 96 districts in 13 states. The total area covered under this programme is about 5.54 lakh sq km.

5. Integrated Watershed Management

Intetrated watershed management as a preventing measure plays a key role in moderating drought conditions. This approach ensures planning on the basis of the total available water resources, conjunctive use of surface and groundwater, allocating priority for rational use of water and also the preparation of a coordinated plan. Thus, watershed management hold the promise conservation of land and water resources and their optimal utilization in reality. Under the National Watershed Programme for Rainfed Areas, a large number of watersheds have been established in different rainfed regions of the country.

REGIONAL DISPARITY

Regional disparity signifies the different phases of development occurring in different parts of the country. After independence due to shortage of resources government implemented trickle down theory for development in the country. This theory proposed that development at one place will automatically leads to development of nearby regions i.e. if an industry has been established in an area it will lead to overall development of the region around it. But this policy of government failed to provide fruits of development to the nearby villages and regions.

This unequal development of region widens the gap between have and haves and have not thus leaded to regional disparity. An in Orissa the area near the coastal plains are more developed than the interiors. Similarly in Uttar Pradesh west U.P. is more advanced economically than the bundelkhand region irrespective of vast mineral resources. Thus regional disparity can be natural (in terms of resources available) or can be manmade (unequal economic growth).

Government has proposed many incentives and schemes for the development of backward region but poor implementation mechanism has further broadened the regional disparity.

LPG era has further worsened the situation because more developed regions has been able to attract multinationals and FDI and underdeveloped regions are left behind, widening the gap and acting as obstacle in the field of inclusive growth. ■■■

11 NATURAL HAZARDS

A disaster is a natural or man-made hazard that causes significant physical damage or destruction, loss of life, or drastic change to the environment. A disaster can be ostensively defined as any tragic event with great loss stemming from events such as earthquakes, floods, catastrophic accidents, fires, or explosions.

Some are discussed below:

EARTHQUAKE

Earthquakes are the main seismic hazards. They affect at least 35 countries and kill directly more people per year, on average, than any other hazard. All the phenomena related to the emergence and manifestations of earthquakes are called seismic.

The term earthquake covers any vibration of the earth's surface brought about by natural causes. From the standpoint of tectonic, events creation and destruction of geo materials and movements of plate margins cause earthquake. There are three types of plate margins involved in earthquake.

Constructive plate margins are characterized by continuous addition of geo materials as there is constant upwelling of molten materials from below along the mid-oceanic ridges. This is also known as divergent plate's margin. Divergent plates move in opposite direction.

Destructive plate margins are those where two convergent plates collide against each other and the heavier plate margin is subducted below the relatively lighter plate margin. This results in constant loss of crustal materials and cause earthquake of high magnitude.

Conservative plate margins are those where two plates slip past each other without any collision. This process results neither in the creation nor in the destruction of crust. Major tectonic events associated with these plate margins are rupture and faults along the constructive plate margins.

Indian Scenario

Depending upon the frequency and intensity of the earthquakes, the whole country can be divided into three broad seismiligical zones.

1. **Himalayan Zone:** The areas most prone to earthquakes in India are the fold mountain ranges of the Himalayan zone. The states of Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Bihar, the Bihar-Nepal border and the north eastern states, especially Assam fall in this zone. The earthquake in this zone are primarily due to plate tectonics. The Indian plate is pushing in the north and north-east direction at an annual rate of 5 cm subducting the Eurasian plate along the Himalayas. The Himalayas have not yet attained isostatic equilibrium and are rising. The region along the Himalayas where two plates meet is highly earthquakt-prone. This is known as the zone of maximum intensity. The absence of Nepal from the list of earthquakes shows that the whole of Himalayas are not dangerous. The Himalayas between Mount Everest and Badrinath are almost peaceful. This patch of tremendously huge landmass, having great heights and width rested with perfect calm and peace. The patches towards and beyond this patch are, however, very violent because of their hurried

movement. Areas north-eash of the arc joining Mussoorie, Shimla, Kangra, Dalhousie, Gulmarg and areas of Bihar, Assam, south of south-east Nepal, Sikkim, Bhutan, Arunchal Pradesh and western part of Nagaland, Manipur are susceptible to high magnitude earthquakes.

2. **The Indo-Gangetic Zone:** To the south of the Himalayan zone and running parallel it is the Indo-Gangetic zone. Most of the earthquakes striking this zone are of moderate intensity of 6 to 6.5 on Richter scale. Therefore, this zone is called the zone of comparative intensity. The earthquakes along the foothill are of medium to high intensity. However, the earthquakes of this zone are more harmful due to high density of population in this area.
3. **The Peninsular Zone:** The Peninsular India has presumably remained a stable landmass and only a few earthquakes have been experienced in this region. This region is, therefore, called the zone of minimum intensity. But severe earthquakes of Koyna (1967), Latur (1993) and Jabalpur (1907), have raised doubts about the seismic stability of this landmass. While the Koyna earthquake was caused due to excessive loading of water in the Shivaji Sagar reservoir formed by damming the Koyna River, the earthquake that hit Latur is supposed to be the result of plate tectonics. The northward drift of the Indian Plate had put pressure on the Tibetan Plate which caused pressure to mount at the centre of the Indian platel, leading to earthquake. The earthquake of Jabalpur also occurred under similar conditions.

The country as a whole has been divided into zones by horizontal seismic coefficient isolines. This coefficient varies from 0.01 to 0.08. The low horizontal seismic coefficient zone (0.01-0.02) constitues the areas that are quite secure from earthquakes. This zone is mainly spread over extensive parts of peninsular India Madhya Pradesh and Rajasthan Areas having medium horizontal seismaic coefficient (0.04-0.05) are spread over the Satluj-Ganga plain, Godavari basin of Andhra Pradesh, Ratnagiri and Raigad districts of Maharashtra and some parts of Gujarat. The areas that come under the high seismic coefficient zone are situated in Jammu and Kashmir, Himachal Pradesh , Uttranchal, northern parts of Bihar, north-eastern states, Kachchh region of Gujarat and Andaman and Nicobar Islands. These regions are highly susceptible to earthquakes.

Hazardous Effects of Earthquakes

It may be stated that the intensity of earthquakes and their hazardous violent contact are set not on the basis of the magnitude of seismic intensity but defined on the basis of quantum of damages done by a specific earthquake to human lives and property. An earthquake becomes jeopardy or disaster only when it knocks the populated area. Occasionally the soft-shell earthquakes on Richter scale administer ample damages by stimulating and multiplying other natural physical processes such as landslides, floods and fire.

Following are the main hazardous effects of earthquake:

1. **Slope Instability and Landslides:** The impact created by earthquakes, especially those in hilly and mountainous areas, which are designed of feeble lithologies cause slope failure and in conclusion cause landslides and debris falls which damage settlements.

The occurrences of earthquakes during wet season in the hilly and mountainous regions cause landslides even if the earthquakes are of very moderate intensity. This is the reason that people notice earth tremors through landslides during wet season.

The Peruvian earthquake of 1970 tells the story of disastrous tragedy caused by slope failure. The shocks triggered off the collapse of ice cap seated on the Peak of High Mountain called Huascaran in Peru. This enormous debris fall buried many buildings and human structures and killed about 25,000 people.

2. **Damage to Human Structures:** The principal damage emanating from earthquake disaster are construction failure. Earth-

quakes inflict great damage to human structures such as buildings, roads, rails, factories, dams, and bridges and thus cause heavy loss of human property.

3. **Damages to the Towns and Cities:** Earthquakes have their worst effects on towns and cities because they have greatest density of buildings and large agglomerations of human population.
4. **Loss of Human Lives and Property:** The destructiveness of an earthquake is determined on the basis of human causalities in terms of deaths. It is not the magnitude (intensity) of earthquake alone which matters as regards the human causalities but the density of human population and houses also matter in terms of human deaths and loss of property.
5. **Severe Floods:** A possible disaster is flash flood. Severe floods are also caused because of blocking of water flow of rivers due to rock blocks produced by severe tremors on the hill slopes facing the river valleys. Sometimes the blockade of rivers is so immense that even the course of the river is changed.
6. **Tsunamis:** The seismic waves caused by the earthquakes travelling through sea water, generates high sea waves and cause great loss of life and property along the coastline. The Kutch earthquake of 1819 generated strong tsunamis which caused very high sea waves, which submerged the coastal area and inflicted great damage to ships and country made boats of the fishermen. The land area measuring 24 km in length was raised upward because of tectonic movement. Tsunami havoc occurred on December 26, 2004 in Indian Ocean is the fourth largest in the world since 1900. It caused thousands of death and devastation in south east Asia.

TSUNAMIS

A tsunami is a series of ocean waves generated by sudden displacements in the sea floor, landslides, or volcanic activity. In the deep ocean, the tsunami wave may only be a few inches high. The tsunami wave may come gently ashore or may increase in height to become a fast moving wall of turbulent water several meters high.

Formation of Tsunamis

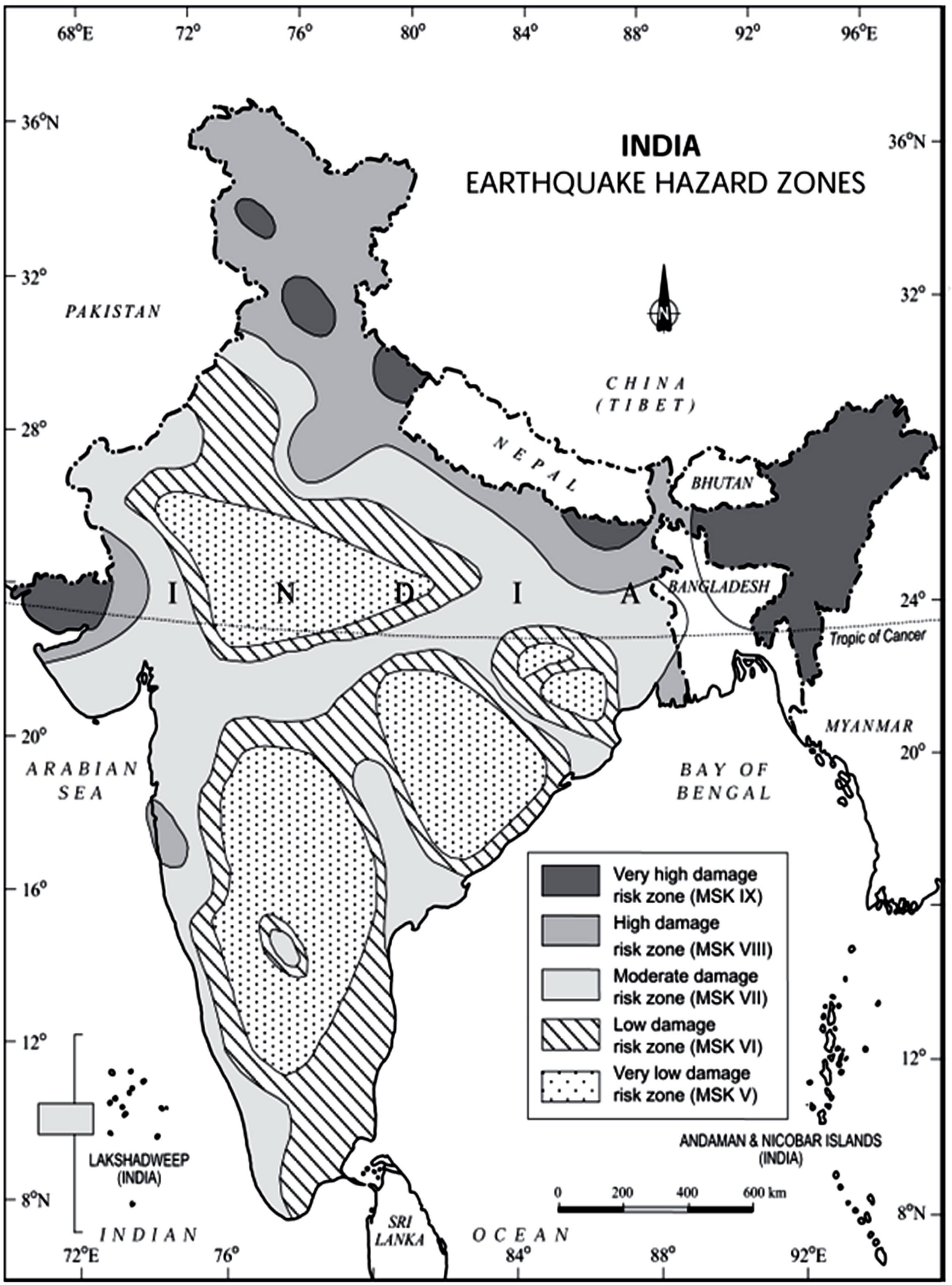
(i) Undersea earthquakes

Although tsunami may be caused by landslides, volcanic eruptions or even by the impact of a large meteorite falling on the ocean, most destructive tsunamis are generated by massive undersea earhquakes, occurring at depth less than 50 km with the epicentre or fault line near or on the ocean floor. A strong undersea earthquake with magnitude greater than 7.5 on the Richter Scale tilts and deforms large areas of the sea floor ranging from a few kilometeres to 1000 kilimetres and even more. As the sea floor is tilted or deformed by the tectonic earthquake (earthqjake associated with the earth's crustal deformation), the sea water above is displaced from its equilibrium position. Waves are formed as the displaced water attempts to regain its equilibrium under the influence of gravity. It is this vertical movement of the entire water coulumn that generates destructive tsunami waves.

The displacement of sea floor, and occurrence of an earthquake and formation of tsunamis can best be explained on the basis of plate tectonics. When two converging ligthospheric plates come closer together heavier plate is thrust under the lighter plate and displacement of the crust takes place at the subduction zone. A fault is created and an earthquake occurs, giving rise to tsunamis.

According to Law of Conservation of Energy, energy cannot be created or destroyed but can be transferred from one form to another. Thus the potential energy that results from pushing water above the mean sea level is transferred to kinetic energy that initiates the horizontal propagation of the tsunami waves.

It must be noted that a tsunami is usually not generated if the sea floor movement is horizontal. Besides,not all undersea earthquakes create tsunami, as it depends upon the nature and



degreee of displacement of seawater column. It is only the vertical displacement of the seawater due to abrupt, jerky movements of fault blocks on seabed that gives birth to tsunamis. Once formed, the monstrous waves soon begin their journey towards coastlinel ringing the bells of doom the nearest.

(ii) Landslides

Tsunami waves are also generated by displacement of seawater resulting from landslides as well as rock falls,icefalls etc. Construction work of an airport runway along the coast of Southern France in the 1980s caused an underwater landslide. This triggered the destructive tsunami waves in the harbour of Thebes. Underwater landslides may also occur when a strong earthquake shakes the sea floor, thus froming tsunamis. These waves rapidly travel away from the source due to dissipation of energy, and create havoc in the nearby coastlines.

(iii) Volcanic Eruptions

Whenever a violent volcanic eruption takes place under the sea, it causes sudden displacement of a large volume of seawater and tsunami waves are formed. Similarly, when the roof of a volcano collapes that has a large empty magma chamber owing to continuous flow of lava, a crater sometimes as large as one kilometre in diameter is formed. As the seawater gushes into this crater, the water columb of the sea is distrubed which gives rise to tsunami waves.

One of the largest and the most destructive tsunami ever recorded was generated on August 26, 1883 after the explosion and collapse of the volcano of Krakatoa in Indonesia. This explosion generated waves with a towering height of about 40 m, that wrecked havoc on the coastal areas along the Sunda Strait in both the islands of Java and Sumatra killing more than 36,000 people. It is believed that the destruction of the Minoan civilisation in Greece in 1490 B.C. was caused by tsunamis which were formed by the explosion of the volcano of Santorin in the Aegean Sea.

(iv) Meteorites and Asteroid

There is a potential danger of tsunami being formed by the fall of meteorites and asteroids in the ocean. Researchers in California have developed a computer simulation depicting the ocean impact of asteroid 1950 DA, a gigantic space rock that would be very close to the earth in 2880. Although the possibility of such an impact is very remote, the computer model definitely gives the researcher an insight into the destructive power of tsunami caused by near-Earth object. Some of the meteorites have been uncomfortably close to the earth and could wreck havoc in different forms including tsunamis.

Propagation of the Tsunamis

Tsunamis consist of series of very long waves which travel outwards on the surface of the ocean in all directions away from their place of origin. Their movement is just like ripples created by throwing a pebble into a pond of water. In deep sea the tsunamis travel at very very high speed (say 500-800 km per hour), almost as much as much as the speed of a jet aircraft. Their wavelength is very long which often exceeds 500-700 km. However, the amplitude of tsunamis in deep sea is very low and rarely exceeds 1 metre. Physically they propagate as long waves with speed given by

$$(\text{Water depth} \times \text{gravitation acceleration})^{1/2}$$

Since the tsunamis have very long wavelength and very low amplitude, in deep ocean, they cannot be seen or detected from the air. Therefore, passengers on boats cannot feel or see the tsunami waves as the killer waves pass by underneath at high speeds. It may only appear as a gentle rise and fall of the sea. Thus tsunamis are always deceptive and are able to conceal their killing capacity in the deep water of open area. For example, the Great Sanriku tsunami, which struck Honshu in Japanon June 15, 1896 was completely undetected by fishermen as its deep water height was only about 40 cm. A monster in disguise, this tsunami transformed into huge waves when it arrived on the shore and ravaged 275 km of coastline killing 28,000 people. So from the sky tsunami waves cannot be distinguished from ordinary ocean

waves. But beneath, a tremendous amount of energy lurks. Since the rate at which the wave loses its energy is inversely related to its wave length, tsunamis not only propagate at high speeds, they can also travel great transoceanic distances with limited energy losses.

As the tsunamis leave the deep water of the open ocean and travel towards the shallow water, they are transformed in two ways. Firstly their speed is reduced considerably and secondly they attain emormous height often exceeding 10 metres and occasionally may reach 30 metres.

Since the speed of the tsunami is related to the water depth it diminishes in shallow water. Fricitional force of lthe sea bed also plays its part in reducing the speed of lthe tsunami. Thus the initial speed of 50-60 km per hour near the coast. When the tsunami finally reaches the shore it may appear as a series of breaking waves. The successive waves stack up onto each other forming a pile of waves due to which the tsunami waves get compressed near the coast. Consequently, the wavelength of the tsunami waves is shortened and the wave energy is directed upwards. This makes the wave grow in height. Since the total energy of the waves remains constant (Law of Conservation of Energy), the height of these waves increases dangerously. This is also known as 'shoaling' effect because it transforms a seemingly harmless wave that was almost imperceptible in deep water into and incredibly dangerous wall of water on the shore. So if the amplitude of the 'tsunami' wave have been just one metre or even less in the deep water, it grows into a mammoth 30-35 m wave when it sweeps over the shore. That is why tsunami waves smash into the shore with devastating impact of a water bomb.

The maximum height reached by a tsunami on the shore is called the run up. This is the vertical distance between the means sea level surface and the maximum height reached by the tsunami waves on the shore. Generally the tsunami run-up over a metre is considered dangerous. After run up, a part of tsunami energy is dissipated back to open ocean. This generates particular type of waves called 'edge waves' that travel back-and forth parallel to the shore. Sometimes tsunami causes the water to recede, exposing the ocean floor.

Tsunamis undergo a lot refraction on the shore. Refraction of tsunamis depends upon water depth and configuration of the sea floor near the shore. The process of refraction converges a part of energy of the tsunami waves to particular area on the shore. So on reaching the shore, the presence of coral reefs (fringing or barrier reefs), bays slope of the beach and other undersea features may modify the tsunamis.

Effect of Tsunamis

Tsunami pose serious danger to the inhabitants of the coastal areas. They attack the sea shore as gigantic waves moving with great force, appearing without a warning and hitting the coastline like a water bomb. Loaded with enormous energy, the killer waves wreck havoc by flooding hundreds of metres inland, past the typical high water level. They flatten houses and wipe out villages, uproot electric poles, throw cars into swirling water and toss boats ashore all in mad fury, and finally drag thousands of hapless victims out to sea as they recede. Large rocks weighing several hundred tonnes and other debris can be moved hundreds of metres inland by a tsunami. Tsunamis can even travel up rivers and streams that lead to the ocean.

FLOODS

Flood directly means submerging of extensive land area with water for several days in continuation. Infact, flood is characteristic of physical environment and thus is a component of hydrological cycle of a drainage basin.

Floods are very much associated with alluvial rivers draining extensive flood plains. About 3.5 per cent of the total geographical areas of the world are covered by floodplains that give habitation to more than 16 per cent of the world population.

Causes of Floods

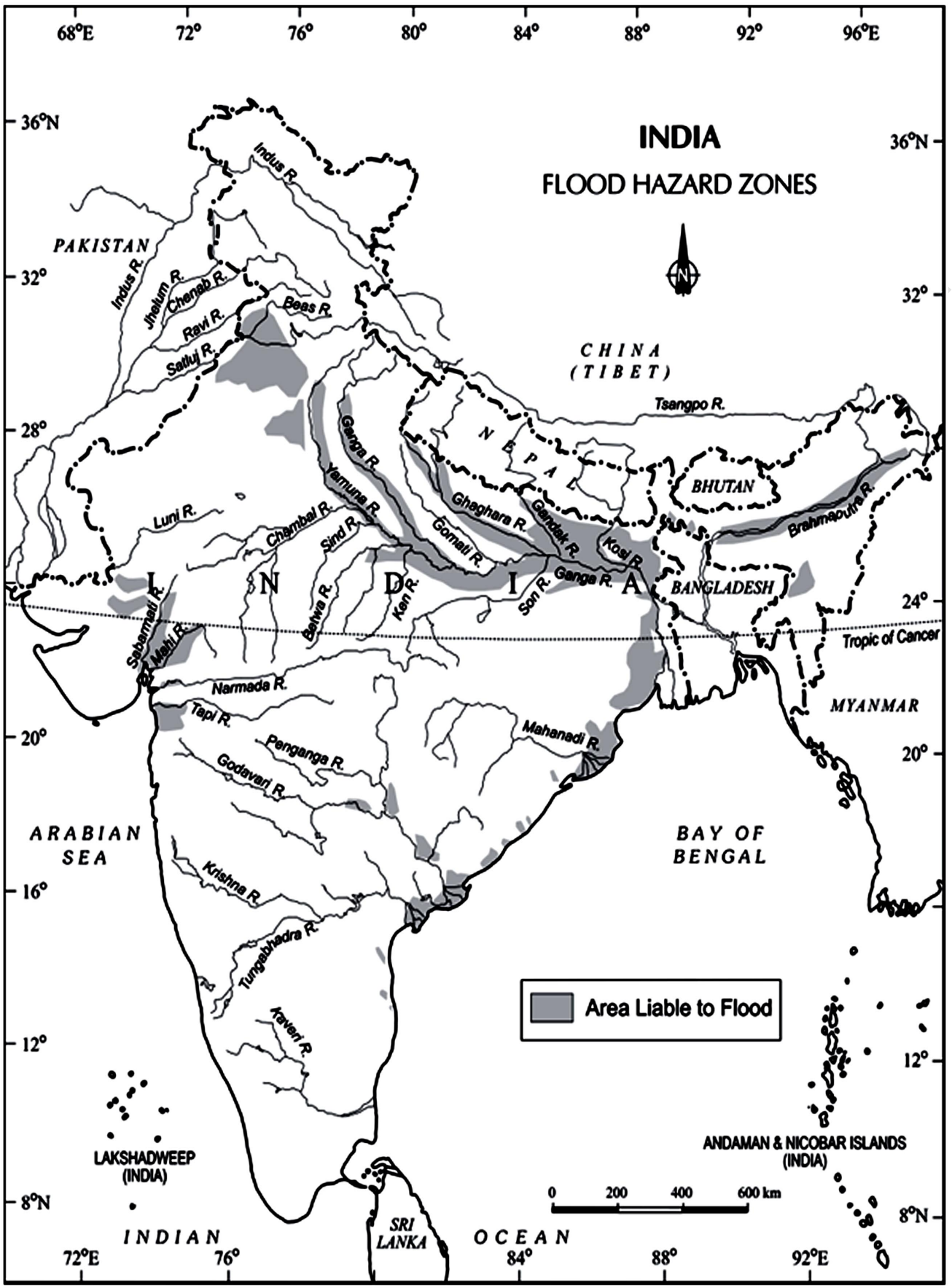
Floods have become highly complex since the floods are the responses of both natural and anthropogenic factors. Their relative nature varies from place to place. Among the important factors are:

1. **Prolonged high intensity rainfall:** Heavy rainfall for long period in continuation is the root cause of river floods. Heavy rainfall in the upper catchment areas of the concerned river causes sudden increase in the volume of water downstream. This causes overtopping of river bank by enormous volume of water and consequent inundation and flooding of flood plain areas. Heavy spell of rainfall in arid and semi-arid areas where the rainfall is scant, low and infrequent causes flash floods because such areas have poor natural drainage systems and existing rivers and streams are unable to accommodate enormous volume of water caused due to huge volume of runoff resulting from high intensity rainfall during occasional rainstorms.
2. **Meandering courses of the river:** Highly meandering courses of the rivers impede the usual discharge of water and thus the velocity is reduced that lag the passage of water resulting into stagnation of water which causes flood in the meandering valley.
3. **Deforestation:** Large-scale deforestation in the upper catchments is perhaps the most important anthropogenic factor of the river floods. Large-scale deforestation decreases infiltration capacity of the land and consequently increases surface runoff. Dense vegetation allows maximum infiltration of rainwater into the ground because raindrops are intercepted by forest canopy and thus reach the ground slowly through the leaves, branches and stems of trees. In the absence of forests and other vegetarian covers, rain drops strike the ground surface directly and in case of heavy downpour the rainfall exceeds the limit of infiltration. Increased surface runoff also accelerates the rate of soil erosion and thus increases the sediment load of the rivers. Increased sediment load causes siltation of riverbeds and filling of the valleys. This process results into gradual rise in the riverbeds and decrease in the cross sectional areas of the river and hence reduction in the water accomodating capacity of the river.
4. **Blocking of free flow of the rivers because of enormous debris:** Blocking of natural flow of the rivers by landslides or other natural factors or anthropogenic factors causes sudden severe flash floods in the downstream section of the rivers.
5. **Anthropogenic activities:** Such as building activities, urbanization, channel manipulation through diversion of the river's course, construction of bridges, barrages and reservoirs, agricultural practices, land use changes etc. are also responsible for the flood.

As urbanization is increasing, extention in the pucca ground cover through the construction of building, courtyards, roads, pavements etc. are the natural out come. It increases the surface runoff and therefore dimension and magnitudes of floods also widens because extension in the pucca ground reduces infiltration of rainwater significantly and increases surface runoff considerably.

The rainwater resulting from torrential rainfall is quickly disposed off through the city storm drains to nearby streams and thus the volume of river water is increased, causing floods. Besides obstruction of river flow due to bridges across the rivers, silting of river beds due to pouring of wastes and garbages from the nearby urban centres, gradual encroachment of human settlements towards the channels and lowlying areas, filling of 'nallas' (natural urban drains), constuction of new roads and bridges etc, are also significant factors, related to urbanization, causing floods.

6. **Others:** Apart from the above mentioned factors few causes are cyclone, topographical factor of the regions, tides, level of the ground water, etc.



Flood Prone Areas

The Rashtriya Barh Ayog (RBA) or National Commission on Floods, set up the Government of Indian in 1976, provided statistical evidence of flood problem in the country. The commission took the maximum area affected by floods ina state in any one year, as its flood prone are ans added up the flood prone areas of all the state to get the flood prone area of the country. This proved to be erroneous method andit underestimates the severity of the problem. This is due to the fact that there is no guarantee that floods in any year will affect only those areas which were never flooded before. Yet the commission found that the country's flood prone area increased from 25 mha in 1960s to 34 mha in 1978. At present 40 mha or one eights of the total land area of the country is assessed to be flood-prone. This shows that there has been a rapid increase in he flood-prone area of the country. A glance at Figure will show how the flood prone areas are distributed. It is estimated that over three-fourth of the total damage done to crops and property is in the plains of Northern India comprising Punjab, Haryana Uttar Pradesh, Bihar, West Bengal and Assam. The geographical distribution of floods prone areas in India is as under.

The Ganga River Region

In Uttar Pradesh and Bihar, the mighty Ganga receives a large number of tributaries such as the Gomati, the Ghaghra, the Gandak and the Kosi from the left as well as the Yamuna and the Son from the right. This brings huge quantities of water to these areas both from the Himalayan region and from the Peninsular India resulting the devastating floods. River Kosi oftern shifts its course flooding new areas and converting once fertile areas into wasterland. The Kosi which means kosna (curse), brings flood fury to vast area every year and is living upto its name. The Yamuna is an important right bank tributary of the Ganga and floods large areas in Uttar Pradesh and Haryana. The Chambal and the Betwa meet the Yamuna and add to the flooding capacity of the Yamuna.

In Uttar Pradesh flood is frequent in the eastern districts, mainly due to spilling of Rapti, the Sharda, the Ghaghra and the Gandak. The problem of drainage congestion exists in the western parts of Uttar Pradesh, particularly in Agra. Mathura and Meerut districts. The erosion is experienced in some places on the left bank of the Ganga and on the right banks of the Ghaghra and the Gandak. In 1998, floods occurred in many parts of the country including Uttar Pradesh, Assam, Bihar, Delhi and West Bengal. However, Uttar Pradesh received most serve blow and the Gorakhpur divisions was the worst hit area.

In Bihar the floods are largely confined to the northern part of the state where occurrence of floods is almost an annual feature. The rivers such as the Burhi Gandak, the Bahagmati and the Kamula and other smaller rivers of the Adhwara Group, th Kosi in the lower reaches and the Mahananda spill over their banks causing considerable damage to crops and dislocation of traffic.

Uttar Pradesh and Bihar are the worst flood affected states and account for over one-third of the flood prone area of the country.

In West Bengal the southern and the central parts are flooded by the Mahananda. The Bhagirathi, the Ajoy, the Damodar etc. due to an inadequate capacity of river channels and tidal effect. There are occasional floods caused by the Damodar river even after the construction of four dams and a barage under the Damodar Valley Project. In 1956, about 25,000 sq km of area was flooded in Southern districts fo West Bengal by this river. The Ganga delta is ofern flooded. There is also the problem of erosion of banks of some of the rivers and on left and right banks of the Ganga upstream and downstream respectively of the Farakka Barrage.

The Bhramaputra River Region

In the Brahmaputra basin, floods are almost an annual feature. The main cause of floods here is heavy rainfall amounting over 250 cm during the rainy season. Large amount of slit is deposited here by the Brahmaputra and its

tributaties which makes the river channed shallow and its capacity to carry large amount of water is reduced. This results in flooding of the vast areas in and around the valley. Earthquakes, which occur at frequant intervals, causes change in the level of river course and the flow of water in the river is obstructed. This leads to erosion of large areas in this region. Landslides are very common here. Huge rock material falling as a result of landslides acts as a temporary dam across the river and vast area is submerged under water. Later it gives way under the pressure of water and floods lartge area downstream. The Assam Valley is considered to be one of the worst flood-affected areas of India. The main causes of floods in th Brahmaputra river system can be summed up as under:

(i) There are 34 major tributary rivers of the Brahmaputra. These bring huge quantities of water and silt which cause floods.

(ii) Very heavy rainfall exceeding 250 cm per annum.

(iii) Narrowness of the Brahmaputra valley with a maximum width of about 81 km surrounded by hills.

(iv) Heavy deposit of silt has raised the river bed considerably which has reduced the water accommodating capacity of the river.

(v) Occasional earthquakes, such as earthquakes of 1897, 1930, 1950 and 1984 have brought about changes in the course of the river.

(vi) Very high population pressure, primarily due to migration form Bangladesh and some other Indian states has forced people ot live in the flood prone area.

According to the reports of the Assam government, all the districts of the Brahmaputra valley are inundated almost every year.

Though most of the flood affected areas in Assam are rural in character, yet some urban areas are also affected by floods each year. The worst flood affected area of the Brahmaputra valley is the world's largest river island, Majuli. The urban areas of Assam, namely Dhubri, Guwahati, Dibrugarh, Tezpur etc. ate frequently flooded. It has been estimated that an area of 30 lakh hectares out of 78 lakh hectares i.e., about 45 per cent of Assam's total area is flood prone.

The North West Rivers Region

The flood problem in this region is less serious as compared to the one prevailing in the Ganga and the Brahmaputra river regions. The major problem is that of inadequate surface drainage which causes inundation and waterlogging over vast areas. In the Punjab-Haryana Plain rain water in the waterlogged and poorly drained areas inundate large parts. Major and minor rivers like the Satluj, the Beas, the Ghaggar and the Markanda are in spate during the rainy season and bring flood havoc to vast areas.

In Punjab floods are an annual feature though intense floods are experienced at an interval of 4-5 years. The main reason of floods in Punjab is obstruction of poor natural drainage by man made features. Some of the major canals (the Bhakra System) do not follow the natural flow and create obstacles. Secondly, National Highway No.1 and the main railway line run almost perpendicular to the natural flow. Cultivationof area near river banks and construction activities in low lying areas, especially in cities like Ludhiana, Patiala, etc. have together created obstacles in the natural flow of water. In th recent years Punjab was hit by a severe flood in 1993. This flood affected 13 (out of 14) districts, 5,017 villages, 44 cities, 1,47,608 dwellings and a populaiton of 34.85 lakh. Moreover, 76,000 tubewells were damaged and rail/traffic was badly affected.

Sometimes, floods are caused by the Ghaggar river also. This river used to disappear in the sands of Rajasthan after flowing through Punjab and Haryana. In recent years, besides flooding Punjab and Haryana areas, it has become active in Rajasthan terriotory also, occasionally submerging large areas.

In the north-western river basin covering Jammu and Kashmir and Himachal Pradesh, the Satluj, the Beas, the Ravi and the Chenab often flood large areas. Floods occur periodi-

cally in Jhelum and its trubutaries in the Kashmir Valley causing a rise in level of the Wullar Lake thereby submerging marginal areas of the lakes and sometimes threatening Srinagar and other areas along the river banks. Similarly the Chenab and its tributaries like Tawi are often in spate endangering several densely populated areas in Jammu and Akhnoor. In the year 2004, large parts of Himachal Pradesh was threatened by a very severe flood in the Satluj river due to large quantity of water released from the Rakas Lake in Tibet.

The Central India and the Deccan Region

The southern states of Andhra Pradesh, Karnataka, Tamil Nadu, Orissa, Jharkhand, Chhattisgarh, Maharashtra, the state of Gujarat and parts of Madhya Pradesh are included in this region. The floods do not pose a serious problem in this region because most of the rivers have well defined and stable courses. However, the deltas of the Godavari, the Krishna and the Cauvery suffer from occasional floods owing to the large scale silting and the consequent change in the river courses. Indiscriminate felling of trees in the catchment areas of major rivers has complicated the flood problem. High tide at the time of flood aggravates the flood situation. Lower courses of the Narmada and the Tapi in Gujarat are also prone to floods.

In Andhra Pradesh, the flood problem is confined to spilling by smaller rivers and the submergence of marginal seas along the Kolleru Lake. The Godavari and the Krishna rivers have acute drainage problem and face floods particularly in the wake of cyclonic storms. The Godavari basin is particularly notorious for recurring floods. Significant floods have been reported in August, 1886, October 1900, August-September 1907 and August 1953. In 1986, Godavari delta starts. Many big and small developmental schemes were affected. In East Godavari, 16,69,000 people were affected. About 81 people and 1,000 cattle per shed, nearly 1,43,000 hectare standing crop was destroyed.

In Orissa, floods are caused by the Mahandi, the Brahmani and the Baitarni which have a common delta where the flood waters intermingle and when in spate simultaneously, cause considerable havoc. The problem is accentuated when the flood synchronises with high tides. The slit deposited by these rivers in their delta region raises the river bed and the rivers often overflow their banks or break through new channels causing heavy damage. Even the construction of Hirakud dam across the Mahanadi has not made the lower area absolutely free from flood. The flood of August-September 1960 is an eye opener. The lower reaches along the Subarnrekha are affected by floods and drainage congestion.

There is uniform addition in the cycle, intensity, dimensions and magnitude of damages of floods in India every year. There are numbers of factor responsible for increasing flood in India, like:

1. Rapid rate of deforestation in the source catchments of major rivers and their tributaries and consequent acclerated rate of runoff of rainwater and soil erosion.
2. Increase in sediment load of rivers.
3. Siltation and rise of river beds and marked reduction in the water accomodating capacity of the river valleys.
4. Increasing urbanization.
5. Germination of settlements in the floodplains.
6. Construction of bridges, embankments and dikes etc.

The nature and intesity of the flood problems varies from one river system to another. The problem is the most acute, as also complex, in the Brahmaputra and the Ganga basin states like Assam, Uttar Pradesh, Bihar and West Bengal. The menace is also quite formidable in river systems of Orissa and the Central India. River systems in the Deccan, such as Mahanadi, Godavari delta area and Krishna, also face recurring flood menace.

In the North-West river systems, the problem is relatively less severe though floods have not been entirely eliminated. States like Punjab, Haryana, Jammu and Kashmir and even Rajasthan have suffered due to floods in the recent past despite the fact that these states

remained more or less free from major floods for many decades.

The irony of the situation is that the flood damage is on the rise notwithstanding increasing investment on measures for the prevention, control and warning on floods. The reasons for this are not far to seek. Denudation of the catchment areas of rivers due to unabated deforestation is the biggest single factor responsible for increased intensity as well as frequency of floods.

Flood Damage

Lack of adequate maintenance of existing water management structures due to paucity of non-plan allocation is another significant factor contributing to rising flood damage. At times, even the loss to crops and property caused by water-logging due to inadequate provision of drainage for rainwater is also reported as flood damage. Besides, a tendency has been noticed of late, among the state governments to overestimate the loss in a bid to get higher relief assistance from the Centre.

According to long-term data, the value of the average annual damage inflicted by floods on crops, houses and public utilities in the country is estimated at a whopping Rs. 980 crore. On an average, about 7.75 million hectares get inundated by gushing flood water every year, resulting in loss of 500 human lives and 1,00,000 heads of cattle.

Flood Control Measures

It may be pointed out that the floods are natural phenomena and one cannot entirely get rid off them but their impacts can be minimised by man's technological skills, better warning systems and positive human response to flood warnings and various control measures adopted by the governments.

A. The inaugural step to control floods is to look into their fundamental reason, which is the high intensity rainfall and resultant surface runoff. Man cannot stop high intensity rainfall and there is no need at all to interfere with natural processes. What man can do is to delay the return of surface runoff resulting from the high intensity rainfall to the rivers. This can be achieved by large-scale reforestation and afforestation in the hilly source catchment areas of those rivers. It will encourage more infiltration of rainwater, reduction of the soil erosion and hence reduce the sediment load of the river.

B. The volume of water during flood stage of a river may be reduced through a series of engineering devices such as construction of flood-control storage reservoirs. Such storage reservoirs impound enormous volume of water during flood period and thus these help in two ways e.g. firstly, these storage reservoirs reduce the volume of water of the rivers and secondly, these provide water for irrigation purpose.

C. Flood-diversion systems, which imply diversion of floodwater in lowlying areas, depression or artificially constructed channels bordered by artifical dykes so that the flood crests can be, reduced and the flood magnitude may be decreased.

D. Embankments, dykes and floodwalls are used to confine the floodwater within the valley or say within a narrow channel. These engineering works include the building of aritificial levees of earthern materials, stones or even concrete walls.

New Approach

In the past, the flood menance was sought to be tackled by strategies based on experience and intuition with an overwhelming emphasis on physical measures. The objective was to prevent gushing waters from reaching potential damage centres. This approach essentially helped to tame and modify floods rather than really controlling them effectively. It relied chiefly on undertaking protective works like embarkments, detention reservoirs, anti-erosion and bank stabilistion works. Multi-purpose river valley projects were viewed as means of preventing floods besides producing power and utilising water for irrigation and other gainful purposes.

To tide over the problem of funds scarcity, the Union government institutions try to secure

external assistance for some selected flood control projects. The Water Resources Ministry is identifying the project, which will be placed before these institutions. Only major projects will be selected for seeking external assistance.

1. **Flood Plain Zoning:** Flood plain zoning essentially involves regulation of economic activity in flood plains. Experts view it as an effective way to deal with this problem as flood plain zoning cuts across district and state boundaries. It is indeed capable of reversing the floods. The model flood plain zoning bill was prepared and circulated to the states by the centre way back in 1975. Manipur lost little time in actually enacting the legislation on flood plain zoning and started implementing it in December 1985. No other state, however, did so. The governments of Bihar and West Bengal are reported to be contemplating to bring legislation for this purpose. Andhra Paradesh has also accepted it in principle. In Madhya Pradesh some work is said to have been done on demarcating flood zones for several important towns and villages threatened by this calamity. The Centre is still trying to persuade other states to follow suit.

2. **Non-Structural Measures:** Encouraged by the success of nonstructural measures in minimising the loss of livestock and human lives, besides other damage, the government now seems inclined to use them in the chronic flood-prone belt in the North East.Of the total geographical area of 2.55 lakh sq. kms., comprising seven North-Eastern states of Arunachal Pradesh, Assam, Manipur, Nagaland, Meghalaya, Mizoram and Tripura, about 43.41 lakh hectares have been identified as chronically flood-prone. The problem of course, is the most acute in Assam, which alone accounts for 38.2 lakh hectares. The Brahmaputra and Barak valleys are affected by flood practically every year.

   Apart from better upkeep and maintenance of existing works, the new approach accords priority to flood proofing through raised platforms, assured communication, drinking water supplies and post-flood reliefs. In the last three years, the Planning Commission approved 22 flood management schemes, costing around Rs. 80 crore for implementation

3. **Forewarning:** Forewarning of flood can indeed go a long way in preventing much of the potential damage due to floods. A country-wide flood forecasting and warning system has successfully been established by the Central Water Commission (CWC) to cover most of the flood prone inter-state rivers. The CWC is presently issuing river stage forecasts in respect of 132 stations covering 62 river basins and sub-basins. Besides, inflow forecasts are being issued for 25 sites for operation of certain major reservoirs, raising the number of the total forecasting stations in the country to 157. Of these 109 stations are on the Ganga-Brahmaputra-Meghana system alone. There are 15 stations for west flowing rivers, eight for river Krishna, three for river Mahanadi, nine for eastern rivers and 13 for Godavari. Nearly 60 per cent of the catchment areas of seven river systems, which cause extensive floods in U.P., Bihar and West Bengal every year, lie in the upper reaches in Nepal. These rivers include Ghaghra (along with Sharda and Rapti), Gandak, Bagmati, Kamla, Adhwara groups of rivers, Kosi and Mahananda. Reliable flood forecasts for this region are not possible without data from their catchments in Nepal. An understanding has been reached between the two countries to establish 45 hydrometeorological sites in Nepalese territory and to improve 18 sites on the Indian side to make the forecasting network in this area efficient for the benefit of both the countries.

A wireless communication network has been created for collection of hydrological and hydrometeorological data from about 550 hydrometeorological stations located in different river systems throughout the country. The forecasts, based on the analysis of this data, are communicated to the concerned administrative and engineering authorities over telephone or

through special messenger or other means depending on the gravity of the situation and vulnerability of the area.

There is, however, still ample scope for futher improvements in the flood-warning network as also in the quality of forecasts. Indeed, CWC seems to have been aware of it & has been reviewing techniques of observation of hydrological data & its transmission to the forecasting divisions. A few modernisation schemes have also been taken up.

DROUGHT

Drought in simple terms is the dryness due to deficient rainfall or shortage of water for an extended period, a season, a year or several years over a particular region. It can be defined according to meteorological, hydrological and agricultural criteria. Any substantial, prolonged deficit of rainfall qualifies as meteorological drought. In India, the South-West monsoon describes the meteorological drought. The monsoon rainfall avove 19 per cent of the normal value is termed as excess rain. When the rainfall departure is within 19 per cent it is known as normal rain, below 19 per cent it is deficient rain and scanty if the rainfall is below 59 per cent. There is no consensus over the threshold of the defcit or the minimum duration of the lack or precipitation that makes a dry spell an official drought. The term drought hinges on the societal expectations and public perception that availabe water is too meagre to sustain normal activities.Thus, the meteorological drought is only a representation of the rainfall distribution pattern and statistics.

The hydrological drought is the manifestation of critically low ground water tables and noticeably reduced river and stream flow. It involves the water availability and the offtake rates in normal reaquirement i.e. domestic, agricultural and industrial usages. The agricultural drought refers to extended dry peiods in which the lack of rainfall or the watersource results in insufficient moisture in root zone of the soil causing adverse effects on cultivated vegetation. The agricultural drought is the impact of meteorological and hydrological droughts on the crop yeields. It is the agricultural drought that affects socio-economically the most and causes serious disruption to the nation's food supply.

Droughts may occur at any place and time, causing from mild annoyance to deaths through famine. The severity depends on the intensity of the rainfall deficiency, duration of dry spell, size of the affected area and the extent of available water resouces such as irrigation facilities. To describe the severity an index called "Palmer Drought Severity Index" is used. The index ranges between +6 (very much wetter than normal) to -6 (extremely severe drought). The index measures the relative dryness of local weather within successive time intervals. It accounts for the differences between the actual precipitation and the amount normally expected to sustain evapo-transpiration, run-off and moisture storage in a given climate and location.

Factors Promoting Droughts

India is the seventh largest country in the world covering an area of 3, 287, 782 sq. km. With a huge population of about 100 crores, the entire population (about 28 percent urban and 72 percent rural) is distributed over the four well-defined regions viz. the Himalayan mountain zone in the North, the Gangetic plains in the Cenre, a desert in the West and a peninsular plateau in the South. The rural population is scattered over 5,55,137 villages out of which about 2,31,000 are defined as problem villages where surface water is not available within a radius of 1.6 km or if available locally, is unfit for consumption. About 68 percent of the sown area is still dependent on rainfall. There is gross variation in the rainfall distribution over the 35 meteorological subdivisions in the country.The variation is such that there is about 118.70 cm of rain in Cherrapunji (Meghalaya) and about 10 mm or less rain in the desert part of West Rajasthan. In all, about 16 percent of the country is drought prone. The drought areas are the arid, semi arid and dry subhumid areas of West Rajasthan, Gujarat, Saurashtra and Kutch, Marathwada, Telengana, Rayalseema, Bihar and

some parts of Orissa (Koraput distircts).

The major factors responsible for the droughts in India are deficient rainfall, demographic pattern, poor water management strategy, indiscriminate exploitation of the ground water by the industries and the agricultural sectors and large scale deforestation for various purposes. The meteorological causes of drought vary according to the climate of the affected region. In the monsoon blessed areas like our country, most of the annual rainfall (about 70-80 percent) is received in a single rainy season. The rainy conditions failing to make an incursion into the interior of the continent is responsible for diminished accumulation of seasonal precipitation.

Impact of Drought

Drought devastates crops and ushers in difficult times leading to famines, malnutrition, epidemics, forced migration, economic destabilization, loss of lives and social conflicts. The primary effects of drought mainly stem from lack of water. However, the secondary effects follow resulting from the primary effects.The primary effects are loss of water for drinking and hygienic use, loss of crops, livestocks and other animals. Also there is a loss of employment in agricultural and farm sectors. The secondary effects start with the migration of people in search of better grazing lands for their heards or to the cities to seek alternate source of income. If water, food and fodder are not supplied in time the condition further deteriorates to famine causing large-scale deaths.This further accelerates migration and spreading of epidemics. Long-term drought results in permanent changes in settlement patterns and the social and living styles.

The drought disrupts the productive base of the affected economy through damaging or destroying parts of its capital stocks. The failure of crops prompts large-scale migration that causes pressure on urban centres creating new demands and infrastructure. Among major ecological effects are decreased scrub growth, increase in erosion of soils and increased desertification. Among the ecological changes the desertification cycle is of utmost concern. The whole process gradually spreads usually elliptically, bringing more and more land under desert conditions. Thus, the impacts of the drought cannot be assessed on the basis of the economic loss alone. The social and the ecological/environmental damges are irreversible, so their impacts remain for years together (like the great Bengal Famine).

Droutht Prone Areas

A drought prone area is defined as one in which the probability of a drought year is greater than 20 per cent. A chronic drought prone area is one in which the probability of a drought year is grater than 40 per cent. A Drought year occurs when less than 75 per cent of the normal rainfall is received.

In India, the hard core of recurring drought affects 16 per cent of the total area and 12 per cent of the population, although the total average drought prone area may be as muchas 10 lakh sq km or about one third of the total land area of the country. The areas regularly haunted by droughts are those receiving low (generally below 75 cm annually) and highly unreliable (varibility over 40 per cent) rainfall and with inadequate irrigation facilities. In all 77 districts receiving less than 75 cm of rainfall per annum are drought prone. This accounts for 34 per cent of net sopwn area. In addition, there are 22 districts in Maharasthra, Gujarat, Madhya Pradesh, Karnataka, Rajasthan and Uttar Pradesh accountinhg for 9 per cent of the cultivated area of the country which receives 75 to 85 cm of rainfall per annum. This rainfall is of doubtful efficacy and as such these districts should also be considered vulnerable to drought. However, the severest droughts have ocurred in comparatively wet areas such as West Bengal, Bihar and Orissa where rainfall is normally plentiful enough to allow high density of population and where failure of rainfall can afffect milions of people.

There some well defined tracts of drought which are briefly described as under.

(a) The desert and semidesert region covering tracts of drought formed by lines from

Ahemdabad to Kanpur on one side and from Kanpur to Jalandhar on the other.

(b) The dry region lying in the leeside of the Western Ghats upto a width of 300 km stretching eastwards up to 100 km from the East Coast and reaching right upto the southern tip of the peninsula. It covers an area of about 3.7 lakh sq km.

(c) Outside the above mentioned two major regions, there are isolated pockets which experience frequent droughts and are termed as drought prone areas. They are (i) Coimbatore and Nellai Kottabomman districts in Tamil Nadu; (ii) Sourashtra and Kachchh regions; (iii) Jhansi, Lalitpur, Banda, Mirzapur, Philibhit, Kheri and Bahraich districts of Uttar Pradesh; (iv) Palamau plateau of Jharkhand; (v) Purulia district of West Bengal and (vi) Kalahandi region of Orissa, (vii) Large parts of Uttranchal, and (viii) Jammu and Uddampur in Jammu and Kashmir. These scattered pockets account for about one lakh sq km.

Coping with Droughts

Two major points emerge from the subject: [1] drought is more of a man-made disaster resulting from a total mismanagement of our water resourcs, and [2] the debate over the issue revolves around two extreme positions. The first propagates that big dams and irrigation projects are badly needed to solve the present water crisis and the second searches for answers in our traditional rainwater harvesting techniques of domestic and agricultural purposes.

It is argued by the supporters of modern techniques of development that large development projects such as dams and hydropower ventures are a precondition to growth. Big dams have brought prosperity to many a parched areas. These have been a source of power and water. Even the green revolution owes its success to large development ventures. However, many traditionalists feel that the revolution has been instrumental in causing vulnerability to droughts. In fact, those who oppose the so-called modern development are labelled eco-romanticists and neo-Luddites. It is believed that traditional practices appear anachronistic and seem to have outlived their utility. The food and irrigation requirements have increased manifold and these can in no way be met by following age-old water harvesting practices.

The arguments in defence of modern scientific development are quite potent. But as per the other side of the debate pressures of only local population have seldom destroyed micro-subsistence systems. Unplanned development practices have led to many afflictions. Dam induced floods are very common. Dams have cost several times the budget, acres and acres of land and devoured millions of people. These have even been constructed in water retentive soil areas. The Narmada valley project is considered by many as India's greatest planned environmental disaster. It is maintained that every small, local and quicker scheme has been sacrificed at the altar of mega projects.

Ever since the dawn of civilization, the people in Indian civilization, have followed certain water management practices that displayed ingenuity and self sufficiency. Science and Centre for Science and Environment have done extensive research on our traditional but dying waterharvesting techniques. Traditional water storing and harvesting practices have been bailed. There is no other substitute of the water harvesting.

LANDSLIDE

In recent decades it has become fashionable to begin discussions of landslide hazard with dramatic descriptions of the devastation achieved by catastrophic failures involving the collapse of large volumes of rock, usually in mountainous areas. The three most quoted catastrophes are: the Vaiont Dam disaster in the Italian Alps (1963), when 250 × 106 m^3 of rock slid into the impounded lake causing huge waves up to 100 m high, to overtop the dam and drown 2600 people in the valley below, the Huascaran rock avalanche in the Peruvian Andes (1970), when part of the ice-cap on the northern peak of Nevadas Huascaran (6654 m) collapsed, causing 20,000 to 25,000 people dead and the huge

Mayunmarca rockslide, also in the Peruvian Andes (1974), when 1000 × 106 m^3 of moving material killed 450 people. The existence of such high-magnitude low-frequency events underline the potential significance of the land slide threat to developmental issues and undoubtedly poses very severe problems in terms of hazard management.

As a consequence, the main problems to be overcome with respect to minimising landsliding are:

(a) the need to heighten the perception of development planners as to the nature, scale, distribution and causes of land sliding and the significance and spatial variation of landslide hazard;

(b) the need to increase awareness as to the range of adjustments (both structural and otherwise) that can be adopted to ameliorate the problem;

(c) the need for landslide management to be incorporated as an element of development planning in those areas prone to slope instability; and

(d) the necessity of developing and refining rapid and meaningful landslide hazard evaluation practices for areas which lack the benefit of comprehensive geological and geomorphological base-line information.

Causes of Mass-Movement

The following causes of mass-movements are recognised. Absence of surface drainage and existence of channels of openings for seepage from internal sources greatly promote slope failure. This explains the frequent occurrence of landslides during or after heavy or prolonged spells of rainfall. However, rainfall duration and intensity alone are not a major factor. In Nepal the groundwater table comes within one metre of the surface, the consequent heavy rains produce landslides. The reversal of this phenomenon, such as withdrawal of water from reservoirs, may also cause landslides, owing to the change in the balance. An example of rainwater-induced mass-movement is the landslide which wholly ravaged the upper part of the township of Nainital in 1980.

If the rocks are porus and shattered, they will naturally become saturated with water. Their shear strength will consequently be less, so that the driving force will overwhelm them leading to perceptible sliding. Thus the degree of fracturing or jointing has a strong influence upon the shear strength of rocks.

Earthquake shocks, particularly those of shorter duration, acceleration of ground motion, tilt of the slope, modify the system of forces in a manner that driving forces get the upper hand. Thus the seismic shocks are the biggest triggering factor. Extensive landslides caused by the 1950 earthquake in eastern Arunachal Pradesh, and by the 1934 North Bihar earthquake bear eloquent testimony to this fact.

The slope angle greatly influences the strength of the driving force-the steeper the slope the greater are the chances of its failure. Erosion and excavation make slopes steeper and thus create conditions conductive to slope failure. On the Hardwar-Badarinath highway, the 30 m wide and chronically active Kaliasaur landslide is a result of combined action of rushing water of the Alaknanda (toe erosion) and road cutting entailing formation of steep and high wall of the cut.

The addition of weight on the slope like the dumping of debris or wastes and the construction of heavy structures (dams, reservoirs, etc.) increase the intensity of the driving force and reduces the slope stability. In the townships of Shimla and Nainital, the deposition of debris produced from the excavation for building foundations and for roads, and construction of multistoried concrete structures have appreciably changed the balance in favour of the driving force, leading to creep movements as evident on the slopes of Lakkar Bazar (Shimla) and Sherka-danda(Nainital).

Landslides in India

In mountain regions such as the Himalaya and the Nilgiri, the problem of hillside instability is very serious. The occurrence of landslides is particularly common in geodynamically sensi-

tive belts, i.e., zones and areas repeatedly rocked by earthquakes and affected by other neotectonic activities. The Darjeeling Himalaya, for example, recorded more than 20,000 landslides in one day in vulnerable belts. The principal factors that initiate or trigger mass-movement are: (i) heavy and prolonged rainfall, (ii) cutting and deep excavations on slopes for buildings, roads, canals and mining without appropriate disposal of debris, and (iii) earthquake shocks and tremors. All these factors operate in the Himalayan region and in the Nilgiri belt overlooking Karnataka and Kerala. In every slope, gravity-induced shear stresses exist which increase with the slope height, slope inclination and unit because of thermal expansion and contraction, freezing and thawing, shrinkage and swelling and by action of other agents of weathering. When the shearing stresses build up to a level that exceeds the shearing resistance of the slope along the most vulnerable, critical or the weakest surface, a landslide takes place inducing downward and outward movement. When supplemented by seismic activity, they could be very serious.

Landslide Zones

Landslide Belts in Kumaun Himalaya: In the Himalayan region the zones of the Main Boundary Thrust (MBT) in the southern front and the Main Central Thrust (MCT) in the interior are two exteremely vulnerable landslide-prone zones. The MCT separating the Great Himalayan ranges from the populated Lesser Himalayan terrain had served as the plane along which the Lesser Himalayan domain had slide under the Great Himalaya, causing tremendous uplift of the latter and wholesale splitting, shattering and crushing of the Lesser Himalayan rocks. Along the MBT, the Indian plate along with its Siwalik front is slipping under the Lesser Himalayan crustal plate. The shattered and highly deformed rocks have been tightly folded and repeatedly split by thrust planes into multitudes of rock-slabs, some of which are highly mylonitized or are in a friable condition. In the MCT and MBT zones, the weak rocks easily give way to onslaughts of rains, shocks of explosions and earthquakes, vibrations generated by movements of heavy vehicles, and human interference. As a result, these 5 to 20-km wide belts in the Kumaun Himalaya are marked by almost continuous fringes or aprons of gigantic fans and cones of landslide debris, both ancient and recent. Most of the ancient landslide cones are comouflaged by thick vegetation. The situation is particularly severe along the MBT, registering neotectonic movements.

Landslide Zones in the Western Ghat: In western India landslides are common along the Western Ghat on the steep (600 m) slopes overlooking the Konkan coast. The Ghat scraps expose a succession of vesicular basalts interbedded with volcanic ash, red boles and agglomerates-the dense basalts forming the scraps and the ashbeds with the gentler slopes. The mass-movements are generally confined to the plastic and semiplastic 20 m thick overburdened material that has accumulated on the gently sloping (100 m) vesicular lava and volcaniclastics. The movement takes place due to loss of shear strength at the interface of the volcaniclastics or bed boles with the lavas as and when rainwater infiltrates. The rainfall is vey heavy (>300 cm/yr) in this belt. Steeply inclined shear faults and vertical joints provide easy access to the water, which triggers landslides. The landslide scraps are 60 to 180 m along the Koyna dam, the frequency of earthquake occurrence (M 2 to 5) has increased, especially in the Ratnagiri district, thus creating favourable conditions for landsliding.

South Indian Landslide Zones: In South India landslides are common in the Nilgiri-Anamudi massif on the steep slopes of the horst that was uplifted to its present height (>2600 m) during pleistocene times. Demarcated by fault scarps, the massif in its upper largely deforested part has been ravaged by large landslides. The plateau is characterized by a lateritic cap, and so yields easily to the impacts of rain, which is very intensive.

Controlling Landslides

As the principal cause of initiation or acceleration of mass-movements is water, this agent has to be prevented from entering into the

affected area. It is not possible to prevent a landslide from occurring but, it is certainly possible to minimize the hazard and damage by taking timely preventive measures. By constructing an efficient drainage network and making use of appropriate engineering practices of mass-movements, the damage can be minimized. Many landslides are preceded by creep movements over a long period of time. This natural warning system can be used to ensure that preventive and ameliorative measures are taken in time.

Drainage Control and Dewatering Measures: The first step in a programme of slope stabilization is to get rid of water- the agent of provocation-by dewatering the affected mass and directing the water away from the landslide area. This is accomplished by constructing an eaborate drainage network. All streams and watercourses must be diverted around the crown of the slide or the potentially hazardous area through properly lined drains and ditches that have adequate gradient. The springs within the area are entrapped and likewise diverted through pipes into the drains. The drains within the affected area can be filled with gravel and coarse sand.

Construction of a drainage network is accompanied by levelling the ground surface to eliminate all depressions where water can accumulate and cause difficulties.

Vegetating Damaged Slopes: An effective method of arresting erosion and protecting damaged or exposed subsurface material is to cover it with a net of coir, jute or synthetic yarn of about 1.5 cm to 2.5 cm opening, which will allow quick growth of vegetation, the area is fenced before the seed bed is prepared. The netting prevents the soil from breaking due to impacts of rain and wind, and allows unhindered vegetation growth. The soil is first seeded with quick-growing local grass, the root slips being dibbled 15-20 cm apart-root to root, row taking care that no turfs or clumps are dibbled. It is also admixed with an appropriate fertilizer or leguminous plant or organic manure to promote quicker and richer vegetation growth.

To ensure further protection of the slope and dislodgement of rootslips in the seed beds, asphalt emulsion (mulch) can be sprayed (at the rate of 1/ liter/m2). The mulch eventually disintegrates into another fertilizers. The mulching is done just before rainfall. In extreme cases, plastic or latex stablilizer is sprayed after seeding. A much simpler and more pragmatic method would be to mix the grass seed with a small proporation of rapidly growing stemmy plants such as sorgum, which acts as a nurse crop. Inoculation of seed with Rhizobium bacterial culture would ensure quick realization of the desired results.

A number of grasses have been found useful for protection of slopes, such as 'nara' (Arundo donax), lemongrass, napier (Pennisteum purpureum), kikiyu (Peninsetum clandestinum), 'gorda (Chrysopogon fulvus), C. Nepalensis, etc.-the choice depending on local conditions including climate and soil composition. The legume Pureraria hirsuta (P. Thunbergiana) with deep roots has been found very promising. It is planted in January and February.

Slope Modification: The stability of the slope can be increased by grading it -by constructing benches which not only reduce the slope but also serve as traps for falling, sliding and creeping material so that downslope damage is prevented. But the reshaping of a slope involves appropriate disposal of debris generated. Another method of stabilizing a slope is to reduce the load at the head of the landslide and/or strengthen the base by enlarging the toe.

Retaining Walls and Buttresses: To provide support at the base of threatened slope or solid mass and to prevent toe erosion, a variety of retaining walls can be constructed of concrete masonary or cribs. A buttress wall is a heavy, low height structure at the base, providing safeguards against toe erosion. If free space is available, the wall is built a little away from the toe and the intervening space filled with gravel and other permeable material to allow drainage of water. The free passage of water prevents buildup of water pressure inside the solid mass behind the wall. The retaining and buttress walls must be supplemented with weep holes

and drop channels, if these are to be effective and long lived.

Another very effective, fast and economical method of preventing slope failure is the one adopted in deep cuts in the Tallahatti Channel of the Kalindi project, Karnataka. Prestressed anchor pads are installed at the toe of the slope, each anchor weighing one another by crossbeams.

CYCLONE

Cyclones are one of the natural hazards that affect India almost every year causing large loss of lives and properties. A tropical cyclone can be regarded as a large and tall rotating cylinder of clouds containing enormous amount of water and packing heavy winds. It is like a giant heat engine held by the release of latent heat due to condensation of huge quantity of water vapour drawn from the warm sea surface waters. The released latent heat warms up the air, the air lighter in that column rises up creating a drop in pressure near the sea surface. This gives rise to rapid inflow of air making more warm and moist air to rise and consequently more release of latent heat over the place. Thus air rushes in from all sides and rises vertically up creating a rotating vortex. If the process continues for a longer time, the pressure fall in that place could be very much below normal resulting in further growth of the tropical cyclone and strengthening the winds.

The necessary conditions for the formation of cyclones are:

(i) sufficiently large areas of ocean with sell-surface temperature around26-27 degree Celsius;

(ii) depth of warm water, atleast 50 to 60 metres so that sufficient supply of warm and moist air is ensured; and

(iii) initial rotation trigger should be provided by some favourable meteorological condition.

The Indian subcontinent is one of the worst affected regions in the world. The subcontinent with a long coastline of 8041 kilometre is exposed to nearly 10 per cent of the world•fs tropical cyclones. Of these, the majority have their initial genesis over the Bay of Bengal and strike the east coast of India. On an average, five to six tropical cyclones form every year, of which two or three could be severe. More cyclones occur in the Bay of Bengal than the Arabian Sea and the ratio is approximately 4:1. Cyclones occur frequently on both the coasts (The west coast - Arabian Sea; and the east coast - Bay of Bengal). An analysis of the frequency of cyclones on the east and west coasts of India between 1891 and 1990 shows that nearly 262 cyclones occurred (92 severe) in a 50 km wide strip on the east coast. Less severe cyclonic activity has been noticed on the west coast, with 33 cyclones occurringin the same period, out of which 19 of these were severe.

Tropical cyclones occur in the months of May-June and October-November. The cyclones of severe intensity and frequency in the north Indian Ocean are bi-modal in character, with their primary peak in November and secondary peak in May. The disaster potential is particularly high at the time of landfall in the north Indian Ocean (Bay of Bengal and the Arabian Sea) due to the accompanying destructive wind, storm surges and torrential rainfall. Of these, storm surges are the greatest killers of a cyclone, by which sea water inundates low lying areas of coastal regions and causes heavy floods, erodes beaches and embankments, destroys vegetation and reduces soil fertility.

Cyclones vary in diameter from 50 to 320 km but their effects dominate thousands of square kilometers of ocean surface and the lower atmosphere. The perimeter may measure 1,000 km but the powerhouse is located within the 100-km radius. Nearer the eye, winds may hit 320 kmph. Thus tropical cyclones, characterized by destructive winds, torrential rainfall and storm surges disrupt normal life with accompanying the phenomena of floods due to the exceptional level of rainfall and storm surge inundation into inland areas. Cyclones are characterized by their devastating potential to damage structures, viz. houses; lifeline infrastructure-power and communication towers; hospitals; food storage facilities; roads, bridges and culverts; crops

etc. The most fatalities come from storm surges and the torrential rain flooding the lowland areas of the coastal territories. Storm surges (tidal waves) are defined as the rise in sea level above the normally predicted astronomical tide.

Cyclone warning and forecasting system in India

Cyclone forecasts are provided through six-cyclone warning centers located at Kolkata, Bhubaneswar, Visakhapatnam, Chennai, Mumbai and Ahmedabad. These centers have their distinct area wise responsibilities covering both the east and west coasts of India and the oceanic areas of the Bay of Bengal and the Arabian Sea, including Andaman & Nicobar and Lakshadweep.

Cyclone warnings are issued to the All India Radio (AIR) and the Doordarshan for broadcast/telecast in different languages. Cyclone warnings are also given to control room and Crisis Management Group in the Ministry of Agriculture, Government of India, who are finally responsible for coordinating various activities of Centre and State Governments and other agencies in respect of cyclone warnings. Forecasts and warnings are simultaneously communicated to the States and the Districts likely to be attached. Ports, airports and other user agencies also receive the forecasts and warnings at the same time.

Cyclones are tracked with the help of INSAT, powerful cyclone detection radars and conventional meteorological observations including weather reports from ships. At present cyclone detection radars are installed at (i) Kolkata, (ii) Paradeep, (iii) Visakhapatnam, (iv) Machilipatnam, (v) Chennai, (vi) Karaikal on the east coast; and (vii) Goa, (viii) Cochin, (ix) Mumbai and (x) Bhuj along the west coast. Present cyclone surveillance system in India is such that no cyclone in the region will go undetected at any time of its life cycle.

The important components of cyclone warnings are the forecast of future path and intensity of a eye tone and the associated hazardous weather. For the preparation of future position (path) of tropical cyclones and for estimation of storm surges, modern, and computer based techniques are used in addition to conventional methods. Intensity forecasts are made by using satellite techniques.

IMD introduced a 4-Stage warning system to issue cyclone warnings to the disaster managers. They are as follows:

(1) Pre-Cyclone Watch

Issued when a depression forms over the Bay of Bengal irrespective of its distance from the coast and is likely to affect Indian coast in future. The pre-cyclone watch is issued by the name of Director General of Meteorology and is issued at least 72 hours in advance of the commencement of adverse weather. It is issued at least once a day.

(2) Cyclone Alert

Issued atleast 48 hours before the commencement of the bad weather when the cyclone is located beyond 500 Km from the coast. It is issued every three hours.

(3) Cyclone Warning

Issued at least 24 hours before the commencement of the bad weather when the cyclone is located within 500 Km from the coast. Information about time /place of landfall are indicated in the bulletin. Confidence in estimation increases as the cyclone comes closer to the coast.

(4) **Post landfall outlook**

It is issued 12 hours before the cyclone landfall, when the cyclone is located within 200 Km from the coast. More accurate & specific information about time /place of landfall and associated bad weather indicated in the bulletin. In addition, the interior distraction is likely to be affected due to the cyclone are warned in this bulletin.

Cyclone Warning Dissemination System

a) It is Designed by ISRO and implemented by IMD in the mid-eighties, the CWDS is used all these years to disseminate cyclone warnings effectively.

b) Selective addressing (Separate messages for each district) is done by transmitting a digital code followed by the actual warning message.

c) Cyclone warnings are generated in English and other local languages (Tamil, Telugu, Oriya, Bengali, Marathi, Gujarati etc)

d) Though Radio/TV broadcast are for one and all, the messages through CWDS can be accessed only at centres equipped with a receiver and addressed specifically for receiving the message

e) CWDS is one-way communication system and will be complimentary to other systems of cyclone warning dissemination. Facility of acknowledgment is available in the upgraded (Digital) version of CWDS

f) The present CWDS network covers 252 stations spread over coastal areas of maritime districts along the east and e west coast

g) Through World Bank assistance Govt. of Andhra Pradesh had installed 100 Digital CWDS receivers along Andhra Coast. For this purpose a digital up-linking station also functions at Chennai.

National Cyclone Risk Mitigation Project

The National Cyclone Risk Mitigation Project (NCRMP) is a pioneer project drawn up by Ministry of Home Affairs (MHA), Government of India (GoI) with the purpose of creating suitable infrastructure to mitigate the effects of cyclones in the coastal states of India in a sustainable way. The project was transferred to National Disaster Management Authority (NDMA) in September 2006. The project has identified 13 cyclone prone States and Union Territories (UTs), with varying levels of vulnerability.

These States/UTs have further been classified into two categories; based on the frequency of occurrence of cyclones, size of population and the existing institutional mechanism for disaster management. These categories are:

- **Category I:** Higher vulnerability States i.e. Andhra Pradesh, Gujarat, Orissa, Tamil Nadu and West Bengal.
- **Category II:** Lower vulnerability States i.e. Maharashtra, Goa, Karnataka, Kerala, Daman & Diu,Pondicherry, Lakshadweep and Andaman & Nicobar Islands.

The key objectives of the project are:

- Reduction in vulnerability of coastal states through creation of appropriate infrastructure which can help mitigate the adverse impacts of cyclones, while preserving the ecological balance of a coastal region.
- Strengthening of cyclone warning systems enabling quick and effective dissemination of warning and advisories from source/district/sub-district level to the relevant communities. ■■■