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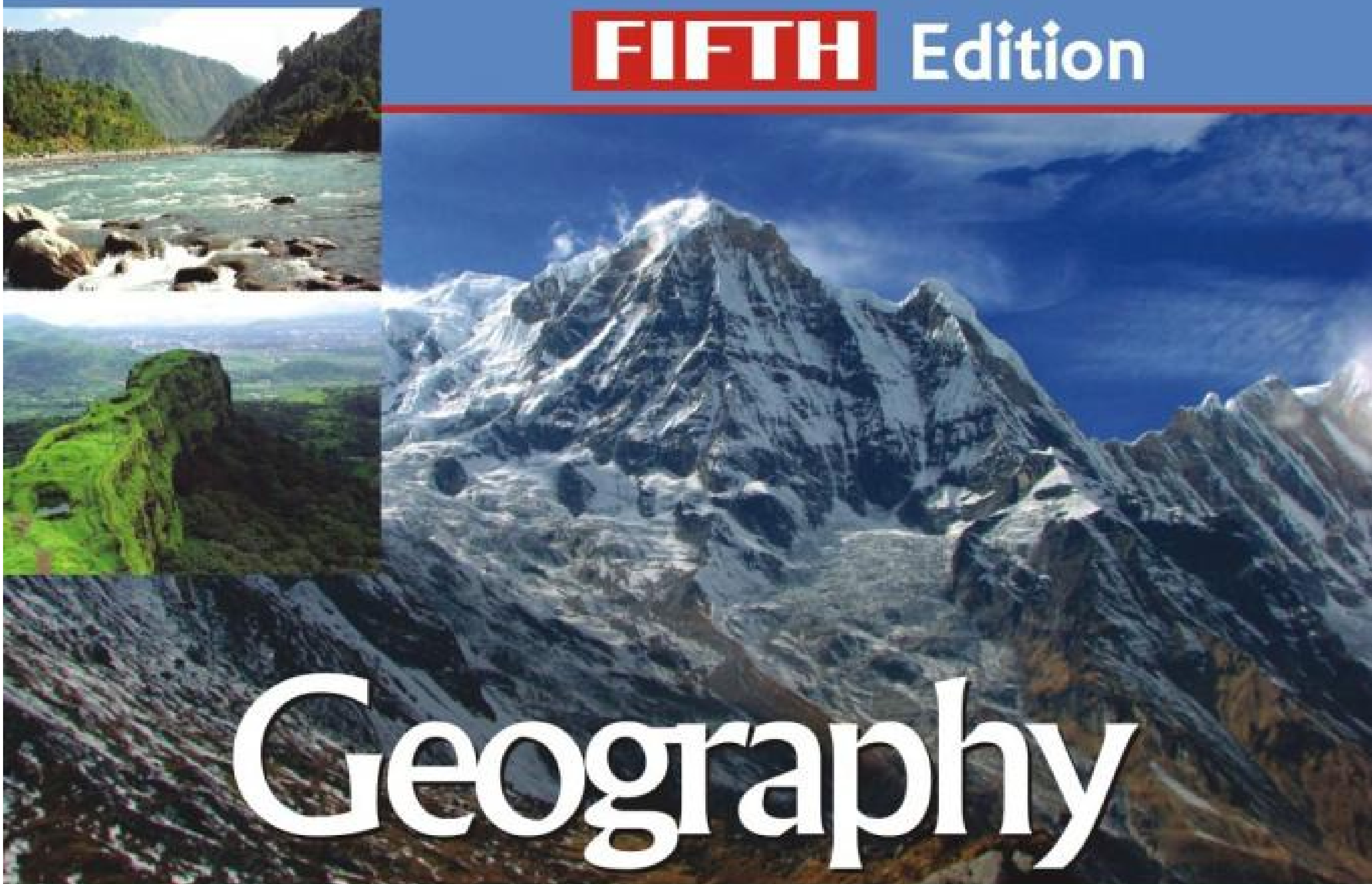
FIFTH Edition



Geography of India

MAJID HUSAIN

McGRAW HILL EDUCATION WINNING EDGE (WE) SERIES

Geography of India

Fifth Edition

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Delhi

McGraw Hill Education (India) Private Limited
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ABOUT THE CIVIL SERVICES EXAMINATION

The Civil Services examination comprises two successive stages:

(i) Civil Services (Preliminary) Examination (Objective Type) for the selection of candidates for Main Examination; and

(ii) Civil Services (Main) Examination (Written and Interview) for the selection of candidates for the various services and posts.

Scheme and subjects for the Preliminary and Main Examination.

A. Preliminary Examination

The Examination shall comprise two compulsory Papers of 200 marks each.

Note:

(i) Both the question papers will be of the objective type (multiple choice questions).

(ii) The question papers will be set both in Hindi and English. However, questions relating to English Language Comprehension Skills of Class X level will be tested through passages from English language only without providing Hindi translation thereof in the question paper.

B. Main Examination

The written examination will consist of the following papers:

Qualifying Papers:

Paper A: (One of the Indian Language to be selected by the candidate from the Languages included in the Eighth Schedule to the Constitution). 300 Marks

Paper B: English 300 Marks

The papers on Indian Languages and English (Paper A and Paper B) will be of Matriculation or equivalent standard and will be of qualifying nature. The marks obtained in these papers will not be counted for ranking.

Papers to be counted for merit

Paper I: Essay 250 Marks

Paper II: General Studies–I 250 Marks

(Indian Heritage and Culture, History and Geography of the World and Society)

Paper III: General Studies –II 250 Marks
(Governance, Constitution, Polity, Social Justice and International Relations)

Paper IV: General Studies –III 250 Marks
(Technology, Economic Development, Bio-diversity, Environment, Security and Disaster Management)

Paper V: General Studies –IV 250 Marks
(Ethics, Integrity and Aptitude)

Paper VI: Optional Subject – Paper 1 250 Marks

Paper VII: Optional Subject – Paper 2 250 Marks
Sub Total (Written test): 1750 Marks
Personality Test: 275 Marks
Grand Total: 2025 Marks
Candidates may choose any one of the optional subjects from amongst the list of subjects given below:

List of optional subjects for Main Examination:

(i) Agriculture
(ii) Animal Husbandry and Veterinary Science
(iii) Anthropology
(iv) Botany
(v) Chemistry
(vi) Civil Engineering
(vii) Commerce and Accountancy
(viii) Economics
(ix) Electrical Engineering
(x) Geography
(xi) Geology
(xii) History
(xiii) Law
(xiv) Management
(xv) Mathematics
(xvi) Mechanical Engineering
(xvii) Medical Science
(xviii) Philosophy
(xix) Physics
(xx) Political Science and International Relations
(xxi) Psychology
(xxii) Public Administration
(xxiii) Sociology
(xxiv) Statistics
(xxv) Zoology
(xxvi) Literature of any one of the following

Assamese, Bengali, Bodo, Dogri, Gujarati, Hindi, Kannada, Kashmiri, Konkani, Maithili, Malayalam, Manipuri, Marathi, Nepali, Oriya, Punjabi, Sanskrit, Santhali, Sindhi, Tamil, Telugu, Urdu and English.

GEOGRAPHY SYLLABUS FOR MAIN EXAMINATION

Paper-I

Principles of Geography

Physical Geography

(i) **Geomorphology :** Factors controlling landform development; endogenetic and exogenetic forces; Origin and evolution of the earth's crust; Fundamentals of geomagnetism; Physical conditions of the earth's interior; Geosynclines; Continental drift; Isostasy; Plate tectonics; Recent views on mountain building; Vulcanicity; Earthquakes and Tsunamis; Concepts of geomorphic cycles and Landscape development ; Denudation chronology; Channel morphology; Erosion surfaces; Slope development ;Appl ied Geomorphology: Geohydrology, economic geology and environment

(ii) **Climatology :** Temperature and pressure belts of the world; Heat budget of the earth; Atmospheric circulation; atmospheric stability and instability. Planetary and local winds; Monsoons and jet streams; Air masses and fronto genesis, Temperate and tropical cyclones; Types and distribution of precipitation; Weather and Climate; Koppen's, Thornthwaite's and Trewartha's classification of world climates; Hydrological cycle; Global climatic change and role and response of man in climatic changes, Applied climatology and Urban climate.

(iii) **Oceanography :** Bottom topography of the Atlantic, Indian and Pacific Oceans; Temperature and salinity of the oceans; Heat and salt budgets, Ocean deposits; Waves, currents and tides; Marine resources: biotic, mineral and energy resources; Coral reefs, coral bleaching; sealevel changes; law of the sea and marine pollution.

(iv) **Biogeography :** : Genesis of soils; Classification and distribution of soils; Soil profile; Soil erosion, Degradation and conservation; Factors influencing world distribution of plants and animals; Problems of deforestation and conservation measures; Social forestry; agro-forestry; Wild life; Major gene pool centres.

(v) **Environmental Geography :** Principle of ecology; Human ecological adaptations; Influence of man on ecology and environment ; Global and regional ecological changes and imbalances; Ecosystem their management and conservation; Environmental degradat ion, management and conservation; Biodiversity and sustainable development; Environmental policy; Environmental hazards and remedial measures; Environmental education and legislation.

Human Geography

(i) **Perspectives in Human Geography :** Areal differentiation; regional synthesis; Dichotomy and dualism; Environmentalism; Quant i tat ive revolut ion and locat ional analysis; radical, behavioural, human and welfare approaches; Languages, religions and secularisation; Cultural regions of the world; Human development index.

(ii) Economic Geography : : World economic development: measurement and problems; World resources and their distribution; Energy crisis; the limits to growth; World agriculture: typology of agricultural regions; agricultural inputs and productivity; Food and nutrition problems; Food security; famine: causes, effects and remedies; World industries: locational patterns and problems; patterns of world trade.

(iii) Population and Settlement Geography : Growth and distribution of world population; demographic attributes; Causes and consequences of migration; concepts of over - under-and optimum population; Population theories, world population problems and policies, Social well-being and quality of life; Population as social capital. Types and patterns of rural settlements; Environmental issues in rural settlements; Hierarchy of urban settlements; Urban morphology: Concepts of primate city and rank-size rule; Functional classification of towns; Sphere of urban influence; Rural - urban fringe; Satellite towns; Problems and remedies of urbanization; Sustainable development of cities.

(iv) Regional Planning : Concept of a region; types of regions and methods of regionalisation; growth centres and growth poles; regional imbalances; environmental issues in regional planning; planning for sustainable development.

(v) Models, Theories and Laws in Human Geography : System analysis in Human Geography; Malthusian, Marxian and Demographic Transition models; Central Place theories of Christaller and Losch; Von Thunen's model of agricultural location; Weber's model of industrial location; Rostov's model of stages of growth. Heart-land and Rimland theories; laws of international boundaries and frontiers.

Note: Candidates will be required to answer one compulsory map question pertinent to subjects covered by this paper.

PART II

Geography Of India

1. **Physical Setting:** Space relationship of India with neighboring countries; Structure and relief; Drainage system and watersheds; Physiographic regions; Mechanism of Indian monsoons and rainfall patterns, Tropical cyclones and western distur - bances; Floods and droughts; Climatic regions; Natural vegetation; Soil types and their distributions.
2. **Resources:** Land, surface and ground water, energy, minerals, biotic and marine resources; Forest and wild life resources and their conservation; Energy crisis.
3. **Agriculture:** Infrastructure: irrigation, seeds, fertilizers, power; Institutional factors: land holdings, land tenure and land reforms; Cropping pattern, agricultural productivity, agricultural intensity, crop combination, land capability; Agro and socialforestry; Green revolution and its socioeconomic and ecological implications; Significance of dry farming; Livestock resources and white revolution; aqua - culture; sericulture, apiculture and poultry; agr icul tural regional isat ion; agro-cl imat ic zones; agro-ecological regions.
4. **Industry :** Evolution of industries ; Locational factors of cotton, jute, textile, iron and steel, aluminium, fertilizer, paper, chemical and pharmaceutical, automobile, cottage and agro-based industries; Industrial houses and complexes including public sector undertakings; Industrial regionalisation; New industrial policies; Multinationals and liberalization; Special Economic Zones; Tourism including eco -tourism.
5. **Transport, Communication and Trade:** Road, railway, waterway, airway and pipeline networks and their complementary roles in regional development; Growing importance of ports on national and

foreign trade; Trade balance; Trade Policy; Export processing zones; Developments in communication and information technology and their impacts on economy and society; Indian space programme.

6. **Cultural Setting:** Historical Perspective of Indian Society; Racial, linguistic and ethnic diversities; religious minorities; major tribes, tribal areas and their problems; cultural regions; Growth, distribution and density of population; Demographic attributes: sex-ratio, age structure, literacy rate, work-force, dependency ratio, longevity; migration (inter-regional, intra- regional and international) and associated problems; Population problems and policies; Health indicators.
7. **Settlements:** Types, patterns and morphology of rural settlements; Urban developments; Morphology of Indian cities; Functional cla ssification of Indian cities ; Conurbations and metropolitan regions; urban sprawl; Slums and associated problems; town planning; Problems of urbanization and remedies.
8. **Regional Development and Planning:** Experience of regional planning in India; Five Year Plans; Integrated rural development programmes; Panchayati Raj and decentralised planning; Command area development; Watershed management; Planning for backward area ,desert , drought prone, hill, tribal area development; multi-level planning; Regional planning and development of island territories.
9. **Political Aspects:** Geographical basis of Indian federalism; State reorganisation; Emergence of new states; Regional consciousness and inter state issues; international boundary of India and related issues; Cross border terrorism; India's role in world affairs; Geopolitics of South Asia and Indian Ocean realm.
10. **Contemporary Issues:** Ecological issues: Environmental hazards: landslides earth quakes , Tsunamis , floods and droughts, epidemics; Issues relating to environmental pollution; Changes in patterns of land use; Principles of environmental impact assessment and environmental management; Population explosion and food security; Environmental degradation; Deforestation, desertification and soil erosion; Problems of agrarian and industrial unrest; Regional disparities in economic development ; Concept of sustainable growth and development; Environmental awareness; Linkage of rivers; Globalisation and Indian economy.

Note: Candidates will be required to answer one compulsory map question pertinent to subjects covered by this paper.

CONTENTS

Chapter 1

Structure of India

INTRODUCTION

The geological structure of a country helps in understanding the types and character of rocks and slopes, the physical and chemical properties of soils, the availability of minerals, and the surface and underground water resources. All these resources have a direct impact on the socio-economic development of the people of a country, or region.

Geologically, the subcontinent of India was a part of the Gondwanaland (the Southern Continent). The geological history of India is unique, as Peninsular India was a part of the old landmass since the formation of the Earth's crust, which grew in complexity as a succession of Alpine-orogeny resulting in the upheaval of the Himalayas in the Tertiary Period and the aggradational formation of the Indo-Gangetic Plain during the Pleistocene Period. The latter continues till today, through sedimentation in the flood plains of the rivers and the lower part of the Gangetic Plain, namely the Hugli basin. The geological history of India is complex as well as varied. It begins with the first formation of the Earth's crust, first deposited sedimentary rocks, first orogeny, and extends up to the recent laying down of alluvial deposits. Many of these rock formations occur in superimposed positions and have been subjected to intense folding and faulting. The geological structure of India has been described briefly in the following sections (**Fig. 1.1**).

THE ARCHAEAN FORMATIONS (PRE-CAMBRIAN)

The Archaean Era is also known as the Precambrian Period. This is the division of geologic time scale from the formation of the Earth (about 4.6 billion years ago) to the beginning of the Cambrian Period of the Paleozoic Era (about 570 million years ago).

The Precambrian time constitutes about 86.7% of the Earth's history. The term 'Archaean', introduced by J.D. Dana in 1782, refers to the oldest rocks of the Earth's crust. The oldest known rocks of the Earth, the evolutionary atmosphere, the first chemosynthesis, the first photosynthesis, the life-supporting atmosphere and the Earth's modern atmosphere, were developed during the Precambrian Era (Archaean and Protozoic). Rocks of the Archaean System are devoid of any form of life. In other words, the Archaean rocks are all azoic or unfossiliferous. They are thoroughly crystalline, extremely contorted and faulted, and practically devoid of any sediment. They are largely intruded by plutonic intrusions and generally have a well-defined foliated structure. These rocks are known as the ***basement complex*** **or** ***fundamental gneisses***. Thus, all over the world, the Archaean rocks are the foundation of all the great ancient plateaux, and they form the core of all the great folded mountain ranges of the world.

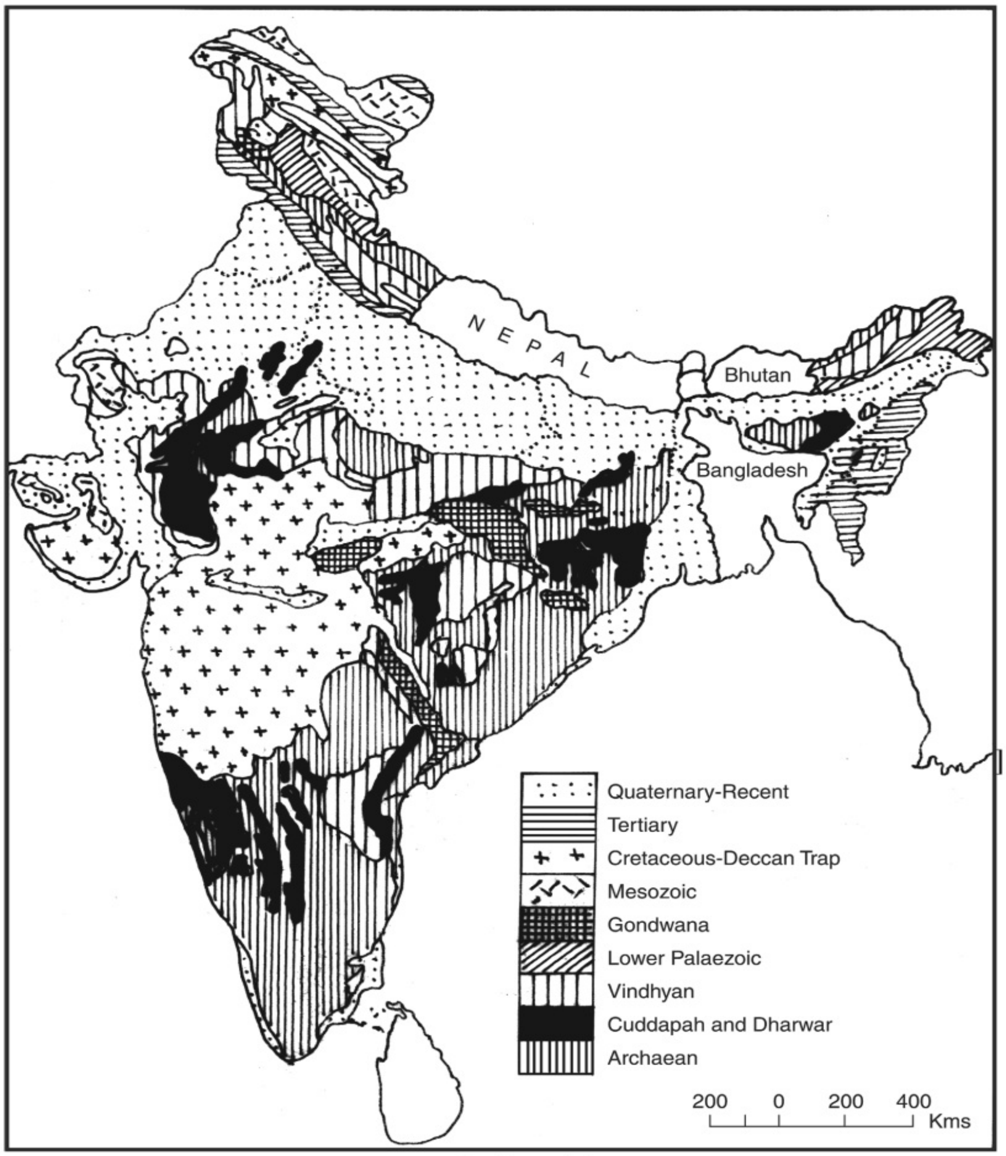

Fig. 1.1 Geological Systems

In the Indian Geological Time Scale, advocated by T.S. Holland, the Pre-Cambrian Era is known as the *Purana*. The Archean System includes the Aravalli, Dharwar, Cuddapah, Vindhyan, Meghalaya Plateau and Mikir Hills. These are also called the Archean gneiss. The mineral composition of Archaen gneiss varies from granite to gabbro. The constituent minerals are: orthoclase, oligoclase, quartz, muscovite, biotite and hornblends. The Archaen rocks cover two-thirds of Peninsular India. They also occur in the roots of the mountain peaks all along the Greater Himalayas from the western most part of Kashmir to the eastern-most part of Arunachal Pradesh as well as in the Trans-Himalayan ranges of Zaskar (Zanskar), Ladakh and the Karakoram **(Fig. 1.1 and Fig. 1.2).**

The Archaean rocks cover two-thirds of Peninsular India. In the Peninsular region, the Archaean rocks are known to be of three well-defined types:

(i) The Bengal Gneiss

The Bengal Gneiss is highly foliated, which occurs in the Eastern Ghats, Odisha (known as Khodolites after Khond tribes in Koraput and Bolangir districts), stretching over Manbhum and Hazaribagh districts of Jharkhand, Nellore district of Andhra Pradesh and Salem district of Tamil Nadu. They also occur in the Son Valley, Meghalaya Plateau and Mikir Hills.These formations are very thinly foliated. For the first time these rocks were identified in the Midnapur district of West Bengal.

(ii) The Bundelkhand Gneiss

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

(iii) The Nilgiri Gneiss

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

The Archaean rocks are the repositories of the mineral wealth of India. These rocks are rich in ferrous and non-ferrous minerals like iron ore, copper, manganese, mica, dolomite, lead, zinc, silver and gold.

DHARWAR SYSTEM (PROTEROZOIC FORMATIONS)

This geologic time extends from 2500 million years ago to 1800 million years ago**.** These are the first metamorphosed sedimentary rock systems known as the Dharwar System in the Indian Geological Time Scale. In India, these rocks were studied for the first time in the Dharwar district of Karnataka. They are composed largely of igneous debris, schists and gneisses. The Dharwar rocks occur in scattered patches in (i) Dharwar and Bellary districts of Karnataka and extend up to the

Nilgiris and Madurai districts of Tamil Nadu, (ii) Central and eastern parts of the Chotanagpur Plateau, Meghalaya Plateau and Mikir Hills, and (iii) the Aravallis, Rialo (Delhi series), from Delhi to the south of Alwar and the Himalayan region (**Fig. 1.3**).

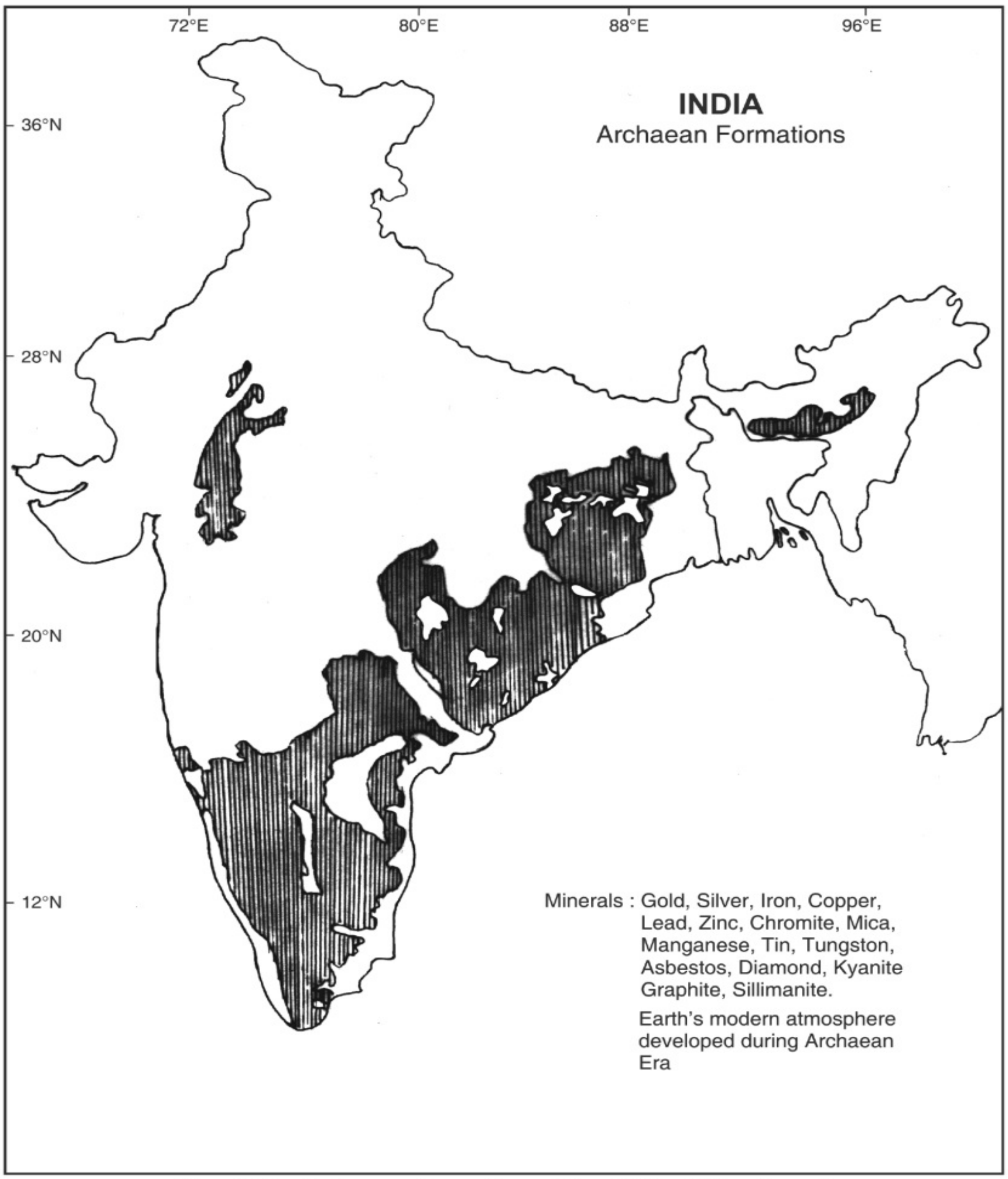

Fig. 1.2 Archaean Formations (Pre–2500 Million Years)

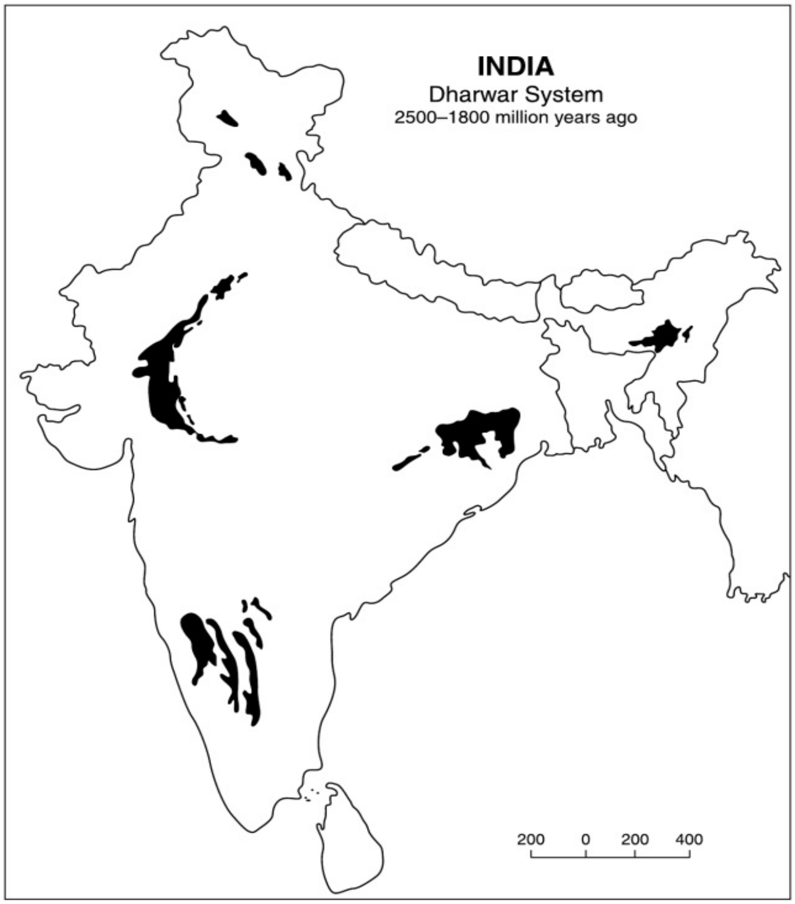

Fig. 1.3 Dharwar System (2500–1800 million years ago)

The Dharwar rocks are highly metalliferous. They are rich in iron ore, manganese, lead, zinc, gold, silver, dolomite, mica, copper, tungsten, nickel, precious stones and building materials. Some of the important series of the Dharwar System are:

(a) Champion Series

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

(b) Champaner Series

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

(c) Chilpi Series

It occupies parts of Balaghat, Jabalpur and Chhindwara districts of Madhya Pradesh. The series consists of grit, phyllite, quartzites, green stones and magniferous rocks.

(d) Closepet Series

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

(e) Iron-Ore Series

It occurs in Singhbhum, Bonai, Mayurbhanj and Keonjhar in the form of a range. The iron-ore series is about 65 kilometres in length and reserves about three thousand million tons of iron-ore. Iron-ore from this series is supplied to Jamshedpur, Durgapur, Raurkela and Bokaro steel plants.

(f) Khondolite Series

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

(g) Rialo Series

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

(h) Sakoli Series

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

(i) Sausar Series

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

THE CUDDAPAH SYSTEM (THE PURANA GROUP)

The Cuddapah system is made of shales, slates, limestone and quartzite. The rocks are generally without fossils. The Cuddapah formations, named after the district of Cuddapah in Andhra Pradesh, are sedimentary-metamorphic formations. The Cuddapah System occurs in the (i) Cuddapah and Kurnool districts of Andhra Pradesh, (ii) Chhattisgarh, (iii) Rajasthan-Delhi to the south of Alwar, and (iv) the Lesser Himalayas in the extra-Peninsular region. (**Fig. 1.4**)

At places the Cuddapah formations are six thousand metres in thickness. The enormous thickness of these rocks indicates the sinking of beds of the basin with growing sedimentation.

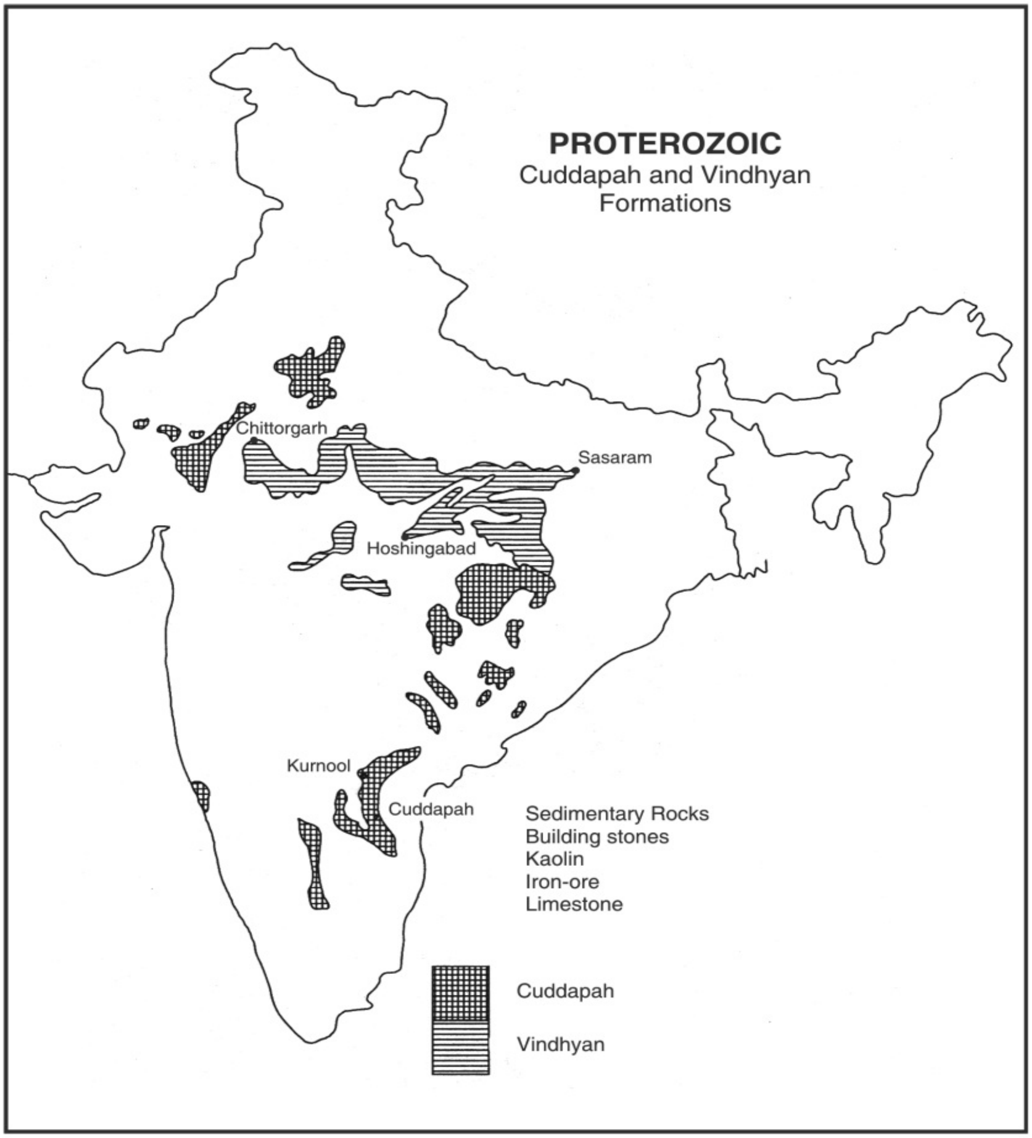

Fig. 1.4 Proterozoic Formations (2500–570 Million years)

The principle rocks of the Cuddapah System are sandstones, shales, limestone, quartzites slates, inferior quality of iron-ore, manganese ore, asbestos, copper, nickel, cobalt (Delhi System), marble, jasper, building material and stones for interior decoration. The metallic contents in the ores of Cuddapah rocks are, however, low and at places uneconomical for extraction.

Papaghani Series

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

THE VINDHYAN SYSTEM

The Vindhyan System derives its name from the Vindhyan Mountain. This mountain forms a dividing line between the Ganga Plain and the Deccan Plateau. The system covers an extensive area of 103,600 sq km from Chittorgarh in Rajasthan to Sasaram in Bihar. It has enormous sedimentary deposits and at places their depth is more than 4000 metres. In some tracts, the Vindhyan rocks are buried under Deccan lava. The Great Boundary Fault (GBF) separates the Vindhyan System from the Aravallis for a distance of about eight hundred km **(Fig. 1.4).**

The Vindhyan system is well known for red-sandstone, sandstone, building material, ornamental stone, conglomerates, diamondiferous and raw materials for cement, lime, glass and chemical industries. In certain places these rocks yield inferior quality of iron ore and manganese. The well known diamond mines of Panna and Golconda lie in the Vindhyan System. The historical buildings of Qutab Minar, Humayun's Tomb, Fatehpur Sikri, Agra Fort, Red Fort, Jama-Masjid, Birla Mandir, the Buddhist Stupa of Sanchi, etc. have been constructed from the red-sandstone obtained from the Vindhyan Ranges. Coarser sandstones have been used as grindstones and millstones.

Bhander Series

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

Bijwar Series

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

Kaimur Series

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

THE PALAEOZOIC GROUP (CAMBRIAN TO CARBONIFEROUS PERIOD)

The Palaeozoic Era includes the Ordovician, Silurian, Devonian, Carboniferous and the Permian periods of the Standard Geological Time Scale. This is known as the Dravidian Era in the Indian Geological Time Scale.

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

Palaeozoic System in the Indian Geologic Time Scale

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

THE MESOZOIC ERA (THE GONDWANA SYSTEM)

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

The Gondwana group begins with the Permo-Carboniferous period which, in the Standard Geologic Time Scale, is known as a period of coal formation (**Fig. 1.5**). The Lower Gondwana rocks are found in the Talcher, Panchet and Damuda series. Most of the good quality coal deposits (bituminous and anthracite) of India are found in Gondwana formations. Moreover, iron ore occurs in the iron-stone shales of Raniganj coal fields. In addition to coal and iron, kaolin, fire-clay, sandstone and grits are also found in the Gondwana formations.

Talcher Series

It is the series of the Gondwana system named after Talcher in Dhankenal District of Odisha. It is rich in good quality coal used for smelting and in thermal power plants.

The Damuda Series

The Damuda series belongs to the Middle Gondwana Period which contains enormous deposits of coal seams.The coal seams are thicker and more elongated in the eastern coal fields than in the west. The important coal bearing areas of this period are Raniganj, Jharaia, Karanpura and Bokaro of the Damodar basin, Singrauli, Korba, and Pench valley in Chhattigarh and Madhya Pradesh, Talcher in Mahanadi Basin in Odisha, and Singareni of Satpura Basin in Madhya Pradesh. The *Jhingurda Coal Seam* with a thickness of about 131 metres is the thickest coal seam in India. The Gondwana rocks are also found in Himalayas from Kashmir to Arunachal Pradesh and Poorvanchal. The coal seams of these areas are metamorphosed. They are also found in Saurashtra, Kachchh, western Rajasthan, Coromandal Coast, and Rajmahal Hills (**Fig. 1.5**).

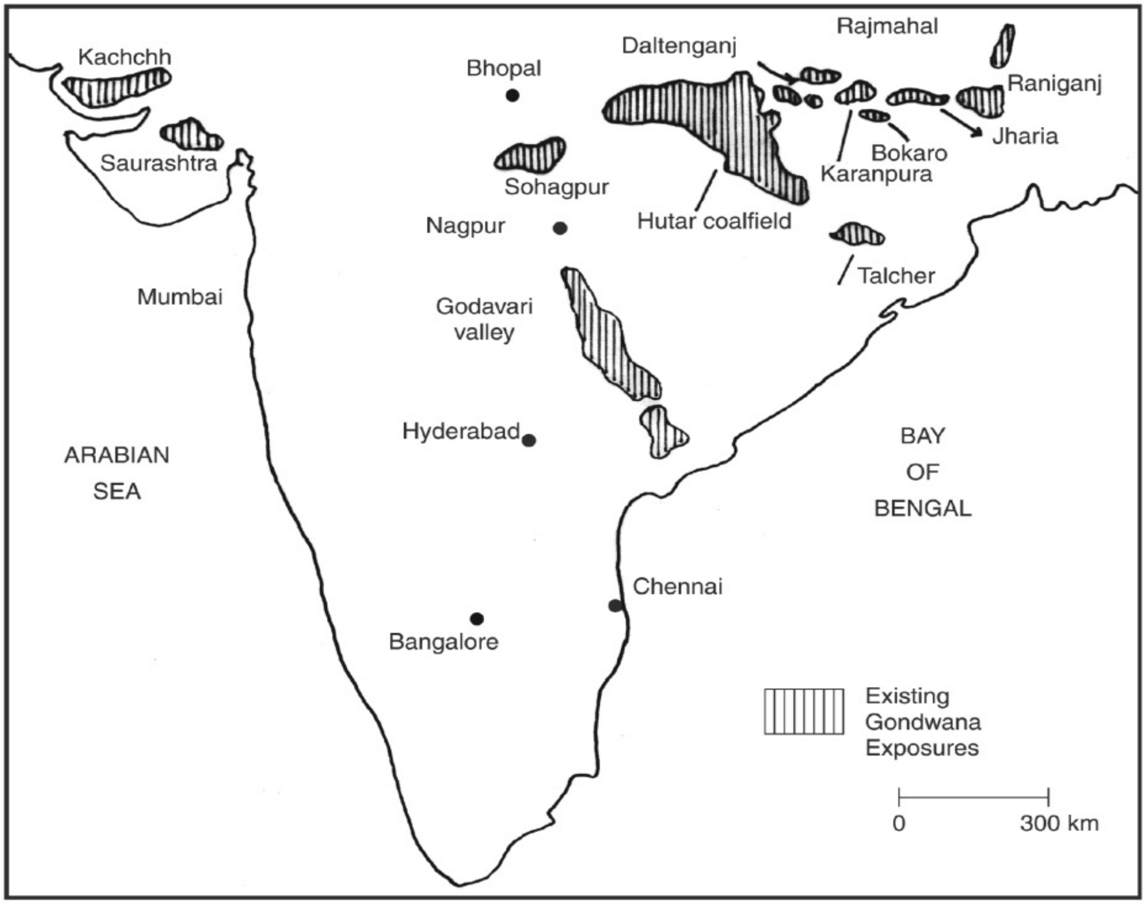

Fig. 1.5 Gondwana System (345–280 million years before present)

Panchet Series

It is the youngest series of the Lower Gondwana System, which derives its name from the hill of that name south of Raniganj. The series consists of greenish-sandstone and shales. It is, however, devoid of coal-seams.

The iron-ore shales of the Lower Gondwana System are particularly well developed in the Raniganj coalfield of West Bengal. However, they contain inferior quality iron ore, i.e. siderite and limonite. Being inferior in quality, they are generally not mined for iron. The Gondwana System of rocks provides over 95% of the coal of India. Moreover, it provides iron-ore, limestone, sandstone and raw material for ceramic industry.

India's best and largest coal deposits are found in the Gondwana System—mainly in the Damodar Valley of West Bengal, Jharkhand, the Mahanadi valley of Odisha and Chhattisgarh, the Godavari valley of Andhra Pradesh and the Satpura basin of Madhya Pradesh **(Fig. 1.5).**

As stated above, the beginning of the Upper Carboniferous Period is known as the Aryan period. The salient features of the Aryan formations are:

(i) During the Upper Carboniferous Period, the Himalayan region was occupied by a vast geosyncline which was connected to the Pacific Ocean in the east through China and the Atlantic Ocean in the west through Afghanistan, Iran, Asia Minor and the present Mediterranean Sea. This was called the Tethys Sea.

(ii) The area of the Kashmir Himalayas (from Pir Panjal to Hazara in the north-west and Ladakh in the north-east) witnessed violent volcanic activity.

(iii) The Upper continent of Gondwanaland developed fissures and its broken parts started drifting away from each other. The Subcontinent of India drifted towards north and north-east to collide with the Asian land mass (Eurasian Plate).

(iv) There was large scale eruption of lava in the Deccan Trap.

(v) The development and expansion of the Arabian Sea and the Bay of Bengal.

(vi) The Tertiary mountain building gave birth to Himalayas.

(vii) The Subcontinent of India assumed its present shape.

(viii) The beginning of Ice Age, belonging to the Pleistocene Period, covering large parts of the earth under ice-sheet.

(ix) Evolution and spread of man in different parts of the world.

THE CRETACEOUS SYSTEM (THE DECCAN TRAP)

The Cretaceous Period extends from about 146 million years ago to 65 million years ago. The term 'Cretaceous' has been obtained from the Latin *creta*, meaning 'chalk'. This is a very widely distributed system in the country which has divergent facies of deposits in different parts of India. This period is marked by the transgression of the sea (Coromandal coast, Narmada valley) and outpouring of huge quantity of lava (basalt) so as to form the Deccan Trap and intrusion of plutonic rocks such as gabbro and granite.

Towards the end of the Cretaceous period the Peninsula was affected by intense volcanic activity. During this period, enormous quantity of basaltic lava was poured out to the surface assuming a great thickness of over three thousand metres. The Lava Plateau (the Deccan Trap) is the result of that lava eruption. The Deccan lava covers about five lakh sq km of area in Gujarat (Kachchh, Kathiawad), Maharashtra, Madhya Pradesh (Malwa Plateau), Chhattisgarh, Jharkhand, northern Andhra Pradesh and north-western Karnataka **(Fig. 1.6).**

The lava plateau of India (Deccan Trap) has a maximum thickness of about 3000 m along the coast of Mumbai from where it decreases towards south and east. It is about 800 m in Kachchh, 150 m at Amarkantak and 60 m at Belgaum (Karnataka). The individual lava flows, on an average, have a thickness of about 5 m to 29 m. Such flows have been identified in a boring near Bhusawal (Maharashtra). These are inter-bedded with sedimentary beds called 'inter-trappean beds'.

The basalt of the Deccan Trap is used for the construction of roads and buildings. Moreover, quartz, bauxite, magnetite, agate and semi-precious stones are also found in the trap. It is also rich in magnesium, carbonate, potash and phosphates.

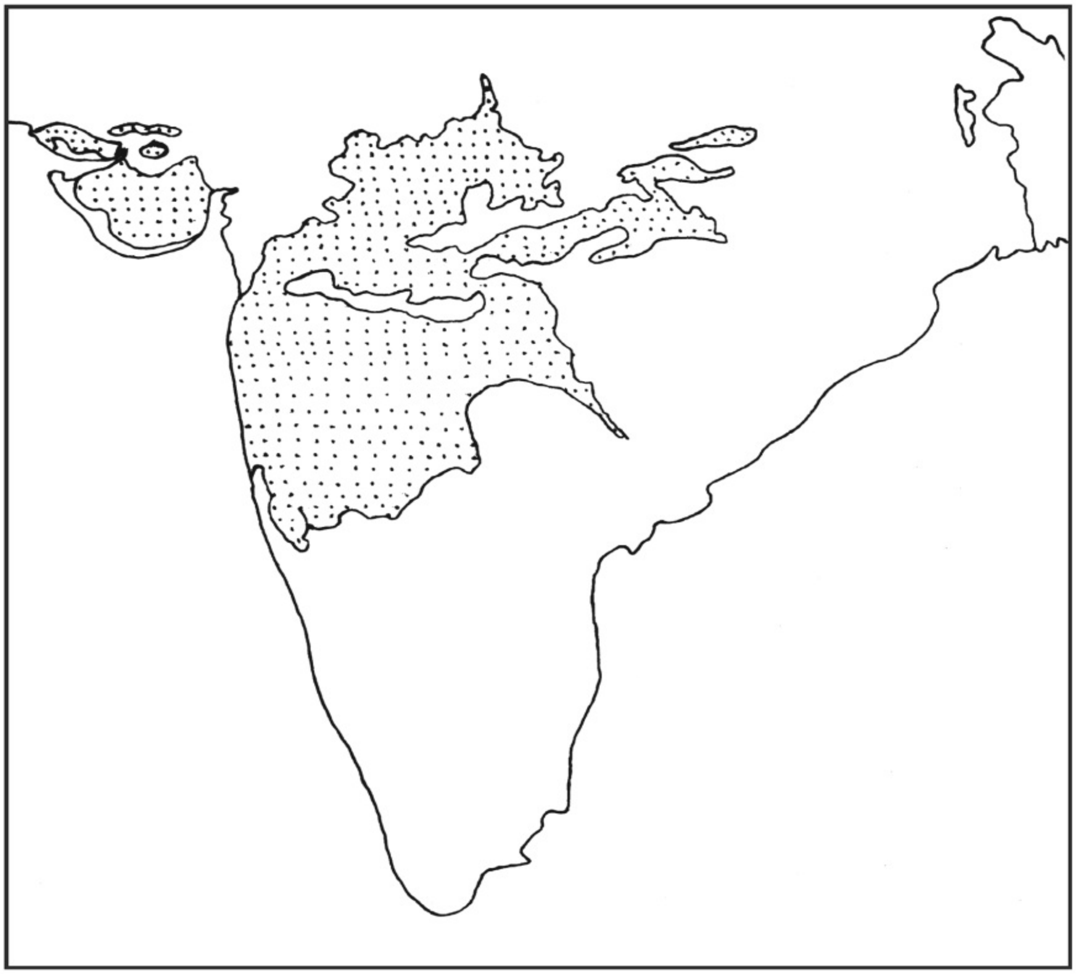

Fig. 1.6 The Cretaceous System (The Deccan Trap)—146–65 million years ago

THE TERTIARY SYSTEM (THE CENOZOIC ERA)

Cenozoic means recent life. The beginning of the Tertiary Period is about 65 million years ago. Fossils in these rocks include many types, closely related to modern forms, including mammals, plants and invertebrates. The Cenozoic Era has two periods: The Tertiary and the Quaternary.

The two great events that occurred during the Tertiary Period include: (i) the final beaking-up of the old Gondwana continent, and (ii) the uplift of the Tethys geosyncline in the form of the Himalayas. During the early Tertiary Period, as India collided with Tibet, the sediments which had been accumulating in the Tethys basin had begun to rise by a slow rise of ocean bottom. The upheaval of the Himalayas altered the old topography of the subcontinent (**Fig. 1.7**).

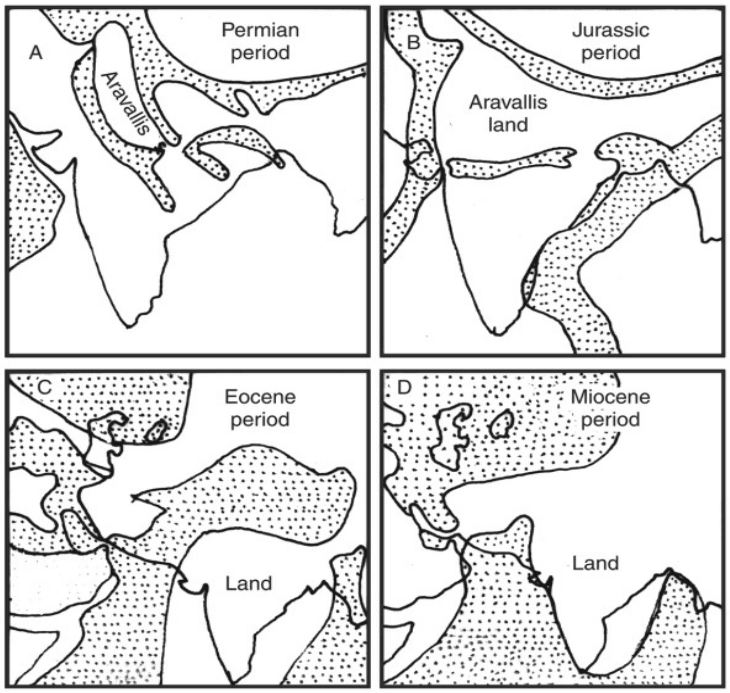

Fig. 1.7 Change in Topography of Subcontinent

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

(i) During the first upheaval (Eocene—about 65 million years ago), which culminated in the Oligocene, and resulted in the upheaval of the Greater Himalayas.

(ii) It was followed by a more intense movement during the mid-Miocene period about 45 million years ago, which resulted in the folding of Lesser Himalayas.

(iii) The third upheaval took place during the Post-Pliocene period, about 1.4 million years ago which resulted in the folding of Shiwaliks or the Outer Himalayas**.** There is enough evidence to prove that the Himalayas are still rising**.**

In the Peninsular region, the Tertiary System occurred on the coast of Kachchh, Kathiawar, Konkan, Malabar, Nilgiris, and the Eastern Ghats.

THE QUATERNARY PERIOD (THE PLEISTOCENE AND RECENT FORMATIONS)

Quaternary is the name proposed for very recent deposits, which contain fossils of species with living representatives. The Northern Plains of India came into existence during the Pleistocene Period (**Fig. 1.8**)**.** During the Quaternary Period, the ice-sheets descended to as low as 1500 metres in altitude. The third physical division of India which is the Great Indo-Gangetic-Brahmaputra Plain had not figured at all till the Quaternary Period. The bottom configuration of this plain occupies largely a synclinal basin, called foredeep, which is a downwarp of the Himalayan foreland of variable depth, formed concommitantly with the rise of the Himalayas to the north. The Pleistocene period is marked by Ice Age and glaciation on a large scale in the Northern Hemisphere. The moraine deposits and the *karewa* formations of Kashmir Valley and the Bhadarwa (Doda District of Jammu Division) are of the Pleistocene period. It forms the terraces of the Jhelum, on the flanks of the Pir-Panjal. The thickness of the karewas at places is up to 1400 metres. The river terraces of the Narmada, Tapi, Godavari, Krishna, and Kaveri, etc. are also of the Pleistocene Period.

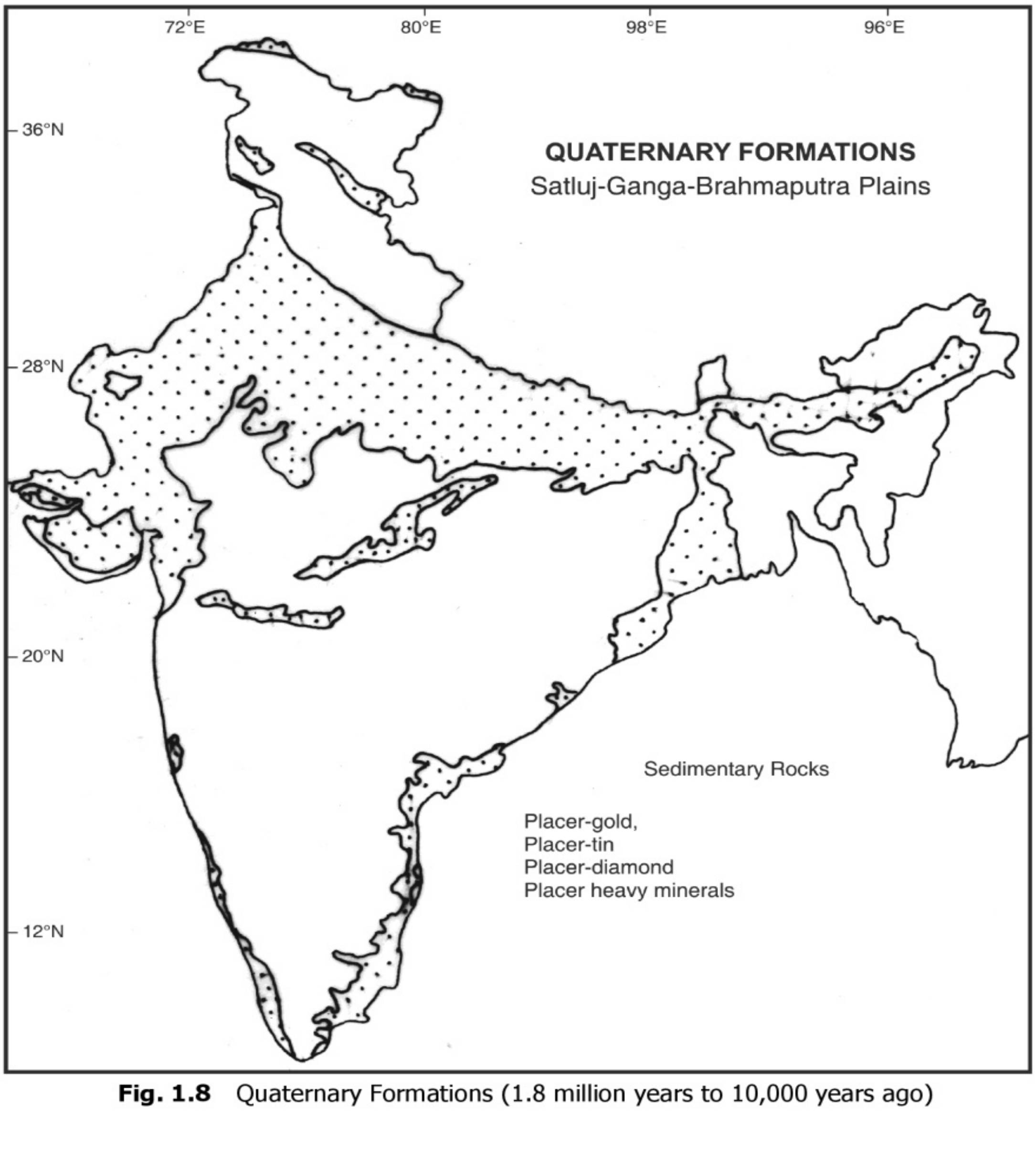

Fig. 1.8 Quaternary Formations (1.8 million years to 10,000 years ago)

Karewas

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

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Chapter 2

Physiography

INTRODUCTION

Physiography deals with the study of the surface features and landforms of the Earth. On the basis of tectonic history, stratigraphy and physiography, India may be divided into the following four physiographic divisions (**Fig. 2.1**):

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

ORIGIN AND PHYSIOGRAPHY OF THE PENINSULAR INDIA

The origin of rocks of Peninsular India is more than 3600 million years old. Before the Carboniferous period, it was a part of the Gondwanaland. In the opinion of geologists, during the Archaean Period, the India Peninsula never subsided under the sea permanently. It was more rigid, stable and had remained almost unaffected by the mountain building forces. However, it experienced block faulting and displacement during the subsequent periods as evidenced by the Dharwar and Gondwana formations and the fault valleys of the Narmada, Tapi and Son rivers.

It was during the Carboniferous Period that coal was formed in the Damodar, Son, Mahanadi and Godavari basins. During the Cretaceous Period, large scale vulcanicity produced the Deccan Trap (the Lava Plateau of India), comprising lava sheets of several thousand metres in depth. The Deccan Trap originated about 146 million years back when the magma flowed from the depth of about 40 km below the crust.

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

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

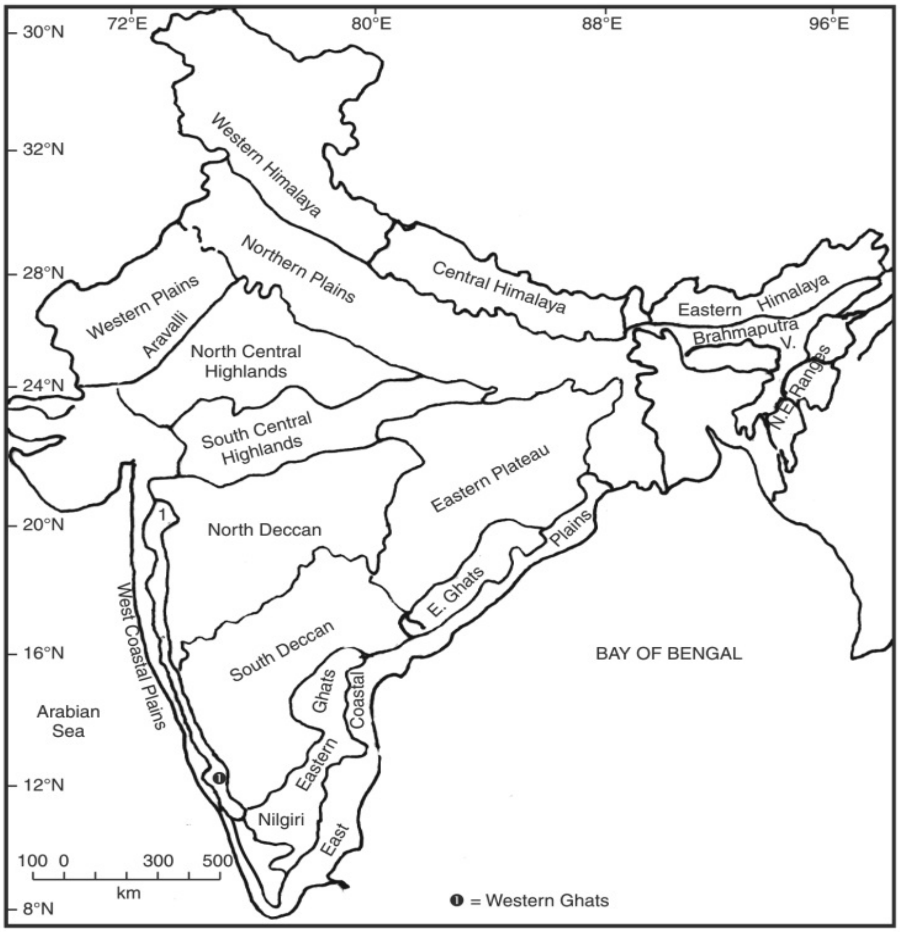

Fig. 2.1 Physiographic Divisions

1. The Archaean Group

Ancient crystalline and highly metamorphosed gneisses of the Archaean System are found in the plateaus of Tamil Nadu, Nilgiris, Karnataka, Andhra Pradesh, Maharashtra, Chhotanagpur, West Bengal, Odisha, Jharkhand, Chhattisgarh, Madhya Pradesh, Meghalaya, Mikir, Bundelkhand (U.P.) and the Aravallis (Rajasthan). The Bengal gneiss known as Khondolite is found in the Eastern Ghats. These rocks are rich in metallic and non-metallic minerals, precious stones and building materials.

2. The Dharwar System

These are the oldest metamorphosed-sedimentary rocks found in narrow geosynclines flanking the Archaean gneiss. They occur mainly in (i) Dharwar, Bellary and Hospet districts of Karnataka, (ii) the Chhotanagpur Plateau, (iii) the upper reaches of Godavari (Durg, Bastar, Dantewala, Chandrapur, etc.), and (iv) the Aravallis (Delhi, Rajasthan, and Gujarat).

It is presumed that the majority of the Dharwar rocks had escaped folding completely and had deposited into the hollows and the corrugations of landmasses or were only mildly folded. These rocks are rich in iron ore, manganese, mica, copper, zinc, lead, silver, gold, slate, asbestos, marble, and limestone.

3. The Cuddapah System

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

4. The Vindhyan System

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

5. Gondwana System

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

6. The Deccan Trap

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

7. The Tertiary System

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

8. The Pleistocene Period

The Pleistocene deposits are found in the lower reaches and deltas of Mahanadi, Godavari, Krishna and Kaveri and the western coastal plains of Gujarat, Konkan and Malabar. These deposits are, however, more pronounced along the eastern coast of India.

Physiography and Relief Features of Peninsular India

Covering an area of about 16 lakh sq km, the peninsular upland forms the largest physiographic division of India. With a general elevation between 600–900 metres, the region constitutes an irregular triangle with its base lying between the Delhi Ridge and the Rajmahal Hills and the apex formed by Kanyakumari. It is bounded by the Aravallis in the north-west, Maikal Range in the north, Hazaribagh and Rajmahal Hills in the northeast, the Western Ghats (Sahayadri Mountains.) in the west and the Eastern Ghats in the east (**Fig. 2.1**). The highest peak of Peninsular India-Anai-Mudi (Nilgiris), is 2695 metres above sea level. According to Prof. S. P Chatterji (1964), the Peninsular Uplands can be divided into the following eight macro-physiographic units (**Table 2.1**).

Table 2.1 *The Physiographic Regions of Peninsular India*

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

Source: S.P. Chatterji, 1964, ***National Atlas Organisation***, Kolkata.

1. The North Central Highlands

The central highlands of peninsular India include the Aravallis, the Malwa Plateau, and the Vindhyan Range (**Fig. 2.2**).

(i) **The Aravallis**: It is a range that runs from north-east to south-west for about 800 km between Delhi to Palanpur (Gujarat). It is one of the oldest folded mountains of the world. Being highly denuded, its highest peak—Guru-Sikhar—is only 1722 metres in height. The Aravillis are mainly composed of quartzites, gneisses and schists of the Precambrian period. Northwest of Udaipur, the Aravallis are called Jarga Hills (1431 m). The Goranghat Pass separates Gurushikar from Mount Abu. The Great Boundary Fault (GBF) separates the Aravallis from the Vindhyan Mountains.

(ii) **The Malwa Plateau:** It is bordered by the Aravallis in the north, the Vindhyan Range in the south and the Bundelkhand Plateau in the east. The Malwa Plateau has two drainage systems, one towards the Arabian Sea (Narmada, and Mahi), and another towards the Bay of Bengal (Chambal, Sind, Betwa and Ken) joining the Yamuna river.

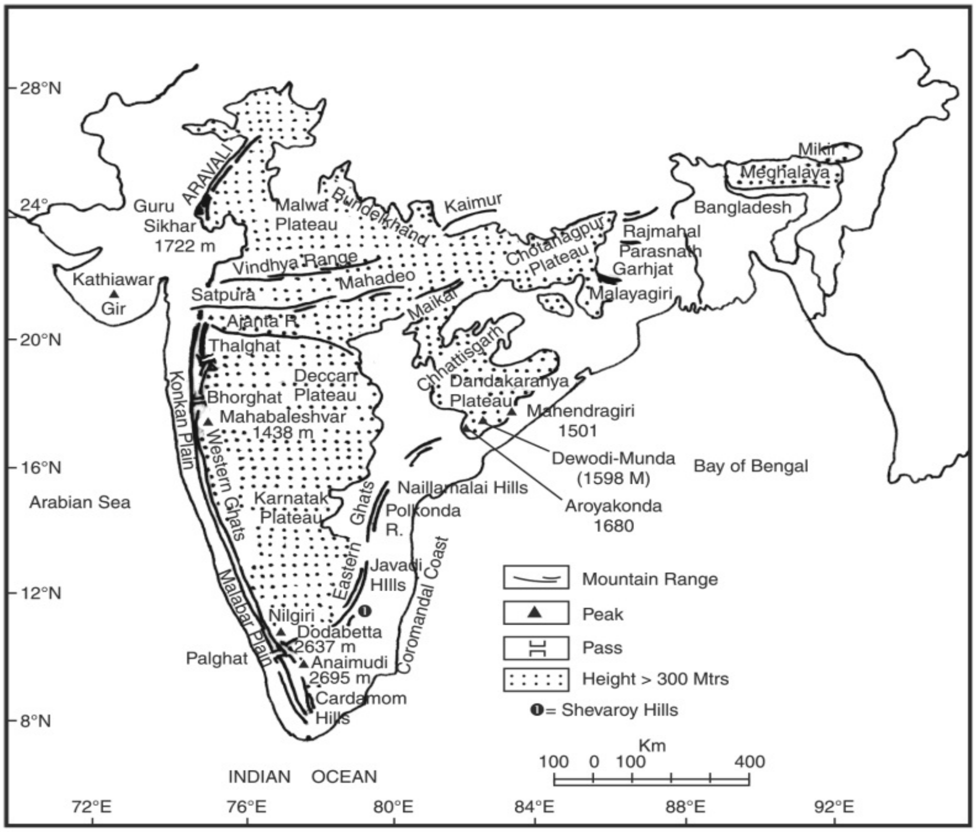

Fig. 2.2 Peninsular India: Relief

2. The South Central Highlands

The Vindhyan Range extends from Jobat (Gujarat) and Chittorgarh (Rajasthan) to Sasaram in Bihar. It extends for about 1050 km with general elevation between 450 to 600 metres. Apart from the Kaimur Hills in the east, the Maikal Range forms a connecting link between the Vindhyans and the Satpura mountains.

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

(ii) **The Vindhyachal-Baghelkhand or Vindhyachal Plateau**: It includes the plateaux of Satna, Rewa (M.P.) and Mirzapur (U.P.). Its elevation varies between 150 to 1200 metres with uneven relief. To the south of this lies the Narmada-Son trough (rift valley) characterised by the Archaeans and Bijwar series. South of this trough is the eastward extension of the Satpura which is an area of radial drainage. Among the basins, Singrauli and Dudhi (150–300 M) are Upper Gondwana basins, which are rich in coal deposits. Besides the Narmada and Son, this region is drained by the Karmanasa, Tons, Ken and Belandare rivers.

Parallel to the Vindhyas between the Narmada and the Tapi rivers is the Satpura Range. Satpura consists of Rajpipla Hills, Mahadev Hills and the Maikal Range. Dhupgarh (1350 m, near Pachmarhi) is the highest peak of Satpura. Amarkantak (1064 metres) is another important peak of the Satpura mountains.

3. The Chotanagpur Plateau

The Chotanagpur Plateau sprawls over parts of West Bengal, Jharkhand, Chhattisgarh, Odisha and northeastern part of Andhra Pradesh. This plateau has a series of the meso and micro plateaux (Ranchi, Hazaribagh, Singhbhum, Dhanbad, Palamu, Santhal, Parganas and Purulia districts of West Bengal). It is composed of Archaean granite and gneiss rocks with patches of Dharwar (mica-schists), the Damuda series of the Gondwana Period, and the lava flow of the Cretaceous Period.

Moreover, the Chhotanagpur Plateau consists of plateaux at different levels of elevation, the highest general elevation of about 1100 m in the mid-western part is known as ***pat*** lands. The rivers which drain the Chhotanagpur Plateau are Barakar, Damodar, Subarnarekha, and Koels. These rivers have carved out deep gorges, rapids, cataracts, and waterfalls in the plateau region.

4. The Meghalaya Plateau and Mikir Hills

Consisting of the Garo, Khasi, Jaintia hills and the outlying Mikir and Rengma hills, it is a plateau which has been detached from the Indian Peninsula by the Malda Gap. The Meghalaya Plateau has a chequered evolutionary history of emergence, submergence, planation surface with several phsases of erosion, sedimentation, diastrophism and intrusions. The Shillong Peak is the highest elevation (1823 m) in the Meghalaya Plateau, while Norkek (1515 m) is the highest peak of the Garo Hills. Mawsynram (25°15′N, 91°44′E) about 16 km west of Cherrapunji records the highest rainfall in the world.

The Mikir Hills are detached from the Meghalaya Plateau and are surrounded by plains from three sides. The southern range of the Mikir Hills is known as the Rengma Hills (900 m). The Mikir Hills are characterised by radial drainage with Dhansiri and Jamuna being the main rivers.

5. The North Deccan (Maharashtra Plateau)

The plateau of Maharashtra includes the entire state of Maharashtra, except the Konkan coast and the Sahyadris. It is mainly covered by the basalt of the Cretaceous Period. The basaltic sheet has a thickness of about 3 km in the western parts which diminishes towards the east and south-east. The most striking feature of the Maharashtra Plateau is the fault (1000 metres), giving rise to the present shoreline of the Arabian Sea.

Through the northern part of the Maharashtra Plateau flows the Tapi River from east to west. It has a gentle slope in the south and steep gradient in the north (towards the Satpura Hills).

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

(ii) **The Chhattisgarh Plain**: It is bordered by a series of hills and plateaux. The northern boundary is formed by the Lomari Plateau, Pendra Plateau, the Chhuri and the Raigarh Hills. The Korba coalfields of Chhattisgarh lie in this basin. The Gondwana formations are rich in bituminous coal which is supplied to the Bhilai Steel Plant. The western rimland includes the Maikal Range with crest line of 700–900 metres. The southern rimland includes the Dhalli-Rajhara Hills in southern Durg district and the Raipur uplands in the south-eastern Raipur district. The Rajhara Hill contains Dharwarian rocks in which iron ore of haematite type is found. The iron ore from the Dhalli–Rajahara mines is supplied to the Bhilai Steel Plant.

(iii) Garhjat Hills: The Garhjat Hills are also known as the Odisha Highlands. It is bordered by the Chotanagpur Plateau in the north, Mahanadi basin in the west, Eastern Ghats in the south and Utkal plains in the east. The region is mainly composed of Archaean rocks like granite, gneisses and magmatic rocks. The Gondwana, Talcher, Barakar and Kamathi series are also located in this region.

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

6. The South Deccan

The South Deccan consists of several plateaux:

(i) Karnataka Plateau: This plateau spans in the state of Karnataka and the Cannanore and Kozhikode districts of Kerala. It shows dominance of Archaean and Dharwar formations. This plateau has an average elevation of 600–900 metres. Mulangiri (1913 metres) is the highest peak in Baba-Budan Hills, followed by the Kudermukh (1892 metres) peak.

The northern upland of the Karnataka plateau is known as Malnad, while the southern part is called a Maidan. It is drained by the Kaveri and the Tungbhadra rivers. The Nandi valley is a summer resort in this region.

(ii) The Telengana Plateau: The plateau of Telengana consists of Dharwar and Cuddapah formations. Hyderabad, the capital and cultural city of the state lies in Telengana.

(iii) The Tamil Nadu Uplands: This upland lies between the South Sahyadri and Tamil Nadu coastal plains. It is largely covered by the Archaean rocks. The charnockites are found in Javadi and Shevaroy hills. Moreover, there are Cuddapah and alluvial formations. Between Coimbatore and Anaimalais, there is a broad gap, known as Palakkad Gap (Palghat), about 25 km wide, through which flows the Gayitri river from east to west joining Tamil Nadu with the coast of Kerala.

7. The Western Ghats

The Western Ghats in Sanskrit Sahyadris run parallel to the western coast for about 1600 km in the north south direction from the mouth of the Tapi river to Kanyakumari (Cape Camorin). The western slope of Sahyadri is steep while the eastern slope is gentle. These are block mountains formed due to the downwarping of a part of land into the Arabian Sea. The Sahyadris form a watershed of the peninsula. All the important rivers of Peninsular India, like the Godavari, Krishna and Kaveri rise from the Western Ghats. The western rivers merging into the Arabian Sea are swift. The Gersoppa (Jog Falls) on Sharvati is the highest waterfall in India. The average elevation of the Western Ghats varies between 1000 to 1300 metres **(Fig. 2.3).**

The important peaks of the Western Ghats are Kudermukh (1892 m), Pushpagiri (1714 m), Kalsubai (1646 m) and Salher (1567 m), Mahabaleshwar (1438 m) and Harishchandra (1424 m). In the Nilgiris

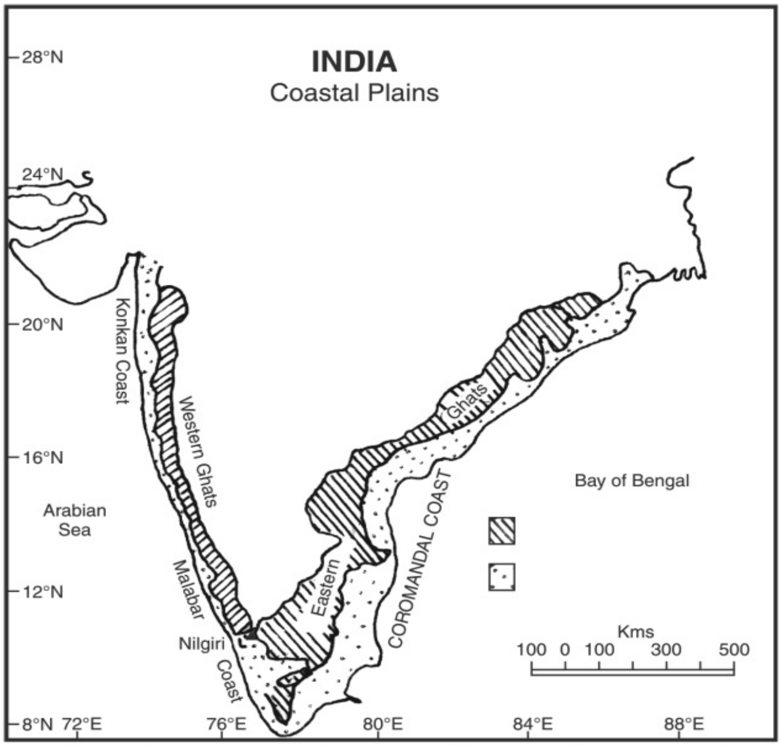

Fig. 2.3 The Eastern and Western Ghats and the Coastal Plains

the Eastern Ghat joins the Western Ghat to form a mountain knot (Nilgiri) whose highest point is Anaimudi (2695 m). South of Nilgiri lies the Palghat (Palakkad Gap). South of Palghat, the Western Ghat is known as Anaimalai Hills. Anaimudi is the highest peak of Sahayadris Mt. is 2695 m above the sea level. The other important passes of the western Ghat are Thal Ghat and Bhor Ghat.

Bhor Ghat: (Joins Mumbai with Pune): Having an elevation of about one thousand metres above sea level, the Bhorghat joins Mumbai with Pune. It is one of the most busy passes in the Western Ghats. The frequency of trains and commercial vehicles is enormous.

Goran Ghat: Lying to the south of Mount Abu, it connects the city of Udaipur with Sirohi and Jalore in Rajasthan. It is about 1200 metres above sea level. The surrounding rocks are desolate, characterised by thorny bushes and cacti.

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

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

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

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

Kudarmukh: Situated in the state of Karnataka, the Kudarmukh range (1892 m) is rich in iron ore. The iron-ore is of haematite and magnetite type. Iron ore from here is exported to Iran through the port at Mangalore.

Mahabaleshwar: Having an elevation of 1438 metres, Mahabaleshwar is one of the important peaks of the Western Ghats. It is a religious and cultural tourist attraction for domestic and international tourists.

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

Palghat (Western Ghats; joins Coimbatore with Kochi and Kozhikode): Also known as the Palakkad Gap, it lies to the south of Nilgiri Hills. It has an elevation ranging from 75 to 300 m above the sea level. The width of this gap is about 25 km. It joins the state of Tamil Nadu with the seaports of Kerala. The river Gayitri flows through it from east to west.

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

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

Thal Ghat (Western Ghats; joins Nashik with Mumbai): Located in the Sahyadri Ranges, Thal Ghat is over one thousand metres above sea level. The National Highway No. 3 and the Bhopal-Indore Railway Line pass through the Thal Ghat.

8. The Eastern Ghats

The Eastetrn Ghats form the eastern boundary of the Deccan Plateau. It is a massive outlying block of hills. The average height of the Eastern Ghats is about 600 m. The Eastern Ghat is a series of the detached hills of heterogeneous composition which are called by various local names. Between Mahanadi and Godavari, the average elevation of the Eastern Ghats is about 1100 m (**Fig. 2.3**). The peak of Aroya-Konda (Andhra Pradesh) with an elevation of 1680 metres is the highest peak of the Eastern Ghats. Among other peaks Dewodi-Munda (1598 m), Singa-Raju (1516 m) and Nimalgiri (1515 m) in the Koraput District and Mahendragiri (1501 m) in Ganjam District are the other important peaks. The predominant rocks of the Eastern Ghats are khondalites, metamorphosed-sedimentary, and charnokites (intrusive rocks being granite). Between the Krishna river and Chinnai are the Kondavidu, Nallamalai, Velikonds, Palkonda, and Erramala Ranges. Their continuation can be seen in the Seshachalam (Cuddapah and Anantapur districts), Javadi, Shevaroy, Panchaimalai, Sirumalai, and Varushnad Hills south west of Madurai (Tamil Nadu).

Significance of the Peninsular Plateau

Richly endowed with natural resources, Peninsular India has an important role in the economic development of the country. The importance of Peninsular India is mainly because of the following benefits from its location and rock formations:

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

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

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

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

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

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

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

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

THE HIMALAYAS

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

Origin of the Himalayas

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

(i) The Geosynclinal Origin

The main supporters of the geosynclinal origin of the Himalayas are Argand, Kober and Suess. According to these geologists, the disintegration of Pangaea, about 200 million years back, led to the formation of a long Tethys Sea between the Lauratian Shield (Angaraland) of the north and the Gondwanaland of the south. This sea was occupying the region of Himalayas during the Mesozoic Era (180 m years ago). At the end of the Palaeozoic and beginning of the Mesozoic Eras, the Tethys almost girdled the whole Earth running from Europe in the west to China in the east. Eroded material from the two land masses (Eurasian Shield—Angaraland and Gondwanaland) was deposited in the Tethys Sea and assumed considerable thickness due to the sinking nature of the sea bed **(Fig. 2.4 and Fig. 2.5)**. During the Cretaceous Period, the bed of the sea started rising which led to the folding of three successive ranges of the Himalayas. The first upheaval led to the formation of the Greater Himalayas during the Eocene Period (about 65 m years back). Similarly, the second

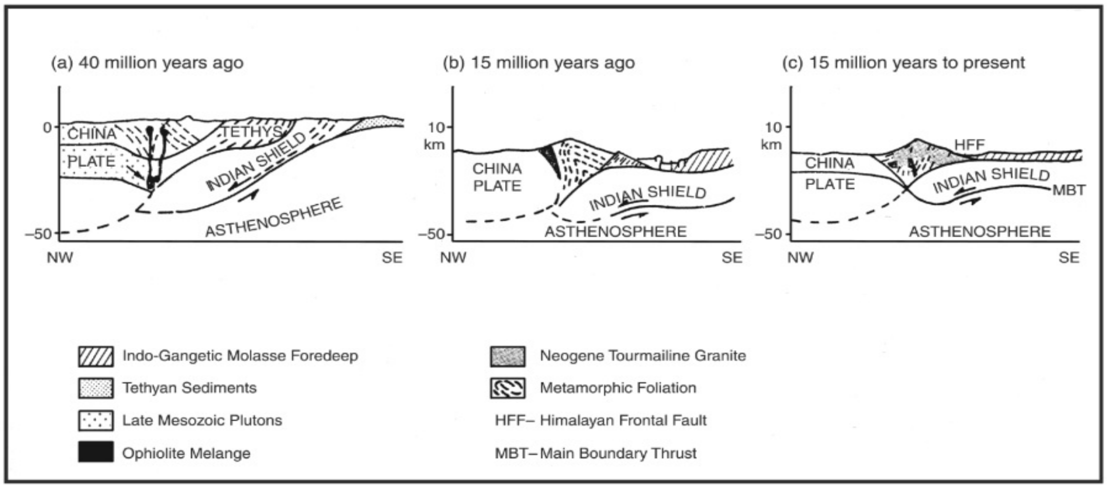

Fig. 2.4 Origin of the Himalayas

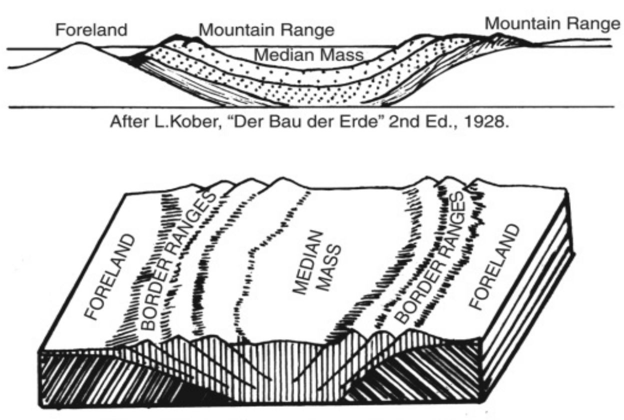

Fig. 2.5 Formation of the Himalayas

upheaval took place during the Miocene Period (about 45 million years back) resulting in the formation of the Lesser Himalayas, and the third upheaval started in the Pliocene period (about 1.4 million years back) resulting in the formation of the Shiwaliks or the Outer Himalayas.

(ii) The Plate Tectonic Origin of the Himalayas

The theory of Plate Tectonics was put forward by W.J. Morgan of Princeton University in 1967. This theory is based on the concept of 'Sea-Floor Spreading' advocated by H.H. Hess. According to this theory, about 70 or 65 million years ago there was an extensive geosyncline, called the Tethys, in place of the Himalayas. About 65–30 million years ago the Indian plate came very close to the Asian plate and started subducting under the Asian plate (**Fig. 2.6**). This caused lateral compression due to which the sediments of the Tethys were squeezed and folded into three parallel ranges of the Himalayas. It has been estimated that this convergence has caused a crustal shortening of about 500 km in the Himalayan region and is compensated by sea floor spreading along the oceanic ridge in the Indian ocean region. Since the northward movement of the Indian plate is still continuing, the height of the Himalayan peaks is increasing. The Indian Plate is moving

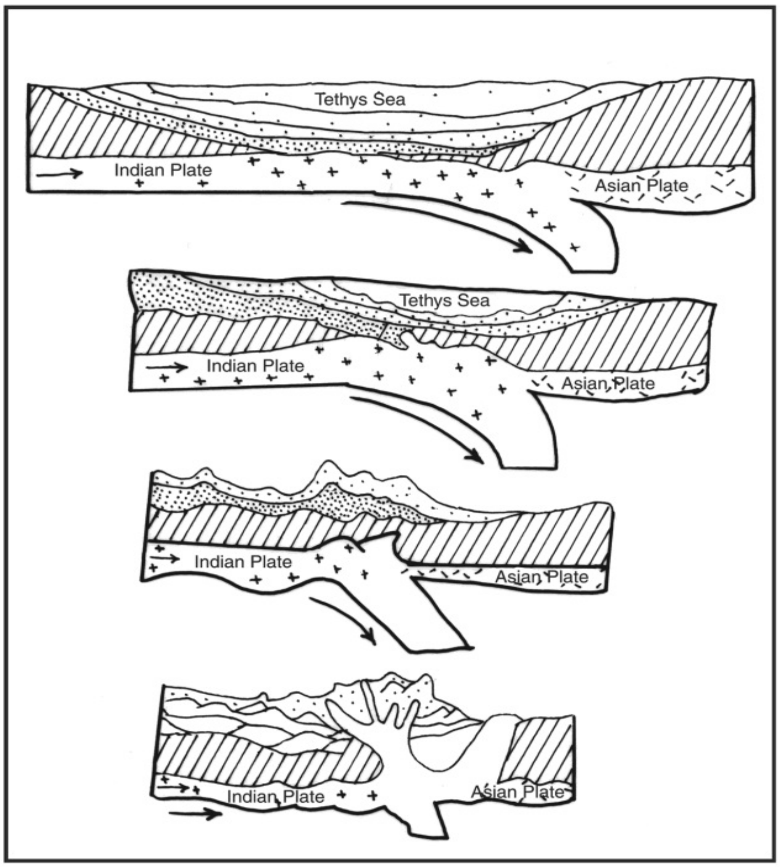

Fig. 2.6 Plate Tectonics and Origin of the Himalayas

northward and the center of rotation is constantly changing. The northward drift of the Indian Plate and the subcontinent of India have been shown in **Fig. 2.7 and Fig. 2.8.**

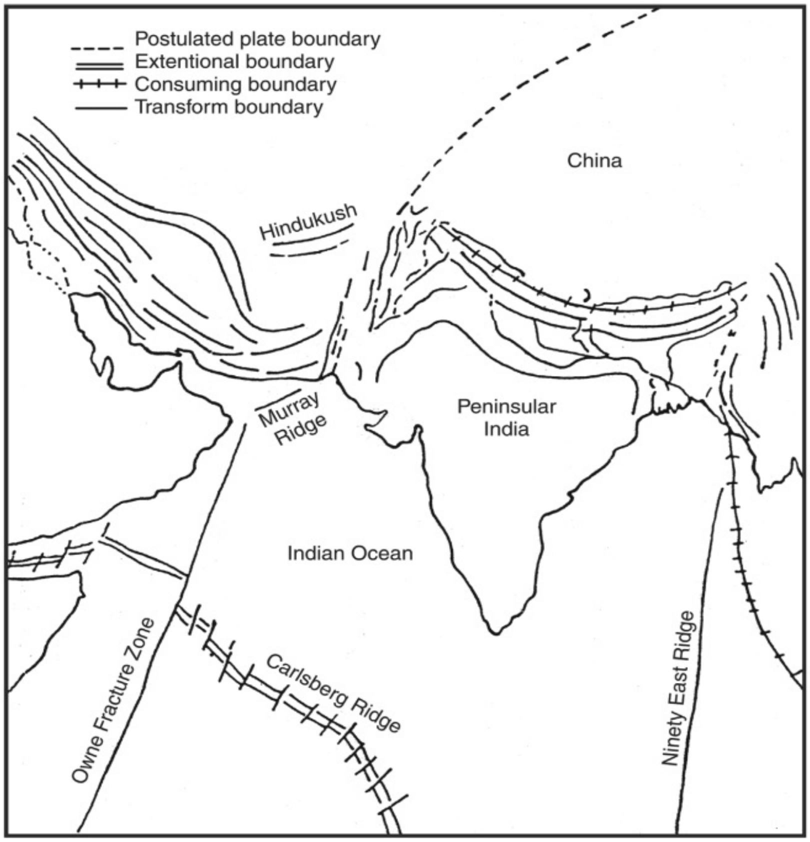

Fig. 2.7 Northward Drift of the Indian Plate

The continent-to-continent collision between the Indian and the Asiatic plates started around 65 million years ago and caused the Himalayas to rise from the Tethys geosyncline. Thus, the first major phase of uplift in the Himalayas occurred around 65 million years ago. This orgenic movement elevated the central axis of ancient crystalline and meta-sedimentary rocks which have been intruded by large masses of granite. It is believed that the first major phase of uplift initially produced the Ladakh and Zaskar ranges of the Trans-Himalayas before the formation of the Great Himalayas. Hence, it is to be realized that except the Kashmir part of the Himalayas, the Himalayan ranges have not developed from a geosyncline and are made up of elements formerly connected to the marginal parts of the Indian shield. During the main Himalayan orogeny, this continuous geosynclinal sedimentation led to the underthrusting of the Indian shield against the Tibetan Massif which buckled down the geosynclinal deposits, resulting in the outflow of a large amount of ultrabasic rocks known as ophiolites. These ophiolites are seen as exotic blocks on the Ladakh and Zaskar Ranges of the Trans-Himalayas. The end effect of the buckling of the geosyncline was not only the crustaline thrust effect on Ladakh and Zaskar leading to their rise as ranges, but also the creation of the sharp tectonic line of the Indus suture along which large geosynclinal areas disappeared.

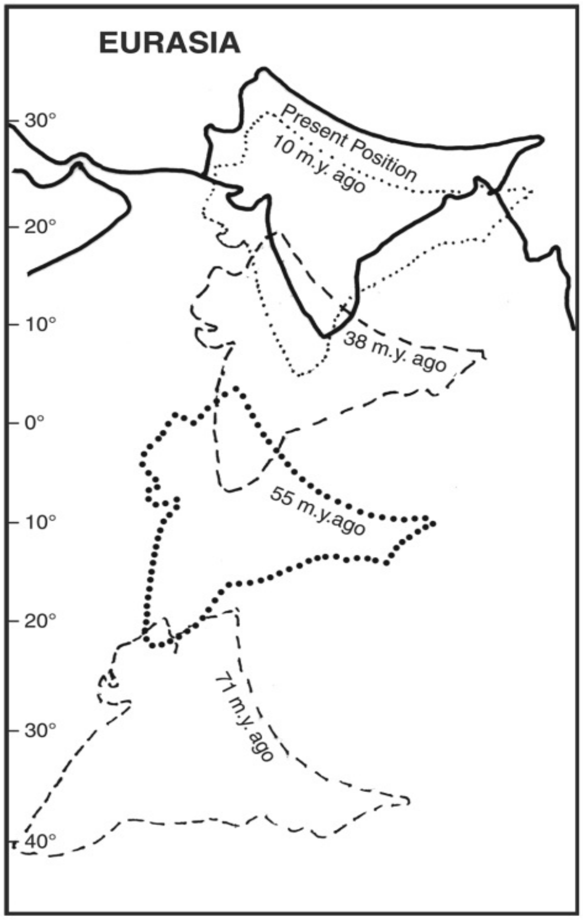

Fig. 2.8 Northward Drift of the Indian Subcontinent

The intermontane basins in the Indus suture zone of Ladakh continued to receive molasses sedimentation in this period. The second major uplift which took place around 45 million years ago, caused the rapid uplift of the southern mountain front of the Lesser Himalayas, giving rise to the extremely rugged and youthful Pir-Panjal, Dhauladhar, Karol, and Mahabharat Ranges abruptly and steeply. The Greater Himalayas and the Lesser Himalayas are separated by the Main Central Thrust (MCT). These spurs of the Lesser Himalayas again formed, in their turn, the intermontane basins of Kashmir, the Karol-basin, Dun Valley (Uttarakhand) and the Kathmandu Valley of Nepal. The foredeep which was formed further away received the thick sequence of terrestrial sediments called Shiwaliks from the middle-Miocene to the middle-Pleistocene periods, covering a span of about 1.4 million years. The Lesser Himalayas and the Shiwaliks are separated from each other by the Main Boundary Thrust (MBT). The 5000 metres thick Shiwaliks dominated by boulder

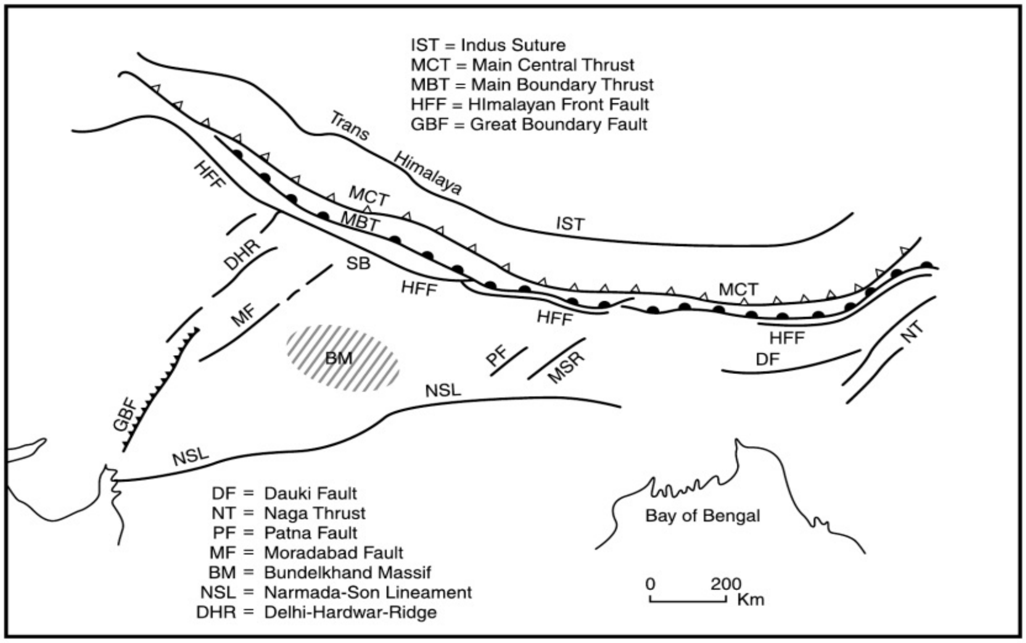

Fig. 2.9 Major Faults of the Himalayas

and conglomerate, reflect the progressive uplift of the Himalayas from which they have been derived as a result of the third major phase of uplift. The Shiwaliks are separated from the Northern Plains of India by the Himalayan Front Fault or HFF (**Fig. 2.9 and Fig. 2.10**).

The Shiwaliks form the normal Jura type of structures with wider basin-like synclines alternating with steep, often faulted, asymmetric anticlines. At present, the Himalayan Front Fault (HFF) is quite active recording frequent tremors and earthquakes **.**

Physiographic Divisions of the Himalayas

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

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

1. The Trans-Himalayas

The Trans-Himalayas are about 40 km wide. They contain the Tethys sediments. The rocks of this region contain fossils bearing marine sediments which are underlain by 'Tertiary granite'. It has partly metamorphosed sediments and constitutes the core of the Himalayan axis. It has a great accumulation of debris in the valleys of defeated streams which could not maintain their southerly course across the rising barrier of the Himalayas (**Fig. 2.10**).

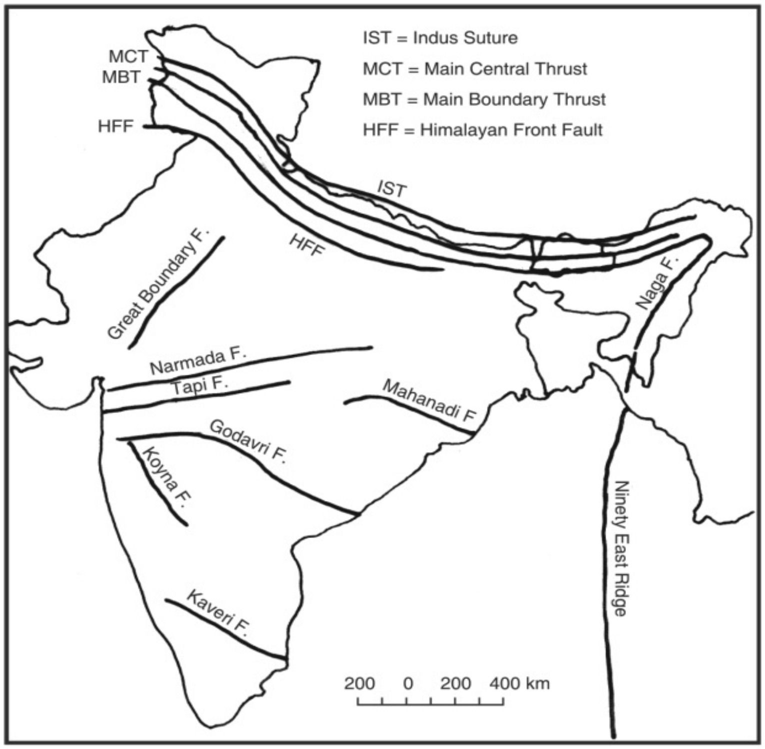

Fig. 2.10 Major Faults of India

2. The Greater Himalayas

The Greater Himalayas rise abruptly like a wall north of the Lesser Himalayas. The Main Central Thrust separates the Greater Himalayas from the Lesser Himalayas. The Greater Himalayas are about 25 km wide with an average height above 6100 metres (Wadia, D.N.). Almost all the lofty peaks of the Himalayas Mt. Everest, Kanchanjunga, Nanga-Parbat, Gasherbrum, Manaslu, Dhaulagiri, Annapurna, Gosainthan, Cho-Cyu, Nanda-Devi, Kamet, Badrinath, etc. Nanda Devi, etc., lie in this zone. The Greater Himalayas are composed of crystalline, igneous or metamorphic rocks (granite, schists, and geneiss). The basal complex of the Himalayas is Archaean. At places, due to heavy thrust, older rocks are found overlying the newer rocks. The Greater Himalayas are almost a contiguous range. The range has very few gaps mainly provided by the antecedent rivers. The Greater Himalayas receive less rainfall as compared to the Lesser Himalayas and the Shiwaliks. Physical weathering is pronounced. Erosion is, however, less effective over the Greater Himalayas as compared to the Lesser Himalayas. Being lofty, they have very little forest area.

3. The Lesser Himalayas

The width of the Lesser Himalayas is about 80 km with an average height of 1300–4600 m. It consists, generally, of unfossiliferous sediments or metamorphosed crystalline. The main rocks are slate, limestone and quartzites. Along the southern margin of the Lesser Himalayas lies the autochthonous belt of highly compressed Upper Palaeozoic to Eocene rocks, often containing volcanic material. Examples of autochthonous belts are found between Murree and Panjal thrust in Kashmir, Giri thrusts in the Shimla region and Krol and Main Boundary Thrust (MBT) in Garhwal region. This region is subjected to extensive erosion due to heavy rainfall, deforestation and urbanisation.

4. The Shiwaliks or Outer Himalayas/Sub-Himalayas

The Shiwaliks extend from Jammu Division of Jammu and Kashmir State to Assam. In width, Shiwaliks vary from 8 km in the east to 45 km in the west with an average elevation of about 900–1500 m above sea level. It is not a continuous range. It is broader in the west and narrows down in the east. Between the Shiwaliks and the Lesser Himalayas are longitudinal valleys called Doons/Duns. Some of the important Duns are Dehra Dun, Potli, Kothri, Kathmandu, Chumbi and Kyarda. The Shiwaliks are mainly composed of sandstones, sand-rocks, clay, conglomerates and limestones, mostly belonging to the Upper Tertiary Period.

Longitudinal Divisions of the Himalayas

The Himalayas have also been divided by Sir S. Burrard into four divisions, namely (i) The Western Himalayas, (ii) The Kumaun Himalayas, (iii) The Nepal Himalayas, (iv) The Assam Himalayas. Prof. S.P. Chatterjee (1973), divided the Himalayas into the following six transverse divisions from west to east (**Fig. 2.11, Fig. 2.12(a)** and **Fig. 2.12(b)**):

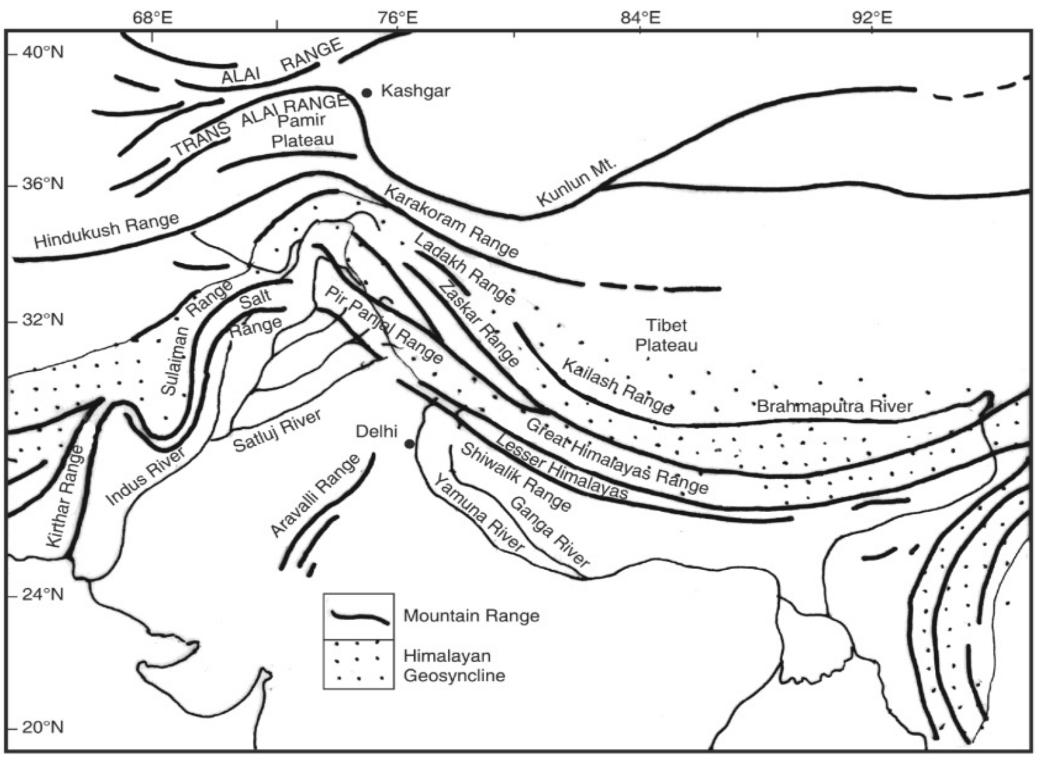

Fig. 2.11 Physiographic Divisions of the Himalayas

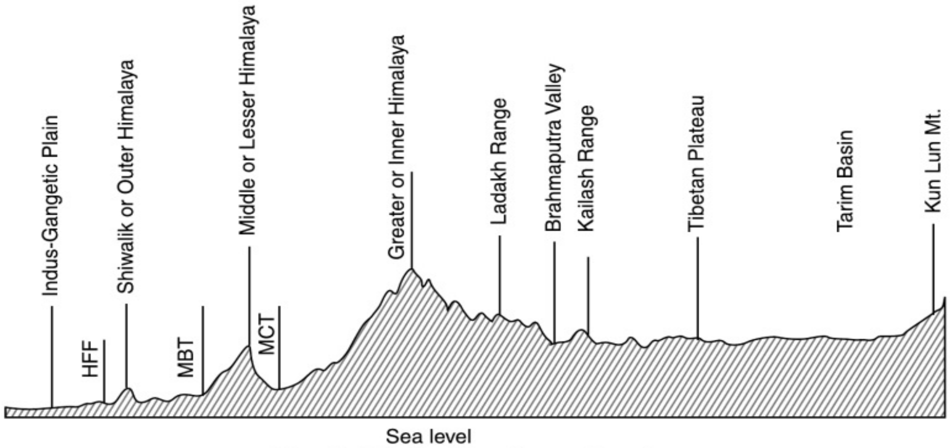

Fig. 2.12(a) Himalayan Complex

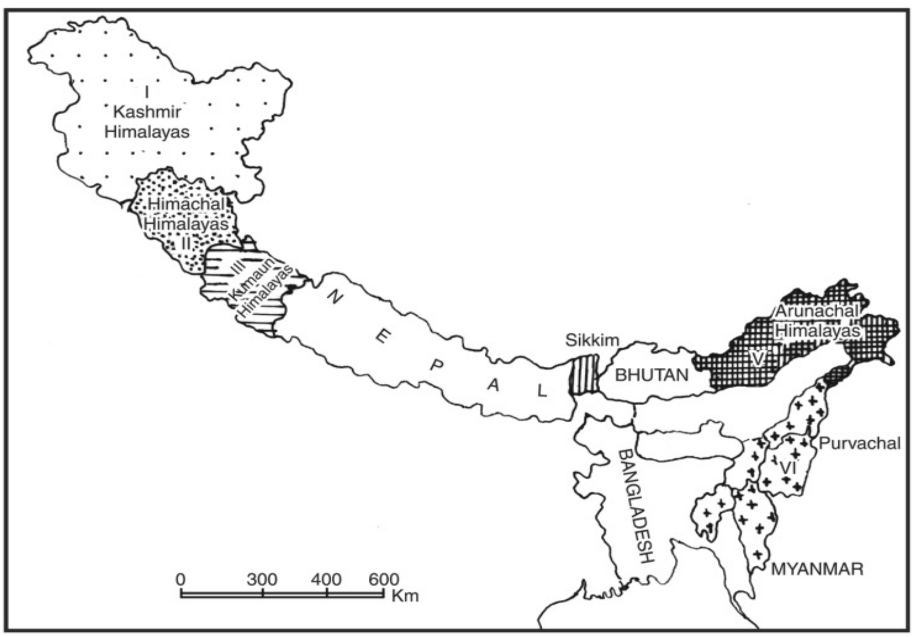

Fig. 2.12(b) Himalayan—Longitudinal Divisions

1. The Kashmir Himalayas
2. The Himachal Himalayas
3. The Kumaun Himalayas
4. The Central Himalayas
5. The Eastern Himalayas

1. The Kashmir Himalayas

Sprawling over an area of about 350,000 sq km in the state of Jammu and Kashmir, the range stretches about 700 km in length and 500 km in width. With an average height of 3000 m, it has the largest number of glaciers in India. The Ladakh region of the Kashmir Himalayas is characterised by cold desert conditions. Ladakh is one of the loftiest inhabited regions of the world (3600-4600 m). The gorge of Gilgit is 5200 m in height above the sea level of the water at its bed. Surrounded by the Greater Himalayas and the Lesser Himalayas is the Kashmir Valley. Having a height of 1585 m above the sea-level, the total area of the Kashmir Valley is about 4920 sq km. It is a structural longitudinal 'Dun' (D.N. Wadia). A special feature of the the Vale of Kashmir is the *Karewa* (lacustrine) deposits consisting of silt, sand and clay. These karewas are mainly devoted to the cultivation of saffron and have orchards of apple, peach, almond, walnut and apricot. Kashmir Himalayas are characterised by high snow covered peaks, deep valleys, interlocked spurs and high mountain passes. Pir-Panjal, Banihal (Jawahar Tunnel), Zoji-La, Burzil, Khardungla, Pensi-La, Saser-La, Lanak-La, Jara-La, Taska-La, Chang-La, Umasi-La, and Qara-Tagh-La (Karakoram) are the important passes of the Kashmir Himalayas **(Fig. 2.13).**

***The Himadri*:** Called the abode of gods, this section of the Himalayas has many snow capped peaks, such as Nanga-Parbat (8119 m), Nanda Devi 7817 m), Trisul (7140 m), Nunkun (7135 m), Kamath (7756 m) etc.

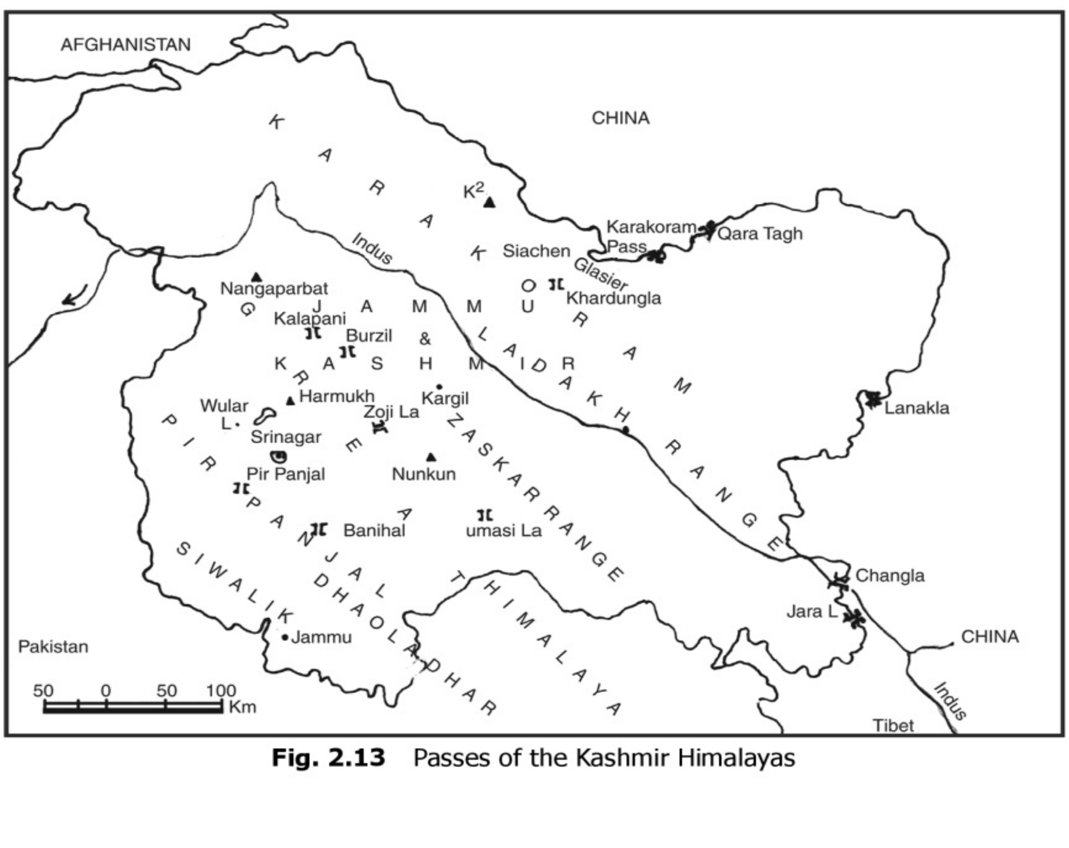

Fig. 2.13 Passes of the Kashmir Himalayas

2. The Himachal Himalayas

Stretching over Himachal Pradesh, it occupies an area of about 45,000 sq km. All the three ranges (the Greater, the Lesser and the Outer Himalayas) are well represented in this region. The northern slopes of the Himachal Himalayas are clothed with thick forests and show plains and lakes, while the southern slopes are rugged and forest clad. Rohtang, Bara-Lacha, and Shipki-La are the important passes which join Himachal Pradesh with Tibet (China). The beautiful and highly productive valleys of Kangra, Kullu, Manali, Lahul, and Spiti lie in Himachal Pradesh. These valleys are well known for orchards and scenic beauty. Shimla, Dalhousie, Chamba, Dharamshala, Kullu-Manali are the important hill stations of this region.

3. The Kumaun Himalayas

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

4. The Central Himalayas

This range stretches from river Kali to river Tista for about 800 km occupying an area of about 116,800 sq km. A major part of it lies in Nepal except the extreme eastern part called Sikkim Himalayas and in the Darjeeling District of West Bengal. All the three ranges of the Himalayas are represented here. The highest peaks of the world like Mt. Everest (8850 m), Kanchenjunga (8598 m), Makalu (8481 m), Dhaulagiri (8172 m), Annapurna (8078 m), Manaslu (8154 m) and Gosainath (8014 m) are situated in this part of the Himalayas. It has very few passes. The passes of Nathu-La and Jelep-La (4538 m in Sikkim) connect Gangtok (Sikkim) with Lhasa (Tibet, China).

Kanchenjunga: Situated on the border of Sikkim and Tibet, it is the third highest mountain peak in the world. It is 8,598 metres above sea level and remains snow covered throughout the year. Some of the important rivers of India like Kosi and Tista have their origin in this mountain.

5. The Eastern Himalayas

These lie between the Tista and the Brahmaputra rivers, covering a distance of about 720 km with an area of 67,500 sq km. The Eastern Himalayas occupy the state of Arunachal Pradesh (India) and Bhutan. In this part, the Himalayas rise very rapidly from the plains of Assam, and the foothills of Shiwaliks are very narrow. The Eastern Himalayas include the Aka Hills, the Dafla Hills, Miri Hills, Abor Hills, Mishmi Hills, and Namcha Barwa (7756 m). It has a number of mountain passes among which Bomdi-La, Bom La, Tunga, Yonggyap, Diphu, Pangsau, Tse-La, Dihang, Debang (Arunachal Pradesh) are the most important. In the Eastern Himalayas, due to heavy rainfall, fluvial erosion is quite pronounced.

On the southern border of Arunachal Pradesh, the Himalayas take a southerly turn and the ranges are arranged in a north-south direction. Passing through the states of Arunachal Pradesh (Tirap Division) Nagaland, Manipur, Tripura, and Mizoram, the Himalayas are locally known as

Purvanchal. The main hills of the Eastern Himalayas are Patkai-Bum (Arunachal Pradesh), Naga-Hills (Nagaland), Manipur Hills, Blue Mountains (Mizoram), Tripura Range, and Brail range. On the border of Nagaland and Myanmar lies the Arakanyoma. These hills are heavily forested. Northern Myanmar is connected through Diphu, Hpungan, Chaukan, Pangsau, and Likhapani (Arunachal Pradesh). Southwards, a pass joins Imphal (Manipur) with Mandalay (Myanmar). The Purvanchal is joined by the Meghalaya Plateau in the west. The extension of the Myanmar mountain chain continues southward up to Andaman and Nicobar Islands and even up to the Archipelago of Indonesia.

The Syntaxial Bends of the Himalayas

The general east-west trend of the Himalayas terminates suddenly at its western and eastern extremities and the ranges are sharply bent southward in deep knee-bend flextures which are called syntaxial bends. The western syntaxial bend is near Nanga Prabat where the Indus has cut a deep gorge. The geological formations here take sharp hairpin bends as if they were bent round pivotal points obstructing them. There is a similar hair- pin bend in Arunachal Pradesh where the mountains take a sharp bend from the eastern to southern direction after crossing the Brahmaputra river. The tectonic strike also undergoes a deep knee-bend from an easterly to southerly trend **(Fig. 2.14).**

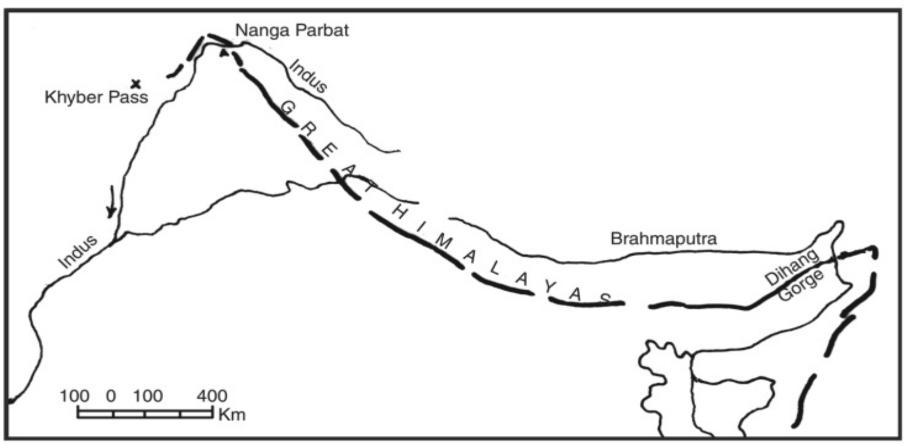

Fig. 2.14 The Syntaxial Bends of Himalayas

Main Passes of Himalayas

Aghil Pass (Karakoram-Ladakh): Situated to the north of K^2 in the Karakoram at an elevation of about 5000 m above the sea level, it joins Ladakh with the Xinjiang (Sinkiang) Province of China. It remains closed during the winter season from November to the first week of May (**Fig. 2.15**).

Banihal Pass (Jawahar Tunnel): Situated at an elevation of 2835 m in the Pir-Panjal Range, joins Jammu with Srinagar. The pass remains snow covered during the winter season. The Jawahar Tunnel (named after Pandit Jawaharlal Nehru), inaugurated in December 1956, was constructed for round-the-year surface transport.

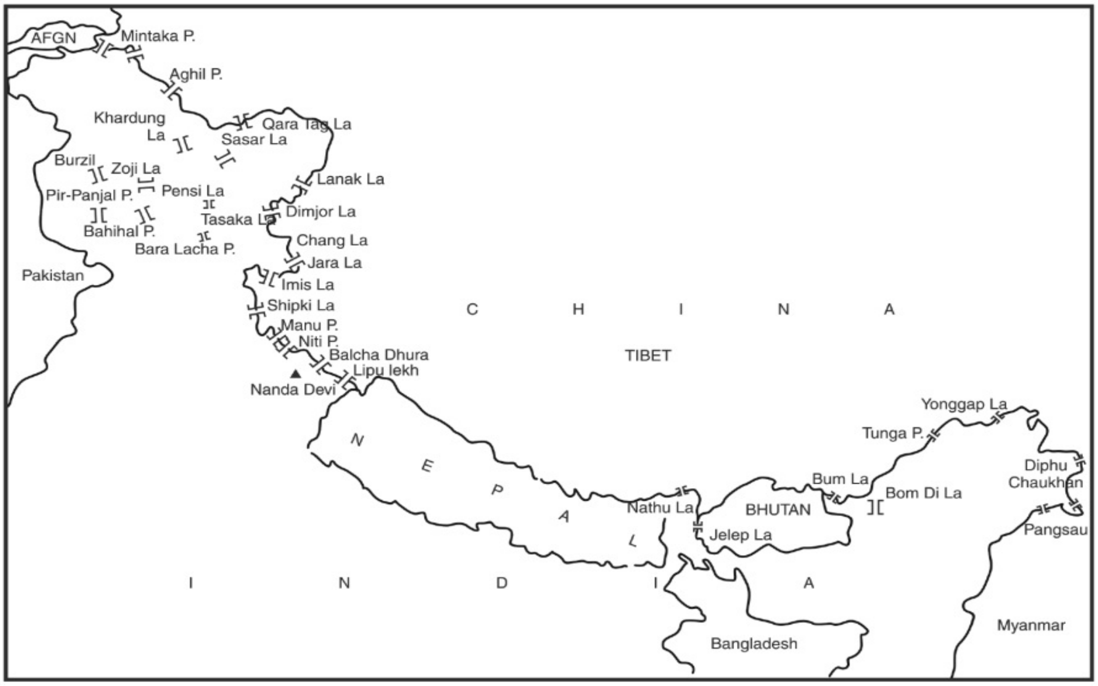

Fig. 2.15 Main Passes of the Himalayas

Bara Lacha (Himachal Pradesh with Leh-Ladakh): Situated in the state of Jammu and Kashmir at an altitude of 4843 m. It is on the National Highway connecting Manali and Leh. Being a high mountain pass, it remains snow covered from November to mid-May.

Bomdi La (4331 m, Arunachal Pradesh): Situated to the east of Bhutan in the Greater Himalayas in Arunachal Pradesh at an altitude of about 2600 m above sea level, it connects Arunachal Pradesh with Lhasa, the capital of Tibet. It remains closed in the winter season owing to snowfall and adverse weather.

Burzail Pass (Srinagar with Kishan-Ganga Valley): Situated at an altitude of more than five thousand feet above sea level, this pass connects the Kashmir Valley with the Deosai Plains of Ladakh. Being snow covered during the winter season it remains closed for trade and transsport.

Chang-La (Ladakh with Tibet): Situated at an elevation of over 5270 m, it is a high mountain pass in the Greater Himalayas. The road after Chang-la is extremely steep, leading to the small town of tangtse. The pass has a temple dedicated to Chang-la Baba after whom the pass has been named. Being snow-covered, it remains closed during the winter season.

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

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

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

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

Khardung La: Situated at an elevation of more than six thousand m above sea level, it is the highest motorable pass in the country. It joins Leh with Siachin glacier. The road, however, remains closed during the winter season.

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

Jelep La (4538 m): Situated at an elevation of 4538 m above sea level, this pass connects Sikkim with Lhasa. It passes through the Chumbi Valley.

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

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

Lipu Lekh (Uttarakhand): Situated in the Pithoragarh District, it connects Uttarakhand with Tibet. The pilgrims for Mansarovar Lake travel through this pass. The pass is one of India's important border post for trade with China. Landslides in the rainy season and avalanches in winter create great problems for movement and transportation.

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

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

Muling La (Uttarakhand): Situated north of Gangotri, this seasonal pass joins Uttarakhand with Tibet. It remains snow covered during the winter season.

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

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

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

Pensi La: Situated in the Greater Himalayas at an elevation of more than 5000 m above sea level, this pass connects the Valley of Kashmir with Kargil (Ladakh). It remains snow covered from

November to mid-May.

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

Qara Tagh Pass: Located in the Karakoram Mountains at an elevation of more than 6000 ft above sea level, this pass was an offshoot of the Great Silk Road. It remains snow covered during the winter season.

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

Shencottah-Gap: Located in Western Ghats, this pass connects the Madurai city of Tamil Nadu with Kottayam city of Kerala. Shencottah is a small town also near this pass in Tamil Nadu.

Shipki La : Located at an altitude of more than 4300 m above sea level through the Satluj Gorge, the Shipki-La joins Himachal Pradesh with Tibet. It is through this pass, the river Satluj enters India, from Tibet. The pass (Indian National Highway 22) is India's third border post for trade with China after Nathula in Sikkim and Lipulekh in Uttarakhand. It remains snow covered during the winter season.

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

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

Zoji La: Located at an altitude of 3850 m above sea level, it joins Srinagar with Kargil and Leh. Because of heavy snowfall, it remains closed from December to mid-May. The Border Road Organisation (BRO) has been trying to keep the road open for most part of the year. Beacon Force of Border Road Organisation (BRO) is responsible for clearing and maintenance of the road during the winter season. Recently, the Srinagar–Zoji-La Road has been declared a National Highway (NH-1D) by the centre.

Glaciers and Snowline

The lower limit of perpetual snow is known as 'snowline'. The snowline in the Himalayas has different heights in different parts, depending on latitude, altitude, amount of precipitation, moisture, slope and local topography. In the Himalayas, glaciers (snowfields) cover about 40,000 sq km of area between Karakoram (J & K) and Arunachal Pradesh. There are about 15,000 glaciers in the Himalayas lying between the two syntaxial bends in the east and the west. In the Assam Himalaya, the snowline is about 4400 m, whereas in the Kashmir Himalayas it varies between 5200 to 5800 m. In the Kumaun Himalaya the snowline is about 5100 m and about 5500 m in the Karakoram. On the Tibetan side, the altitude of the snowline is about 900 m higher owing to great desiccation of the region and scarcity of moisture. Thus, there is a direct relationship between the presence of moisture and the altitude of the snowline. In general, more the moisture in the atmosphere, lower the altitude of the snowline and vice versa.

Table 2.2 *Altitude of Snowline in the Himalayas*

Himalayan Region	*Altitude of Snowline*
1. North Eastern Himalayas (Arunachal Pradesh)	4400 m
2. Kashmir Himalayas	5200 m to 5800 m
3. Kumaun Himalayas	5100 m to 5500 m
4. Karakoram	5500 m and above

The main glaciers in the northern mountains are found in the Greater Himalayas and the Trans-Himalayan mountains (Karakoram, Ladakh and Zaskar). The Lesser Himalayas have small glaciers, though traces of large glaciers are found in the Pir-Panjal and Dhauladhar ranges. Some of the important glaciers of the Karakoram and the Himalayas are given in **Fig. 2.16 (Table 2.3).**

Table 2.3 *Main Glaciers of India*

Name of the glacier	*Location*	*Length in km*
1. Siachin	Karakoram	75
2. Sasaini	Karakoram	68
3. Hispara	Karakoram	61
4. Biafo	Karakoram	60
5. Baltora	Karakoram	58
6. Chogo Lungma	Karakoram	50
7. Khordopin	Karakoram	47
8. Rimo	Kashmir	40
9. Punmah	Kashmir	27
10. Gangotri	Uttarakhand	26
11. Zemu	Sikkim/Nepal	25
12. Rupal	Kashmir	16
13. Diamir	Kashmir	11

Most of the glaciers of the Lesser Himalayas are smaller in size, ranging from 3 to 5 km in length. There are, however, some larger-sized glaciers also in Karakoram and the Greater Himalayas. Some of the important glaciers are Siachen (75 km), Sasaini (68 km), Hispara (61 km), Biafo (60 km), Baltora (58 km) (Karakoram mountains).The Chogo Lungma Glacier (50 km) terminates at an altitude of 2070 m, the lowest recorded in the Karakoram (**Fig. 2.16).** In Uttarakhand, Gangotri, Milam and Pindari are the main glaciers. The glaciers of Karakoram are the remnants of the Pleistocene Age. The diurnal rate of movement of these glaciers is between 8 to 15 cm at the side and 20 to 30 cm in the middle. The glaciers of the Pir-Panjal are less numerous and smaller in size as compared to those of the Karakoram and the Greater Himalayan ranges. The longest glacier of the Pir-Panjal is Sonapani glacier in the Chandra Valley of Lahul and Spiti region. Its length is about 15 km at an altitude of about 4000 m near the Rohtang Pass.The largest glacier in the Nun-Kun peak is the Gangri Glacier which is about 13 km in length. The glaciers of the Nanga Parbat Massif are small in size and are moving fast due to a steep slope. The Chungphar, Rakhiot, Buzhi and Tashan are the other important glaciers of the Pir-Panjal Range. The glaciers are not only the source of Himalayan rivers, but also maintain a regular supply of water in these rivers during off-monsoon period. The Himalayan glaciers are, however, receding. According to new Isro satellite

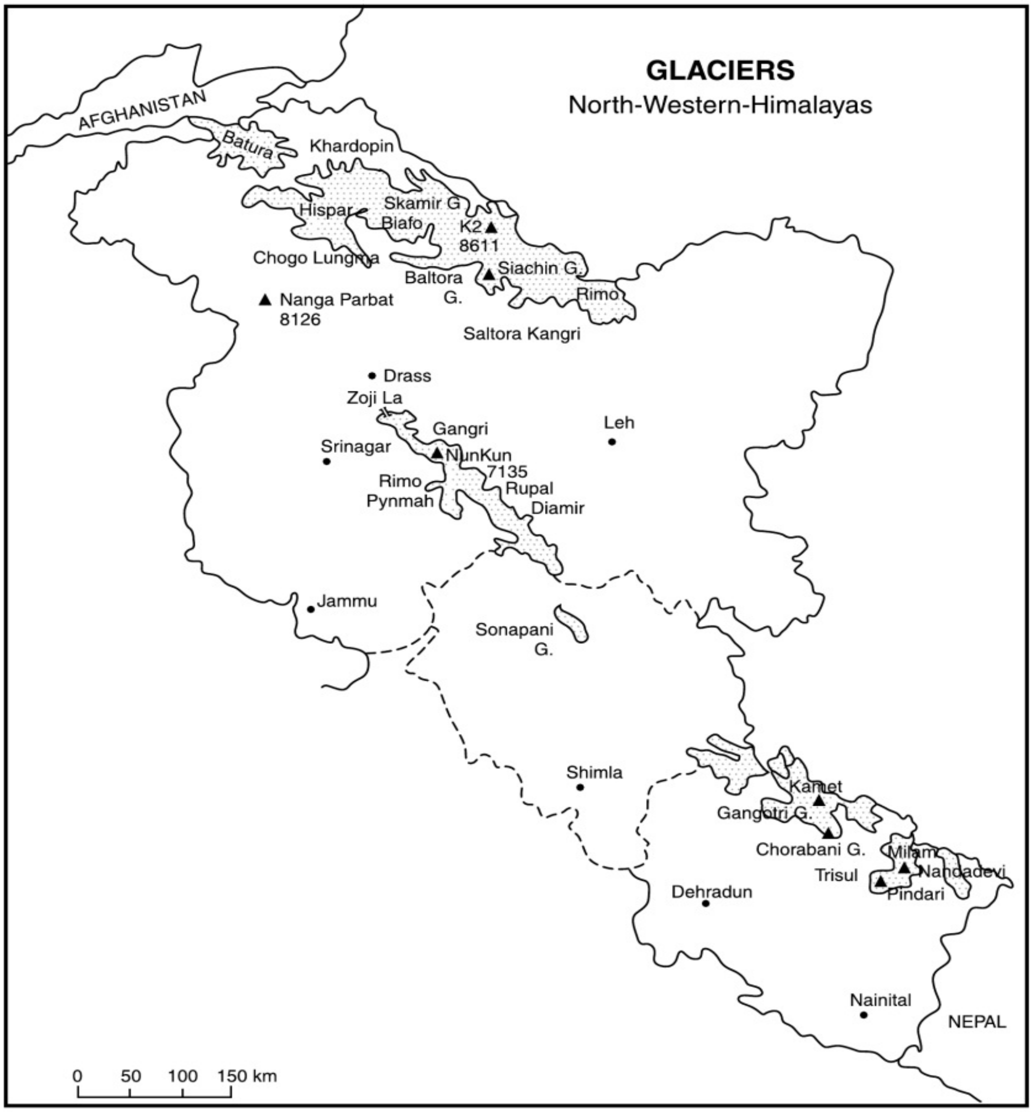

Fig. 2.16 North-West Himalayas—Major Glaciers

study, 75% of Himalayan glaciers are melting, 8% advancing and 17% showing no change. Commissioned by the environment ministry, the study is different from an IPCC report, claiming, without sufficient evidence, that the glaciers would vanish by 2035 (Times of India 16.5.2011, p.1).

Ice Ages in India

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

1. The Dharwar Ice Age

The moraine deposits and other glaciated topographical features observed in the Dharwar District of Karnataka indicate an ice age during the Dharwadian Period, i.e. about 1700 million years ago.

2. The Gondwana Ice Age

The Telcher Series (Odisha) of the Gondwana System provides a good proof of the glaciation during the Gondwana Period.

3. The Pleistocene Ice Age

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

The Significance of the Himalayas

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

1. Climatic Influence

The impact of the Himalayas on the climate, especially on the distribution of precipitation and temperature, is quite significant. The altitude of the Himalayas, their sprawl and extension intercept the summer monsoon coming from the Bay of Bengal and the Arabian Sea. They also prevent the cold Siberian air masses from entering into India. Had there been no Himalayas, the whole of northern India would have been a desert. According to the latest meteorological studies, the Himalayas are responsible for the splitting of the jet streams into two branches, and these in turn, play an important role in the arrival, success and failure of the monsoons in India.

2. Defence

Throughout history, the foreign invaders never entered India from the northern side. Despite modern technology of warfare, the Himalayas have great defence value. At present, a network of highways has been developed up to China, Tibet, Nepal, and Bhutan borders.

3. Source of Perennial Rivers

Most of the perennial rivers of northern India have their origin in the glaciers, lakes, and springs of the Himalayas. These rivers sustain the teeming millions of the India population.

4. Source of Fertile Soils

The perennial rivers and their tributaries carry enormous quantities of alluvial soils. In fact, the Great Plains of India are covered by the fertile alluvial soils deposited by the rivers coming down from the Himalayas.

5. Generation of Hydroelectricity

The Himalayan Mountains offer numerous sites suitable for the generation of hydel power. The Bhakra-Nangal Dam, Silal, Dulhasti Baghliar Projects, Tehri Dam, etc., are some of the important hydel-power generating multi-purpose projects located in the Himalayas.

6. Forest Wealth

The Himalayan ranges are very rich in forest resources. There is horizontal zonation of vegetation in the Himalayas. The natural vegetation in the Himalayas varies from the humid tropical to the conifers and alpine pastures. These forests provide fuelwood, timber, gum, resins, lac, medicinal herbs, and a variety of materials for the industries. At the higher altitudes are the alpine pastures (margs) used by the tribals for grazing cattle during the summer season.

7. Orchards

The Himalayas are known for the apple, peach, cherry, pear, mulberry, walnut, almond, and apricot orchards.

8. Minerals

The Himalayas are rich in many metallic and non-metallic minerals. Coal is found in Jammu Division of Jammu and Kashmir. Copper, lead, zinc, nickel, cobalt, gold, silver, antimony, tungsten, magnesite, limestone, semi-precious, and precious stones are found in the states of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh. The poor accessibility is however, a barrier in the exploitation of the mineral wealth of the Himalayas.

9. Tourism

The Himalayas are known for their scenic and aesthetic beauty all over the world. The Himalayas offer cool, invigorating climate when the neighbouring plains are in the grip of scorching heat of the summer season. Millions of national and international tourists visit the hill stations in the Himalayas. The famous tourist centres in the Himalayas are Srinagar, Pahalgam, Gulmarg, Sonmarg, Yushmarg, Wular-round, Chamba, Dalhousie, Dharamshala, Shimla, Solan, Kangra, Kullu, Manali, Mussoorie, Nainital, Ranikhet, Almora, and Darjeeling.

10. Pilgrimage

Apart from places of tourist interest, the Himalayas have numerous shrines and pilgrimage centres. Some of the important shrines in the Himalayas are the Amarnath, Hazratbal (Srinagar), Kailash, Vaishno Devi, Kedarnath, Badrinath, Gangotri, Yamunotri, Jwalaji, etc.

THE GREAT PLAINS OF INDIA

The Great Plains of India lies to the south of the Shiwalik separated by the Himalayan Front Fault (HFF). It is a transitional zone between the Himalayas of the north and Peninsular India of the south. It is an aggradational plain formed by the alluvial deposits of the Indus, Ganga, Brahmaputra and their tributaries. The plain stretches for about 2400 km from west to east. It has varying width; 90–100 km in Assam, 160 km near Rajmahal (Jharkhand), 200 km in Bihar, 280 km near Allahabad and 500 km in Punjab. In general, the width of the plain increases from east to west **(Fig. 2.17).**

The Great Plains of India consist largely of alluvial deposits brought down by the rivers originating in the Himalayan and the Peninsular region. The exact depth of alluvium has not yet been fully

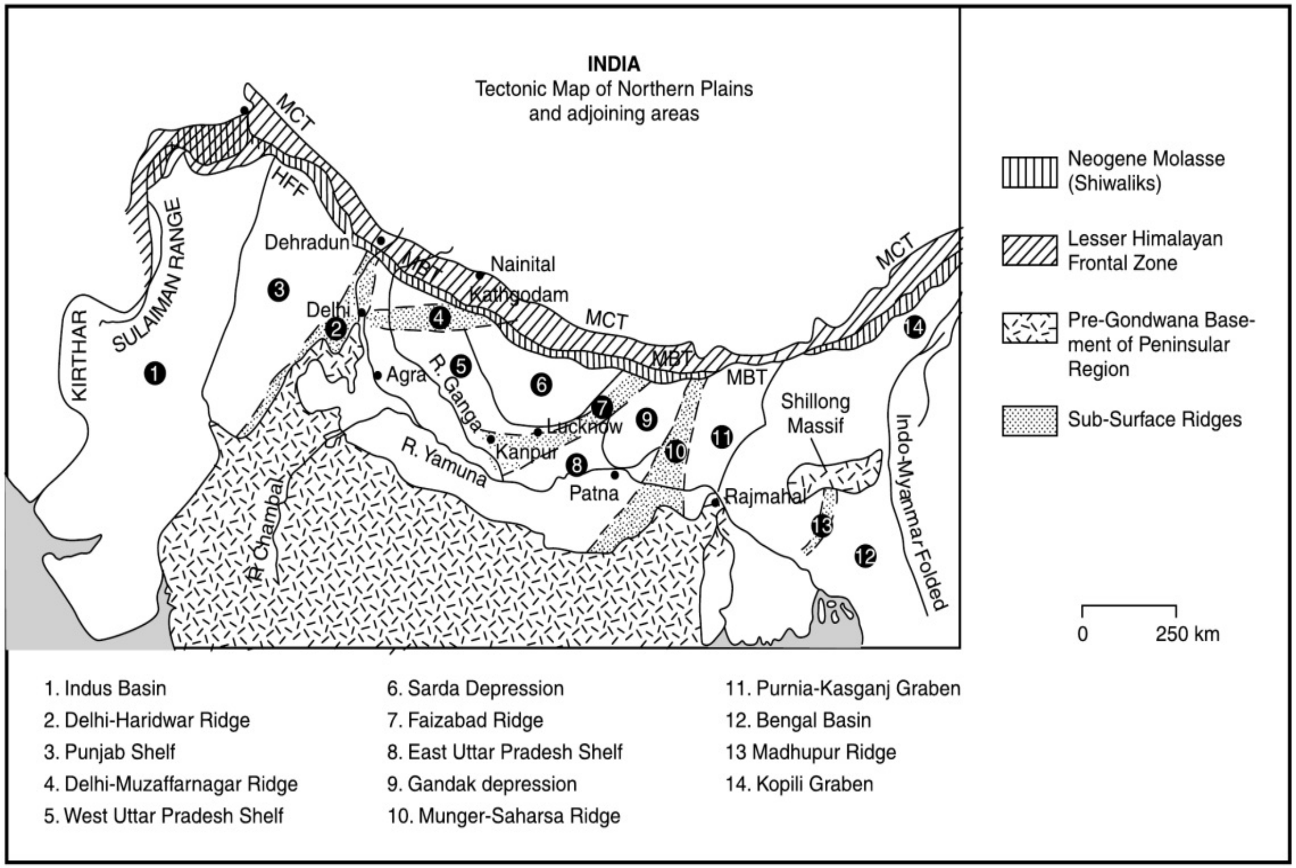

Fig. 2.17 The Great Plains of India and adjoining areas

determined. According to recent estimates the average depth of alluvium in the southern side of the plain (north of Bundelkhand) varies between 1300 to 1400 metres, while towards the Shiwaliks, the depth of alluvium increases. The maximum depth of over 8000 metres has been reached near Ambala, Yamunanagar and Jagadhri (Haryana).

The Great plains are remarkably homogeneous with little variation in relief features for hundreds of kilometers. The monotony of the physical landscape is broken at micro-level by the river bluffs, *Bhurs,* levees, dead-arms of river channels, the ravines and ***khols***. Changing river courses in the areas of frequent floods is a unique geomorphic process in the plains. The frequent floods, although a cause of immense damage to life and property, lay down fresh layer of silts in the flood-plains every year, providing rich fertile soils.

Origin of the Great Plains of India

There is no unanimity amongst the geologists about the origin of the Great Plains of India. The puzzling questions are related to the enormous thickness of the alluvium, nature of the depression, mode of its formation, subterranean rock-beds and the underlying geological structure. Some of the important views about the origin of the Northern Plains of India have been presented briefly in the following section:

1. Alluviation of the Foredeep

According to Edward Suess, an eminent Austrian geologist, a 'foredeep' was formed in front of the high crust-waves of the Himalayas as they were checked in their southward advance by the more rigid landmass of the Peninsula of India. This foredeep was like a large synclinorium (a large syncline with a number of small anticlines and synclines) owing to the unevenness of its bottom. According to Suess, the bed of this foredeep had a gentle slope towards north whereas the Peninsular side depicted a steep gradient. This bed rests on the basement of hard crystalline Peninsular rocks through which the region is connected to the Himalayan and the Peninsular blocks **(Fig. 2.18).** The alluviation of this foredeep led to the formation of the Great Plains by the rivers, descending from the Himalayan region. One of the serious gaps in Suess' theory is related to his inability to give suitable explanation to the uneven slope of the bed of the plain. Moreover, no conclusive evidence is available through which it could be inferred that there exists crustal connection between the Himalayan region and the Peninsular block through the Great Plains.

2. Infilling of a Rift Valley

In the opinion of Sir G. Burrard, the Northern Plains of India are the result of infilling of a rift valley. Burrard opined that during the formation of the Himalayas a rift valley was created between the two parallel faults (one along the southern boundary of the Shiwaliks and the other along the northern boundary of the Peninsula). This rift valley was filled up by the detritus brought down by the Himalayan rivers. In order to support his argument Burrard has cited examples of the formation of similar rift valleys in the Himalayas and the Peninsular region especially the Narmada and Tapi rift valleys.

This concept, however, does not find approval of the modern geologists. The main criticism raised against this concept is that nowhere in the world has such a giant rift valley with a length of 2400 km and a width of over 500 km ever been formed by crustal downwarping. Also, there is no geological evidence of the formation of such a rift valley in the northern part of the Peninsular foreland. The uneven bottom and the northward slope of the bottom of the Great Plains of India have also not been explained by this concept.

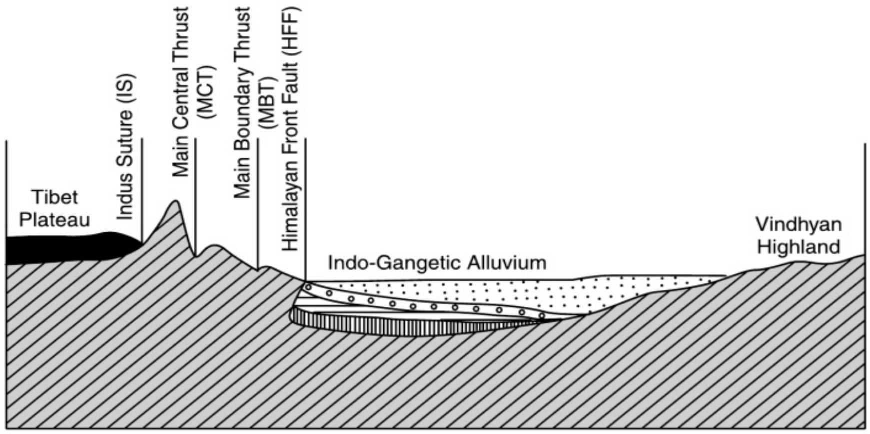

Fig. 2.18 Basement Complex—Hard Crystalline Rocks

3. Recession of the Sea

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

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

4. Remnant of the Tethys

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

5. Recent Views

According to the recent views, the Northern Plains of India represent a sag in the crust formed between the northward drifting of the Indian Subcontinent and the comparatively soft sediments accumulated in the Tethyan basin when the latter were crumpled and lifted up into a mountain system. Subsequently, it was filled up by the river deposits.

Physiographic Divisions of the Great Plains of India

The Great Plains of India are a remarkably homogeneous surface with an imperceptible slope. In fact, they are a featureless alluvial fertile plains formed mostly by the depositional process of the Himalayan and Vindhyan rivers. These rivers deposit enormous quantity of sediments along the foothills. Beyond the foothills, the rivers deposit the alluvium in their flood plains**.** The Northern Plains of India may be divided into the following sub-regions:

1. The Bhabar Plain

It lies to the south of the Shiwalik from west to east (Jammu Division to Assam). Its width is however, more in the western plains than in the eastern plains of Assam. In width, the Bhabar tract is generally 8 to 15 km, consisting of gravel and unassorted sediments deposited by the rivers descending from the Himalayas and the Shiwalik. The porosity is so high that most of the small streams (*chos* and *raos*) disappear in the Bhabar tract. Only the big rivers are seen flowing over the surface in this tract. The Bhabar tract is not suitable for cultivation of crops. Only big trees with large roots thrive in his region. The inhabitants of the Bhabar are largely the cattle keeping Gujjars.

2. The Tarai Tract

South of the Bhabar tract lies the Tarai belt which is 15–30 km wide. It is a marshy tract infested with mosquitoes. The Tarai is more wide in the eastern parts of the Great Plains, especially in Brahmaputra Valley due to heavy rainfall. It is a zone of excessive dampness, thick forests, rich wild life and malarial climate. In Uttarakhand, Uttar Pradesh, Haryana, Punjab, and Jammu Divisions (J & K) the Tarai forests have been cleared for cultivation of crops. At present, the Tarai belt is known for the good cultivation of sugarcane, rice, wheat, maize, oilseeds, pulses, and fodder.

The Tarai, once a marshy zone of jungle and wild grass along the southern edge of the Shiwaliks, has been almost entirely reclaimed for agriculture.

3. The Bhangar (Bangar) Plains

The Bhangar or older alluvial plain, represent the upland alluvial tracts of the Great Plains of India, formed by the older alluviums. The Bhangar formations were deposited during the middle Pleistocene Period. The Bhangar land lies above the flood limits of the rivers. The soil is dark in colour, rich in humus content and productive. It contains concretions and nodules of impure calcium carbonate or ***'Kankar'***. In relatively drier areas, the Bhangar also exhibits small tracts of saline and alkaline efflorescences known as '***Reh***', '***Kallar***' or ***'Thur'***. Bhangar is generally a well drained and the most productive land of the Great Plains of India. The Bhangar deposits have the fossils of elephants, horses, man, rhinoceros, hippopotamus, etc.

4. The Khadar Plains

The new alluvium tracts along the courses of the rivers are known as the ***'Khadar'*** or '***Bet***' lands. The khadar tracts are enriched by fresh deposits of silt every year during the rainy season. The Khadar land consists of sand, silt, clay and mud. After Independence, most of the Khadar land has been brought under cultivation and devoted to sugarcane, rice, wheat, maize, oilseeds, legumes, and fodder crops. The Khadar deposits have the fossils of living species like man, deer, oxen, buffaloes, horses, elephants, rhino, etc.

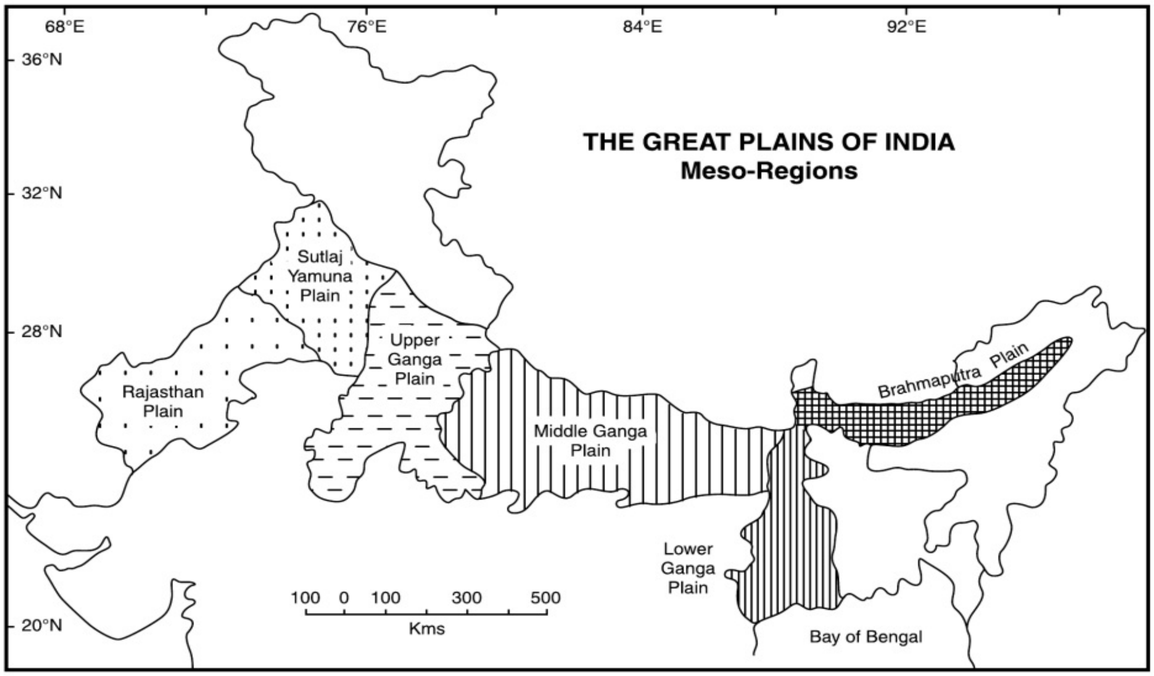

Fig. 2.19 The Great Plains of India

5. Delta Plains

The deltaic plain is an extension of the Khadar land. It covers about 1.9 lakh sq km of area in the lower reaches of the Ganga River. In fact, it is an area of deposition as the river flows in this tract sluggishly. The deltaic plain consists mainly of old mud, new mud and marsh. In the delta region, the uplands are called '***Chars'*** while marshy areas are known as '***Bils***'. The delta of Ganga being an active one, is extending towards the Bay of Bengal.

Meso-regions of the Northern Plains of India

On the basis of geo-climatic and topographical characteristics, the Northern Plains of India may be divided into the following four meso-regions (**Fig. 2.19**)**:**

1. The Plains of Rajasthan
2. The Punjab Haryana Plains
3. The Ganga Plains
4. The Brahmaputra Plains.

1. The Plains of Rajasthan

They lie to the west of the Aravallis and include the **Marusthali** and the **Bagar** of Rajasthan. The Rajasthan plains cover a total area of about 175,000 sq km. This plain has a general slope from north-east to south-west. In the lower reaches of the Luni river (Gujarat), this plain is only 20 metres above sea level. A substantial part of this plain has been formed by the recession of the sea as is evidenced by the presence of salt water lakes (Sambhar, Degana, Didwana Kuchaman, Lunkaransar-

Tal, and Pachpadra). The Sambhar Lake occupying an area of about 300 sq km during the rainy season lies about 65 km to the north-west of Jaipur city.

During the Permo-carboniferous Period, the greater part of the Rajasthan Plain was under the sea. It has several dry beds of rivers, like Saraswati and Drisdavati which indicate that the area earlier was fertile. At present, Luni is the only flowing river which reaches the Arabian Sea through the marshes of the Rann of Kachchh. Its water is sweet in the upper reaches but turns brackish in the lower parts. North of the Luni, there is a large area of inland drainage.

At present, the greater part of the Rajasthan Plains are a desert covered with longitudinal and transverse sand-dunes and barchans (Barkhans). A large number of playa lakes occur in the basins. In the south-western parts of the Rajasthan plain, there are the alluvial tracts known as *Rohi* (fertile plains). In the north-eastern part they consist of dry beds of the Ghaggar known as the Ghaggar Plains.

2. The Punjab Haryana Plains (total area 1.75 lakh sq km)

Stretching over an area of about 650 km from north-east to south-west and 300 km from west to east, the Punjab–Haryana Plain is an aggradational plain, deposited by the Satluj, Beas and Ravi rivers. The height of the plains varies from 300 m in the north near Jammu and Kathua to 200 m in the south-east. In the east the Delhi Ridge separates it from the Gangetic Plain. The general direction of slope is from north-east to south-west and south. The main topographical features of the Punjab-Haryana Plains are bluffs, locally called as *Dhaya*, as high as three metres or more, and the *Khadar* belts known as *Bet.* The undulating topography south of the Shiwaliks is adversely affected by erosion, caused by the seasonal streams locally called as *Chos.* The south western parts, especially Hissar District is sandy, characterised by shifting sand-dunes. Satluj, Beas, and Ravi are the only perinneal rivers. Between the Satluj and the Yamuna, the Ghaggar (the ancient Saraswati) is a seasonal stream which passes through Ambala Cantt. Its course is about ten km wide and contains water only during the rainy season.

The Punjab-Haryana Plains may be divided into: (i) the Bari-Doab between the Beas and Ravi, (ii) the Bist Doab, between the Beas and Satluj, (iii) the Malwa Plain, the central part of the region, and (iv) the Haryana-Bhiwani Bagar in the southern and south-eastern parts of the region.

3. The Ganga Plains (Total area 357,000 sq. km.)

The Ganga Plains lie between the Yamuna catchment in the west to the Bangladesh border in the east (**Fig. 2.20**). It is about 1400 km from west to east and has an average width of 300 km from north to south. The general gradient of the plain is about 15 cm per km from north-west to south-east. The maximum height of this plain is found to the north of Saharanpur (276 m) followed by Roorkee (274 m), Agra (169 m), Kanpur (125 m), Allahabad (98 m), Patna (53 m), Kolkata (6 m), and Sagar Island only 3 metres above sea level.

The main topographical variations in the plains include, *Bhabar, Tarai, Bhangar, Khadar*, river bluffs (levees), abandoned courses, *Khols*, dead-channels, *Bills, Tals,* and badlands. The Ganga Plains can be subdivided into the following sub-regions:

(a) The Upper Ganga Plain The Upper Ganga Plain includes the Ganga-Yamuna Doab, Rohilkhand Division and parts of the Agra Division. The catchment area of the Yamuna river makes its western boundary, Shiwaliks in the north and 125 m contour in the south. The elevation of the Upper Ganga Plain varies between 100 m to about 300 m. In addition to Ganga and the Yamuna, it is traversed by the Kali and Sharda rivers. A unique feature of the Upper Ganga Plain is the presence

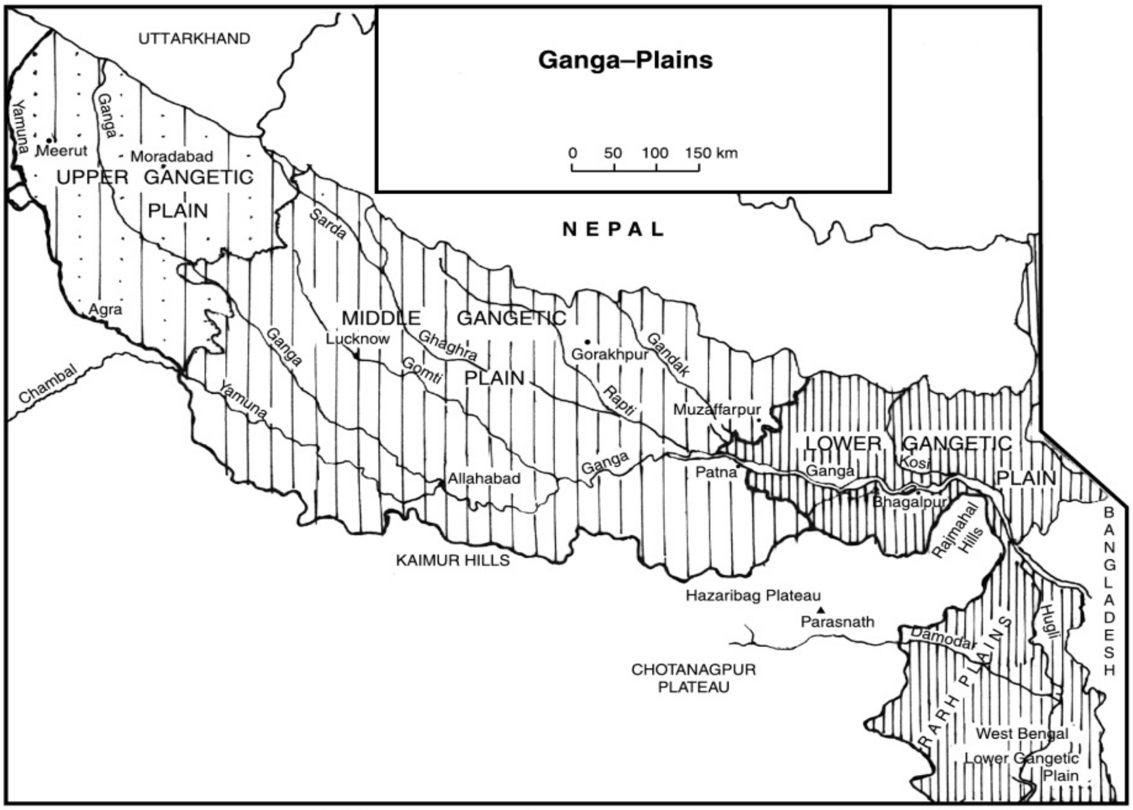

Fig. 2.20 Physiographic Divisions of Gangetic Plain

of ***Bhur*** (undulating, aeolian sandy deposits). Devoted to sugarcane, rice, wheat, maize, pulses, mustard, fodder, vegetables and orchards, it is one of the most productive plains of India in which the Green Revolution is a big success (**Fig. 2.20**).

(b) The Middle Ganga Plain Sprawling over an area of about 144,400 sq km, the Middle Ganga Plain includes central and eastern Uttar Pradesh, and the Bihar Plains up to Muzaffarpur and Patna. In the north, it is bounded by the Shiwaliks along the Indo-Nepal border. It has thick alluvial deposits with less ***Kankar*** formation. The region is homogeneous and featureless where monotony is broken by river levees, bluffs, ox-bow lakes, *Dhus*, *Tals*, *Jala* and *Chaurs* (marshy lands). Being a low gradient plain, the rivers often change their courses in this region. Gandak and Kosi are the main left hand tributaries, while the Son is an important right hand tributary of the Ganga in the Middle Ganga Plain.

(c) The Lower Ganga Plain (Area 80,970 sq km) The Lower Ganga Plain extends from Patna in the west, the foot of Darjeeling Himalaya in the north to the Bay of Bengal in the south. It is bordered by Assam and Bangladesh in the east and the Chotanagpur Plateau in the west. In the lower part of the Lower Ganga Plain is Sundarban Delta. The plain has a monotonous surface.

The eastern part of the plain is drained by the Tista, Jaldhakia, Sankosh joining the Brahmaputra, and the western part by the Mahananda, Ajay and Damodar. In the extreme south-west, Kasai and Subarnarekha are the main rivers. The general slope of this plain is towards south and south-east.

The Lower Ganga Plain has been formed by the downwarping of a part of the Peninsular India between Rajmahal Hills and the Meghalaya Plateau and subsequent sedimentation by the Ganga and the Brahmaputra rivers. The plain has a monotonous surface dissected frequently by the channels of the main streams and their tributaries.

Rahr Plain: Lying to the east of the Chotanagpur Plateau, it is a part of the Lower Gangetic Plains. Drained by the Damodar and Subarnarekha, it is covered by the lateritic-alluvium soils. Soil erosion is the main problem of the Rahr plain. Rice, maize and pulses are the main crops of the Rahr plain.

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

4. The Brahmaputra Plain

Stretching over an area of about 56,275 sq km, it is the eastern part of the Great Plains of India. It is about 720 km long and about 80 km wide. The region is surrounded by high mountains on all sides, except on the west. It is a depositional plain. The general altitude of the Brahmaputra Plain varies between 130 m in the east to only 30 m in the west (**Fig. 2.21**). The Assam Valley is characterised by a steep slope along its northern margin but the southern side has a gradual fall from the Meghalaya Plateau. The whole length of the plain is traversed by the Brahmaputra. Due to the low gradient, the Brahmaputra is a highly braided river having numerous islands. Majuli (area 930 sq km) is the largest river island of India and the second largest in the world after the Marajo Island of the Amazon River. The valley of Brahmaputra also has a number of isolated hillocks on both flanks of the Brahmaputra River. It is one of the most productive plains of India in which rice and jute are the main crops.

There is a marked difference between the physiography of the north and the south banks of the Brahmaputra river. The northern tributaries descending from the Arunachal and Assam Hills form a series of alluvial fans which coalesce and obstruct the courses of the tributaries forcing them to form meanders and adopt parallel course along the main stream, Brahmaputra. Consequently, there are numerous levees along the north bank. This has led to the formation of ***Bils***, ox-bow lakes, marshy tracts, and ***Tarai*** lands with dense forest cover. The southern bank of the Brahmaputra is less uneven and less wide. Moreover, the tributaries in the southern part are considerably larger. Here, Dhansiri and Kapili, through their headward erosion have almost isolated the Mikir and Rengma hills from the Meghalaya Plateau.

The valley of Assam may be divided into (i) the Upper Assam and (ii) the Lower Assam. These are demarcated along 94° East longitude. The Upper Assam Valley includes the districts of Lakhimpur, Dibrugarh, Jorhat, and Sibsagar and the Tezpur Tehsil of Darrang District. It is a monotonous plain except for the low hill ranges along the southern and south-eastern border. The Lower Assam Valley consists of Nagaon, Dhubri, Goalpara, Barpeta, Kamrup, Nalbari, Kokrajhar, and parts of the Darrang District. This region does not posses monotonous physiographic characteristics since its landscape is interspersed with the spurs of Meghalaya Plateau. Here, the right bank tributaries form a trellis pattern of drainage, while the left bank tributaries exhibit the dendritic pattern. Swamps and marshes are numerous in the northern region of the Lower Brahmaputra Valley.

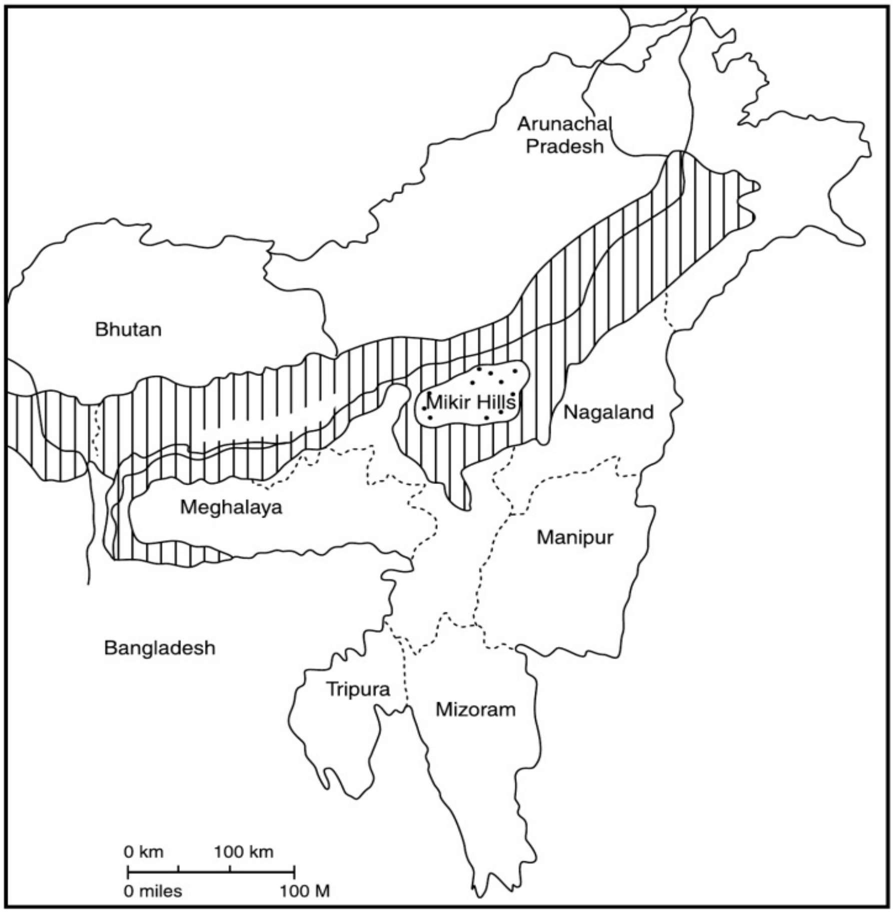

Fig. 2.21 Brahmaputra Valley

The Brahmaputra: It is one of the great rivers of the world. Flowing eastward to the north of the Himalayas in Tibet (China), it turns sharply south and passes through Assam before entering Bangladesh. The river valley has fertile alluvial plain which is conducive to growing rice and jute. It is also famous for its tea and the two national parks at Kaziranga and Manas.

Significance of the Great Plains of India

The Great Plains of India have been the repository of the Indian culture. This is covered with one of the most productive soils of the world. Its soils have the capacity to grow any crop of the tropical and temperate regions. The main points of significance of the Great Plains of India are as under:

(i) The soils of the plains are agriculturally most fertile. They are being devoted to the cereal and non-cereal crops. The plains are often termed as the 'Granary of India'.

(ii) Most of the rivers traversing the Northern Plains of India are perennial in nature. A number of canals have been carved out of these rivers which make agriculture more remunerative and sustainable.

(iii) The northern plains have a rich underground water-table which is being utilised through tube-wells and pumping sets for irrigation, domestic and industrial purposes.
(iv) The rivers of the plain have very gentle gradients which makes them navigable over long distances.
(v) Development of infrastructure like roads and railways could become easy in the plains.
(vi) The sedimentary rocks of plains have petroleum and natural gas deposits.
(vii) The plains constitute less than one-third of the total area of the country, but support over 40 per cent of the total population of the country.
(viii) The plains have witnessed several religious, political, cultural and social movements since the dawn of history. Some of the great religions of the world, like Hinduism, Buddhism, Jainism and Sikhism have their origin in the Great Plains of India. Several sacred places and centres of pilgrimage (Amritsar, Hardwar, Allahabad, Varanasi, Kushinagar, Bodh-Gaya, etc.) are situated in these plains.

THE COASTAL PLAINS

The Peninsular Plateau of India is flanked by narrow coastal plains of varied width from north to south, known as the West-Coastal Plains and the East Coastal Plains. These coastal plains differ from each other. They were formed by the depositional action of the rivers and the erosional and depositional actions of the sea-waves.

According to geologists the origin of the western and eastern coasts of India may be attributed to the faulting and subsidence of the Arabian Sea and the Bay of Bengal towards the close of the Eocene Period. Consequently, alluvial deposits along these coasts are of very recent origin, ranging from Pliocene to recent times. These coastal plains have the evidence of submergence and emergence. The Indian coastal plains may be subdivided into the following three divisions: (i) The Gujarat Coastal Plain, (ii) the West Coastal Plain, and (iii) the East Coastal Plain.

(i) The Gujarat Coastal Plain

The Gujarat plain covers almost the entire state of Gujarat, except the districts of Banaskantha and Sabarkantha. It is formed by the alluvial deposits of Sabarmati, Mahi, Luni, and numerous tiny parallel consequent streams. Part of this plain is the product of depositional activity of the winds and recession of the sea. It contains the Gondwana rocks (Umia Series), resting over the marine Jurassic rocks and capped by Lower Cretaceous (Apatian) beds. The Deccan lava lies over the Umia series.

The eastern section of Gujarat Plain is a projected jet of Sindhu-Ganga alluvial tract in Peninsular India. This projection is the outcome of an extensive Pleistocene sedimentation. Present rivers have further advanced this deposition to the Gulf of Khambat. Among the highlands, mention may be made of the Arasur mountains in eastern Gujarat, the Rajpipla Hills (Satpura)-famous for agate quaries, the Parnera Hills in Bulsar district, Sahyadris in the southern side and igneous complex of the Girnar Hills (Gorakhnath Peak, 1117 m) and Mandav Hills in Kathiwad.

The Rann of Kachchh is an extensive tract of naked tidal mudflats transected by abandoned and live creeks. The Gulf of Kachchh separates the Rann of Kachchh from the Kathiawar Peninsula. The salt in the soil makes this low-lying marshy area almost barren and unproductive. The whitish vertebrae of salts appear as white bony structures of the dried creeks. Live creeks form dendritic pattern of drainage and there has been accentuation in this pattern due to earthquakes. South of the Rann lies Kuchchh, formerly an island, which is almost surrounded by the Rann except in the south-west.

(ii) The West Coastal Plain

It lies between the Sahyadris and the Arabian Sea. It is about 1400 km long and 10 to 80 km wide. It has an elevation up to 150 m above sea level, reaching more than 300 m at places. The Western Coastal Plain is characterised mainly by sandy beaches, coastal sand-dunes, mud-flats, lagoons, alluvial tracts along rivers, estuary, laterite-platforms and residual hills. The Sahaydris (elevation 750–1225 m) run parallel to the plain and present their steep face to the low lands with Thalghaat and Bhorghat (gaps) in the north and the Palghat (Plakkad Gap) in the south of Nilgiri. The northern part of the west coastal plain, known as the Konkan Plain, is about 530 km long and 30 to 50 km wide. Southward is the Karnataka coastal plain which is about 525 km long and 8 to 25 km wide. It is the narrowest part of the West coastal plain. The southern part is known as the Malabar coast which is about 550 km long and 20–100 km wide. The maximum extension of the Malabar coast is found in the valleys of the Beypore, the Ponnani (draining through Palghat), the Periyar and Pamba Achankovil rivers. This coast is characterised by sand dunes. Along the coast, there are numerous shallow lagoons and backwaters—*Kayals* and *Teris*. These lagoons are linked together to facilitate navigation through small country boats. Here, Vembanad and Asthamudi are the important lagoons of the Malabar coast. The coast shows evidence of emergence.

The Eastern Coastal Plain

The eastern coastal plain lies between the Eastern Ghats and the Bay of Bengal, and stretches along the coasts of Odisha, Andhra Pradesh and Tamil Nadu. These plains are formed by the alluvial fillings of the littoral zone comprising some of the largest deltas of the world. The East coastal plains consist mainly of Recent and Tertiary alluvial deposits. These are gentle, monotonous plains rising gently westward to the foot of the Eastern Ghats. The monotony of the topography is broken by the presence of numerous hills. This coastal plain has a straight shoreline with well defined beaches of sand and shingles. The most famous is the Marina Beach in Chennai. All along the coast, there are several sandbars generally in front of the river mouths. There are some of the important lagoons of India along the Eastern coast, of which, Chilka in the south-west of the Mahanadi delta is the biggest lake (65 km $\times$ 8 km) in the country. The Kulleru lake lies between the deltas of Godavari and Krishna, while the Pulicat lake lies further south on the border of Andhra Pradesh and Tamil Nadu.

The Indian Islands

India has a total of 615 islands, of which 572 lie in the Bay of Bengal, and the remaining 43 in the Arabian Sea. Out of the 572 islands of Andaman and Nicobar, only 36 are inhabited. The Bay of Bengal islands include the Andaman and Nicobar Islands which are largely tectonic and volcanic in origin, while the islands of the Arabian Sea are mainly coral formations. Moreover, there are a number of offshore islands along the mouth of the Ganga, eastern and western coasts and in the Gulfs of Khambat and Mannar.

Islands of the Bay of Bengal

The main islands of the Bay of Bengal are the Andaman and Nicobar groups. The Andaman and Nicobar islands are separated by the Ten Degree Channel. The shortest distance of the Andaman Islands from the mainland (Bay of Bengal Head) is about 2000 km and the extreme southern point is the Indira Point—the southern most point of the Great Nicobar Island (**Fig. 2.22**).

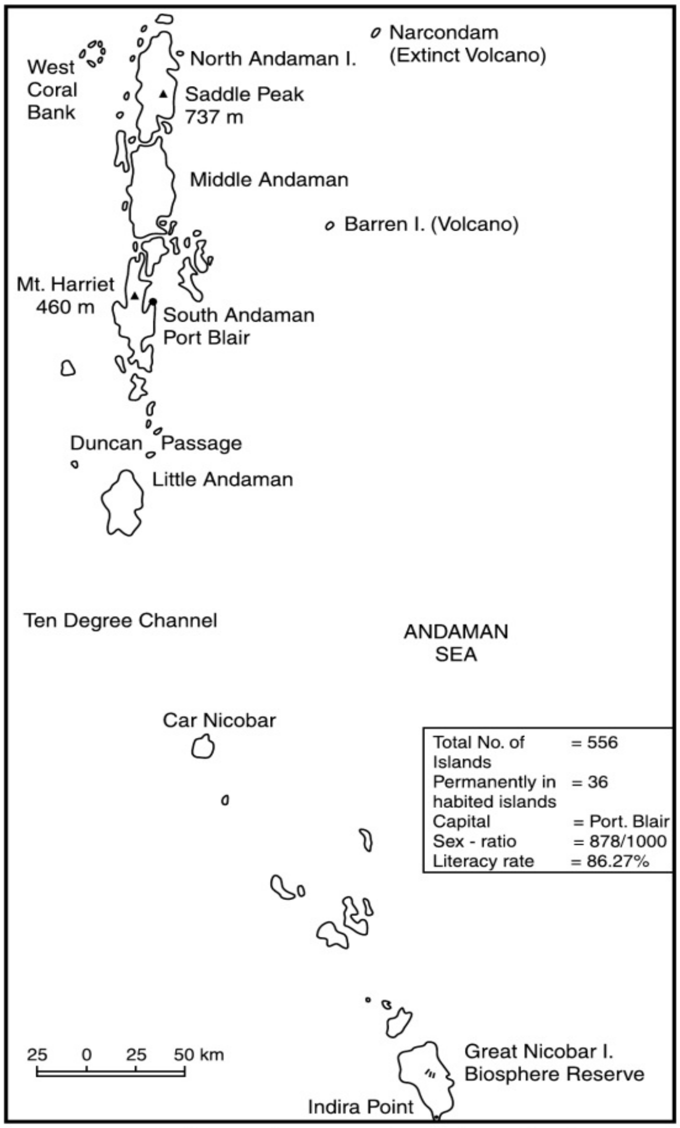

Fig. 2.22 Andaman and Nicobar Islands

The Andaman and Nicobar Islands have a warm tropical climate all year round with two monsoons. Temperatures are around 35° C, but the sea breeze has a cooling effect. The islands receive heavy rain, with the monsoon season lasting from mid-May to mid-September and from November to mid-December.

The Andaman Islands are thickly forested and have a rich marine life among the reefs. The islands are a birdwatcher's paradise with 242 species recorded. The entire region falls in a major earthquake zone. The Barren Island in the Andamans has an active volcano.

In the Bay of Bengal, there are two volcanic islands (Barren and Narcondam) situated within 80 km east of the Andaman Islands. The Andaman Islands have been formed by the extension of the Tertiary mountain chain of Arakanyoma. The main rocks of these islands are sandstone, limestone and shale. The Nicobar group of islands comprise 18 islands of which only 11 are inhabited. The physiography of the Nicobar islands is mainly of coral origin.

Rice is the main crop in Andaman and Nicobar Islands. Coconut and arecanut are the main cash crops of Nicobar. Tropical fruits like pineapple, a variety of bananas, sweet papaya and mango grow on a smaller scale in the Andaman group of islands.

The Tribal population in the Andaman Islands is fast dwindling. Most of its present inhabitants are migrants from Bangladesh, Myanmar, and India and Tamils from Sri Lanka. Some of the well known surviving tribes of the Andamans and Nicobar are the Onges, Jarawas and Sentinelese.

One of the largest and also the rarest crabs in the world, the *Giant Robber Crab*, can be found in the Wandoor Marine Biosphere Resrve in south Andaman and Great Nicobar Islands. Its powerful claws help it to climb the coconut tree and break the hard shell of its fruit.

The Arabian Sea Islands

There are 43 islands in the Arabian Sea, out of which only 11 are inhabited. The shortest distance from the mainland (Calicut) is about 109 km. Kavaratti, located on the island of this name is the capital of Lakshadweep. Lakshadweep islands are separated from the Maldive Islands by the Eight Degree Channel. Hills and streams are absent on these islands. The Minicoy is the largest (4.5 sq km) and has a light house and a weather observatory. Fishing is the main occupation of the people of Lakshadweep. In Lakshadweep coconut is the only major crop, although pulses and vegetables are also grown. The sea around the island is rich in marine life **(Fig. 2.23).**

Offshore Islands

There are numerous islands in the delta region of Ganga and in the Gulf of Mannar. Among the Western coast islands Piram, Bhaisala (Kathiawar), Diu, Vaida, Nora, Pirotan (Pirothan), Karunbhar (Kachchh coast), Khadiabet, Aliabet (Narmada-Tapi mouths), Butchers, Elephanta, Karanja, Cross (near Mumbai), Bhatkal, Pegioncock, St. Mary (Mangalore coast), Anjidiv (Goa coast), Vypin near Kochi, Pamban, Crocodile, Adunda (Gulf of Mannar), Sri Harikota (mouth of Pulicat Lake, Pairkud (mouth of Chilka Lake), Short, Wheeler (Mahanadi-Brahmani mouth), and New Moore, and Ganga-Sagar and Sagar (Ganga Delta). Many of these islands are uninhabited and administered by the adjacent states.

EARTHQUAKES IN INDIA

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

The structure of the subcontinent of India is characterised with plate-boundaries in which folding, and faultings are a regular feature. Man has constructed numerous dams and reservoirs across rivers. All these factors, individually or collectively lead to earthquakes in the country. Consequently,

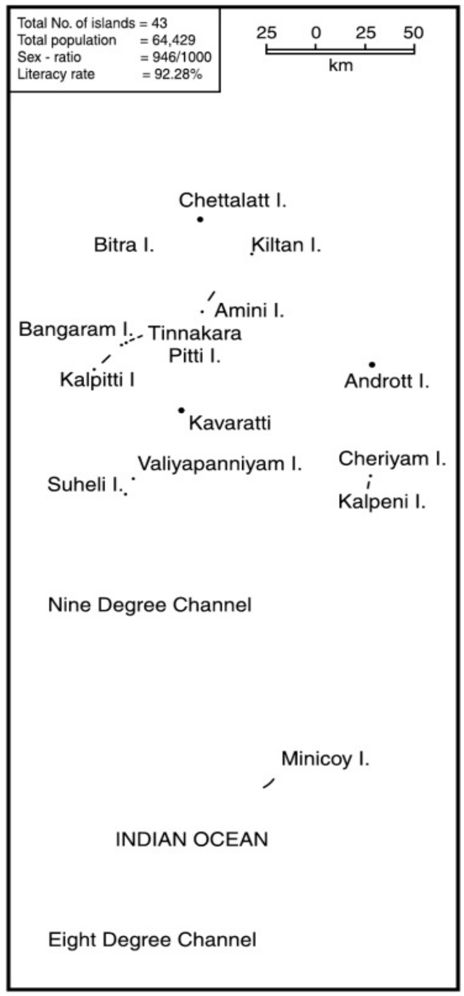

Fig. 2.23 Lakshadweep Islands

every year numerous earthquakes are recorded in the Himalayan region, the Great Plains of India, Purvanchal and the Islands of Andaman and Nicobar. Some of the important earthquakes of great magnitude have been plotted in **Fig. 2.24**. It may be seen from this figure that most of earthquakes of high magnitude occurred in the folded mountains of Himalayas. Their frequency is, however, low in the relatively more stable Peninsular India. On the basis of seismic intensity and frequency, a committee of experts comprising seismologists and geologists have divided India into six seismic zones (**Fig. 2.25**).

About 60 per cent of the total area of the country is under moderate and high seismic zones. A belt of about 3500 km length and about 500 km width in north India is the main earthquake prone zone of India, characterised with devastating earthquakes of high magnitude. Some of the important earthquakes recorded in India during the last one hundred years have been plotted in **Fig. 2.24.**

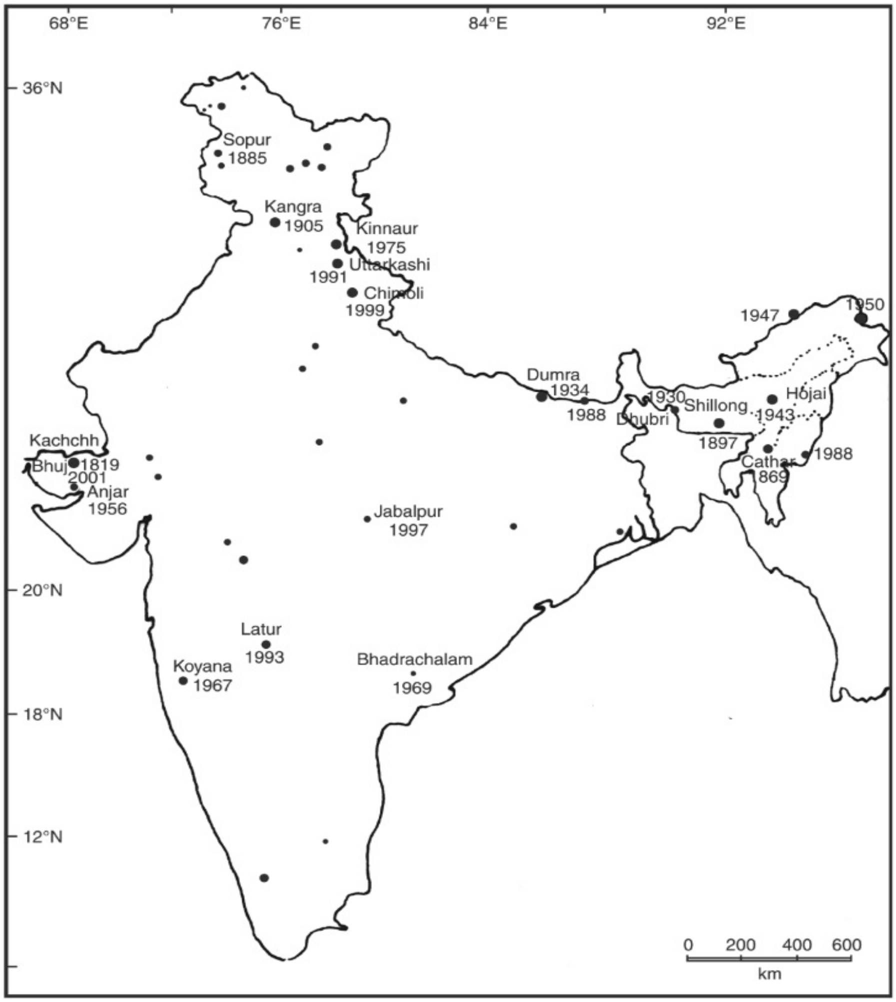

Fig. 2.24 India—Major Earthquakes (1819-2001)

VULCANICITY

A volcano is an opening in the crust of the earth, connected by a conduit to an underlying magma chamber, from which molten lava, volcanic gases, steam, and pyroclastic materials are ejected. It is usually in the form of a peak which may be cone shaped or dome-shaped depending on the type of volcano and type of material ejected. The main causes of volcanic eruptions are associated with sea-floor spreading, plate-tectonics and mountain building processes.

At present, the only active volcanoes in India are at the Barren and Narcondom Islands (Andaman group of Islands), but geographical evidence is available for vulcanicity in the past. Prof. H.L. Chibber (1945) has identified six areas of vulcanicity in the country which are given as follows:

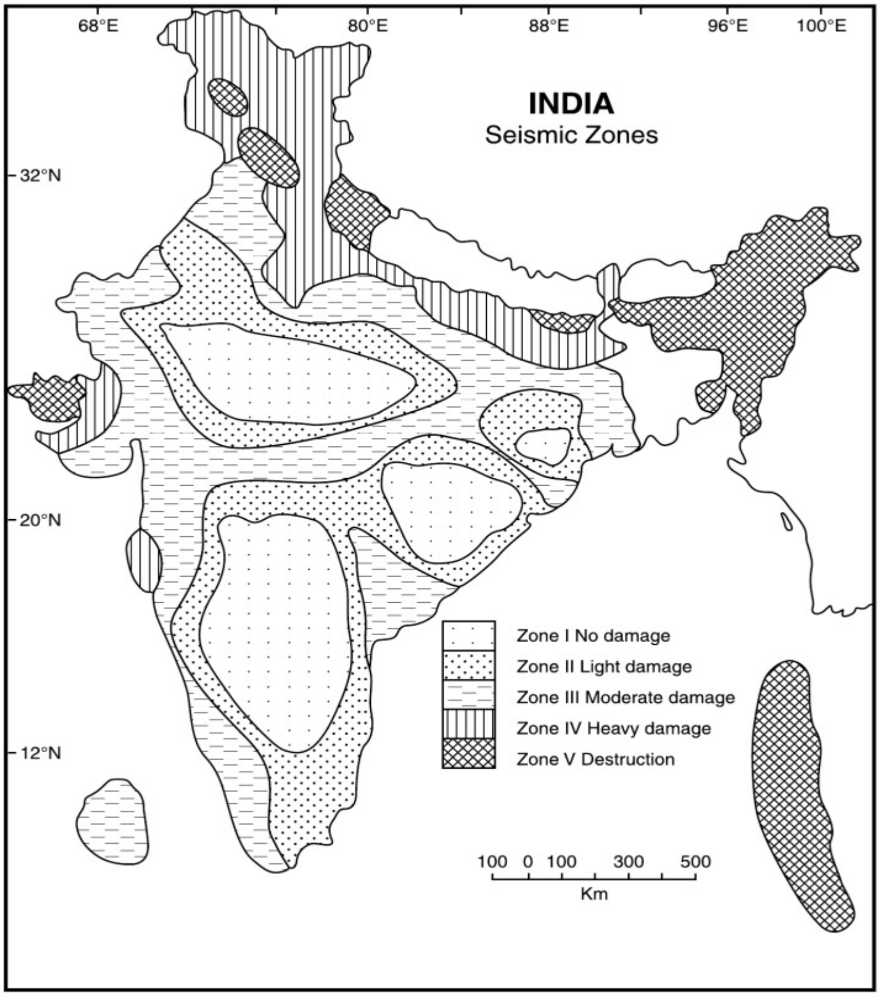

Fig. 2.25 India—Seismic Zones

1. **The Dharwar Vulcanicity**: Traces of basalt deposits are found in the form of Dalma Trap in Jharkhand.
2. **Cuddapah Vulcanicity**: This occupies Cuddapah, Bijapur and Gwalior areas.
3. **Vindhyan Vulcanicity**: Its evidences are found in the Malani (Jodhpur) and Kirana (Punjan) Hills in Rajasthan.
4. **Palaeozoic Vulcanicity**: During this phase, volcanic eruptions were noticed in Kashmir and Himachal Pradesh. Traces of volcanic deposits have been found in Pir Panjal Range, Dalhousie (H.P.), Bhuwali, Bhimtal, and Saugaon (Kumaun-Uttarakhand).
5. **Mesozoic Vulcanicity:** During this period, volcanic eruption took place in Rajmahal Hills (Jharkhand) and Abor Hills of Arunachal Pradesh.

6. **The Cretaceous Vulcanicity:** During this period, enormous quantity of basalt upwelled through fissure eruptions over the north-western part of the Peninsula, forming the Deccan Trap.

Geologists opine that apart from the Barren Islands, volcanic activity is going on beneath the Himalayan crust due to the subduction and melting of the northern margin of the Indian Plate.

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Chapter 3

Drainage

THE DRAINAGE SYSTEM

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

(i) They can be placed in an orderly hierarchy,
(ii) They are areal units whose geomorphological and hydroloical characteristics can be measured quantitatively, and
(iii) They can be treated as working systems with energy inputs of climatological variables like temperature and rainfall and output of river discharge as runoff.

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

DRAINAGE PATTERN

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

1. The Antecedent or Inconsequent Drainage

The rivers that existed before the upheaval of the Himalayas and cut their courses southward by making gorges in the mountains are known as the antecedent rivers. The Indus, Satluj, Ganga, Sarju (Kali), Arun (a tributary of Kosi), Tista and Brahmaputra are some of the important antecedent rivers, originating from beyond the Greater Himalayas.

2. Consequent Rivers

The rivers which follow the general direction of slope are known as the consequent rivers. Most of the rivers of peninsular India are consequent rivers. For example, rivers like Godavari, Krishna and Kaveri, descending from the Western Ghats and flowing into the Bay of Bengal, are some of the consequent rivers of Peninsular India (**Fig. 3.1**).

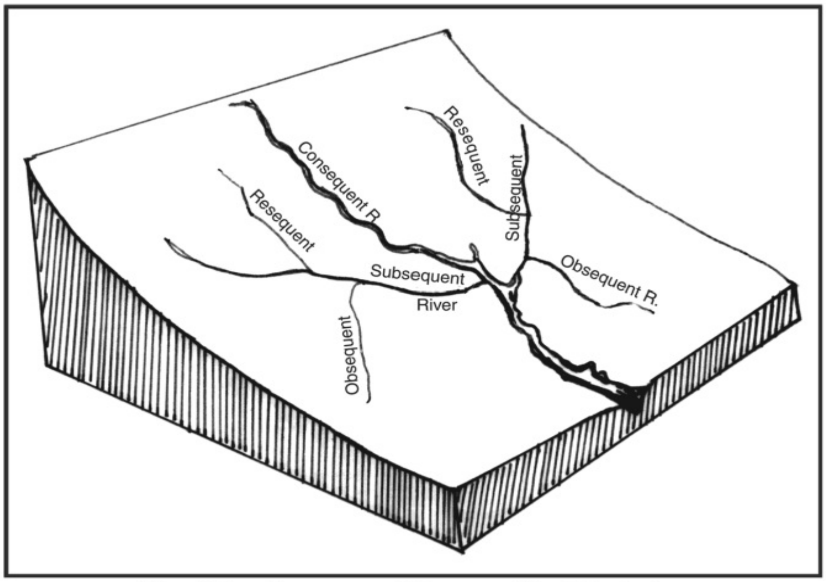


Fig. 3.1 Consequent River and its Tributaries

3. Subsequent Rivers

A tributary stream that is eroded along an underlying belt of non-resistant rock after the main drainage pattern (consequent river) has been established is known as a subsequent river. Due to the northward slope of the Peninsula towards the Great Plains, the rivers originating from the Vindhyan and the Satpura ranges flow northward into the Ganga system. The Chambal, Sind, Ken, Betwa, Tons and Son meet the Yamuna and the Ganga at right angles. They are the subsequent drainage of the Ganga drainage system.

4. Superimposed, Epigenetic (Discordant) or Superinduced Drainage

It is formed when a stream with a course originally established on a cover of rock now removed by erosion, so that the stream or drainage system is independent of the newly exposed rocks and structures. In other words, it is a drainage pattern which exhibits discordance with the underlying rock structure because it originally developed on a cover of rocks that has now disappeared due to denudation. Consequently, river directions relate to the former cover rocks and, as the latter were being eroded, the rivers have been able to retain their courses unaffected by the newly exposed structures. The stream pattern is thus superposed on, or placed on, ridges or structural features that were previously buried. The Damodar, the Subarnarekha, the Chambal, the Banas and the rivers flowing at the Rewa Plateau present some good examples of superimposed drainage.

5. Dendritic Drainage

A term used for drainage which is branching, ramifying or dichotomising, thereby giving the appearance of a tree. Thus, a dendritic pattern develops in a terrain which has uniform lithology, and where faulting and jointing are insignificant; e.g., massive crystalline rocks or thick plains consisting of clays. Most of the rivers of the Indo-Gangetic Plains are of dendritic type. The term dendritic, coined by I.C. Russel (1898), is used to denote the most common type of drainage pattern and is a distinctive feature of the regions having horizontally bedded sedimentary rocks or massive igneous rocks (**Fig. 3.2-A**).

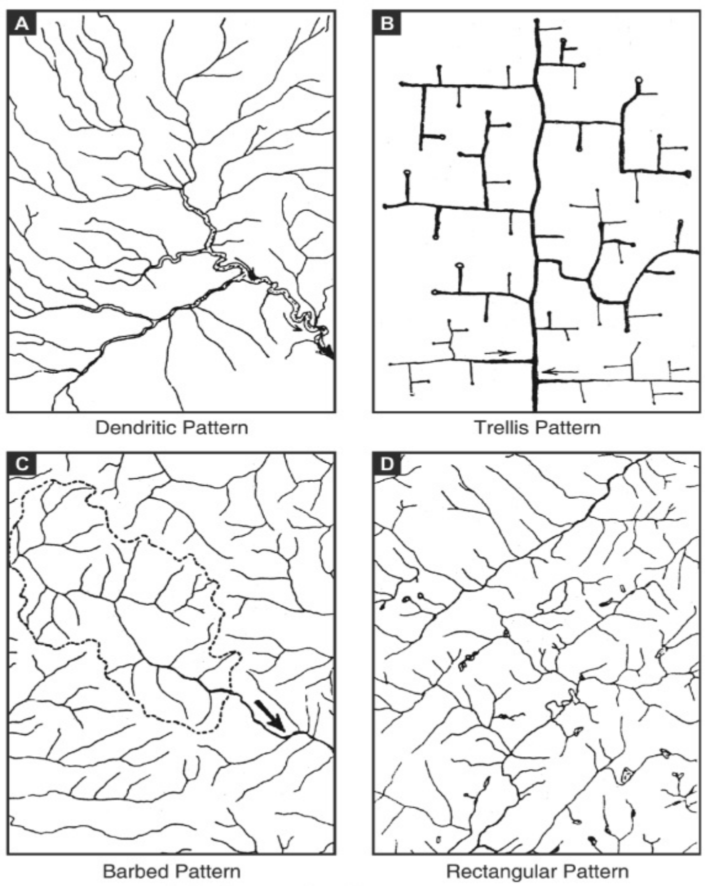


Fig. 3.2-(A, B, C, D) Drainage Patterns

6. Trellis Drainage

Trellis is a rectangular pattern formed where two sets of structural controls occurs at right angles. In a trellis pattern, the river forms a net like system and the tributaries flow roughly parallel to each other. The old folded mountains of the Singhbhum (Chotanagpur Plateau) have a drainage of trellis pattern **(Fig. 3.2-B).**

7. Barbed Pattern

A pattern of drainage in which the confluence of a tributary with the main river is characterised by a discordant junction—as if the tributary intends to flow upstream and not downstream. This pattern is the result of capture of the main river which completely reverses its direction of flow, while the tributaries continue to point in the direction of former flow. The Arun River (Nepal), a tributary of the Kosi is an interesting example of barbed drainage pattern **(Fig. 3.2-C).**

8. Rectangular Drainage

The drainage pattern marked by right-angled bends and right-angled junctions between tributaries and the main stream is known as rectangular drainage. It differs from the trellis pattern in so far as it is more irregular and its tributary streams are neither as long, nor parallel as in trellis drainage. A typical example of this drainage pattern is found is the Vindhyan Mountains of India **(Fig. 3.2-D).**

9. Radial Pattern

It is a pattern characterised by outflowing rivers, away from a central point, analogous with the spokes of a wheel. It tends to develop on the flanks of a dome or a volcanic cone. A good example of a radial drainage pattern is provided by the rivers originating from the Amarkantak mountain. Rivers like Narmada, Son and Mahanadi originating from Amarkantak Hills flow in different directions and are good examples of radial pattern. Radial drainage patterns are also found in the Girnar Hills (Kathiwar, Gujarat), and Mikir Hills of Assam **(Fig. 3.3-A).**

10. Annular Pattern

In this drainage pattern, the subsequent streams follow curving or arcuate courses prior to joining the consequent stream. This results from a partial adaptation to an underground circular structure; a dome like igneous intrusion (batholith). The subsequent streams find it easier to erode the concentric, less resistant strata. This is not a very common drainage pattern in India. Some examples of this are however found in Pithoragarh (Uttarakhand), Nilgiri Hills in Tamil Nadu and Kerala **(Fig. 3.3-B).**

11. Parallel Drainage

The drainage pattern in which the rivers flow almost parallel to each other is known as parallel drainage. The small and swift rivers originating in the Western Ghats and discharging their water into the Arabian Sea provide a good example of parallel drainage pattern in India **(Fig. 3.3-C).**

12. Deranged Pattern

This is an uncoordinated pattern of drainage characteristic of a region recently vacated by an ice-sheet. This is probably due to the irregularities produced by glacially deposited materials, e.g., Kame and

Kettle, and by the fact that there has been insufficient time for the drainage to become adjusted to the structures of the solid rock underlying the glacial drift. The picture is one of numerous water courses, lakes and marshes; some inter-connected and some in local drainage basins of their own. This type of drainage is found in the glaciated valleys of Karakoram (**Fig. 3.3-D**).

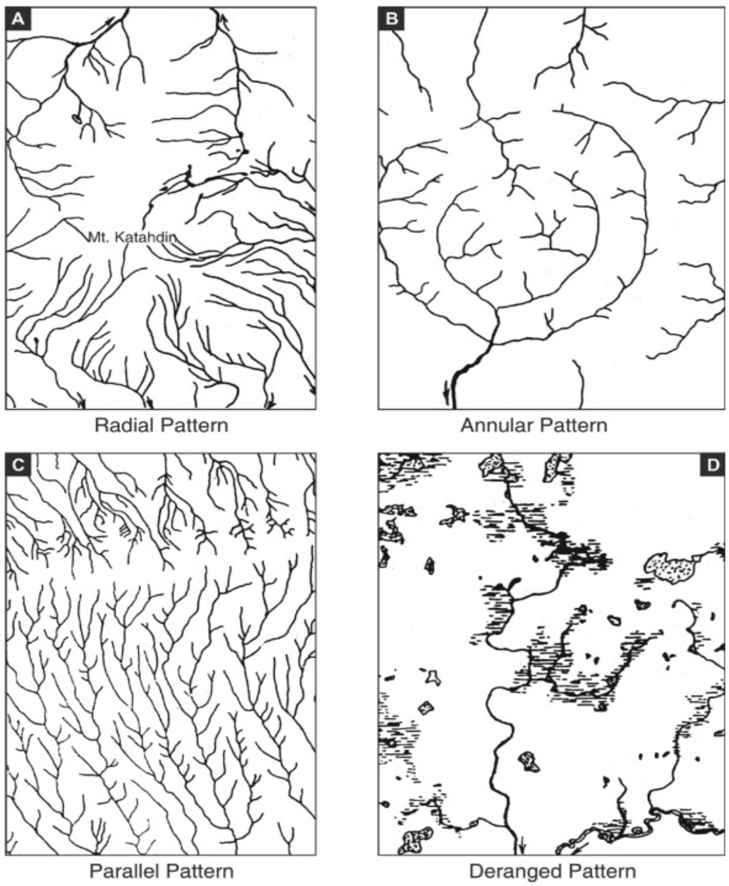


Fig. 3.3-(A, B, C, D) Drainage Patterns

RIVER BASINS OF INDIA

Rivers with their tributaries are the main channels of drainage of the land surface; they are at the same time also the chief agents of land-erosion, and the main lines for transport waste-products of the land to the sea. The area drained by the main river including all its tributaries is known as its drainage basin. On the basis of the area drained, the river basins of India have been classified into three categories: (i) river basins with catchment area of more than 20,000 sq km known as large river basins; (ii) river basins having a catchment area between 2000 to 20,000 sq km known as the medium basins, and (iii) the rivers having a catchment area less than 2000 sq km known as minor river basins. India has one hundred and thirteen river basins, of which 14 are large, 44 medium and 55 minor river basins. The major river basins of India in descending order of area are: the Ganga, Indus, Godavari, Krishna, Brahmaputra, Luni, Mahanadi, Narmada, Kaveri, Tapi, Pennar, Brahmani, Mahi, Sabarmati, Barak, and Subarnarekha. The major river basins form about 84 per cent of the total drainage area of the country **(Fig. 3.4).**

The three major river systems (Ganga, Indus, and Brahmaputra) are international rivers. The Indus and some of its important tributaries traverse Tibet (China), India, and Pakistan, while the

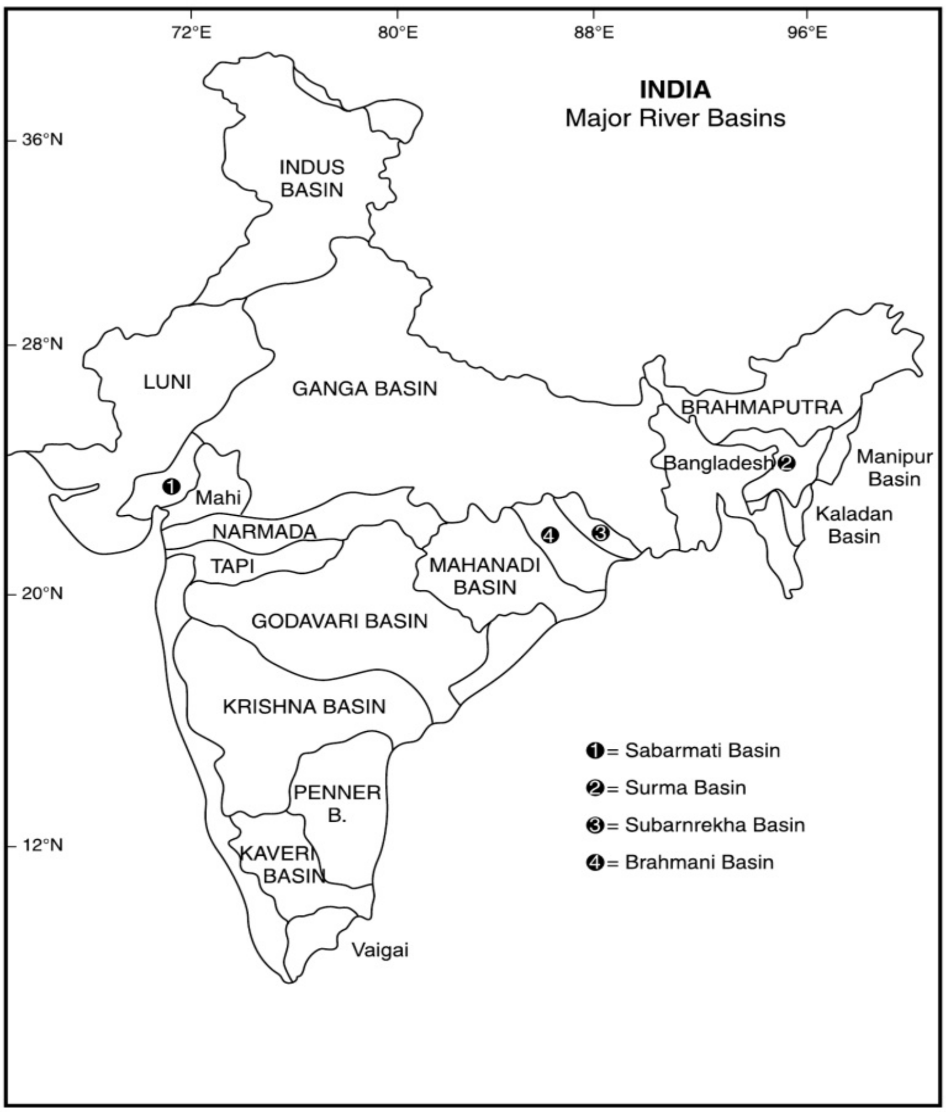


Fig. 3.4 Major River Basins

Ganga and Brahmaputra, and their tributaries cross Tibet, Nepal, Bhutan, and Bangladesh. The main river basins, their basin area, and annual discharge has been shown in Table 3.1.

On the basis of mode of origin, the drainage of India may be divided into (i) Himalayan or the Extra-Peninsular Drainage, and (ii) the Peninsular Drainage.

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

Table 3.1 *Major Rivers of India and their Surface Flow*

River Basin	*Basin Area**	*Percentage area*	*Annual Discharge (M^3/km^2)*	*%*
Ganga	861,404	26.2	468,700	25.2
Indus	321,284	9.8	79,500	4.3
Godavari	312,812	9.5	118,000	6.4
Krishna	258,948	7.9	62,800	3.4
Brahmaputra	258,008	7.8	627,000	33.8
Mahanadi	141,589	4.3	66,640	3.6
Narmada	98,795	3.0	54,600	2.9
Kaveri	87,900	2.7	20,950	1.1
Tapi	65,150	2.0	17,982	0.9
Pennar	55,213	1.7	3,238	0.2
Brahmani	39,033	1.2	18310	1.0
Mahi	34,481	1.0	11,800	0.6
Subarnarekha	19,296	0.6	7,940	0.4
Sabarmati	21,895	0.7	3,800	0.2
Medium and Minor Rivers	711,833	23.6	—	16.0
Total (India)	328,76,97	100.00	1,561,170	100.00

*Area means basin area in India.
Source: S.P. Das Gupta, 1989.

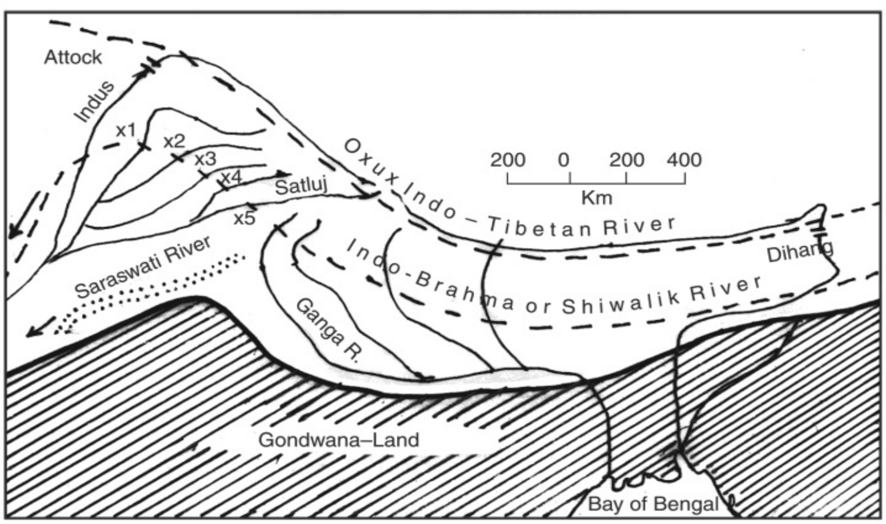
The Himalayan Drainage

The Himalayan drainage system comprises all the international rivers of India, i.e, the Indus, the Ganga, and the Brahmaputra. Most of these rivers and their major tributaries are perennial in character, obtaining their water from the glaciers and rains. These rivers are in their youthful stage carving out a number of erosional landforms like waterfalls, cataracts, rapids, gorges, steep slopes, and river terraces. The Himalayan rivers are not only eroding agents, but are also depositing agents in the plains and deltas. The great Himalayan rivers (Indus, Satluj, Ganga, Kali, Karnali, Gandak, Kosi, Tista and Brahmaputra) are older than the Greater Himalayas. They are antecedent, and drain not only the southern slopes of the Himalayas but to a large extent, the northern Tibetan slopes as well. The Himalayan courses of these rivers are highly tortuous, but in plains they display a strong meandering tendency and shift their courses frequently. The river regimes, although perennial, exhibit wide seasonal fluctuations; causing devastating floods during rainy season but shrinking to the bottom of the valley with a number of shoals during the dry season. These rivers continue to cause intensive erosion and transport heavy loads of sand and silt annually. Several of the Himalayan rivers are older to the Himalayas. Such rivers are known as the antecedent rivers. The Himalayan rivers have great socio-economic and cultural importance in the life of the Indian people. The water of the Himalayan rivers is utilised for irrigation, industries, hydel-power generation, navigation and domestic purposes. Moreover, the big rivers are navigable in the plain areas of their courses.

Evolution of the Himalayan Rivers

The geologists and geomorphologists are not unanimous about the origin of the Himalayan rivers. The Himalayan rivers have a long geological history. The major rivers of the Himalayas like Indus, Brahmaputra, Satluj, Ganga (Alaknanda and Bhagirathi), Gandak, Kali, Kosi, Tista, Manas, etc. originate on the southern slopes of the Tibetan Highlands. Rivers like Indus, Satluj and Brahmaputra first flowed parallel to the main axis of the moutain in longitudinal troughs, then they take sudden bends towards the south, carving out deep gorges across the mountain ranges to reach the northern plains of India. Such deep gorges created by the Indus, Satluj, Alaknanda, Sarju (Kali), Gandak, Kosi, Tista and Brahmaputra suggest that they are older than the Himalayan mountains, and are antecedent in character.

E. H. Pascoe (1919) and G.E. Pilgrim (1919) attempted to give a tangible explanation to the problem of the Himalayan drainage. According to them, the Tibetan Plateau was drained to the west by the mighty Tsangpo-Indus-Oxus combine with the Tibetan river merging into Oxus Lake before the upheaval of the Himalayas **(Fig. 3.5)**. Similarly, another big river called the Indo-Brahma River (Pascoe, 1919) or the Shiwalik River (Pilgrim, 1919) traversed the entire longitudinal extent of the Himalaya from Assam to Punjab from north-east to empty into the Gulf of Sindh, near lower Punjab, during the Miocene Period **(Fig. 3.5)**. The former (Tsangpo-Indus-Oxus) was disrupted by the headward erosion of its left hand tributaries, i.e. the Proto-Sind, the Proto-Satluj, the Proto-Brahmaputra, and later was captured by the present lower Irradwady-Chindwin, the lower Brahmaputra, the lower Satluj, and the lower Indus which are the probable remnants of the Shiwalik River.



Capture of Tibetan River Indus at Attock and Brahmaputra at Dihang X_1-X_5: successive captures of Indo-Brahma or Shiwalik Rivers by the rivers of Punjab.

Fig. 3.5 Evolution of Himalayan Drainage

Later the mighty Shiwalik river was dismembered into three main systems: (i) the Indus and its tributaries in the western part, (ii) the Ganga and its Himalayan tributaries in the central part, and (iii) the Brahmaputra in Assam and its Himalayan tributaries in the eastern part (**Fig. 3.5**). The dismemberment is attributed to the Pleistocene upheaval in the Western Himalayas including the uplift of the Potwar Plateau (the Delhi Ridge) which acted as a water divide between the Indus and the Ganga systems. Similarly, the down thrusting of the Malda-Gap area between Rajmahal Hills and the Meghalaya Plateau during the mid-Pleistocence period (about 5 lakh years ago) caused the Ganga and the Brahmaputra systems to flow towards the Bay of Bengal. These developments brought a reversal in the direction of flow in the middle section of the severed stream, i.e. the Ganga of today, resulting in its taking a southerly course and eventually annexing the Yamuna and its tributaries. Earlier, the Yamuna had a south-westerly course and was a tributary of the Indus. This entire event was completed by the late Pleistocene period leading to the evolution of the present drainage systems of northern India.

Pascoe's and Pilgrim's concepts about the origin of the Himalayan drainage systems have been criticised on the following grounds:

(i) It is not necessary to postulate a stream of the size of Shiwalik River flowing all along the longitudinal extent of the Himalayas to explain the occurrence of the Shiwalik alluvial deposits and the boulder beds. They might represent a succession of alluvial fans deposited by rivers descending from the Himalayas, which have coalesced over time. Leading geologists, M.S. Krishnan and N.K.N. Iyangar (1940) found it difficult to accept the existence of such a mighty river on geological as well as physiographic grounds.

(ii) The evidence furnished by the depositional history of the Ganga Delta does not fit well with the theory. In fact, the alluvium should have been laid down over a much longer period of time than that suggested in the concept.

(iii) The evidence of the Tipam sandstones of Assam, which were deposited in an estuary situated too close to the source of the Indo-Brahma River, also cast doubts over the acceptance of the theory.

Professor Enayat Ahmad (1965–71) has given his own interpretation of evolution of the Himalayan drainage. He opined that the Tethys remained as a basin of sedimentation from the Cambrian to the Eocene Periods, but the major portion of the Himalayan region was occupied by Gondwana Landmass. During the Himalayan upheaval in the Oligocene period, part of the Tethysian geosyncline and probably, part of the Gondwana Land, were uplifted. Most probably, this marked the initiation of the Himalayan drainage. The Tethys Sea was raised into a landmass with a median mass of the high Tibetan Plateau in the centre and the two bordering ranges namely, the Kun-Lun in the north and the Himadari in the south. The drainage started from the southern edge of the median mass and flowed south towards the foredeep. As the formation of east-west ranges created east-west valleys, the rivers partly flowed along these valleys. This is indicated by the upper course of several rivers such as the Indus, the Shyok, the Satluj, the Ganga, the Brahmaputra, the Arun (Kosi), etc. Since the whole of the Tethys was not fully raised to become land surface, there existed patches of sea along the margins and drainage lines were not fully defined.

The second Himalayan upheaval during the mid-Miocene period increased the altitude of the medium mass and the bordering ranges. The remnant sea was raised to form the landmass. The rise in land resulted in greater and more invigorated drainage. Alongwith these changes, the region to the south of the first Himalayan range was raised as the Lesser Himalayan range. Earlier, streams on the southern margin of the Tibetan Plateau cut down deep valleys to maintain their courses. Along the southern slopes of the Lesser Himalayas, a number of consequent streams also merged which drained into the southern foredeep.

The third Himalayan upheaval during the Pleistocene perioid resulted into the folding of the Shiwalik foredeep into hill ranges. Also, the height of earlier ranges and the Tibetan Plateau were raised. The rise in the Tibetan Plateau blocked the streams that had gone northward into the Tibetan Sea. These streams were diverted east and west, which probably led to the formation of the Trans-Himalayan master stream. This master stream was broken into two (the Proto-Indus and the Proto-Brahmaputra) by the formation of the Kailash Range. The uplift of the Shiwalik range gave rise to the last set of consequents, originating on the crest of the range, into older streams.

THE MULTIPLE RIVER THEORY

An alternative explanation regarding the evolution of the Himalayan drainage has been offered by the Multiple River Theory. The protagonists of this theory find it difficult to accept the existence of a large river like the Indo-Brahma or Shiwalik on geological and physiographic grounds.

This theory postulates that the Eocene Sea (Tethys Sea) extended from Sindh (Pakistan), Rajasthan, Jammu, and Punjab to Lansdown and Nainital (Uttarakhand). The existence of such a sea is evidenced by the presence of shallow water facies indicative of coast near Lansdown (Garhwal, Uttarakhand). This limit also coincides with the eastern continuation of one of the ridges of the Aravalli Ranges which presumably acted as a barrier. At the same time, another ridge extended from the Rajmahal Hills to the Meghalaya or Shillong Plateau (Rajmahal-Garo Gap) which is now occupied by the Ganga Brahmaputra basin. The sea was broken by the first upheaval of the Himalayas to form an isolated basin in which sediments were deposited. In the next upheaval, a pronounced foredeep all along the southern border of the Himalayas was formed. This foredeep contained numerous lagoons into which flowed streams from the Peninsular area and the newly uplifted Himalayas. These streams brought down sediments which later came to be known as the Shiwalik deposits. The outlet of this foredeep was through the Rajmahal-Garo-Gap in the Bay of Bengal in the east and the Arabian Sea in the west. Later on, the lagoons got dried up and numerous transverse streams flowing from the Himalayan region formed what is now known the Himalayan drainage.

RIVER SYSTEMS OF THE HIMALAYAN DRAINAGE

The rivers originating from the Himalayan and Trans-Himalayan regions consist of three river systems, namely: (i) the Indus System, (ii) the Ganga System, and (iii) the Brahmaputra System (**Fig. 3.6**).

1. The Indus (Sindhu)

The Indus is one of the most important drainage systems of the subcontinent of India. It has a length of 2880 km, of which 709 km lies in India. The catchment area of the Indus is about 1,165,000 sq km, out of which about 321,284 sq km is in India.

The Indus is the westernmost river system in the Subcontinent. Jhelum, Chenab, Ravi, Beas, and Satluj are its main tributaries. The Indus originates from the Bokhar Chu (glacier) in northern slopes of Mt. Kailash (6714 m). It drains the largest number of glaciers and mountain slopes of the Karakoram,

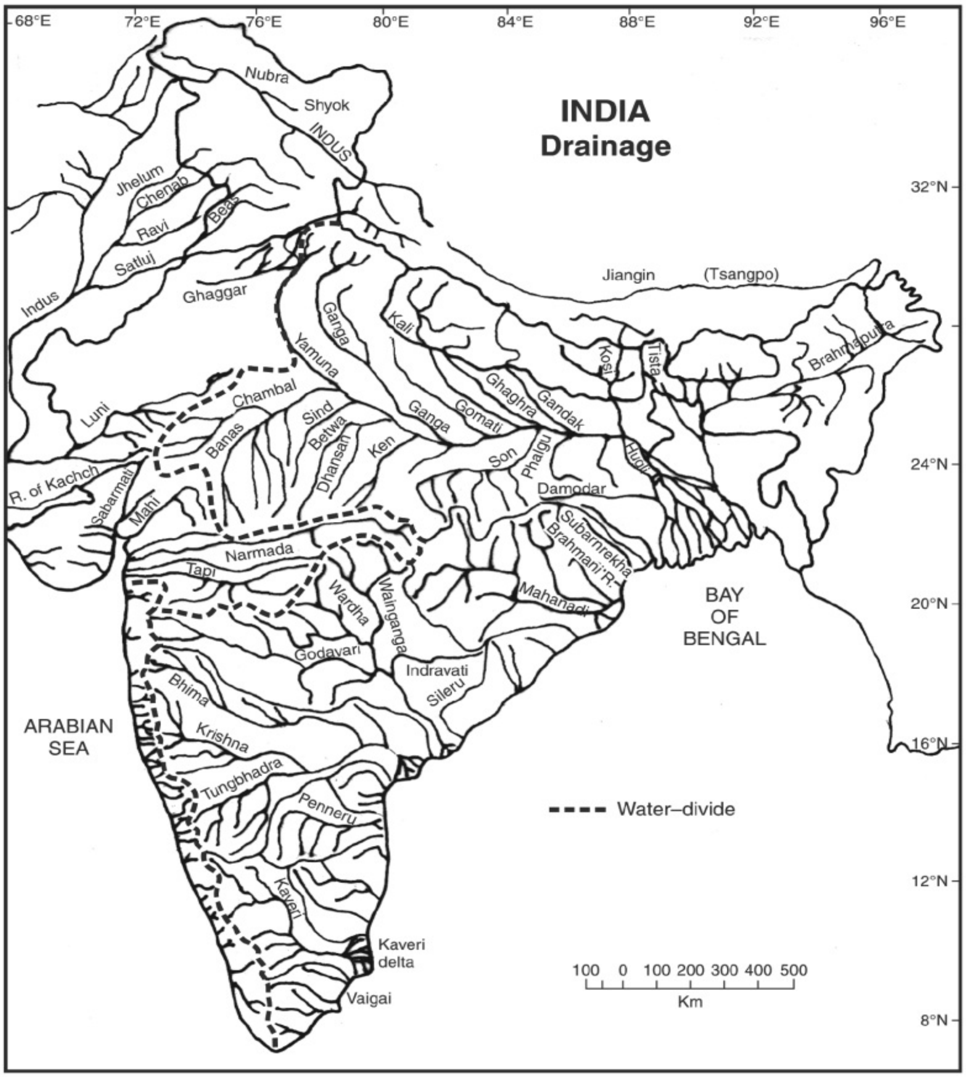


Fig. 3.6 River Systems of India

Ladakh, Zaskar, and Himalayan Ranges. Originating from the Kailash Mountain, it flows in a constricted valley north-westwards through Tibet (China), where it is called as Singi Khamban or Lion's mouth. In Ladakh, it follows a long, nearly straight course between the Ladakh Range and the Zaskar Range. In the first 480 kilometres, it flows along the northern flank of the Zaskar Range over a flat country at heights over 3200 metres where it receives river Zaskar below Leh. Suru and Dras are the other left bank tributaries which join the Indus near Kargil. Moving north-westward, the Indus is joined by the Shyok-Nubra tributaries. These tributaries arise from the Siachin Glacier (Karakoram Range). At Skardu, at a little distance below the Shyok, the Shigar river, which drains the northern slopes of

Mt. K^2, meets river Indus. In this region, River Indus is more wide than in Ladakh. The transverse glaciers and landslides periodically dam the river. The Gilgit is another important tributary which comes from the west to join Indus. Downwards, the Indus crosses the Central Himalayan Range through a huge synclinal gorge. The Indus makes saveral deep gorges. The deepest of all is at Gilgit, which is 5200 m in height above the level of the water at its bed. The river passes by the Nanga-Parbat and turns south-west to enter Pakistan.

The Jhelum (Vitasta)

The Jhelum rises from a spring at **Verinag** in the south-eastern part of the Vale of Kashmir. It flows north-westward for about 110 kilometres where it enters the Wular Lake. Further downstream from Baramula, it enters a gorge, 2130 metres deep, and moves towards Muzaffarabad (Pakistan). It joins the Chenab at Trimmu. Its gradient is gentle in the entire Vale of Kashmir and it is thus navigable between Anantnag and Baramulla. It is the most important river of Kashmir.

The Chenab (Asikni)

It flows in India for about 1180 km draining 26,755 sq km of area in India. The river Chenab is known as Chandra-Bhaga in Himachal Pradesh. The Chandra and Bhaga, the two main upper tributaries of the river, originate on either side of the Bara-Lacha Pass (4843 metres) in the Lahul District of Himachal Pradesh. Of these streams, Chandra originates from the glacier, while the Bhaga is precipitous downward, they make a confluence at Tandi. After uniting, the Chenab flows between the Pir-Panjal and the Greater Himalayas. Near Kishtwar, it makes a hair pin bend and flows across the Pir-Panjal at Riasi to enter into Pakistan. The important hydel projects installed across the Chenab are Salal, Baghliar and Dulhasti. The construction of the Baghliar Project in Doda District, financed by the World Bank, has been approved in Feb. 2007. The total dam height of the Baghliar Project will be 144.5 m. This project will cost Rs. 4500 crore and will produce 450 MW of power. The much delayed project (delayed by 15 years) promises to bring enough power to the state of Jammu and Kashmir.

The Ravi (Parushni or Iravati)

It flows for about 725 km and drains 5957 sq km area in India.The Ravi rises near the Rohtang Pass in Kullu, very close to the source of the Beas river. It drains the western slope of Pir-Panjal and the northern slope of Dhauladhar Range. Below the Chamba Town, it turns to the south-west, cuts a gorge in Dhaula Dhar Range and enters the plain of Punjab. In Punjab plains, it runs along the Indo-Pak boundary, along Gurdaspur and Amritsar districts, before entering into Pakistan.

The Beas (Vipasa or Argikiya)

The river Beas has its source at Beas Kund near the southern face of the Rohtang Pass in Kullu (4000 m), where it runs for a few kilometers and then cuts through the Dhauladhar Range in a deep gorge near Koti and Larji. Then it flows from north to south along Manali and Kullu towns, where the river has a transverse valley popularly known as Kullu Valley. Further down, it flows through Kangra Valley and then turns to the west to enter the Punjab Plain. It finally passes through Kapurthala and Amritsar and joins the Satluj near Harike (within India) after flowing for a total distance of 465 km.

The Satluj (Satadru or Satudri)

The Satluj river rises from the Rakas Lake (Rakas-Tal) which is situated at an altitutude of about 4600 metres near the Mansarovar Lake in Tibet (China). This is an antecedent river, called Langechen Khambab in Tibet. It makes gorges through the Zaskar and the Greater Himalayan Ranges. At the pass of Shipki La (4300 m), it enters Himachal Pradesh where it cuts through the Zaskar Range. From here the river flows westward and passes Kalpa, and then crosses Dhaula Dhar Range near Rampur through a narrow gorge. It passes through the Shiwalik, and at the gorge near Bhakra village, the Bhakra Dam has been constructed across the river. Below the Bhakra Dam, the river comes to the Punjab Plain at Rupar. From Rupar, Satluj River flows westward, and at Harike in the southwest corner of Kapurthala, it meets the Beas. After the confluence, the combined river enters Pakistan. In India, the length of its course is 1050 km, draining an area of about 28,090 sq km.

Ghaggar (the legendary Saraswati)

This is an inland drainage which rises in the talus fan of the Shiwaliks of Sirmur near Ambala (Haryana). After entering the plains, it disappears, but reappears at Karnal District (**Fig. 3.8**). Further on, the stream is called Hakra which gets lost near Hanumangarh in Bikaner. The considerably large size of this river bed, 5 to 8 kilometres wide, with the loamy soil in the river bed, led to the belief that in old times the Satluj flowed south through this Ghaggar-Harka river instead of flowing southwestward (in the form of a much bigger river known as river Saraswati in Vedic literature, probably 5000 BC or earlier). This river is traced further on as Eastern Nara which is, at present, an old channel of the Indus in Sind (Pakistan), and flows into the Rann of Kachch which was described as a ***deep fairly gulf*** at that time. At present, the entire area is practically a desert, and the Ghaggar-Hakra are practically ephemeral streams coming into flow only during the season of general rains.

2. The Ganga Basin (length 2510 km; area 861,404 sq km)

The Ganga basin is the largest river basin in India. It drains about one-fourth of the total area of the country. It is an international river as it passes through Bangladesh before merging into the Bay of Bengal (**Fig. 3.7**).

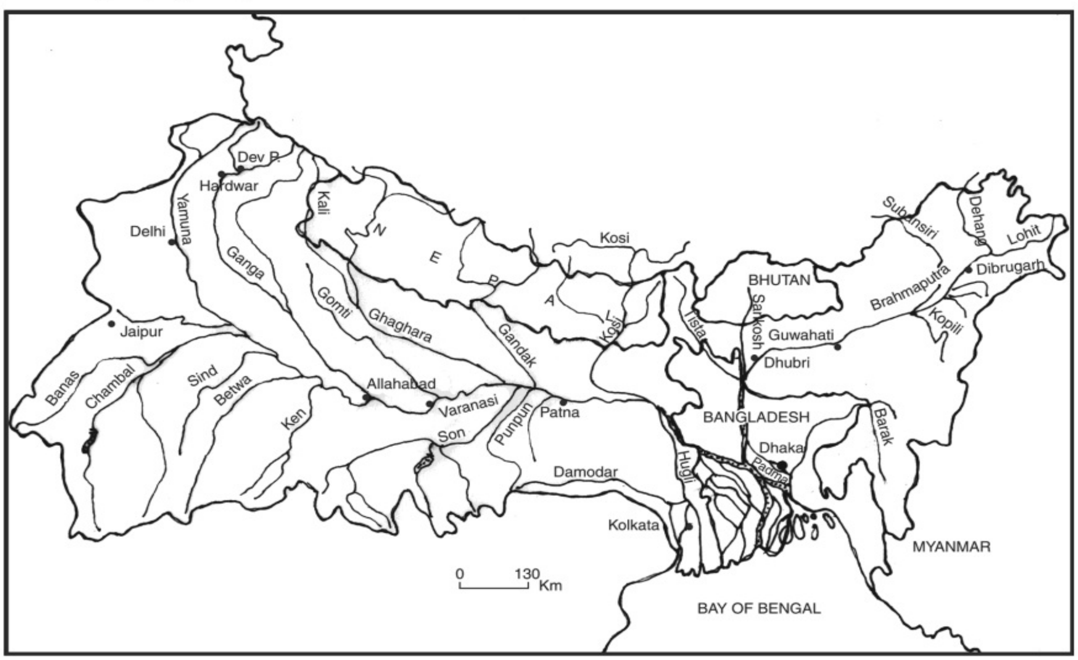


Fig. 3.7 Ganga–Brahmaputra Basins

The Ganga is the most important river of India. In the opinion of Nehru, "From her source to the sea, from old times to new, the Ganga is the story of India's Civilisation." In fact, the Ganga is virtually synonymous with Indian Civilisation. Beyond water's material uses, which are critical to life and development, Ganga water is associated with fertility, purity, and spiritual nourishment of the people.

The Ganga rises from the Gomukh Glacier (about 7000 m) near Mana Pass in Uttar Kashi District of Uttarakhand. This river is known as Bhagirathi, which cuts through the Greater Himalayas and the Lesser Himalayas in narrow gorges. At Devprayag, the Bhagirathi river meets Alaknanda river which has its source (7800 m) in the Satopanth Glacier to the north of Badrinath near Niti Pass. After the confluence of the Bhagirathi and Alaknanda at Devprayag, the river is called Ganga. Passing by Rishikesh, the Ganga debouches into the plains at Hardwar. From Hardwar, it turns towards the south-east upto Mirzapur in the Upper Gangetic Plains, and further down eastwards, in Bihar in the Middle Gangetic Plains. Near the Rajmahal Hills, it turns to the southeast below Farakka Barrage in Malda District of West Bengal. After the barrage, the river splits into two branches

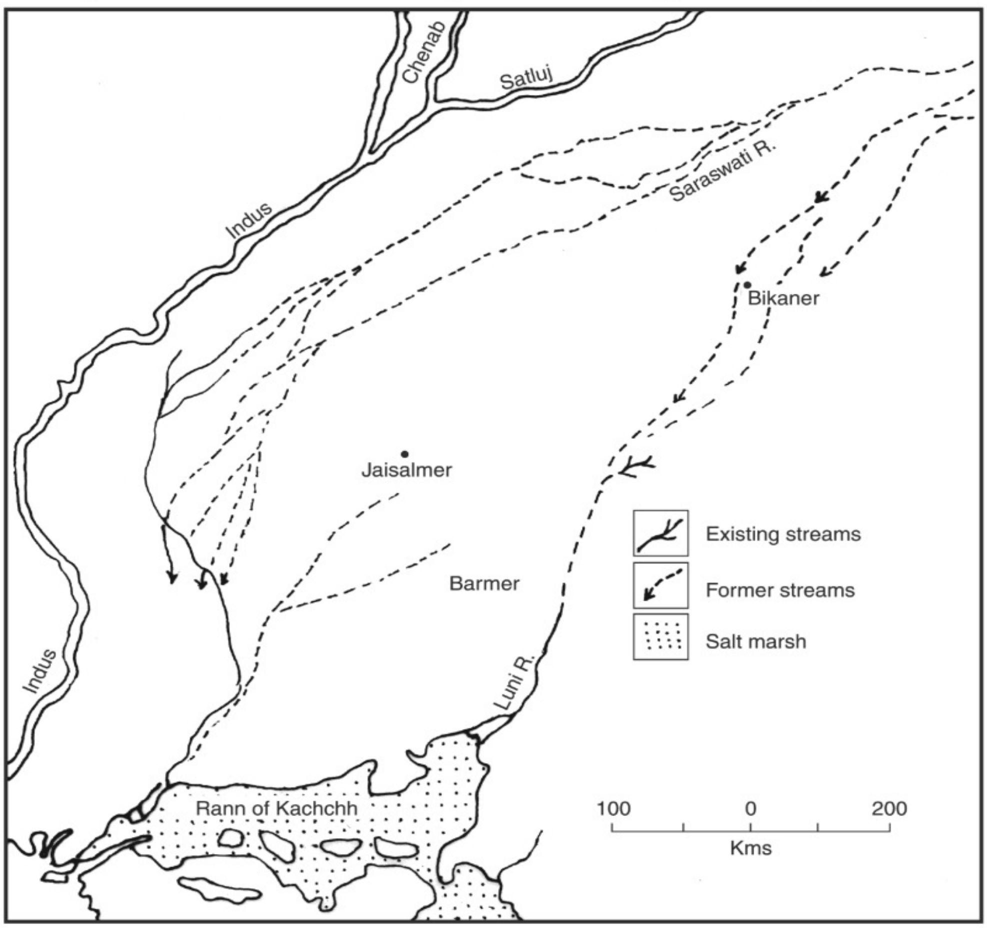


Fig. 3.8 Ghaggar

namely, the Bhagirathi-Hugli and the Padma. The Hugli flows through Kolkata, while the Padma enters Bangladesh. At present, the Hugli is the westernmost distributary in the Bengal delta. The Hugli is a tidal river on which the Kolkata port is situated. Further 121 km downstream, the Hugli river merges into the Bay of Bengal. The Bengal delta is the result of the filling-up of geological sag formed between the Rajmahal Hills and the Chotanagpur Plateau on the west, and the Plateau of Meghalaya in the east. This delta, known as the Sundarban Delta, stretches in West Bengal and Bangladesh. The Sundarban Delta is the result of the depositional action of the Ganga-Brahmaputra and the Meghna rivers.

This most important and sacred river of India is highly polluted and dying. Pollution, over-extraction of water, emaciated tributaries and climatic changes are killing the mighty river, on whose fertile plains live one in twelve people of the earth. The Ganga basin makes up almost a third of India's land area and its rich soil is home to millions of people.

However, indiscriminate extraction of water with modern tube-wells from the rivers as well as its basin, coupled with the damming of its tributaries for irrigation, have seriously reduced its flow. Climatic change has added to the threat. According to the WWF Programme Director, Sejal Worah: "Glaciers account for 30 to 40 per cent of water in the Ganga and this goes up to 70–80 per cent in the case of Indus. Studies are required to gauge the impact of melting glaciers on the flow."

Apart from humans, many other kinds of lives are in danger due to Ganga's degeneration. The river is home to more than 140 fish species, 90 amphibian species, and the endangered Ganga river dolphin. The Ganga is, of course, sacred to the people of India, besides having spawned many great cities on its banks. The maintenance of this sacred river is imperative from socio-cultural and ecological point of view.

The Yamuna River (length 1380 km.)

This is the longest and the western-most tributary of the Ganga. Its source lies in the Yamunotri Glacier on the western slopes of Banderpunch (6316 m). Downwards, it is joined by Tons river behind the Mussoorie Range (Uttarakhand). From the Mussoorie Range, it debouches into the plains where it flows in a broad curve. Making a boundary between Haryana and Uttar Pradesh, it passes Delhi, Mathura, Agra and flows southward until it joins the Ganga at Allahabad. The important tributaries of the Yamuna are mostly the right bank tributaries, originating from the Aravallis (Rajasthan), Vindhyan Range, and the Malwa Plateau of Madhya Pradesh. The Chambal, Sind, Betwa, Ken and Tons are the main righthand tributaries of the Yamuna River.

It is believed that during the Vedic period, the River Yamuna might have flowed towards south and southwest through Bikaner in Rajasthan, and shared its water with the legendary River Saraswati.

The Chambal (length 960 km)

The Chambal River rises near Mhow Cantt.—south-west of Indore in Malwa Plateau from the Vindhyan Range—and flows towards the north in a gorge upto the city of Kota. Below Kota, it turns to the north-east, and after passing Bundi, Sawai-Madhopur and Dholpur, it finally joins the Yamuna about 40 km to the west of Etawah. The Banas River, rising from the Aravalli Range is its main left bank tributary. Kali Sind and Parbati originating from the Malwa Plateau are the right bank tributaries of Chambal. The Chambal River is famous for its extensive ravines which it has carved all along in the Lower Chambal Valley. The ravines of the Chambal Basin are attributed to a slight uplift during the recent geological times, and they merge into the Yamuna alluvial plain where the landscape is extensively etched out by other tributaries of the Yamuna to the east and west of Chambal. Multipurpose projects have been constructed across the river. The main dams across the river are Gandhi Sagar, Rana Pratap Sagar (Rawatbhata) and Jawahar Sagar.

Chambal Ravines

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

The Ramganga

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

The Sharda

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

The Karnali

The Karnali is known as Kauriala in the Nepal Himalayas and as Ghagra in the Ganga Plain. The Karnali is an antecedent river originating from the Gurla Mandhata Peak (7720 m) of the Nepal Himalayas. Before making a gorge in the Greater Himalayas, the Karnali river traverses a 160 km long tract in the Trans-Himalayan region. This river cuts through the Mahabharata Range in the western part of Nepal through a deep gorge. In the Plains, it is joined by the Sharda river and acquires the name Ghagra meaning ***rattling*** or ***lahnga.*** Passing through Ayodhya and Faizabad towns, it joins River Ganga at Chapra near Ballia town. Ghagra is a large river with its vagaries of shifting course.

River Gandak

Draining the Central parts of Nepal, Gandak River rises in the Nepal Himalayas between Dhaulagiri and Mt. Everest. It enters the Great Plains of India in Champaran District of Bihar, and turning south-east, it joins the Ganga River at Sonpur opposite the city of Patna. This river also changes its course frequently.

The Kosi

The Kosi is also an antecedent river. It is often referred to as the '***Sorrow of Bihar'***. Arun is its main stream which originates from the northern slopes of Mt. Everest in Tibet (China). After piercing the Greater Himalayas in Nepal, it is joined by the Sun-Kosi from the west and the Tamur-Kosi from the east. Both these rivers run for a fairly long distance parallel to, and north of, the Mahabharata Range and join River Arun to form the *Sapt-Kosi.* This river cuts across the Mahabharata Range and the Shiwalik Hills, and emerges into the Bihar Plains near Chatra in Saharsa District. In Bihar Plains, it splits into numerous capricious channels. It is known that about 200 years ago, the Kosi used to flow by the side of Purnea town, but now by its westward migration it is about 160 km to the west of Purnea. In July, 2008, the Kosi River shifted its course towards east by more than 100 km. The devastating flood was declared as a national calamity. The Kosi river joins the Ganga River 30 km west of Manihari. It has however, been tamed since 1962 by the construction of embankments on its two banks.

The Tista

This is the westernmost right bank tributary of the Brahmaputra. Rising from Kanchenjunga, it is a wild mountain torrent in the Darjeeling Hills with a number of tributaries like the Rangpo, Rangit, and Sevak. Situated on its bank, the Jalpaiguri town, was completely swept away in the flood of 1968. At present, river Tista joins the Brahmaputra river in Bangladesh. It shifted its course substantially in the flash flood of 1787, prior to which it used to make a confluence with the Ganga.

The Mahananda River

This river rises in the Darjeeling Hills of West Bengal. Near Siliguri, it merges into the ***duars*** (Bhabhar) of West Bengal. Making sharp curves, it joins the Ganga river. This is the last north bank tributary of the Ganga.

Ken-River

Originating for the Malwa Plateau, Ken passes through Panna District (M.P), where it makes a gorge at Gangau. It joins the Yamuna river in Banda District of U.P. Sonar and Beawar are its main tributaries.

The Son (length 780 km, basin: 54,000 sq km)

This is a large south bank tributary of the Ganga River. It originates from the Amarkantak Plateau not far from the source of Narmada. It leaves the plateau in a series of waterfalls and meets the Kaimur Range which turns its course towards the north-east and allows it to follow a strike valley. Below Garwa, it enters the Ganga Plain, where it widens upto about 5 kilometres, and finally flows into the Ganga at Bankipora near Aara to the west of Patna. During the rainy season, the river often flows in spate with an annual peak discharge of about 750,000 cusecs in the rainy season, while in the dry season it has little water.

The Damodar River

The Damodar drains the eastern parts of the Chotanagpur Plateau. This river runs from west to east and, in the narrow bottleneck at Asansol, it emerges on the deltaic plains of Bengal. Barakar is the largest feeder of the Damodar river which meets the main river above Asansol. Below Bardhaman (Burdwan), the river makes a right-angled bend and meets the Hughli river at Falta to the north of Kolkata.

3. The Brahmaputra River

Originating from the glaciers lying to the east of the Mansarovar Lake, at an elevation of 5150 m, the Brahmaputra is known as the Tsangpo in Tibet. It pierces the Greater Himalayas (7755 m) near Namcha Barwa. It passes the Dihang-Gorge in Arunachal Pradesh. At Sadiya, the river comes down to 135 m above sea level.

In India, the river is known as Brahmaputra. The river flows to the west in Assam upto Dhubri (28 m), and further below, it takes a sharp southward bend to enter into Bangladesh.

The catchment area of the Brahmaputra receives heavy rainfall. Consequently, it has numerous tributaries on both of its banks in the 750 kilometre long Assam Valley. Most of the tributaries are large and pour large quantity of water and sediment into the Brahmaputra River. During the rainy season, the river oscillates from one bank to other for a width of 10 kilometres (on an average), and being turbulent with heavy loads of silt, the channel is heavily braided. There is a constant silt movement resulting in the instability of river regime, channel shifting and formation of sandy shoals. *Majuli,* the largest river island in Asia, lies in this river which is bounded by the Lakhimpur District in the north and the Jorhat District in the south. The Brahmaputra river basin is notorious for flooding and river bank erosion. The floods affect on average, an area of 100,000 hectares annually. The peak annual discharge at Pandu, near Guwahati, is more than 2.5 million cusecs (650,000 cumecs), while the low discharge is 120,000 cusecs (4210 cumecs). Below Pasighat, the river draws a number of tributaries such as Subansiri, Bhareli, Manas, Sankos, Tista and Raidak on its right bank, while the Dihang, Lohit, and Burhi Dihang are from the east, and Dhansiri, Kalang and Kapili are the left bank tributaries of the Brahmaputra.

Rangit River

Originating from Sikkim, Rangit river has a large number of rapids. This river is well known all over the world for rafting sports. Its banks provide good camping grounds.

The Sankosh

This is the main river of Bhutan. It meets Brahmaputra River below Dhubri.

The Manas

It is an antecedent river. Rising from Tibet, it pierces the Greater Himalayas in a gorge with river bed at 3000 metres. It collects a number of tributaries in the Lesser Himalayas and debouches into the plains to join the river Brahmaputra.

The Subansiri

This is a large tributary of the Brahmaputra River. It has a long course in the Himalayas and, after leaving the mountains, it has a long 160 km course in the Upper Assam Plain before joining the Brahmaputra. It separates the Miri Hills from the Abor Hills.

The Dhansiri

This river rises from the Naga Hills and after flowing for about 300 km through Nagaon, it joins the Brahmaputra River.

The Manipur River

It rises from the northern part of Manipur and flows southwards. On passing through Imphal, this river drains the Loktak Lake and joins the Chindwin Valley, a tributary of the River Irrawaddy in Myanmar (Burma).

Kaldan River

This river drains the southern parts of Manipur and Mizoram where it flows southward to the Bay of Bengal.

Barak River

This river rises from Mt. Japov (Nagaland), flows southwards in Manipur and makes a hair pin bend. Several of its affluents, which drain the northern part of Mizoram, combine together to flow past Silchar in the Cachar District. The Barak basin has Mawsynram and Cherrapunji which receive the highest rainfall in the world. Consequently, the Barak river discharges heavy quantity of water. It flows to Bangladesh where it is called as Surma. The Barak river meets the Padma at Chandpur below Dacca, after which the combined river of Surma (Barak) and Padma is known as Meghna.

MAIN RIVERS OF PENINSULAR INDIA

The main rivers of peninsular India have been described in the following section and shown in **Fig. 3.9**.

Luni River

The Luni River rises near Ajmer in the Aravalli Range and receives a few streams like the Bandi, Sukri and the Jawai only on its left bank. The streams which drain the western flank of the Aravalli Range south of Ajmer are seasonal. The Luni turns brackish below Balotra and loses itself southwestwards into the Rann of Kachchh.

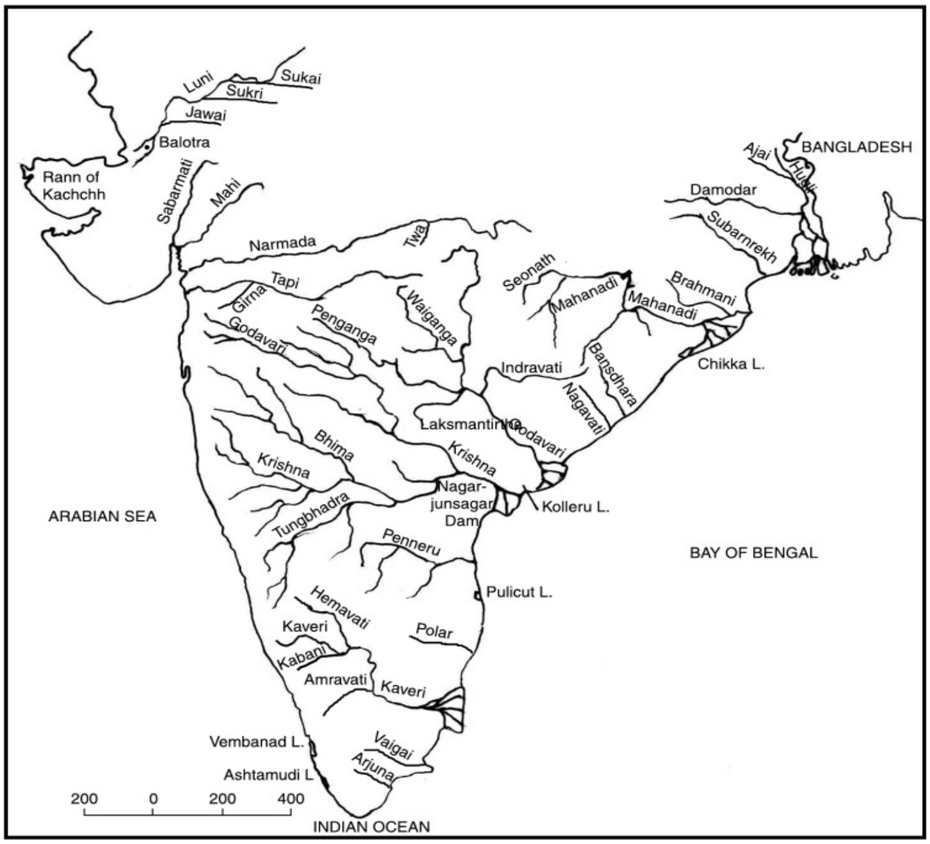


Fig. 3.9 Major Rivers of Peninsular India

Sabarmati

This river drains the southern slope of the Aravalli Range. It has a narrow long basin with an area of 21,700 sq km. Sabarmati receives its tributaries on its eastern flank and follows a nealy north-south course before merging into the Gulf of Khambat.

Mahi

The Mahi has its source in the Vindyan Hills of Madhya Pradesh. It flows southwest through the Banswara and Anand districts and finally, making an estuary, merges into the Gulf of Khambat.

Most of the rivers draining the west-facing scarp of the Western Ghats, particularly in the Konkan coastal belt, are short and swift-flowing over a humid tropical landscape at 100 to 280 metres above sea level along narrow to broad V-shaped valleys. These small streams have great erosive capacity. They display a parallel pattern of drainage, characterised by sharp bends, and fall into the Arabian Sea through estuaries. Some of the important streams draining the western slopes of the Western Ghats are Ulhas, Savitri, Vashist, Netravati, Periyar and Pambiyar. Some of these streams make waterfalls and rapids when they descend their steep gorges.

Sharavati

Sharavati rises in Shimoga district in Karnataka and creates the Garsopa Falls, the most spectacular waterfalls in India, commonly known as Jog Falls (271 m). The only break in the unbroken watershed of the Western Ghats face is the 13 km wide Palakkad Gap also known as Pal-Ghat. The river Ponnani flowing westward through this gap appears to be a misfit river.

Narmada (length 1300 km, drainage basin 98,800 sq km)

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

Tapi

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

EASTERLY RIVERS OF THE PENINSULAR REGION

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

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

The Subernrekha rises a little to the southwest of Ranchi where it has a number of waterfalls. In a general easterly direction, it passes through Jamshedpur and flows to the Bay of Bengal near Balasore. Its drainage basin is shared by the states of Jharkhand, Odisha and West Bengal.

The Brahmani (length 420 km)

The Brahmani river is formed by the confluence of the Koel and Sankh rivers. They join together at Rourkela and drain the western parts of the Garhjat Hills. Flowing through Bonai, Talcher and

Balsore districts, it merges into the Bay of Bengal above the Paradwip-port. With the Baitarani river to its north, a delta complex forms below Bhadrak.

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

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

The Godavari (length 1465 km, basin 312,800 sq km)

Godavari is the largest river of peninsular India. It rises in the Western Ghats from a spring below Nasik, drains eastern and southeastern Maharashtra, Bastar plateau (Chhattisgarh), and Telengana and Andhra regions of Andhra Pradesh. It receives a large number of tributaries, particularly on its left bank, such as Purna, Maner, Penganga, Pranhita (the combined Wardha and Wainganga), Indravati, Tal and Sabri. The Manjira is the only important right bank tributary. The Indravati and Sabri are the two streams which rise on the western slopes of the Eastern Ghats, but they flow east and southeastwards respectively. Below the confluence with Indravati, it flows in a picturesque gorge through the Eastern Ghats. Below Rajamundry, it has constructed a large symmetrical delta and reaches the Bay of Bengal by its three main ditributaries. The delta of Godavari is characterised by a number of palaeo-channels and mangroves associated with lagoons. The Kolleru Lake, lying to the southeast of Kakinada, is one such inland lagoon.

The Krishna (length 1290 km, basin 259,000 sq km)

The river of Krishna has its origin near Mahabaleshwar in the vertical faces of the Western Ghats. A number of minor streams like Koyna and Ghataparbha join the Krishna river to give a subdendritic pattern. The Bhima in the north and the Tungbhadra in the south are the other important tributaries of the Krishna river. Downwards passing through the quartzite scarps, the Krishna has been dammed to form the Nagarjun-Sagar Reservoir. Further east, beyond the gorge in the Srisailam Hills below Vijaiwada, it has built its fertile bird-foot delta (Mississippi-type).

The Pennar

The Pennar river rises in the Kolar District of the South Mysore Plateau. Its main tributaries are Chitravati and Papaghni. It flows through a gorge of Cuddapah quartzite and enters the Bay of Bengal in the form of an estuary.

The Kaveri (length 765 km, basin 87,900 sq km)

The Kaveri is a sacred river like the Ganga. Hence, it is called the Ganga of South India. It rises from the southern part of Mysore Plateau as a rocky mountain stream forming rapids, cataracts and waterfalls. Its drainage basin receives rainfall during the summer monsoon as well as during the retreating and winter monsoon. Only 20 km above Mysore, it has been dammed to form the

Krishnasagar Reservoir. It passes through the islands of Srinagapatnam and Sivasamudram. The channel around the Sivasamudram makes a succession of rapids which were harnessed to develop hydel-power in 1902. Below the island, Kaveri River plunges through a succession of beautiful gorges with hair pin bends. This scenic landscape, known as the Hagenakal Fall, may be taken as the end of the plateau course of the river. There is however, another narrow gorge in the Nilgiri Hills to the east of Dodabetta Peak (2636 m) which is drained by the Bhavani and its tributary, the Moyar, which provides the site for the Mettur Dam. Draining the Coimbatore basin, the Kaveri enters the plains after its confluence with the Bhavani. A few kilometers above Tiruchirappalli, the river fans out forming a quadrant-delta in Thajavur District of Tamil Nadu.

Amravathi River

Amravathi river is a tributary of the Kaveri river in Coimbatore District of Tamil Nadu. Having its origin at the Kerala-Tamil Nadu border, it is 175 km in length. It joins with the Kaveri in Karur District. It irrigates over 60,000 acres of land in Coimbatore. Due to the heavy industrialisation in its basin, the river is highly polluted.

The Tambraparni

This is a river of Tiruneveli District. It rises on the slopes of the Palni Hills of the Western Ghats and passes Madurai to flow into the Gulf of Mannar through the Ramanathapuram Peninsula.

RIVER REGIMES

The pattern of the seasonal flow of water in a river is called its regime. The main difference in the flow pattern of the Himalayan and the Peninsular rivers is caused by the differences in climate. The Himalayan rivers are perennial and their regimes are dependent on the pattern of water supply both from snow-melt and rainfall. Their regimes are monsoonal as well as glacial. The regime of most of the peninsular rivers, on the other hand, are only monsoonal as they are controlled by rainfall alone. Even regimes of different peninsular rivers are not the same because of the differences in the seasonal distribution of rainfall in various parts of the plateau **(Fig. 3.10)**

The discharge is the volume of water flowing in a river measured over time. It is measured either in cusecs (cubic feet per second) or cumecs (cubic metres per second). The Ganga has its minimum flow during the period of January to June. The maximum flow of water in the Ganga occurs either in July or August. After September, there is a steady fall in the flow of Ganga. The river thus has a typical monsoonal regime. There are striking differences in the river regimes in the eastern and western parts of the Ganga basin. The Ganga maintains a sizable flow in the early parts of summer before the monsoon rains begin. This is largely due to the water supply from the Himalayan snow-melt. The discharge data, however, do not include the volume of water diverted for irrigational purposes at different points before the Farakka Barrage (Malda, West Bengal). The mean maximum discharge of the Ganga at Farakka is about 55,000 cusecs, while the mean minimum is only 1300 cusecs.

The two peninsular rivers display an interesting difference in their regime as compared to the Himalayan rivers. The Narmada has a very low volume of discharge from January to July. It suddenly rises in August when the maximum discharge is attained. The fall in October is as spectacular as the rise in August. The Godavari flows at a low level until May. It has the minimum discharge in

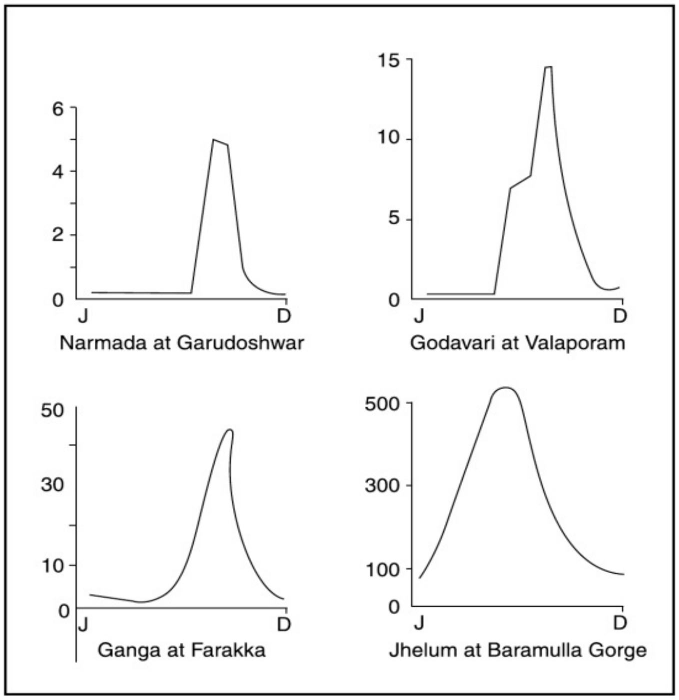


Fig. 3.10 River Regimes

May and the maximum in July–August. After August there is a sharp fall in water flow, although the volume of flow in October and November is higher than that in any of the months from January to May. The mean maximum discharge of Godavari at Valaporam is 3200 cusecs. These figures give an idea of the regime of the river. The flow of water in the Narmada, as recorded at Gurudeshwar, shows that the maximum flow is of the order of 2300 cusecs, while minimum flow is only 15 cusecs.

The data on water discharge in different rivers in different parts of the year have important implications to their utilization by states. It is on this count that inter-state disputes arise.

Table 3.2 *Major Rivers of Peninsular India*

River	*Source*	*Length in km*	*Main tributaries*
1. Godavari	Trimbak Plateau Near Nasik (Maharashtra)	1465	Manjra, Penganga, Wardha Wainganga, Indravati, Sabari, Pranhita
2. Krishna	Near Mahabaleshwar (Maharashtra)	1400	Koyna, Ghataprabha, Malprabha, Bhima, Tungbhadra, Musi, Muneru
3. Narmada	Amarkantak	1310	Hiran, Orsang, Barna, Kolar, Burhnar, Tawa, Kundi

(*Contd.*)

(*Contd.*)

4. Mahanadi	Dandakaranya Plateau near Raipur	857	Ib, Mand, Hasdeo, Seonath, Ong, Jonk, Tel
5. Kaveri	Taal Kaveri	800	Herangi, Hemavati, Lokpavni, Shimsa, Arkavati, Kabani,Bhavani, Amravathi
6. Tapi	Multai in Betul Distt. (M.P.)	730	Purna, Betul, Patki, Ganjal, Dhatranj, Bokad, Amravati

Comparison of the Peninsular and the Extra-Peninsular Rivers

Peninsular Rivers	*Extra-Peninsular Rivers*
1. The rivers of Peninsular India are much older. Some of them are as old as the Pre-Cambrian Period.	1. The rivers of the Extra-Peninsular India are much younger, excepting a few antecedent rivers like Indus, Satluj, Ganga, Brahmaputra, etc.
2. They are mostly consequent or rejuvenated rivers.	2. Many of them like Indus, Satluj, Kali, Kosi, Brahmaputra, Tista are inconsequent rivers.
3. These rivers, except Godavari, have relatively small basins.	3. These rivers generally have large basins.
4. The channels of these rivers are broad.	4. The channels of these rivers in the upper courses form gorges waterfalls, and rapids.
5. There is hardly any vertical erosion.	5. Both vertical and lateral erosions are significant.
6. These are slow moving.	6. These are both swift and have sluggish movements.
7. These have low carrying capacity.	7. They transport huge quantities of sediments.
8. These are mainly depositional agents.	8. These are active erosional and depositional agents.
9. They make shallow meanders.	9. In the plains, they make numerous sharp meanders and ox-bow lakes.
10. These are generally not navigable.	10. Most of them are navigable in the plains.
11. These are mostly seasonal.	11. These are perennial.
12. Most of them originate from the Western Ghats and plateaux.	12. Most of them originate from the Himalayan Glaciers.
13. Most of them are in the senile stage.	13. Most of them are in the late youth stage.
14. There is no river capturing.	14. River capturing is a common phenomenon.
15. These rivers have been harnessed for the generation of hydel-power, e.g. Hirakund, Koyna, Nagarjunasagar.	15. There are numerous multipurpose projects on these rivers, e.g. Bhakra, Tehri, Salal, etc.
16. These rivers make deltas (Godavari, Krishna, Kaveri) and estuaries like Narmada and Tapi.	16. These rivers make only deltas. The Sundarban Delta is the largest in the world.
17. Their channels are near the base level.	17. These rivers are in the ending part of youth stage. In their mountainous course they do river capturing.

SHIFTING COURSES OF THE RIVERS

An interesting phenomenon of most of the Extra-Peninsular rivers and that of the Peninsular have shifting courses, especially in their lower reaches. In the upper reaches, the Himalayan rivers have the tendencies of river capturing. River capturing is mainly caused by the headward erosion of the river. In the plain areas, generally, the rivers form meanders in their courses. During floods, due to increased quantity of water, the streams try to straigthen their courses. Earth movements do have their role in affecting these processes. Some of the important river captures are as under:

The ancient Saraswati River, which provided an abode for early Aryan settlers, presents a typical example of shifting courses and river capturing. Descending from the Himalayan ranges, its initial course during the pre-historic period was passing near Churu (about 2000 to 3000 BC), and the Luni river was one of its tributaries. It gradually shifted towards west till it joined the Satluj near Ahmadpur. Later on, the water of its upper course was captured by a tributary of the Ganga River as a result of which its lower course became dry. This gave birth to Yamuna River, an important tributary of the Ganga System. Even today the dry valley of the Saraswati River is found in Rajasthan area in the form of Ghaggar valley. Similar shifting has also been observed in the rivers of the Punjab during the historical past. The records of the third century BC show that the Indus flowed more than 130 km east of its present course, through the now practically dry beds of the deserted channel, to the Rann of Kachchh which was then a gulf of the Arabian Sea. Later on, it gradually shifted towards the west and occupied its present position. During the reign of Akbar the Great, the Chenab and Jhelum rivers joined the Indus near Uch (Pakistan), but their present confluence lies near Mithankot about 100 km downstream of the old place of confluence. Similarly, Multan was formerly located along the Ravi River, but today it is situated about 60 km south of its confluence with the Chenab. About 250 years ago the Beas river changed its old course, traces of which are still found between Montgomery and Multan, and joined the Satluj river near Sultanpur. In the early part of the Christian Era the Satluj had more easterly course and independently discharged its water into the Arabian Sea.

About 250 years ago, the Brahmaputra flowing through Mymensingh was discharging its waters into the Meghna River. In due course of time, it straightened its course and joined the Ganga (Padma) River forming a new stream called Jamuna in Rangpur and Jamalpur districts of Banglasesh. A feeble channel of the Brahmaputra is still flowing along the same old course and retains the old name. This change in the course was associated with 30 m rise in Madhopur forest area between 1720–1830 AD Even the entry of the Brahmaputra to the plains of Assam is also the outcome of the process of river capturing. According to geologists, during early days, the Tsangpo river of Tibet taking an easterly course used to join the Irrawaddy River (Myanmar) through the Chindwin, which was then a large river, transporting huge quantity of water. Later on, a small river flowing along the southern slopes of the Himalayas through its headward erosion captured the water of the Tsangpo River and, thus, helped in the evolution of the stream of Brahmaputra.

Similarly, Kapili, a tributary of the Brahmaputra, has captured the waters of the Meghna river of Bangladesh. In old days, the Meghna originated from the Brail Ranges (between Meghalaya and Manipur) and flowing southward, emptied its waters in the eastern part of the Bay of Bengal. But Kapili, through headward erosion, captured its northern course. The Lumding-Halflong Pass is an evidence of this abandoned valley. In a similar way, the Dhansiri River capturing the water of a tributary, Kapili River has helped in the formation of a new river called Jumuna (Assam).

There can be numerous causes responsible for the shifting of river courses. These include the shifting gentle slope of the Great Plains of India, meandering courses of the rivers, straightening of the river courses during floods, upliftment of the Potwar Plateau (Delhi-Sirhind Plateau), downwarping of the Malda Gap, rise in the Madhopur forest area and uplift of the Barind area.

TYPES OF LAKES

A lake is a natural depression filled with water. In this period of population explosion and scarcity of water, lakes are an important source of water supply to humanity. They also help in the prevention of sudden floods and droughts. The lakes of India have different origins. Some of the important lakes of India have been described briefly in the following section**:**

1. The Tectonic Lakes

These are formed due to the fractures and faults in the earth's crust. Most of the lakes in the hilly areas of Kashmir and Kumaun belong to this type of lakes. The Tso Moriri, and Pangong Tso (Ladakh) are some of the examples of such lakes.

2. The Crater Lakes

Crater lakes are formed when the craters and calderas are filled with water. They are very few in number in India. The Lonar Lake of Buldhana (Maharashtra) is one of the examples of crater lakes.

3. Glacial Lakes (Tarns)

These lakes are the result of glacial erosion. *Tarn* is a small mountain lake, especially one that collects in a cirque basin behind rises of rock material. Most of the glacial lakes in India are small in size. The Gangabal lake of Kashmir, located in the Greater Himalayas of Kashmir, is one such examples. Glacial lakes are also found in Ladakh (J&K), Himachal Pradesh and Kumaun region of Uttarakhand.

4. Fluvial Lakes

Rivers form different types of lakes through their erosional and depositional work. In general, rivers are the destroyers of lakes. In fact, lakes are often obliterated due to filling of sediments and headward erosion by rivers. Fluvially originated lakes are generally temporary and are soon obliterated. Fluviaslly originated lakes include plunge-pool lakes (in front of a waterfall), ox-bow-lakes, alluvial fan lakes, delta lakes, flood plain lakes and raft-dammed lakes. All these lakes may be observed in the upper, middle and lower courses of the Ganga and the Brahmaputra rivers. Lakes formed to the meandering of rivers in the plains of gentle gradient are known as alluvial lakes. The ox-bow lakes found in the Middle and Lower Ganga Plains are some such examples.

5. Aeolian Lakes

These are small temporary hollows or depressions lying on the wind blown sand surface. Western Rajasthan has several lakes of this type. The desert lakes generally have a larger proportion of salt content and are often been called salt lakes. The Dhands of western Rajasthan are some of such examples.

6. Dissolution Lakes

These lakes are formed due to a depression of the surface by underground dissolution of soluble rocks like limestone and gypsum. Such lakes are found in and around Cherrapunji, Shillong (Meghalaya), Bhimtal (Kumaun), and Garhwal (Uttarakhand).

7. Lagoons

These are formed by deposition of sandbars along the sea coast. The Lake Chilka of Odisha; Pulicat (Andhra Pradesh); Vembanad, Asthamudi, and Kayals of Kerala are some of the examples of lagoons.

8. Landslide Lakes

These lakes are produced by landslides and rock-falls causing obstruction in the course of streams. The Gohna Lake of Garhwal was formed due to a huge landslip across a tributary of the Ganga.

MAIN LAKES OF INDIA

Ashtamudi Lake (Astamudi Kayal)

It is a lagoon in the Kollam district of Kerala. Ashtamudi means 'eight branches'. In fact, this is a lake with multiple branches. It has been registered as a wetland of international importance under the Ramsar Convention.

Bhimtal

Situated near the town of Bhimtal in Kumaun Divison of Uttarakhand, it is a fascinating lake with an island in the centre. The Bhimtal town, though ancient, was never prominent because of the greater popularity of Nainital. At present, it attracts a large number of the domestic and international tourists.

Bhoj Wetland

Located in the city of Bhopal (capital of Madhya Pradesh), it consists of two lakes, namely the Upper Lake and the Lower Lake. Being in the vicinity of the capital city, it is one of the highly polluted lakes of India.

Chandra Tal

It is a high altitude lake in Lahaul and Spiti district of Himachal Pradesh. It is about 4300 m above sea level. The Kunzam Pass, which connects Lahaul and Spiti, is only about 6 km from this lake.

Chembarambakkam Lake

It is located in the Chengalpattu district of Tamil Nadu, about 40 km south of Chennai. The Adyar River originates from this lake. A part of the water supply of the Chennai metropolis is drawn from this lake.

Chilka Lake (Chilika Lake)

Situated in the state of Odisha, it is a brackish water coastal lake. It is the largest coastal lake in India. The lake was formed due to the silting action of the Mahanadi River which drains into the northern end of the lake. The area of the lake varies from 1175 sq km in the monsoon season to 900 sq km in the dry season.

Dal Lake

Dal is a famous lake in Srinagar. Stretching over an area of 18 sq km, it is divided by causeways into four basins; namely, Gagribal, Lokut Dal, Bod Dal and Nagin. It is well known for approximately five hundred houseboats. Apart from houseboats, the lake provides a good opportunity to the tourists for canoeing, water-surfing and kayaking. Being highly polluted, the lake is shrinking at a faster pace. The lake has some interesting flora like lotus flowers and water lilies and water-chestnut.

Dhebar Lake (Jaisamand)

Situated in the state of Rajasthan, about 45 km to the east of Udaipur, it is the largest artificial lake of India. It stretches over an area of about 87 sq km. It was built in the 17^{th} century when Rana Jai Singh of Udaipur built a marble dam across the Gomati River. This lake has three islands; the Jaisamand Resort is located on the biggest island.

Himayat Sagar

Located at a distance of 20 km from the city of Hyderabad, it was named after the youngest son of the seventh Nizam, Himayat Ali Khan. It is an artificial lake constructed across the Musi river in 1927.

Hussain Sagar

Hussain Sagar is in the city of Hyderabad. It was built across a tributary of the Musi River by Hussain Shah Wali in 1562. Its water is supplied to the city of Hyderabad.

Kaliveli Lake

It is a coastal lake in the district of Viluppuram in Tamil Nadu. It lies about 10 km to the north of Pondicherry. The lake is one of the largest wetlands in the peninsular India. It is being encroached by agricultural fields. Its area is shrinking fast.

Khajjiar Lake

Located in the Chamba district of Himachal Pradesh, it is only 24 kms from the important hill station of Dalhousie. Surrounded by the giant deodar trees, it presents a panoramic view for the tourists.

Khecheopalri Lake

It lies in West Sikkim. It is considered a holy lake, both by the Buddhists and the Hindus. The lake is surrounded by thick forests of bamboo. The placid waters of the lake are visited by many pilgrims and tourists.

Kolleru Lake

Situated in Andhra Pradesh, it is the largest fresh water lake of India. It is located between the deltas of the Krishna and Godavari rivers in the Krishna and Godavari districts. The lake serves as a natural flood-balancing reservoir for the two rivers. The lake was an important habitat for an estimated 20 million residents and migratory birds Grey or Spot-billed pelicans. Rich in flora and fauna, it attracts birds from Siberia and eastern Europe between the months of October and March.

The lake was notified as a wildlife sanctuary in 1999 under India's Wild Life Protection Act. It was declared a wetland of international importance in 2002 under Ramsar convention. Increasing pollution has reduced the bio-diversity in the lake.

Loktak Lake

It is the largest fresh water lake in north-east India. It is also called the only 'Floating Islands Lake' in the world due to the floating Phundis (floating islands) on it. It was designated a wetland of inter- national importance under Ramsar Convention in 1990. It serves as a source of water for hydro-power generation, irrigation and drinking. The lake is also a source of livelihood for the rural fishermen who live in the surrounding areas and on Phundis (floating islands), which are actually heterogeneous mass of vegetation, soil and organic matter.

Nako Lake

Situated in the district of Kinnaur (Himachal Pradesh), it is a high altitude lake. This lake is surrounded by willow and poplar trees. Near the lake there are four Buddhist temples. It is considered a sacred lake.

Osman Sagar

It is an artificial lake in Hyderabad. It was created by damming the Musi River in 1920 by the last Nizam of Hyderabad (Osman Ali Khan) for providing a drinking water source to Hyderabad. A guest house called 'Sagar Mahal' overlooking the lake, now a heritage building, was the summer resort of the erstwhile Nizam.

Pongong Tso

Situated in Ladakh, this lake lies at a distance of five hours from the city of Leh. The road traverses the third highest pass in the world; the Changla Pass. A special permit is required to visit the lake. For security reasons, no boating is allowed. There is a small hotel and campsite, and houses with primitive guestrooms in the village.

Pulicat Lake

It is the second largest brackish water lake on the Coromandal Coast. It lies on the border of Andhra Pradesh and Tamil Nadu. The barrier island of Sriharikota separates the lake from the Bay of Bengal. The lake is 60 km long and varies 0.5 to 18 km in width. It is the habitat of numerous local and migratory birds. Nearly 15,000 flamingos visit the lake every year, along with pelicans, kingfishers, herons, painted storks, spoonbills and ducks.

Pushkar Lake

Situated in the district of Ajmer, it is an artificial lake. The lake was created in the 12^{th} century when a dam was built across the headwaters of the Luni River. Thousands of pilgrims come to bathe in the waters of the lake during the festival of Kartika Poornima in November.

Renuka Lake

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

Roopkund

Situated in Uttarakhand, it is a lake around which 600 skeletons were found at the edge of the lake. The location is uninhabited and is located at an altitude of about 5030 m. The skeletons were discovered in 1942. Radio-carbon dating suggest that these people died in an epidemic.

Sambhar Lake

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

Sasthamkotta Lake

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

Satta or Sat Tal

It is the calm, quiet group of seven lakes near Bhimtal town of the Kumaun Division of Uttarakhand. These lakes are situated at an altitude of 1370 m above mean sea level. These lakes are a paradise for migratory birds.

Suraj Tal

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

Tawa Reservoir

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

Tsongmo Lake

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

Veeranam Lake

It is located in Cuddalore District of Tamil Nadu, about 235 km from Chennai. It is one of the water reservoirs from where water is supplied to Chennai.

Vembanad Lake (Vembanad Kayal or Vembanad Kol)

Covering an area of about 200 sq km, it is the largest lake in Kerala. The lake lies at sea level, and is separated from the Arabian Sea by a narrow barrier island. Several rivers flow into the lake including the Pamba and Periyar. The lake surrounds the islands of Pallipuram and Perumbalam.

Veeranpuzha Lake

Located in Kochi, it is the northern extension of Vembanad Lake. It attracts a large number of tourists from different parts of the country and abroad.

Vembanattu Lake

About 16 km from Kottayam is a vast network of rivers and canals forming Vembanattu Lake. An enchanting picnic spot and a fast developing back water tourism spot providing boating, fishing and sightseeing experiences that are truly exhilarating. Kumarakom Bird sanctuary is on the banks of Vembanattu Lake.

Wular Lake

Situated in the Valley of Kashmir between Sopore and Bandipore, it is the largest fresh water lake in India. The lake was formed as a result of tectonic activity during the Pleistocene Period. Depending on the season, the size of the lake varies between 30 and 250 kilometres. The River Jhelum feeds the lake, which acts as a natural reservoir. The Tulbul Project is a 'navigation lock-cum-control structure' at the mouth of the Wular lake. It envisages regulated water release from the natural storage in the lake to maintain a minimum draught of 4.5 feet in the river up to Baramulla during the lean winter months.

WATER RESOURCES OF INDIA

Water is a primary natural resource, a basic human need and a precious national asset. Water is critical to our daily lives and a principal compound in nature. A human can survive 50 to 60 days without food, but only 2 or 3 days without water. The water we use must be adequate in quantity as well as quality for its many tasks—everything from personal hygiene to vast national water projects. Water indeed occupies that place between land and sky, mediating energy and shaping both, the lithosphere and atmosphere. The significane of water is increasing with the tremendous increase in population. We need water for drinking, personal hygiene, domestic consumption, irrigation, industrial purposes, generation of hydel-power, transport and recreation.

The average annual water availability of the country is assessed at 1869 billion cubic metres (BCM). Of this, total utilisable water resource is assessed at 1123 BCM; surface water 690 BCM and ground water 433 BCM. The per capita availability of water at the national level has been reduced from about 5177 cubic metres in 1951 to the estimated level of cubic metres in 2012 with variation in water availability in different river basins.

There are two main sources of water, i.e. (i) the surface water, and (ii) the underground water. According to Prof. K.L. Rao (1975), the total quantity of water annually carried by the rivers of the country is about 1,645,000 million cu m. The utilisation of water as estimated by Rao is given in **Table 3.3.**

Table 3.3 *India's Water Utilisation by 2000 (in thousand million cubic metres)*

Sector	*per cent use*	*water used*	*water consumed*	*water reused*
1. Agriculture				
(a) Irrigation	77.0	860	774	86
(b) Livestock	1.0	9	9	—
2. Power	13.0	150	5	145
3. Industries	3.0	35	10	25
4. Municipal/Rural (domestic consumption)	6.0	62	31	31

Source: Rao, K.L. (1975)***: India's Water Wealth.***

It may be noted from Table 3.3 that about 77 per cent of the available water is used for irrigation purposes, 13 per cent for power generation, 3 per cent for industries and the remaining 6 per cent for domestic consumption.

According to one estimate the total ground water reserve up to a depth of 300 m is about 3700 mham, almost ten times of the annual rainfall. In terms of exploitation of ground water potential, Punjab comes on top (about 94%) followed by Haryana (84%), Tamil Nadu (61%), Rajasthan (51%), Gujarat (42%), Uttar Pradesh (38%), Maharashtra (31%), West Bengal (25%), and Andhra Pradesh (24%). States like Assam, Odisha, Madhya Pradesh, and Bihar have not been able to utilise even 20 per cent of their total ground water potential.

The main problems associated with the utilisation of water are: (a) high fluctuations in the regimes of rivers, (b) uneven spatial distribution of precipitation, (c) wastage of water during floods, (d) unscientific utilisation of water, (e) pollution of rivers, and (f) dispute on water distribution among the states.

India's rivers are highly polluted. The rapid growth of population, agricultural modernization, industrialization and urbanization have reduced the per capita availability of water. The pollution of rivers, lakes and ponds have aggrevated the situations.

Water Harvesting in India

Water is a prime national resource, a basic human need and a precious asset. The U.N. report published in 2003 at the time of the Third World Water Forum in Kyoto says that water reserves are drying up fast, and booming population, and global warming will combine to cut the average person's supply by a third by 2020. The report also ranked 122 countries on the quality of their water provision. India was placed at the bottom of the list.

The agricultural output depends on monsoon as nearly 60 per cent of the area sown is dependent on rainfall. In the areas of rain-fed agriculture, watershed harvesting has great economic and ecological significance. The greater parts of Rajasthan, Gujarat, parts of Haryana, Punjab and Uttar Pradesh, western Madhya Pradesh, eastern Maharashtra, northern Andhra Pradesh, western Karnataka, parts of Tamil Nadu, Odisha, Jharkhand, and Chhattisgarh frequently suffer from droughts. These regions face two critical issues:

(i) They have severe droughts in summer with an acute scarcity of water and a declining water-table, resulting in the loss of crop productivity for major and minor crops.

(ii) Heavy and intensive rainfall and surface run-off leads to soil erosion and sedimentation in the lower courses of the rivers, resulting in the formation of ravines and gulleys across the region.

These are the areas which are economically poor, struggling around the vicious cycle of underdevelopment. These areas require appraisal of land and soil resources based on micro watersheds (within an area of 10 to 1000 hectares), and macro watersheds (area over 1000 hectares) to draw plans for *in-situ* water harvesting and conservation through conjunctive uses, and thus monitor the development mode in a harmonised manner. The entire watershed management involves innovation in group decisions followed by action involving joint decisions. Thus, starting with a watershed (which is a manageable hydrological unit) as a land unit, it takes up water as the most important resource for development. It aims at containing the deterioration of land and its approach to development is not confined just to agricultural land alone, but covers the watershed area, starting from the highest point of the area to the outlet or the natural drainage line. This involves the implementation of ameliorative measures for barren hill slopes, marginal lands, agricultural lands, gullies and ravines.

Optimal sustainable development can occur only with the maintenance of quality and efficient use of the country's water resources to match the growing demands on this precious natural resource with the active involvement of all in order to achieve accelerated, equitable economic development of the country.

It is rightly said that water resources hold the key to the socio-economic development of any country, and India is not an exception to this. It is a fact that water, a fragile and finite resource, is fast becoming scarce day by day. A recent study by the world bank indicates that per capita availability of water in India, which was to the order of 5000 cubic metres per year at the time of independence, has drastically come down to 2000 cubic metre per year at present. The average annual rainfall of 110 cm in the country, though fairly high, is marked by wide variations, both spatial and temporal. About 67 per cent of the water resources are reported to be available in the Indo-Gangetic alluvial basins covering 33 per cent of the geographical area of the country, as against 33 per cent of the potential in the hard rock regions, occupying 67 per cent of the geographical area. Looking at the existing scenario of water availability in the country, there is an urgent need for propagating water harvestring and transforming it into a mass movement. With regard to the water resource, the main challenges that need to be addressed are:

(a) ground water depletion, (b) water quality deterioration, (c) low water use efficiency, (d) expensive new water resources, (e) resource degradation, (f) development of new water resources (g) reformed price incentives, (h) appropriate technology, (i) tradable water rights, and (j) international cooperation.

Rain-water Harvesting

Rainwater is biologically pure, soft in nature and free from organic matter. Rainwater harvesting is an effective technique of conserving water by guiding the rainwater that falls on rooftops to storage tanks or underground pumps for future usage. Groundwater recharging, on the other hand, is undertaken by guiding water through pipes to wells, bore wells or recharge pits to ensure recharging water in the underground aquifers, for later use, whenever the need arises. Tamil Nadu is the first and only state in India which has made roof-top rain-water harvesting structure compulsory to all the houses across the state. There are legal provisions to punish the defaulters.

The collection of water from a catchment surface is referred to as rainwater harvesting. Water harvesting also includes activities aimed at harvesting surface and groundwater and other techniques aimed at conservation and efficient utilisation of limited water endowment. In general, water harvesting is the activity of direct collection of rainwater. The collected water can be stored for direct use or can be used to recharge the groundwater.

The quantum of harvested rainwater depends on:

1. Frequency, duration and intensity of rainfall.
2. Nature of catchment.
3. Run-off characteristics.

Merits of Rainwater Harvesting

Following are the main advantages of rainwater harvesting:

1. Improves soil moisture.
2. Increases groundwater level.
3. Improves the quality of water.
4. Allows drought-proofing.
5. Prevents flooding of storm water drains.
6. Saves energy required to lift water.
7. Reduces flooding of roads.
8. Reduces soil erosion.
9. An ideal solution to water problem in areas having inadequate water resources.

Rainwater Harvesting Practices

There are two main practices of rainwater harvesting:

1. Storage of rainwater on surface for future use. It is a traditional practice and structures used are underground tanks, ponds, check-dams, weirs, etc.
2. Recharge of groundwater. It is a new concept of rainwater harvesting and the structures generally used are:
    - (a) **Pits-recharge**: Pits are constructed for recharging the shallow aquifers.
    - (b) **Trenches**: These are constructed when the permeable strata is available at shallow depths.
    - (c) **Dug wells**: Drainpipes carry the water to a filtration tank from which it flows into the dug well. Rainwater that is collected on rooftop of buildings is also diverted to the dug wells.
    - (d) **Hand pumps**: The existing hand pump may be used for recharging the shallow/deep aquifers, if the availability of water is limited.
    - (e) **Recharge well**: Recharge wells are generally constructed for recharging the deeper aquifers and water is guided through filter media to avoid choking of recharged well.
    - (f) **Recharge shafts**: For recharging the shallow aquifers which are located below clayey surface, recharge shafts are used.
    - (g) **Lateral shafts**: Lateral shafts with bore wells for recharging the upper as well as deeper aquifers.
    - (h) **Spreading techniques**: When permeable strata from top is available, then water spreading technique is used. Water is spread in streams/*nalas* by making check-dams, cement plugs or percolation ponds.

Government Strategy

The total renewable water resources of India are estimated at about 1900 sq km per annum. It is predicted that by 2025 large parts of India will join countries or regions having absolute water scarcity. Groundwater has emerged as the prime source of drinking and irrigation. About 92 per cent of present groundwater withdrawl is being used for irrigation purpose, thus contributing largely in food security of the country.

The following steps have been taken by the government to implement the water harvesting programme:

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

By adopting watershed as a unit, different location-specific measures are adopted and executed carefully in each of the topo-sequences according to capability. Considering the fact that the rainfed area in India is about 60 per cent of the country's net sown area, and the vast area should not suffer from neglect and poverty, investment in watershed management for water-scarce regions (receiving rainfall below 75 cm) of India is an appropriate development intervention which warrants top priority from the point of social justice and containing the widening spatial imbalance between irrigated wet farming and dryland farming systems.

In brief, watershed development approach being an intensive one, appears to be infinitely expensive in a relative sense over the seed and fertilizer approach, but economic evaluation conducted at the *Central Soil and Water Conservation Research Institute* at Dehra Dun shows that this is not so. On the other hand, the realisation that a crop-based approach, or an approach which treats the country as a single unit, would not address the major issue for agricultural development in different location-specific conditions, watershed management (or alternative drainage, flood control and conjunctive uses of water of different sources, or again, a more appropriate management of hill and forest-based agriculture) are alternative regimes, each having a different investment and policy support strategy.

There are a number of successful watershed management experiences like *Sukhomajri*, near Kalka and *Pani-Panchayats* (water collectives) at Ralegaon in Maharashtra, where the basic problems of food and fuelwood requirements of poor rural communities have been largely solved by water harvesting.

It is being suggested that in many rural or agricultural situations in our country, we require community participation interfaced with institutional support at the level of, say, 'watershed' land and water managements in difficult ecological regimes to develop the slender resource base of the areas. The replication of successes like *Sukhomajri* would be for the better.

Studies to develop a baseline data for better understanding of the existing and emerging situations need to be undertaken. Recycling of water and water conservation will be a critical component of our daily lives in the new millennium. As far as possible, the technologies should be indigenously developed so as to make them socially acceptable and economically viable.

THE INTER-STATE WATER DISPUTES

Water being the most precious resource is required for domestic, irrigation and industrial purposes. River is more than an amenity, it is a treasure. It offers a necessity of life that must be rationed among those who have power over it. Most of the Indian rivers traverse more than one state. Each of the states of a river basin tries to obtain the maximum quantity of water. This has resulted in many water disputes in the country. In the Indian Constitution (1950), water is a state subject. Consequently, the state governments virtually exercise full control on planning, development, regulation, distribution and control of water flowing through their territories. Under Article 262 of the Indian Constitution, the Parliament is empowered to provide the adjudication or control of water on any interstate river. Most of the rivers of India travese several states. Under the Water Dispute Act, 1956 a tribunal of three sitting judges of the Supreme Court has to be constituted by the Central Government for the settlement of an interstate water dispute when a request is received from a state government. According to the Interstate Water Dispute Act, 1968, the Central Government has also been given the responsibility of regulation and development of interstate rivers and river valleys to the extent to which such regulation and development under the control of the Union is declared by the Parliament, by law, to be expedient in public interest. Some of the important interstate water disputes in India are as under:

1. The Kaveri water dispute between Karnataka, Kerala, and Tamil Nadu.
2. The Krishna water dispute between Maharashtra, Karnataka, and Andhra Pradesh.
3. The Tungbhadra water dispute between Andhra Pradesh and Karnataka.
4. The Godavari water dispute between Andhra Pradesh, Madhya Pradesh, Maharashtra, and Odisha.
5. The Narmada water dispute between Gujarat, Madhya Pradesh, Maharashtra, and Rajasthan.
6. The Ravi, Beas and Satluj water dispute between Punjab, Haryana, Rajasthan, Delhi, and Jammu and Kashmir.
7. The Yamuna River water dispute between Uttar Pradesh, Haryana, Himachal Pradesh, Punjab, Rajasthan, Madhya Pradesh, and Delhi.

Many of these water disputes have been settled on the basis of equitable apportionment which is the universally accepted principle. However, there are some interstate water disputes whose final solution, acceptable to all parties, has not yet been worked out. The Kaveri water dispute has been resolved by the Supreme Court in February, 2007, but the government and people of Karnataka are not satisfied with the decision of the court. The Ravi and Beas water dispute is still a bone of contention between Punjab and Haryana governments.

In developing countries like India, the interstate water dispute must be resolved quickly so that water resources could be utilised and harnessed properly for economic development. One of the measures could be to declare all the major rivers as national property, and national schemes under Central assistance should be launched for the development of total command area of the concerned states. Establishment of separate corporations on the pattern of the Damodar Valley Corporation may be immensely useful in this direction.

INTERNATIONAL AGREEMENTS FOR SURFACE WATER RESOURCES

Several of the Indian rivers flow through Tibet (China), Pakistan, Bangladesh, Bhutan, Nepal, and Myanmar. India has many international agreements with these neighbouring countries regarding the sharing of international river waters.

The Indus Water Treaty

This treaty was signed between India and Pakistan on September 19, 1960, regarding the sharing of water of the Indus and its tributaries. It was reached through the arbitration of the International Bank for Reconstruction and Developemnt which has set up a permanent Indus Commission to look after disagreement arising between India and Pakistan. Under this agreement, India has been given exclusive rights to use the waters of the three eastern rivers (Ravi, Beas and Satluj), leaving out the remaining three (Chenab, Jhelum, and Indus) to Pakistan, which will also take into account the water needs of the Indian state of Jammu and Kashmir. The agreement between India and Pakistan of the Salal, Baghliar and Dulhasti projects (Chenab River) are an excellent example of co-operation between the two countries.

Similarly, a thirty-year agreement was also reached between India and Bangladesh on December 12, 1996, for the sharing of Ganga waters. Under the agreement, India and Bangladesh would share alternately for 10 days each, 35,000 cusecs of water during the lean season (1^{st} March to 10^{th} May) to fulfill their water needs. A similar agreement has been concluded between India and Nepal for sharing river waters. Moreover, India is helping Nepal in executing many river valley projects. The Mahakali Project is the outcome of one such Indo-Nepal joint ventures. Mutual agreement has also been reached between India and Bhutan for harnessing the waters of the international rivers affecting these countries. The king of Bhutan has agreed to join a sub-regional plan for sharing river waters and power with India and Bangladesh. Bhutan is willing to divert 12,000 cusecs of water from the Sankosh River to Tista and from Tista to Farakka Barrage to be shared by India and Bangladesh. The plan also envisages India purchasing 4000 megawatt of hydel power from Bhutan to strengthen its National Power Grid and to meet the power needs of the north-eastern region.

NATIONAL WATER GRID

The distribution of rainfall in India is highly unequal and seasonal. The rivers having their origin in the Himalayas are perennial, while those of Peninsular India are generally seasonal. During the months of general rains, much of the water is wasted during floods and flows down to the sea, but in the dry months of the year there is scarcity of water. Consequently, there are droughts and famines in one part of the country and floods in the other regions. The problems of droughts and floods can be minimised through the inter-basin linkages or through national water grid, under which, water from one river basin can be transferred to another basin for optimum and judicious utilisation. The salient features of the National Water Grid are as follows:

1. The Ganga-Kaveri Link Canal passing through the basins of Son, Narmada, Tapi, Godavari, Krishna, Penner, and Kaveri.
2. The Brahmaputra-Ganga Link Canal passing through Bangladesh.
3. The Narmada Canal passing through Gujarat and Rajasthan.
4. The Canal from Chambal to Central Rajasthan.
5. The Link Canals between the rivers of the Western Ghats towards the east.

1. The Ganga–Kaveri Link Canal

At the request of the Government of India, a UNO team prepared a project report on the Ganga-Kaveri Link Canal (**Fig. 3.11**). The main objectives of the project are to safeguard against the recurring floods in the Ganga Basin and to assure more water to the comparatively less rainfall receiving areas of central India. Under this project, the Ganga is to be linked with Kaveri by a man-made canal; 2636 km or 1650 miles long. This canal was proposed not only to provide drinking water to its command area, but also to provide water for irrigation and sanitation. In addition to these, the canal is supposed to help in the generation of hydel-power, navigation, flood control, tourism promotion, and recreation. The Ganga-Kaveri Link Canal is thus, a multi-purpose project of immense size. If completed, the country will no longer have to depend so much on monsoon, the vagaries of which are well known.

The scheme proposes to draw 1700 cumecs (60,000 cusecs) of water from the Ganga, constructing a barrage near Patna, and lift its water by large pumps to a point near the boundary of the basins of Ganga and the Narmada from where it will be possible to distribute the water by

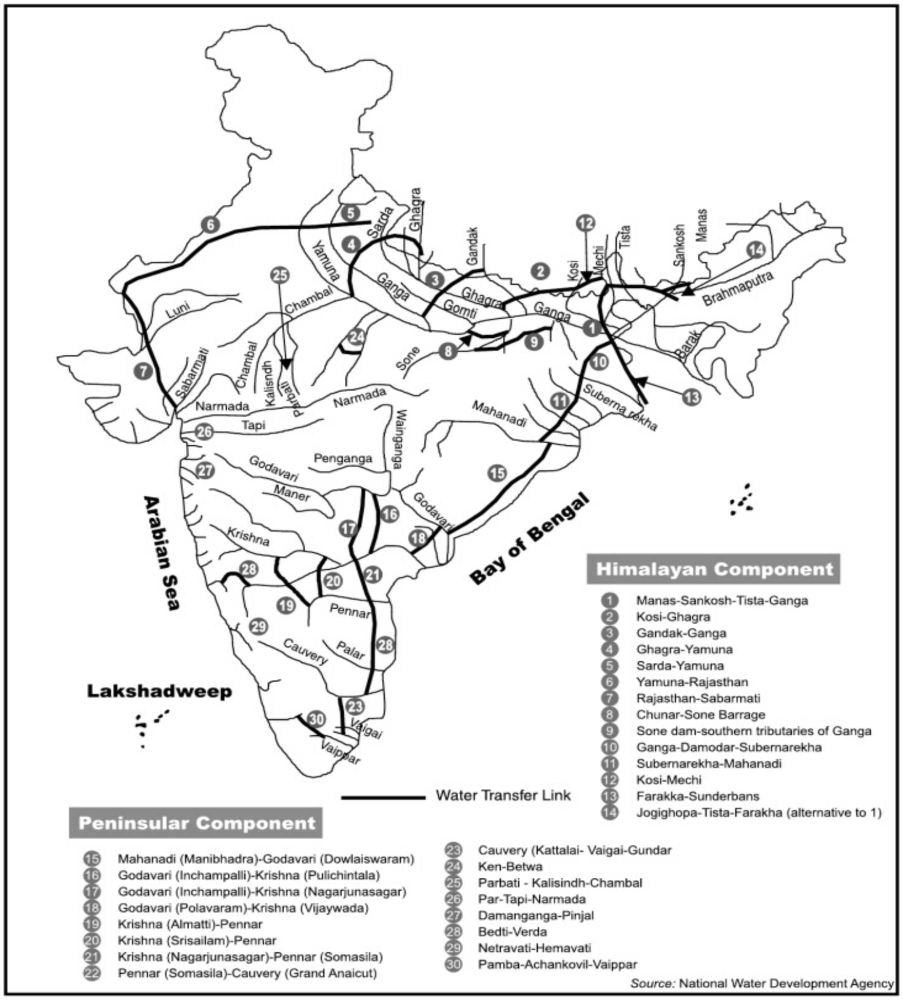


Fig. 3.11 Inter Basin Water Transfer

gravity via dug-up canals or through existing rivers to the west or south. The flood waters of the Narmada (flowing into the Arabian Sea) and the Godavari (flowing into the Bay of Bengal) could also be used profitably by a separate water grid. Water for the inter-basin transfer would be derived from the Ganga only during the four months of the rainy season (July to October) when the flow exceeds on an average by 2850 cumecs (100,000 cusecs).

The length of the Ganga-Kaveri Link Canal will be between 2400–3200 km, depending upon the actual alignment finally chosen, with smaller secondary branches connecting areas chronically prone to droughts. It is also proposed to supply the Ganga water to Bihar, Uttar Pradesh, Jharkhand, Chhattisgarh, Madhya Pradesh, and Rajasthan by pumping additional water during the lean water season. Similarly, 1410 cumecs (50,000 cusecs) of water pumped for 150 days or more, depending upon the surplus waters in the Ganga, would be diverted during the high flow period only, and would be transferred outside the basin to meet partially the water demand of the chronically drought prone areas of Rajasthan, Gujarat, Madhya Pradesh, Chhattisgarh, Maharashtra, Andhra Pradesh, Karnataka, and Tamil Nadu.

A site near Patna having an elevation of about 46 metres above sea level will be the starting point which would collect the surplus water from the Ganga. From here, the water would be pumped into a series of reservoirs between the watersheds of the Narmada and Son, involving a pumping lift of 335 to 400 m. From this elevation (Bagri Reservoir on the Narmada 423 m above sea level), a lined aquaduct will convey the water to the south utilising the natural water resources of the Wainganga, Pranhita, and Godavari, and crossing the Krishna and the Penner to Kaveri, upstream of the Upper Anicut.

Storage would be provided enroute, especially on the ridge regions to conserve the water for the dry season. These storages would be located inside valleys, which do not have sufficient catchment area of their own to provide adequate run-off which would be utilised during the dry season. On the way, water would also be released into the basins of the Narmada and the Tapi rivers which flows westward into the Arabian Sea, and the Godavari, the Krishna, the Penner, the Kaveri which flow eastward into the Bay of Bengal. From the selected points on the Son River itself, water pumped separately for the basin will be diverted to the drought prone areas in the Ganga basin.

The project involves huge expenditure, massive survey operations and strong administrative decisions. Since it will take a decade or more to complete the project which has several administrative and socio-ecological constraints, the government has not yet taken any decision to execute the project.

2. The Brahmaputra–Ganga Link Canal

The Brahmaputra is a mighty river which carries a discharge of 3500 to 5000 cumecs even during the dry season. Much of this water is beyond the requirement limit of the basin and is wasted. On the other hand, there is a scarcity of water in the lower Ganga basin, especially during the dry months. Hence, the diversion of excess water from the Brahmaputra to the Ganga may meet this water deficit, which shall help in the economic development of the region.

The Brahmaputra-Ganga Link Canal Project involves the construction of a diversion barrage at Dhubri (Lower Assam), and a 320 km long feeder canal linking the Dhubri Barrage to the Farakka Barrage. A portion of this feeder canal will lie in Bangladesh for which an interenational agreement between India and Bangladesh has to be signed. This canal will provide irrigatioin water to Bangladesh also. The canal may augment the flow of water in the Padma River (Ganga in Bangladesh) during the lean months of the year. Besides, the link canal would provide cheap inland navigation facility to both the countries. Due to lack of concurrence from Bangladesh and involvement of huge financial expenditure, the scheme has not yet been started.

3. The Narmada Link Canal to Gujarat and Rajasthan

Under the Sardar Sarovar Project, there is a proposal to build a terminal storage dam across the Narmada River near Navagam, and a diversion canal linking the place to regions of Kachchh (Gujarat) and western Rajasthan. This link canal will be of immense help to the drought prone areas of Gujarat and western Rajasthan.

4. The Chambal Link Canal

A canal of about 500 km connecting the Chambal River with the Indira Gandhi Canal has also been proposed. The canal would provide water to the central parts of Rajasthan. It will involve a lift of 200 to 250 m. Moreover, Chambal-Parbati, Betwa-Ken, Ghagra-Yamuna, Gandak-Ganga, Mechi-Kosi-Ganga, Par-Tapi-Narmada, Mahanadi-Godavari are also under consideration (**Fig. 3.11**)

5. Links between the Rivers of the Western Ghats to the East

The rivers of the Western Ghats carry enormous quantity of water during the rainy season. Due to steep gradient and the narrow coastal plains much of the water goes to the Arabian Sea as waste. This water may be diverted to the rain-shadow areas of the Western Ghats through the diversion canals where it can be utilised for irrigation. The Periyar Diversion Scheme, constructed several years ago, is such a type of model scheme where the surplus water of the west-flowing Periyar river has been collected in a barrage and diverted through a tunnel across the Sayadri, so as to meet the water needs of the drought prone areas of Tamil Nadu in the east. Other projects of western Ghats include: Damanganga with Pinjal, Bedti with Varda, Netravati with Hemavati and Pamba with Vaippar (**Fig. 3.11**). Similar schemes may also be executed in case of other rivers of the Western Ghats.

GROUND WATER RESOURCES OF INDIA

India is rich in underground water. Its spatial distribution, however, is most uneven. For example, the average annual rainfall in India is about 110 cm. While Mawsynram and Cherrapunji receive more than 1000 cm rainfall annually, the average annual rainfall in Ganganagar is only about 20 cm.

The underground water resource is a function of geological structure, topography, slope, precipitation, runoff, soils and hydrological conditions of a region. In the opinion of Prof. R.L. Singh (1971), India may be divided into eight ground water provinces (**Fig. 3.12**). A brief account of these provinces has been given in the following section:

1. The Pre-Cambrian Crystalline Province

The Pre-cambrian province stretches over about 50 per cent of the total area of the country, especially over Peninsular India. It sprawls over Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Chhattisgarh, Chotanagpur Plateau and Aravallis. This province is generally poor in under-ground water resource.

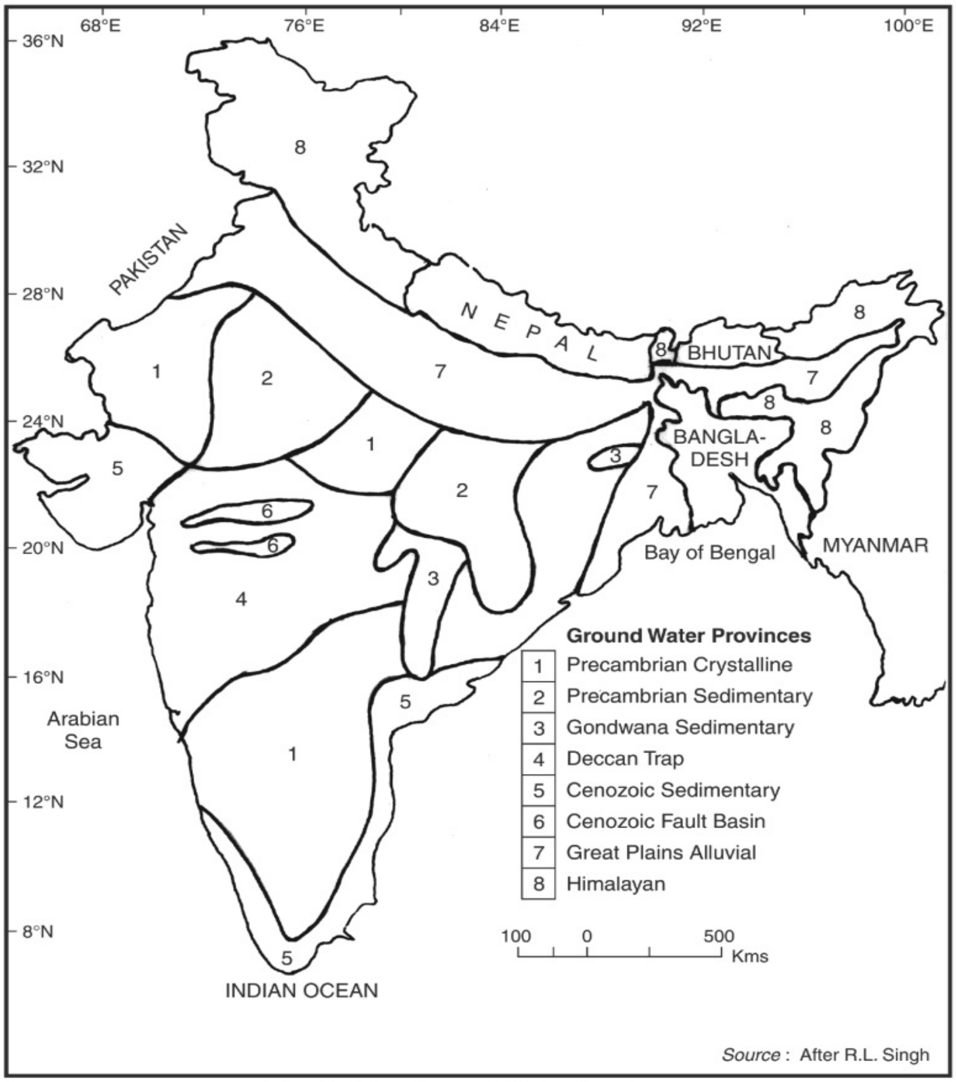


Fig. 3.12 Ground Water Provinces

2. Pre-Cambrian Sedimentary Rocks Province

The Archaean, Dharwar, Cuddappah and Vindhyan formations are included in this province. These regions are also not rich in ground-water resource.

3. The Gondwana Sedimentary Province

Stretching over the Godavari basin, this province is fairly rich in underground water resource.

4. The Deccan Trap Province

Stretching over the states of Mahrashtra, parts of Gujarat, Madhya Pradesh, Chhattisgarh, Andhra Pradesh and Karnataka, this province is also deficient in underground water resource. In fact, the Deccan Trap is a deep lava formation of the Cretaceous Period in which the seepage of water is possible only through the cracks and fissures. The limited under-ground water is however, of immense help for the irrigation of cereal crops, orchards, sugarcane, vegetables, flowers, and grasses.

5. The Cenozoic Sedimentary Province

This province includes the coastal areas of Andhra Pradesh, Tamil Nadu, Kerala, and Gujarat. The sandstones of the Tertiary Period in these regions are rich in the underground water resource.

6. The Cenozoic Fault Basin

The rift valleys of the Narmada and Tapi rivers are included in this province, which are quite rich in underground water.

7. The Ganga Brahmaputra Alluvial Province

Sprawling over Punjab, Haryana, Uttarakhand, Uttar Pradesh, Bihar, West Bengal, Assam and parts of Rajasthan, this province has the richest underground water resource. About 44 per cent of the Indian underground water resource is found in this province. Thousands of tube-wells have been installed in the Northern Plains of India to utilise this resource for irrigation, domestic, and industrial purposes.

8. The Himalayan Province

This is complex structural, physiographic and geographical region of India. In general, it is deficient in underground water except the intermontane valleys, like the Dun, Kashmir, Kangra, Kullu, and Manali valleys. There are numerous springs in this region.

THE NATIONAL WATER POLICY

The government of India designed the National Water Policy for the optimum and judicious utilisation, management and conservation of water resources in the country. The main features of the policy are given in the following paras:

According to one estimate, out of the total precipitation of about 400 million hectare metres in the country, only 178 million hectare metres is the available surface water. Out of this, about 50 per cent can be put to beneficial use because of topographical and other features. Moreover, there is a ground water potential of about 42 million hectare metres. The distribution of water resource as stated above is highly uneven in terms of both space and time. Precipitation over the greater part of the country is seasonal, mainly concentrated to three or four months of the rainy season. It varies from about 20 cm in Ganganagar (western Rajasthan) to over 1000 cm at Mawsynram (Meghalaya). Hence, there is a water surplus in one part of the country and water deficit in another part. The National Water Policy proposes to evolve a national water grid for the proper management and utilisation of the water of the country. The main objective of the policy is to provide water from the surplus areas to the deficit areas. The national water policy proposes to initiate investigation for a national plan for inter-basin transfer for water from the water surplus areas to the water deficit areas. Its aims are enumerated below:

1. Water is a primary natural resource, a basic human need and a precious national asset. Hence, the planning and development of water resources need to be governed by national perspective.
2. The National Water Policy aims at planning the surface water resources of the country on the basis of hydrological units such as drainage basin as a whole for a sub-basin. This will ensure an optimum utilisation of the water resources of the country.
3. There is an increasing demand of water for irrigation, industries and domestic uses. The national water policy aims at taking suitable measures for proper management and conservation of water resources of the country, minimising losses at the storage and diversion points in the distribution system.
4. The policy aims to reduce water pollution and to improve the quality of water of the rivers. There is an emphasis on the recycling of water also.
5. It proposes an adequate maintenance of canals and distribution systems by making adequate financial allocations for maintenance of canals and their distributaries.
6. It suggests a detailed survey for the preparation of new projects on priority basis for tribal areas, drought prone areas as well as for the economically weaker sections of society.
7. The policy lays emphasis on the supply of good quality drinking water to rural areas besides meeting the needs of the urban areas.
8. It proposes a proper survey of the underground water resources and how to utilise them judiciously. The conservation and recharging of ground water is also a priority of the national water policy.
9. The policy also focuses attention on devising suitable strategies for such problems as waterlogging, salinisation, degradation of fertile arable lands, deteriorating water quality, over exploitation of ground water resources, and uprooting of families due to development projects.
10. The policy also aims at reducing the runoff, soil erosion and silting of river beds.

MAIN WATERFALLS OF INDIA

Agaya Gangai Waterfall

Located in the Kolli Hills (Eastern Ghats, Tamil Nadu). It provides serene solitude, and is a great attraction in the Tamil Nadu tourism. The approach is, however, tortuous.

Ayyanar Waterfall

It is situated in the Virudhunagar District of Tamil Nadu in the Western Ghats. It gets water mainly during the retreating monsoon rain. The water from the falls is mainly used for drinking purposes by the people of Rajapalayam. It is a famous tourist spot for the people of neighbouring districts.

Barakana Falls

Situated in the Shimoga District of Karnataka, Barakana is one of the highest water falls of the country. Currently, Barkamna Falls are the prime source of one of the hydro-electric projects of Karnataka.

Dudhsagar (Goa)

Dudhsagar (The Sea of Milk) is a tiered water fall located in the upper reaches of Mandovi River in the state of Goa. It is a great attraction for the national and international tourists.

Duduma Waterfall (158 m)

Situated about 92 km from Koraput, it lies on the Machhkund River in Odisha. A large hydro-electric project has been constructed at this waterfall. Machhkund is an important place for pilgrimage.

Gokak Falls (53 m)

They are located in the upper reaches of the Ghataprabha (a tributary of the Krishna) in Belgaum District of Karnataka. The waterfall is about six km. away from Gokak, a nearby town. It resembles to Niagra Falls. It is a great attraction for the domestic and international tourists.

Jog Falls (253 m)

Located on the Sharavathi River in the Shimoga District of Karnataka, they are the highest untiered waterfalls in India. Jog falls is one of the major attractions in Karnataka tourism. It is also called by alternative names of Gerusoppe Falls, Gersoppa Falls and Jogada Gundi.

Kiliyur Falls

Kiliyur are the waterfalls in the Servary Hill of Eastern Ghats (Tamil Nadu). Having an elevation of about 100 m, it is a great attraction in the tourism of Tamil Nadu.

Kurtalam Falls

Situated in the Tirunelveli District, Tamil Nadu, the Kurtalam waterfalls is a great attraction for the domestic and international tourists.

Lodh Waterfalls (also known as Buddha Ghagh Falls)

The Lodh Waterfalls are located on the Budh River about 40 km from Ranchi (Jharkhand). The falls, named Gautam Budha, also have a Buddha Temple there.

Shivasamudram Waterfall

Shivasamudram Falls formerly known as the Cauvery Falls are the second highest waterfall in India. It is located 80 km from Mysore and 120 km from Bangalore. It is a major attraction in Karnataka tourism.

Siruvani Waterfall

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

Thalaiyar Waterfall (Rattail)

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

Vattaparai Waterfall

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

Vazhachal Waterfall

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

Some of the other important Waterfalls in India

Chhattisgarh

Teerathgarh.

Madhya Pradesh

Dhunwadhar (Narmada River, near Jabalpur).

Himachal Pradesh

Bundla and *Palani* falls.

Jharkhand

Ghaghri, Hundru and *Johna* falls.

Karnataka

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

Kerala

Athirappilly Falls, Meenmutty Falls, Palaruvi Falls, Soochipara Falls, Thusharagiri Falls.

Maharashtra

Chchai Falls, Gatha Falls, Keoti Falls, Rajat Pratap Falls (M.P.), Kune Falls, Marleshwar Falls, Pandavgat Fall.

Meghalaya

Beodon Falls, Bishopfalls, Elephant Falls (Shillong Peak), Kynrem Falls (308 m), Langshiang Falls (341 m), Margaret Falls, Nohkalikai Falls (338 m), Spread Eagle Falls, Sweet Falls (97 m).

Mizoram

Vantawng Falls.

Odisha

Joranda Falls (151 m), Khandadhar Falls near Buguda (246 m).

Tamil Nadu

Aintharuvi (five-falls), Beman Falls (Palani Hills), Bear Shola Falls (Kotagiri), Chitraruvi Falls (Small falls), Courtallam Falls, Elk Falls (in Palni Hills National Park),

Fairy Falls (5 km from Kodaikanal), Glen Falls in Palani Hills National Park), Hogenakal Falls (20 m).

Kalikesam Falls (in Kanyakumari District), Koraiyar Falls (in Panchaimalai near Arumbavur), Kovai Kutaralam Falls (at Siruvani 37 km from Coimbatore), Kumbakkarai Falls (in the foothills 8 km from Periyakulam), Kuthiraiyar Falls (167 m).

Mangalam Aruvi Falls (in Pachaimalai), Mayil Utha Falls, Monkey Falls (near Coimbatore), Mutyalamaduvu Waterfalls, Neptune Falls (in Palani National Park).

Palaruvi Waterfalls, Pambar Falls (4 km from Kodaikanal), Pazhathotta Aruvi Falls (Fruit Garden Falls or Orchid Falls), Pazhaya Courtallam Falls (Old Falls), Peraruvi Waterfalls (Main Falls), Periyar Falls, Pudur Megan Falls, Puli Aruvi (Tiger Falls), Puthu Aruvi (New Falls- Milk Falls), Pyakara Falls (Nilgiri).

Sengupathi Falls, Shenbaga Devi Falls, Thenaruvi Falls (Honey Falls), Shimsha Falls, Silver Cascade (8 km from Kodaikanal), Skamba Waterfalls (8 km from Kodaikanal), Snake Falls (in Palani Hills Nationalpark), Suruli Waterfalls (123 km from Madurai).

Thakkam Thootam Falls (near Palani), Tirparappu Waterfalls (in Kanyakumari District), Thirumoorthy Falls (about 20 km from Udumalpet), Thoovannam Falls or Dhuvanam Falls (near Amaravathinagar).

Vaideki Falls (about 30 km from Coimbatore).

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Chapter 4

Climate

INTRODUCTION

The climate of India is essentially sub-tropical monsoonic. The word 'monsoon' has been derived from the Arabic word ***'mausim'*** which means 'season'. Originally, the word 'monsoon' was used by Arab navigators several centuries ago, to describe a system of seasonal reversal of winds along the shores of the Indian Ocean, especially over the Arabian Sea, in which the winds blow from the south-west to north-east during the summer season and from the north-east to south-west during the winter season. In other words, monsoons are periodic (seasonal) winds in which there is a complete reversal of the wind direction after every six months.

In the opinion of Chang-Chia-Cheng: "Monsoon is a flow pattern of the general atmospheric circulation over a wide geographical area, in which there are clearly dominant winds in one direction in every part of the region concerned, but in which this prevailing direction of wind is reversed or almost reversed from winter to summer, and from summer to winter."

Monsoons are especially prominent within the tropics on the eastern sides of the great landmass, but in Asia, it also occurs outside the tropics in China, Korea, and Japan, and may be observed up to 60° north. South-East Asia, especially the subcontinent of India, however, is a typical example of a monsoon region. Other areas which experience similar but less pronounced seasonal changes of wind direction include south-eastern USA, the Caribbean Islands, Madagascar, East Africa, the Guinea coast of West Africa, South-east Asia, Philippines, south-eastern China, South Korea, and North Australia (**Fig. 4.1**).

INDIAN MONSOON

Monsoons are a complex meteorological phenomenon. Experts of meteorology have developed a number of concepts about the origin of monsoons. Some of the important concepts about the origin of monsoons have been given as under.

The Thermal Concept of Halley (1686)

Halley, a noted astronomer, hypothesised that the primary cause of the annual cycle of the Indian monsoon circulation was the differential heating effects of the land and the sea. According to this

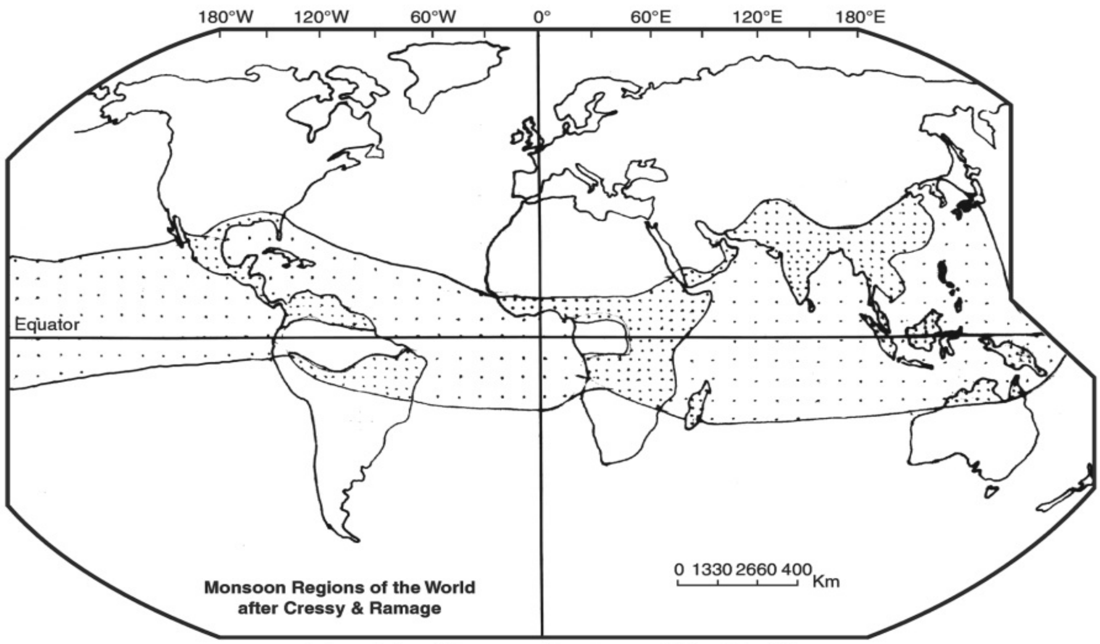


Fig. 4.1 Monsoon Regions of the World

concept *monsoons are the extended land breeze and sea breeze on a large scale, produced by the differential heating of continents and ocean basins* (**Fig. 4.2**). During the summer season in the Northern Hemisphere, when the Sun's rays are vertical over the Tropic of Cancer, the huge landmass of Asia heats quickly and develops a strong low pressure centre near Lake Baikal (Siberia) and Peshawar (Pakistan). This thermal low extends up to 700 mb. Moreover, the pole-ward shift of the Inter-Tropical Convergence Zone (ITCZ) to a position over southern Asia reinforces the thermally induced low pressure centre. In comparison to this, the pressure over the adjacent water of the Indian and the Pacific Oceans is relatively high. Under these conditions, a sea-to-land pressure gradient develops. Consequently, the surface air flow is from the high pressure over the oceans towards the low pressure areas over the heated landmass. Under the extreme low pressure condition on land, the wind from the southern part of the Indian Ocean (south of Equator) is attracted towards the subcontinent of

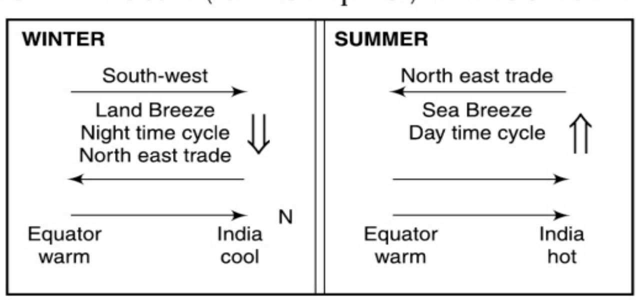


Fig. 4.2 Land Breeze and Sea Breeze: Monsoon Cycle

India. The air coming from oceans towards land is warm and moist. When land barriers like mountain ranges and plateaus come in the way of the moisture-laden winds, they ascend and result into saturation, condensation, and precipitation (**Fig.4.3**).

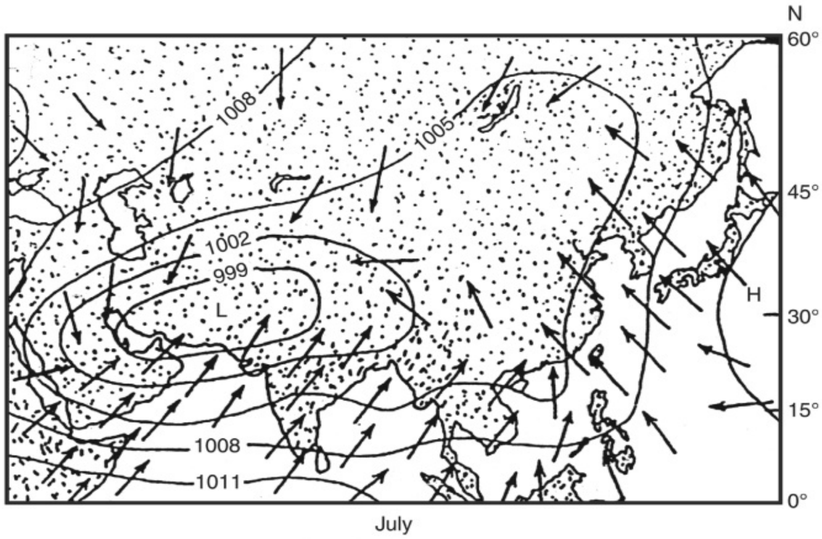


Fig. 4.3 The Summer Monsoon

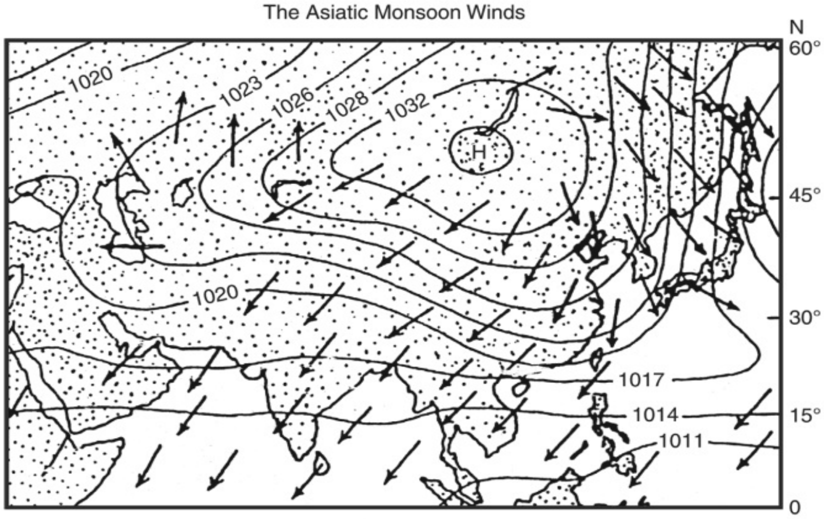
Contrary to this, in the Northern Hemisphere during winter season, there develops high pressure areas near Baikal Lake (Siberia), and Peshawar (Pakistan). As compared to these high pressures, the Indian Ocean and the Pacific Ocean (south of Japan) remain relatively warm, having low pressure areas. Consequently, there is an outflow of air from the high pressure of the land to the low pressure areas of the oceans. The air blowing from high pressure areas of land towards the sea is cold and dry. This cold and dry air is incapable of giving precipitation unless it comes into contact with some water body (ocean/sea) (**Fig. 4.4**)

The thermal concept about the origin of monsoon has, however, not been accepted universally as it fails to explain the intricacies of monsoon. Besides differential heating, the origin and development of monsoon are also influenced by the shape of the continents, orography, and the conditions of air circulation in the upper troposphere. The Halley's concept has been criticised on more than one count as follows:

1. The low pressure areas that develop over the continents during the summer season in the Northern Hemisphere are not stationary. These low pressure areas change their position (location) suddenly. This sudden change in the low pressure areas are not exclusively related to low thermal conditions. The low pressure areas stabilises in June in the north-eastern parts of the subcontinent. In fact, they represent the cyclonic lows associated with the dynamic factors, and therefore, these low pressure areas cannot be termed as only thermally induced.
2. Had the monsoon been thermally induced, there would be anti-monsoon circulation in the upper air of the troposphere, which is lacking.
3. Although high temperature and the consequent low pressure takes the north-west in its grip from the middle of April, no rain starts in northern India till the middle of June.

4. The modern researches in meteorology have shown that the monsoon rainfall is not wholly orographic. They are an amalgamation of convectional, orographic and cyclonic rainfall.
5. Instead of two broad seasons (winter and summer) the monsoon climate has more seasons (four in India), due to the highly variable characteristics of temperature and precipitation.
6. Halley did not take into consideration the Coriolis effect of rotation of the earth on its axis. On a rotating earth, the wind has a tendency to move towards its right in the Northern Hemisphere and towards its left in the Southern Hemisphere.
7. The role of latent heat passing into the atmosphere through water vapour was also not considered by Halley; water vapour also plays an important role in the origin and development of monsoons.

The Asiatic Monsoon Winds



January

Fig. 4.4 The Winter Monsoon

The Dynamic Concept by Flohn

The dynamic concept about the origin of monsoons was put forward by Flohn in 1951. According to this concept, monsoon is the result of seasonal migration of planetary winds and pressure belts. The Inter-Tropical Convergence Zone (ITCZ) is formed due to the convergence of north-east and south-east trade winds near the equator. The northern and the southern boundaries of the ITCZ are called NITC (Northern Inter-Tropical Convergence) and SITC (Southern Inter-Tropical Convergence) respectively. There is a belt of doldrums within the Inter-Tropical Convergence, characterised by equatorial westerlies. At the time of the summer solstice (21st June), when the Sun's rays are vertical over the Tropic of Cancer, the NITC is extended up to 30° N latitude, covering South and south-east Asia. Thus, equatorial westerlies are established over these areas. The equatorial westerlies become south-west or summer monsoons. On a rotating earth, the trade winds of the Southern Hemisphere after crossing the equator turn towards their right (Coriolis effect) (**Fig. 4.5**). The NITC is associated with numerous atmospheric storms (cyclones) which yield heavy rainfall during wet monsoon months (July to September). Similarly, the north-east or winter monsoon

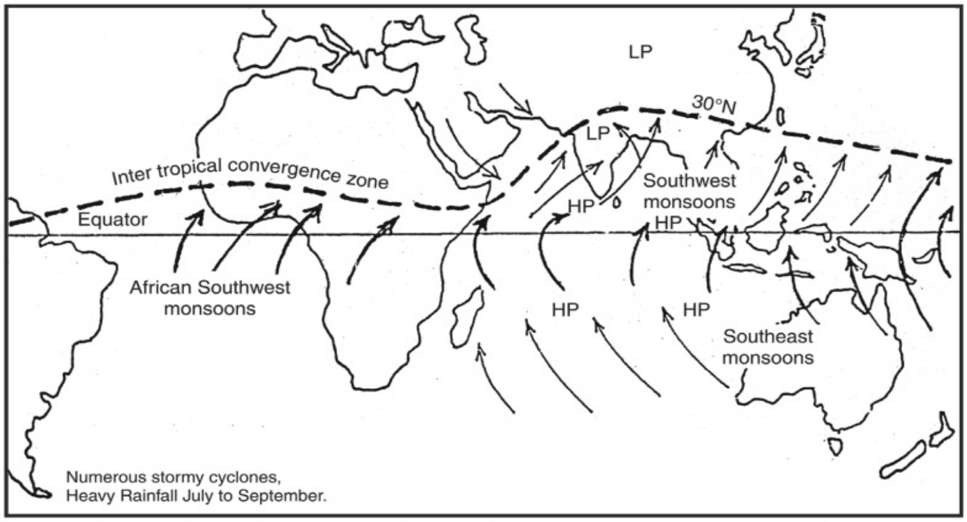


Fig. 4.5 South–West Monsoon (*Patterns of Surface Monsoon Winds in July (Summer)*)

does not originate only due to low pressure in the Southern Hemisphere during winter solstice (when the Sun's rays are vertical over the Tropic of Capricorn). In fact, the north-east monsoons are north-east trade winds which are re-established over south-east Asia due to southward shifting of pressure and wind belts. It is obvious that due to southward movement of the Sun at the time of winter solstice, the NITC is withdrawn from over south and south-east Asia, and north-east trade winds occupy their normal position. These north-east trades, thus, become winter monsoons. The north-east monsoons having their origin on land are generally dry and devoid of rains (**Fig. 4.6**).

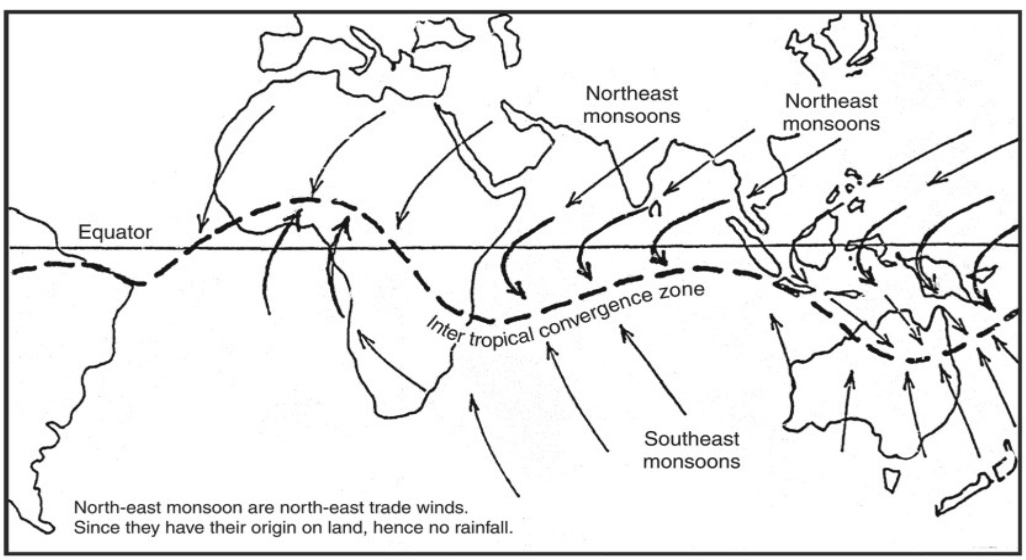


Fig. 4.6 North–East Monsoon (*Patterns of Surface Monsoon Winds in January (Winter)*)

In brief, according to Flohn, the existence of monsoons in Asia, especially in the subcontinent of India, is not due to temperature contrasts between land and sea, but mainly due to the annual migration of thermally produced planetary winds and pressure belts. Despite the relative shifting of Inter-Tropical Convergence (thermal equator) and pressure belts, Flohn seems to have ignored the upper atmospheric circulation (jet streams) and the southern oscillation, which make the Asiatic monsoon a fairly complex system. He also could not explain the causes of early arrival of Indian monsoons in the states of north-east India. The dynamic concept, therefore, was also not taken as the sole explanation of the origin of monsoons.

Recent Concepts about the Origin of Indian Monsoons

During the last five decades, the upper atmospheric circulation has been studied significantly, as a result of which meteorologists have raised certain doubts about the validity of the classical concept of the origin of Indian monsoon. It is now believed that the differential heating of land and sea cannot produce the monsoon circulation. More recent theories have laid greater emphasis on the circulation in atmosphere over the subcontinent and the adjoining areas. Apart from the upper atmospheric circulation, recent concepts rely heavily on the role of the Tibetan Plateau, jet streams, and the El-Nino (Southern Oscillation).

The data gathered by meteorologists after the Second World War have revealed that the origin and mechanism of monsoons are related to the following phenomena:

(i) The role of the Himalayas and Tibetan Plateau as a physical barrier and a source of high-level heat.
(ii) The circulation of upper air jet streams in the troposphere.
(iii) The existence of upper air circum-polar whirl over north and south poles in the troposphere.
(iv) The differential heating and cooling of the huge landmass of Asia and the Indian and the Pacific Oceans.
(v) The occurrence of El-Nino in the South Pacific and Indian Oceans.

INDIAN MONSOONS AND THE TIBET PLATEAU

In 1973, the Monsoon Expedition (Monex) was organised as a joint venture of the Soviet Union and India. Under this expedition, four Russian and two Indian ships equipped with modern scientific instruments were pressed into service in the Indian Ocean and the Arabian Sea to investigate the phenomenon of Indian monsoons. The period of investigation extended from the month of May to July, 1973. On the basis of the data obtained, the Soviet meteorologists arrived at the conclusion that the Tibet Plateau plays a crucial role in initiating the monsoon circulation over the Indian subcontinent. In 1958, Dr. P. Koteswaram, the Director General of the Indian Meteorological Observatories, while participating in the international symposium on 'The Monsoons of the World' had expressed views that the summer-time heating of the Plateau of Tibet was the most important factor in the causation and maintenance of monsoonal circulation. The Indian as well as the Soviet scientists were unanimous in their views on this point.

The plateau of Tibet is 600 km wide in the west and 1000 km in the east. Its length from west to east is about 2000 km. The average height of the plateau is about 4000 m. Thus, it is an enormous block of high ground acting as a formidable barrier. Due to its enormous height it receives 2°C to 3°C more insolation than the neighbouring areas. It is also one of the most important geographical controls on the general atmospheric circulation in the region. The Plateau of Tibet affects the atmosphere in two ways, acting separately or in combination: (i) as a physical barrier, and (ii) as a high-level heat source. The meridional cross-section of the Indian summer monsoon and its relationship with the Tibetan-Himalayan massif has been shown in **Fig. 4.7 and Fig. 4.8.**

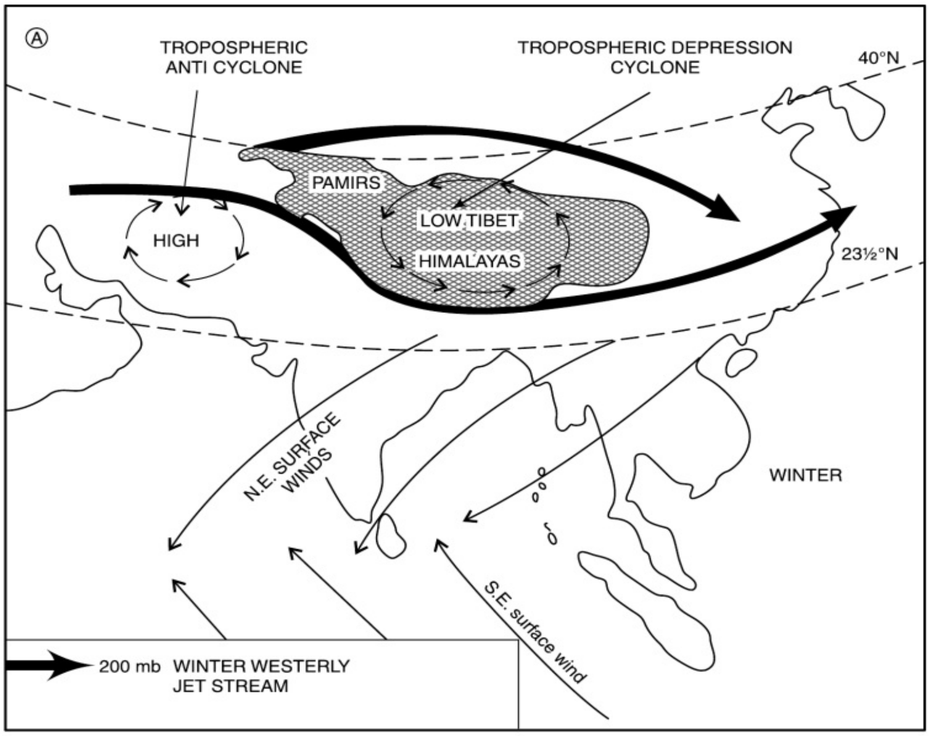


Fig. 4.7 Cross Section of the Indian Summer Monsoon

According to Maung Tun Yin, the Tibetan Plateau acts as a physical barrier. At the beginning of June, the subtropical jet stream disappears completely over northern India **(Fig. 4.8).** At this time, the jet stream shifts to the north of the Himalayas and Tibet, and takes up a position at about 40° N. Yin considers that there is a correspondence between the shifting of the jet and the slowing down of the westerlies over the whole of Eurasia. In fact, the plateau of Tibet becomes very cold in winter, and proves to be the most important factor in causing the advance of the jet far to the south in the middle of October. Thus, he opines that the abrupt onset of summer monsoon at the beginning of June is prompted by the hydro-dynamic effect of the Himalayas and not by the thermally induced low pressure centre over northwest India. In the middle of October, the plateau proves to be the most important factor in causing the advance of the jet south of the Himalayas or bifurcate it into two parts **(Fig. 4.7).**

The summer-time heating of the Tibetan Plateau makes it a high-level heat source. This 'Heat Engine' produces a thermal anticyclone over this region. A warm core anticyclone (high pressure) is formed over this plateau during the summer monsoon period. The formation of this anticyclone takes place in the middle part of the troposphere at 500 mb level. It is the result of a process called

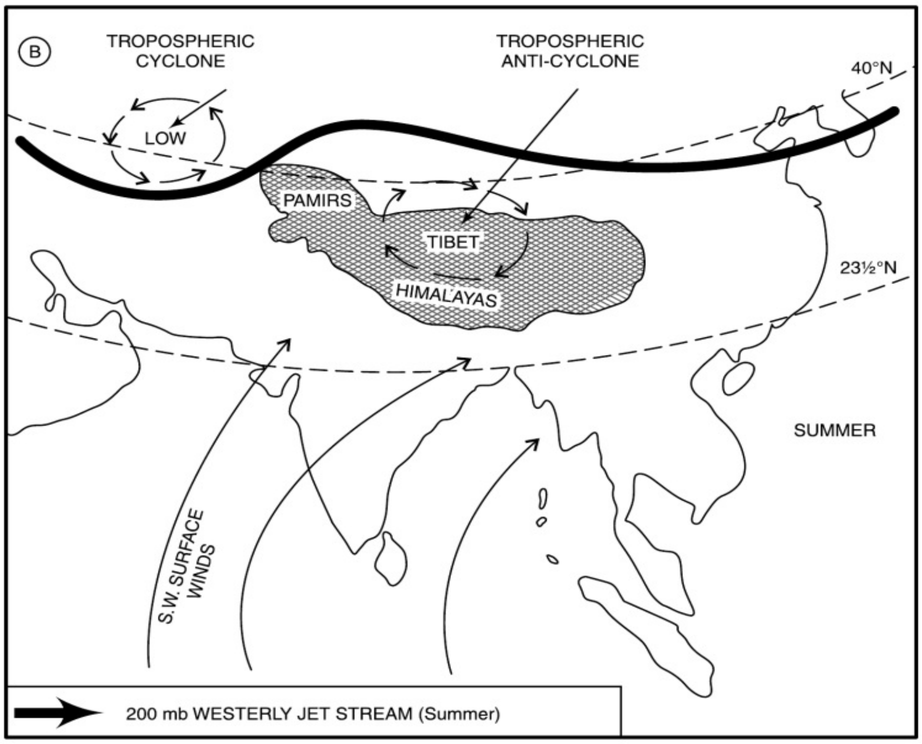


Fig. 4.8 Monsoon and the Tibetan-Himalayan Highlands

anti-cyclogenesis. The anticyclone at 500 mb at Tibet weakens the western sub-tropical jet-stream south of Himalayas, but produces tropical easterly jet on the southern side of the anticyclone. This tropical easterly jet stream first develops in longitudes east of India and then extends westwards across India and the Arabian Sea to eastern Africa. Blowing along Kolkata-Banglore axis the air under this jet descends over the Indian ocean and intensifies its high pressure cell, so as to finally move as south-west monsoon. The data collected under Monex support that higher the inensity of the tropical easterly jet greater would be potency of the high pressure cell over the Indian Ocean and stronger would be impact of south-west monsoon. Fig. 4.9 shows the meridional cross section

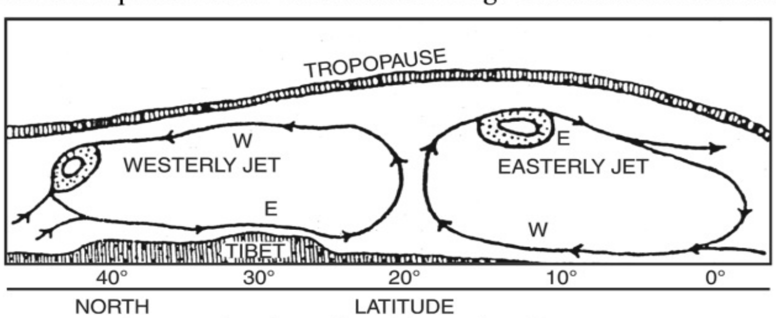


Fig. 4.9 Meridional Profile of the Indian Summer Monsoon

of the westerly and easterly jet-streams and their relationship with the Tibetan Plateau. However, on the southern side of this upper air anticyclone, the direction of air flow is from east to west. In fact, these easterly winds blowing in the mid-troposphere are known as tropical easterly jets. **Fig. 4.9** shows the meridional cross section of the Indian summer monsoon and its relationship with the Tibetan-Himalayan Highlands.

JET STREAM AND INDIAN MONSOONS

Jet stream is the most prominent movement in upper level westerly wind flows; irregular, concentrated, meandering bands of geo-strophic wind, travelling at speeds of 300 to 400 kmph. The jet streams are high altitude (9000–12000 m) westerly winds between middle latitudes (summer 35°N–45°N; winter 20°N–35°N) in the Northern Hemisphere. Recent researches have shown that these winds exert considerable impact on surface weather conditions.

The influence of jet streams on the origin and development of Indian monsoons may be appreciated from the following description of weather phenomena during the summer and the winter seasons. The upper air westerly jet streams are extended upto 20°N–35°N (Nagpur, Raipur latitudes) due to equator-ward shift of upper air north polar whirl during northern winter (October to February). In the winter season, the upper air westerly jet streams are bifurcated into two branches due to physical obstruction of the Himalayas and Tibetan Plateau. One branch is located to the south of the Himalayas, while the second branch is positioned to the north of the Tibetan Plateau (**Fig. 4.7**). The upper air high pressure and anticyclonic (with clockwise air circulation) conditions are developed in the troposphere over Afghanistan and Pakistan. Consequently, the winds tend to descend over the north-western parts of India, resulting into the development of atmospheric stability and dry conditions. Besides, the upper air westerly jet streams also cause periodic changes in general weather conditions because they lie over the temperate low pressure (cyclonic wave) which moves from west to east under the influence of upper air westerly jet streams across the Mediterranean Sea and reach Afghanistan, Pakistan and north-west India. These storms are not frontal cyclones, but waves which move at the height of 2000 metres from the mean sea level, while at the surface they are north-east trade winds. The arrival of these temperate storms (western disturbances) causes precipitation leading to an abrupt decrease in air temperature. The weather becomes clear after the western disturbance passes away. On an average, 4 to 6 cyclonic waves reach north-western India between October and April each year. They (the western disturbances) affect weather conditions during the winter season up to Patna (Bihar) and give occasional rainfall which is highly beneficial for the standing rabi crops, (wheat, barley, mustard, gram, lentil, etc.).

The tropical easterly jet stream extends far to the north of Tibet and the air flow is roughly along the Kolkata-Bangalore axis. These upper air easterlies descend into the permanent high pressure area formed over the southern Indian Ocean. This naturally intensifies the 'High' already present there. It is from this high pressure cell that the onshore winds start blowing towards the thermally induced low pressure area, developed in the northern part of the Indian subcontinent. After crossing the equator such winds become south-westerly and are known as the south-westerly summer monsoons. These surface winds have vast potentiality for south-westerly summer monsoon and precipitation. It is, therefore, clear that the strength of the easterly jet stream is directly related to the intensification of permanent 'High' formed over the southern Indian Ocean. Since this high pressure makes the pressure gradient steeper, so it is the main causative factor for determining the vigour of the summer monsoon.

During the summer season in the Northern Hemisphere, low pressure areas develop at the ground surface near Peshawar (Pakistan) and north-west India due to intense heating of ground surface during April, May, and June. But as long as the position of the upper air jet stream is maintained above the surface low pressure (to the south of Himalayas), the dynamic cyclonic conditions persist over Iran, Afghanistan, Pakistan, and north-west India. The winds descending from the upper air high pressure obstructs the ascent of winds from the surface low pressure areas, with the result that the weather remains warm and dry. This is why the months of April and May are generally dry and rainless in spite of high temperatures (low pressure on land) and high evaporation. It may be pointed out that monsoon arrives in Myanmar and north east Indian states in May or early June. Upper-air low pressure is formed to the east of the eastern limit of the Himalayas due to upper air easterly jet streams, with the result that the winds coming from the south of Myanmar are forced to ascend and yield copious rainfall. The Myanmar monsoon also affects Bangladesh and the hilly states of north-east India which receive pre-monsoon showers in the months of April, May, and the first week of June.

EL-NINO AND THE INDIAN MONSOON

The Indian monsoon is also influenced by EL-Nino, Southern oscillation and Somalian ocean current. El-Nino, meaning ***"Child Christ",*** is a warm ocean current appearing along the Peru coast, generally in December. It replaces the cold Peru Ocean Current flowing along the Peru coast in normal years. Under normal conditions, the Peru is a cold water current, while over the western Pacific, (Indonesia and eastern Australia) the ocean current is warm and deep **(Fig. 4.10).** The appearance of El-Nino *'reverses the condition'* there, and develops warm conditions over the eastern Pacific (Peru coast) and cold conditions in the western Pacific (east of Australia and Indonesia). Whenever this usually warm ocean current (El-Nino) is produced near the Peruvian coast, the amount of precipitation in the coastal areas of South America is usually high, while the eastern coasts of Australia and Indonesia record drought conditions. In brief, the occurrence of El-Nino results into a weak monsoon causing drought, floods and failure of crops.

The Southern Oscillation (SOI) is the name ascribed to the seesaw pattern of meteorological changes that are often observed between the Pacific and the Indian Oceans. It has been observed that whenever the surface pressure is higher over the Pacific, the pressure over the Indian Ocean tends to be low. As pressures are inversely related to rainfall, this suggests that when low pressure prevails over the Indian Ocean in the winter months (positive Southern Oscillation) the chances are that the coming monsoon rains will be good. In opposition to this, when high pressure prevails over the Indian Ocean in winter season, the coming monsoon will be weak. The term Southern Oscillation was discovered by Sir Gilbert Walker, the first Director General of the Indian Meteorological Service in 1924.

The oscillation has a period varying from 2–7 years. The intensity of Southern Oscillation (SOI) is measured by the differences in sea level pressures at Tahiti (18°S and 149°W), a station in the mid-Pacific, and Port Darwin (12°S and 130°E), a representative station in the Indian Ocean (**Walker Cell, Fig. 4.10**) A negative value of Southern Oscillation Index (SOI) implies low pressure over Peru Current and higher pressure over north Indian Ocean during the winter season and a poor or indifferent monsoon. Thus, there is a close relationship between the appearance of El-Nino and negative SOI. The low and negative phase of the Southern Oscillation in combination with El-Nino is called ENSO event.

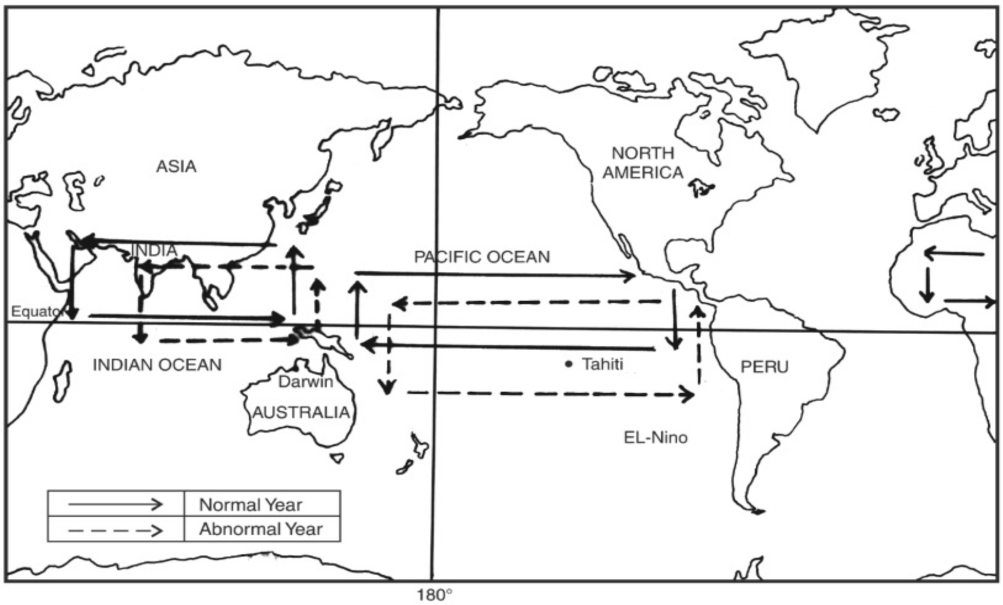


Fig. 4.10 Walker cells (*Southern Oscillation (SOI) and Indian Monsoon*)

As stated above, the Southern Oscillation is closely linked with the Walker Circulation. With a high positive Southern Oscillation, there would be a zone of low atmospheric pressure over Australia and Indonesian Archipelago. It will be accompanied by large convective clouds, heavy rainfall and raining air motion. This air eventually runs eastward, and after traversing the Pacific as a high level westerly wind at 200 mb, it descends over South America.

In terms of global winds, the Walker circulation suggests a strong belt of convergence between the trade winds of both the hemispheres at a location slightly to the north of the equator. These trade winds pile up a huge quantity of warm water in the western Pacific, produce equatorial counter-current from the Indonesian coast and facilitate upwelling of cold water from below, near Peru coast, giving rise to cold Peru current. Hence, high positive value of Southern Oscillation (SOI) indicates:

(i) a cold Peru current,
(ii) strong trade winds,
(iii) accumulation of water in western Pacific which is balanced by the Equatorial Counter Current and under-current,
(iv) a rise in the depth of thermo-cline as we proceed from the western half of the Pacific, and
(v) an ascending branch of the Walker Circulation over Australia and Indonesia with its descending branch over South America (**Fig. 4.10**). Such a normal condition leads to a normal south-west monsoon.

The appearance of El-Nino leads to a *'warm phase'* of the Pacific or negative Southern Oscillation (SOI). Now, the ascending branch of the Walker Cell shifts to the central regions of the Pacific Ocean and the descending air branch to the south-eastern parts of the ocean (**Fig. 4.10**). As upwelling off the South American coast decreases, the sea surface temperature rises. This leads to weaker trade winds, less accumulation of warm water on the western half of the Pacific Ocean, weakening of the Equatorial under current, heavy rain and floods along the South American coast and poor monsoon or monsoon failure over the subcontinent.

Somalian Current

The Somalian current changes its direction of flow after every six months. Normally, there remains a low pressure area along the eastern coast of Somalia. In exceptional years, after every six or seven years, the low pressure area in Western Arabian Sea becomes a high pressure area. Such a pressure reversal results into a weaker monsoon in the subcontinent of India.

BURST OF MONSOON

The suddenness and abruptness of the Indian monsoon is known as the *'burst of monsoon'*. The onset over the Indian sub-continent is abrupt and dramatic. It is always accompanied by turbulent weather. The so called burst of monsoon is associated with certain basic changes in the general upper-air circulation over southern Asia. In April and May, the insolation heating of the sub-continent tends to establish the south-westerly monsoon flow from the adjacent warm ocean, but northward surge of the same is retarded by the westerly zonal flow associated with the subtropical jet stream over northern India. However, in late May or early June, when the thermal conditions are satisfied, the jet stream disappears completely from the south of the Himalayas and shifts to a position to the north of the Himalayas and Tibet. At the same time, the upper trough low (low pressure) also moves westward from 85° E to 75°E. It may be pointed out that the jet stream does not retreat slowly. The process of this shift is rather quick. Now, with the disappearance of the jet, a definite monsoon circulation from the sea on to the land is established. The summer monsoon generally begins in late May in most parts of south-east Asia. But over India, it is delayed until the middle or late June. The change from one regime to another is abrupt. It is well to remember that the onset of monsoon occurs in several stages depending on the periodic advance and withdrawal of the equatorial convergence zone.

In the opinion of Koteswaram, the burst of monsoon is closely related to the development of a warm-core upper anticyclone (high pressure) over the extensive and lofty Tibetan Highland. This upper level anticyclone produces an easterly jet over India which is positioned at about 15°N. It is definitely a part of readjustment in the general planetary circulation pattern. Gradually, the easterly jet covers the entire region extending from India to east Africa. The above mentioned upper air condition paves the way for the advance of south-westerly monsoon current over the subcontinent. The monsoon current, therefore prevails throughout India. The depth of the monsoon in India is about 6.5 km, while over the Gangetic Plain it is only about 5 kilometres. The current is overlain by a layer of easterly winds (easterly jet stream).

The abrupt arrival of monsoon is of great climatic and social significance to the people of the subcontinent of India. The onset of monsoon puts an end to the scorching weather and the local hot winds *(loo)* in the northern plains of India. The relative humidity increases in the atmosphere tremendously. The arrival of monsoon is also the beginning of agricultural operations for the kharif crops in the rain-fed areas. The high temperature and high relative humidity are, however, oppressive and injurious to health. It is in the season of general rains (July to September) that people suffer from many diseases and epidemics.

BREAKS IN THE MONSOON

The migration of the monsoon rainfall zone is one of the major sub-seasonal variations of the summer (or south-westerly) monsoon. Thus, the monsoon is not a continual deluge of a number of months, duration, but has inter-seasonal variability; being made of a series of discrete events, both pluvial and dry. Viewed locally, these are the active and break monsoons respectively which exist on a time scale ranging from a few days to few weeks. Thus, while the monsoon appears to have a well-defined annual cycle, closer examination shows that the monsoon has substantial variability which becomes evident as the intensity of monsoon rains wax and wane through the wet season. Periods during which there is a rapid succession of weather disturbances or storms lasting a few days are referred to as *active periods* of the monsoon. Periods during which there is no rainfall for few days are the *break periods* of the monsoon. During an active phase, the Tropical Easterly Jet Stream (TEJ) remains very strong in the upper troposphere indicating strong convection and latent heating. But, when the maximum cloudiness remains locked up in the foothills of the Himalayas and the monsoon rainfall zone moves in this direction, subsidence occurs to produce a weak easterly flow in the upper troposphere. This creates the condition of break in monsoons.

In break monsoon condition, there is a general rise of pressure (as well as temperature) over the country and the isobars show marked refraction along the west coast. Cloudiness decreases and the south-easterlies at the surface levels over northern India are replaced by hot westerly air which blows over the plains, since the broad-scale surface pressure (the monsoon trough) shifts to the Himalayas and the rainfall practically ceases over the country outside the Himalayan regions and the southern slopes of the Himalayas, leading to high floods in the plains of these Himalayan rivers. Thus, though there is no rain over the plains, all the major northern and eastern Indian rivers rise and floods ensue.

Under weak monsoon conditions and in the years when the eastern end of the axis of the monsoon trough is oriented southward in Odisha, Jharkhand, Chhattisgarh and Madhya Pradesh, a low valley trough develops over the Assam Plain aligned along river Brahmaputra between the eastern Himalayas and the Shillong Plateau. The vertical extent of this low valley trough is 2 to 3 kilometres with the south west Monsoon lying to the south of the trough, remaining independent of the main monsoon trough. But, when the latter moves northwards and extends to the Himalayas, it joins the trough over the Assam Plain to cause heavy rainfall there.

The break in monsoon conditions generally occurs in the peak months of July and August, and lasts for at least 3 to 5 days over 500 to 1000 kilometres length in these months. The breaks occur on two time scales, usually from 10 to 20 days which on some occasions gets locked to a 40 to 50 days' break configuration. Depending upon their timing and duration, the break monsoon conditions are the harbingers of regional droughts.

Onset of the Monsoon

The onset of monsoon rains is viewed in monsoon literature as the burst of the monsoon, commonly in the form of a great thunderstorm. Prediction of the onset of monsoon helps farmers to select the most suitable crops to sow and to determine when to prepare the land. Predicting the timing of the monsoon has been an onerous task for the Indian Meteorological Department (IMD), almost from its beginning. Since 1878, forecasts of monsoon rainfall has been issued by this department regularly.

Progress of the Monsoons

The normal date of the onset of the monsoon is towards the end of May in Sri Lanka and over Andaman and Nicobar Islands in the Bay of Bengal (**Fig. 4.11**). Thereafter, it bursts on the Malabar Coast in Kerala a week later by June 1, and the isolines on the onset chart display a pronounced curve over the Bay of Bengal. The subsequent progress of the monsoon in the country is divided by the tapering peninsula into two bifurcating currents, i.e. (i) the Bay of Bengal Current, and (ii) the Arabian Sea Current. The Arabian Sea branch gradually advances northwards reaching Mumbai by 10th June and Central India by 15th June.

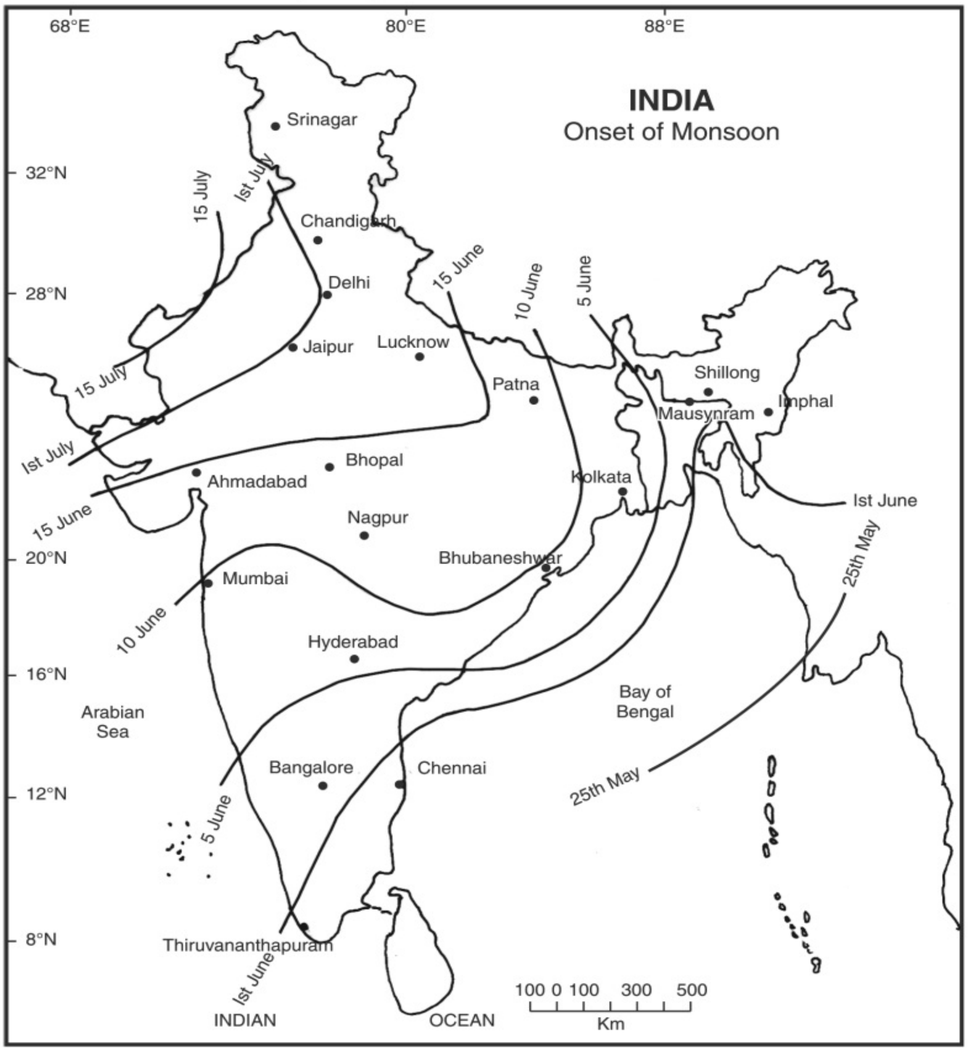


Fig. 4.11 Normal Dates of Onset of South-West Monsson

In the meantime, the progress of the Bay of Bengal branch is no less spectacular. It moves northwards into the central Bay of Bengal and advances to nearly 20° N latitude in the Bay by the third week of May. It rapidly strikes the Arakan Coast and Chittagong Hills with full force, the direction being southwesterly, but the greatest force is felt in the angle between the east-west Meghalaya Plateau of the Khasi Hills and the north-eastern Lushai Hills; Mizoram (Blue Mountains). Here Mawsynram to the west of Cherrapunji at an elevation of about 1313 metres receives nearly 1200 centimetres of rainfall annually. The Brahmaputra Valley is in the rainshadow of the Khasi Hills and receives less than 250 centimetres. The rainfall increases once again in the Himalayas, but the Bay of Bengal monsoon branch is deflected westwards due to the combined effect of the monsoon trough and the channelling by the Himalayas. As a consequence, its further progress is towards the Gangetic Plain of India, giving more rain to Himalayas and less in the plains. The arrival of the monsoon over Kolkata is 7th June, where, as mentioned earlier, the Arabian Sea branch of monsoon normally strikes Mumbai on 10th June. Both the branches of the monsoon current merge in the Gangetic Plain and gradually extend over Bihar, Jharkhand, Chhattisgarh, Uttar Pradesh, Uttarakhand, Haryana, Himachal Pradesh, Punjab, Jammu and Kashmir, and finally to Rajasthan, so that by the first week of July, i.e., within a mean interval of 29 days since the onset in Kerala, the south-west Monsoon is established all over India, excluding the Thar Desert. In the Thar Desert, the monsoon reaches by the middle of July, but only as a descending, drying wind, since by this time it has almost shed most of its moisture. It can be noted from **Fig. 4.11** that for parts of the country west of 80°E and south of 25°N, the advance of monsoon is from south to north, while in the rest of the country it is from south-east to north-west.

SEASONS IN INDIA

The subcontinent of India has great latitudinal dimensions. There are different seasons from Kanniyakumari (Cape-Camorin) to Jammu and Kashmir. The Meteorological Department of India, however, divides the seasons of India into the following four seasons:

A. Seasons of North-East Monsoon

1. Winter season, mid-December to mid-March
2. Hot weather season, mid-March to May.

B. Seasons of South-West Monsoon

3. Rainy season, June to September
4. Season of retreating monsoon, October to mid-December.

I. The Cold Weather Season

The cold weather season in the greater parts of India begins in the later part of November in the north, and by the beginning of December in the rest of the country. The cold weather season is characterised by out-flowing winds, dry and stable air, and clear skies. There develops a high pressure (anti-cyclone) area over north India, and a north-westerly flow prevails down the Indus and Ganges Valleys. During this season the southern branch of the subtropical jet stream is positioned over northern India. The middle latitude westerlies reach down to the surface north of about 25°N. South of this latitude the general movement of air is from the north-east. This north-easterly wind is called the winter monsoon. In Peninsular India, the general direction of wind is from east to west. Because of its trajectory over the Bay of Bengal, the easterlies are full of moisture and yield some precipitation along south-east coastal regions.

During winter season there is a general decrease in temperature from south to north. The isotherms run almost parallel to the latitudes. The 18° C isotherm for the month of January runs in a east-west direction through the middle of the country, connecting the Tapi estuary in the west and the Mahanadi delta in the east (**Fig. 4.12**). In the month of January, the north-western parts of the Great Plains of India (Punjab, Haryana, western Uttar Pradesh and Rajasthan) experience less than 15°C mean monthly temperature. The night temperature in the plains of Punjab, Haryana and Rajasthan (Amritsar, Hissar, and Jodhpur) occasionally reads below the freezing point, producing ground frost condition. Often, there is a decrease of more than 6°C in the mean temperature, resulting into **cold wave** in the northern plains of India. In south India, the isotherms tend to bend to the south and run almost parallel to the coast. The western coast is warmer than that of the eastern coast by about 2°C. The diurnal range of temperature is about 15°C in the Great Plains and only

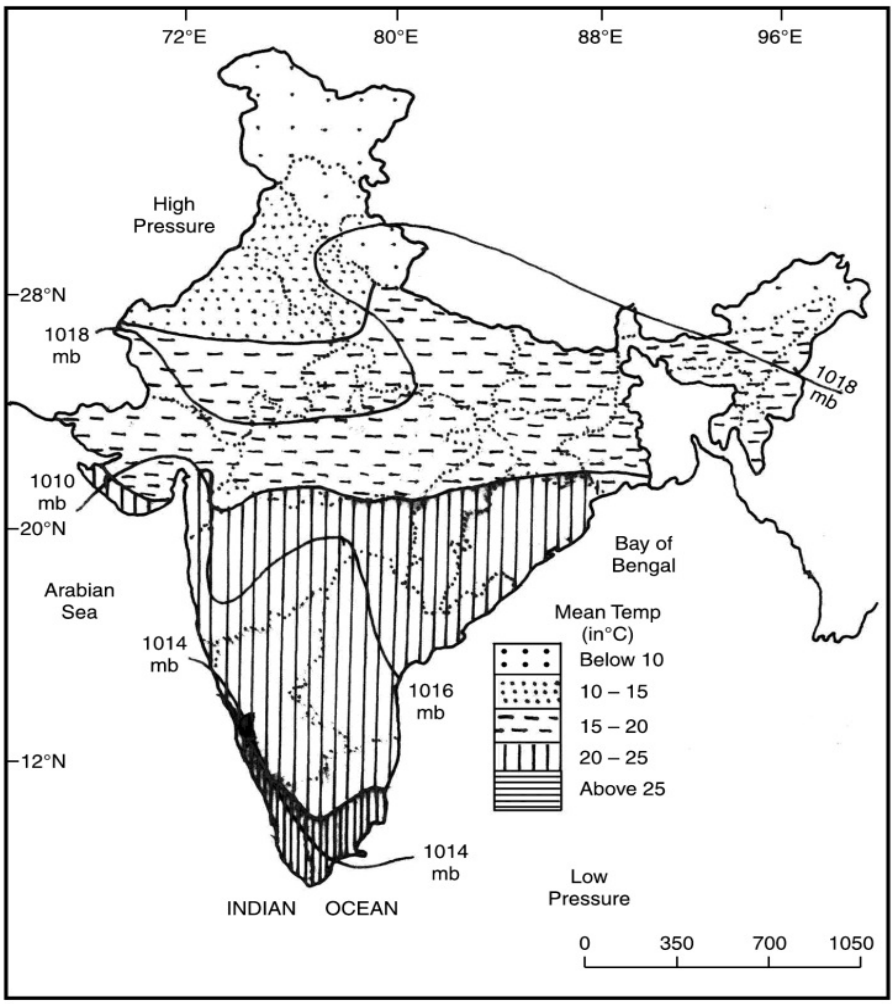


Fig. 4.12 Mean January Temperature

about 5°C in the coastal areas of the Peninsula. January is the coldest month in India, especially in northern India. Peninsular India, however, does not have a well defined cold weather season. The mean maximum temperature for the month of January at Thiruvananthapuram and Chennai reads 31°C and 30°C respectively (**Fig. 4.12**).

A characteristic feature of the cold weather season is the inflow of western disturbances originating from the Mediterranean Sea. The frequency of these disturbances is 4 to 6 per month between December and January. In north-western region of the subcontinent, winter precipitation is caused by the depressions that are associated with the westerly disturbances moving out from the Mediterranean Sea. The cold weather precipitation, though small, is highly beneficial to '*Rabi*' crops. Besides, snowfall from the western disturbances feed the glaciers of the Western Himalayas.

The north-eastern parts of India also get some rainfall during the winter season. Arunachal Pradesh, Nagaland and Assam may get about 50 cm of rainfall during these months (**Fig. 4.13**).

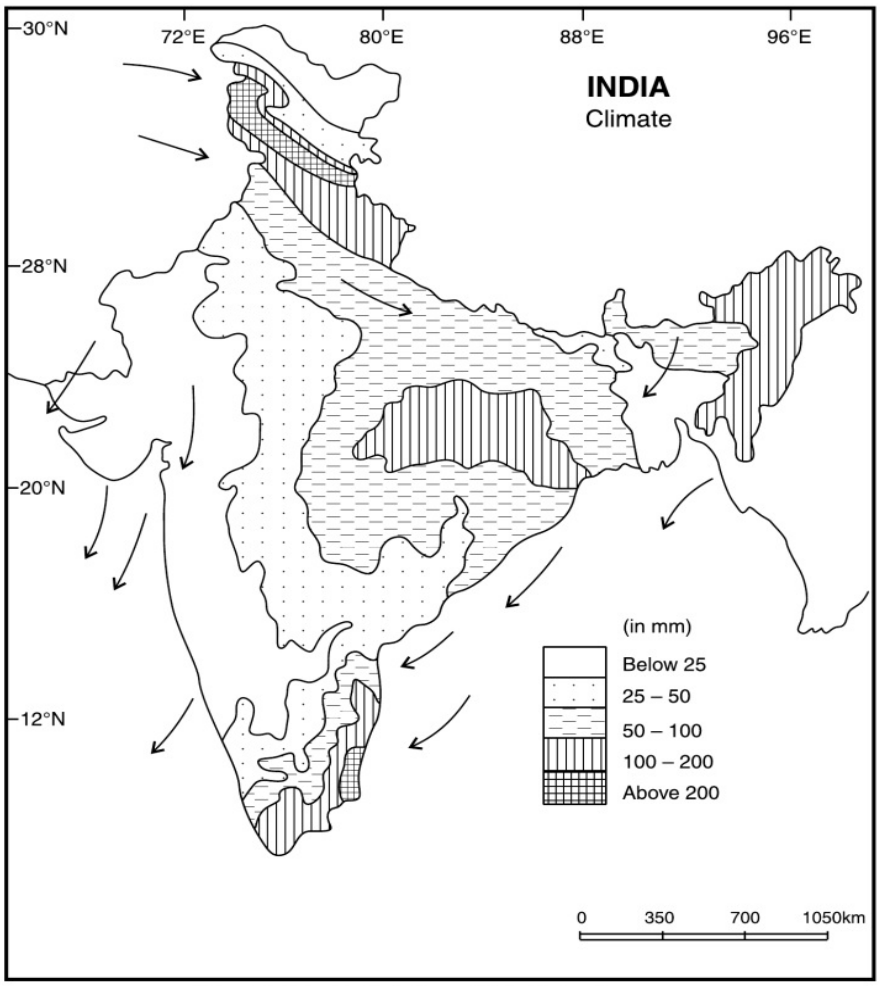


Fig. 4.13 Rainfall and Winds in January

2. The Hot Weather Season

The north Indian region experiences a well defined hot weather season from mid-March to mid-June. With the northward march of the sun towards the Tropic of Cancer after the vernal Equinox the temperature begins to rise. Thermal heating over north-western India gradually establishes a thermal 'low' at the surface but, while the jet stream remains south of the Himalayas, it maintains its dynamic anticyclone aloft over Afghanistan and the borderland of Pakistan. This 'lid' of subsiding warming dry air prevents the surface thermal 'low' from having sufficient effect as a lifting agent to carry air aloft and so to bring about precipitation (Johnson, 1969, p.l7).

At the advent of March, the temperature starts rising abruptly. By April, the Peninsular regions south of the Vindhyan Range heat up with mean maximum temperature of 40°C. In May, the mean maximum temperature reaches 42°C in Rajasthan, Delhi, west Uttar Pradesh, south Punjab,

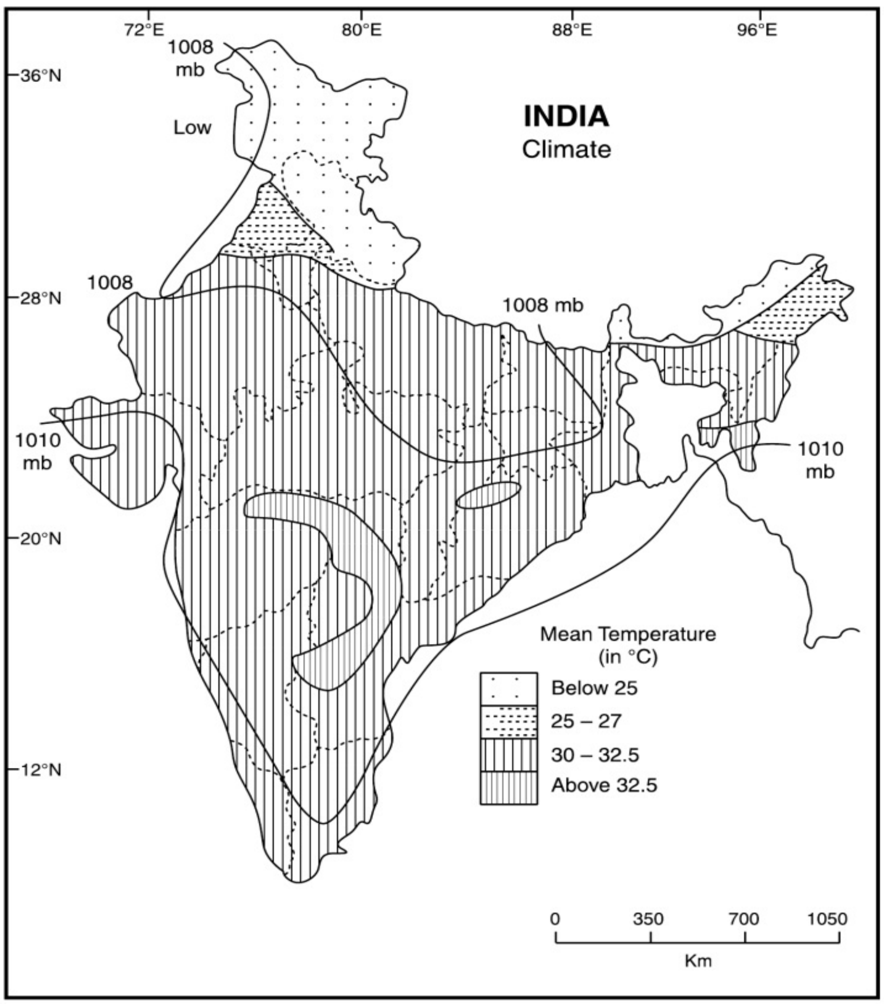


Fig. 4.14 Mean Temperature in April

and reaches Kolkata around 11th June. In Delhi, western Uttar Pradesh, Haryana, and Punjab, the monsoon reaches around 1st July.

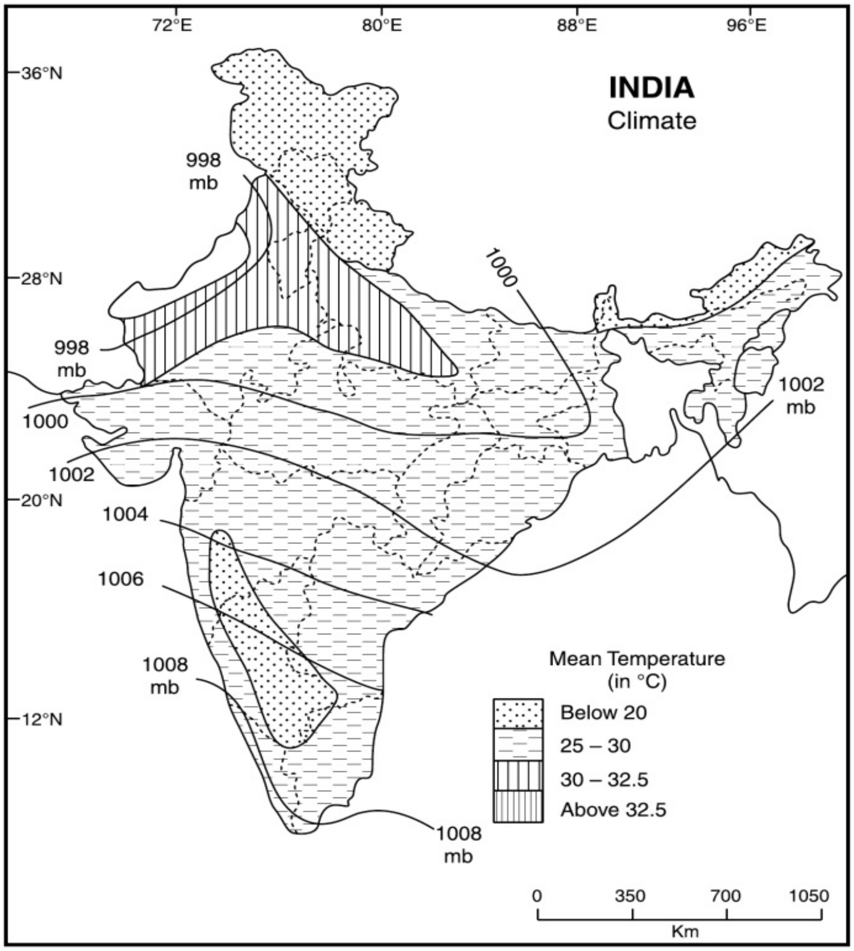


Fig. 4.15 Mean Temperature in July

During the season of general rains, most of the country experiences good cloud cover (from 1/8 to overcast sky). During this season, the relative humidity is generally over 65 per cent. Assam and Kerala record the highest percentage of relative humidity; over 80 per cent over the greater part of the rainy season.

The greater parts of the subcontinent of India receive over 85 per cent of their total rainfall during the season of general rains. The Arabian Sea current causes rainfall all along the Malabar coast, Konkan coast, Western Ghats, Maharashtra, Gujarat, and parts of Madhya Pradesh. Mumbai records about 190 cm of rainfall during this season. As the Arabian current crosses the Sahyadris, the places situated on the leeward side of the Western Ghats receive substantially less rainfall. For example, Pune (about 160 km to the east of Mumbai) gets only 125 cm of rainfall. Nagpur records

Jammu city and Haryana. Temperature exceeding 54°C was recorded at Sri Ganganagar in 1967. At some places, particularly in north-western India, day temperature may be as high as 45°C or 47°C. The mean minimum daily temperature in May also remains quite high being about 26°C at Delhi and Jaipur. The temperature in the eastern states of India and in the hilly regions in the month of May is generally cool and invigorating **(Fig. 4.14).**

In the month of April the 30°C isotherm of average temperature encloses a vast area of the country between 10°N and 26°N latitudes (except the west coast and the hilly states of north -east India). The diurnal range of temperature ranges between 5°C and 6°C in coastal areas, but reaches 20°C in the interior parts of the country and in the north-west Satluj Ganga Plains.

Being a transitional season between the north-east and the south-west monsoon (rainy season), it is characterised by unstable air pressure and wind circulation. With the northward movement of the sun, the low pressure area also moves from south-east to north-west. It finally settles over north-western India in the end of May or early part of June. The pressure generally increases towards south in the neighbouring sea. The general direction of winds is from north-west and west in north-western India; from south-west in the Arabian Sea and the adjoining coasts. The tornado-like dust storms of Punjab, Haryana, and western Uttar Pradesh, the hot winds (*Loo*) in western India, the Norwesters (*Kalbaisakhis*) of West Bengal are the characteristics of summer season.

During summer season, the Sun is scorching and the relative humidity is generally below 30 per cent, occasionally reaching below 10 per cent. The total rainfall of the season is below 2 cm in Rajasthan, Gujarat, Madhya Pradesh; between 5 and 15 cm in the sub-montane region of Uttarakhand, Himachal Pradesh, Punjab, Bihar and Odisha; and between 15 and 25 cm in the Malabar coast and over 50 cm in Assam, Meghalaya, Mizoram, and Nagaland. The rains caused by thunderstorms in Karnataka are called as 'Cherry Blossoms' (where these are beneficial for coffee plantation) and elsewhere in south India as 'mango showers'.

3. The Season of General Rains

By the end of June, a low pressure area develops over Punjab and Rajasthan. The southern branch of the jet stream weakens and is finally withdrawn from the southern slopes of the Himalayas by mid-June, leading to the formation of a dynamic depression over the surface thermal low. The Inter-Tropical-Convergence (ITC) moves further northwards occupying a position of 25°N by mid-June and allowing equatorial westerlies to gush in the subcontinent. The cyclonic vortices developed in the ITC cause rains in the country. The tropical easterly jet streams originating due to thermal heating of Tibet intensifies Indian Ocean high pressure cell from which south-east trade winds are pushed by the Antarctic circumpolar whirl to develop as south-west monsoon.

In the northern plains of India, the temperature reaches its maximum in June to break the monsoon. At places, the day temperature touches 46°C and more. The mean maximum temperature in the month of June at Jodhpur reaches 41°C , Delhi 40°C, Allahabad 39°C, Kolkata 33°C, 29°C at Kochi and 23°C at Shimla and Srinagar. The diurnal range of temperature is high being about 30°C at Leh, and 15°C at Delhi. The diurnal range of temperature is, however, less than that of the month of May (**Fig. 4.15**).

Generally in the afternoon of a scorching day, rains begin suddenly. This is known as a 'monsoon burst'. The Arabian Sea current advances northwards by 1st June on the Kerala coast and reaches Mumbai by about 10^{th} June. By mid-June, it spreads over Saurashtra, Kachchh and Madhya Pradesh.

The Bay of Bengal current first strikes Andaman and Nicobar islands by about 25^{th} of May and reaches Meghalaya, Mizoram and Tripura by about 1^{st} June. It rapidly spreads over most of Assam, 125 cm and Thanjavur only 85 cm of rainfall. The sub-branch of the Arabian Sea current which moves northwards through Kachchh, Gujarat and Rajasthan gives little rainfall to these regions due to the parallel alignment of the Aravallis. The Arabian sea current goes straight up to the western Himalayas, where it gives appreciable rainfall in Uttarakhand and Himachal Pradesh.

The Bay of Bengal current first dashes against the Myanmar coast, and obstructed by the eastern hills, is deflected westward towards the Ganga Plain. This current causes the heaviest rainfall at Mawsynram (about 1200 cm) and Cherrapunji (1100 cm) annually. A major part of this rainfall occurs in the morning hours. Here also, the leeward sides of the Meghalaya Plateau receive lower rainfall; 150 cm and 160 cm at Shillong and Guwahati, between June and September respectively. Moving westward, the Bay of Bengal current gives Kolkata 120 cm, Patna 105 cm, Allahabad 90 cm, Delhi 65 cm, Bikaner 25 cm and Srinagar (J&K) only 20 cm of rainfall between June and September (**Fig. 4.16**).

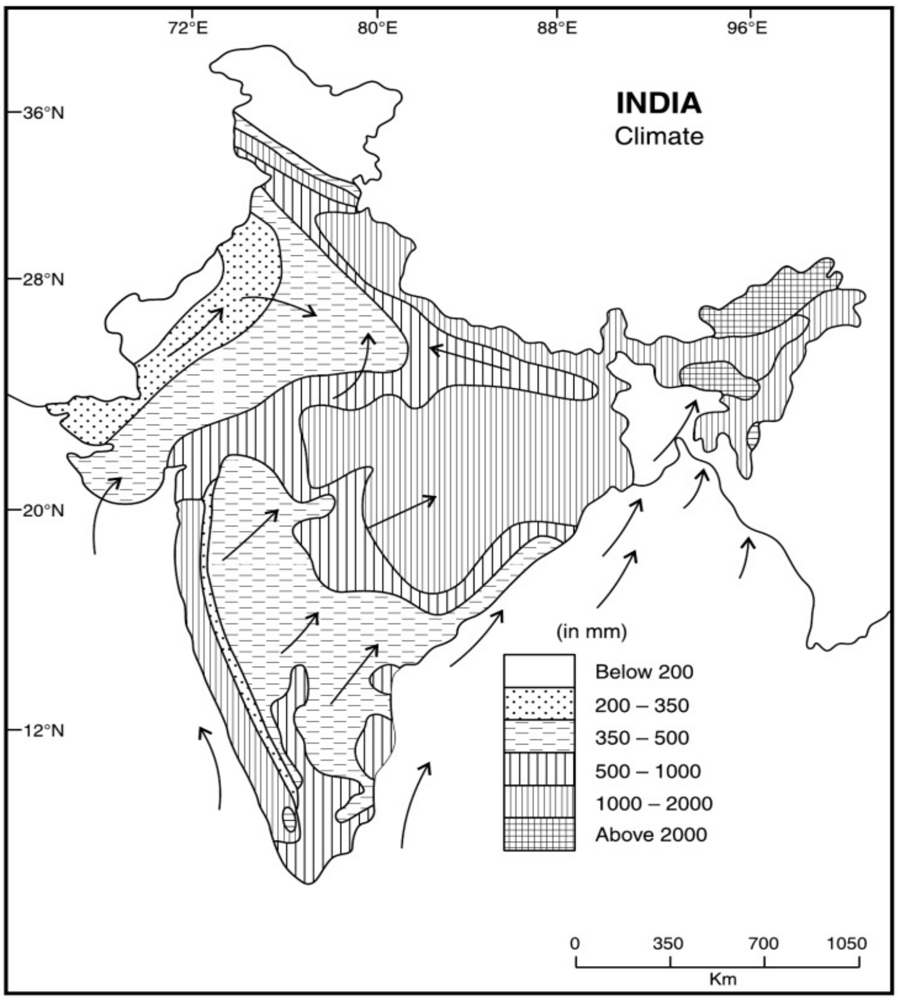


Fig. 4.16 Rainfall and Winds in July

The weather and amount of rainfall received are also affected by a number of cyclonic depressions which enter the country through the Bay of Bengal and the Arabian Sea (**Fig. 4.17**). About 20 to 25 such depressions are developed during the monsoon period, of which some are stronger, causing immense damage to life and property of the people residing in the coastal areas of West—Bengal, Odisha, Andhra Pradesh, Tamil Nadu, and Gujarat. The cyclone of October 29, 1999 with a velocity of over 300km/h killed over one lakh people. More than two million houses were washed away and about 12 million people were rendered homeless. These cyclones are generally accompanied with heavy rain, the amount of which decreases going away from the coastal areas.

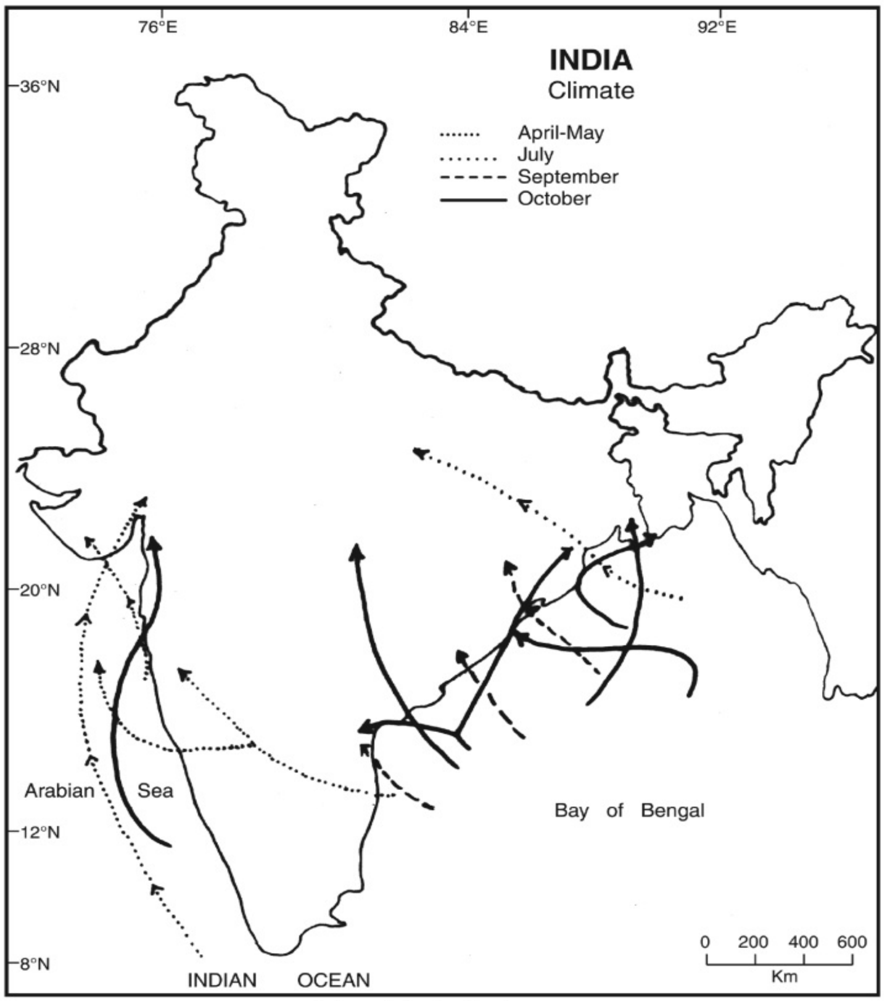


Fig. 4.17 Cyclones

The distribution of rainfall during the rainy season has been plotted in **Fig. 4.16.** It may be seen from this figure that the western coast, Sahyadris, Meghalaya, Arunachal Pradesh, Mizoram, Nagaland, Sikkim, and Darjeeling hills get more than 200 cm of rainfall. The remaining parts of north-eastern India, West Bengal, Odisha, Jharkhand, Bihar, Chhattisgarh, the Tarai region and hills of Uttarakhand and U.P. receive rainfall between 100 to 200 cm. Similarly, the southern and western Uttar Pradesh, northern and western Madhya Pradesh, eastern Maharashtra and Gujarat, and northern Andhra Pradesh experience rainfall between 50 and 100 cm. Rajasthan, western Gujarat, southern Andhra Pradesh, Karnataka plateau, Tamil Nadu, plains of Haryana, Punjab, and Jammu and Kashmir receive less than 60 cm of rainfall. The lowest rainfall is recorded in the Thar desert along the border of Pakistan, and the Ladakh region of Jammu and Kashmir state (**Fig. 4.20**).

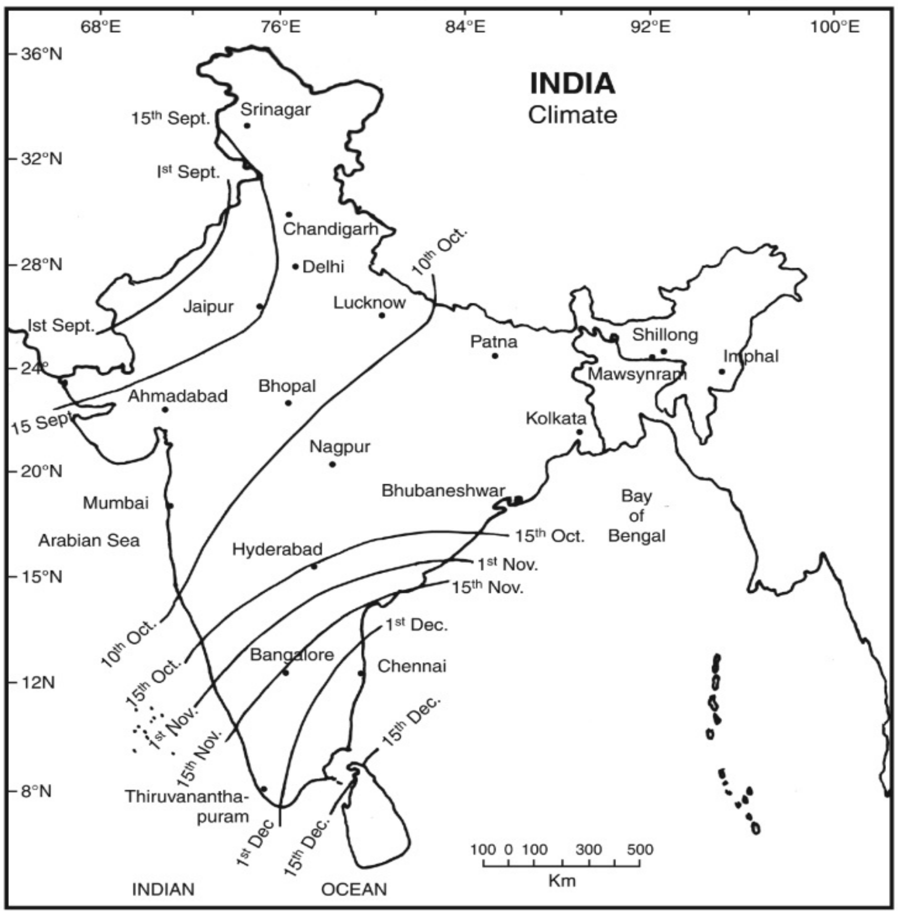


Fig. 4.18 Normal dates of Withdrawal (Retreat) of South-West Monsoon

4. Season of Retreating Monsoon

The south-west monsoon begins to retreat from northern India by the third week of September with the southward migration of the sun. By the end of September, the south-west monsoon retreats from the Punjab plains and adjacent regions. However, unlike the sudden burst of monsoon, the retreat is steady and gradual (**Fig. 4.19**). By mid-October, the southerly branch of the jet stream returns to its winter position south of the Himalayas.

The temperature during the season of retreating monsoon is uniformally high being about 25°C in the beginning of October in Northern India. The day temperature is generally high, but nights become pleasant with the mean going down to 20°C or even lower. The temperature begins to decline in November and by December cold weather sets in with about 15°C average temperature in the north and north-west parts of Indian plains, about 20°C in the central parts of India, and about 25°C along the coasts.

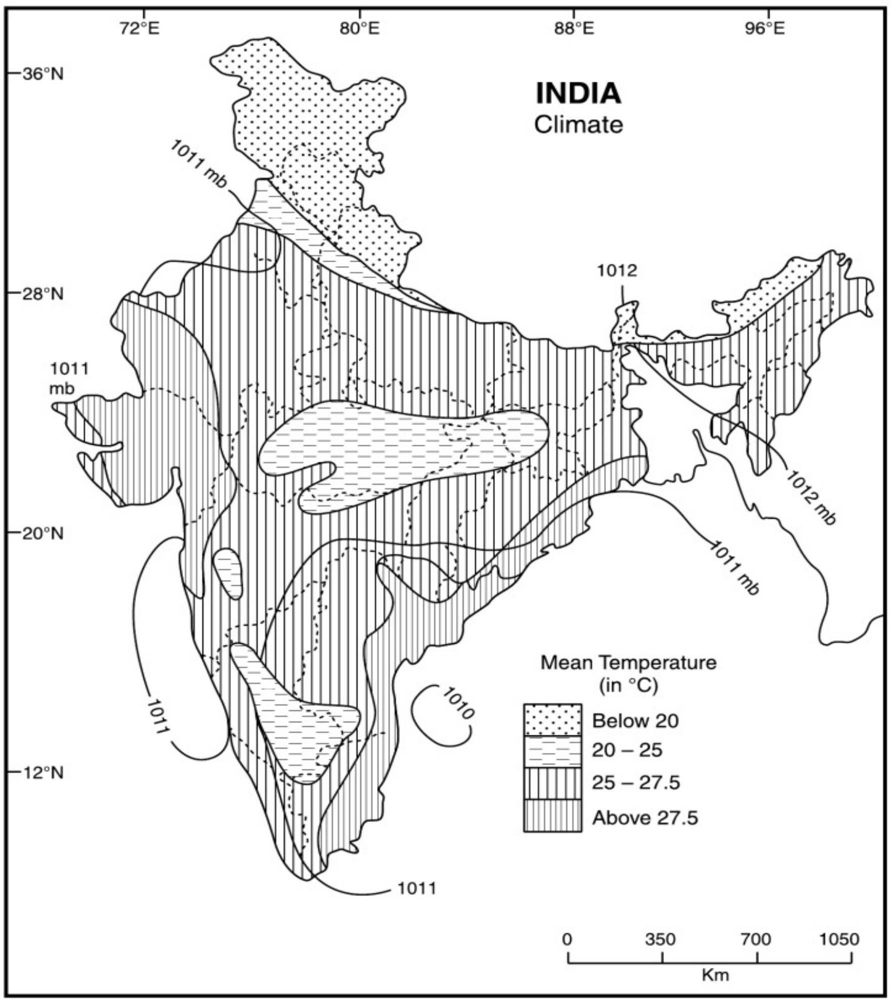


Fig. 4.19 Mean October Temperature

With the advent of October, the low pressure area over the north-western parts of India is dissipated and its place is taken by the low pressure cell located over the northern parts of Bengal. By the beginning of December it moves further southwards and by month end, it merges with the equatorial low. The winds are westerly in the north-western parts of the country and in the Ganga Plain, north-easterly in the Peninsular region and north-westerly in the east coast.

RAINFALL DISTRIBUTION

The distribution of rainfall in India is highly uneven. Its distribution is largely controlled by the nearness of the sea and the orographic features. The influence of the Western Ghats, the Plateau of Meghalaya, the north-eastern Hills, and the Himalaya Mountain is quite significant. The average annual distribution of rainfall in India has been shown in **Fig. 4.20**. It may be observed from **Fig. 4.20** that the regional variations in the distribution of average annual rainfall over India are quite pronounced. In the southern parts of the Meghalaya Plateau (Mawsynram and Cherrapunji), the average annual rainfall is more than 1200 cm. However, it drops to 200 cm or less in the Brahmaputra Valley and the adjoining hills.

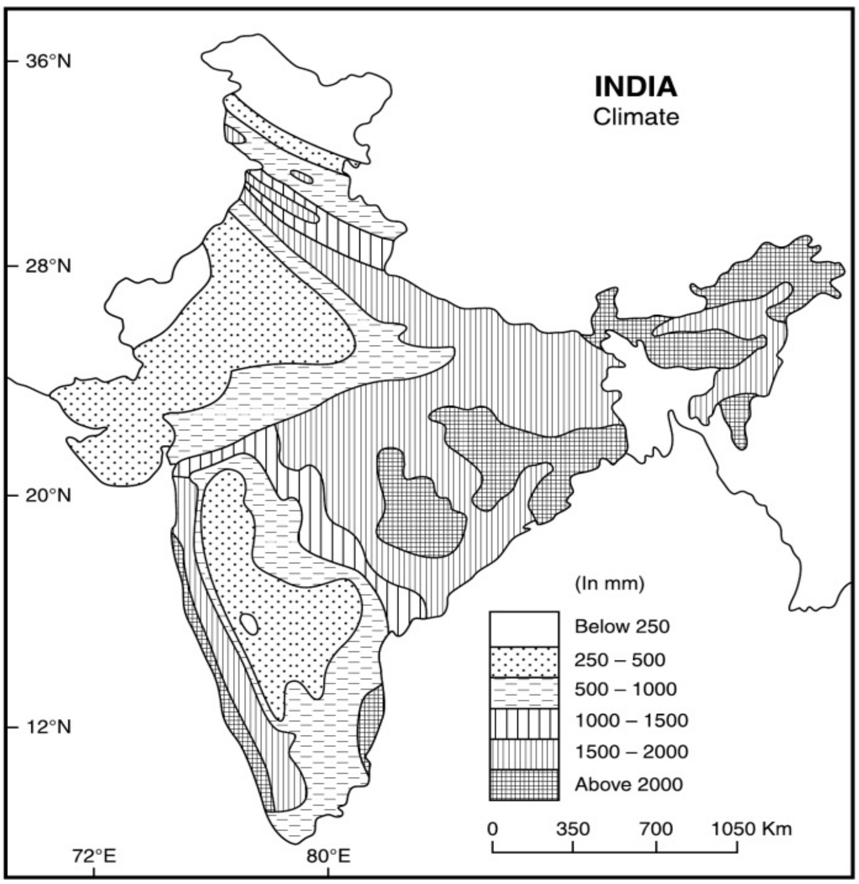


Fig. 4.20 Annual Rainfall (1950–2005)

In Peninsular India, the highest rainfall occurs along the Konkan and Malabar coasts. The isohyte of 150 cm rainfall runs southwards from the Gujarat coast, roughly parallel to the crest of the Western Ghats upto Kanniyakumari. In nortern India, it includes the hills of Himachal Pradesh, Uttarakhand, Chhattisgarh, eastern Maharashtra, and northern Andhra Pradesh. The regions lying to the west and south-west of this line have generally deficient rainfall where agriculture is largely vulnerable to drought. Along the Coromandal Coast of India the average annual rainfall is over 100 cm. In Punjab, Haryana and northern Rajasthan the mean annual rainfall is 60 cm or less. The lowest rainfall is recorded in western Rajasthan, the north-western parts of Gujarat, and Ladakh where it is less than 20 cm (**Fig. 4.20**).

VARIABILITY OF RAINFALL

The rainfall in India is highly variable. The actual rainfall of a place in a year deviates from its average rainfall by 10 to over 60 per cent. The mean annual variability of rainfall in India has been plotted in **Fig. 4.21**.

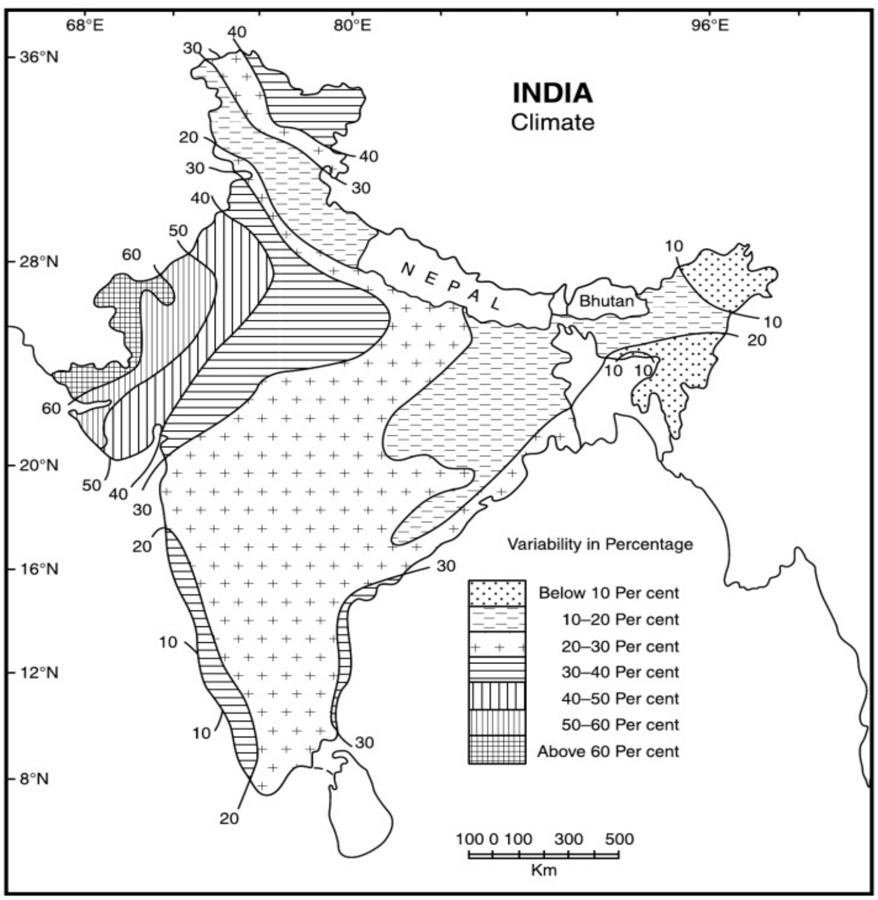


Fig. 4.21 Variability of Rainfall (1950–2005)

It may be noted from **Fig. 4.21** that the highest variability is found in the areas where the average annual rainfall is the lowest. For example, the desert areas of Barmer, Ganganagar, Jaisalmer, Jodhpur, etc. have less than 20 cm of average annual rainfall. In these areas the variability of rainfall is around 60 per cent. Contrary to this, in the areas where the average annual rainfall is over 200 cm (Mawsynram and Cherrapunji, Meghalaya Plateau), the annual variability of rainfall is less than 10 per cent. The Western slopes of Western Ghats, the Lesser Himalayas, the Shiwaliks and the Tarai belt also record between 100–200 cm of average annual rainfall. The variability of rainfall in these regions is around 10 to 20 per cent. Thus, there is an inverse relationship between the average annual rainfall and variability in rainfall.

The variability of rainfall has a significant role in the agricultural operations and other economic activities of the country. The areas showing high variability of rainfall have chronic deficiency of water. Such regions are highly prone to droughts, floods and famines, while the areas with high average annual rainfall are less affected by droughts; though flood is a regular feature in flood prone areas.

CLIMATIC REGIONS OF INDIA

India is often referred to as a country with tropical monsoon type of climate. The large size of India, its latitudinal extent, the presence of the Himalayas in the north, and the Indian Ocean, Arabian Sea and Bay of Bengal in the south have resulted in great variations in the distribution of temperature and precipitation in the subcontinent of India.

A number of attempts have been made by climatologists, geographers and experts of agriculture to divide India into climatic regions. While some of these classifications have been suggested for world climates, others are exclusively applied to Indian conditions. Some of the important climatic divisions of India were made by the following experts:

1. H.E. Blandford, 1889
2. W. Koppen, 1918, 1931, 1936
3. C.W. Thornthwaite 1931,1933, 1948
4. L.D. Stamp and W.G. Kendrew, 1953
5. S.P. Chatterji, 1953
6. G.T. Trewartha, 1954
7. V.P. Subramanyam, 1956
8. B.L.C. Johnson, 1969
9. K.L Rao, et.al., 1971
10. R.L. Singh, 1971

A systematic study of the climatic divisions of India was attempted for the first time by H.E. Blandford—the first Director General of the Indian Meteorological Department—in 1889, who discovered that all types of climates found in the world are present within the subcontinent of India. This classification based on temperature and rainfall of a few selected stations of India was almost an overgeneralisation. A brief description of some of the important classifications of Indian climate has been given in the following:

KOPPEN'S CLASSIFICATION OF INDIAN CLIMATE

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

1. Humid (A)
2. Arid (B)
3. Semi-Arid (C and D)

These three broad climatic divisions were sub-divided into sub-types on the basis of seasonal variations in the distribution pattern of precipitation and temperature for which the symbols S, W, m, f, w, s, c, and h have been used. Based on Koppen' s climatic scheme, India can be divided into the following nine climatic regions (**Fig. 4.22**).

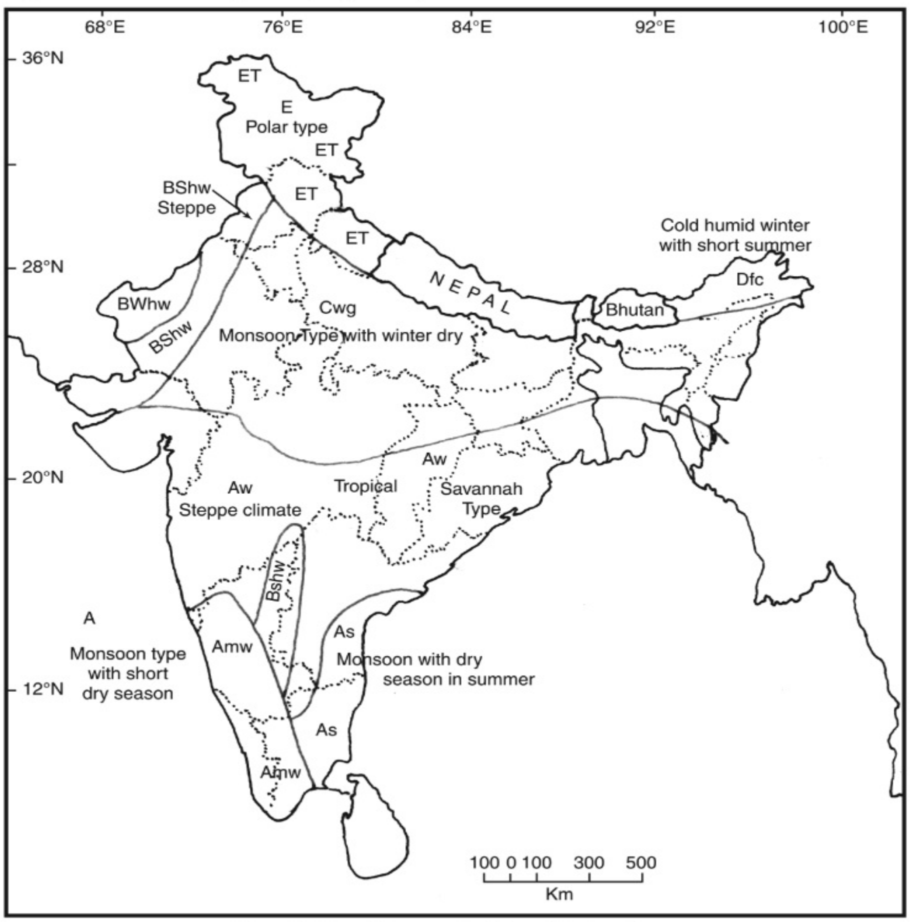


Fig. 4.22 Koppen's Climatic Regions

1. Aw (Tropical Savanna Type)

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

2. Amw (Tropical Monsoon Type)

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

3. As (Tropical Moist Climate)

It is characterised by dry summer season. The mean monthly temperature is more than 18°C in all the months. The average annual rainfall varies between 75–100 cm, and about 75 per cent of the total annual rainfall occurs between September and December. It occupies a narrow zone along the Coromandal coast.

4. BShw (Semi-Arid Steppe Climate)

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

5. BWhw (Hot Desert Type)

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

6. Cwg (Mesothermal Climate—Gangetic Plain Type)

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

7. Dfc (Cold Humid Winter Type)

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

8. E (Polar Type)

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

9. ET (Tundra Type)

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

CLIMATIC DIVISIONS BY STAMP AND KENDREW

Professor L.D. Stamp and W.G. Kendrew divided India into several climatic divisions. This classification is arbitrary and subjective. Stamp used 18°C isotherm of mean temperature for January to divide the country into two broad climatic regions, namely:

A. the subtropical or continental zone lying to the north of this isotherm, and
B. the tropical zone lying to the south of this isotherm (**Fig. 4.23**). It may be seen from **Fig. 4.23** that the isotherm of 18°C runs roughly parallel to the Tropic of Cancer.

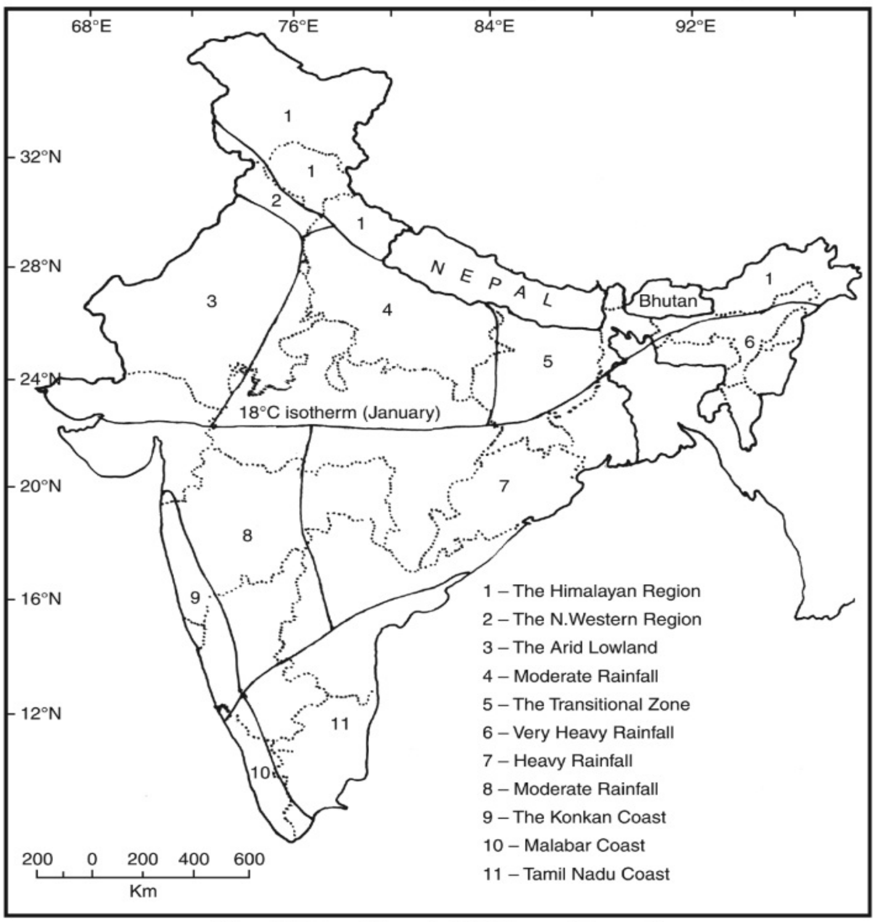


Fig. 4.23 Climatic Divisions (Stamp)

The two major climatic divisions, on the basis of rainfall, have been further divided into eleven regions:

A. The Subtropical or Continental climate has been divided into the following five divisions:
   1. The Himalayan Region
   2. The North-Western Region
   3. The arid lowland (dry plains)
   4. The region of moderate rainfall
   5. The transitional zone

B. Tropical India has been divided into the following six regions:
   6. Region of very heavy rainfall
   7. Region of heavy rainfall
   8. Region of moderate rainfall
   9. The Konkan Coast
   10. The Malabar Coast
   11. The Tamil Nadu region

A. Subtropical Climate

The subtropical climate has been subdivided into:

1. The Himalayan Region

Stretching over the mountainous parts of the states of Jammu and Kashmir, Himachal Pradesh Uttarakhand, Sikkim and Arunachal Pradesh, it has mild summers and cold winters. The regional distribution of temperature is largely controlled by the topography and aspect of slope. Upto a height of 2500 metres, the average temperature of winter season ranges from 4°C to 8°C, and the summer temperature varies from 12°C to 18°C. Rainfall is recorded from the South-West Monsoon in summer and from the western disturbances in the winter season. The amount of rainfall decreases from east to west. For example, in eastern Uttarakhand the average annual rainfall is over 200 cm, while in western parts of Jammu and Kashmir it falls below 150 cm. Snowfall and sleet are the common features in the Greater and Lesser Himalayas during the winter months (December to March).

2. The North-Western Region

This type of climate is found to the north-west of Satluj river where the average temperature of the winter season reads around 15°C. The mean minimum temperature in the month of January may occasionally fall below the freezing point at Amritsar. The mean maximum temperature in the month of May and June may cross 45°C. Hot winds (*Loo*) and dust storms during the scorching summers are the other features of this climatic region.

3. The Dry Plains of North-West India

This climate stretches over Rajasthan, Kachchh, and south-western parts of Haryana. In this region the winter temperature ranges between 15°C and 25°C, but occasionally, the maximum temperature crosses 47°C in the months of May and June. The average annual rainfall is below 25 cm and occurs mainly during the months of July and August; the season of general rainfall.

4. Areas of Moderate Rainfall

This climatic division stretches over Punjab, Haryana, the Union Territory of Delhi, western Uttar Pradesh, eastern Rajasthan, and western Madhya Pradesh. The average rainfall in this climatic division varies between 40 to 100 cm. The mean temperature of January varies between 15°C to 18°C. Over 85 % of the total rainfall is recorded during the season of general rains. Delhi, Ludhiana and Meerut are typical examples of this climate.

5. The Transitional Zone

This climate is found in Eastern Uttar Pradesh, western and north-western Bihar, and north-western Jharkhand. The average annual rainfall in this zone varies between 100 to 150 cm. Over 90 per cent of the total annual rainfall is recorded during the season of general rains from the Bay of Bengal stream of the South-West Monsoon. The mean January temperature reads about l5ºC while the mean maximum in the month of July reads over 40°C.

B. Tropical India

6. Region of Very Heavy Rainfall

This climatic divison stretches over Assam, Meghalaya, Nagaland, Manipur, Tripura and Mizoram. The average annual rainfall in these areas is over 200 cm. The heaviest rainfall in the world is recorded in this region at the stations of Mawsynram and Cherrapunji. Over 90 per cent of the average annual rainfall is recorded during the season of the South-West Monsoon. There are significant variations in the mean monthly temperature of January and July owing to undulating and mountainous topography.

7. Region of Heavy Rainfall

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

8. Region of Moderate Rainfall

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

9. The Konkan Coast

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

10. The Malabar Coast

This climatic division lies between Goa and Cape Camorin (Kanniyakumari). The Malabar coast records over 250 cm of rainfall. The average annual temperature reads around 27ºC with 3ºC being the annual range of temperature. Kochi is a typical example of this region.

11. The Tamil Nadu Region

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

TREWARTHA'S CLASSIFICATION OF INDIAN CLIMATE

G.T. Trewartha modified the climatic classification of Koppen in 1954. His classification of climate is empirical, based on the temperature and precipitation data. He also used English alphabets as the symbols to show the different types of climate. His scheme, applied to India, divides the country into four major climatic regions which are further sub-divided into seven meso-climatic divisions (**Fig. 4.24(a)**).

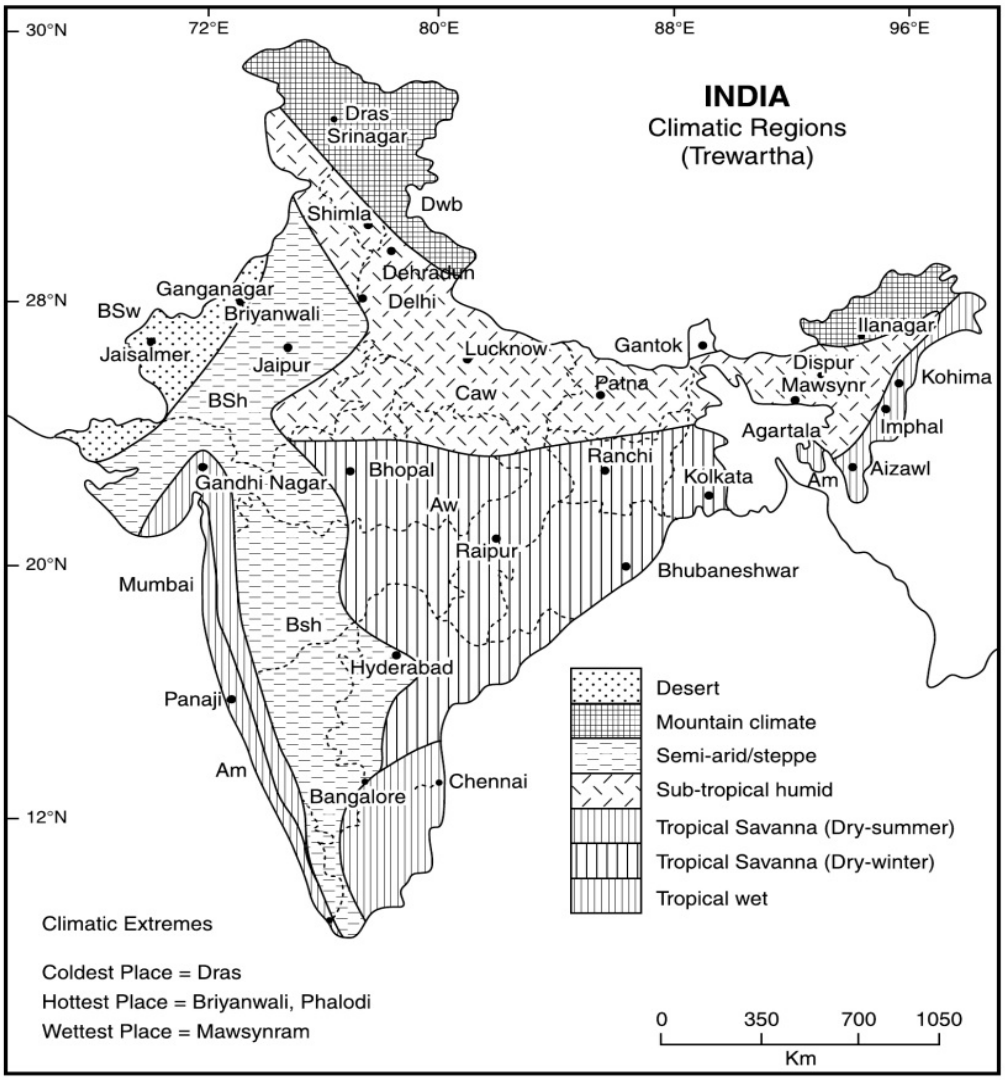


Fig. 4.24(a) Trewartha's Climatic Regions

1. The Tropical Rainy Climate (Am)

The mean annual temperature in this climate is about 27°C and the mean annual rainfall exceeds 250 cm. The Western Ghats and the state of Tripura exhibit this type of climate.

2. The Tropical Savannah Climate (Aw)

In this climatic type, the mean annual temperature remains around 27°C. The mean annual rainfall is less than 100 cm. It has a marked dry season. The greater parts of the Peninsular India, excluding the coastal plains and the western slopes of the Western Ghats, have been included in this climate type.

3. The Tropical Steppe Climate (BSw)

The mean annual temperature in this climatic zone is about 27°C. It covers peninsular India east of the Western Ghats. In fact, it is the rain-shadow area of the Western Ghats including parts of Maharashtra, Andhra Pradesh, Karnataka, and Tamil Nadu.

4. The Sub-tropical Steppe Climate (BSh)

This is a semi-arid climate stretching over parts of Gujarat, eastern Rajasthan, Maharashtra, Andhra Pradesh, and southern Haryana. The mean annual temperature in this climatic region is over 27°C, though the mean monthly January temperature reads only about 15°C. The annual range of temperature is significantly high. The mean annual rainfall varies between 60 to 75 cm.

5. The Tropical Arid Climate (BWh)

It lies to the west of the Aravallis, stretching over the Thar Desert. The mean maximum temperature during the months of May and June occasionally crosses 48ºC. The mean annual rainfall is less than 25 cm. The lowest rainfall in the country is recorded in this climate in the district of Ganganagar. Consequenty, the natural vegetation is in the form of thorny bushes.

6. The Humid Sub-tropical Climate (Caw)

This climate occupies the greater parts of the Great Plains of India, stretching from Punjab to Assam. The mean January temperature for the coldest month of January is less than 18°C, while the mean maximum in the summer season may cross 45°C. The average annual rainfall varies from 250 cm in the east to only about 65 cm in the west.

7. The Humid Mountain Climate (Dwb)

This climate is found in the hilly parts of the states of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Arunachal Pradesh, and the other hilly parts of north-east India. In this climate, the average temperature for the summer season reads around 17°C, while the average January temperature is generally around 8°C. The average temperature of all the months is however, closely influenced by the topographical features and slope. In general, the rainfall decreases from east to west. The Western Himalayas record some amount of rainfall from the western disturbances during the winter season.

CLIMATIC DIVISIONS OF INDIA BY R.L. SINGH (1971)

Professor R.L. Singh modified the climatic divisions of Stamp and Kendrew in 1971. Prof. Singh has divided India into 10 major climatic divisions. His classification is quantitative as well as qualitative, largely based on the amount of rainfall and temperature. In fact, the modifications have been done on the basis of variations in temperature (**Fig. 4.24(b)**). A brief account of Singh's classification has been presented in the following section:

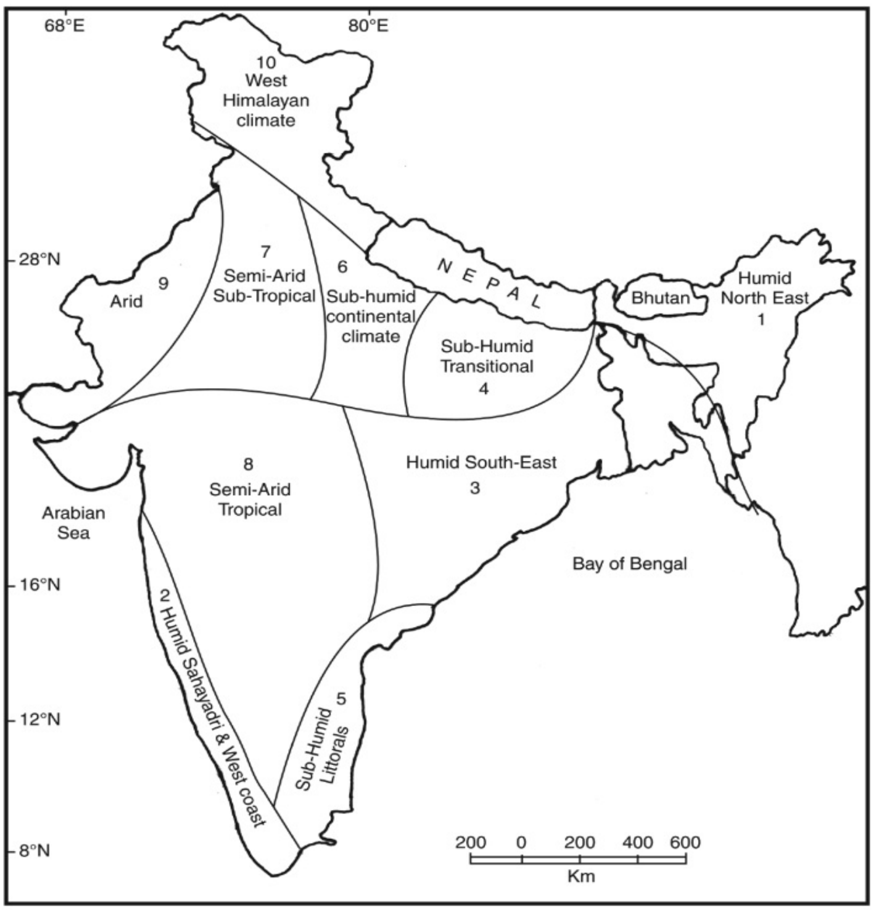


Fig. 4.24(b) R.L. Singh's Climatic Divisions

I. The Humid North-East

This climatic division includes the whole of north-east India (except Tripura), Sikkim and north-western West Bengal. The average annual rainfall in this climatic division is more than 200 cm. The mean July temperature varies between 25°C and 33°C, while mean January temperature reads between 10°C and 25°C.

2. Humid Sahyadri and Western Coast

This climatic zone includes the Konkan and Malabar coasts from the mouth of Tapi river to Kanniyakumari. The average annual rainfall in this zone is about 200 cm. The mean July temperature ranges between 25°C and 30°C, while that of January ranges between 18°C and 28°C.

3. The Humid South-East

This climate spreads over the greater part of West Bengal, Jharkhand, Chhattisgarh, Odisha and parts of Andhra Pardesh. It records an average annual rainfall between 100–200 cm. The mean July temperature varies between 25°C to 35°C, while the mean January temperature reads between 12°C–27°C.

4. The Sub-Humid Transition

This climate includes those parts of the Gangetic Plain in which the average annual rainfall is between 100 and 200 cm, Average temperature for July varies between 25°C, and 40°C and January temperature between 10°C and 25°C.

5. The Sub-Humid Littoral

This type of climate is found along the Coromandal coast. The mean annual rainfall varies between 75–150 cm. The May temperature reads between 28°C and 38° C, while the January temperature ranges between 20°C–30°C.

6. The Sub-Humid Continental

Covering mostly the Upper Ganga Plain, it receives average annual rainfall between 75–150 cm. The average temperature for July ranges between 25°C and 40° C, and the average January temperature recorded varies between 17°C and 25°C.

7. Semi-Arid Subtropical

This type of climate spreads over eastern Rajasthan, Haryana, and Punjab. The average annual rainfall in this climate varies between 25 to 75 cm. The average temperature for January ranges between 25°C to 28°C, while the average temperature for January ranges between 15°C and 25°C.

8. The Semi-Arid Tropical

It covers the largest area of the central and western Peninsula covering Gujarat, Maharashtra, Madhya Pradesh, Karnataka and western Andhra Pradesh. The average annual rainfall in this region varies between 50 and 100 cm, the mean monthly temperature in July varies between 26°C and 40° C, while the mean average temperature for January reads between 15°C and 28°C.

9. Arid

Covering the greater part of Kachchh, western Rajasthan, and south-western Haryana, it receives rainfall less than 25 cm. In fact, the Thar desert of India has been included in this type of climate. June is the hottest month here in which the average temperature varies between 30°C and 40°C. In January, the mean minimum monthly temperature fluctuates between 10°C and 15°C. It is the most drought affected area of the country in which every third year is a drought year.

2. Humid Sahyadri and Western Coast

This climatic zone includes the Konkan and Malabar coasts from the mouth of Tapi river to Kanniyakumari. The average annual rainfall in this zone is about 200 cm. The mean July temperature ranges between 25°C and 30°C, while that of January ranges between 18°C and 28°C.

3. The Humid South-East

This climate spreads over the greater part of West Bengal, Jharkhand, Chhattisgarh, Odisha and parts of Andhra Pardesh. It records an average annual rainfall between 100–200 cm. The mean July temperature varies between 25°C to 35°C, while the mean January temperature reads between 12°C–27°C.

4. The Sub-Humid Transition

This climate includes those parts of the Gangetic Plain in which the average annual rainfall is between 100 and 200 cm, Average temperature for July varies between 25°C, and 40°C and January temperature between 10°C and 25°C.

5. The Sub-Humid Littoral

This type of climate is found along the Coromandal coast. The mean annual rainfall varies between 75–150 cm. The May temperature reads between 28°C and 38° C, while the January temperature ranges between 20°C–30°C.

6. The Sub-Humid Continental

Covering mostly the Upper Ganga Plain, it receives average annual rainfall between 75–150 cm. The average temperature for July ranges between 25°C and 40° C, and the average January temperature recorded varies between 17°C and 25°C.

7. Semi-Arid Subtropical

This type of climate spreads over eastern Rajasthan, Haryana, and Punjab. The average annual rainfall in this climate varies between 25 to 75 cm. The average temperature for January ranges between 25°C to 28°C, while the average temperature for January ranges between 15°C and 25°C.

8. The Semi-Arid Tropical

It covers the largest area of the central and western Peninsula covering Gujarat, Maharashtra, Madhya Pradesh, Karnataka and western Andhra Pradesh. The average annual rainfall in this region varies between 50 and 100 cm, the mean monthly temperature in July varies between 26°C and 40° C, while the mean average temperature for January reads between 15°C and 28°C.

9. Arid

Covering the greater part of Kachchh, western Rajasthan, and south-western Haryana, it receives rainfall less than 25 cm. In fact, the Thar desert of India has been included in this type of climate. June is the hottest month here in which the average temperature varies between 30°C and 40°C. In January, the mean minimum monthly temperature fluctuates between 10°C and 15°C. It is the most drought affected area of the country in which every third year is a drought year.

10. The Western Himalayas

It includes the mountainous areas of Jammu and Kashmir, Himachal Pradesh and Uttarakhand. The average annual rainfall in this climatic division is up to 150 cm. The rainfall however, decreases from east to west and south to north. Rainfall from the western disturbances during the winter season is also a unique characteristic of this climatic zone. This small amount of rainfall is highly beneficial for the standing ***Rabi*** (winter) crops. The mean July temperature ranges from 5°C to 30° C, while the average temperature of January varies from 0°C to 5° C.

DROUGHTS

Drought is a continuous and lengthy period during which no significant rainfall is recorded. In India, the Meteorological Department of India defined drought as a period of at least 22 consecutive days on none of which is there more than 0.25 mm (0.01 inch) of rainfall. This definition however, does not apply to the whole of India. In areas like Mawsynram and Cherrapunji (recording over 1200 cm of average annual rainfall) even one week recording less than 0.25 mm of rainfall may be considered as a drought period. In general, the areas recording less than 60 cm of rainfall annually and in which the variability of rainfall is more than 20 per cent are the drought prone areas in India. Areas where the variability of rainfall varies between 20 to 60 per cent (like Rajasthan, west of Aravallis, and east of the Western Ghats) are the chronic drought prone areas. In India, droughts are more frequent in the areas where the average annual rainfall is less than 60 cm and the variability of rainfall is over 20 per cent, provided canal and tube-well irrigation is not available. The variability of rainfall over greater parts of the country is more than 25 per cent, and thus over 50 per cent of the country is vulnerable to droughts.

According to the Ministry of Agriculture and the Ministry of Environment, 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 greater than 40 per cent. A drought year occurs when less than 75 per cent of the average annual rainfall is recorded.

On an average, one in every five years is a drought year in India, while in western Rajasthan every third year is a drought year. Although over 60 per cent of the area has high variability of rainfall, there are three areas which are highly vulnerable to droughts (**Fig. 4.25**). The drought prone areas of India are:

1. **The Arid and Semi-arid Areas of Rajasthan:** There is a contiguous region, covering greater parts of northern Gujarat, Rajasthan, south-west Haryana, southern parts of Punjab, western Madhya Pradesh, and parts of the Agra Division of Uttar Pradesh. This drought prone area, having a variability of rainfall of over 40 per cent, stretches over 65 lakh sq km. Parts of these contiguous drought prone areas, irrigated by canals and tube-wells are, however, less affected by droughts.
2. **The Rain-shadow Areas of Western Ghats:** This is the area lying to the east of the Western Ghats (Sahyadri Mts), stretching from Jalgaon (Mahrashtra) to Hyderabad and Mahbubnagar (Andhra Pradesh), Bidar, Bijapur, Gulbarga, and Raichur of Karnataka, and Coimbatore, Madurai, Salem and Remanathapuram of Tamil Nadu. The variability of rainfall in this region varies between 30 to 40 per cent. It is in this areas that several thousand farmers have committed suicide during the last decade.

3. **Other Drought Prone Areas:** There are isolated tracts, covering an area of about one lakh sq km in different parts of the country, which are drought prone areas. These areas include Kalahandi region of Odisha, Purulia District of West Bengal, Palamu plateau of Jharkhand, Mirzapur Plateau, and Bundelkhand (U.P.), Baghelkhand (Madhya Pradesh), Coimbatore, Madurai and Tirunelveli District of Tamil Nadu. These scattered pockets cover over one lakh sq km.

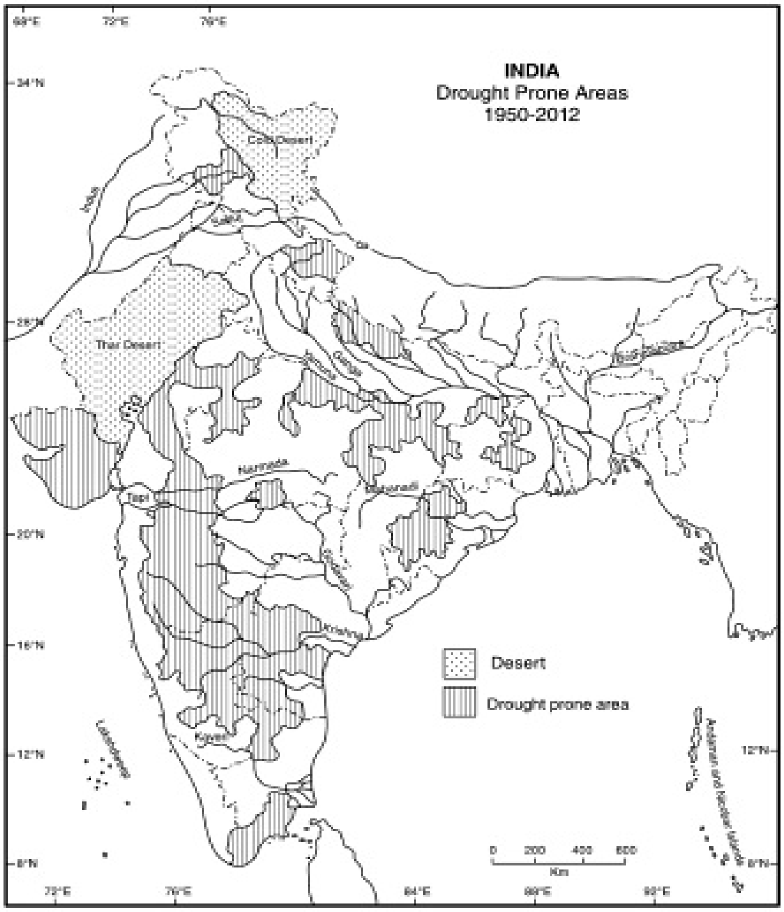


Fig. 4.25 Drought Prone Areas (1950–2012)

Though droughts are recurring physical phenomena and their severity was more during the medieval period, some of the serious droughts of the 20th century have been briefly described in the following section:

The Maharashtra drought of 1965–66, the Bihar drought of 1966–67, the Kalahandi drought of 1996–97 and the continuous deficient rainfall in Andhra Pradesh, Karnataka and western Tamil Nadu during the last decade forced a number of the farmers to commit suicide. The monsoon failure in 2009 over greater parts of the country resulted into drought. Consequently the Kharif cropped area decreased by about 40 per cent.

The adverse effects of droughts can be minimised by an extension in the irrigation projects, adoption of sprinkle irrigation, water harvesting, suitable rotation of crops, deviation from the more water requiring crops, and dry-farming techniques. If all these steps are taken together, the miseries of the farmers and inhabitants of the drought prone areas may be reduced substantially.

Droughts are disasters which affect the people and economy of the country adversely. Their frequency, according to experts of climatology, is likely to increase in future due to greenhouse gases, climatic change and ecological imbalances created by interference of man.

The years of 1965–67, 1972–73, 1979–80, 1985–88, 1999, 2000, 2001, 2002 and 2009 have been the drought years in India after Independence. According to the experts the drought of 2002 and 2009 was one of the worst droughts in the last one hundred years. In these years, the states of Haryana, Punjab, Uttar Pradesh, Uttarakhand, Bihar, Madhya Pradesh, Gujarat, Tamil Nadu, Karnataka, Jharkhand, Odisha, parts of Kerala, and the whole state of Rajasthan were the worst affected.

Drought Management

The government of India has paid enough attention to droughts and drought affected areas right from the first Five Year Plan. Before 1987, the government tried to provide relief to the people of the drought affected areas by providing employment opportunities to the affected population and distribution of food-grains through Public Distribution System (PDS). The contingent drought relief expenditure imposed a serious strain on public finances as huge amounts had to be divested from development for undertaking relief projects. In some states like Rajasthan, the drought relief outlays exceeded the developmental outlays.

In order to overcome this problem, the drought management strategy was adopted in the early 1970s. The drought management approach differed from drought relief approach with regard to objectives, reliance of early warning indicators and timing of public intervention. The objective of relief approach was to protect entitlement of the affected population by ensuring physical and economic access to food through relief projects and public distribution of food-grains. As against this, the drought management approach aimed at ensuring entitlement to produce food so as to obviate the need for taking up ad hoc relief projects. While drought relief approach relied on socio-economic indicators like crop production data, price rise, migration of the drought affected people and increased rate of crimes for drought declaration and intervention; drought management approach relied on hydro-agriculture indicators, like rainfall, water level of reservoirs and progress of cropping pattern to detect early signs of developing drought situation. While drought relief approach enabled the government to intervene only in the months of November and December when the rainy season is over and the kharif crops have been harvested, the drought management approach enabled the government to intervene in the monsoon season itself.

According to the Committee of Disaster Management (2002), drought management is generally done by focusing on employment generation, water conservation, and power supply, standing crop saving and public distribution of supplies of essential commodities.

Drought Prone Area Programme (DPAP)

The drought prone area programme which covers 615 blocks, spread over ninety districts in the western, central and southern parts of the country, is an integrated area development programme in agricultural sector. The main objectives of the Drought Prone Area Programme are:

(i) to make judicious and scientific utilisation of agricultural land, water and livestock resources,

(ii) to enhance and stabilise the income of the people of drought prone areas, particularly of the weaker section of society, and
(iii) restoration of ecological balance.

Some of the important elements of the programme include:

(a) Integrated watershed management and management of water resources.
(b) Soil and moisture conservation measures.
(c) Afforestation with special emphasis on social and agro-forestry.
(d) Development of pasture lands and forest range management in conjunction with development of sheep husbandry.
(e) Livestock development and dairy development.
(f) Restructuring of cropping patterns and changes in agronomic practices.
(g) Adoption of scientific rotation of crops with an emphasis on the leguminous (pulses) crops.
(h) Development of subsidiary occupations.
(i) Water harvesting.
(j) Development of minor irrigation projects.
(k) Construction of underground canals and lined canals.
(l) Desalination of sea-water for irrigation and domestic use.
(m) Diversification of agriculture.
(n) Development of cottage and household industries.
(o) Development of alternate sources of energy (solar, wind and biogas) for domestic and industrial purposes.
(p) More research is required to increase agricultural productivity in the dry farming regions.

These steps, if taken together, can go a long way in minimising the miseries of people living in the drought prone areas of the county.

Some of the important achievements of the Drought Prone Area Programme include the Indira Gandhi Canal Project, Sardar Sarovar Project (Narmada), and the Central Arid Research Institute, Jodhpur to promote drought resistant plants, trees and crops.

FLOODS

Floods occur when peak discharge exceeds channel capacity, and this may be brought about naturally by intense precipitation, snow and ice-melt, storm surges in coastal regions, and the rifting of barriers, such as ice-dams, or by the failure of man-made structures, by deforestation, urbanisations, (which reduce infiltration and interception), and by engineering works such as land drainage or the straightening of embankments of rivers.

Flood has also been defined as a state of high water level along a river channel or coast that leads to inundation of land which is normally submerged. Flood is an important component of hydrological cycle of a drainage basin. In fact, droughts and floods are the two extremes of the hydrological cycle. While droughts occur due to the failure of rainfall; floods generally occur in the event of excessive rainfall. Thus, flood is a natural hazard which occurs in response to heavy rains and it becomes a disaster when it inflicts heavy loss to life and property.

Causes of Floods

The main factors responsible for the occurrence of floods are: (i) Meteorological, (ii) Geomorphic, and (iii) Anthropogenic.

Meteorological factors include heavy rainfall, snowfall due to tropical cyclones, and cloud burst. Most of the floods in India are the result of heavy precipitation, especillay during the season of south-west Monsoon.

Geomorphic factors like the large catchment area of a river, gentle slope and the low gradient of river course, and poor drainage also lead to floods in the Northern Plains and Coastal Plains of India. The Jodhpur Barmer, and Bikaner flood in July 2006 mainly occurred due to cloud burst and poor drainage in the region.

The Anthropogenic causes including deforestation, encroachment for agriculture into pastures and forest areas, shifting cultivation, unscientific rotation of crops, bursting of dams and embankments, urbanisation, and construction of houses in the river beds are also responsible for a number of floods in the country. The July 2005 flood in Mumbai was mainly due to the construction of houses and structures in the bed of the Methi River.

Flood Prone Areas of India

Out of the country's total geographical area (329 millions hectares) about 45 million hectares (13.6 %) is prone to floods (2012). The flood prone areas of India have been plotted in **Fig. 4.26.** An examination of **Fig. 4.26** shows that the flood prone areas are well scattered in different parts of the country, ranging from the heavy rainfall areas to the scanty rainfall areas. Flood is, however, a recurring feature during the rainy season in Assam, West Bengal, Bihar, Uttar Pradesh, Haryana and Punjab. Floods also occur along the eastern coastal plains, the valley of Kashmir, the lower reaches of the rivers discharging their water in the Bay of Bengal and the Gulf of Khambat (Arabian Sea). The flood affected areas of India are as under:

1. The Ganga River Basin
2. The Brahmaputra River Basin
3. The Punjab Haryana Flood Plain
4. Flood Prone Areas of the Coastal Plains.

1. The Ganga River Basin

Stretching over an area of about 861,400 sq km, the Ganga and its tributaries drain the states of Uttarakhand, Himachal Pradesh, Haryana, Uttar Pradesh, Bihar, West Bengal, Jharkhand, Chhattisgarh, Madhya Pradesh, and Rajasthan. Its large left hand tributaries are Sharda, Kali, Gomti, Ghagra, Gandak, Kosi, and Mahananda; while the right hand tributaries include, the Yamuna, Chambal, Sind, Betwa, Ken, Son, and Damodar. Thus, from the mighty Himalayas and the northern Peninsular India, the Ganga and its tributaries carry enormous quantity of water. These rivers, due to heavy rains in the rainy season and melting of snow in the spring season, cause heavy floods in the middle and lower reaches of their catchments. Kosi (means *cuise-Kosna*) has often been called the "Sorrow of Bihar". Its flood in July 2008 caused heavy loss to life and property.

The cloud burst on 16th June, 2013 in Uttarakhand resulted into disaster in which the sacred places such as Kedarnath Rambara, Joshimath were seriously damaged. Except the Kedarnath temple almost the entire settlement was burried under sediments, boulders and coarse-sand.

The state of Uttar Pradesh alone constitutes about 22 per cent of the flood prone area of the country. The river channels of these rivers are increasingly getting shallower, especially in their middle and lower reaches. In the event of heavy rainfall, these rivers cross their banks and inundate the neighbouring khadar areas.

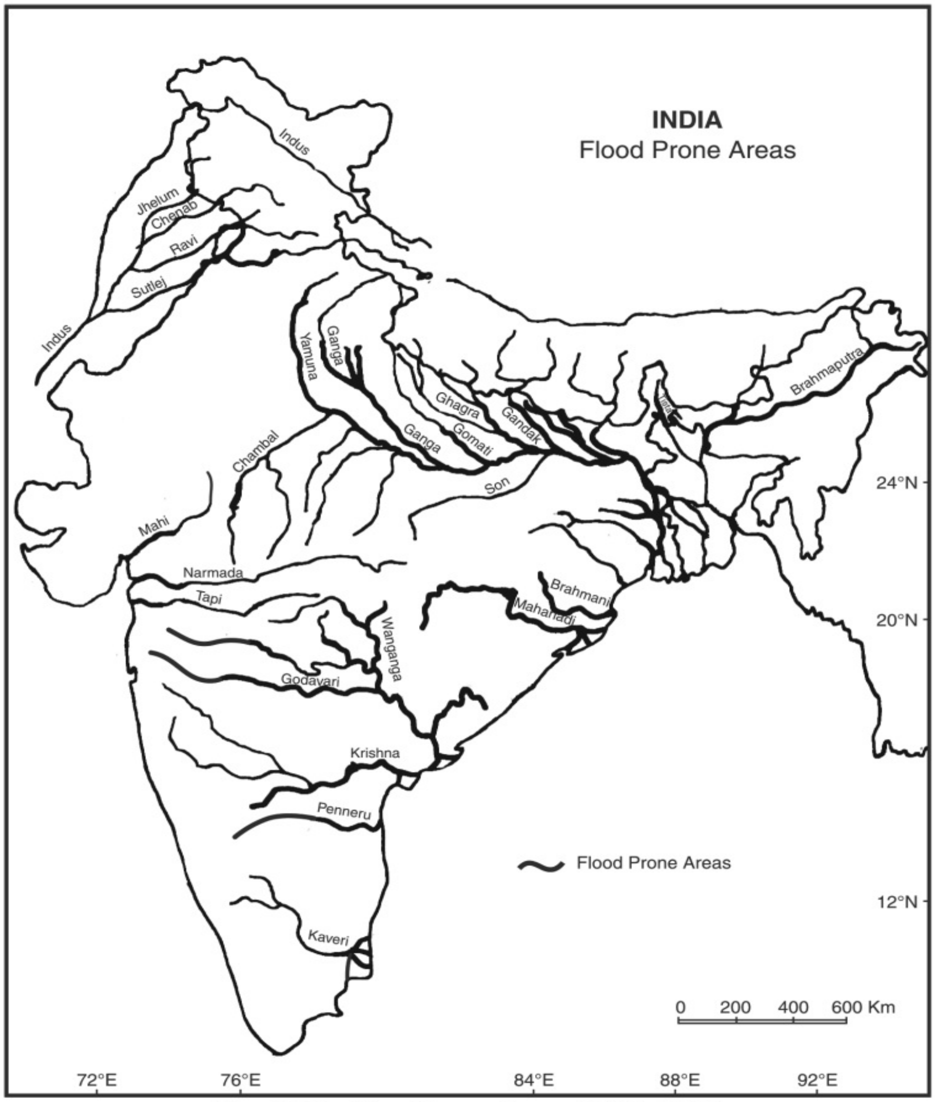


Fig. 4.26 Flood Prone Areas (1950–2012)

In Bihar, floods are largely confined to the northern part of the state where occurrence of flood is almost an annual feature during the season of general rains. The rivers like Burhi Gandak, Bagmati, Kosi, and the lower reaches of the Mahananda spill over their banks and inundate the low lying khadar areas. The Kosi flood 2009, created havoc in the districts Saharsa, Medhapur, and Khagaria of Bihar. Many of the cities and towns were submerged under water causing enromous loss to life and property.

In West Bengal, the southern and central parts are frequently flooded during the season of south-west monsoon. The Mahananda, Bhagirithi, Ajoy, and Damodar (Sorrow of Bengal) are often in floods in rainy season. Even after the formation of the Damodar Valley Corporation (DVC), there occur occasional floods in the rivers.

2. The Brahmaputra River Basin

The maximum discharge of water among the Indian rivers is in the Brahmaputra River. The Assam Valley is considered to be one of the worst flood affected areas of India. In fact, in Assam, floods are almost an annual feature. The main cause of floods in the Brahmaputra basin are: (i) heavy and torrential rainfall—during the rainy season over 200 cm of rainfall is recorded over greater parts of its middle and lower reaches, (ii) silting of the river course due to heavy soil erosion, (iii) landslides, (iv) heavy pressure of population, and (v) shifting cultivation on the surrounding hilly areas. All these factors collectively result in flooding of the vast areas in and around the Brahmaputra Valley.

All the districts of Assam are inundated almost every year. The worst affected areas in Assam are 'Majuli'—India's largest river island, Dhubri, Kokrajhar, Barpeta, Guwahati, Mangaldoi, Sibsagar, Jorhat, Dibrugarh, and Tezpur. According to one estimate, about 80 lakh hectares, i.e. over 45 per cent of the total area of Assam, is flood prone.

3. The Punjab Haryana Flood Plain

This area falls under the scanty rainfall recording areas of India. Despite low rainfall, Punjab and Haryana are adversely affected by floods because of the inadequate surface drainage. In Punjab and Haryana, the rainfall water is waterlogged. Consequently, the ill-drained areas are inundated. The rivers, like Satluj, Beas, Ghaggar, and Markanda record floods almost annually. The main reasons of floods in Punjab and Haryana are: (i) deforestation in the Lower Himalayas and the Siwalik, (ii) increase in soil erosion in the upper reaches of the rivers leading to silting of river beds, (iii) construction of structures in the ***Bet*** (Khadar) areas of the rivers, (iv) unscientific land use, cropping patterns and rotation of crops, and (v) obstruction of natural drainage by the construction of roads, railways and human establishments.

Floods are frequent in the Ghaggar plain of Punjab, Haryana and also Rajasthan. The Ghaggar river is seasonal in character. Its course disappears in the sand-dunes of Rajasthan after crossing Punjab and Haryana.

In the Valley of Kashmir, floods are caused by the Jhelum river. Tawi river is the main cause of floods in Jammu. In 2004, the release of huge quantity of water in Satluj river from the Rakas Lake threatened many areas of Himachal Pradesh.

4. Flood Prone Areas of the Coastal Plains

The coastal areas of Odisha, Andhra Pradesh, Tamil Nadu, Kerala, Maharashtra and Gujarat are included in this region. The magnitude of floods becomes serious in the lower reaches of the Mahanadi, Godavari, Krishna, and Kaveri. The beds of these rivers are shallow which inundate after a heavy downpour in their catchments. Indiscriminate felling of trees in the catchment areas of the main rivers and their tributaries has accelerated soil erosion and silting of river beds. The estuaries of Narmada and Tapi lead to floods at the occurrence of spring tides. The coastal areas also submerge due to the surge of sea water at the time of tropical cyclones in the Bay of Bengal and the Arabia Sea. The occurrence of Tsunamis, as on December 26, 2004, may cause serious damage to life and property of the coastal areas. The small swift moving rivers of the western coastal plains may cause considerable damage when in spate.

Flood Control and Management

The main steps taken by the government of India are briefly given below:

1. Flood Forecasting

The Central Water Commission started flood forecasting since November 1958, when the first forecasting station was established at the Old Railway Bridge of Delhi. Since then, it has extended the flood-forecasting stations to cover almost all the major flood prone rivers of the country. At present, there are 175 flood forecasting stations on different major and minor rivers of the country. The centre issues daily flood forecasts and warnings throughtout the season of general rains.

The Central Flood Forecasting Organisation monitors floods all over the country and issues warnings. The main flood forecasting centres are located at Surat (Tapi), Bharuch (Narmada), Varanasi, Buxar, Patna, Hathidah, and Aimabad (Ganga), Dibrugarh and Guwahati (Assam), Jalpaiguri (Tista), Delhi (Yamuna), Lucknow (Gomti), Bhubaneshwar (Subarnrekha, Burtha, Balang, Brahmani and Baitarni), Sahibi (Rajasthan), and Gandhi-Sagar (Chambal). In addition to these, there are 157 flood forecasting stations from which about 6000 forecasts are issued every year.

2. Reduction of Runoff

Reduction in runoff is one of the most effective methods of flood control. Runoff can be reduced by inducing and increasing the infiltration of the surface water into the ground. Afforestation in the catchment areas of rivers is a very effective step to check the runoff and to increase the percolation of water.

3. Construction of Dams and Reservoirs

The floods can be reduced by construction of dams and reservoirs. Dams have the capacity of holding huge quantity of water during the flood period and help in reducing the menace of floods. Water stored in reservoirs of dams can be released under controlled conditions, depending upon the carrying capacity of the river channel. A number of dams across the Damodar, Kosi, Satluj, Rihand, Mahanadi, Krishna, Kaveri, Chambal, Narmada, Tapi, and Sabarmati have been constructed to check floods.

4. Control of Flood Levels

A number of steps may be taken to control the flood levels. Among these steps, stream channelisation, channel improvement, and flood diversion are important.

5. Construction of Embankments

Construction of embankments is a very effective method against floods. Construction of embankments has been taken in a big way after the establishment of the Central Water Commission and the Flood Control Commission. Over 12,000 km long embankments have been constructed after the establishment of the Flood Control Commission. Most of these embankments have been constructed along the Brahmaputra, Ganga, Yamuna, Satluj, Beas, Ravi, Mahanadi, Kosi, Godavari, Krishna, and the Kaveri.

6. Flood Plain Zoning

Flood plain zoning is another very effective method of flood management. It is based on information regarding land use in flood plains. Some areas are more prone to floods than others. Construction of buildings, factories, etc. in the zone adjacent to the river channels should be prohibited. The areas occasionally flooded after a few years should be under green-belts in which social forestry is a priority.

7. Other Measures

The following additional measures are suggested by the Flood Control Commission: (i) restriction on indiscriminate felling of trees in hilly regions, (ii) protecting one kilometre tract along the major rivers for massive afforestation, where agriculture and house construction prohibited, (iii) Regular dredging of river beds, (iv) formation of National Water Grid through which flood waters could be diverted to dry areas through diversion channels or could be stored in reservoirs, (v) to develop suitable drainage channels in water-logged areas, and (vi) engineering effective methods to protect the coastal areas from tides and sea-surges.

Flood Control Programme and Strategies

The National Flood Control Programme was launched in India after the devastating flood of 1954. The programme consists of three phases which have been briefly described in the following section:

1. **The Immediate Phase:** This phase extends over two years and includes the collection of basic hydrological data and execution of immediate flood protection measures like construction of embankments, improvement of river channels and raising the vulnerable villages above the flood level.
2. **The Short-Term Phase:** This phase lasts for the next five years. In this phase there is emphasis on improvement of surface drainage, establishment of effective flood warning system, shifting or raising of villages above flood level, construction of diversion channels, construction of embankments and raised platforms to be used during the period of floods.
3. **The Long-Term Phase:** The long-term phase includes construction of dams and storage reservoirs, digging large diversion channels, taking suitable steps for land-use improvement, and soil conservation in the catchment area of the main river and its tributaries.

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

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Chapter 5

Natural Vegetation and National Parks

INTRODUCTION

Natural vegetation of India reflects a state of perfect harmony with the relief and climatic conditions of the subcontinent. In fact, this correspondence is so perfect that if one superimposes the two maps showing the annual rainfall and the altitude above the mean sea level, one can easily infer the types of vegetation that will be found in each major region of the country.

The present vegetal cover has a long history. According to Palaeo-botanists, most of our Himalayan and peninsular areas are covered with indigenous or endemic flora, while the Indo-Gangetic Plain and the Thar desert contain plant species that have come generally from outside. Here, the plant species are exotic and have migrated from the Trans-Himalayan areas (Tibet and China). This natural vegetation is classified as boreal. Plants which have come from the adjacent tropical regions are known as palaeo-tropical. Those plants which came from north Africa have influenced the vegetation of the arid and semi-arid regions, such as the Thar, as well as a good deal of the Great Plains of India. Those immigrating from Indo-Malaysia have influenced the vegetal cover of the hilly regions of north-eastern India. This process of the immigration of uninvited plant species is not only continuous, but has actually become more marked with the increase in communication with other lands, both by sea and air. Some of the exotic varieties are troublesome weeds. They thrive under conditions of tropical sun with abundant moisture, multiply rapidly and spread out as there are no 'natural' enemies to curb them in the new habitat. In course of time, their eradication becomes difficult; they invade the land and reduce the area for other uses, prevent the growth of plants which are economically important and become a hazard to public health by indirectly helping the spread of several diseases. We can cite two striking examples: lantana (*Lantana camara varauyleata Mold*) and water hyacinth (*Eichhornia crassipes Solms*).

Both were brought into India as decorative garden plants; the former having now spread out in forests and pasture lands, and the latter choking up our rivers, lakes and ponds so much so, as to earn its nickname 'terror of Bengal' because of its phenomenal growth in that region. It is spreading to almost all water sources, ponds and canals in the rest of the country.

It may be ascertained from the above description that much of our natural vegetal cover is not that natural, except perhaps in the inaccessible parts of the Himalayas and the interior of the

Thar desert. A considerable part of it has been replaced or destroyed as a result of human occupancy of the land. Much of the plant cover is in a degraded condition, that is, low in quality and content. What we usually designate as 'natural' vegetation now refers to a plant community that has been left undisturbed over a long time, so as to allow individual species to adjust themselves to geo-climatic conditions, as far as possible.

FLORISTIC REGIONS OF INDIA

Depending on the geo-climatic conditions, the flora of India differs from region to region and altitude to altitude. In 1937, C.C. Calder identified eight floristic regions of India (**Fig. 5.1**). These floristic regions are:

1. The Eastern Himalayan Region
2. The North-Western Himalayan Region
3. The Assam Region
4. The Gangetic Plain
5. The Indus Plain
6. The Deccan Region
7. The Malabar Region
8. Andaman and Nicobar Islands

1. The Eastern Himalayan Region

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

2.The North-Western Himalayan Region

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

3. The Assam Region

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

4. The Gangetic Plain

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

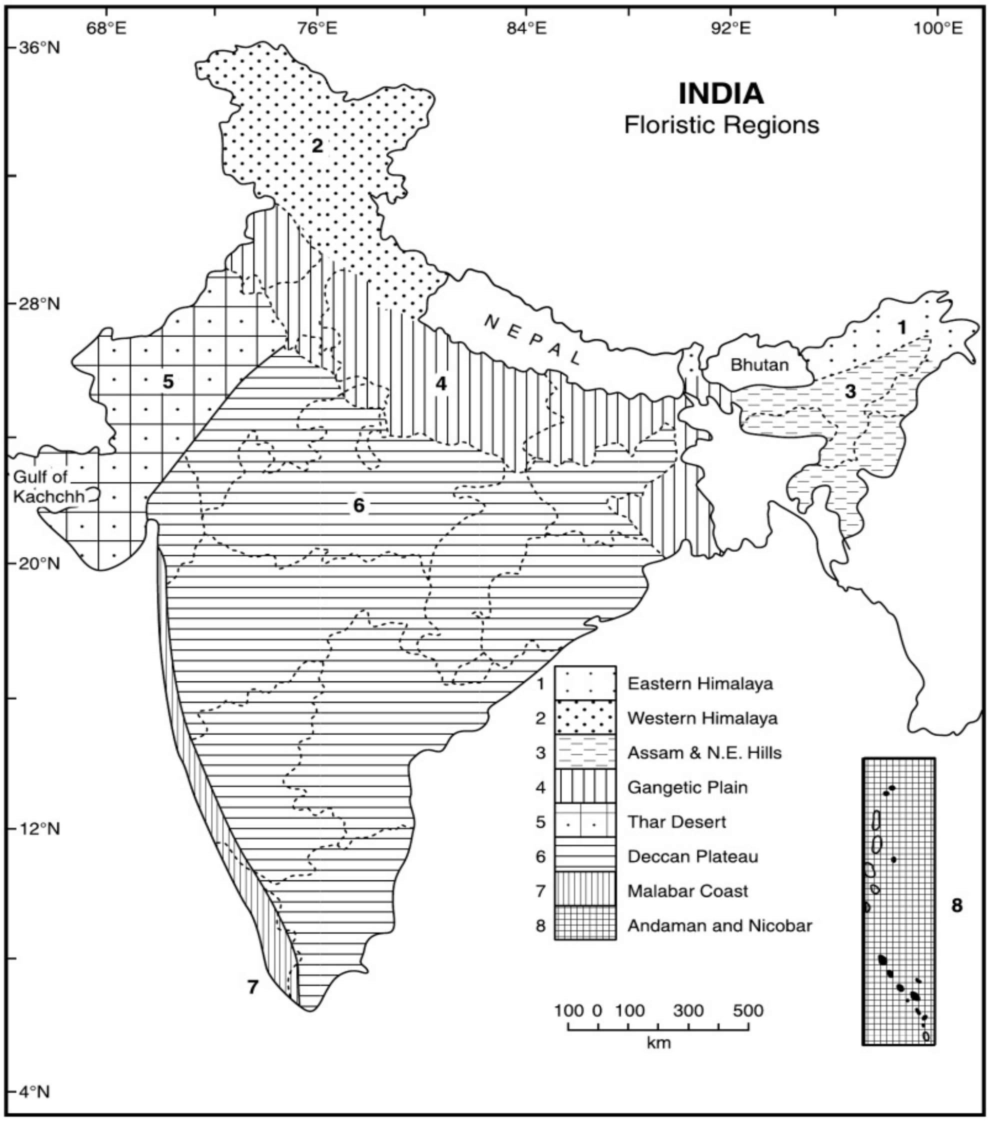

Fig. 5.1 Floristic Regions

5. The Indus Plain

This floristic region spreads over Punjab, Haryana, Rajasthan, west of the Aravallis, Kuchchh, and north-western parts of Gujarat. In this region the average annual rainfall is less than 75 cm . Consequently, its vegetation is of the type which can bear the arid and severe drought conditions. Acacias, cacti, wild-palms, khejra, and palas, etc. are the main trees of this region. During the rainy season, numerous grasses develop which wither during the dry season.

6. The Deccan Region

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

7. The Malabar Region

This region stretches all along the western coast from the Gulf of Khambat (Cambay) to Cape Camorin (Kanniyakumari). Here, the vegetation type ranges from moist tropical evergreen to broad leafed mixed and monsoon deciduous type. The Nilgiri Hills show temperate forests at higher altitudes. The region also contains several species of plants of the Malay origin.

8. Andaman and Nicobar

The Andaman and Nicobar Islands are covered by the equatorial evergreen forests of heavy wood.

SPATIAL DISTRIBUTION OF FORESTS IN INDIA

The total geographical area of India is 32,87,263 sq km, of which about 6,75,500 sq km—equal to 22.50 per cent—is under forests. According to the National Forest Policy (1952) about 33 per cent of the geographical area should be under forest. However, the existing forest area is much below the desired level. The areas under forest cover in India have been shown in **Fig. 5.2**. It may be observed from **Fig. 5.2** that the Himalayan mountains, Bhabhar and Tarai, Western Ghats, Eastern Ghats, Bundelkhand, Baghelkhand, Chotanagpur Plateau, North-eastern Hills, Nilgiris, and the hills of Peninsular India are the main areas of Indian forests. Unfortunately, about 5 to 6 per cent of the total forest area of the country is under the category of degraded forests.

The forest area in India is much below the world average of 34.5 per cent and that of Brazil (57 per cent), Sweden (58 per cent), USA (42 per cent), Germany (41 per cent), and Canada (36 per cent). Similarly, the per head forest area in India is only 0.07 hectare as against the world average of 1.10 hectares, Canada at 23 hectares, Brazil 8.6 hectares, Australia 5 hectares, Sweden 4 hectares, and USA 3.5 hectares per head of population.

Table 5.1 *The Region-wise Distribution of Forests in India*

Geographical region	*% of total forest area of India*
1. Himalayan Region	18.00
2. The Great Plains of India	5.00
3. Peninsular Plateau and Hills	57.00
4. Western-Ghats and Coastal Plains	10.00
5. Eastern-Ghats and Eastern Coastal Plains	10.00
Total	**100.00**

It may be observed from Table 5.2 that the largest forest area lies in Peninsular India accounting for 57 per cent of the total forest area of India. The Himalayan region has the second largest forest area having 18 per cent of the forest area of the country. The Eastern and Western Ghats have 10 per cent each, while the Gangetic-Plains have only 5 per cent of the forest area of the country.

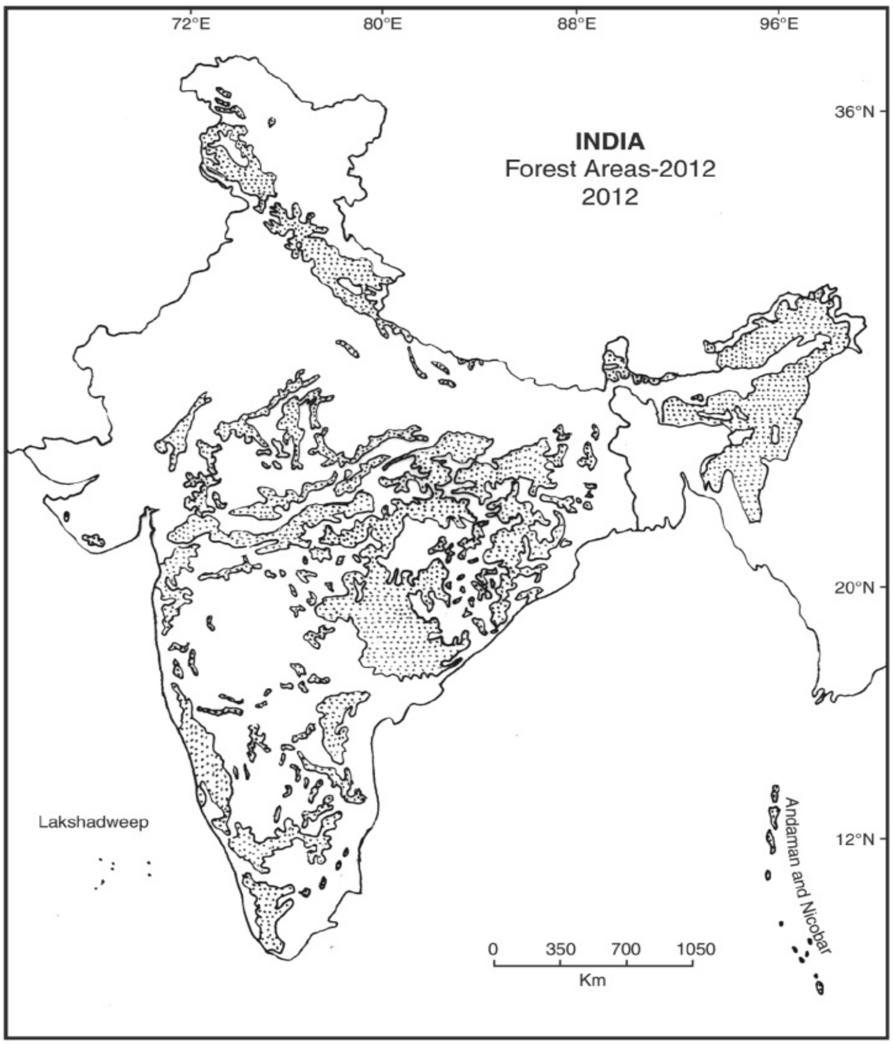

Fig. 5.2 Forest Areas (2012)

Table 5.2 *India—Statewise-Distribution of Forest*

State/Union Territory	*Geographical area*	*Total Forest Area*	*Percentage of forest area to geographical area*
State			
Andhra Pradesh	275069	44637	16.23
Arunachal Pradesh	83743	68045	81.25
Assam	78438	27714	35.33
Bihar	94163	5720	6.07
Chhattisgarh	135191	56448	41.75
Goa	3702	2095	56.59
Gujarat	196022	15152	7.73
Haryana	44212	1754	3.97
Himachal Pradesh	55673	14360	25.79
Jammu & Kashmir	222236	21237	9.56
Jharkhand	79714	22637	28.40
Karnataka	191791	36991	19.29
Kerala	38863	15560	40.04
Madhya Pradesh	308245	77265	25.07
Maharashtra	307713	47482	15.43
Manipur	22327	16926	75.81
Meghalaya	22429	15584	69.48
Mizoram	21081	17494	82.98
Nagaland	16579	13345	80.49
Odisha	155707	48838	31.37
Punjab	50362	2432	4.82
Rajasthan	342239	16367	4.78
Sikkim	7096	3193	44.99
Tamil Nadu	130058	21482	16.52
Tripura	10486	7065	67.38
Uttarakhand	53483	23938	44.76
Uttar Pradesh	240928	13746	5.71
West Bengal	88752	10693	12.05
Union Territories			
Andaman & Nicobar Islands	8249	6930	84.01
Chandigarh	114	9	7.89
Dadra & Nagar Haveli	491	219	44.60
Daman & Diu	112	6	5.36
Delhi	1483	111	7.48
Lakshadweep	32	27	84.38
Poducherry	480	36	7.50
India	**3287263**	**675538**	**22.50**

Source: ***India 2005, Govt. of India Publication***, New Delhi

An examination of Table 5.2 shows that Madhya Pradesh with 77,265 sq km has the largest area under forests in India, followed by Arunachal Pradesh with 68,045 sq km and Chhattisgarh with 56,448 sq. km. The rank of Odisha and Maharashtra are fourth and fifth respectively. With only 1754 sq. km, Haryana has the lowest area under forest among the states of India.

In terms of percentage, Mizoram with 83 per cent of its area under forest holds the first rank, followed by Arunachal Pradesh at 81 per cent and Nagaland at 80.50 per cent. The percentage of forest area in Meghalaya and Tripura are 69 and 67 per cent respectively. The lowest percentage of forest area is in Haryana (3.97 per cent) followed by Rajasthan (4.78 per cent) and Punjab (4.8 per cent). In general, the hilly and mountainous states have more percentage of area under forest while the forest cover in the states with plains is almost insignificant.

CLASSIFICATION OF FORESTS

The forests of India have been classified in a number of ways.

A. On the basis of **administration**, the forests have been classified into the following three categories:

1. **Reserved Forests:** These forests are under the direct supervision of the government and no public entry is allowed for collection of timber or grazing of cattle. About 53 per cent of the total forest area falls in this category.
2. **Protected Forests:** These forests are looked after by the government, but the local people are allowed to collect fuel-wood/timber and graze their cattle without causing serious damage to the forests. These forests occupy about 29 per cent of the total forest area of the country.
3. **Unclassified Forests:** The unclassified forests are those in which there is no restriction on the cutting of trees and grazing of cattle. About 18 per cent of the total forest area of the country falls under this category.

B. In the **Constitution of India**, forests have been classified under the following categories:

1. **State Forests:** These are under the full control of the government (State/Central) and include almost all the important forest areas of the country. They constitute about 94 per cent of the total forest area of the country.
2. **Commercial Forests:** These forests are owned and administered by the local bodies (municipal corporations, municipal boards, town areas, district boards, and village-panchayats). They occupy about 5 per cent of the total forest area of the country.
3. **Private Forests:** These are under private ownership and cover slightly more than one per cent of the total forest area of the country.

C. On the basis of **merchantability**, Indian forests may be grouped under two categories:

1. **Merchantable:** which are accessible. About 82 per cent of the total forest area belongs to this category.
2. **Non-Merchantable:** These are not accessible being situated in high mountainous areas with inaccessible topographical features. About 18 per cent of the total forest area (especially conifers) of the country fall in this category.

D. Based on Composition: Based on composition and types of leaves, Indian forests fall into two broad groups:

1. **Conifer Forests**: These are temperate forests occupying about 6.50 per cent of the total forest area of the country.
2. **Broad-leaf Forests**: These are tropical and subtropical monsoon forests. About 94 per cent of the country's forests belong to this category. They are found in the plains, plateau, and mountainous areas of the country.

E. Based on Exploitability: On the basis of exploitability, the Indian forests may be classified into:

1. **Exploitable Forests:** These forests contribute 58 per cent of the total forest area of the country.
2. **Potentially Exploitable**: These forests are reserved to be utilised in future. These forests cover about 22 per cent of the total forest area of the country.
3. **Other Forests:** These forests also cover about 20 per cent of the total forest area of the country. There is no restriction on their exploitation.

F. On the basis of Average Annual Rainfall: On the basis of average annual rainfall, Indian forests have been classified by L.D. Stamp into the following four categories (**Table 5.3**):

Table 5.3 *India—Classification of Forests on the basis of Rainfall Distribution*

Vegetation Type	*Average Annual Rainfall (cm)*	*Zone*
1. Evergreen forests	Above 200	Humid
2. Monsoon forests	100–200	Semi-Humid
3. Dry forests	50–100	Dry
4. Desert forests	Below 50	Very Dry (deserts)

The natural vegetation of India has been shown in **Fig. 5.3**.

The Indian forests were also classified by H.G. Champion (1936) into eleven categories. The main categories according to this classification are as under:

1. **Tropical Evergreen:** These forests are mainly found in the areas recording over 150 cm of average annual rainfall where the temperature varies between 25°C to 27°C. North-East India, parts of Western Ghats, the Andaman and Nicobar, upper Assam, lower slopes of Eastern Himalayas, Odisha, along the foot-hills of Himalayas, Bhabhar and Tarai regions (**Fig. 5.3**). In the areas where the average annual rainfall is more than 250 cm, the forests are dense; composed of tall trees (45 m) epiphytes, parasites, lianas and rattans so as to look like a green carpet when viewed from above. Trees have multi-storeyed structures with good canopies. These trees do not shed their leaves annually and are hence evergreen. The floor lacks grasses because of deep shade. There are, however, canes, palms, bamboos, ferns, and climbers which make passage difficult. The important species of these forests are white cedar, toon, dhup, palaquinum, mesua, collophyllum, hopea, and canes, gurjan, chaplas, agor, muli, and bamboo. Due to poor accessibility these forests have not been properly exploited.

   In areas where rainfall varies between 200 to 250 cm and the mean monthly temperature varies between 24°C to 27°C , the evergreen forests degenerate into semi-evergreen forests. These forests are found along the Western Ghats, upper Assam, slopes of the Himalayas, and Odisha. The important varieties include aini, semul, gutel, mundane, hopea, kadam, irul, rosewood, laurel, haldu, kanju, holloch, champa, and mesua.
2. **The Tropical Moist Deciduous**: These are typical monsoon forests with teak (*Tectona grandis*) and sal (*Shorea robusta*) as the dominant species. They form the natural vegetation all over the country where the average annual rainfall ranges between 100–200 cm. The tropical moist deciduous forests are found in Sahyadris, the north-eastern parts of the peninsula and along the foothills of the Himalayas (**Fig. 5.3**). These forests on the whole have gregarious species. The typical landscape consists of tall teak trees with sal, bamboos, and shrubs growing

fairly close together to form thickets. Both teak and sal are economically important and so are the Sandalwood (*Santalum album)* Shisham (*Dalbergia sissoo*), Hurra (*Terminalia chebula*), and Khair (*Acacia catechu*).

3. **The Tropical Thorny Forests:** The tropical thorny forest is a degraded version of the moist deciduous forest. They are found in the average annual rainfall varies between 75 and 100 cm and the average annual temperature between 16°C and 22.5°C. These forests are found in peninsular India, Rajasthan, Haryana, Punjab, western Uttar Pradesh, Kachchh, Madhya Pradesh and the foothills of the Himalayas (**Fig. 5.3**)**.** The important trees of these forests are acacia, wild-palms, euphorbias, jhad, tamarix, khair, kokko, dhaman, erunjha, cacti, kanju, and palas.
4. **The Subtropical Montane Forests**: These forests are found in areas where the average annual rainfall varies between 100 to 200 cm and the temperature varies between 15° and 22°C. These forests are found in the north-western Himalayas (except in Ladakh and Kashmir), Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh and on the slopes of north-eastern hill states (**Fig. 5.3**)**.** Chir (pine) is the main tree but broad leaved trees are also found in these areas. Oak, jamun, and rhododendron are the other varieties in these forests.
5. **The Dry Deciduous Forests:** These forests are found in areas where the average annual rainfall ranges between 100–150 cm. These forests are characterised by closed and rather uneven canopies. Enough light reaches the ground to permit the growth of grasses and climbers. Acacia, jamun, modesta, and pistacia are the main trees. Grasses and shrubs appear during the season of general rains.
6. **The Himalayan Moist Forests**: These forests are found in Jammu and Kashmir, Himachal Pradesh, Uttarakhand, and northern hilly parts of North Bengal (**Fig. 5.3**)**.** The wet temperate type is found in a belt where the altitude varies between 1000 and 2000 metres. They occur largely as bands of crested dark green landscape of coniferous varieties. The important varieties are oak, chestnut, chir, sal, shrubs, and nutritious grasses.
7. **The Himalayan Dry Temperate Forests:** These forests are found in Jammu and Kashmir, Lahul, Chamba, Kinnaur (Himachal Pradesh), and Sikkim (**Fig. 5.3**). These are predominantly coniferous forests with shrubs. The important varieties of trees are deodar, oak, chilgoza, ash, maple, olive, mulberry, willow, celtis, and parrotia.
8. **Montane Wet Temperate Forests:** These forests are found in the entire Himalayas from Jammu and Kashmir to Arunachal Pradesh between the altitudes of 1500 m to 3500 m where the temperature varies between 12°C to 15°C, and the mean annual rainfall is between 100 to 250 cm. Oak, fir, spruce *Picea*, deodar, (*Cedrus deodara*), magnolia *(Magnolia glandifora*) celtis, chestnut, cedar (*Chamaecyparis*) and maple, spruce, deodar, silver-fir (*Abies alba)*, kail, and yew are found here. These forests also contain scrubs, creepers, and ferns. The woods of these forests are durable. At higher altitudes above 3500m, are the alpine pastures known as **Margs** in Kashmir and **Bugyals** in Uttarkhand.
9. **Alpine and Sub-alpine Forests:** The Alpine forests are found all along the Himalayas at altitudes ranging between 2500 to 3500 metres. These areas are characterised with short dwarf conifers and lush green nutritious grasses during the summer season. The trees found in the zone are kail, spruce, yew, firs, birch, honeysuckle, artemesia, potentilla, and small scrubs.
10. **Desert Vegetation:** The desert vegetation is confined to the west of Aravallis in the states of Rajasthan and northern Gujarat (**Fig. 5.3**)**.** The average annual rainfall in this zone is

less than 50 cm, the diurnal and annual range of temperature are high. Acacia, cacti, jhar and khejra, kanju, and wild palms are the main trees of the desert.

11. **Tidal (Mangrove):** These forests are found along the coastal areas of the Bay of Bengal in the states of West Bengal, Odisha, Andhra Pradesh, and Tamil Nadu, and along the coastal areas of Kachchh, Kathiwar, and Gulf of Khambat. Their main concentration is found in areas where tides are frequent. The mangrove which attains a height up to 30 metres is the most important tree. It is utilised for fuel. The famous delta of Sundarban is covered by the

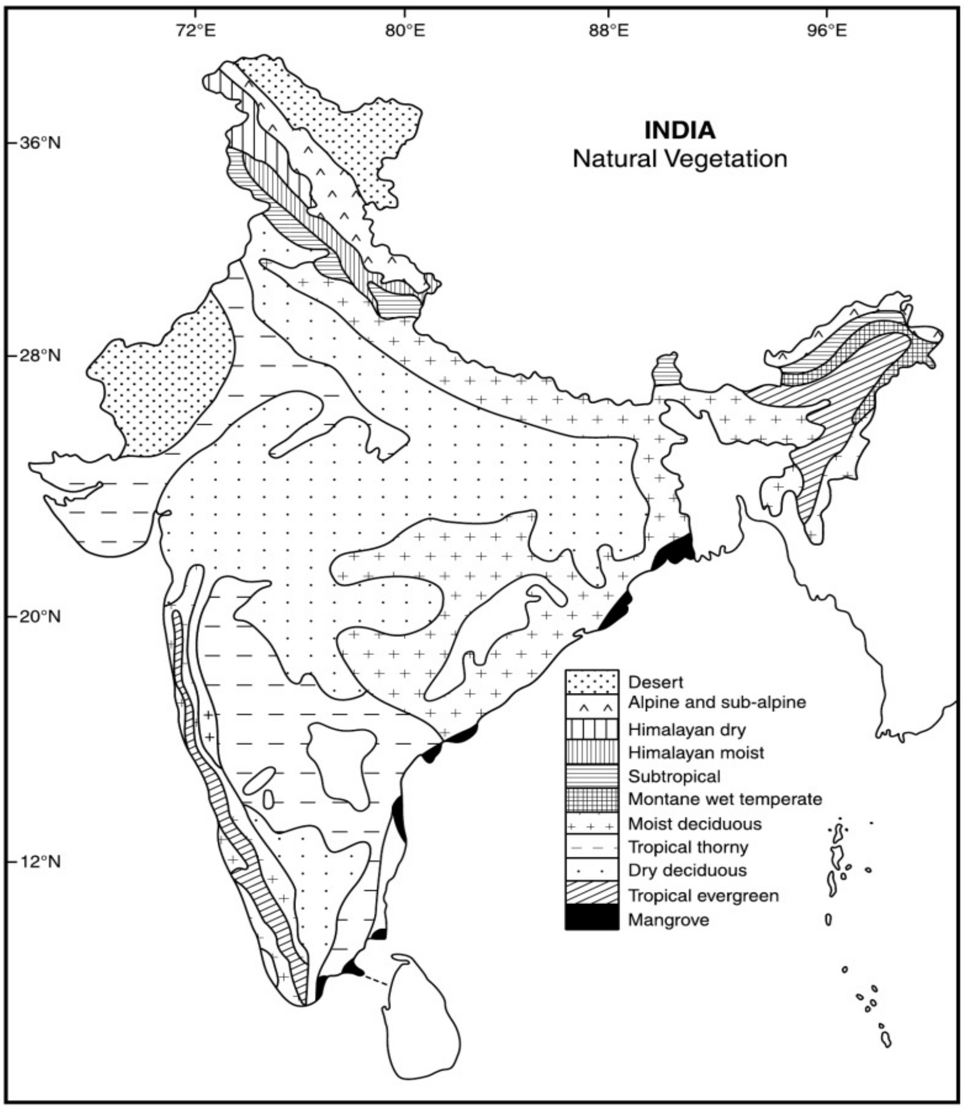

Fig. 5.3 Natural Vegetation—2012

Sundri (*Heritiera minor*) trees which supply hard durable timber for construction and boat making. Here, higher grounds support screw-pines (*Pennanus spp.*). Palms occupy creeks, and epiphytes are predominant all over the region (**Fig. 5.3**).

The percentage share of the different categories of forests have been given in the **Table 5.4**.

Table 5.4 *Percentage Share of Different Types of Forests (2001)*

Type of Forest	*Per cent (Total Forest Area)*
1. Tropical Moist Deciduous	37.0
2. Tropical Dry Deciduous	28.8
3. Tropical Evergreen	12.1
4. Subtropical	9.5
5. Montane Wet Temperate	7.0
6. Alpine and Sub-alpine	2.9
7. Tropical Thorny	2.6
8. Mangrove	0.06

Source: ***Oxford School Atlas***, 2004.

It may be seen from Table 5.4 that tropical moist deciduous forests cover 37 per cent of the total forest area of the country followed by the tropical dry deciduous at 28.8 per cent. The tropical evergreen forests occupy 12.1 per cent and the subtropical 9.5 per cent. The rest of the forest area is under montane wet temperate (7.0 per cent) and alpine and sub-alpine (2.9 per cent). The tropical thorny forest occupy about 2.6 per cent and about 0.06 per cent is under mangrove vegetation.

IMPORTANT SPECIES OF TREES AND THEIR UTILITY

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

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

1. Woods from the Evergreen Forests

The main trees from the evergreen forests are:

(i) Rosewood

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

(ii) Gurjan

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

(iii) Telsur or Irupu

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

(iv) Toon

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

(v) Ebony (Diospyros Ebenum)

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

(vi) Chaplas

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

(vii) Nahar

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

(viii) Poon

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

2. Woods of the Monsoon Forests

The main trees of the monsoon forests are as under:

(i) Sal (Shorea Robusta)

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

(ii) Teak (Tectona Grandis)

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

(iii) Shisham (Dalbergia Sissoo)

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

(iv) Haldu

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

(v) Palas

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

(vi) Arjun

It is also an important tree of monsoon forests which is used for the making of agricultural equipments and bullock carts.

(vii) Mahua (Madhuca Indica)

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

(viii) Semul

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

(ix) Mulberry

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

(x) Jamun (Syzygium cumini)

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

3. Woods from the High Altitudinal Forests of the Himalayas

The main woods of the Himalayan forests are deodar, chir (pine), blue-pine, silver fir, spruce, walnut, white willow, Indian birch, and cypress.

(i) Chir (Pinus Longifolia)

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

(ii) Deodar (Cedrus Deodara)

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

(iii) Blue-Pine (Pinus Excelsa)

It grows along the entire length of the Himalayas from Chumbi Valley to Sikkim between the elevation of 1800 m and 3600 m. The wood is pink in colour, moderately hard and of good quality. It is used for making doors, windows, furniture, and railway sleepers. It also yields resins and turpentine.

(iv) Silver-fir (Abies)

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

(v) Spruce (Picea Mithiana)

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

(vi) Walnut (Juglans Regia)

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

(vii) White Willow (Salix Alba)

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

(viii) Indian Birch

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

(ix) Cypress

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

FOREST PRODUCTS AND THEIR UTILITY

In addition to fuel-wood, timber, and charcoal, the forests provide a number of other products. These include bamboos, canes, tendu leaves, grasses, oils, lac, resins, gums, medicinal herbs, tanning material, dyes, honey, bees wax, ivory, vegetables, fruits, roots, and tubers.

1. Bamboo

Bamboo is found in most of the monsoon regions where the average annual rainfall is more than 150 cm. Some of the bambooes may attain a height of 30 m. It is used for a variety of purposes—basket making, roofing, and thatching, construction, paper, and pulp making. In India more than 100 varieties of bamboos are found. According to the Planning Commission bamboo occupies

100,210 sq km of the forest area of the country with an annual production of four million tonnes. Different types of decorative items such as flower pots, trays, vases, caskets, and even ornaments are made of bamboo in states like Mizoram, Nagaland, Meghalaya, Manipur, and Tripura. Bamboo also finds a place in cultural activities of the Mizo people, i.e. Cherraw (bamboo) dance.

2. Canes

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

3. Tendu

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

4. Grasses

A large variety of grasses are found in the Indian forests. Some of the important grasses are *Sabai* (sub-Himalayan Tarai tracts), elephant-grass (Assam), spear-grass, *ulla*, and *panni* grasses, etc. *Khus-Khus* grass (Bharatpur, and Sawai-Madhopur, Rajasthan) is used for making cooling screens during summer season. *Rosha, lemon*, and ginger-grasses yield medicinal and perfumed oils.

5. Oils

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

6. Medicinal Herbs and Plants

A number of medicinal plants, herbs and trees are found in Indian forests. The leaves, stems, flowers, fruits, barks, roots, and seeds of different plants and scrubs are used as raw materials for the manufacture of a number of medicines. Some of the important herbs used for medicines are aconite, Keera-jari (insect herb), celery, belladone, colocynth, sarasaparilla, jalap, leadwort, chitraka, serpentine, and liquorice. The root of serpentine is an antidote for snake and insect bite. Barks of mountain ebony, Indian oak, quinine, Spanish-cherry, bay-berry, lodh-tree, Indian-red-wood, ashoka, arjuna, and Indian barberry have medicinal value. The stem of ephedrine, white sandal-wood, catechu, and long needle-pine are also of great medicinal importance. Leaves of vasaka, Indian aloe, poison-bulb, fever-nut, life-plant, swallow wart, Indian-penny-word, Tasmanian blue-gum, physic-nut, holy-basil, betel, pepper, and typlophora yield different drugs. Similarly, flowers of saffron, iron-wood, violet and fruits of bel, fish-berry, purging-cassia, coriander, cumin, fennel, emblic, opium, long-pepper, black and white pepper, belleric, myrobalan, ammi and solanum are used in medicine making. Keera-jari (insect herb) known as cordyceps sinensis is highly valued as a tremendous energy booster which cost about Rs. 2.5 lakh per kg.

7. Shellac

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

8. Resins

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

9. Gums

Gum is obtained from acacia, carob, mesquite, kateera-gum. These are used as adhesives in printing and finishing textiles, in the paint and candy industries, and drugs.

10. Tannins and Dyes

Tannins are used for coagulating the protein in hides and skins, so that resistant leather can be produced. Lighter vegetable tannins dominate in the production of leather. Tannins are obtained from the bark of mangrove, sundri trees, wattle, avaram, sumac, arjun, Indian almond, jujube, Cuddapah-almond, hog-plum, chestnut, and leaves of smoke trees.

The dyes are coloured compounds. On being fixed to fabrics, they do not wash out with soap and water or fade on exposure to light. About 150 dye yielding plants are available in Indian forests, but only a few have been utilised so far.

11. Katha

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

12. Fruits and Vegetables

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

13. Valuable Things

In addition to the given benefits from forests, the collection of ivory, honey, bees wax, hides, horns, and furs is also done from the forests.

14. Grazing Grounds

Forests are the grazing grounds for domesticated animals and the abode for over 30,000 species of plants, animals, and micro-organisms.

15. Forests and Climate

Climate, temperature, and precipitation are also directly affected by the presence or absence of forests. It is said that larger the area under forests, greater is the amount of precipitation.

PROBLEMS OF INDIAN FORESTRY

The specific problems of Indian forestry are the following:

1. Low Forest cover

(i) The forest cover in India is only 22.50 per cent as against the world average of about 35 per cent. The overall desired forest area as recommended in the National Forest Policy of India 1952, should be 33 per cent (25 per cent in plains and 60 per cent in hilly regions) of the total geographical area of the country. This percentage is missing in almost all the states and UTs except Andaman and Nicobar, Assam, Goa, Kerala, Meghalaya, Sikkim, Uttrakhand, Mizoram, Arunachal Pradesh, Nagaland, Manipur and Lakshadweep. The states of Haryana, Punjab, and Rajasthan have less than 5 per cent of their areas under forest. India has 99 National Parks, 513 wild-life sanctuaries and 18 Biosphere Reserves.

(ii) Most of the forests of India are not gregarious which creates problems in their exploitation. Teak, sal, bamboo, pines, oak, deodar, fir, spruce and larch are, however, exceptions.

(iii) About 40 per cent of the total forest area in not easily accessible.

(iv) In about 50 per cent of the total forest area, tribals have been given the rights of free grazing and cutting fuel-wood and timber for their personal consumption. This right is often misused.

(v) The felling of trees is still primitive and indigenous in most of the forests. This damages the ecosystem, leads to more soil erosion and delays the regeneration of forests.

(vi) There is inadequate trained personnel in forestry. Much of the energy of the available man-power is used in the protection and conservation of forests instead of their regeneration.

(vii) There is inadequate protection against forest fire, insects, pests and plant diseases.

(viii) The shifting cultivation in the wet mountainous regions of the country is another serious problem of the Indian forests.

(ix) According to the data published by the new environmentalists, India is losing 135 hectare forest daily (12th June-2013, Hindu, Delhi ed.)

2. Open Grazing

Extensive damage to the Indian forests is being done by the grazing of cattle, sheep and goats, especially in the hilly and mountainous areas, by the local people. Nomadic tribes like Bakarwals, Bhutias, Gaddis, Gujjars, and Lepchas, practicing transhumance (seasonal migration) damage the forest ecosystems.

3. Shifting Cultivation

Tribals in the areas where rainfall is more than 100 cm generally practice shifting cultivation (*Jhuming*) in the hilly and mountainous areas. The increasing pressure of population has reduced the Jhum Cycle to only five years in many parts of Nagaland, Meghalaya, Mizoram, Manipur, and Tripura. Consequently, the forests do not have sufficient time to regenerate.

4. Growing Demand for Agricultural Land

With the tremendous increase in population during the last 65 years, the demand for cereals and agricultural raw materials has increased significantly. Consequently, the forest area has been brought under cultivation leading to a continuous shrinkage of the forest area.

5. Urbanisation and Industrialisation

Fast urbanisation and industrialisation in the forest and hilly areas is also an important cause of forest degradation. The size of cities like Shimla, Mussoorie, Dehra-Dun, Nainital, Ranikhet, Chamba, Dalhousie, Darjeeling etc. has increased over ten times during the last thirty years. There has been rapid expansion of roads in the Himalayas and other forest areas as a result of which the valuable forests have been exposed to tourists and pleasure-seekers.

6. Construction of Multi-Purpose Projects

The construction of reservoirs of big dams like Bhakra-Nangal, Rihand, Hirakud, Tehri, Koteshwar, Salal, Dulhasti, Sardar-Sarovar, etc. has resulted in the submergence of large forest tracts.

7. Commercial Activities

Commercial activities like resin extraction, mining, quarrying, oil-extraction, plantation, orchard development have also led to large-scale deforestation. Unfortunately, paper mills, and saw-factories have been located in the forests areas which accelerate the process of deforestation.

THE NATIONAL FOREST POLICY

India is one of the very few countries of the world where forest policy is in operation since 1894. In 1952 and 1988, revisions were made in the forest policy of 1894. The National Forest Policy of 1952 recommended that the country should aim at a coverage of one-third of the total land area under forest (60 per cent in hilly and mountainous areas, and 25 per cent in the plains). It has suggested the extension of tree-lands on river/canal banks, roads, railways, culturable waste and in such areas which are not suitable for cultivation.

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

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

The National Forest Policy 1952 lays emphasis on :

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

The National Forest Policy 1988

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

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

SOCIAL FORESTRY

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

Agro-forestry which includes community forestry and agro-forestry (commercial and non-commercial farm forestry).

Objectives

(i) To meet the need for fuel wood, small timber, bamboo, fodder and other minor forest produce on sustainable basis. (ii) To release cow dung as manure for increasing agricultural production, (iii) To provide gainful employment opportunities to the rural population, (iv) To develop cottage industries, (v) To provide efficient soil and water conservation, (vi) To provide efficient soil and water conservation, (vii) to improve aesthetic value of an area and to meet the recreational needs of the population.

Community Forestry

Community forestry is a part of social forestry. It involves the raising of trees on community lands with the set objective to provide benefits to the community as a whole. Although the plants and seedlings are provided by the forest departments, the protection of planted trees is primarily the responsibility of the community as a whole.

India has performed superbly in community forestry and stands only next to China in this respect. The states in which community forestry is a big success are Gujarat, Haryana, Himachal Pradesh, Karnataka, Kerala, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttarakhand, and Uttar Pradesh.

Agro-Forestry

Agro-forestry is a sustainable management for land that increases overall production, combines agricultural crops, tree crops, forest plants and animals simultaneously and applies management practices that are compatible with cultural patterns of local population.
Agro-forestry is a type of social forestry in which individual farmer undertakes tree-farming and grows fodder plants, grasses and legumes on his own land. In agro-forestry, trees (forest) are considered as a crop and they (trees) become a part of crop combinations.

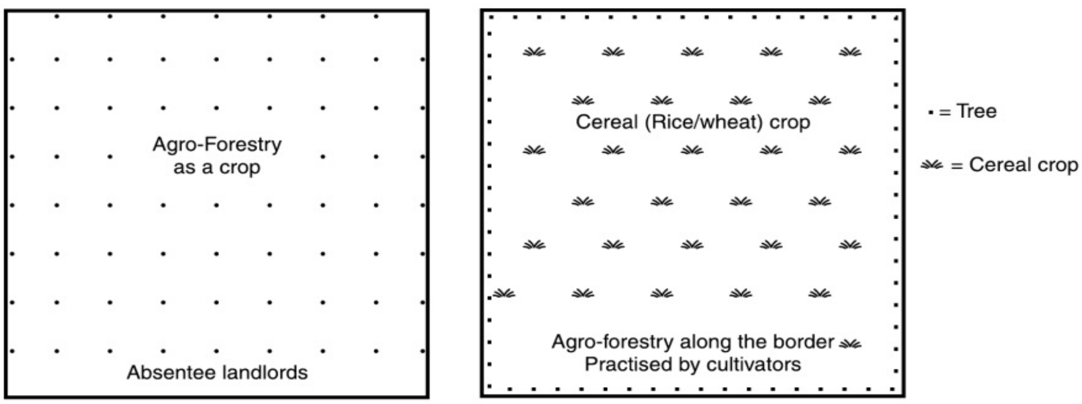

Fig. 5.4 Patterns of Agro-Forestry

There is an increasing number of farmers who plant trees either along the boundaries or in the whole field/farm as a crop (**Fig. 5.4**). In fact, in the Northern Plains of India, trees are planted by most of the farmers irrespective of the size of their holdings, but the large farmers and absentee landlords put part of their holdings or total agriculture area under tree crops.

Under agro-forestry, a farmer generally uses his degraded or useful land to plant trees for domestic use or commercial use. Such land may be his own or obtained on lease under social forestry programme.

Agro-forestry involves both the big and the small farmers. It fetches additional income to farmers, improves their income and thereby, their standard of living, and provide them employment during lean agricultural seasons. These trees are normally harvested after 6 to 10 years from the date of plantation, depending on the needs and requirements of the farmer. The main advantages of agro-forestry are:

(i) The absentee landlords go for agro-forestry to retain title of the land and to increase their income.
(ii) To manage the agricultural land even without the availability of family labour.
(iii) To ensure better land use.
(iv) To generate employment.
(v) To conserve soil moisture.
(vi) To meet the needs of fuel-wood, fodder and timber.
(vii) To protect the arable land from winds and water erosion.

Despite numerous material and geo-climatic benefits, agro-forestry has some adverse effects on agricultural land. Some of its shortcomings are given below:

(i) The market-oriented trees are preferred which damage the ecosystem. Instead of poplar and eucalyptus, the farmers should go for the plantation of Neem, Mahua, Karanj, Arjun, and acacia.
(ii) Fuelwood and fodder trees are generally neglected.
(iii) The exotic varieties planted by the farmers in the form of agro-forestry are soil-moisture and water exhaustive. Consequently, the underground water-table is adversely affected.
(iv) The land under agro-forestry becomes unproductive as the roots of trees become so dense that their digging and removal to bring the land under cultivation becomes very difficult unless heavy investment is made in the digging and removing of roots.
(v) In the fields along which trees have been planted, the productivity per unit area decreases, as at least in about two metres from the trees the moisture content in the soil is significantly reduced.
(vi) The trees become the habitat of many pests and diseases, adversely affecting the crops.
(vii) Unscientific method of spacing of trees, reduces the growth and mass of the trees.

In brief, Agro-forestry is a system of agricultural land utilisation which not only provides fuel-wood, fodder, and grasses, but helps in the promotion of forests and their conservation. The Indian Council of Agricultural Research and the Forestry Department jointly undertake agro-forestry research in order to develop suitable systems of land management which involves integration of silviculture, with horticulture, agriculture and animal husbandry. Agro-forestry thus integrates agri-silviculture, silvi-pastoral system, and medicinal plants culture. Under agro-forestry, a farmer generally uses his degraded or useful land to plant trees for his domestic use or for commercial use.

Agro-forestry has become very popular in Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Kerala, Punjab, Rajasthan, Uttarakhand, and Uttar Pradesh. The main species of trees planted by farmers in their fields are eucalyptus, poplar and casuarinas. The wood of these forests is used mainly for fuel-wood, plywood, paper and pulp manufacturing, and match industries.

Agro-forestry has benefited the big farmers more than the marginal and small farmers. Many of the absentee land-lords plant commercial trees in their agricultural land-holdings to save their land from dispossession. Thus, the agricultural labourers are thrown out of employment. The diversion of good agricultural land from cereal and commercial crops may create the problem of scarcity of food stuffs and industrial raw material. The programme, therefore, needs a new strategy and reorientation to achieve its real objectives.

EXISTING POSITION OF FOREST ECOSYSTEMS

The continuing exploitation of our forest resources has damaged the forest ecosystem almost beyond repair. The depletion of forest cover is due to expansion of agriculture, habitat destruction, over-exploitation, pollution, toxic imbalances in community structure, epedemics, floods, droughts and cyclones. As a consequence of the denudation of hill slopes, soil erosion and recurrent floods have emerged as major problems. According to one estimate by the National Remote Sensing Agency, India has been losing about 1.3 million hectares of forest cover every year. This is an alarming rate indeed. It is now generally realised that forests are life sustaining agents. They play a vital role in maintaining the ecological balance. The recent concern for environment has resulted in rethinking on these issues. Looking at the present state of our forest resources and their degradation, it is imperative to utilise them in a judicious manner, so that they may be regenerated in a short time to make them sustainable.

FOREST CONSERVATION

The utility of forests, their social relevance and climatic importance have been discussed in the preceding paras. The conservation of forest resources is imperative for our survival. Some of the steps which can go a long way in making forests healthy and sustainable are as under:

(i) *Afforestation:* There should be massive afforestation programmes with main emphasis being on the production of fuel-wood, timber, grasses, and small trees to cover up degraded and denuded lands.

(ii) Plantation of trees along the roads, railway lines, rivers, and canal banks, and along lakes and ponds.

(iii) Development of Green-belts in the urban areas and plantation of trees on community lands.

(iv) Plantation of community forests on *Gram-Sabha* lands.

(v) Villagers should be given loans at easy interest rates to revive degraded forest.

(vi) Encroachment of agriculture in forests should be made punishable.

(vii) The customary rights and concessions like grazing, collection of fuel-wood and fodder from forests by the local people should not be allowed to exceed the carrying capacity of the forests.

(viii) Rural population should be provided alternate sources of fuel-wood and wood-based products.

(ix) The development projects including mining and industrial activities should be so planned to cause minimum damage to forest ecosystems.

(x) Mining contracts should have an obligatory clause of reforestation when the process of mining is over.

(xi) Industries should adopt anti-pollution devices and must develop and compensate the forest loss by new plantation.

(xii) Tribal and local people should be directly involved in the protection, regeneration, and management of forests.

(xiii) Shifting cultivation should be gradually replaced by terraced farming and orchards development and silviculture.

(xiv) Scientific methods should be adopted to check and contain forest fires. There should be strict control in issuing license for the establishment of industries in forest areas.

(xv) There should be more research on forestry in agricultural universities, for which facilities and funds should be provided by the Central and State governments. Forestry should be made an important part of the course structures in schools, colleges and universities.

(xvi) There should be arrangements to protect the forests from pests and diseases for which trimming and spraying of the trees should be a regular practice.

(xvii) There should be perfect co-ordination between the forest department and other departments of the government for effective and judicious utilisation of forests and their conservation.

(xviii) People should be encouraged to participate in the *Van-Mahotsav* and should be made aware about the *Chipko Movement*.

(xix) There is a need to change our outlook towards forests. A forest should not be treated as a perennial resource and a source of revenue only. The planning and conservation of forests is not only the duty of the government, but also all the citizens of the country.

(xx) There should be special audio-visual programmes, demonstrations, seminars and workshops to develop awareness among the people about the social relevance of forests.

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

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

WILDLIFE

India has a great diversity in its geo-climatic environment. This diversity of environment provides natural habitats for wild animals, birds and insects. Out of the world's total of about 15 lakh species of animals, India has 81,251 or (6.7 per cent). According to S.H. Prater (1934), India can be divided into six zoo-geographic regions. India has 350 different mammals, 1200 species of birds, 453 species of reptiles, and 45000 plant species. Moreover, India has 50,000 known species of insects, including 13,000 butterflies and moths. They are: (i) The Himalayan region (ii) The Northern Plains, (iii) The Thar Desert, (iv) The Peninsular Plateau, (v) The Malabar Coast, and (vi) The Nilgiri.

Under the pressure of a fast increasing population and heavy demand of food and industrial raw material, the forest cover of India has shrunk substantially. Moreover, the density of trees in the forests is very low as compared to the forests of other countries. Consequently, the natural habitat of wild animals are disappearing. The growing trade of furs of big cats and tiger bones has diminished their number. There is increasing demand of rhino-horns and deer musk which are used in medicines and aromatic substances. Moreover, due to the continuous hunting of wild animals and illegal poaching, the number of wild animals is decreasing day by day. Some of the species are on the verge of extinction. Asiatic lion, clouded leopard, tiger, musk-deer, rhinoceros, great Indian bustard, Nilgiri langur, python and vultures are the species in danger.

In order to conserve wildlife, the Government of India passed the Wildlife Protection Act in 1972. Large tracts in various parts of the country covering 1.56 lakh sq km—4.75% of the total area of the country—were declared as national parks, sanctuaries and biosphere reserves. At present, the number of national parks and sanctuaries has gone up to 89 and 490 respectively.

To increase the number of animals classified under endangered species, Project Tiger (1973), Crocodile Breeding Project (1975), Rhinoceros Project (1987), Snow-leopard Project, and Project Elephant (1988) have been launched.

National Park: A national park is a relatively large area of one or several ecosystems that are not being materially altered by human exploitation and occupation. Here, plant and animal species, geomorphological sites and habitats for special scientific education and recreation are preserved. The National Parks of India have been plotted in **Fig. 5.5** and some of the important national parks have been described in the following section:

Wildlife Sanctuary: Similar to a national park, a wildlife sanctuary is dedicated to protect wildlife and particular species. In a sanctuary, human activities are allowed, but in a national park human interference is totally prohibited.

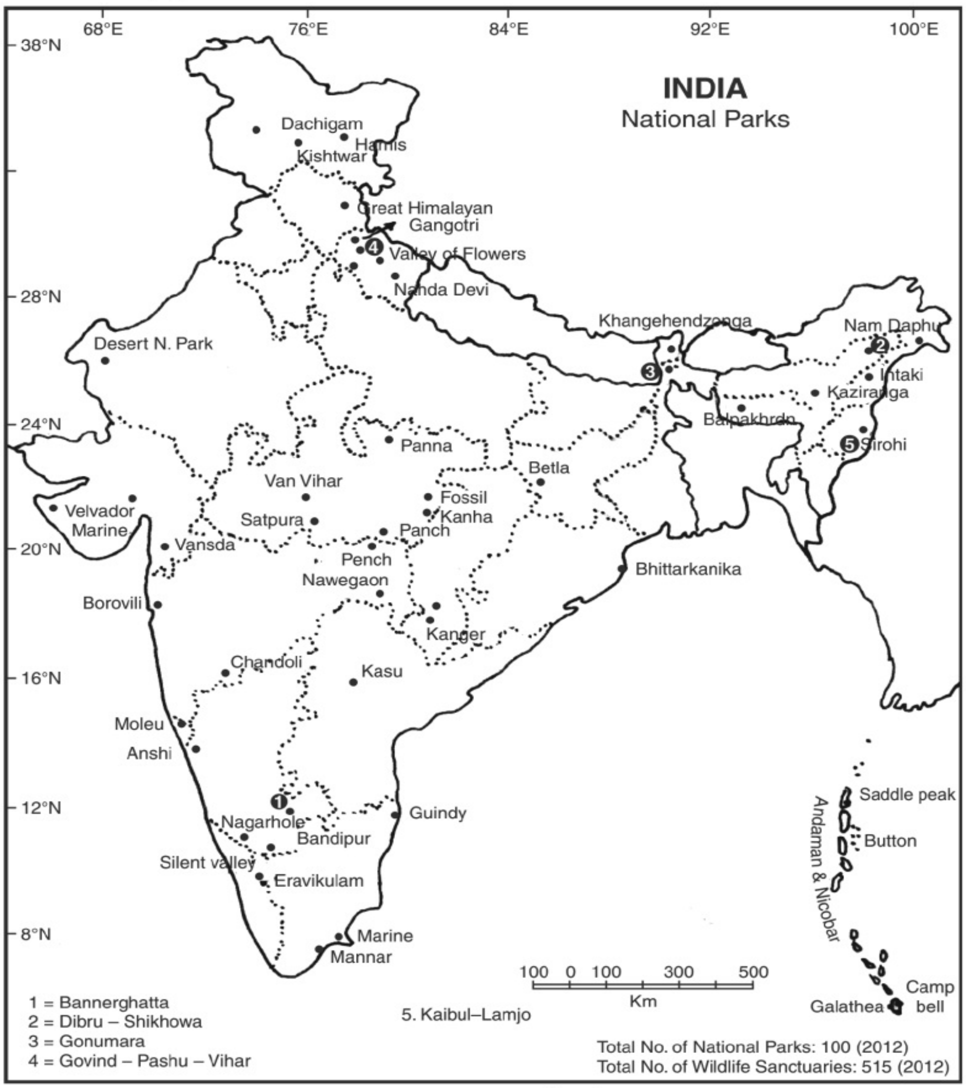

Fig. 5.5 National Parks

Tiger Reserves: Some of the important Tiger Reserves of India have been discussed in the subsequent pages. Their geographical distribution has been shown in **Fig. 5.6.**

Fig. 5.6 Tiger Reserves

Biosphere Reserves

Biosphere reserves are areas of terrestrial and coastal ecosystems which are internationally recognised within the framework of UNESCO's *'Man and Biosphere (MAB) Programme'*. These reserves are required to meet a minimal set of criteria and adhere to a minimal set of conditions before being admitted to the *World Network of Biosphere Reserves* designated by the UNESCO. These reserves are rich in biological and cultural diversity and encompass unique features of exceptionally pristine nature. The scheme is a pioneering effort at pursuing the increasing difficult yet urgent task of conserving ecological diversity under mounting pressures.

The main objectives for the delineation of biosphere reserves are:

1. To conserve biological and cultural diversity and integrity of plants animals, birds, reptiles, micro-organisms and unique features of pristine nature.
2. To promote research on ecological conservation and other environmental aspects, and
3. To provide facilities for education, research, awareness and training.

The Biosphere Reserves Programme was initiated in India in 1986 and till date, 18 sites have been designated as Biosphere Reserves (BR) in different parts of the country. The names of the biosphere reserves of India have been given in **Table 5.1** and their locations have been shown in **Fig. 5.7.**

Table 5.5 *Biosphere Reserves of India*

	Biosphere Reserve	*Geographical Area in sq km*	*States*
1.	Nilgiri	5520	Tamil Nadu, Kerala, Kamataka
2.	Nanada Devi	5861	Uttarkhand
3.	Nokrek	0820	Meghalaya
4.	Manas	2837	Assam
5.	Sundarban	9630	West Bengal
6.	Gulf of Mannar	10,500	Tamil Nadu coast
7.	Great Nicobar	0885	Andaman and Nicobar Islands
8.	Simlipal	4,374	Odisha
9.	Dibru-Saikhowa	0765	Arunachal Pradesh
10.	Dehang-Debang	0512	Arunachal Pradesh
11.	Kangchendzonga	2620	Sikkim (Kanchenjunga)
12.	Panchmarhi	4928	Madhya Pradesh
13.	Agasthymalai	3500	Kerala
14.	Achanakmar Amarkantak	38351	Madhya Pradesh
15.	Kachchh	12,454	Gujarat
16.	Cold Desert	7555	Lahaul-Spiti and ladakh
17.	Sheshachalam	4500	Andhra Pradesh
18.	Panna	4100	Madhya Pradesh
	Total	1,19,712	

The programme was initiated in 1986 and till date, 18 sites have been designated as Biosphere Reserves in different parts of the country. Out of the 18 biosphere reserves, seven biosphere reserves have been included in the World Network of Biosphere Reserves so far. These 7 include: Sundarban, Gulf of Mannar, Nilgiri, Nanda Devi, Panchmarhi, Simlipal and Nokrek.

These biosphere reserves include:

1. Nilgiri, 2. Nokrek, 3. Nanda Devi, 4. Sundraban, 5. Gulf of Mannar, 6. Manas, 7. Great Nicobar, 8. Simlipal, 9. Dibru-Saikhova, 10. Dehang-Dibang, 11. Panchmarhi, 12. Kanchanjunga, 13. Agasthamalai, 14. Achanakamar, 15. Great Rann of Kachchh, 16. Cold Desert (Pin-Valley-H.P.), 17. Seshachalam (Andhra Pradesh), 18. Panna (M.P.).

Seven out of the 18 biosphere reserves are a part of the World Network of Biosphere Reserves, based on the UNESCO Man and Biosphere Programme List. Their names are: 1. Nilgiri, 2. Sundarban, 3. Gulf of Mannar, 4. Nanda Devi, 5. Kokrek, 6. Panchmarhi, and 7. Simplipal.

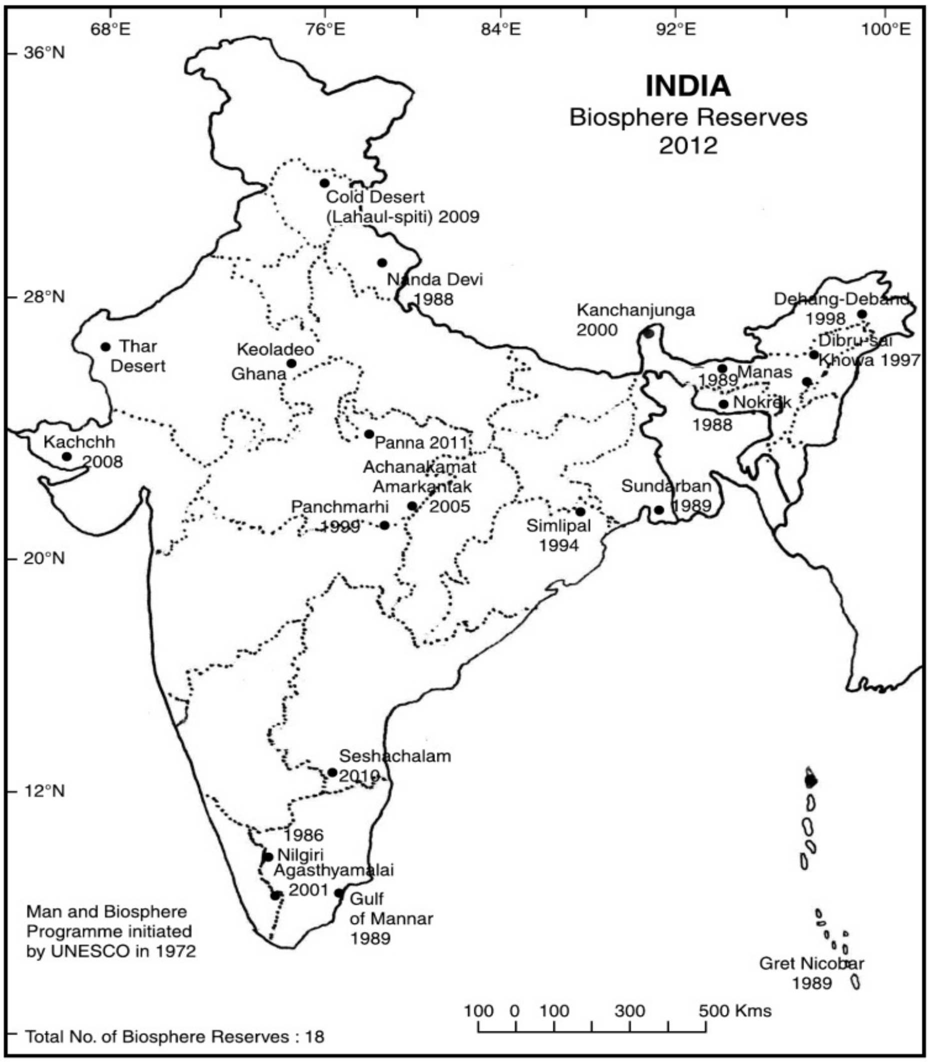

Fig. 5.7 Biosphere Reserves

MANGROVES

Mangroves are large flowering shrubs or trees that grow in dense thickest forests along muddy or silty tropical coasts. According to the latest assessment mangrove covers 4639 sq. km or 0.14 per cent of the geographical area of the country. The government of India has identified 28 mangrove areas. The statewise distribution of mangroves has been given in Table: 5.6.

Table 5.6 *Mangroves in India*

S.No.	*Mangrove*	*State/Union Territory*
1.	Bhitarkanika	Odisha
2.	Coondapur	Kamataka
3.	Goa	Goa
4.	Godavari Delta	Andhra Pradesh
5.	Gulf of Kachchh	Gujarat
6.	Krishna Delta	Andhra Pradesh
7.	Loringa	Andhra Pradesh
8.	Mahanadi Delta	Odisha
9.	North Andaman and Nicobar	Andman & Nicobar Islands
10.	Piahavaram	Tamil Nadu
11.	Point Collimere	Tamil Nadu
12.	Sundarban	West Bengal

Source: India 2012

Coral Reefs

The four major coral reef areas identified for intensive conservation and management are: (i) Gulf of Mannar, (ii) Gulf of Kachchh, (iii) Lakshdweep, and (iv) Andaman and Nicobar Islands.

Wetlands (Ramsar Convention)

The convention on wetlands (Ramsar-lran, 1971) - called the 'Ramsar Convention' is an intergovernmental treaty that embodies the commitment of its member countries to maintain the ecological character of their wetlands of international importance and to plan for the 'wise-use' or sustainable use.

Any wetland to be declared a wetland of international importance should support vulnerable, endangered or threatened species and attract more than 20.00 water birds.

In India, the scheme on conservation and management of wetlands was initiated in 1987. Over the years, based on the recommendations of National Wetlands Committee 115 wetlands have been identified for conservation under the programme. The main wetlands which have been included in the Ramsar List are given in Table.5.7.

Table 5.7 *India-Wetlands included in Ramsan List*

SI.No.	*Name*	*Area (Km^2)*
1.	Ashtamudi Wetland, Kerala (19 08/02)	614
2.	Bhitarkanika Mangroves, Odisha (19/08/02)	650
3.	Bhoj Wetland, Madhya Pradesh (19/08/02)	32
4.	Chandeital Wetland, Himachal Pradesh (08/11/05)	49
5.	Chilika Lake, Odisha (01/10,81)	1165
6.	Deepor Beel, Assam (19/08/02)	40
7.	East Calcutta Wetlands, West Bengal (19/08/02)	125
8.	Harike Lake, Punjab (23/03/90)	41
9.	Hokera Wetland, Jammu and Kashmir (08/11/05)	13.75
10.	Kanjli, Punjab (22/01/02)	1.83
11.	Keoladeo National Park, Rajasthan (01/10/81)	28.73
12.	Kolleru Lake, Andhra Pradesh (19/08/02)	901
13.	Loktak Lake, Manipur (23/03/90)	266
14.	Point Calimere Wildlife and Bird Sanctuary, Tamil Nadu (19/08/02)	385
15.	Pong Dam Lake, Himachal Pradesh (19/08/02)	156.62
16.	Renuka Wetland, Himachal Pradesh (08/11/05)	2
17.	Ropar, Punjab (22/01/02)	13.65
18.	Rudrasagar Lake, Tripura (08/11/05)	2.4
19.	Sambhar Lake, Rajasthan (23/03/90)	240
20.	Sasthamkotta Lake, Kerala (19/08/02)	3.73
21.	Surinsar –Mansar Lakes, Jammu and Kashmir (08/T1/05)	3.5
22.	Tsomoriri, Jammu and Kashmir (19/08/02)	120
23.	Upper Ganga River (Brijghat to Narora Stretch), Uttar Pradesh (08/11/05)	265.9
24.	Vembanad-Kol Wetland, Kerala (19/08/02)	1512.5
25.	Wular Lake, Jammu and Kashmir (23/03/90)	189

Strategy for the Conservation of Wildlife

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

(i) Hunting should be strictly prohibited in the national parks, sanctuaries, tiger reserves and biosphere reserves.

(ii) Poachers and herdsmen should not be allowed to enter the reserved parks and sanctuaries.

(iii) More national parks and wildlife sanctuaries should be established.

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

WESTERN GHATS: A WORLD HERITAGE SITE

Western Ghats has been included in the UNESCO World Heritage List in the meeting of the World Heritage Committee held at St. Petersburg in Russia on 1st July, 2012.

The Western Ghats has "outstanding examples representing significant ongoing ecological and biological processes in the evolution and development of terrestrial, freshwater, coastal and marine ecosystems and communities of plants and animals. It is also the most significant natural habitat for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science and conservation. Apart from the World Heritage Site, it is one of the eight hottest **hot spots** of biological diversity in the world.

The Western Ghats or the Sahyadri is a mountain ranee sec *'re western* see of the Peninsular India. It separates the Deccan Plateau from the narrow coastal plain along the Arabian Sea **(Fig.5.8).**

The Western Ghats starts south of the Tapi river in Gujarat and runs about 1600 km through the states of Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala ending at Kanniyakumari, at the southern tip of India.

The main peaks of the Western Ghats are: Anaimudi (2695m), Doddabetta (2636m), Mukurthi (2554m), Kodaikanal (2133m), Bababudangiri (1895m), Kudremukh (1894m), Agasthymalai (1866m), Pushpagiri (1712m), Kalsubai (1646m), and Salher (1567m). The important hill stations of Ooty (2500m) and Kodaikanal (2285m) are also located in the Western Ghats.

The area has 5000 species of flowering plants, 139 mammal species, 508 bird species and 179 amphibian species. According to one estimate 325 globally threatened species occur in the Western Ghats.

The Western Ghats are covered with the tropical and subtropical forests that provide food and natural habitats for the native tribal people. The area is ecologically sensitive to development. The Government of India has established many protected areas including 2 biosphere reserves, 13 national parks and several wildlife sanctuaries to protect specific endangered species. The Nilgiri Biosphere Reserve (5500 sq.km) of the evergreen forests of Nagarhole, the Bandipur National Park covered with deciduous forest, the Mudumalai National Park and the Mukurthi National Park in the states of Kerala and Tamil Nadu are the other important protected areas. A judicious use of resources and conservation practices can improve the resilience characteristics of the ecosystems of this important world heritage site.

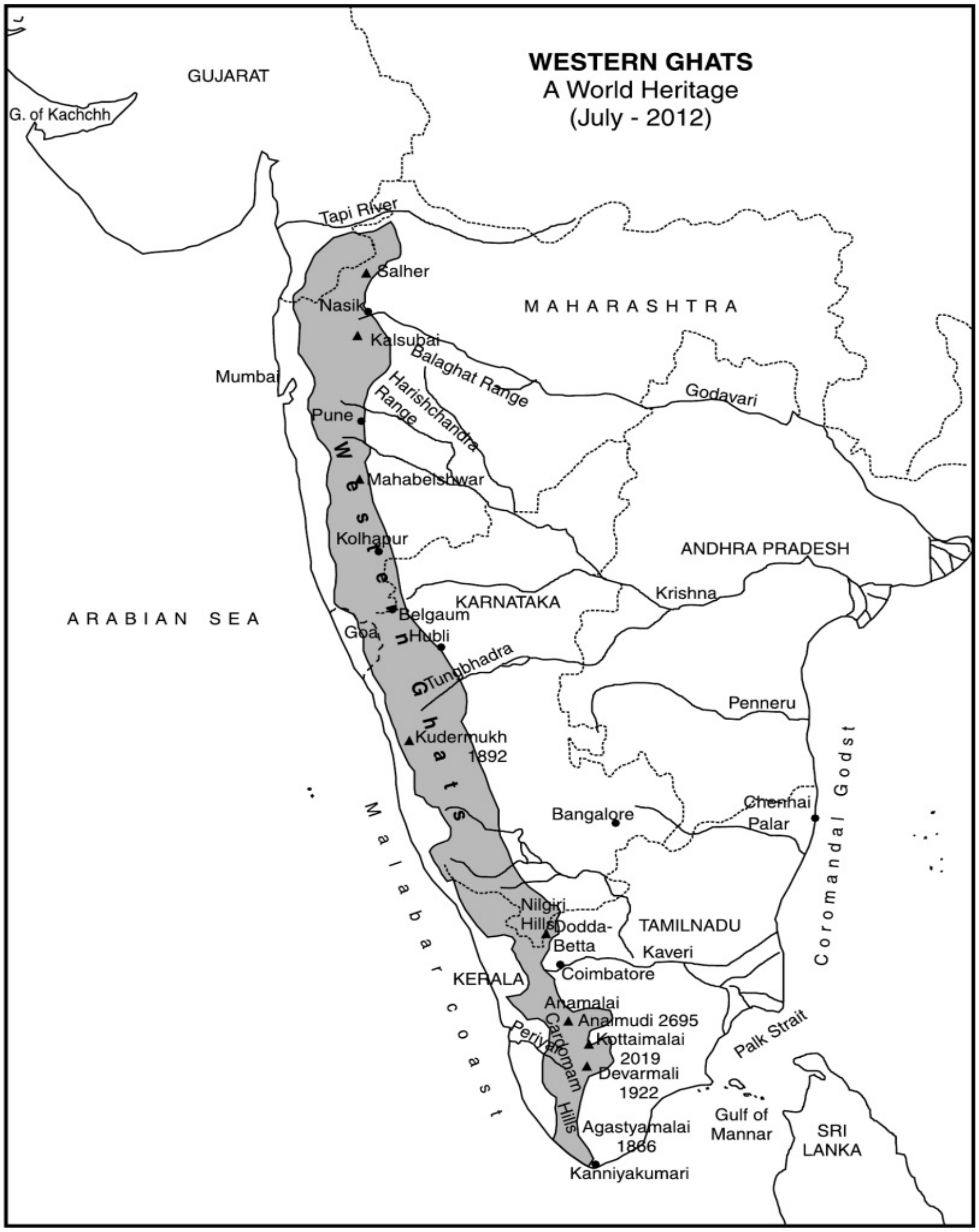

Fig. 5.8 Western Ghats: A World Heritage Site (UNESCO)

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Chapter 6

Soils

INTRODUCTION

The loose material or the upper layer of the mantle rock (regolith—a layer of lose, heterogeneous material covering solid rock) consisting mainly of very small particles and humus which can support the growth of plants is known as soil. Soil mainly consists of mineral/rock particles, a certain proportion of decayed organic matter, soil water, soil air, and living organisms which exist in a complicated and dynamic relationship with each other. The naturally occurring soil is influenced by (i) parent material, (ii) relief, (iii) climate, (iv) physical, chemical and biological agents (micro-organisms) in it, (v) land use practices, and (vi) time. In general, soil is made up of four elements: (a) inorganic or mineral fraction (derived from the parent material), (b) organic matter (decayed and decomposed plants and animals), (c) air, and (d) water.

CHARACTERISTICS OF SOIL

Parent Material

The parent material includes both, hard, resistant rocks such as granite, marble as well as slate, apart from less resistant rocks such as recent volcanic lavas and ashes, and the metamorphic (schist, gneiss) and sedimentary rocks (sandstone, clay, silt, and limestone). The term 'rock' is strictly applied not only to granite, sandstone and the like, but also to gravel, clay, and unconsolidated sand, loess, and alluvium which are less compact and less resistant soils.

Humus

The end product of breakdown of dead organic material is known as humus. It is a structureless, dark-brown or black jelly found beneath or within the soil surface. The humus of ordinary soil is black, and is thus, responsible for making the top soil darker than the subsoil. It helps in the maintenance of soil fertility. The amount of humus in different soils varies considerably.

Soil Texture

A soil is generally characterised by the size of its particles. A clayey soil may thus be described as fine, sandy as coarse, while silt is an intermediate (**Fig. 6.1**). The standard unit for the measurement of soil particles is the millimetre, but a smaller unit is the micron (1 micron = 0.001 mm), which is applicable, for instance, to the measurement of soil colloids. In sandy soil, the size of individual grains varies between 0.05 and 0.2 mm which are visible to the naked eye. The individual grains of clayey soil are 0.002 mm in diameter. Silty soil is finer than sand but coarser than clay. Its particles are found to have a diameter between 0.02 and 0.002 mm.

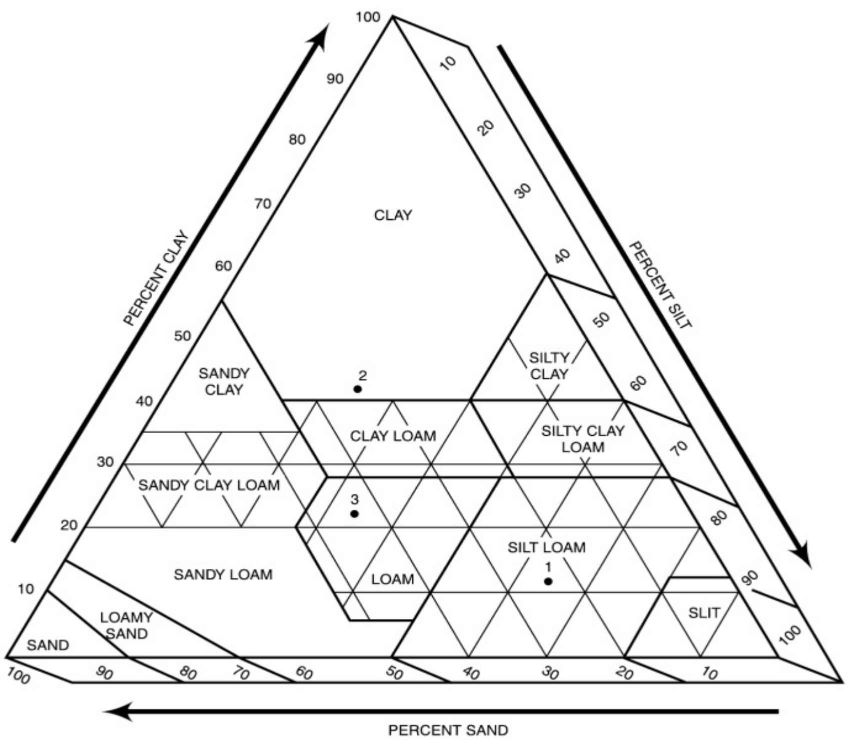

Fig. 6.1 Soil Texture Triangle

Soil Structure

Soil structure refers to the arrangement of soil particles. The way in which sand, silt, clay, and humus bond together to form beds is known as soil structure.

Soil Acidity

The acidity and alkalinity of soils is expressed in the pH value, which is a scale that measures the concentration of hydrogen ion held by the soil colloids (particles). In pure water, one part in 10 million is dissociated to form hydrogen ions, i.e., 10^{-7}, and the pH is thus 7; this is a neutral state on the scale of acidity. If a strong alkali such as caustic soda is dissolved in water, the solution is marked as alkaline (pH 14). By contrast, hydrochloric acid has a pH value of 3. A neutral soil has a pH value of about 7.2, and acid soil less than 7.2 (sometimes as low as 3). A strongly alkaline soil has a pH value of about 8 or higher.

Soil Air

The air content of soil is vital, both to itself and to organic life within it. The air in the soil helps in the process of oxidation which converts nitrogen into a form readily available to the plants. On the other hand, too high degree of oxidation (in the tropical regions) may consume so much organic material that the soil becomes increasingly sterile. Moreover, most bacteria, present in the soil in infinite numbers, require oxygen and are said to be *aerobic*. As these organisms are partly responsible for breaking down plant and animals remains, absence of air limits their activity.

Soil Water

Depending on the texture of the soil, water moves downward by percolation. The amount of water in the soil varies from nil in arid climates, which makes life virtually impossible for organisms, to a state of complete water-logging which excludes air, causes a reduction in bacteriological activity, and limits decomposition.

Soil Horizon

It is a distinct layer within soil which differs chemically and/or physically from the layer below or above. It is a layer of soil which lies more or less parallel to the surface and has fairly distinctive soil properties (**Fig. 6.2**).

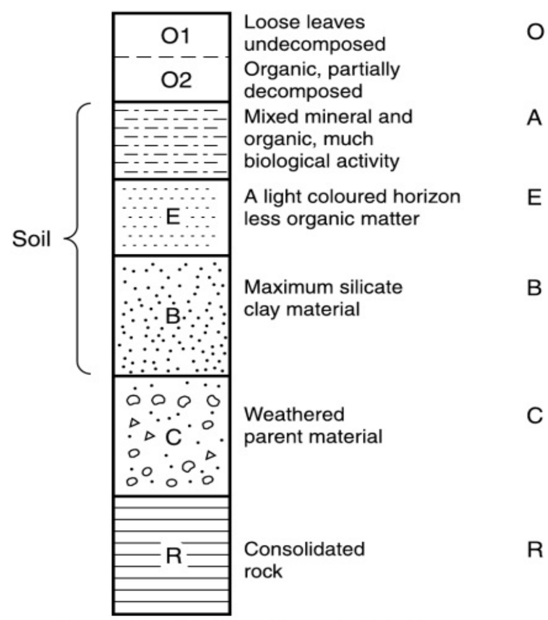

Fig. 6.2 Soil Profile and Soil Horizons

Soil Profile

It is a vertical series of soil horizons from the ground surface to the parent rock. The profile results from the same parent rock having similar horizons and soil profiles, but with varying characteristics according to their location (**Fig. 6.2**).

India is a vast country having great variations in its terrain and climatic conditions. The geo-climatic conditions of India have affected the general distribution of soils, their texture, structure, colour, pH value, and porosity. In general, the soils of India follow the climatic and vegetation belts.

Soil is formed under specific natural conditions and each of the elements of the natural environment contributes to this complex process described by soil scientists as the process of pedogenesis or soil formation. The soil of a place is closely influenced by the nature of parent rock, surface features of relief, climatic conditions, natural vegetation, land use practices, organisms, insects, micro-organisms (bacteria), and time. These factors do not act on soil independently or in isolation, but in close association with each other leading to a whole network of inter-relationships of quite a complex nature. The material for soil formation, termed by soil scientists as the parent material, is derived from the rocks exposed on the surface. The relief and characteristics of slope along with the work of the various agents of weathering, determine conditions for the disintegration of the rock materials. Thus, the original soil characteristics, including the chemical constituents, are borrowed from the rock below. Soils may be transported by running water, wind or other agents of erosion, or may remain in the original position. When soil remains in its original position, it is said to be *in situ*, and in that state it is further modified by the climate, particularly moisture supply, plant growth and bacterial activity dependent on these factors.

As a natural resource, soil is of immense value to humans. Its nature and fertility determines the agricultural productivity on which depends the carrying capacity of the soil and the level of development of the rural communities.

CLASSIFICATION OF SOILS OF INDIA

A number of attempts have been made to classify the soils of India during the last century. The first scientific classification of Indian soils was made by Voeleker (1893) and Leather (1898). According to them the Indian soils may be classified into four categories, namely (i) alluvial, (ii) regur (black-earth), (iii) red soil, and (iv) lateritic soil.

Subsequently, on the basis of texture, structure, colour, pH value and porosity, the All India Soil and Land Use Survey Organisation attempted a classification of soils of India in 1956. In 1957, the National Atlas and Thematic Mapping Organisation published a soil map of India in which Indian soils were classified into six major groups and eleven sub-groups. In 1963, the Indian Council of Agricultural Research, under the supervision of S.P. Ray Chaudhry, published a soil map of India in which the soils have been divided into seven groups. More recently, the Indian Council of Agricultural Research, on the basis of texture, structure, colour, pH value, and porosity has identified the following types of soil groups. [**Table 6.1** (**Fig. 6.3**)].

1. Alluvial soils
2. Red soils
3. Regur (Black-earth) soils

4. Desert soils
5. Laterite soils
6. Mountain soils
7. Red and Black soils
8. Grey and Brown soils
9. Submontane soils
10. Snowfields.

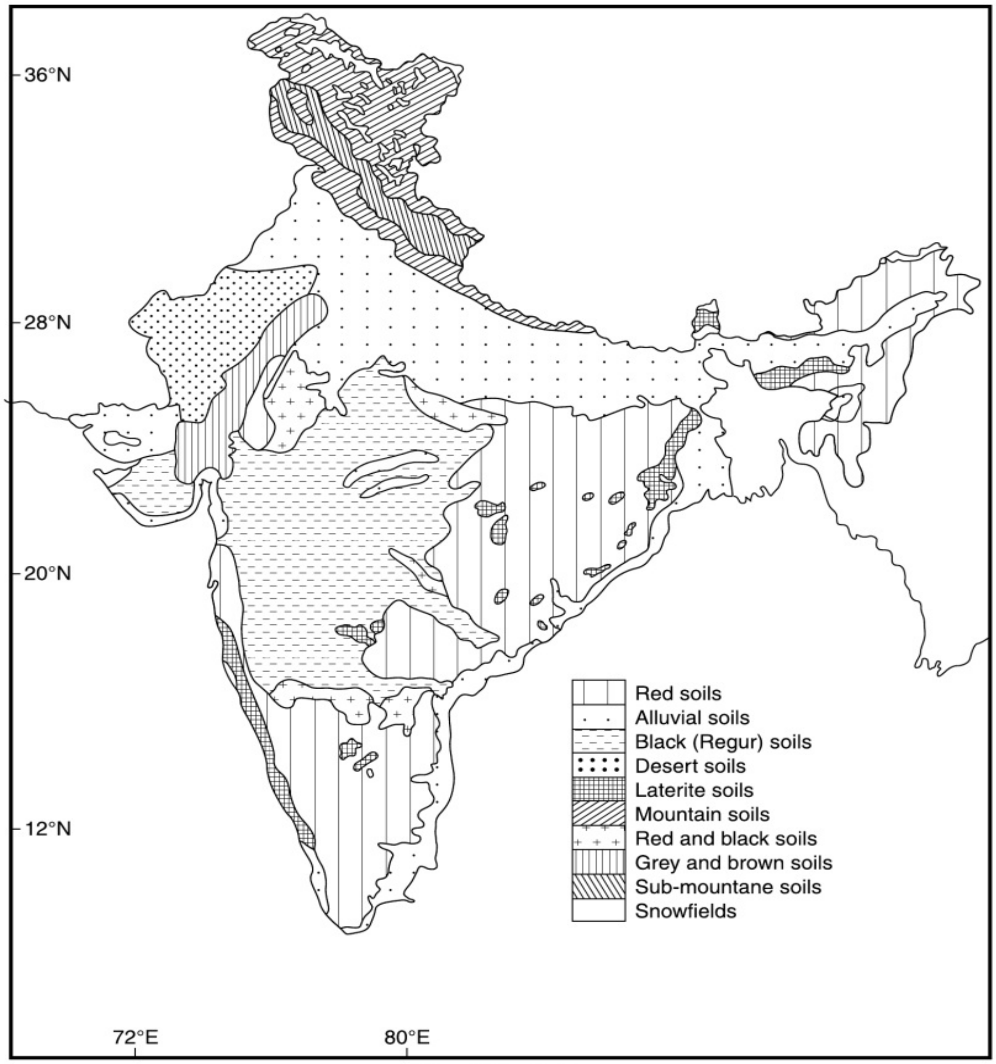

Fig. 6.3 Soils

Table 6.1 *Types of Soils, their Area and Percentage to Total Reporting Area*

Soil types	*Area in million hectares*	*Percentage*
1. Alluvial soil	143.1	43.36
2. Red soil	61.0	18.49
3. Black (Regur) soil	49.8	15.09
4. Mountain soil	18.2	5.51
5. Red and Black soil	17.8	5.40
6. Desert soil	14.6	4.42
7. Laterite soil	12.2	3.70
8. Grey and Brown soil	3.6	1.09
9. Submontane-soil	5.7	1.73
10. Snowfields	4.0	1.21
11. Other soils		
12. Total reported area	330.0	100.00

1. Alluvial Soils

The alluvial soil covers about 143.1 million sq km accounting for about 43.4 per cent of the total reporting area. The alluvial soils occur mainly in the Satluj-Ganga-Brahmaputra Plains. They are also found in the valleys of Narmada, Tapi and in the Eastern and Western coastal plains (**Fig. 6.2**). These soils are mainly derived from the debris brought down from the Himalayas or from the silt left out by the retreating sea. The colour of the alluvial soils varies from light grey to ash grey and the texture is sandy to silty-loam. These soils are both well drained and poorly drained. In general, they have an immature profile in undulating areas, while in the leveled areas they have a well developed and mature profile.

These soils may be divided into the (i) *Khadar* soil: The khadar soils are low-lying, frequently inundated by floods during the rainy season. Thus, the khadar occupies the flood plains of the rivers and is enriched by fresh silt deposits every year. The khadar tracts are generally rich in concretions, and nodules of impure calcium carbonate or *Kankar*. In the drier areas, it also exhibits stretches of saline and alkaline efflorescences locally known as '*reh*', *kallar* or *thur*, (ii) The *Bhangar* soil is above the flood level. It is generally well-drained but contains concretion (kankars) of impure calcium carbonate. The soil texture varies from loamy soil to clayey-loam. It is well drained and suited to wheat, rice, maize, sugarcane, pulses, oilseeds, *barseem* (fodder), fruits and vegetables. Alluvial soils are rich in humus, phosphoric acid, lime and organic matter. They are, however, deficient in potash.

2. Red Soils

Red soils occupy the second largest area of about 61 million hectares or 18.5 per cent of the total reporting area. They are found mainly over the Peninsula from Tamil Nadu in the south to Bundelkhand in the north, and Rajmahal in the east to Kathiawad and Kachchh in the west (**Fig. 6.3**).

These soils are also found in tracts in western Tamil Nadu, Karnataka, southern Maharashtra, Andhra Pradesh, Chhattisgarh, Jharkhand, Odisha, and in scattered patches in Bundelkhand, Mirzapur, Sonbhadra (Uttar Pradesh), Banswara, Bhilwara, Udaipur, (Rajasthan).

Developed on Archaean granite, these soils are also known as the omnibus group. Their colour is mainly red because of the presence of ferric oxides. Generally, the top layer is red, while the horizon below is yellowish in colour. The texture of red soils varies from sand to clay and loam. Their other characteristics include porous and friable structure, absence of lime, *kankar* and carbonates and small quantity of soluble salts. In general, these soils are deficient in lime, phosphate, magnesia, nitrogen, humus, and potash. Intense leaching is a menace to these soils. In the uplands, they are thin, poor, gravelly, sandy, or stony and porous, light-coloured soils, but in the lower plains and valleys, they are rich, deep, dark coloured fertile loams. In places where irrigation water is available, they are devoted to wheat, cotton, pulses, tobacco, millets, oilseeds (linseed), potato, and orchards.

3. Black or *Regur* Soils

Black soils, also known as *Regur* (cotton-soil) and internationally as 'tropical chernozems', are the third largest soil group in India. They sprawl over about 50 million hectares accounting for 15 per cent of the total reporting area of the country. Getting their parent material from the weathered rocks of Cretaceous lava, they stretch over the greater parts of Gujarat, Maharashtra, western Madhya Pradesh, north-western Andhra Pradesh, Karnataka, Tamil Nadu, Rajasthan, Chhattisgarh, and Jharkhand, up to Rajmahal Hills. They are mature soils. Over the greater parts of the black earth soil, the average annual rainfall varies between 50 and 75 cm.

The colour of these soils varies from deep black to light black. In general, these soils have clayey texture and are rich in iron, lime, calcium, potash, aluminium and magnesium. They are, however, deficient in nitrogen, phosphorous and organic matter. Moreover, these soils have a high water retaining capacity. They are extremely compact and tenacious when wet, and develop wide cracks when dry. In other words, they swell greatly and become sticky when wet in rainy season. When the soil is wet, it becomes difficult to plough the field as the plough gets stuck in mud. In the dry season, the moisture evaporates, the soil shrinks and develops wide cracks, often 10-15 cm deep. These soils are highly productive, and thus well suited for the cultivation of cotton, pulses, millets, linseed, castor, tobacco, sugarcane, vegetables, and citrus fruits.

4. Desert Soils

Sprawling over about 15 million hectares, the desert soils account for over 4.42 per cent of the total reporting area of the country. These soils are developed under the arid and semi-arid conditions and deposited mainly by wind action. They are found mainly in Rajasthan, west of the Aravallis, northen Gujarat, Saurashtra, Kachchh, western parts of Haryana, and the south-western parts of Punjab.

The desert soils are sandy to gravelly with low organic matter, low nitrogen and varying percentage of calcium carbonate. These soils contain high percentage of soluble salts, but have low moisture content and low water retaining capacity. If irrigated, they give high agricultural returns. The availability of water from the Indira-Gandhi Canal has transformed the agricultural landscape of the desert soils of western Rajasthan. These soils are mainly devoted to *bajra*, pulses, *guar,* fodder, and less water requiring crops.

5. Laterite Soils

These soils were studied first by the British geographer F. Buchanan in 1905. Their name has been derived from the Latin word "Later' which means 'brick'. These soils, when wet, are as soft as butter, but become quite hard and cloddy on drying. These are the typical soils of the monsoon climate which is characterised by seasonal rainfall. The alternating wet and dry seasons lead to the leaching away of the siliceous matter of the rocks leading to the formation of such soils. The red colour of the soils is due to the presence of iron-oxide. These soils developed mainly in the highland areas of the plateau. The soils in the higher areas are generally more acidic than those in the low-lying areas.

Laterite soils cover an area of about 12.2 million hectares accounting for about 3.7 per cent of the total reporting area of the country. They are found mainly in the hills of Western Ghats, Eastern Ghats, Rajmahal Hills, Satpura, Vindhya, Odisha, Chhattisgarh, Jharkhand, West Bengal, North Cachar Hills of Assam, and the Garo Hills of Meghalaya.

These soils are rich in iron and aluminium, but poor in nitrogen, potash, potassium, lime and organic matter. Although they have low fertility, they respond well to manuring. They are mainly devoted to rice, ragi, sugarcane, and cashewnuts.

6. Mountain Soils

Covering an area of about 18.2 million hectares or about 5.5 per cent of the total reporting area of the country, these soils are found in the valleys and hill slopes of the Himalayas between 200 and 300 metres. These soils are generally immature and are still to be probed systematically. In structure and texture, they vary from silt-loam to loam. Their colour is dark brown. These soils can be divided into: (i) loamy podzols , and (ii) high altitude soils.

Podzols occupy the mid-latitude zone in the Himalayas corresponding with the deodar, pine and blue-pine areas of Assam, Darjeeling, Uttarakhand, Himachal Pradesh, and Jammu and Kashmir. These soils are acidic in character with low humus content. They are devoted to maize, rice, legumes, fodder and orchards.

The High altitude soils, depending on the forest cover, slope, and rainfall are classified as brown earth type and red-loam. The sub-soil surface of these soils remains frozen under snow. Their soil profile is generally less developed.

7. Red and Black Soils

The red and black soil is found in isolated patches in Bundelkhand, and to the east of Aravallis in Rajasthan and Gujarat (**Fig. 6.3**). They developed over the granite, gneiss, and quartzite of the Archaean and Pre-Cambrian period. These soils are relatively less productive, but perform well under irrigation conditions. They are devoted to maize, bajra, millets, pulses, and oilseeds.

8. Grey and Brown Soils

These soils have been formed by the weathering of granite, gneiss, and quartzite. These are loose friable soils. Due to the presence of iron-oxide (haematite and limonite) these soils vary from red to black and brown in colour. These soils are found in Rajasthan and Gujarat (**Fig. 6.3**).

9. Submontane Soils

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

10. Saline and Alkaline Soils

The saline soils are characterised by the presence of sodium chloride and sodium sulphate. In these soils, the saline and alkaline efflorescence appears on the surface as a layer of white salt through capillary action. These soils are known by different names in different parts of the country. They are called as *reh, kallar, usar, rakar, thur, karl,* and *chopan.* These soils are found in Rajasthan, Haryana, Punjab, Uttar Pradesh, Bihar, and Maharashtra.

Texturally, these soils vary from sandy to sandy-loam. They are deficient in nitrogen, calcium and have very low water bearing capacity. These soils can be reclaimed by improving drainage, by applying gypsum and/or lime and by cultivating salt resistant crops like barseem, *dhaincha*, and other leguminous crops.

11. Peaty and Marshy Soils

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

12. Karewa Soil

Karewas are the lacustrine deposits in the Valley of Kashmir and in Bhadarwah Valley of the Doda District of the Jammu Division. These are the flat topped mounds that border the Kashmir Valley on all sides. They are composed of fine silt, clay, sand, and bouldery-gravel. They are characterised with fossils of mammals and at places by peat. According to geologists, during the Pleistocene Period, the entire Valley of Kashmir was under water. Subsequently, due to endogenetic forces, the Baramullah Gorge was created and the lake was drained through this gorge. The deposits left in the process are known as karewas (**Fig. 6.4**).

According to Middlemiss, the thickness of karewas is about 1400 m. In fact, the karewas have been elevated, dissected and in great measure removed by subaerial denudation as well as by the Jhelum river giving them the present position. The karewas are mainly devoted to the cultivation of saffron, almond, walnut, apple and orchards. The karewas, devoted to saffron cultivation are fetching good income to the growers. The karewas of Palmpur, Pulwama, and Kulgam are well known for their production of superior quality of saffron.

13. Snowfields

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

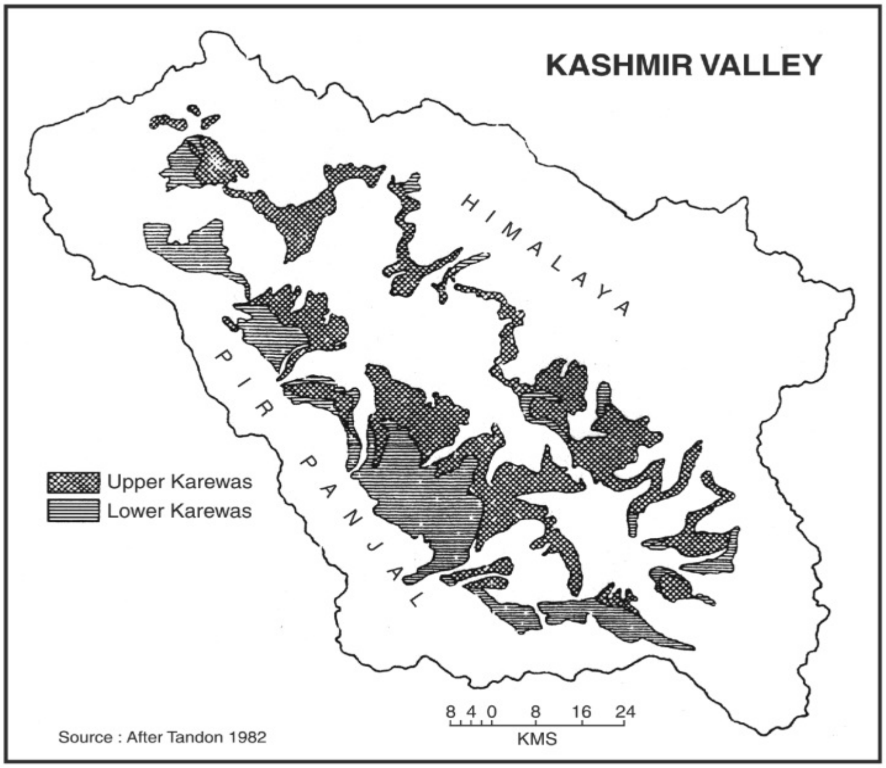

Fig. 6.4 Karewas

PROBLEMS OF INDIAN SOILS

The forces of nature often destroy the soil cover of an area. The process of soil destruction is the result of natural forces. Soils are however, also being damaged and destroyed by human activities, such as deforestation, over-grazing of animals and unscientific use of agricultural land. The main problems of the Indian soils are (i) soil erosion, (ii) declining fertility of soil, (iii) salinity and alkalinity, (iv) water-logging, and (v) desertification.

(i) Soil Erosion

Soil erosion refers to the removal of top soil. Soil erosion is a growing menace in many parts of India. When the top soil is removed, it is known as sheet erosion, and when the runoff makes gullies, it is known as gully erosion. In India, soil erosion is a universal problem. In the areas where rainfall is heavy water is the main agent of soil erosion, while in the arid and semi-arid areas wind is responsible for soil erosion. According to one estimate about 180 million hectare (about 60 per cent of the total area of the country) is adversely affected by soil erosion.

The main agents of soil erosion are water, wind, sea-waves, glaciers, and shifting cultivation. The areas adversely affected by the different agents of erosion have been shown in **(Fig. 6.5).** Out

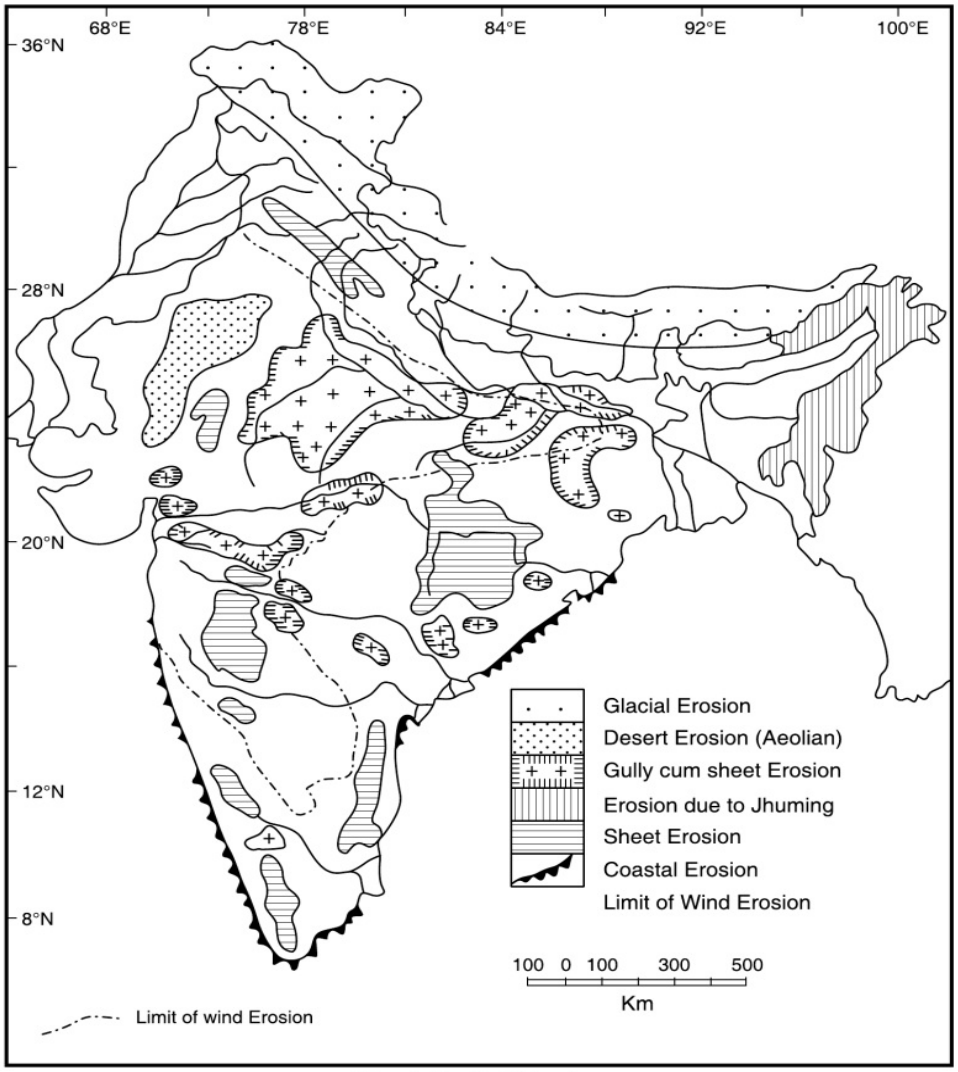

Fig. 6.5 Soil Erosion

of these, water is the most important agent of erosion. Water erosion may be classified under three categories: (a) surface erosion or the uniform removal of soil from the surface, (b) Rill erosion in which the running water makes finger-shaped grooves in the land, and (c) gully formations, in which the rills are enlarged, making the land bad and unsuitable for cultivation. A typical example of gully erosion is provided in the Chambal valley in Madhya Pradesh. Rajasthan, and Uttar Pradesh also provide typical examples of gully erosion. (**Fig. 6.6**). Gully erosion is also significant in the Shiwalik tracts of Punjab, Haryana, Himachal Pradesh, Jammu and Kashmir, Uttarakhand, Uttar Pradesh and along the southern slopes of Himalayas, and the Western and Eastern Ghats.

Wind erosion is significant in the arid and semi-arid areas of Rajasthan, Haryana, Punjab, western Madhya Pradesh and Gujarat. Wind erodes soil along the coastal plains of Peninsular India. Thousands of hectares of fertile lands of Uttar Pradesh, Gujarat, Haryana, Punjab, and western Madhya Pradesh have been adversely affected by this process.

The tidal waters of the Arabian Sea and the Bay of Bengal cause considerable damage to the soils along the coastal areas. Severe erosion of beaches along the Kerala, Tamil Nadu, Andhra Pradesh, Odisha, and Gujarat coasts is the example of sea-wave erosion.

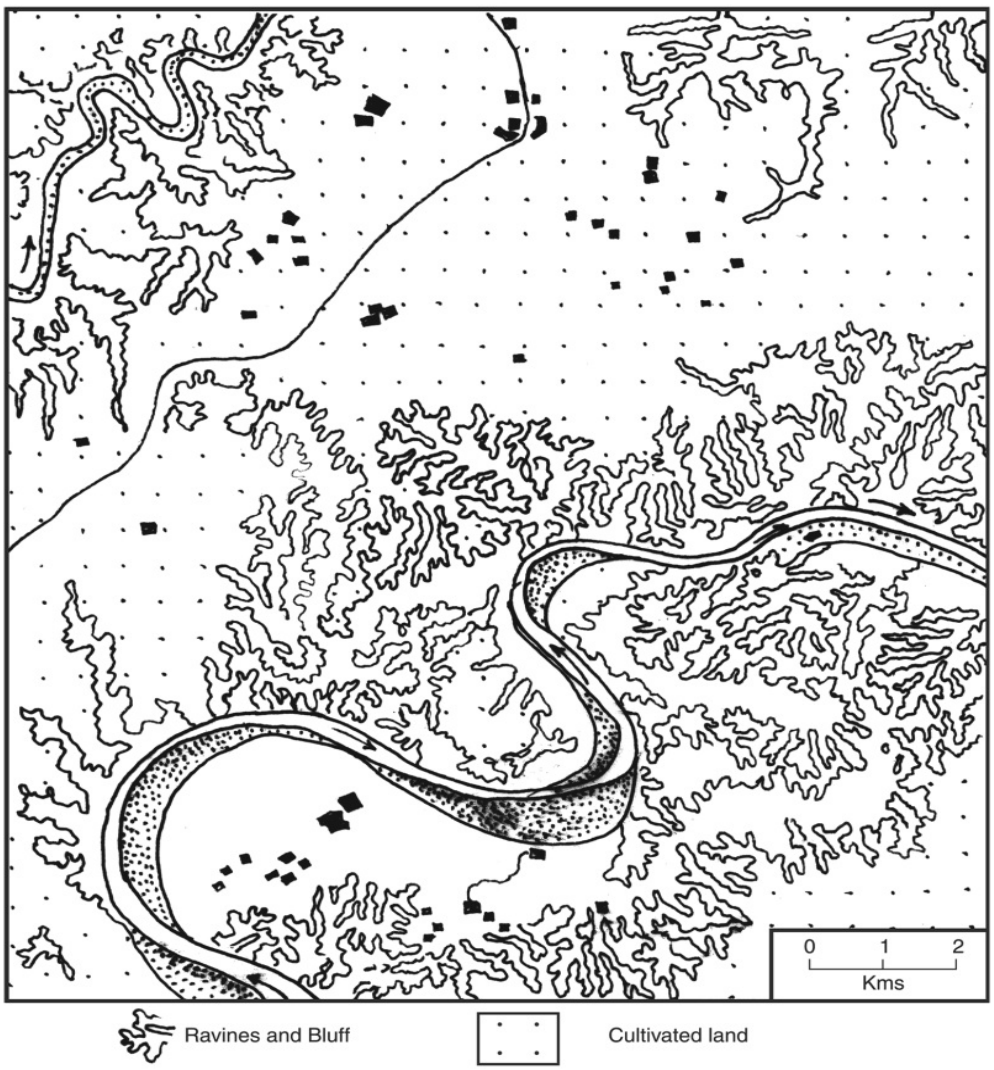

Fig. 6.6 Gully Erosion in Chambal Valley

The largest area affected by soil erosion is in the state of Rajasthan, followed by Madhya Pradesh, Maharashtra, Uttar Pradesh, Gujarat, Andhra Pradesh and Karnataka. The worst affected areas of soil erosion include: (i) Chambal and Yamuna rivers **(Fig. 6.6),** (ii) the southern slopes of Shiwaliks, Lesser and Greater Himalayas, (iii) the Western and Eastern Ghats, (iv) the Chotanagpur Plateau, and (v) the arid and semi-arid areas of Rajasthan, Gujarat, Haryana, and Punjab.

(ii) Declining Soil Fertility

Being utilised for centuries, and multiple cropping without fallowing the agricultural land, the natural fertility of soil is depleting fast. The farmers of Punjab, Haryana, and western Uttar Pradesh often complain about the decreasing fertility of their soils. It has been reported that the farmers are using more inputs each subsequent year to get the return to the level of the previous year. This testifies to the diminishing fertility of land. In fact, the unscientific rotation of crops (wheat and rice) over several decades has depleted the soil fertility in the Great Plains of India substantially. The cultivation of leguminous crops after a soil exhaustive crop can improve the soil fertility affected regions.

(iii) Water-Logging

An area is said to be waterlogged when the water table rises to the extent that soil pores in the root zone of a crop become saturated, resulting in the restriction of normal circulation of the air, decline in the level of oxygen, and an increase in the level of carbon dioxide**.**

Apart from soil erosion, there are many ill-drained, low lying areas in India where the soil has been damaged by water-logging (**Fig. 6.7**). The main causes of waterlogging are: (i) seepage of water from canals, (ii) faulty on farm water management, (iii) lack of drainage, (iv) interception of natural drainge, (v) indiscriminate cultivation in bed of drainage channel, and (vi) inundation of marine delta cycles, and (vii) inundation in coastal areas during cyclonic storms. Water logging has affected substantial tracts of land along the Indira Gandhi Canal (Rajasthan) and the canals of Punjab, Haryana, and Uttar Pradesh**.** Adequate development of drainage and lining of the canals to reduce water seepage can go a long way in the reclamation of water-logged areas**.**

(iv) Saline and Alkaline Soils

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

(v) Salt Flats

The soils seriously damaged by the excess of calcium chlorides are found in the Rann of Kachchh (**Fig. 6.7**). These soils are saline, marshy and infested with tall grasses, bushes and scrubs. They are almost useless from agricultural point of view. A sound strategy needs to be developed to bring the salt flats under agriculture or pastures.

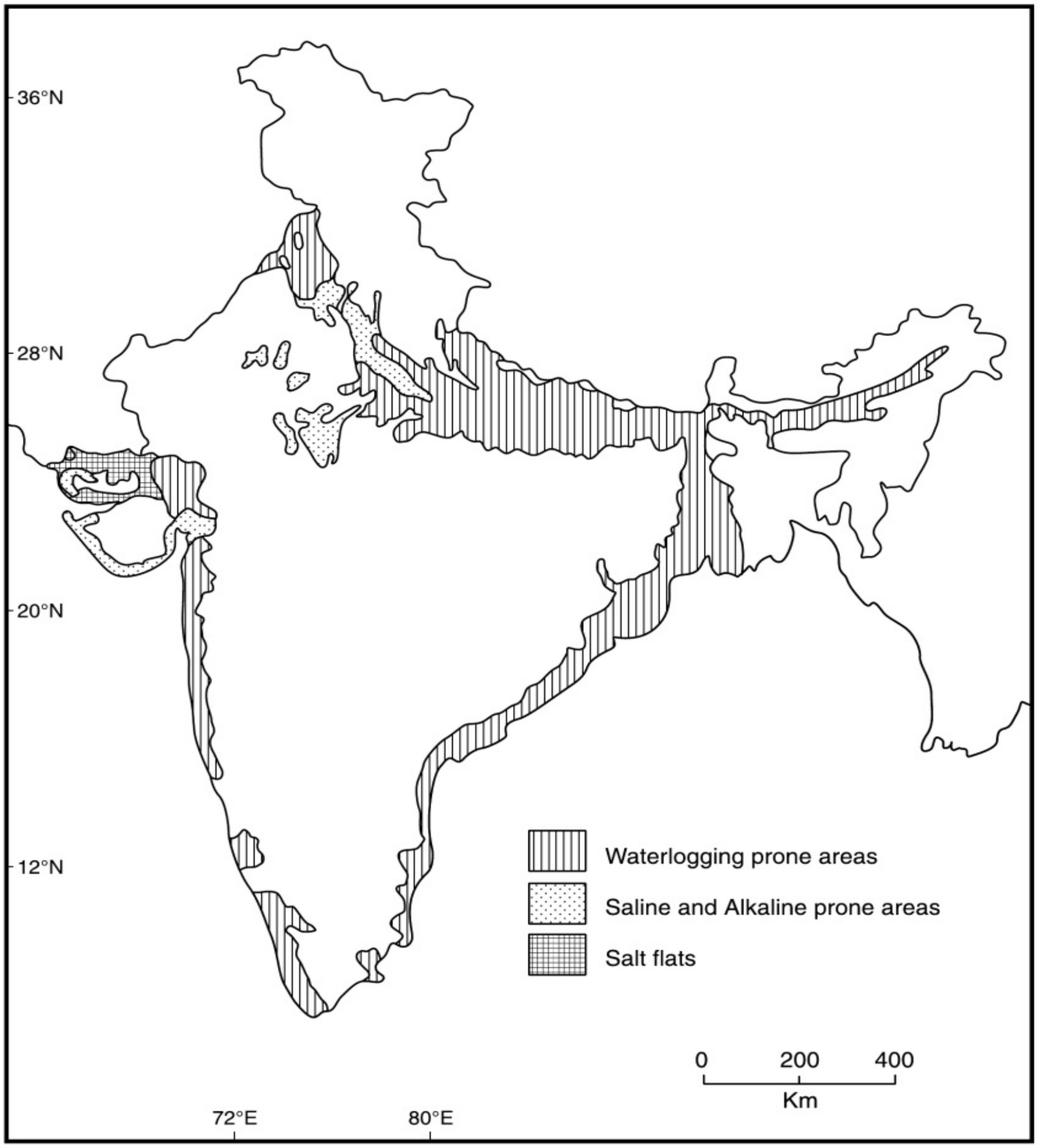

Fig. 6.7 Soil Affected Areas

The Planning Commission, on the basis of data provided by the Ministry of Agriculture in 1985, mentions the types of degraded soils/land and their causes. These categories of land and their causes have been given in **Tables 6.2 and 6.3.**

Table 6.2 *Types of Degraded Land*

Categories	*Area in million hectares*
Gullied lands	2.05
Land with/without scrub	19.40
Water logged and marshy lands	1.66
Land affected by salinity and alkalinity	2.05
Shifting cultivation area	3.51
Under utilised/degraded forests	14.06
Degraded pastures and grazing lands	2.60
Degraded land under plantation crops	0.58
Sand (inland/coastal)	5.00
Mining/industrial wasteland	0.12
Barren rock/strong waste sheet rock area	6.42
Steep sloping area	0.77
Snow covered/glacial area	5.58
Total	63.80

Source: ***Planning Commission and Five Year Plan,*** New Delhi, p. 582

Table 6.3 *Causes and Extent of Degradation*

Causes of degradation	*Area in million hectares*	*Total Area percentage*
Water erosion	107.12	61.71
Wind erosion	17.79	10.25
Ravines	3.97	2.28
Salt affected	7.61	4.38
Water logging	8.52	4.91
Degraded forest land	19.49	11.23
Special problems	2.73	1.57
Coastal sandy areas	1.46	0.84
Degraded land due to shifting cultivation	4.91	2.83
Total	173.60	100.00

Source: ***Planning Commission and Five Year Plan,*** New Delhi. p. 582.

The causes of soil degradation differ from region to region and from place to place. In some places, it is due to water erosion, while at others it is due to wind erosion, or salt and toxic chemicals.

It may be seen from **Table 6.2** that over 2 million hectares of land is gullied and about 1.66 million hectares are waterlogged and marshy lands. Moreover, 3.51 million hectares are adversely affected by shifting cultivation. The degraded notified forests cover over 14 million hectares and over 19 million hectares of land is without scrub. These lands need immediate attention for reclamation.

Water and wind erosion are the most potent causes of land degradation. Water erosion produces gully erosion, while water and wind erosion lead to sheet erosion. Wind erosion becomes active when the vegetation is removed from the land and land is exposed to wind action. Soil degradation by wind and water erosion have been shown in **Fig. 6.8**. It may be observed from this figure that wind erosion is mainly in the Thar desert while soil erosion by water is well spread in the Himalayas, Gangetic plains and the Peninsular India (**Fig. 6.8**). Intensive agricultural practices that rely heavily on water, chemical fertilisers, and insecticides and pesticides have caused water-logging and salinity in many parts of India. The expansion of irrigation without proper drainage has accentuated this. The extent of degraded land is not precisely known. According to land use statistics 2002, published by the Department of Agriculture of India, the estimates of cultivable wastelands are 13.9 million hectares (**Table 6.2**).

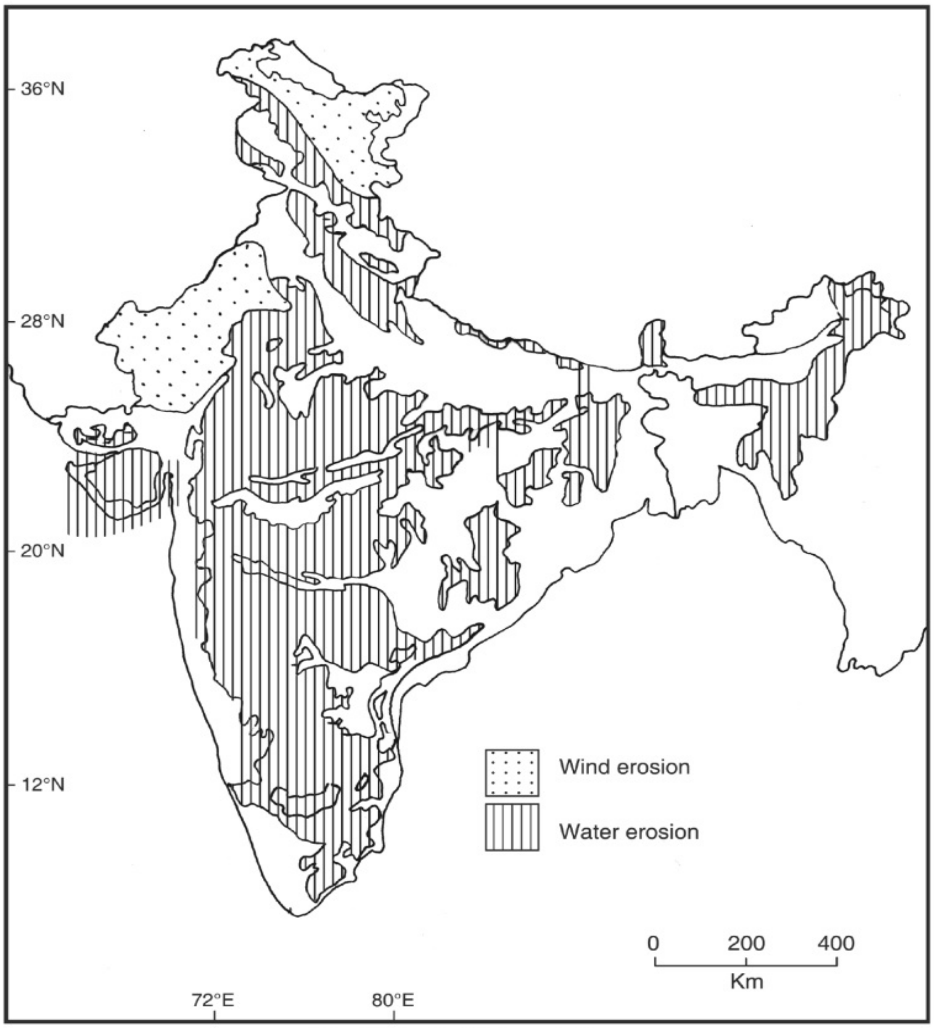

Fig. 6.8 Soil Degradation

CONSEQUENCES OF SOIL EROSION

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

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

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

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

SOIL CONSERVATION

Looking at the importance of soil resources for a country of over a billion people, a judicious utilisation and conservation of soil is of parmount importance.

The farmers in the drier parts of Gujarat, Haryana, Rajasthan, and western Madhya Pradesh have successfully protected their fields from soil erosion by planting rows of trees to reduce the velocity of winds which continually erode soil cover. Soil conservation includes reduction in soil erosion, afforestation, rational utilisation of soils and ways to enhance their sustainability. Some of the important steps which can go a long way in the conservation of soils are as under:

1. Afforestation

Tree plantation helps in the reduction of soil erosion. Trees reduce the intensity of runoff and increase the seepage of water to the underground water-table. Social forestry can be developed along the banks of rivers, canals, lakes, roads, and railway tracks.

2. Restriction on the Felling of Trees

Apart from afforestation, it is equally important to check the indiscriminate felling of trees. People's awareness that resulted in the launch of the *Chipko Movement* can help in achieving this objective.

3. Contour Ploughing and Strip Cultivation

In the hilly and mountainous areas, ploughing should be done according to the contours and not in an up-down direction of slope. The contour ploughing is an effective way of checking soil erosion.

Similarly, small strips can be developed on gentle slopes for sowing crops which help in overcoming the menace of soil erosion.

4. Control of Floods

In India, the problem of soil erosion is closely associated with floods. The floods generally occur during the rainy season. Efforts, therefore, need to be made for the storage of flood water or the diversion of additional rain-water. The inter-connecting of rivers as in the Garland Canal Project or the Ganga-Kaveri Link Canal Project can be of immense help in this direction.

5. Reclamation of Ravine and Badlands

Reclamation of gullies and ravines is also necessary to overcome the problem of soil erosion. Several such schemes involving plugging of gully mouths, construction of bunds across the gullies, levelling of gullies, afforestation, restriction on grazing are under implementation in the Chambal ravines of Madhya Pradesh, Uttar Pradesh, and Rajasthan.

6. Restriction on Shifting Cultivation

In the states of north-east India and Western and Eastern Ghats, shifting cultivation (slash and burn) is one of the main causes of soil erosion. The shifting cultivators need to be persuaded to stop the practice of shifting cultivation and should be trained and motivated to adopt terraced farming. A scheme to control shifting cultivation has been launched in the seven states of north-east India. This is a beneficiary oriented programme which aims at the rehabilitation families of the Jhumias (shifting cultivators). There is a need to extend this programme to other states of the country and gradually replace this agricultural system by sedentary farming.

7. Restoration of Long Fallow

There are 96 lakh hectares of fallow land. The old fallow land is mainly found in Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu, Bihar, Uttarakhand, and Uttar Pradesh. This old fallow land can be brought under cultivation, grazing and orchards which shall be helpful in the reduction of soil erosion.

8. Reclamation of Saline and Alkaline (usar) Soil

The saline and alkaline affected area in the country is more than 80 lakh hectares. The state-wise distribution in the major states of India has been given in **Table 6.4.**

This land needs reclamation. Application of cow-dung and gypsum are quite helpful in the reclamation of salt-affected soils.

9. Other Measures of Soil Conservation

The government of India has been attempting to check the soil erosion through out the planning period. The following steps can go a long way in reducing the rate of soil erosion.

(i) Construction of small dams across the tributaries of rivers in their upper reaches to control floods and soil erosion.

Table 6.4 *Salinity Affected Areas in the Major States of India*

States	*Area (in lakh hectares)*
Uttar Pradesh	12.95
Punjab	12.25
Gujarat	12.14
West Bengal	8.50
Rajasthan	7.28
Maharashtra	5.34
Haryana	5.26
Karnataka	4.04
Odisha	4.04
Madhya Pradesh	2.24
Andhra Pradesh	0.42
Total	74.46

(ii) Lining of canals to stop seepage of water which leads to waterlogging.
(iii) Solving the problem of waterlogging by improving the surface and vertical drainage.
(iv) Formation of windbreak and shelter belts in arid and semi-arid regions.
(v) Increasing use of organic and compost manure.
(vi) Popularising the application of cowdung and green manure.
(vii) Conversion of human waste and city garbage into manures.
(viii) Scientific rotation of crops.
(ix) Filling up gullies and forming terraces along the slopes.
(x) Levelling of ravines and planting of trees and grasses in the slopes.
(xi) Check on shifting cultivation and conversion of Jhum lands into sedentary agriculture.
(xii) Promotion of afforestation in the degraded soils.
(xiii) Adopting the techniques of sustainable agriculture.
(xiv) To educate public about the adverse effects of soil erosion through seminars, conferences, and workshops in the regions of degraded soils.

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Chapter 7

Resources

NATURAL RESOURCES

Any matter or energy derived from the environment (nature) that is used by living things including humans is called a natural resource. Resources are the basis for the development of any country. India, one of the largest countries in the world, is blessed with diverse and abundant resources. Only a judicious use of resources will help the development of a country. Over exploitation and unscientific land-use practices will lead to environmental problems and to resource depletion. Natural resources include air, water, soil, minerals, fossil fuels, plants and wild life. Many of these natural resources are essential for human survival; e.g. air, water, and plants. Others are used for satisfying other material needs and desires.

Natural resources have been classified in many ways. One way is to classify them on the basis of the source of their origin. Accordingly, there are land, soil, water, plant, animal, mineral, and energy resources.

Another method of classification is according to the stage of development of a resource. Those resources which are found in the region, but have not been put to proper use are called **Potential resources**. For example, the state of Assam and the Brahmaputra River have a vast potential of water resources, but all of them have not yet been determined and utilized, fully. The resources which have been surveyed and quantified for actual use are called **Actual resources**. The development of the actual resource depends on the technology available and the cost involved. That portion of the actual resource which can be developed profitably with available technology is termed a **Reserve resource**. For example, an increase in the world price of metal such as iron makes it profitable to utilise even low grade ore, thus turning a resource into a reserve. Natural resources may also be classified as **renewable** and **non-renewable** resources. The main characteristics of these resources are given below:

Renewable Resources: Resources which get renewed or replenished fast, are called renewable resources. Some of these resources are always available (continuous) and do not get affected by human activities; e.g., solar and wind energy. Many resources, on the other hand, get depleted after use. These may, however, be replenished without endangering future use, provided that the rate of consumption does not exceed the rate of renewal or replenishment. Hence, they maintain a flow. Some resources like crops take short time for renewal. Others like water can be renewed in a comparatively longer time. Some other resources like forests take even longer.

Non-renewable Resources: Non-renewable resources are built over a long geological time span. Minerals and fossil fuels are the examples of non-renewable resources. Since the rate of their formation is extremely slow, they can not be replenished within a time frame meaningful to human-beings. Though these resources are normally found in large quantities, they are distributed most unevenly. Their economic use is viable only when they are found in sufficiently large concentrations and are extractable. Some of these resources like gold, silver and iron are recyclable in nature. It means that the metal content obtained from the ore may be used again and again after necessary processing. Fossil fuels such as coal, mineral oil and natural gas get exhausted. Hence, they are non-recyclable.

MINERAL RESOURCES

A mineral is an aggregate of two or more than two elements. A mineral has a definite chemical composition, atomic structure and is formed by inorganic processes. In economic geography, the term mineral is used for any naturally occurring material that is mined and is of economic value.

Minerals generally occur in the earth's crust in the form of ore. It is extracted, processed and utilised for the economic benefits of society. The availability and per capita consumption of minerals is taken as an important indicator to assess the economic development of a country.

India is fairly rich in mineral resources but their distribution is highly uneven. The distribution of minerals in India has been described in the following section:

Distribution of Minerals

The mineral wealth of India is largely confined to the igneous and metamorphic rocks of Peninsular India, while the Great Plains of India and the Himalayan region are almost devoid of the metallic minerals. The states which are rich in the metallic and non-metallic minerals are Jharkhand, Chhattisgarh, Odisha, Bihar, West Bengal, Madhya Pradesh, Karnataka, Maharashtra, Tamil Nadu, Gujarat, Uttarakhand, Andhra Pradesh, and Assam. The states of Uttar Pradesh, Haryana, Punjab, Himachal Pradesh, Jammu and Kashmir, and Gangetic West Bengal are, however, poor in mineral resources.

Mineral Belts of India

The following mineral belts may be identified in India (**Fig. 7.1**):

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

2. The Midland Belt This belt sprawls over the states of Chhattisgarh, Madhya Pradesh, Andhra Pradesh, and Maharashtra. This belt is rich in manganese ore, bauxite, mica, copper, graphite, limestone, lignite, marble, and limestone.

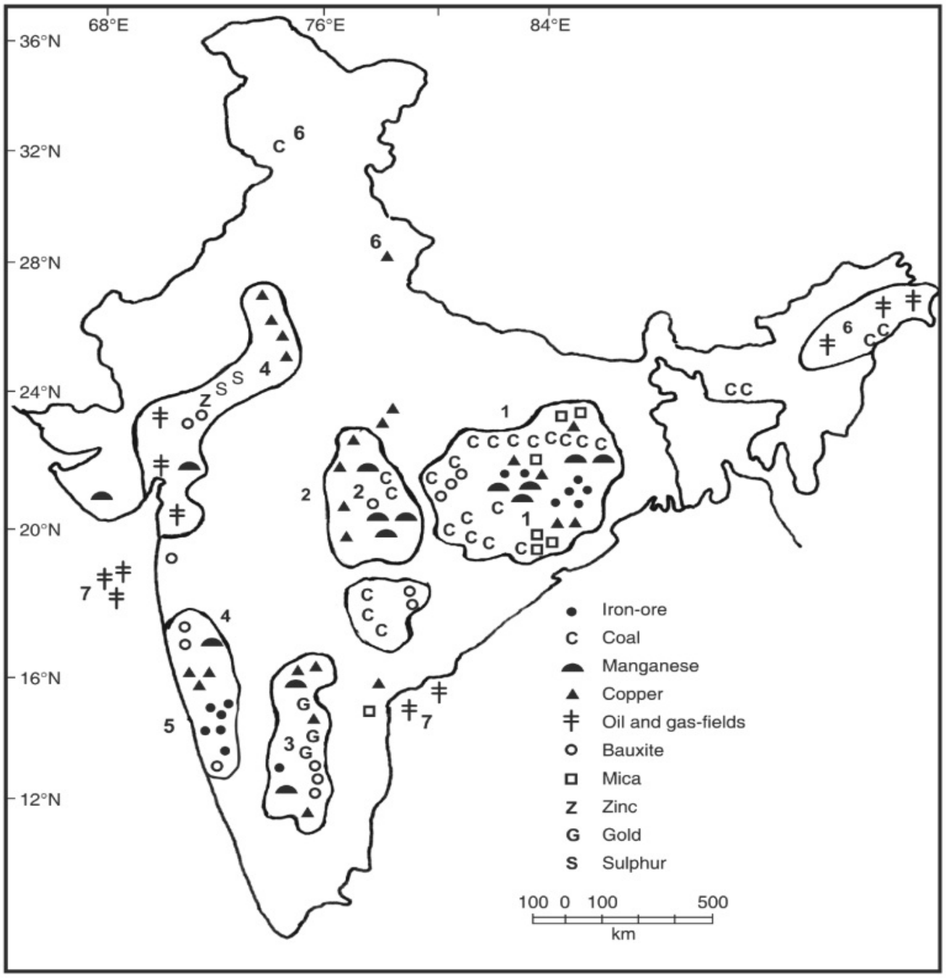

Fig. 7.1 Mineral Belts

3. The Southern Belt It stretches over the states of Andhra Pradesh, Karnataka and Tamil Nadu. This belt is rich in gold, iron ore, chromite, manganese, lignite, mica, bauxite, gypsum, asbestos, dolomite, ilmenite, china-clay, and limestone.

4. The Western Belt This belt stretches over the states of Rajasthan, Gujarat, and Maharashtra. The belt is rich in non-ferrous metals like copper, lead, zinc, uranium, mica, manganese, salt, asbestos, building stonnes, precious stonnes, mineral oil, and natural gas.

5. The South-Western Belt This belt sprawls over Goa, Karnataka, and Kerala. It contains the deposits of iron ore, ilmenite, zircon, monazite sands, garnet, china-clay, bauxite, mica, limestone, and soapstone.

6. The Himalayan Belt In general, the Himalayan belt is poor in metallic minerals. There are, however, valuable pockets of minerals, like copper, lead, zinc, bismuth, bauxite, antimony, nickel, cobalt, tungsten, precious stonnes, gold, silver, gypsum, limestone, and dolomite in the Himalayas.

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

Classification of Mineral Resources

The minerals may be classified under the following three categories:

1. Mineral Fuels (fossil fuels)
2. Metallic Minerals
3. Non-metallic Minerals

1. Mineral Fuels

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

Energy Resources (For details see Chapter 8)

2. Metallic Minerals

Metallic minerals constitute the second most important group of minerals after fossil fuels. These minerals provide a strong base for the development of metallurgical industry, and thereby help the process of industrialisation and urbanisation. India has a substantial reserve of these minerals **(Fig. 7.2).**

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

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

- **(i) Haematite ore** (red-ochre): This is called '*oxide of iron*'. Its metallic content varies between 60 to 70 per cent. It is a massive, hard, compact and lumpy ore with reddish or coral-red in colour. It is mainly found in the Dharwarian rocks. The main deposits of haematite ore are in Jharkhand (Iron-Series), Odisha (Mayurbhanj), Chhattisgarh (Bailadila Dalli-Rajhara), Madhya Pradesh, Karnataka (Kudermukh, Baba-Budan), Goa, Maharashtra, and Andhra Pradesh.
- **(ii) Magnetite**: The magnetite ore is known as *'black ore'*. The metal content of magnetite varies between 60 to 65 per cent. The ore is either igneous of metamorphic. It is mainly found in the Dharwar and Cuddapah Systems of Karnataka (Dharwar, Shimoga Districts), Andhra Pradesh (Bellary District), Tamil Nadu (Salem, Tiruchirappalli districts), and Kerala states.
- **(iii) Limonite:** It is yellowish in colour and is known as the *'hydrated iron-oxide'*. It is inferior and contains 35 to 50 per cent of metal. It is found in the iron-stone shales of the Damuda Series in Raniganj coal fields, Mirzapur District of Uttar Pradesh, Garhwal region of Uttarakhand, and the Kangra Valley of Himachal Pradesh.

Fig. 7.2 Metallic Minerals (Iron, Copper and Zinc)

(iv) Siderite: It is called as *'iron carbonate'*. Its iron content varies between 10 to 40 per cent. It is an inferior variety of iron ore and not economically extractable at most of the places.

Reserves Iron Ore According to the Geological Survey of India, the total reserves of all types of iron ore in the country are 25,500 million tonnes, out of which 14630 million tonnes is of good quality (India-2010). The statewise distribution of Iron ore in the country has been given in **Table 7.1 (Fig. 7.2).**

The production of iron ore in the country after Independence has been shown in **Table 7.1**

Table 7.1 *India: Production of Iron Ore (1950–2006)*

Year	*Production of iron ore (million tonnes)*	*Production growth*
1951	4.15	80.50
1961	18.70	350.5
1971	34.30	83.4
1981	41.60	21.30
1991	54.60	33.60
2001	86.20	21.30
2006	105.00	15.50

Source: ***Year Books & the Statistical Abstracts of India.***

It may be seen from **Table 7.1** that total production of iron ore in 1951 was only 4.15 million tonnes which rose to over 86.20 million tonnes in 2001 and reached 105 million tonnes in 2006. The growth trend of the iron ore production is significantly increasing.

The state-wise production of some of the important states has been given in the **Table 7.2.**

Table 7.2 *India: Production of Iron Ore (2005–06)*

State	*Production in thousand tonnes*	*Percentage of all India production*
Karnataka	25,565	24.90
Odisha	22,560	21.98
Chhattisgarh	20,455	19.92
Goa	18,400	17.92
Jharkhand	14,685	14.32
Others	975	0.96
All India	1,02,640	100.00

Source: ***Statistical Abstract of India***, 2006.

It may be seen from **Table 7.2** that Karnataka is the leading producer of iron ore contributing about 25 per cent of the total production. Odisha contributing about 22 per cent is second in production, while Chhattisgarh and Goa with about 20 per cent and 18 per cent of the total iron ore production in the country are third and fourth respectively. The iron-ore of very high grade are limited to Bailadila (Chhattisgarh) and to a lesser extent in Bellary-Hosepet area of Karnataka and Barajamada sector in Jharkhand and Odisha.

The important iron ore deposits and mining centres have been briefly described in the following section:

1. **Karnataka**: Karnataka is the leading producer of iron ore accounting for about one-fourth of the total ironore production of the country. The high grade deposits belonging to the

haematite and magnetite categories are found in *Kemmangundi* in Bababudan Hills of the Chikmagalur District. The other important iron ore producing districts of Karnataka are Chitradurga, Dharwar, North Kannad, Shimoga, Bellary and Tumkur.

(i) ***Bababudan Hills*:** Lying in Chikmagalur District of Karnataka they stretch over 22 km in length and 20 km in width. They are rich in haematite deposits with ferrous content of 60 to 65 per cent. The iron ore is mainly exported to Iran through the port of Mangalore.

(ii) ***Kudermukh Deposits*:** The Kudermukh iron ore deposits lie in the Chikmagalur District of Karnataka. They contain iron ore of the magnetite category with a metal content of 50 to 65 per cent. The Kudermukh deposits were developed under an export agreement with Iran. The iron ore is exported through the seaport of Mangalore.

(iii) ***Sandur Range*:** The Sandur Range stretches in the Bellary and Hosepet districts of Karnataka. The iron ore of this range is generally hard, compact and steel-grey. The ferrous content varies between 50–65 per cent. Its ore is supplied to the Vijayanagar Steel Plant.

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

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

(ii) ***Bonaigarh Range:*** Situated in the district of Sundergarh, it is one of the most important iron ore bearing ranges. Iron ore is of haematite category which is supplied to Bokaro, Durgapur, Jamshedpur, and Raurkela.

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

3. **Chhattisgarh**:. This state has about 20 per cent of the total iron ore deposits of the country. Bailadila in the Bastar District and Dalli-Rajhara in the Durg district are the main iron ore producing regions of Chhattisgarh state. The iron ore belongs to the haematite and magnetite categories in which the metal content varies between 60 to 70 per cent. The Bailadila mine is the largest mechanised mine in India. A 270-km long slurry pipeline has been constructed to bring the ore from Bailadila to Vishakhapatnam Plant. The Bailadila iron ore is largely exported to Japan through the port of Vishakhapatnam.

The Dalli Rajhara range is about 32 km long with iron ore reserves of about 125 million tonnes. The ferrous content is about 70 per cent. The deposits of this range are being worked by the Hindustan Steel Plant of Bhilai. Bilaspur, Jagdalpur, Raigarh, and Surguja are the other iron ore producing districts of Chhattisgarh State.

(i) ***Dalli Rajhara**:* The Dalli Rajhara Range, well known for the iron ore depsoits, lies in the Durg District of Chhattisgarh. It is 32 km long with an estimated iron ore deposit of 120 million tonnes. The iron ore is supplied to the Hindustan Steel Plant at Bhilai.

(ii) ***Bailadila:*** Situated in the Bastar District of the Chhattisgarh state, it is known for the rich deposits of iron ore of the haematite category. This iron ore was deposited during the Dharwar Period about 2500 to 1800 million years back. The ore is mostly exported to Japan through the seaport of Vishakhapatnam.

4. **Goa**: Goa is the fourth largest producer of iron ore in India. Goa produces about 18 per cent of the total iron ore of the country. The iron ore of north Goa is of superior quality. The main deposits and mining centres are at Pirna-Adolpale-Asnora, Sanquelim Onda, Kundem-Surla, and Sirigao-Bicholim-Dalda in north Goa. The nearby Marmagao seaport is a big advantage to these mines for the export of iron ore. The iron ore is exported mainly to Japan and Iran.
5. **Jharkhand :** Jharkhand has 25 per cent of the iron ore reserves and accounts for about 14 per cent of the total production of iron ore of the country. Iron ore mining was first of all started at Singhbhum in 1904. The main iron ore deposits lie in Bonai Ragne extending for about 50 km. The famous mines are Naomandi, Daltenganj (Palamu District). Iron ore is also mined at Dhanbad, Hazaribagh, Ranchi, and Santhal Pargana.

Other States: Iron ore in small quantities is also mined in Maharashtra, (Chandrapur, and Ratnagiri); Tamil Nadu (Coimbatore, North Arcot, Ambedkar, Madurai, Salem, Tiruchirapalli, Tirunelveli); Andhra Pradesh (Anantapur, Cuddapah, Guntur, Khammam, Kurnool, Nellore); Rajasthan (Alwar, Bundi, Bhilwara, Jaipur, Sikar, Udaipur); Uttar Pradesh (Mirzapur), Uttarakhand (Almora, Garhwal, and Nainital); Himachal Pradesh (Kangra and Mandi); Haryana (Mahendergarh); West Bengal (Birbhum, Burdwan, Darjeeling); Jammu & Kashmir (Udhampur and Jammu); Gujarat (Bhavnagar, Junagarh, Vadodra); and Kerala (Kozhikode).

Export: India is the fifth largest exporter of iron ore in the world. About 55 per cent of our total iron ore production is exported to Japan, South Korea, West European countries, Iran, United Arab Emirates and other Gulf countries. Most of the export is made through the ports of Vishakhapatnam, Paradwip, Marmagao, and Mangalore.

Manganese India has the second largest reserves of manganese in the world after Zimbabwe, and is the fifth largest producer after Brazil, Gabon, South Africa, and Australia **(Fig. 7.3).** It is used mainly for the manufacturing of iron and steel, bleaching powder, insecticides, pesticides, paints, dry-batteries, photography, etc. The total reserves of manganese-ore in the country are placed at 380 million tonnes (India-2010) The regional distribution of manganese has been given in **Table 7.3.**

Table 7.3 *India: Distribution of Manganese (2005–06)*

State	*Production in thousand tonnes*	*Percentage of all India*	*Districts/mining centres*
1. Odisha	715	38.55	Sundargarh, Kalahandi, Koraput, Bolangir and Sambhalpur
2. Maharashtra	425	22.91	Nagpur, Bhandara and Ratnagiri
3. Madhya Pradesh	365	19.68	Balaghat and Chhindwara
4. Karnataka	245	13.20	North Kannada, Shimoga, Bellary, Chitradurga, and Tumkur
5. Andhra Pradesh	85	4.58	Srikakulam, Vishakhapatnam, Cuddapah, Vijaynagram, and Guntur

(*Contd.*)

(*Contd.*)

6. Others	20	1.08	Goa, Panchmahal and Vadodara (Gujarat), Udaipur, Banswara (Rajasthan), Singhbhum, Dhanbad, (Jharkhand).
All India	1855	100.00	

Source: ***Statistical Abstract of India*, 2007**.

1. **Odisha:** The state of Odisha is the single most important state in the production of manganese accounting for over 38 per cent of the total production. The Gondite deposits in Sundargarh and khondolite and kodurite deposits in Kalahandi and Koraput are rich in manganese. Manganese is also mined in Bolangir and Sambhalpur districts of Odisha.
2. **Maharashtra:** Maharashtra is the second largest producer of Manganese, accounting for about 23 per cent of the total production. In Maharashtra, manganese is found in Bhandara, Nagpur, and Ratnagiri districts. The Ratnagiri ore is, however, of superior quality.
3. **Madhya Pradesh:** About 20 per cent of the total manganese production comes from the state of Madhya Pradesh. Balaghat and Chhindwara are the main districts in which it is mined.
4. **Karnataka:** The state of Karnataka produces about 13 per cent of the total production of manganese of the country. Its main deposits are in the districts of North Kannada, Shimoga, Bellary, Chitradurga, and Tumkur.
5. **Andhra Pradesh:** About four-and-a-half per cent of the total manganese production of India is done in Andhra Pradesh. Srikakulam and Vishakhapatnam are the leading producer districts of manganese in Andhra Pradesh. It is also mined in Cuddapah, Guntur, and Vijayanagram.

In addition to these, manganese is also mined in small quantities in Goa, Gujarat (Panchmahal and Vadodara); Rajasthan (Banswara and Udaipur); Jharkhand (Dhanbad and Singhbhum). The growth pattern and production of manganese in India has been shown in **Table 7.4**.

Table 7.4 *India: Production of Manganese Ore (1950–2006) (in lakh tonnes)*

Year	*Production (in lakh tonnes)*
1950–51	13.98
1960–61	14.05
1970–71	18.41
1980–81	15.32
1990–91	13.88
2000–01	15.95
2005–06	17.65

Source: ***Statistical Abstracts of India,*** 2007.

It may be seen from **Table 7.4** that in 1950–51 the total production of manganese was only about 14 lakh tonnes which rose to over 17 lakh tonnes in 2005–06.

Nearly 80 per cent of the manganese production is consumed within the country, while the remaining is exported to USA, UK, Germany, France, Italy, Netherlands, Belgium, Czech Republic, Slovakia, and East European countries including Ukraine.

Fig. 7.3 Metallic Minerals

Copper Copper is highly ductile, strong and good conductor of electricity. It is mainly used in electrical machinery, automobile, stainless steel. When alloyed with zinc, it is known as 'brass' and with tin as 'bronze. Rajasthan has the largest deposits of copper-ore followed by Madhya Pradesh, and Jharkhand. In the production of copper-ore, however, Madhya Pradesh stands first, followed by Rajasthan and Jharkhand. The total resources of copper are about 1.39 billion tonnes with a metal content of 11,418 thousand tonnes (India 2012, p. 7633). The distribution of copper in India has been given in **Table 7.5.**

Table 7.5 *India: Distribution of Copper (2005–06)*

State	*Production in thousand tonnes*	*Percentage of all India*	*Districts/mining centres*
1. Madhya Pradesh	89	55.97	Malanjkhand (Balaghat), Bargaon (Betul)
2. Rajasthan	65	40.88	Jhunjhunu (Khetri-Singhana), Bhilwara, Ajmer, Chittorgarh, Dungarpur, Jaipur, Pali, Sikar, Sirohi
3. Jharkhand	05	03.15	Hazaribagh, Santhal Pargana
All India	159	100.00	

Source: ***Statistical Abstracts of India***, 2007.

1. **Madhya Pradesh**: The state of Madhya Pradesh is the largest producer of copper in India. The state has a large deposit of copper in Taregaon in Malanjkhand belt of Balaghat District. It is also found in Bargaon of the Betul district.
2. **Rajasthan:** Copper is found at Khetri-Singhana belt in Jhunjhunu District. It is also mined in Ajmer, Alwar, Bhilwara, Chittorgarh, Dungarpur, Jaipur, Pali, Sikar, and Sirohi districts. The Koh-Dariba (mountain), about 48 km to the south-west of Alwar city and Delwara-Kirovli area about 30 km from Udaipur are the other important producers of copper ore.
3. **Jharkhand:** It is the third largest producer state of copper in the country. Copper is mined in Hazaribagh, Santhal Pargana (Jharkhand), Gaya, and Palamu districts (Bihar).

Table 7.6 *India: Production of Copper (1950–2006)*

Year	*Production in thousand tonnes*
1950–51	375
1960–61	423
1970–71	666
1980–81	2110
1990–91	5255
2000–01	164
2005–06	156

Source: ***Statistical Abstracts of India***, 2007.

It may be observed from **Table 7.6** that the highest production of copper was in 1990–91 when it reached 5255 thousand tonnes. Its production has a declining trend during the last 25 years as in 2005–06 only about 156 thousand tonnes of copper was produced.

Not being self-sufficient in copper, India is importing substantial quantity of copper from Zimbabwe, Australia, USA, Mexico, and Japan.

***Chilpi Series*:** It stretches over parts of Balaghat, and Chhindwara districts of Madhya Pradesh. The series consists of quartzite, copper-pyrite, mica schist, and marble. The copper obtained from this series is used in the Malanjkhand Copper Plant.

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

Khetri: It is an integrated copper mining-cum-ore refining plant in the Jhunjhunu District of Rajasthan. It was established in 1967. It also obtains copper ore from the Malanjkhand copper mines of Madhya Pradesh. It also has a sulphuric acid plant, and a fertiliser plant.

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

Malanjkhand: It is an open cast copper mine in Balaghat District of Madhya Pradesh. A copper plant has been established at Malanjkhand. The copper ore is also sent to the Khetri Copper Plant of Rajasthan.

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

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

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

Uranium It is mined at Jaduguda, Bhatin, Narwapahar and Turamdih (Singhbhum East), Jharkhand.

Lead Lead is widely used because of its heaviness, malleability, softness and bad conductivity of heat. It is used in alloys, cable cover, lead-sheeting, ammunition, paints, glass making, paints making, automobiles, aeroplanes, type-writers, calculating machines, printing and rubber industry. Lead does not occur free in nature. It is obtained from galena which is found in association with limestone, sandstones and calcareous slates. According to an estimate, India has lead reserves of about 525 million tonnes (India 2010).

Table 7.7 *Production of Lead in India (1950–2006)*

Year	*Production in thousand tonnes*
1950–51	1.81
1960–61	5.53
1970–71	4.26
1980–81	19.95
1990–91	44.23
2000–01	54.49
2005–06	63.50

Source: ***Statistical Abstracts of India,*** 2007.

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

In Andhra Pradesh its deposits are in Cuddapah, Guntur, Khammam, Kurnool, North Arcot-Ambedkar and South Arcot (Tamil Nadu). It is also mined in Uttarakhand (Tehri, and Pithoragarh);

Jharkhand (Hazaribagh, Palamu, Ranchi, and Singhbhum); in Madhya Pradesh (Gwalior, Hoshingabad and Shivpuri); Himachal Pradesh (Kangra and Kullu); Jammu and Kashmir (Baramulla and Udhampur); and West Bengal (Jalpaiguri and Darjeeling districts).

India is not self-reliant in lead and therefore, has to import about 75 per cent of its requirements from Australia, Canada, and Myanmar.

Zinc Zinc is found in association with lead and silver. It is mainly used for alloying and for manufacturing galvanised sheets. It is also used for dry-batteries, white pigments, electrodes, textiles, die-casting, rubber industry, and for making collapsible tubes containing drugs, and pastes.

Rajasthan is the leading producer of zinc accounting for about 99 per cent of the total production. Small quantities of zinc are obtained from Sikkim, Jammu, Bihar, M.P., Maharashtra, Tamil Nadu, Meghalaya and Kashmir (Udhampur District), and South Arcot Vallalar of Tamil Nadu. India imports about 80 per cent of its requirements from Australia, Canada, Russia, and Zaire. The total production of zinc in 2008–09 was 1145 thousand*

Tungsten Tungsten is obtained from the wolfram ore. It is a self hardening mineral and therefore, used in steel industry, manufacturing of ammunition, armour plates, heavy guns, hard-cutting tools, etc. The total resources of Tungsten ore in the country are about 88 million tonnes.

Tungsten deposits are found at Degana near Rawat Hills in Rajasthan, Bankura District of West Bengal, Sakoli basin in Bhandara and Nagpur districts of Maharashtra, and Kolar mines in Mysore. It is also found in Chittoor, and East Godavari District of Andhra Pradesh, Ahmedabad District of Gujarat, and Singhbhum District of Jharkhand.

Bauxite Aluminium is obtained from bauxite. Bauxite is an oxide of aluminium. It is not a specific mineral but a rock consisting mainly of hydrated aluminium oxides. It is a clay like substance which is pinkish, whitish or reddish in colour depending on the amount of **iron content.** The total reserves of bauxite are about 3290 million tonnes (India, 2010, p. 690).

Table 7.8 *India: Production of Bauxite (1950–51 to 2005–06)*

Year	*Production in thousand tonnes*
1950–51	68
1960–61	476
1970–71	1517
1980–81	1955
1990–91	4984
2000–01	8689
2005–06	9854

Source: ***Statistical Abstracts of India,*** 2007.

It may be observed from **Table 7.8** that the production of bauxite has increased from 68 thousand tonnes in 1950–51 to 9854 thousand tonnes in 2005–06. Still, India has to import a substantial proportion of its requirements from abroad.

The distribution and production of bauxite in the different states of India has been given in **Table 7.9 (Fig. 7.3).**

*tonnes (India 2010, p.690).

Table 7.9 *India: Production of Bauxite (1950–2006)*

State	*Production in thousand tonnes*	*Percentage of All India*	*Main districts/mining centres*
Odisha	4904	50.16	Kalahandi, Koraput, Sundargarh, Bolangir and Sambalpur.
Gujarat	1547	15.82	Amreli, Bhavnagar, Jamnagar, Junagarh, Kuchchh
Jharkhand	1161	11.87	Dumka, Lohardaga, Munger, Palamu, Ranchi.
Maharashtra	964	9.87	Kolhapur, Pune, Ratnagiri, Satara Thane
Chhattisgarh	604	6.18	Amarkantak Plateau, Bilaspur, Durg, Raigarh, Surguja
Tamil Nadu	268	2.74	Madurai, Nilgiri and Salem districts
Madhya Pradesh	230	2.35	Balaghat, Katni, Jabalpur, Maikala Range, Mandla, Shahdol.
Others	99	1.04	Andhra Pradesh, Goa, Jammu & Kashmir and Kerala
All India	9777	100.00	

Source: ***Statistical Abstracts of India,*** 2007.

1. **Odisha:** Odisha stands first in the production of bauxite, producing more than 50 per cent of the total bauxite. The Kalahandi-Koraput belt which extends into Andhra Pradesh is the main bauxite deposit region. In addition to this, bauxite is also obtained from the districts of Bolangir, Sambalpur and Sundargarh. The new aluminium plant located at Damanjoli and Doragurha provide a good market for bauxite in this region.
2. **Gujarat**: About 16 per cent of the total bauxite production is from the state of Gujarat. In Gujarat, the main bauxite depsoits are found between the Gulf of Kachchh and the Gulf of Khambat (Arabian Sea) through the districts of Bhavnagar, Junagarh, and Amreli. It is mined in Kheda and Sabarkantha.
3. **Jharkhand–Bihar**: In Jharkhand, bauxite is obtained from Dumka, Gumla, Lohardaga, Munger, Palamu, and Ranchi districts. The Lohardaga mines are, however, known for high grade bauxite deposits.
4. **Maharashtra**: About 10 per cent of the total bauxite production comes from Maharashtra. Kolhapur, Pune, Ratnagiri, Satara, and Thane are its main producing centres.
5. **Chhattisgarh:** In Chhattisgarh, bauxite is obtained from the Maikal Range, Amarkantak Plateau, Bilaspur, Raigarh, and Surguja. Its share in the total production is about 6 per cent.
6. **Tamil Nadu:** The Madurai, Nilgiri and Salem districts are known for the production of bauxite accounting for about 2.75 per cent of the total production.
7. **Madhya Pradesh**: In Madhya Pradesh, bauxite is mined in the districts of Balaghat, Jabalpur, Katni, Mandla, and Shahdol.

Bauxite is also mined in the states of Andhra Pradesh (East Godavari, West Godavari, and Vishakhapatnam districts); Kerala (Kannur, Kollam, Thiruvananthapuram); Rajasthan (Kota); Uttar Pradesh (Banda, Lalitpur), Goa, and Jammu and Kashmir (Jammu, Poonch and Udhampur districts).

Nearly 80 per cent of the total bauxite produced is used for the production of aluminium. Italy and UK are the largest importers of Indian bauxite accounting for 60 per cent and 25 per cent of the total export respectively. The remaining is exported to Germany, Belgium, and Japan. Some of the important aluminium plants are as under:

Balco: The Bharat Aluminium Company Limited (BALCO) was incorporated on 27 November, 1965 as a Central Public Sector Undertaking with an integrated Aluminium Complex at Korba (Chhattisgarh). The Government of India disinvested 51 percent equity in the company along with the transfer of management control in favour of M/s Sterlite Industries (India) Limited with effect from 2nd March 2001, and consequently, the company has ceased to be a public sector undertaking.

Renukoot (HINDALCO): The Renukut aluminium plant was commissioned in 1958 about 160 km away from Mirzapur (Uttar Pradesh). It obtains bauxite from Lohardaga (Jharkhand) and electricity from the Rihand Dam, and the thermal power station near the plant.

Madras Aluminium Company (MALCO): This aluminium plant was commissioned in 1965 near the Mettur Dam (Salem District). It obtains bauxite from the Shevaroy Hills (Tamil Nadu) and electricity from the Mettur Hydel Project.

Koraput Aluminium Plant (NALCO): The Koraput aluminium plant was commissioned in the Koraput District in 1981. This plant was running in loss and therefore, the central government disinvested in this plant in 2006.

Gold Gold is a precious metal used for making ornaments, and is known as an international currency. India has about 390 million tonnes with a metal content of 491 tonnes of gold ore reserves (India 2010). The production of gold in India has been shown in **Table 7.10.**

Table 7.10 *India: Production of Gold (1951–2011)*

Year	*Production in kg.*
1951	7041
1961	4868
1971	3656
1981	2495
1991	2208
2001	2615
2011	3900

Source: ***Statistical Abstracts of India***, 2011.

It may be seen from Table 7.10 that the total production of gold in the country was 7041 kg in 1950–51 which declined to 3900 kg in 2011. About 90 per cent of the total gold is produced in the Karnataka state followed by Rajasthan, West Bengal, Jharkhand, Bihar and Andhra Pradesh. There are three important gold fields in the country, namely, (i) Kolar Gold Field, Mysore (Karnataka), (ii) Hutti Gold Field in Raichur (Karnataka), and (iii) Ramgiri Gold Field in Anantapur District (Andhra Pradesh).

Kolar Gold Mines: Mining from the Kolar Gold Fields was started first in 1871. This field still contributes about 60 per cent of the total gold production in the country. The gold mines of Kolar Field are more than 3000 metres deep. Most of the gold has already been taken out and it is not economically viable to extract gold from a depth of more than three kilometers.

1. **Karnataka:** Karnataka stands first in the reserves and production of gold in India. It is obtained mainly from the Kolar, Dharwar, Hassan and Raichur districts. Some gold deposits have also been found in Belgaum, Bellary, Chikmaglur, Gulbarga, Mandya, and Shimoga districts. Hutti Gold Mine Company is India's only producer of gold.
2. **Andhra Pradesh**: Andhra Pradesh is the second largest producer of gold in India. The main deposits of gold in Andhra Pradesh are found in Ramagiri (Anantapur District). In addition to this, gold is also found in Chittoor and Kurnool districts.

Placer or Alluvial Gold: The gold obtained from the sand and sedimentary deposits of the rivers is known as placer gold. Placer gold is found in the Subarnrekha (Gold Streak) river of Jharkhand. Placer gold is also found near Lowa in Singhbhum District and some other parts of the Chotanagpur Plateau.

Placer gold is also found in the sand of Dras, and Suru rivers of Kargil (J & K), Shimla and Bilaspur in Himachal Pradesh, Punna-Puzha and Chaiyar Puzha rivers of Kerala, Balaghat and Seoni districts of Madhya Pradesh, Bastar, Raigarh, and Raipur of Chhattisgarh and and Purulia District of West Bengal.

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

Silver Silver is also a precious metal. India, however, is not very rich in silver deposits. It is an important currency metal, and used in the manufacture of chemicals, electroplating, photography, and coloring for glasses.

It is found in association with lead and zinc. Zawar mines of Udaipur (Rajasthan) are the largest producer of silver. In Hindustan Zinc Smelter (Udaipur), it is obtained as a by-product of zinc and lead smelting. The Tundoo Lead Smelter in Dhanbad (Jharkhand) is also an important source. Silver is also produced by Kolar Gold Fields and Hutti Gold mines (Raichur) of Karnataka during refining of gold. The Hindustan Copper Limited at Maubhandar Smelter (Singhbhum, Jharkhand) obtains silver from copper mines. Silver is also produced at the Vishakhapatnam Smelter in Andhra Pradesh from lead concentrates.

Non-Metallaic Minerals

India is fairly rich in the non-metallic minerals also. The geographical distribution of some of the important non-metallic minerals has been shown in **Fig. 7.4**.

Mica (Abhrak) Mica is an important non-metallic mineral used mainly in electrical industry as it has great insulating properties, can withstand high voltage and has low power loss factor. It is obtained from muscovite, biotite and phlogopite ores. The total reserves of mica in the country are estimated to be about 3.9 lakh tonnes (India 2010) (**Table 7.11**). Rajasthan accounts for about 51 per cent resources, followed by Andhra Pradesh, Maharashtra and Bihar (India 2012, p. 766)

Fig. 7.4 Metallic Minerals

Table 7.11 *India: Distribution of Mica (2005–06)*

State	*Production in tonnes*	*Percentage of all India*	*Districrts/Mining centres*
1. Andhra Pradesh	910	71.15	Nellore, Krishna. Khamma, Vishakhapatnam, West Godavari.
2. Rajasthan	205	16.03	Ajmer, Bhilwara, Dungarpur, Jaipur, Sikar, Tonk, Udaipur.
3. Jharkhand	148	11.57	Dhanbad, Gaya, Gridh, Hazaribagh, Munger, Ranchi, Singhbhum
4. Bihar	016	1.25	Bhagalpur
All India	1279	100.00	

Source: ***Statistical Abstracts of India***, 2007.

1. **Andhra Pradesh**: Andhra Pardesh is the largest producer of mica. It produces more than 71 per cent of the total mica production of the country. The micabelt of Nellore is about 100 km long and 25 km wide. Nellore mica is generally light green in colour. Mica is also obtained from Dudur, Khamma, Krishna, West Godavari, and Vishakhapatnam.
2. **Rajasthan:** The main mica belt of Rajasthan extends from Jaipur to Udaipur. It is also mined at Ajmer, Bhilwara, Dungarpur, Sikar, and Tonk.
3. **Jharkhand and Bihar:** Mica in Jharkhand and Bihar is found in a belt extending for about 150 km in length and 32 km in width from the eastern part of Gaya through Hazaribagh, Giridh, and Munger to Bhagalpur. The main centre of mica production in Jharkhand and Bihar are Kodarma, Dhorhakola, Dhab, Tisri, Chakai.

Mica is also found in Gujarat (Banaskanth, Vadodara and Sabarkantha); Tamil Nadu (Nilgiri, Coimbatore, Salem, and Tiruchirapalli), Chhattisgarh (Bilaspur, Bastar, and Surguja); Madhya Pradesh (Balaghat and Chhindwara); and Uttar Pradesh (Mirzapur). Some deposits are also found in Haryana, Himachal Pradesh, Odisha, and West Bengal.

Table 7.12 *India: Production of Mica (1950–2006)*

Year	*Production in tonnes*
1950–51	10.0*
1960–61	28.35
1970–71	1510
1980–81	8534
1990–91	4746
2000–01	3806
2005–06	1154

*Relates to dressed mica.
Source: ***Statistical Abstracts***, 2007.

It may be seen from **Table 7.12** that the production of mica was about ten tonnes in 1950–51 which rose to 3806 tonnes in 2000–01 and 1154 tonnes in 2005–06.

India is the largest producer and exporter of mica in the world. It exports mica to Japan, USA, UK, Norway, Russia, Germany, France, Belgium, Netherlands, Poland, Czech Republic, Slovakia, and Hungary.

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

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

Limestone: Limestone is an aggregate of calcium carbonate, carbonate of calcium and magnesium or a mixture of the two. Limestone also contains small quantities of silica, alumina, iron-oxides, phosphorus and sulphur. Limestone deposits are of sedimentary origin and exist in almost all the geological formations from the Pre-Cambrian to Recent except in Gondwana.

Limestone is used in cement, iron and steel, and chemical industries. The rapid industrialisation and urbanisation has resulted into heavy demand of this mineral, especially for the manufacturing of cement. The production trend of limestone in the country has been given in **Table 7.13**.

***The Semri Series*:** This is the main series of the Lower Vidhyan formations in the Son valley. Its thickness is about 900 metres of limestonnes, shales and sandstone with intrusive dolerites and basalt. The upper most stage, known as Rohtas Stage is composed of limestone and shales which provides raw material to the cement industry in the region.

Table 7.13 *India: Production of Limestone (1950–2006)*

Year	*Production in lakh tonnes*
1950–51	30.00
1960–61	148.00
1970–71	151.00
1980–81	324.50
1990–91	685.00
2000–01	1275.00
2005–06	1620.00

Source: ***Statistical Abstract of India,*** 2007.

It may be seen from **Table 7.13** that in 1950–51 the total production of limestone was only 30 lakh tonnes which rose to 1620 lakh tonnes in 2005–06.

Limestone in some quantity is produced in almost all the states of India. Its main producing states are Rajasthan, Madhya Pradesh, Andhra Pradesh, Gujarat, Chhattisgarh, and Tamil Nadu. The production and percentage of limestone in the important states of the country have been given in **Table 7.14.**

Dolomite: Dolomite is a type of limestone which contains more than 10 per cent of magnesium. It is used mainly in the metallurgical industry, especially in the iron and steel industry. The total reserves of all grades of dolomites are 7533 million tonnes (India 2012). The states of Odisha, Chhattisgarh, Andhra Pradesh, Jharkhand, Rajasthan, Gujarat, Maharashtra and Karnataka are its main producers contributing 90% of the total production **(Fig. 7.5).** The state-wise distribution of dolomite has been given in **Table 7.15.**

Table 7.14 *India: Distribution of Limestone (2005–06)*

State	*Production in lakh tonnes*	*Percentage of all India production*	*Main districts/ mining centres*
Rajasthan	240	16.15	Ajmer, Alwar, Bikaner, Chittaurgarh Dungarpur, Kota, Nagaur, Pali
Madhya Pradesh	238	16.01	Betul, Damoh, Jabalpur, Rewa, Satna, Sagar
Andhra Pradesh	235	15.81	Cuddaph, Guntur, Kurnool, Krishna, Nalgonda, Warangal
Gujarat	160	10.77	Amreli, Junagarh, Kheda, Surat
Chhattisgarh	140	9.42	Bastar, Bilaspur, Durg, Raigarh, Raipur
Tamil Nadu	138	9.29	Coimbatore, Madurai, Salem, Thanjavur
Karnataka	125	8.41	Bijapur, Gulbarga, Shimoga
Maharashtra	90	6.06	Chandrapur, Nanded, Ahmednagar, Yavatmal
Himachal Pradesh	68	4.58	Bilaspur, Chamba, Kangra
Odisha	25	1.68	Kalahandi, Sambalpur, Sundargarh
Others	27	1.82	Dehradun, Mussoorie, Darjeeling, Jammu, Ambala, Mahendargarh, Mirzapur
All India	1486	100.00	

Source: ***Statistical Abstracts of India,*** 2007.

Table 7.15 *India: Distribution of Dolomite (2005–06)*

State	*Production in thousand tonnes*	*Percentage of all India production*	*Districts/mining centres*
1. Odisha	1075	28.71	Gangapur, Koraput, Sambalpur, Sundargarh
2. Chhattisgarh	1025	27.38	Bastar, Bilaspur, Durg, Raigarh
3. Andhra Pradesh	687	18.35	Anantapur, Kurnool and Khammam
4. Jharkhand	295	0 7.88	Chaibasa, Singhbhum Ajmer,
5. Rajasthan	215	0 5.74	Alwar, Bhilwara, Jaipur, Jaisalmer, Jhunjhunu, Jodhpur, Nagaur, Pali, Sawai Madhopur, Sikar and Udaipur
6. Karnataka	212	05.66	Belgaum, Bijapur, Chitradurga, Mysore, Uttar Kannada, and Tumkur
Others	235	06.28	Arunachal Pradesh, Haryana, Himachal Pradesh, Maharashtra, Tamil Nadu, Uttar Pradesh, Uttarakhand, West Bengal
All India	3744	100.00	

Source***: Statistical Abstract of India,* 2007.**

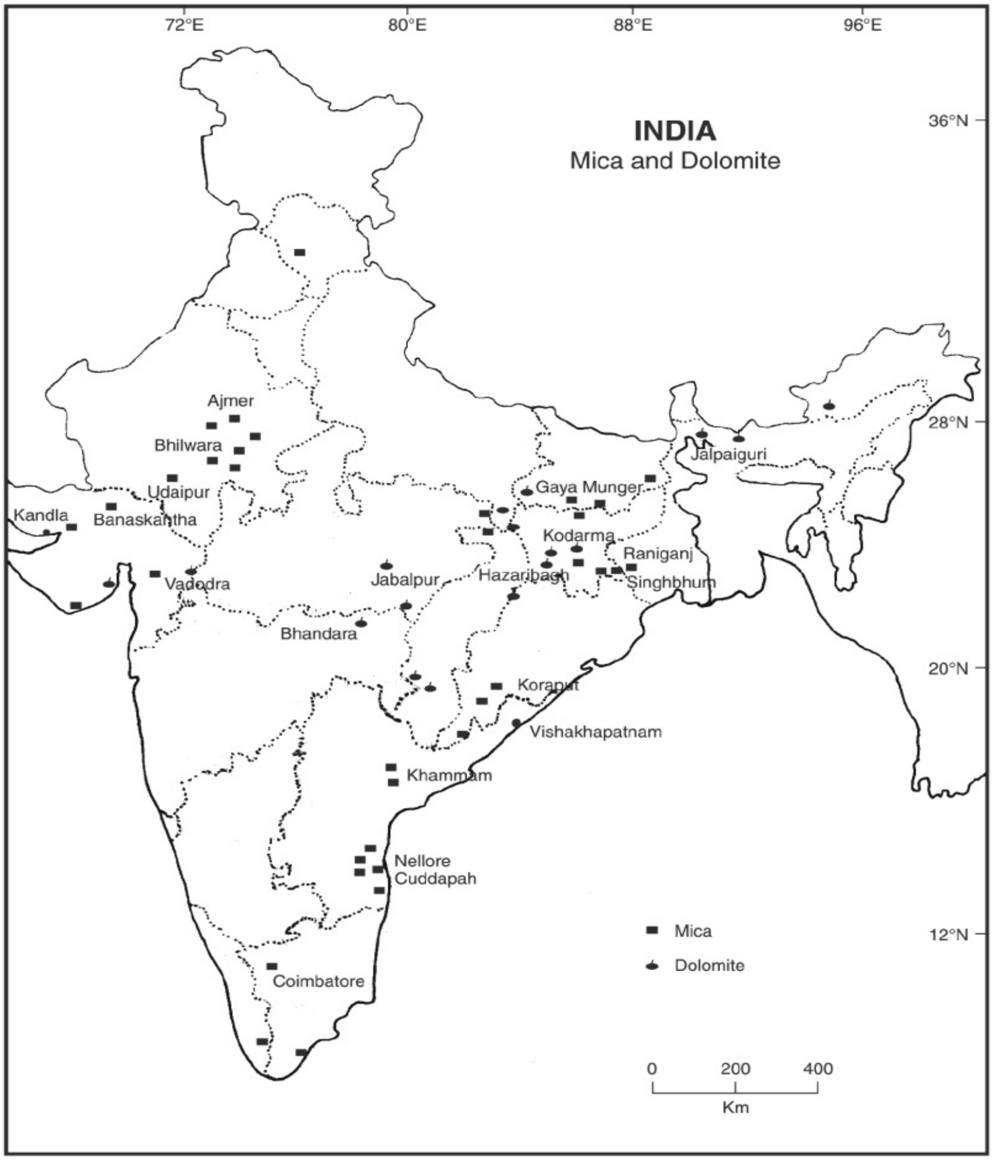

Fig. 7.5 Non-metallic Minerals

1. Odisha is the leading producer of dolomite accounting for about 29 per cent of the total production in the country, followed by Chhattisgarh with over 27 per cent. The share of Andhra Pradesh and Jharkhand is 18.35 per cent and about 8 per cent respectively in the total production. Rajasthan and Karnataka contribute about 6 per cent each. It is mined in several other states also as given in **Table 7.15.**

Asbestos: Asbestos has great commercial value due to its fibrous structure, and its resistance to fire. It is widely used for making fire-proof clothes, rope, paper, sheeting, belt, fireproof safes, insulators, felts, aprons, gloves, curtains, brake linings in automobiles, and insulating mats. Asbestos cement products like sheets, slates, pipes and tiles are used for building purposes. Mixed with magnesia, it is used for making 'magnesia bricks' used for heat insulation.

Rajasthan is the leading producer accounting for about 95 per cent of the total asbestos production of India. It is mined in Ajmer, Alwar, Dungarpur, Pali and Udaipur districts. Andhra Pradesh is the second largest producer. It is produced in Cuddapah District. It is also mined in Karnataka, Jharkhand, Madhya Pradesh, Chhattisgarh, Tamil Nadu, Uttarakhand, and Nagaland.

Magnesite: Magnesite is used for manufacturing refractory bricks, special type of cement, tiles, fire-proof flooring and for extraction of the metal magnesium, and in steel industry. The total reserves of magnesite in India are about 338 million tonnes (India 2012). Its major deposits are found in Uttarakhand (68%), Rajasthan (16%) and Tamil Nadu (13%) . Its deposits have also been found in Jammu and Kashmir, Karnataka, Himachal Pradesh, and Kerala.

Tamil Nadu is the largest producer accounting for over 74 per cent of the total magnesite production, followed by Uttarakhand (20 per cent) and Karnataka (6 per cent).

Kyanite: Found in the metamorphic rocks, kyanite is used in metallurgical, ceramic, refractory, glass and electrical industries. The total reserves of Kyanite are 103 million tonnes. India is the largest producer of kyanite in the world. Kyanite deposits are located in Jharkhand, Maharashtra, and Karnataka. These three states contribute almost the whole production of kyanite of the country.

Gypsum: Gypsum is a hydrated sulphate of calcium which occurs as a white opaque mineral in beds of bands of sedimentary rocks like limestone, sandstone and shale. It is mainly used in making ammonia sulphate, fertilisers and in cement industry. It is also used in making plaster of Paris, ceramic industry, nitrogen-chalk, partition-blocks, sheets, tiles, and plastics.

The total reserves of gypsum are about 1237 million tonnes. Rajasthan is the leading producer of gypsum accounting for about 99 per cent of the total production of the country. It is obtained mainly from the districts of Barmer, Bikaner, Churu, Ganganagar, Jaisalmer, Jodhpur, Nagaur, and Pali. The remaining one per cent is mined in Tamil Nadu, Jammu and Kashmir, Gujarat, and Uttarakhand, Andhra Pradesh, Himachal Pradesh, Karnataka, and Madhya Pradesh. The total reserves of gypsum in India were estimated to be about 1237 million tonnes (India 2010).

Sillimanite: Sillimanite is used is ceramics, metallurgy, glass, refractory, automobiles and cement manufacturing industries. Its main characteristic is that it can withstand high temperatures.

The total reserves of sillimanite are 74 million tonnes. Odisha, contributing about 57 per cent of the total production, is the largest producer of sillimanite in India. Kerala is the second largest producer accounting for about 33 per cent of the total production. It is also produced in Maharashtra, Rajasthan, Meghalaya, Assam (Karbi-Anglong), Madhya Pradesh, (Sidhi), West Bengal (Darjeeling, Bankura and Purulia), and Tamil Nadu (Kanniyakumari, Tirunelveli, and Tiruchirappalli).

Diamond: Diamond is a precious stone. It is known for its brilliance, luster, transparency and hardness. Diamond is mainly found in the Vindhyan formations of Bundelkhand, (M.P.), Andhra Pradesh (Kurnool, Anantapur), and Karnataka (Raichur). Panna District of Madhya Pradesh is the main diamond producing district in India. In India, the total diamond reserves is about 45.8 lakh crates (India, 2010).

Cutting and polishing of diamond is mainly carried on in Surat, Ahmedabad, Navasari, Palanpur, Bhavnagar, Mumbai, Khambat, Jaipur, Trichur, and Goa.

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

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

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

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

Atomic Minerals: Uranium and thorium are the main atomic minerals.

Uranium: deposits occur in Singhbhum and Hazaribagh districts of Jharkhand, and Gaya District of Bihar, and in sedimentary rocks of Saharanpur District of Uttar Pradesh. The largest source of uranium comprise the monazite sands, both beach and alluvial. Monazite sand rich in uranium is found in Kerala. Some uranium is found in the copper and zinc mines of Udaipur (Rajasthan). The total reserves of uranium as estimated by the Department of Atomic Energy, Government of India, are about 31,000 tonnes.

The important uranium mining centres of India are: (i) Jharkhand–Bagjata, Banduhurang, Bhateen, Jaduguda, Mohuldeeh, Narwapur and Turamdeeh, (ii) Meghalaya–Keleng–Pindeng, Maothabah, Shahiyong, and Vakheen, (iii) Andhra Pradesh–Lambapur, Paddagtu and Tummalapalle.

Thorium: Thorium is derived from monazite. It is produced in Kerala, Jharkhand, Bihar, Tamil Nadu, and Rajasthan.

In addition to uranium and thorium, beryllium and lithium are also the atomic minerals found mainly in Jharkhand, Madhya Pradesh, and Rajasthan.

Salt: Salt is used mainly in chemical industry. Common salt (sodium chloride) is used as a food item. Salt is obtained from sea water, brine springs and salt pans in lakes. The main producers of salt are Gujarat, Maharashtra, Tamil Nadu, and Rajasthan. Gujarat coast accounts for about 50 per cent of the total salt production of India. Sambhar lake of Rajasthan contributes about 10 per cent of the total salt production of the country. In addition to this, rock salt is obtained from the Mandi area of Himachal Pradesh. The Mandi salt is hard and massive and has to be blasted.

India exports small quantities of salt to the neighbouring countries like Bangladesh, Bhutan, Indonesia, Japan, Maldive, Nepal, Singapore, South Korea, and Taiwan.

Problems of Mining Industry: India is rich in mineral resources. The mining industry is however, facing a number of problems. Some of the problems have been described briefly in the following:

1. **Ill-Defined Government Policy:** There is no well defined government policy about the prospecting, extraction and processing of mineral resources. A large number of lessees and contractors look upon mines as a quick money-making proposition and use unscientific techniques for the extraction of mineral ores.

2. **Obsolete Technology**: The technology used in mining is generally old and obsolete. Consequently, there is great wastage of mineral wealth.
3. **Inadequate Transport Facilities**: The minerals in the country are not uniformly distributed. For their transportation, the railways are used which are not very efficient, leading to bottlenecks, scarcity, and higher cost of transportation.
4. **Inadequate Exploration and Prospecting of Minerals**: In the absence of trained geologists, there are many areas in Chhattisgarh, Himachal Pradesh, Jammu and Kashmir, Jharkhand, Karnataka, Madhya Pradesh, Maharshtra, Rajasthan, and Uttarakhand which have not been properly surveyed to explore the minerals.
5. **Inadequacy of Funds**: In the absence of inadequate funds, the infrastructure could not be developed in the areas of isolation and relative isolation where many of the most valuable minerals are found.
6. **Lack of Awareness about Conservation**: There is very little awareness about the exhaustible nature of the minerals and their conservation.
7. **Export of Mineral Ores:** The legacy of the colonial period is continuing and many of the basic minerals are exported to the developed countries of the world. Consequently, the minerals fetch low price in the international market.
8. **Strikes and Naxalites:** The mining industry is adversely affected by the frequent strikes of the miners and the Naxalites. The mineral rich parts of the country are unfortunately infested with Naxalites.
9. Mining is a hazardous industry in India. Hundreds of miners are killed every year. For example between 2008-2011, about 325 coal miners lost their life.

Conservation of Minerals: Minerals are the most valuable resources which are imperative for the economic development of the country. They are, however, non-renewable, and can not be replenished in short geological period. A judicious utilisation of mineral resources is necessary to meet the growing demand of our population and to provide the minerals for the future generations. Some of the steps which can go a long way in the conservation of mineral resources have been given in the following:

1. **Judicious Use**: The available minerals need to be utilised judiciously.
2. **Efficient Technology:** For the mining, processing and consumption, efficient technology is required for which continuous research is to be done.
3. **Alternatives to Minerals:** Research should be done to find the alternative to the mineral resources.
4. **Development of Infrastructure:** There should be emphasis on the development of roads and other infrastructure to obtain minerals from the areas of isolation and relative isolation.
5. **Location of Industries near the Mining Sites:** The mineral processing and metallurgical plants should be located near the mining centres to reduce the transportaion cost and problems.
6. **Recycling of Scrap**: The scrap should be recycled and people, especially the students, should be made aware about the exhaustible nature of minerals.
7. **Sustainable Mining**: There should be emphasis on sustainable mining. The miners should be properly trained in the new technology of mining.

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

1. **Public Sector Mining:** Under the New Mineral Policy the government will continue the exploration and prospecting of the mineral wealth of the country, wherein special attention would be paid for the development of (i) strategic minerals, (ii) those minerals in which India has poor or just adequate resource base, and (iii) those minerals which are required for electronic and high-tech industries.
2. **Regular Supply of Minerals to Industries:** To develop mineral resources taking into account the national and strategic considerations, the strategy of development would entail (i) a regular supply of mineral raw material for industrial production, (ii) exploration and supply should address the present needs as well as future long-term needs of the country, (iii) adoption of efficient measures of processing of minerals and effective measures for conservation, and (iv) adoption of scientific methods of exploration.
3. **Foreign Investment**: The new mineral policy invites foreign equity and technology participation in exploration and mining of high value scarce minerals.
4. **Check on Adverse Environmental Effect**: In order to minimise the adverse effect of mining, social forestry will be an integral part of mining.
5. **To Promote Research**: To promote research and development in minerals, the new policy emphasises the promotion of research and development, technology upgradation, research in mining methods, development and processing.

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

BIOTIC RESOURCES

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

Cattle

Animal husbandry and dairy development plays an important role in the rural economy and regional development. Cattle keeping supplements the income of rural households, especially that of marginal farmers and landless workers. It provides a subsidiary occupation in semi-urban areas, and more so for the people living in the hilly and drought prone areas. According to the All India Summary Reports of the 17th livestock Census released in July 2006, India possesses the largest livestock population in the world after Brazil. It accounts for about 56 per cent of the world's buffalo population and 14 per cent cattle population. It ranks first in respect of buffalo and second in respect of cattle population, second in goat population and third in respect of sheep in the world.

At the state level, Madhya Pradesh has the largest number of cattle in the country followed by Uttar Pradesh, Bihar, West Bengal, Odisha, and Karnataka. The percentage of cattle in the states of Sikkim, Arunachal Pradesh, Nagaland, Mizoram, and Meghalaya, is less than 0.2 per cent each. The density of cattle per 100 hectares of the gross cropped area in India is 112 which varies 365 in Manipur and 35 cattle in Haryana.

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

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

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

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

In order to improve the breed of the Indian cattle, seven central breeding farms have been established. Some of the exotic breeds yielding higher quantity of milk like Jersey, Holstein-Erie, Sain, Swiss brown, German Flekvich and Ayreshire have been introduced in the country which are becoming popular amongst the dairy farmers. The seven Central Breeding Centres are at Suratgarh (Rajasthan), Dhamrod (Gujarat), Alamadhi (Tamil Nadu), Chiplima, Similigude (Odisha), Andeshnagar (Uttar Pradesh), and Hessarghatta (Karnataka).

Buffaloes

Buffaloes are the major suppliers of milk to the Indian population. They constitute about 17 per cent of the total livestock of the country, but contribute about 55 per cent of the total milk production. In fact, the dairy industry of India is largely dependent on buffaloes.

As stated earlier, India has more than 56 per cent of the total buffaloes of the world. The better breeds of Indian buffalo are *Murrah, Bhadwari, Jaffarabadi, Saurti, Mehsana, Nagpuri, Rohtak, and Nili Ravi*. Murrah is an indigenous breed of Rohtak, Hissar and Gurgaon (Haryana). These buffaloes have short horn and massive body. The average lactation yield about 2000 kg. He buffaloes are suitable for draught and hard work. The Bhadawari with light colour is an indigenous breed of Etawah and Agra (UP). It yields about 1600 kg milk per lactation. (read White Revolution, Chapter 9).

The Indian cattle and buffaloes are weak in health and suffer from many diseases. In order to control livestock diseases "Livestock Health: Disease Control" has been implemented. The scheme was launched to eradicate the diseases of Rinderpest and Bovine Pleuro-pneumonia.

Goat Rearing

Goat provides milk, meat and hide. It is the main source of meat as about 35 per cent of the meat consumed in India is that of goat. In 1951, India had about 47 million goats which increased to

124 million in 2012. Bihar including Jharkhand has the largest number of goats followed by Rajasthan, West Bengal, Uttar Pradesh, Maharashtra and Madhya Pradesh.

Over 90 per cent of the goats are *desi.* The important breeds of goats are Angora or Himachali (known as Gaddi or Chamba breed of Himachal Pradesh and Jammu and Kashmir). This breed provides soft Pashmina, (wool) meat and hide. The Jamunapari is found between Yamuna and Chambal Valley. In Rajasthan, Gujarat and Madhya Pradesh, the main breeds of goats are Marwari, Mehsanwi, Kathiawari, and Zalwadi. Recently, a number of foreign breeds like Alpine, Nubian, Saanen and Angora (Turkey) have been used for cross-breeding with the indigenous breeds so as to improve the quantity of milk and meat production.

Sheep Rearing

India has about 4 per cent of the total population of sheep in the world. They are an important source of mutton, wool and hide in the country. There were about 39 million sheep in the country in 1951 which increased to 55 million in 2005–06. The total production of raw wool in 2005–06 was 45 thousand tonnes.

Sheep rearing in India is done mainly in Rajasthan (25%), followed by Andhra Pradesh (16%), Tamil Nadu (12%), Karnataka (11%), and Maharashtra (6%) of the total sheep of the country. The important breeds of sheep are *Lohi, Kutchi, Bikaneri, Marwari, Kathiawari, Jaisalmeri, Sonadi, Malpuri, Magra, Shekhawati, Pugal, Deccani, Nellori, Bellary, Gureji, Karna, Bakkarwal, Gaddi.* The Indian wool is, however, inferior to that of Australia and South Africa in quality and is called the coarse carpet wool. India exports wool to USA and UK.

The sheep breeds in India are generally poor. Efforts are being made to improve sheep breeds by crossing local breeds with the imported quality breeds like Australian Merino, Russian Merino, Spanish Merino, Cheviot, Leicester, and Lincoln (UK).

Poultry Farming

Poultry includes domestic fowls like chickens, ducks, geese, Japanese quil/emu, and turkey. These are kept to obtain meat, eggs, and feathers. Poultry farming requires small capital investment and provides good additional income and job opportunity to the rural population. There are over 300 million hens in the country which laid 54 billion eggs in 2009–10.

The poultry sector, with a total value of output exceeding Rs.15,000 crore and providing direct and indirect employment to over three million people, produced around 1.9 million tonnes of chicken meat in 2005.

Andhra Pradesh has the largest number of poultry population followed by Bihar, West Bengal, Tamil Nadu, Assam, Maharashtra, Karnataka, Kerala, Odisha, Madhya Pradesh, and Uttar Pradesh. Poultry farms have been developed around almost all the important urban centres like Mumbai, Kolkata, Delhi, Chandigarh, Chennai, Hyderabad, Pune, Bangalore, Nagpur, Bhubaneswar, Shimla, and Ajmer.

The Indian fowls belong to two categories: (i) Desi, and (ii) exotic or imported. The Desi breed include Chittagong, Punjabi, Brown, Chagas, Lolab, Naked-neck, Titre, Bursa, Tillicherry, etc. The imported breeds include White Leghorn, Rhode Island Red, Black Minorca, Plymouth Rock, New Hampshire, Light Sussex, Brown Leghorn and Australorp, etc.

The Central Poultry Farms are located at Mumbai, Hassarghatta (near Bangalore), Chandigarh and Bhubaneswar. These farms are established to improve poultry breed to produce more eggs.

Export of products such as live poultry, eggs, hatching eggs, frozen eggs, egg-powder, and poultry meat are made to Bangladesh, Sri Lanka, South West Asian countries, Japan, Denmark, Poland, USA, and Angola.

The bird influenza has created numerous problems for poultry development in India. The first outbreak was in 2006 in a small area in Maharashtra. The second outbreak was also reported from Maharashtra a few months later. In order to overcome this problem, an active surveillance programme is being carried out all over the country focusing on an early detection of avian influenza. The Government of India maintains a strategic reserve of poultry vaccine. India has a fully equipped Bio-Security Level 3 laboratory at Bhopal.

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Chapter 8

Energy Resources

Energy is an essential input for economic development and improving the quality of life. Energy may be classified into two categories, namely: (i) conventional (coal, petroleum, natural gas, and electricity), and (ii) non-conventional energy (solar, wind, tidal, geothermal, and biogas energy). Energy can also be classified into non-commercial (fuel-wood, charcoal, dried cow-dung, animal waste and animal power), and commercial energy (coal, mineral oil, natural gas, hydro-power, nuclear power wind energy, solar energy). It is the commercial energy which plays a vital role in the economic development of a country. A brief description of the sources of commercial energy, their distribution and production has been given in the following section.

SOURCES OF CONVENTIONAL ENERGY

Coal

Coal is the main source of energy in the country and accounts for 67% of the commercial requirement of the country. India has coal reserves of 360 billion tonnes (India 2010).

Classification

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

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

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

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

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

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

(iv) Anthracite (Hard Coal) It is the highest quality of coal containing 80 to 90 per cent carbon. It has very little volatile matter and insignificant proportion of moisture. It has short blue flame. Of all the coals, it is the most expensive.

Distribution

The distribution of coalfields has been shown in **Fig. 8.1**, while the state-wise coal reserves and their percentage share have been given in **Table 8.1**.

Table 8.1 *Coal Reserves in India—2005–06*

State	*Total reserves in million tonnes*	*Percentage of all India reserves*
1. Jharkhand	72,565	28.97
2. Odisha	61,684	24.62
3. Chhattisgarh	40,865	16.24
4. West Bengal	27,495	10.98
5. Madhya Pradesh	19,672	7.85
6. Andhra Pradesh	17,595	7.06
7. Maharashtra	8,635	3.45

(*Contd.*)

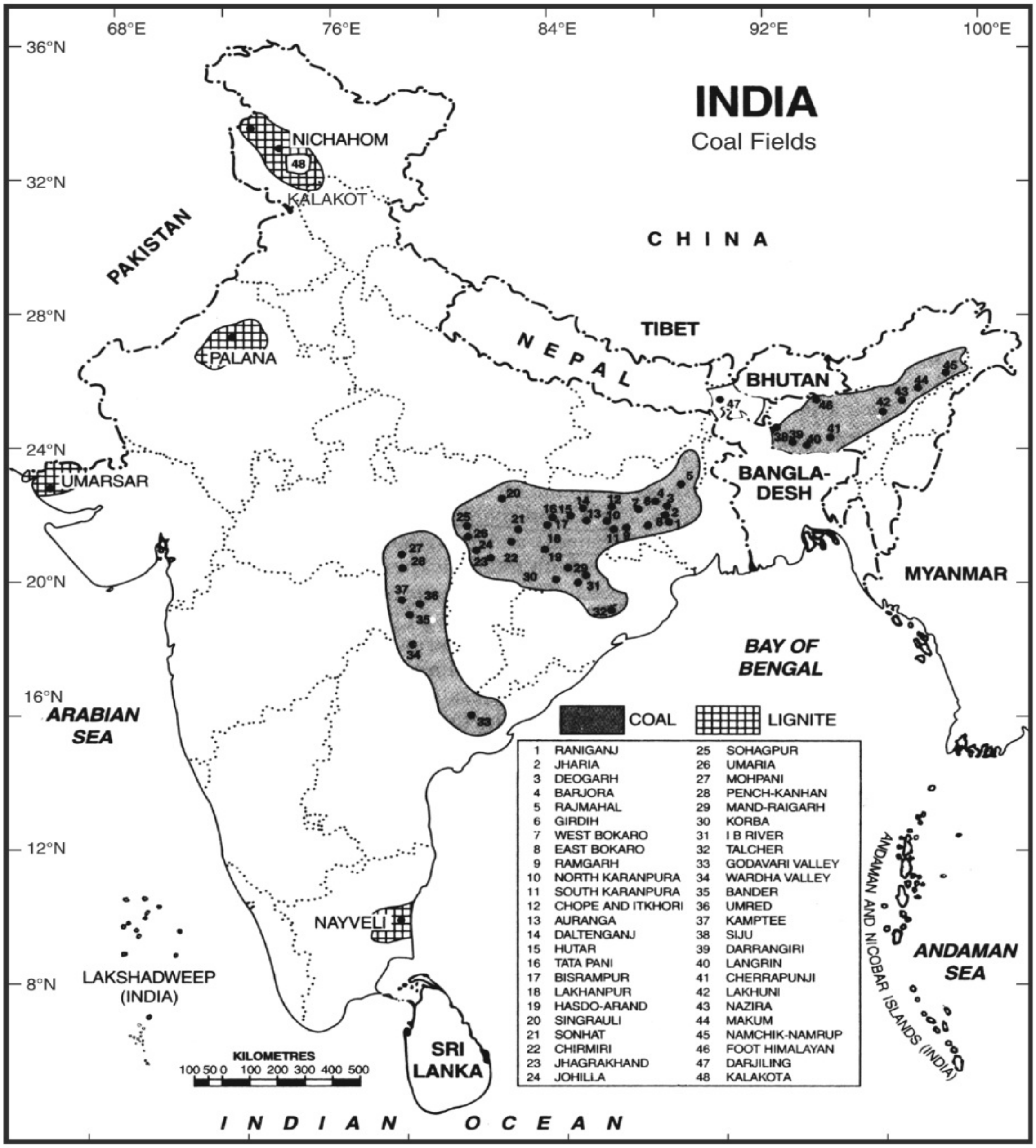

Fig. 8.1 Coal Fields

(*Contd.*)

8. Uttar Pradesh	1,135	0.49
9. Meghalaya	469	0.20
10. Assam	385	0.15
11. Bihar	178	0.07
12. Arunachal Pradesh	95	0.02
13. Nagaland	22	0.01
Total	250,795	100.00

Source: ***Statistical Abstract of India,*** 2007.

The major states having large proportion of the coal reserves of the country are Jharkhand, Odisha, Chhattisgarh, West-Bengal, Madhya Pradesh and Andhra Pradesh **(Fig. 8.2)**. A brief account of coal reserves in these states has been given in the following:

(i) Jharkhand The state of Jharkhand, accounting for about 29 per cent, has the first rank in coal reserves and its production. Most of the coal belongs to the Gondwana period. The districts of Dhanbad, Dumka, Hazaribagh, and Palamu are very rich in coal deposits. The main coal mining centres are Auranga, Bokaro, Daltenganj, Dhanbad, Giridih, Hutar, Jharia, Karanpur, and Ramgarh **(Fig. 8.3)**.

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

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

(c) The Giridih or Karharbari Coalfield The Giridih coalfield stretches in the district of Hazaribagh. Its seams are very close to the surface. It provides one of the finest quality of bituminous coal used for the metallurgical industry. Its coal is supplied to the Bokaro and Jamshedpur steel plants.

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

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

(f) The Hutar Coalfield Stretching over about 200 sq km the Hutar coalfield lies in the Palamau district. Its seams are however, thin and the coal is of inferior quality containing about 50 per cent carbon, 30 per cent volatile matter and 20 per cent ash.

(g) The Daltenganj Coalfield Sprawling over 55 sq km, this coalfield lies in the Palamau district. Its coal is either semi-anthracite or non-coking, of inferior quality which can not be used in metellaurgical industries.

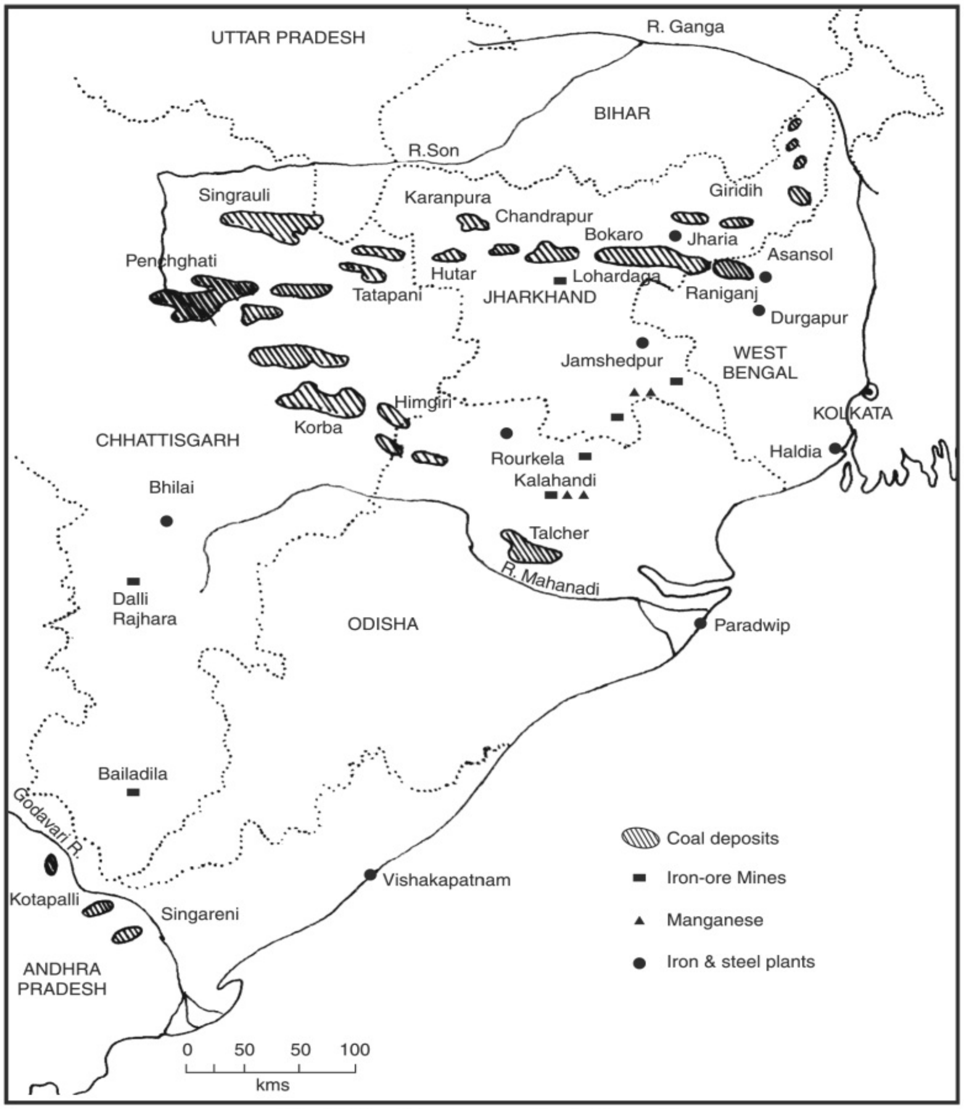

Fig. 8.2 Gondwana Coal Deposits

(h) Deogarh Coalfields This coalfield lies in the Dumka district and stretches over an area of about 20 sq km. The coal is of inferior quality containing about 40 per cent carbon, 25 per cent volatile matter and 35 per cent ash content. Its coal is mainly used in the brick kilns.

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

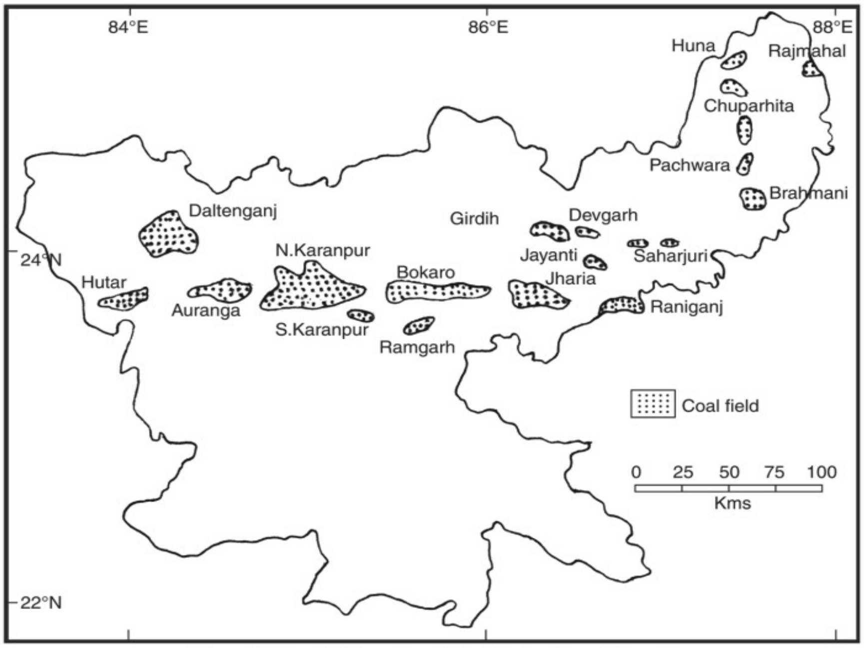

Fig. 8.3 Major Coal-Fields in Jharkhand

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

(iii) Chhattisgarh and Madhya Pradesh The state of Chhattisgarh has the third largest coal reserves (about 17 per cent of all India) in the country after Jharkhand and Odisha, but it holds the first rank in its production. Coal deposits are found in Bilaspur, Betul, Chhindwara, Narsinghpur, Raigarh, Rewa and Surguja districts. Singrauli, Sohagpur and Umaria (Rewa district), Bisrampur, Jhilmilli, Ramkola, Tattapani (Surguja district), Korba and Sandurgarh (Bilaspur district), Pench and Kanha valley (Chhindwara district), Mand river (Raigarh district), and Patakhera and Dulhara (Betul district) are the main mining centres of coal in Chhattisgarh.

(a) The Singrauli Coalfield Stretching over the Sidhi and Shahdol districts is the largest coal-field of Madhya Pradesh. Its Jhingurda coal seam with a thickness of 132 metres is the thickest coal-seam of the country. The coal belongs to the Gondwana period, which contains 40 to 50 per cent of fixed carbon. Its coal is mainly utilised in the thermal powerplant of Obra.

(b) The Korba Coalfield The Korba coalfield lies in the Bilaspur district. Two of its coal seams are more than 30 metres. The coal is of average quality and is used mainly in the Korba thermal power plant.

(c) The Pech-Kanha-Tawa Coalfield It lies in the Chhindwara district. In quality its coal is of coking and semi-coking category.

(d) Umaria Coalfield This coalfield lies about 60 km south of Katni. The coal contains a higher percentage of ash and moisture. It is used mainly in the generation of thermal power. In addition to these, coal is also mined at Jhilmili, Sonahat, and Tattapani coalfields of Surguja district.

(iv) West Bengal West Bengal has about 11 per cent of the total coal reserves of India (**Table 8.1**). The coal deposits of West Bengal lie in Bankura, Bardhman, Birbhum, Darjeeling, Jalpaiguri, and Puruliya districts. The most important of coal reserves and mining coalfield of West Bengal is Raniganj.

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

(b) The Darjeeling Coalfield The coal of Darjeeling district belongs to the Tertiary Period. It is exposed in the Mana and Mahanadi valleys. The coal is in powder form with coking quality.

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

(vi) Andhra Pradesh About 7 per cent of the coal reserves of India are found in Andhra Pradesh. Its main coal deposits are found in the Godavari valley. The districts of Adilabad, Khammam, Nellore and Warangal are known for its production. Coal is mainly used in thermal power plants of Kottagudem, Nellore, Ramagundam, Errazada, Husain-Sagar, and the fertiliser plant at Ramagundam.

The Singareni coalfield lying about 185 km to the east of Hyderabad is the main mining area of coal in Andhra Pradesh. Another important coal producing centre is at Kottagudam. Its coal seam is of about 18 metres and the coal is of good quality.

(vi) Maharashtra The main coal deposits of Maharashtra lie in the Wardha valley, stretching over the Nagpur (Kampte-coalfield), and Yavatmal districts. The coal from these coalfields is utilised by the railways and the thermal power stations of Trombay, Chola (Kalyan), Khaperkheda, Paras, Ballarshah, Nasik and Koradi.

Coal Deposits of the Tertiary Period

The Tertiary coal deposits came into existence during the Eocene, the Oligocene, and Miocene periods. Coal of this period is found in Arunachal Pradesh, Assam, Meghalaya, Nagaland, and Jammu and Kashmir states. It is also known as brown coal. Containing more moisture, it has less carbon content.

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

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

Gujarat In Gujarat coal is found in Bharauch district and Kachchh. The coal is of poor quality with about 35 per cent carbon and more moisture.

Jammu and Kashmir The Tertiary coal in Kashmir is found at Raithan of the Shaliganga, Handwara, Baramulla, Riasi and Udhampur districts, and the karewas of Badgam and Srinagar. It is of inferior quality with less than 30 per cent of carbon, over 15 per cent moisture and 30 per cent volatile matter.

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

India is the fourth largest producer of coal in the world, contributing about 5 per cent of the total coal production. An examination of **Table 8.2** shows that in 1950–51 the total production of coal and lignite was 323 and 0.4 lakh tonnes which rose to 3750 and 280 lakh tonnes in 2005–06 respectively. The coal mines were nationalised in 1972, after which there had been a tremendous increase in the coal production (**Table 8.2**).

Table 8.2 *India: Production of Coal—1950–51 to 2008–09*

Year	*Production (in lakh tonnes)*		
	Coal	*Lignite*	*Total*
1950–51	322.6	0.40	323.00
1960–61	360.00	0.65	360.65
1970–71	720.00	36.50	756.50
1980–81	1230.00	60.00	1290.00
1990–91	2100.00	140.00	2240.00
2000–01	3280.00	230.00	3510.00
2010–11	4660.00	350.00	5010.00

Source: 1. ***Statistical Abstract and The Economic Survey,*** 2011–12.
2. India–2010, p.690.

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

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

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

Problems of Coal Industry

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

1. Unequal Distribution of Coal The distribution of coal in India is confined mainly to Jharkhand, Chattisgarh, Odisha, Madhya Pradesh and West Bengal. The transportation cost is consequently heavy which makes this vital source of energy expensive.

2. Poor Quality of Coal Most of the mines of India are producing non-coking coal which can not be utilised for metallurgical industries.

3. Less Efficient Transport System Most of the coal in India is transported by trains. Adequate number of wagons are not available and railway system is not efficient enough to deliver the coal at distant places in a short time.

4. Obsolete Method of Mining The mining technology is outdated and the per worker production is low. The per tonne cost of production is high.

5. Shortage of Power Supply The shortage of power supply is a big barrier in the mining of coal.

6. Fires and Water-logging There occur heavy losses of coal because of fires and waterlogging in the mines and at the pit-heads.

Conservation of Coal

Coal is an exhaustible resource. It needs to be utilised judiciously. The following steps can go a long way in the conservation of coal in the country.

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

Petroleum

Petroleum is an important source of energy which is much in demand to accelerate the economic development. Apart from an important fuel resource, it provides lubricants and raw materials for a number of chemical industries. Its products include kerosene, diesel, petrol, aviation-fuel, synthetic rubber, synthetic-fibre, thermoplastic resins, benzene-methansol, polystertene, acrylates, detergents, aromatics, gasoline, carbon-black, dyes, colours, food-colours, pigments, explosives, printing ink, film-photography, greases, cosmetics, paints, lubricant oils, paraffin, and wax.

Crude oil is obtained mainly from the sedimentary rocks of marine origin. In India, crude oil is found in the sedimentary rocks of the Tertiary period **(Fig. 8.4).** Normally it does not occur at its place of formation. Being lighter than water, crude oil overlain with gas, gets accumulated in the anticlines above the water surface. The geologists propounded two theories about the origin of crude oil.

Origin: The origin of petroleum and natural gas is considered to be organic. According to organic origin, the living organisms (marine life, like fish) and vegetal matter got buried under the accumulated sediments of mud, silt and sand, etc. Due to pressure and heat, this undergoes chemical changes so as to form crude oil and natural gas after millions of years.

Oil in India was discovered near Margherita (Upper Assam); for the first time in 1860 by the Assam Railway and Trading Company. Subsequently, oil was discovered at Digboi in 1889. In the beginning of the 20^{th} century (1917), oil was discovered at Badarpur (Assam). In 1954, production of oil was started in Naharkatiya region. The Oil and Natural Gas Commission (ONGC) was established in 1956. With the efforts of the Oil and Natural Gas Commission (ONGC), oil was discovered in the Gulf of Cambay (Khambat) in 1961 and in Bombay High in 1976.

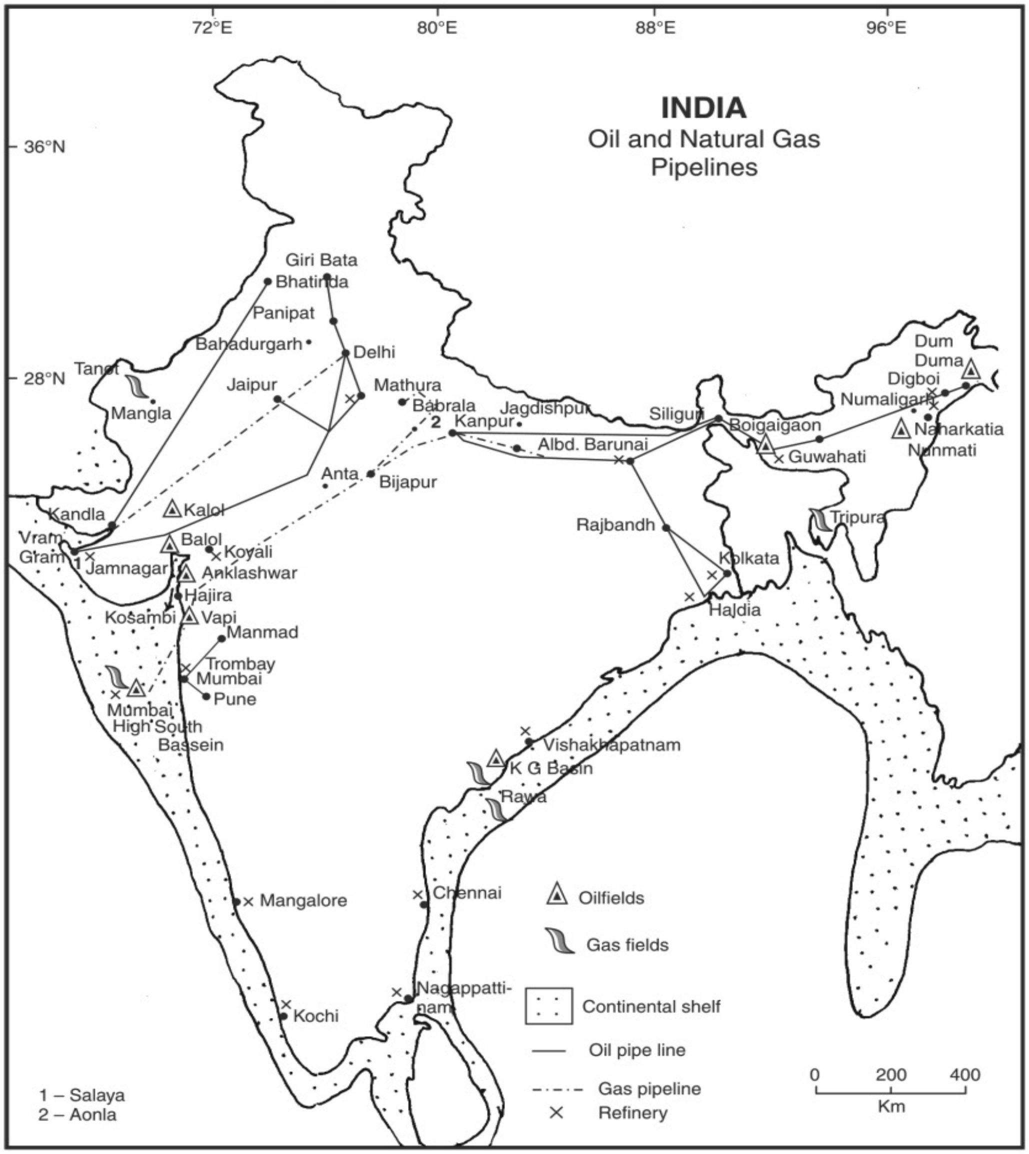

Fig. 8.4 Oil and Natural Gas Deposits

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

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

The production trend of oil has been given in **Table 8.3**

Table 8.3 *India—Production of Crude Oil—1951–2006*

Year	*Production in Million Tonnes*
1950–51	0.27
1960–61	0.50
1970–71	7.20
1980–81	15.5
1990–91	33.0
2000–01	32.5
2005–06	34.0

Source: ***Economic Survey of India, 2009–10.***

It may be seen from **Table 8.3** that the total production of crude oil in 1950–51 was only 0.27 million tonnes which rose to 34 million tonnes in 2005–06. The produced oil is, however, only about 40 per cent of the domestic need. The production of crude oil from the different regions of the country has been shown in **Table 8.4.**

Table 8.4 *India: Production of Crude-Oil—2005–06*

State/Region	*Production in Thousand Tonnes*	*Per cent of all India Production*
1. Bombay High	22.10	65.00
2. Gujarat	06.00	17.65
3. Assam	05.10	15.00
4. Andhra Pradesh	00.39	1.15
5. Tamil Nadu	00.37	1.10
6. Arunachal Pradesh	00.04	0.10
All India	34.00	100.00

Source: ***Statistical Abstracts of India, 2007.***

The crude oil production in India has been shown in **Fig. 8.5**. It may be seen from Fig. 8.5 that the crude oil production was about eleven million tonnes in 1980–81which rose to over 34.0 million tonnes in 2005–06.

It may be observed from Fig. 8.5 that over 65 per cent of the total oil production is from the Bombay High. The second and third ranks are that of Gujarat (about 18 per cent) and Assam (15 per cent).

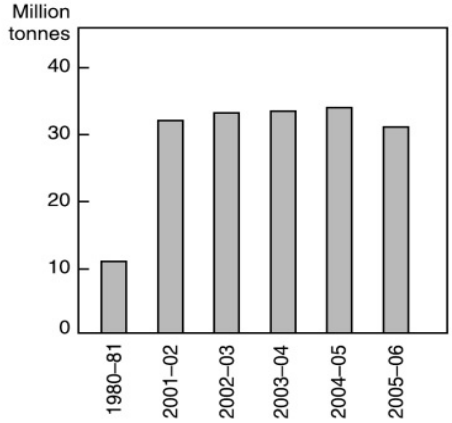

Fig. 8.5 India—Crude Oil Production

Crude-Oil Producing Regions

The major oilfields of India are as under:

1. The Western Coast Offshore Oilfields

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

(ii) Bassein Oilfield This oilfield lies to the south of Bombay High. Here oil occurs at a depth of over 1900 metres. It has rich deposits of oil and natural gas.

(iii) Aliabet Oil-field The Aliabet oilfield is located about 45 km to the south of Bhavnagar.

2. The Gujarat Coast

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

(i) Ankleshwar Situated in the district of Bharauch, it stretches over an area of about 30 sq km. The oil of this region belongs to the Eocene period. Oil production in this region was started in 1961. Ankleshwar oil is rich in gasoline and kerosene. The crude oil from this region is sent to the Koyali petroleum refinery.

(ii) Cambay-Luni Region This oilfield lies about 60 km to the west of Vadodara. The drilling operations in this region were started in 1958. The estimated reserves of crude-oil are over 30 million tonnes. The oil of this region is very light with a sulphur content of less than 0.1 per cent.

(iii) The Ahmadabad-Kalol Region This crude-oil region lies to the north of Gulf of Khambat (Cambay) around the city of Ahmadabad and extends up to Mehsana. Kalol, situated about 25 km to the north of Ahmadabad is an important oilfield of the region. Oil production from this region was started in 1961. Crude oil from this region is supplied mainly to the Koyali refinery.

3. The Brahmaputra Valley As stated above, crude oil was first discovered in the Brahmaputra valley. The oil-bearing rocks spread from the Dehang Basin up to the Surma valley. The main oil producing wells, however, lie in the Dibrugarh and Sibsagar districts of Upper Assam. Some of the important oil producing centres of this region are given below:

(i) The Digboi Oilfield Stretching over an area of about 15 sq km, the Digboi oilfield is one of the oldest oil-fields of the country. The oil of this region belongs to the Eocene and Miocene periods. There are 85 oil wells in this region. Most of the oil is sent to the refinery of Digboi. Since 1959, the Digboi oilfields are worked by the Oil India Limited (OIL).

(ii) The Naharkatiya Oilfield This oil-field lies about 35 km to the south-west of Digboi. Oil production from the Naharkatiya oilfields was started in 1954. Crude oil from this region is supplied to the refineries of Noonamati, New Bongaigaon (Assam), and Barauni (Bihar).

4. The Eastern Coast Oil-fields Petroleum and natural gas have been discovered in marine delta regions of Mahanadi, Godavari, Krishna, and Kaveri rivers. The Rawa field in the Godavari-Krishna offshore is expected to produce about 3 million tonnes of crude-oil annually. Petroleum has also been discovered in the Kaveri delta.

In addition to these, crude oil has been discovered in the Bilaspur Tehsil of Rampur District of Uttar Pradesh, Jawalamukhi area of Punjab, and in the Barmer District of Rajasthan. There are strong possibilities of petroleum and natural gas deposits to be found on the offshore of Andaman and Nicobar, Gulf of Mannar, Baleshwar coast, Punjab, Haryana and Uttar Pradesh.

The Ministry of Petroleum and Natural Gas is entrusted with the responsibility of exploration and production of oil and natural gas including import of Liquefied Natural Gas (LNG), refining, marketing, distribution import, export and conservation of petroleum products.

Oil and Natural Gas Corporation Limited (ONGC) and Oil India Limited (OIL), the two national companies (NOCs), and private and joint venture companies are engaged in the Exploration and Production of oil and natural gas in the country. Crude oil production during 2005–06 was 32190 MMT by ONGC, OIL, and Private/Joint Venture companies.

The natural gas production during the year 2005–06 was 32.20 Billion Cubic Metres (BCM) from ONGC, OIL and Private/Joint Venture Companies.

Import

The total quantity of crude oil and petroleum import during 2004–05 was over 100 MMT, valued at Rs.134,094 crore ($29844 million). In the same year 21.50 MMT of petroleum products valued at Rs.47 crore were exported. Thus, India is not self sufficient in the production of petroleum and over 70 per cent of its demand is fulfilled by imported crude oil and petroleum.

During the year 2005–06, the public sector refineries purchased crude oil on term contract and spot basis. The countries from where term contract purchases were made included Saudi Arabia, Kuwait, UAE, Iran, Oman, Sudan, etc.

Pipelines

Crude oil from oil-wells and finished products from refineries are generally transported through pipelines. Transportation of oil and petroleum through pipelines is cheap, effective and considered to be safe. Looking at these advantages, a network of pipelines has been developed in India. Some of the important pipelines are as under:

1. Pipelines of North-East India

(i) Noonmati-Siliguri-Pipeline to transport petroleum products from Noonmati to Siliguri.
(ii) Lakwa-Rudrasagar-Barauni Pipeline, completed in 1968 to transport crude-oil from Lakwa and Rudrasagar to Barauni Oil Refinery (Bihar).
(iii) Barauni-Haldia Pipeline: This pipeline was laid down in 1966 to carry refined petroleum products to Haldia port and bring back imported crude-oil to Barauni refinery.
(iv) Barauni-Kanpur Pipeline: This pipeline was completed in 1966 to transport refined petroleum products to Kanpur city.
(v) Noonmati-Bongaigaon Pipeline: This pipeline was constructed to transport crude-oil to Bongaigaon petro-chemical complex.
(vi) Haldia-Maurigram-Rajbandh Pipeline: This pipeline was completed in 1998.

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

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

4. The Mathura-Delhi-Ambala-Jalandhar Pipeline This 513 km long pipeline was constructed to transport refinery products of Mathura to the main cities of north and north-west India.

5. Pipelines of Gujarat In Gujarat, there are a number of short distance pipelines to transport crude-oil and natural gas to the refineries and the refined products to the market. These include the Kalol-Sabarmati Crude Pipeline, the Nwagam-Kalol-Koyali Pipeline, the Cambay-Dhuravan Gas Pipeline, the Ankleshwar-Uttran Gas Pipeline, the Ankleshwar-Vadodara Gas Pipeline, and the Koyali-Ahmadabad products Pipeline **(Fig. 8.4).**

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

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

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

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

Oil Refineries of India

The oil refineries are the processing factories of crude-oil. The impurities from the crude oil are removed to obtain petroleum, diesel, kerosene, bitumen, and aviation fuel. Petroleum industry contributes about 15 per cent of the GDP (2010-11). The main refineries of India, their year of commission and production capacity are given in (**Fig. 8.6**) **Table 8.5**.

Table 8.5 *India: Refineries and their Production Capacity*

Refinery	*State*	*Year of Commissioning*	*Capacity (lakh tonnes per year)*
Digboi, IOC	Assam	1901	5.0
Trombay, HPCL	Maharashtra	1954	55.0
Trombay, BPCL	Maharashtra	1955	60.0
Vishakhapatnam, HPCL	Andhra Pradesh	1957	45.0
Noonamati, IOC	Assam	1962	8.5
Barauni, IOC	Bihar	1964	33.0
Koyali, IOC	Gujarat	1965	95.0
Kochi, CRL	Kerala	1966	45.0
Chennai, MRL	Tamil Nadu	1969	56.0
Haldia, IOC	West Bengal	1975	27.5
Bongaigaon, BRPL	Assam	1979	13.5
Mathura, IOC	Uttar Pradesh	1982	75.0
Numaligarh, IOC	Assam	1999	30.0
Jamnagar, RP	Gujarat	1999	270.0
Karnal, IOC	Haryana	1998	60.0
Mangalore, HPCL	Karnataka	1998	30.0
Panagundi, IOC	Tamil Nadu	1999	5.0
Pachpadra HPCL	Rajasthan	2013–17	9.0
Total			913.5

The total refining capacity of crude oil was 2 lakh tonnes per annum in 1901 which rose to more than nine hundred lakh tonnes per annum in 2005–06. All the refineries except the Digboi and the Jamnagar are in the public sector, or the joint section.

Natural Gas

The exploration of natural gas is being done by the Oil and Natural Gas Commission. According to one estimate, India has a total natural gas reserve of about 450 billion cubic metres. Out of the total reserves, about 75 per cent lies in the Bombay High and the Bassein oilfields, about 12 per cent in Gujarat, 7 per cent in Andhra Pradesh and 6 per cent in Assam. Apart from Bombay High, there are rich deposits of natural gas in Ankleshwar and Gulf of Khambat (Gujarat), Godavari and Krishna basins, the Thanjavur and Shingleput districts of Tamil Nadu. Natural gas is also found in Barmar district of Rajasthan, Kangra district of Himachal Pradesh, and Firozpur district of Punjab. The trend of natural gas production in India has been shown in **Table 8.6.**

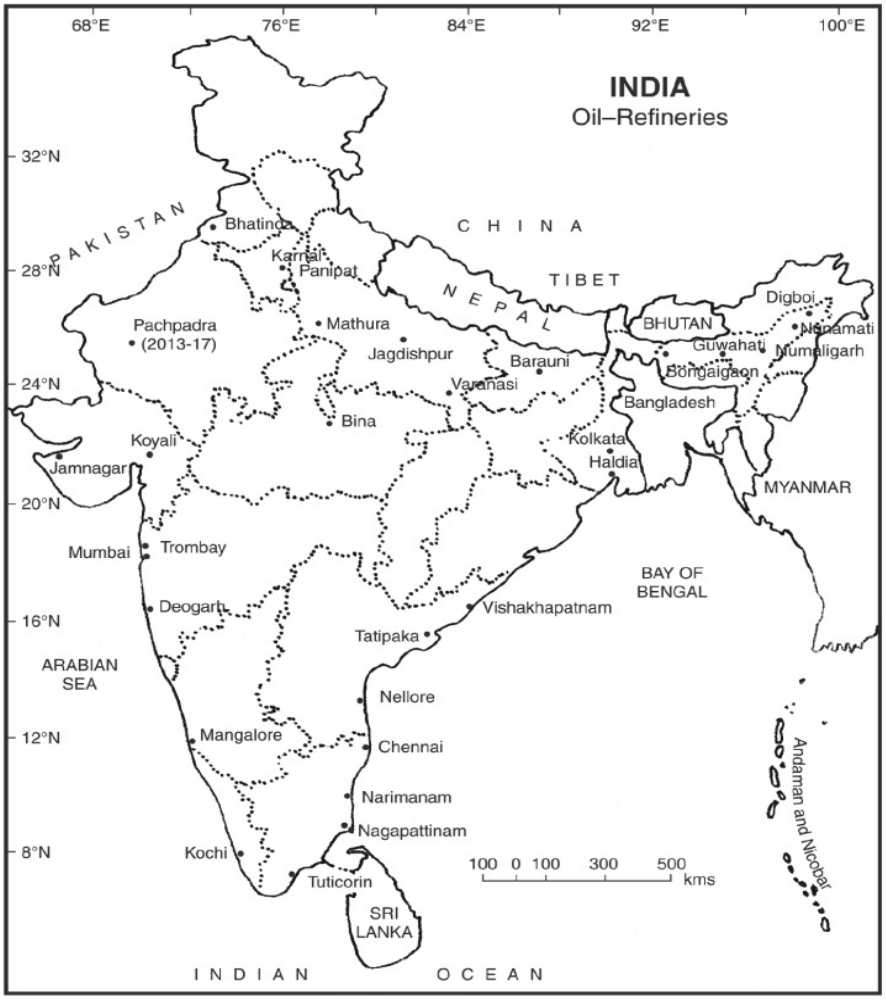

Fig. 8.6 Oil Refineries

Table 8.6 *India—Trends in Natural Gas Production*

Year	*Production (in million cubic metres)*
1960–61	17
1970–71	76
1980–81	200
1990–91	12,870
2000–01	20,920
2005–06	25,750

Source: ***Statistical Abstract, India,*** 2006–07.

The largest share of natural gas is consumed in the production of chemical fertilisers accounting for about 40 per cent, about 30 per cent is used in power generation, and about 10 per cent in L.P.G. (cooking gas).

After 1990, the production of natural gas has increased phenomenally, yet the production falls short of demand. Consequently, natural gas in large quantities has to be imported. Natural gas is imported from Iran, Saudi Arabia, UAE. and the other Gulf countries.

Electricity

Electricity is a clean source of energy. It is generated from water, coal, mineral oil, natural gas, and atomic minerals. Electricity can also be generated through wind energy, solar energy, bio-gas, sea-waves, geothermal and dry batteries. Electricity is relatively cheap, transportable, pollution free and renewable. Because of these advantages it is increasingly becoming popular day by day. The per head consumption of electricity is often considered an important indicator of socio-economic and human development. It is about 350 kWh which is much below the per head consumption in the world 1000 kWh and USA 7000 kWh

Table 8.7 *India—Installed Capacity of Electricity (in thousand MW)*

Year	*Hydro*	*Thermal*	*Nuclear*	*Others*	*Grand Total*
1950–51	0.6	1.1	—	0.6	2.3
1960–61	1.9	2.7	—	1.0	5.6
1970–71	6.4	8.0	0.4	1.6	16.3
1980–81	11.8	17.6	0.9	3.1	33.3
1990–91	18.8	45.8	1.5	8.6	74.7
2000–01	25.0	76.0	2.9	15.2	119.1
2005–06	35.0	95.0	2.8	17.2	150.00

Source: ***The Economic Survey***, 2006–07.

It may be seen from Table 8.7 that the total installed capacity of electricity by different sources was only 2.3 thousand MW in 1950–51 which rose to 150 thousand MW in 2005–06. The highest installed capacity is that of thermal, accounting for over 63 per cent of the total installed capacity.

The electricity production in India was started in 1898 when the Darjeeling hydel power project was commissioned. The first thermal power plant was installed in Kolkata in 1899. Subsequently, the Mettur project in Tamil Nadu and the Sivasamudram project in Karnataka were commissioned. In the initial phase the use of electricity was confined only to the big urban centres. The National Thermal Power Corporation (NTPC) was established in 1975, which established a number of thermal power stations based mainly on coal in different parts of the country.

Table 8.8 *India—Trends in the Power Sector 2005–2006 (billion kWh)*

	2005	*2006*	*Change over previous year*
Power Generation*	487.4	617.5	7.5
Hydro-electric	84.50	80.61	13.8
Thermal	486.1	497.20	6.1
Nuclear	16.8	17.21	3.0

* Excludes generation from captive and non-conventional power plants and thermal power plants below 20 MW units and hydro-power plants below 2 MW.

Source: ***Economic Survey***, 2007, p.179.

It may be seen from Table 8.8 that in 2005, the power generation was 487.4 billion kWh in which the share of hydro-power and thermal power was 84.50 billion kWh and 486.1 billion kWh respectively. In 2006, an increase of 6.1 and 13.8 per cent was recorded in the production of hydro- and thermal power respectively.

Hydro-Electricity

As stated in the preceding paragraph, the first hydro-electric plant in India was commissioned in 1898 at Darjeeling. It was followed by the Mettur (Tamil Nadu) and Sivasamudram (Karnataka) projects which were commissioned in 1899 and 1902 respectively. The fourth hydro-power station was built on the Jhelum river at Mohara in 1909. The real progress in the production of hydro-power took place after independence when a number of multipurpose projects were constructed. Some of these projects are the Bhakra-Nangal Dam, Rihand-Dam, Hirakud-Dam, Nagarjun-sagar, Damodar Valley Corporation, Chambal, Tungbhadra, and Koyna projects.

Regional Patterns

The development of hydro-electricity depends on the perennial and seasonal character of rivers, their monthly regime, undulating topography, suitable rock formations for the construction of dam and the demand for energy. Because of these factors, the development of hydro-power is not uniform. Andhra Pradesh ranks first, followed by Karnataka, Tamil Nadu, Punjab, Maharashtra, Kerala, and Madhya Pradesh. The major Hydro-electric Power Plants have been given in **Table 8.9**.

After Independence, especially in the First Five Year Plan, great emphasis was laid on the development of electricity. To achieve this objective, a number of multipurpose projects were installed. Some of the important multipurpose projects have been described in the following:

Table 8.9 *State-wise Main Hydro-Electric Power Plants*

States	*Names of the Hydro-Electric Power Plants*
1. Andhra Pradesh	Machkund, Nagarjun-Sagar, Nizam -Sagar, Sileru, Srisalem
2. Bihar	Kosi
3. Gujarat	Akrimota, Sardar-Sarovar, Ukai (Tapi), Hathmati (Sabarmati), Bhadra (Kathiawad)
4. Jammu & Kashmir	Dool-Hasti, Lower Jhelum, Salal, Baghliar
5. Jharkhand	Maithon, Panchet, Tilaiya (all three under DVC), Mayurakshi
6. Karnataka	Mahatma-Gandhi (Jog Falls), Sivasamudram (Kaveri), Bhadra, Munirabad, Saravati, Tungbhadra, Krishnaraja-Sagar
7. Kerala	Idikki (Periyar), Kallada, Kuttiaddy, Pallivasal, Parambikulam, Poringal, Panniar, Sabarigiri, Periyar
8. Madhya Pradesh	Jawaharsagar and Pratap-sagar on Chambal, Twa (M.P.)
9. Maharashtra	Bhola, Bhatnagar-Beed, Girna, Khopali, Koyna, Purna, Paithon, Vaiterna
10. North-eastern States	Dikhu, Doyan (both in Nagaland), Gomuti (Tripura), Loktak (Manipur), Kopali (Assam), Khandong and Kyrdemkulai (Meghalaya), Sirlui and Barabi (Mizoram), Ranganadi (Arunachal Pradesh)

(*Contd.*)

(*Contd.*)

11. Odisha	Hirakud (Mahanadi), Balimela, Rengali (Brahmani), Indiravati
12. Punjab and Himachal Pradesh	Bhakra-Nangal on Sutlej, Dehar on Beas, Giri-Bata, Harike Binwa, Andhra, Chamera, Pong, Siul, Bassi
13. Rajasthan	Ranapratap Sagar and Jawahar Sagar on Chambal river
14. Tamil Nadu	Bhavanisagar, Mettur, Periyar, Aliayar, Kodayar, Moyar, Suruliyar, Papnasam
15. Uttarakhand	Tehri-dam and Koteshwar-dam on Bhagirathi
16. Uttar Pradesh	Rihand, Ramganga, Chibro on Tons
17. West Bengal	Panchet

1. Bhakra Nangal Project The Bhakra-Nangal Dam is a joint venture of the Punjab, Haryana and Rajasthan governments. Constructed across the Satluj river near Bhakra gorge, it is one of the highest straightway gravity dam in the world. The dam is 518 m long and 226 m high. Its reservoir is known as the Gobind Sagar (named after Sikh Guru Gobind Singh, the tenth Guru of Sikhs). It is a multipurpose project funded by the Central Government, built to generate electricity, provide irrigation, flood control, soil conservation, silt control, recreation, navigation, pisci-culture, preserving wild-life, and cattle rearing.

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

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

(ii) Konar Dam The Konar dam has been constructed across the Konar river—a tributary of the Damodar River in the Hazaribagh District. It was completed in 1955. It is an earthen dam with concrete spill-way . Beside irrigation and power, it provides cooling water to the Bokaro Steel Plant. The hydel station located near the dam generates about 40,000 kW of electricity.

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

(iv) Panchet Hill Dam The Panchet dam has been constructed across the Damodar river, about 20 km south of the Maithon Dam. It is 45 m high and 2545 m long. The power station near the dam has an installed capacity of 40,000 kW. It irrigates about 3 lakh hectares of agricultural land.

3. Dool Hasti The Dool Hasti Project has been constructed across the Chenab river in the Doda district of the Jammu Division. The main objective of this project was to harness the water of Chenab river and to generate electricity to be supplied to the main cities of the state including the cities of Srinagar and Jammu. It was commissioned in 1986.

4. Gandhi Sagar The Gandhi Sagar project has been constructed across the Chambal river. The installed capacity of the Gandhi Sagar Dam is 115 MW. Five generators have been installed at

Gandhi Sagar; four with a capacity of 2300 kW and one with a capacity of 2700 kW. It is providing power and irrigation to the surrounding regions of Rajasthan and Madhya Pradesh.

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

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

7. Jawahar Sagar Dam This dam has been constructed to the north of Rana Pratap Dam in the state of Rajasthan. It is about 40 km to the north of the Rana Pratap Sagar. It is a multipurpose project constructed to generate electricity, control floods and provide irrigation water to the catchment area.

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

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

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

11. Mahi Project This project has been constructed across the Mahi river which originates from the Vindhyan Hills of Madhya Pradesh. The project on completion will generate 40 MW hydro-power and shall irrigate 80,000 hectares of agricultural land.

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

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

14. Nagarjun Sagar Project The Nagarjunsagar project has been constructed across the Krishna river in Nalgonda District of Andhra Pradesh. Its right and left bank canals have been named after Jawaharlal Nehru and Lal Bahadur Shastri respectively. The power plant generates 210 MW of hydro-electricity. The power is supplied to Hyderabad, Khammam, Mahbubnagar, Nalgonda and Vijaiwada.

15. Pochampad Project This project has been constructed across the Godavari river in Adilabad District. Its 115 km long canals irrigate about 2.5 lakh hectares in Adilabad, and Karimnagar districts of Andhra Pradesh.

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

17. Rampad Sagar Dam This dam has been constructed in the lower reaches of the Godavari river, about 30 km to the north of Rajamundry. It is a multi-purpose project designed to check floods, to provide irrigation in the delta region of the river and to generate electricity.

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

19. Rihand Project Funded by the Central Government, it is the largest multi-purpose project of Uttar Pradesh. It has been constructed across the Rihand river, a tributary of the Son river, near Pipri village in the Sonbhadra District. The reservoir of this dam has been named after Gobind Ballabh Pant. It is connected with the Obra hydro-power station and the Obra thermal power plant located in its vicinity. The power generated from this project is supplied to eastern Uttar Pradesh, western Bihar and northern parts of Madhya Pradesh. Flood control in Son valley, control of soil erosion in Baghelkhand, tourism and pisci-culture are the other benefits from this project.

20. The Salal Project This project has been constructed across the Chenab river in the Riasi District of Jammu Division of Jammu & Kashmir State. The installed capacity of the project is 750 MW. It was inaugurated in 1986. The electricity is supplied to Riasi, Udhampur, Jammu, and other neighbouring urban centres.

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

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

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

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

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

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

Thermal Electricity

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

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

The production of thermal energy is, however, not eco-friendly as the release of carbon dioxide pollutes the atmosphere. Moreover, it consumes the valuable exhaustible resources like coal, petroleum and natural gas.

Some of the important thermal power stations of India have been given in **Table 8.10.**

Table 8.10 *India—Thermal Power Stations*

States	*Thermal Power Stations with Installed Capacity in MW*
1. Andhra Pradesh	Bhadrachalam, Kothagudam (680), Manuguru, Nellore (300), Ramagudam (200), Vijayawada (420)
2. Assam	Bongaigaon (120), Chandarpur (100), Namrup (112)
3. Bihar	Barauni (255), Kahalgaon, DVC (780), Durgapur (285), 1
4. Chhattisgarh	Korba (750)
5. Delhi	Badarpur (720), Indraprastha (285), Rajghat (350)
6. Gujarat	Ahmadabad (180), Banas, Dhuvaram (534), Gandhinagar (240), Kachchh, Kandla, Mahuva, Porbandar, Sabarmati (110), Shahpur, Sikka, Ukai (640), Utaran (200), Wankbori,
7. Haryana	Faridabad (180), Panipat (220), Yamuna Nagar (150)
8. Jammu & Kashmir	Kalakot
9. Jharkhand	Bokaro (248), Chandrapur (780), Subarnrekha
10. Madhya Pradesh	Amarkantak (3000), Satpura (1142), Singrauli, Vindhyachal (1260)

(*Contd.*)

(*Contd.*)

11. Maharashtra	Ballarshah (500), Bhusaval(485), Chandrapur (210), Chola (95), Dhobal (350), Khapar-Kheda (250), Koradi (1100), Nasik (810), Paras (95), Parli (240), Trombay (838), Ujjaini, Uran (240)
12.Manipur	Loktak (Imphal)
13. Punjab	Bhatinda (440), Rupnagar
14. Rajasthan	Anta, Banswara, Kota (240), Palana, Sawai Madhopur.
15. Odisha	Balimela, Talcher (470)
16. Tamil Nadu	Ennore (450), Mettur, Neyveli (2300), Tuticorin (630)
17. Uttar Pradesh	Bahraich, Dorighat, Gorakhpur, Harduaganj (215), Jawaharpur, Kanpur (325), Mau, Moradabad, Obra (450), Panki (345), Parichha (240), (565), Tundla.
18.West Bengal	Birbhum, Bundel (540), Durgapur (285), Farakka (1600), Gauripur (350), Kalaghat, Kolkata (250), Murshidabad, Titagarh, Santaldih (480)

It may be seen from **Table 8.10** that the distribution of thermal power stations is highly unequal. Most of them, however, have been located near the source of inferior coal or lignite mining centres. The state of Maharashtra ranks first in the production of thermal power, followed by Uttar Pradesh, Gujarat, and West Bengal. The rank of Madhya Pradesh (including Chhattisgarh) and Tamil Nadu are sixth and seventh respectively. Arunachal Pradesh, Goa, Himachal Pradesh, Kerala, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura and Uttarakhand are the states which are devoid of the production of thermal electricity. On the zonal basis, the western zone is the largest producer of thermal energy, followed by the northern zone, eastern and southern zones. Thermal power stations have been installed at Raichur (Karnataka) and Loktak (Manipur).

The contribution of National Thermal Power Corporation is quite significant in the generation of thermal energy. The NTPC thermal power stations in the country have been given in **Table 8.11.**

Table 8.11 *India—Major Thermal Power Stations*

Projects/Stations	*Installed Capacity (MW)*
1. Badarpur	720
2. Farakka (West Bengal)	1600
3. Kahalgaon (Bihar)	840
4. Korba (Chhattisgarh)	2100
5. National Capital Thermal Power Plant Dadri (U.P.)	840
6. Ramagundum (Andhra Pradesh)	2100
7. Rihand /Obra (Uttar Pradesh)	1000
8. Singrauli (Madhya Pradesh)	2000
9. Talcher (Odisha)	720
10. Unchahar (Uttar Pradesh)	720
11. Vindhyachal (Madhya Pradesh)	1260
12. Gas Based Projects:	
(i) Anta (Rajasthan)	430
(ii) Auraiya (Uttar Pradesh)	600
(iii) Kawas (Gujarat)	600
Total	15530

Fig. 8.7 Thermal Power Projects

Nuclear Energy

Looking at the exhaustible nature of the fossil fuels, nuclear energy development has become very vital for the economic development of the country. In India, it has a vast potential for future energy development. It is produced from uranium and thorium. At present there are 17 nuclear plants across the country. The atomic power stations are given in **Table 8.12**.

Table 8.12 *India—Atomic Power Stations*

Power Stations	*Unit*	*Year of Commissioning*	*Capacity*
1. Tarapur	First	1969	160
(Maharashtra)	Second	1970	
2. Rawatbhata	First	1972	200
near Kota (Rajasthan)	Second	1981	200
3. Kalpakkam	First	1984	235
(Tamil Nadu)	Second	1986	235
4. Narora (U. P.)	First	1989	235
	Second	1991	235
5. Kakrapara	First	1993	235
(Gujarat)	Second	1995	235
6. Kaiga	First	1993	235
(Karnataka)	Second	1995	235
7. Rawatbhata;	Third		235
Kota (Rajasthan)	Fourth		235
8. Tarapur	Third		500
(Maharashtra)	Fourth		500
9. Kaiga	Third		235
(Karnataka)	Fourth		235
	Fifth		235
	Sixth		235
10. Rawatbhata	Fifth		500
Kota (Rajasthan)	Sixth		500
	Seventh		500
	Eighth		500
11. Kudankulam	First		1000
(Tamil Nadu)	Second		1000
12. Jaitapur	Maharashtra		
13. Haripur	W. Bengal		under-construction
14. Bargi-Chutka	Madhya Pradesh		
15. Kawada	Andhra Pradesh		
16. Maithi-Verdi	Kathiawad (Gujarat)		
17. Kumharia or Gorakhpur	Haryana		

At present, nuclear power constitutes only less than 4 per cent of the total energy production. It requires highly sophisticated technology and technical knowhow. Moreover, for the cooling of plant there is heavy need of fresh water.

The Atomic Energy Institution at Trombay was established in 1954. This was renamed as the 'Bhabha Atomic Research Centre (BARC), in 1967. The first nuclear power station with a capacity of 320 MW was set up at Tarapur near Mumbai in 1969. Subsequently, the Rawatbhata Atomic Plant (300 MW) near Kota was set up in 1969 which was followed by the establishment of Narora (1989), Kaiga (Karnataka), and Kakrapara in Gujarat in1993. Thus, at present, nuclear energy is produced from eleven units located at six centres (**Table 8.12**). The new sites of nuclear power plants include Bargi or Chutka (M.P.), Haripur (W. Bengal), Jaitapur (Maharashtra), Kawada (Andhra

Pradesh), Kudankulam (Tamil Nadu), Kumharia (Haryana), and Mithi-Verdi (Gujarat).

Development of nuclear energy is imperative for the economic development of the country. But the disaster's like Fukushima and Chernobyl have proved that it is full of risk. Thus it is only a parochial solution of the Indian energy crisis. Unfortunately, in India, in case of nuclear accident, the maximum fine that can be imposed by the regulator on an offending nuclear plant is Rs. 500/-. This amount is too low to serve as a deterrent against such infringements.

NON-CONVENTIONAL ENERGY

The non-conventional energy is also called as renewable energy. The non-conventional sources of energy include solar energy, wind energy, bio-mass energy, fuel-cells, electric vehicles, tidal energy, hydrogen energy, and geo-thermal energy.

Solar Energy

Solar energy is one of the most important sources of non-conventional energy. Solar energy is non-exhaustible, reliable, and pollution free. It may be utilised for water heaters, power generation devices, air-conditioning, space heating, development of pisci-culture, and multifarious uses of water and refrigeration.

The average amount of solar energy received in the earth's atmosphere is about 1353 kW per sq metre. It is 1000 times the total consumption of the global energy. Being situated in the sub-tropical latitudes, India receives higher amount of solar energy. The greater part of the country has more than 300 solar days. The total amount of energy received from the Sun is about 5000 trillion kWh per year.

The Solar Photovoltaic (SPV) technology enables the conversion of solar radiation into electricity without involving any moving part like turbine. Over 650,000 solar PV systems have been installed in the country.

In many parts of the country, the solar energy programmes have been implemented. One such example is the Rural Energy Co-operative at Sagar Island in the Sundarban Delta of West Bengal. Similar programmes have been implemented in the other islands in the Bay of Bengal, the desert of Jodhpur (Rajasthan), Kalyanpur (Aligarh), and Coimbatore (**Fig. 8.8**).

Wind Energy

Wind is an important source of non-conventional energy. It is cheap, pollution free, eco-friendly and can be developed away from the sources of fossil fuels (conventional sources of energy). Since ancient times wind energy was utilised in sailing ships and wind mills. India ranks 5th in the world after U.S.A., Spain, Germany and China.

For the generation of wind energy, a wind speed of more than five km per hour is considered to be suitable. Wind speeds above 10 km per hour are prevalent over parts of the coastal regions of Gujarat, Andhra Pradesh, Karnataka, Madhya Pradesh, Rajasthan, Tamil Nadu, Maharashtra, Kerala, Odisha, West Bengal, Uttarakhand, Jammu & Kashmir, and Andaman and Nicobar Islands

(**Fig. 8.8**). The state of Rajasthan and Ladakh also record suitable consistency of wind speed. Wind mills can be operated there to harness wind energy.

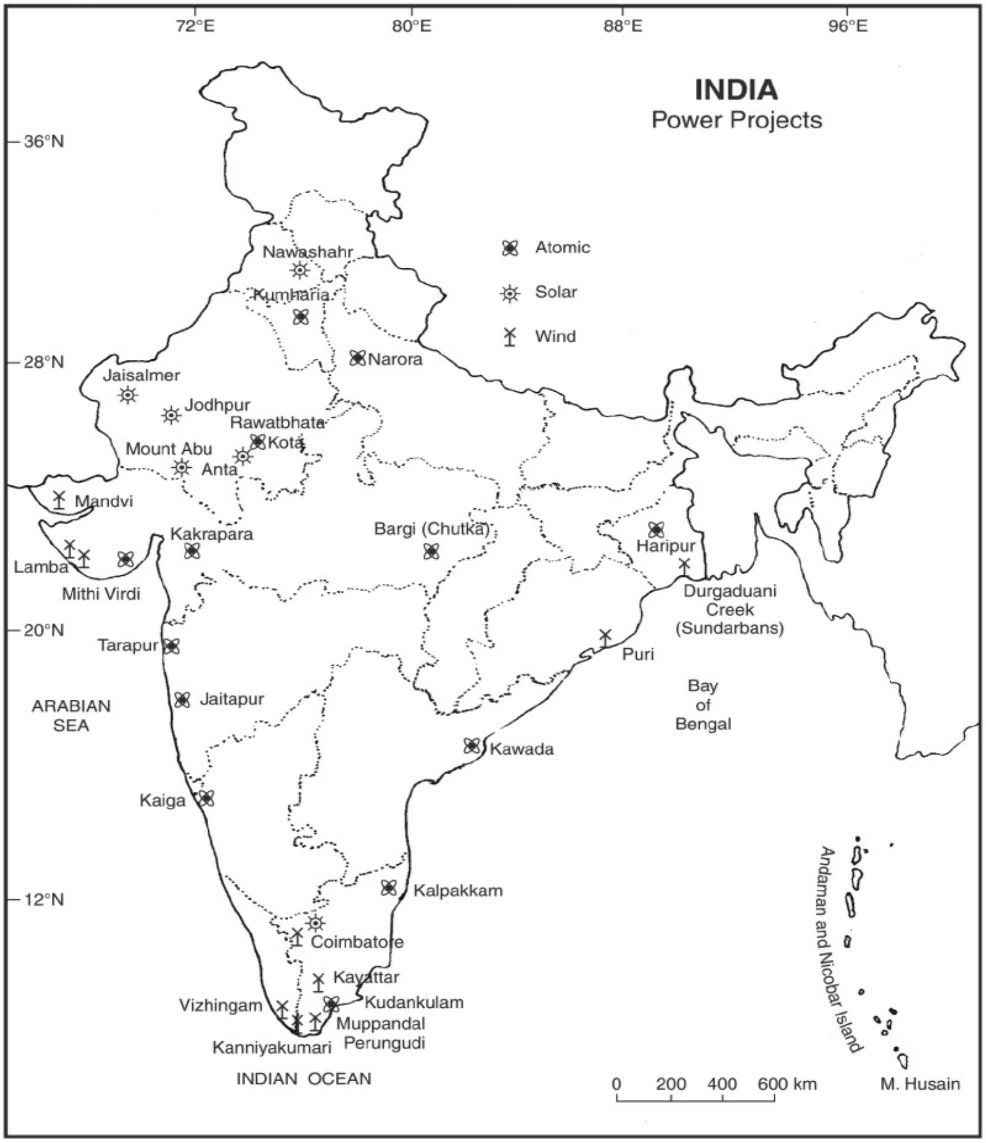

Fig. 8.8 Power Projects

Table 8.13 *India—Wind Power Potential*

State	*Total Potential (MW)*	*Technical Potential (MW)*
1. Gujarat	9675	1750
2. Andhra Pradesh	8275	1550
3. Karnataka	6620	1025
4. Madhya Pradesh	5500	1200
5. Rajasthan	5400	0885
6. Tamil Nadu	3050	1700
7. Others	6675	4725
Total	45,195	12,835

Source: ***Ministry of Non-Conventional Sources of Energy.***

In India, the total potential of wind energy is estimated to be more than 20,000 MW. Wind energy projects have been implemented in 22 states of the country. The maximum potential of wind energy lies in the states of Gujarat and Tamil Nadu. Asia's largest wind farm of 28 MW capacity is located at Lamba in Gujarat. Commercial projects of 1200 MW capacity have been set up in Tamil Nadu, Gujarat, and Andhra Pradesh.

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

Ocean Energy

The tidal waves and sea-waves are the main sources of ocean energy. India has a very long coastline, more than 6100 km, but the ocean energy production is limited. The suitable areas for the generation of tidal and sea-waves energy are:

(i) The Gulf of Khambat
(ii) The Gulf of Kachchh
(iii) The Estuary of Hugli

According to one estimate, the Indian coasts have the potential to generate over 40,000 MW of electricity. A plant has been established near Thiruvanantapuram (Vizhingam) which is generating about 150 MW of electricity through sea-waves.

The main problem in the exploitation of ocean energy is the high cost involved in the construction of civil works.

Geothermal Energy

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

Bio-Energy

Bio-energy is a clean source of energy which improves sanitation, hygiene and the living style of the rural population. The technique is based on the decomposition of organic matter in the absence of air to produce gas. Bio-gas is used for cooking, and lighting fuel in specially designed stove and lamps respectively. According to one estimate, India has a capacity to produce bio-gas to the extent of 25,000 million cubic metres. The left over digested slurry serves as manure. This can meet 50 per cent of the rural domestic fuel requirements. Moreover, it can produce 7 million tonnes to nitrogen, 3 million tonnes phosphate, 5 million tonnes of potassium, and over 50 million tonnes of compost manure.

Table 8.14 *Bio-Gas Development in Major Selected States of India—2005–06*

State	*Estimated Potential*	*Production*	*Percentage of estimated potential*
1. Uttar Pradesh	2,021,000	356,300	18
2. Madhya Pradesh	1,491,000	192,950	13
3. Andhra Pradesh	1,065,600	308,520	29
4. Bihar	939,900	119,110	13
5. Rajasthan	915,300	66,025	7
6. Maharashtra	897,000	662,120	74
7. West Bengal	2,021,000	356,310	18
8. Karnataka	680,000	306,845	45
9. Tamil Nadu	615,800	187,265	27
10. Gujarat	554,000	343,700	62
11. Odisha	605,500	171,760	28

Source: ***Ministry of Non-Conventional Energy.***

It may be seen from **Table 8.14** that Uttar Pradesh has the highest potential in bio-gas, followed by Madhya Pradesh, Andhra Pradesh, and Bihar. The highest production of bio-gas is, however, in the state of Maharashtra (74%) followed by Gujarat (62%) and Karnataka (45%).

The development of bio-gas is adversely affected because of the non-availability of cattle dung, water, labour, space, and low temperatures in certain parts of the country, especially during the winter season.

ENERGY CRISIS

With the rapid growth of population and increase in the per capita income, there is an increasing demand for energy, especially that of conventional sources of energy. The consumption of energy in the country is increasing at the rate of more than 12 per cent per annum. In the absence of energy, there are frequent power failures, load-shedding, closure of factories, etc., resulting in a decrease in industrial and agricultural production.

In comparison to the developed countries, the per head consumption of electricity in the country is very low. For example, the per capita consumption of electricity in India is 350 kWh as against the world average of 1000 kWh and 7000 kWh in U.S.A. According to one estimate, the country's peak demand projected for 2010 is 175,500 MW against the actual installed capacity of 90,000 MW. This requires an additional installed capacity of 85,500 MW.

Since the coal resources are highly unequally distributed, the transportation cost of coal to the distant thermal power stations is quite expensive.

Mismanagement of power sector, low efficiency of power houses, power theft, labour problem, pilferage, and power wastage are also aggravating the power crisis in the country.

ENERGY CONSERVATION

The conventional sources of energy (fossil-fuel) are fixed and exhaustible and the non-conventional sources of energy are not adequately developed. Energy conservation is, however, imperative for our survival and for the survival of the future generations. Some of the steps which can go a long way in the conservation of energy are as under:

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

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

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Chapter 9

Agriculture

Indian economy hinges on agriculture. About 58.2 per cent of Indian population is directly or indirectly dependent on agriculture. Agriculture and allied sectors contribute nearly 14.4 per cent of Gross Domestic Product (GDP) of India (India 2012). Besides, agriculture is an important source of raw material for industrial production, and serves as a huge market for the industrial products. In the opinion of Gunnar Myrdal "It is in the agriculture sector that the battle for long term economic development will be won or lost." If agriculture goes wrong, nothing else will have a chance to go right in India (M.S. Swaminathan). The agricultural output, however, depends on monsoon as nearly 55% of area sown is dependent on rainfall. It not only provides food to its teeming millions; the agro-based industries for their raw material are dependent on agriculture. Moreover, agriculture fetches substantial amount of valuable foreign exchange.

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

LAND UTILISATION

Land utilisation statistics are available for about 93 per cent of the total geographical area (328.75 million hectares) of the country. The net sown area accounts for about 46.15 per cent of the total reporting area of India, against the world average of about 32 per cent. The general land use of the country has been given in **Table 9.1** (**Fig. 9.1**).

Table 9.1 *India—General Land Use in 2009–10*

Land Categories	*Area in Million Hectares 2009–10*	*Percentage*
1. Total geographical area	328.75	
2. Total reporting area for land use	306.25	93.20
3. Area under forests	69.00	22.55
4. Area not available for cultivation		
(a) Area put to non-agricultural uses	23.25	7.61
(b) Barren and uncultivable land	19.18	6.25

(*Contd.*)

(*Contd.*)

5.	Other uncultivated land excluding fallow		
	(a) Permanent pastures and grazing lands	11.00	3.61
	(b) Land under tree crops and groves	3.62	1.18
	(c) Culturable waste	13.83	4.52
6.	Fallow Lands		
	(a) Current fallow	14.80	4.83
	(b) Other fallow	10.11	3.30
7.	Net sown area	141.23	46.15
8.	Area sown more than once	48.51	32.60
9.	Total (gross cropped) cropped area	189.74	
10.	Area under irrigation	78.00	55.3

Source: ***Statistical Abstracts of India—2005–06, Govt. of India Publication***.

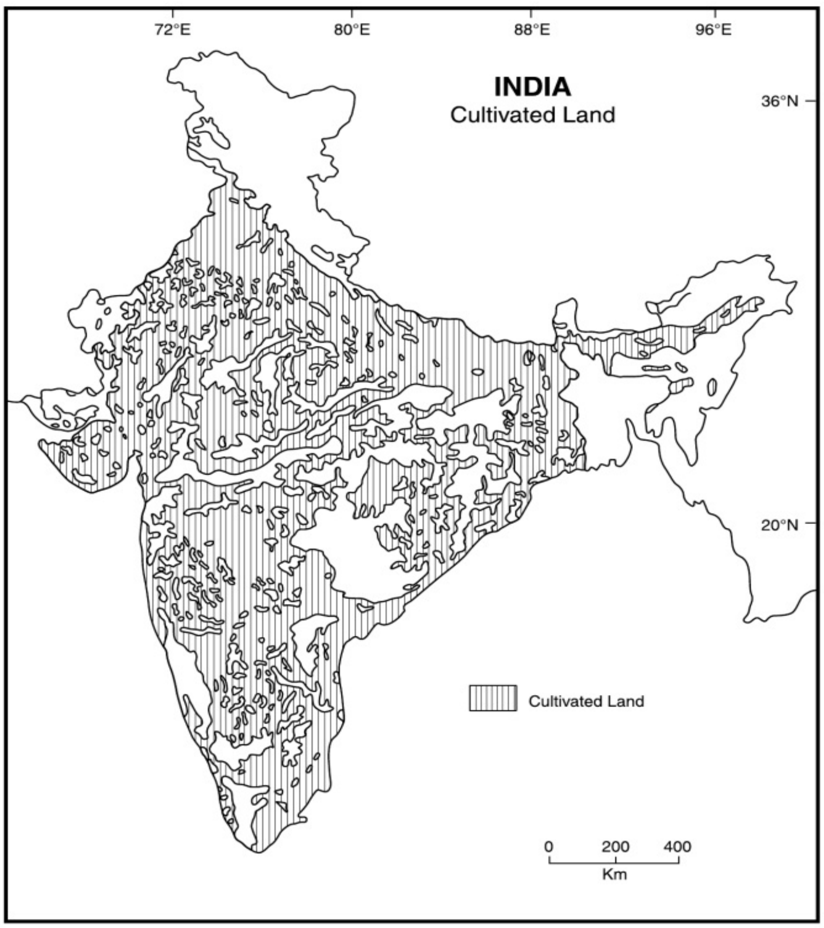


Fig. 9.1 Arable Land (2005–06)

It may be seen from **Table 9.1** that over 46 per cent of the total reporting area was net area sown in 2005–06, and 32 per cent was double cropped area (**Fig. 9.2**). The forest occupied 22.55 per cent while 6.25 was barren and uncultivable land. The barren and wasteland occupy 6.25 per cent of the total reporting area **Table 9.1** (**Fig. 9.3**). The various categories of degraded lands have been given in **Table 9.2**

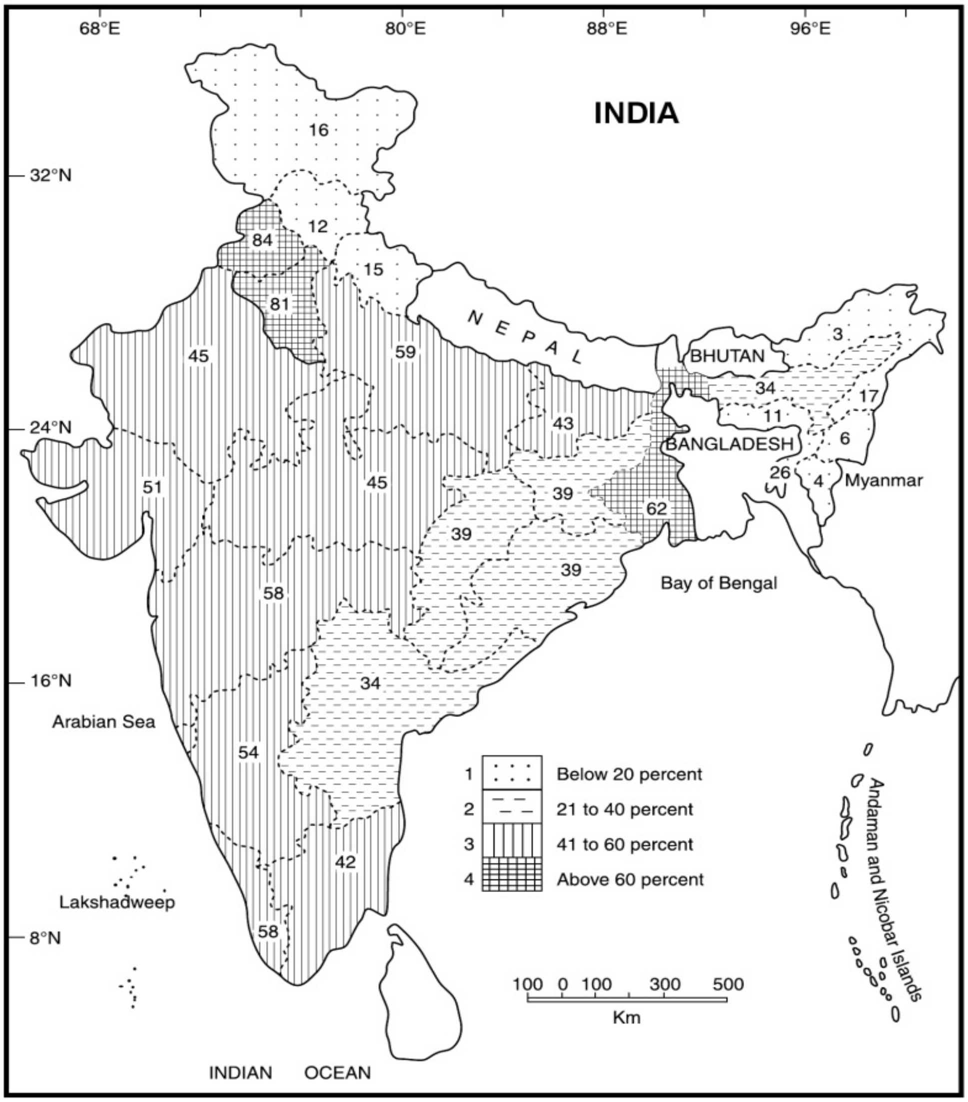


Fig. 9.2 Net Sown Area (2005–06)

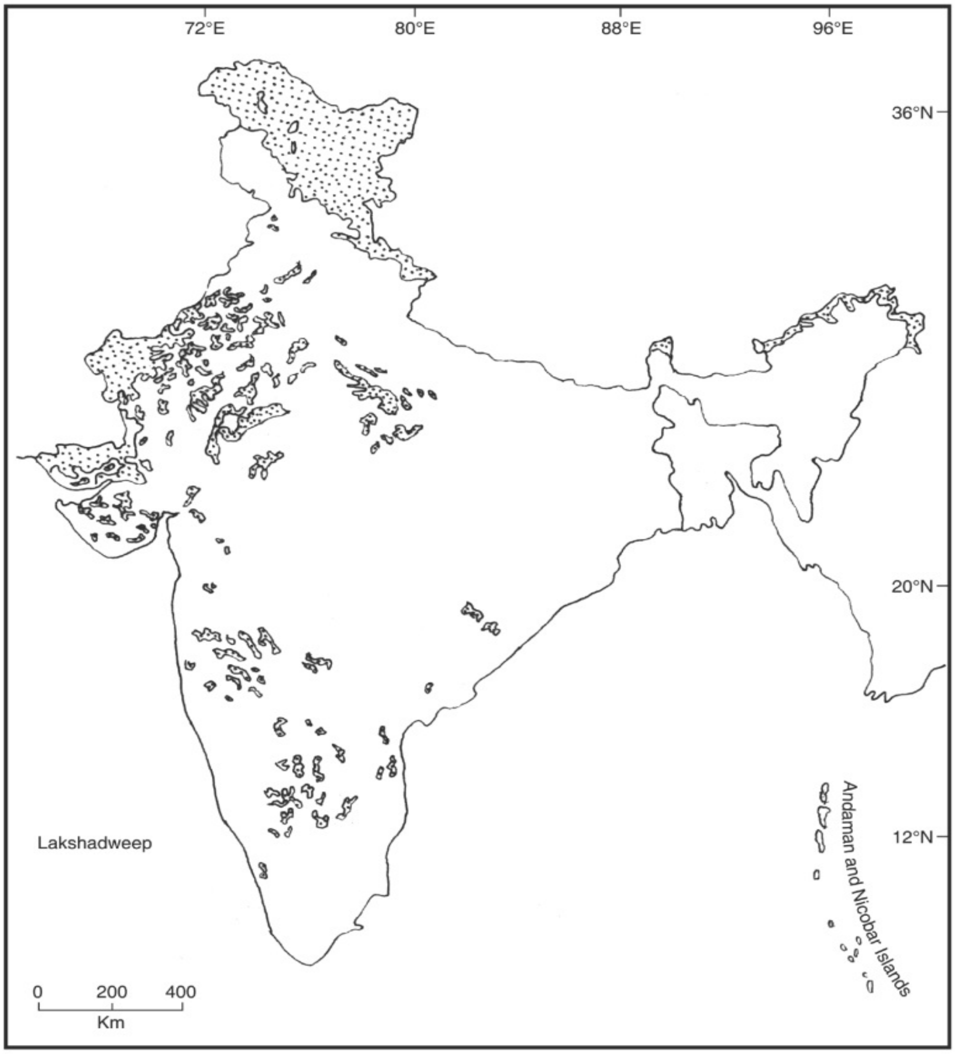


Fig. 9.3 Wasteland (2005–06)

Table 9.2 *Waste Lands and Degraded Lands*

Type of land	*Percentage*
Gullied land	2.05
Land with or without scrub	19.40
Water-logged and marshy land	1.66
Land affected by salinity and alkalinity	2.05

(*Contd.*)

(*Contd.*)

Shifting cultivation area	3.52
Degraded notified forest land	14.06
Degraded pastures	2.60
Degraded land & plantation crop	0.58
Coastal sandy land	5.00
Mining industrial wasteland	0.12
Barren rocky wasteland	6.46
Steep sloping area	0.77
Snow covered and glacial area	5.38
Total	63.65

Source: ***Planning Commission, Government of India, Tenth Five Year Plan***.

An examination of **Table 9.2** reveals that land with or without scrub and degraded notified forests occupied 19.40 and 14.06 per cent of the waste land respectively. The reclamation of degraded and waste lands can help in increasing the agricultural land as well as in improving the ecology and environment.

CHARACTERISTICS AND PROBLEMS OF INDIAN AGRICULTURE

As stated at the outset, Indian economy hinges on agriculture. The socioeconomic status of the people, the national polity and the gamut of life of the people is directly controlled by agriculture. The Indian agriculture, however, has its own characteristics. Some of the important characteristics and problems of Indian agriculture have been described briefly in the following section:

1. Subsistent in Character

Despite eleven five year plans, in greater parts of the country, Indian agriculture is subsistent in character. The cultivators and farmers grow crops mainly for the family consumption. It is only in the controlled irrigated parts of the country like Punjab, Haryana, western Uttar Pradesh, and Kaveri delta where agriculture has become an agri-business or is market oriented.

2. Heavy Pressure of Population

The Indian agriculture is characterised by heavy pressure of population. About 68 per cent of the total population of the country is directly or indirectly dependent on agriculture. At present, the per capita agricultural land is only about 0.10 hectare as against 0.30 hectare in 1951. The world average of per head availability of agricultural land is about 4.5 hectares. The fast growth of population industrialization and urbanization are putting enormous pressure on arable land.

3. Predominance of Food Grains

In both the *Kharif* (summer) and the *rabi* (winter) seasons, grain crops occupy the greater proportion of the cropped area. In fact, rice, maize, millets, *bajra, ragi*, and pulses are the dominant crops in the *kharif* season, and wheat, gram and barley occupy over three-fourth of the total cropped area in the *rabi* season.

4. Mixed Cropping

In the rain-fed areas of the country, mixed cropping is a common practice. The farmers mix millets, maize and pulses in the *kharif* season and wheat, gram and barley in the *rabi* season. In the areas of *Jhuming* (shifting cultivation), ten to sixteen crops are mixed and sown in the same field. The rationale behind mixing of crops is to get good agricultural return. In case the monsoon is good, the rice crop will give better production and in case of failure of monsoon, the less water requiring crops like maize, millets, bajra and pulses will give good harvest. Mixed cropping is a characteristic of subsistent agriculture.

5. High Percentage of the Reporting Area under Cultivation

In India, about 55 per cent of the total reporting area is under cultivation of crops and pastures. This is much higher when compared with about 4 per cent in Canada, 12 per cent in China, 15 per cent in Japan, and 16 per cent in USA.

6. Small Size of Holdings and Fragmentation of Fields

Over 70 per cent of the holdings are either small or marginal, i.e. less than one hectare. The small size of holdings is mainly due to the law of inheritance and other sociocultural and economic factors. Moreover, the fields are scattered and fragmented. The small size of holdings and fragmented fields are unsuitable for the modern methods of agriculture.

Table 9.3 *Size of Holdings*

Category	*Area (hectares)*	*Percentage of holdings*	*No. of operation holdings (in millions)*	*Percentage of area*	*Measure in hectares*
Marginal	Below one	50.6	30	9.0	15
Small	1–2	20.0	14	11.9	19
Semi-medium	2–4	15.2	—	18.5	—
Medium	4–10	11.3	—	20.7	—
Large	Above 10	04.0	—	30.9	—

Source: ***Statistical Abstracts of India*** 2005–06.

It may be seen from **Table 9.3** that about 51 per cent holdings of the country are marginal farmers having less than one hectare of land. About 20 per cent are in the small category, and 11 per cent in the medium category, while only 4 per cent are the large category farmers, having more than 10 hectares.

7. Limited Intensive Agriculture

In India, only about one-third of the total cropped area is under double and multiple cropping. Increase in the double cropped area is difficult unless heavy investment is made in development of canal and tube-well irrigation.

8. Primitive Technology

Most of the farmers of the country, especially in the rain-fed areas, use draught animals (bullocks, male buffaloes and camels) for ploughing and other agricultural operations. The health and efficiency of draught animals is low which often retards the timely operations of sowing, weeding, and harvesting.

9. Indian Agriculture is Labour Intensive

In India, agriculture is a labour based enterprise in which most of the agricultural operations, like ploughing, levelling, sowing, weeding, spraying, sprinkling, harvesting, and threshing are carried on mainly by human hands. The use of machinery is still confined only to the rich farmers of Punjab, Haryana, western Uttar Pradesh, plains of Uttarakhand, Bihar, Madhya Pradesh, Gujarat, and Maharashtra.

10. Rain-fed Agriculture

In the greater parts (over 55%) of the country, agriculture is largely dependent on rainfall, especially the summer monsoon. Unfortunately, the behaviour of summer monsoon is highly erratic. Consequently, the variability of rainfall is high which affects the agricultural return adversely. Only about 55 per cent of the total cropped area is under irrigation in which the farmers are more confident about their agricultural returns even at the failure of monsoon, as it happened in 2009.

11. Less Area under Leguminous and Fodder Crops

The nitrogen fixing crops like pulses are getting less area under their cultivation. Consequently, the natural fertility of the soil is depleting and the soils are losing their resilience characteristics. Moreover, less than 4 per cent of the cropped area is under fodder crops. This, together with lack of good pastures, has detrimental effect over the development of dairy farming and milk-production. India has the largest number of cattle in the world, but it occupies an insignificant place in respect of cattle products in the world.

12. Tradition Bound

By and large, the Indian agriculture is tradition bound. Established several centuries ago, the structures of a self-contained rural economy were founded in caste-derived occupational land tenures, made complex by absentee and parasitic landlords. These institutional factors and tradition bound institutions are a major obstacles in the path of innovations and modernisation of agriculture.

13. Low Productivity

One of the main problems of Indian agriculture is its low productivity. In comparison to the other agricultural countries, the Indian agricultural yields are among the lowest in the world (**Table 9.4 and Table 9.5**). The main cause of low yield per hectare is the low fertility of soil and less care to replenish it through green-manure, fertilisers, fallowing, and scientific rotation of crops. The consumption pattern of chemical fertilizers has been shown in **Fig. 9.4**. It may be seen from this figure that Punjab with 175 Kg/ha is the leading consumer of chemical fertilisers followed by Haryana 160 Kg/ha. Uttar Pradesh, Andhra Pradesh, Tamil-Nadu and West-Bengal. In general the fertiliser consumption level is very low in the areas of dry farming.

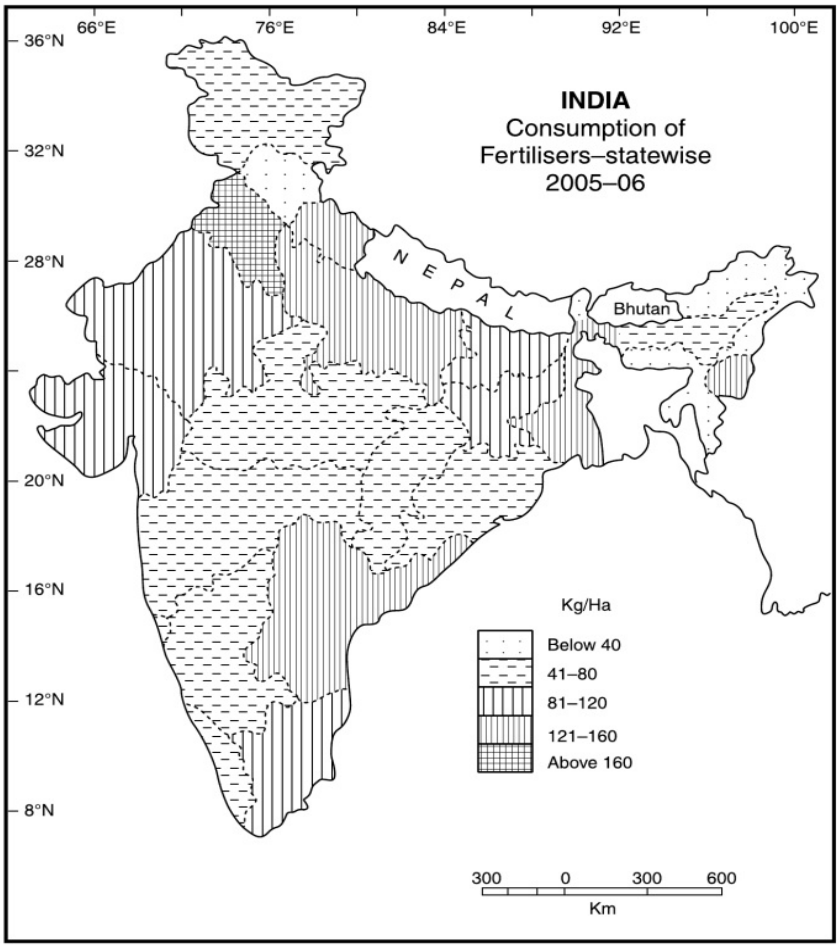


Fig. 9.4 Consumption of Fertilisers (2005–06)

Table 9.4 *International Comparisons of Yield of Rice, 2005–06, (in metric tonnes/hectare)*

Rice/Paddy (in metric tonnes/hectare)	*Yield*	*Rank*
Egypt	9.8	1st
USA	7.3	2nd
Korea	6.73	3rd
Japan	6.42	4th
India	2.9	5th
Thailand	2.63	6th
World	3.96	

Source: ***Economic Survey*** 2006–07, p.160

Table 9.5 *International Comparison of Yield of Wheat, 2004–05, (in metric tonnes/hectare)*

Country	*Yield*	*Rank*
UK	7.7	1st
France	7.58	2nd
China	4.25	3rd
India	2.71	4th
Pakistan	2.37	5th
Iran	2.06	6th
Australia	1.64	7th
World	2.87	

Source: ***Economic Survey 2006–07***, p.160

14. Government Policy

After the First Five-Year Plan, Indian agriculture got a step-motherly treatment. The farming community has been ignored, while there has been more emphasis on industrialisation and urbanisation. The growth rate of agriculture is only about 2.5 per cent, while the overall growth rate of the country is about 9 per cent (2010). The farmers are not getting remunerative prices, most of them are under debts and in several parts of the country, farmers are committing suicides. This dismal picture is the result of continuous careless agricultural land use planning. Much emphasis has however, been laid on the rural and agricultural development in the Eleventh Five-Year Plan to remove the rural, urban inequality. Creation of 580 lakh jobs has also been proposed in this plan to overcome the problem of unemployment and to check the rural-urban migration. The real challenge for the government is in trying to boost food output at home, and increase investment in rural and agricultural infrastructure for the same, while at the same time not letting its guard down on fiscal prudence or inflation management. The severe drought of 2009 over greater part of the country has increased the miseries of the farmers, which is a set-back in the revival of Indian economy.

15. Lack of Definite Agricultural Land Use Policy

In the absence of a definite land use policy, the farmers grow crops according to their convenience. This sometimes leads to excess of production and sometimes scarcity. Many a times the farmers have to burn their sugarcane crop and often get less remunerative price of vegetables (onion, potato and other vegetables).

16. Lack of Marketing and Storage Facilities

Lack of marketing and storage facilities and the role of brokers deprive the farmers to fetch remunerative prices for their agricultural products. Except a few states like Punjab, Haryana, Maharashtra, Gujarat, and Andhra Pradesh, marketing and storage facilities are inadequate. In greater part of the country, farmers are still at the mercy of unscrupulous traders and are easily exploited by secret brokerage, false weights and payment of inflated commissions. Moreover, due to lack of proper pricing policy, farmers fail to obtain fair price for their agricultural products.

17. Low Status of Agriculture in the Society

In greater parts of India, agriculture is not considered as a dignified and honourable profession. This leads to disappointment and lack of enthusiasm among most of the farmers. The younger generation of farmers prefer a petty government job to agriculture. Moreover, rich farmers invest their agricultural profits in non-agricultural sectors which are more remunerative. In fact, there is a mass exodus of people from rural to urban areas in search of lucrative jobs. There is a constant flow of human and material resources from villages to the cities. This has led to fast growth of urban centres which are infested with slums, ghettoes, and shanty colonies.

18. Land Tenancy

In many parts of the country, there are absentee land lords and the tillers are not having the rights on agricultural land. The big landlords who own big farm houses are rich urbanites. The tillers and share croppers who actually cultivate the land of absentee land lords are not much interested in the development, proper management, utilisation of agricultural land, and modernisation of agriculture. This system leads to lack of interest on the part of the tiller and consequently, the per unit yield of most of the crops is low.

19. Poverty and Indebtedness of the Farmers

Although cultivators indebtedness is universal in subsistent farming, its impact is perhaps nowhere as crushing as in India. Unfortunately, over 85 per cent of all the cultivating families are under debt. It is because of heavy indebtedness that several thousand farmers in Andhra Pradesh, Karnataka, Tamil Nadu, Maharashtra, Odisha, Gujarat, Punjab, and Uttar Pradesh have committed suicide during the last ten years. The small and marginal farmers are still dependent on money-lenders who charge exorbitant interest on loans (25 to 40 per cent per annum). In the case of non-payment, the money-lenders grab their mortgage property making them pauper. Some special provisions have been made in the draft of the Eleventh Five Year Plan to overcome the problem of farmers indebtedness. A scheme of debt waiving for small and marginal farmers and debt relief for other farmers was announced by the government in the Union Budget of 2008–09.

20. Inadequacy of Extension Service

For the diffusion of agricultural innovations both in the irrigated and rain-fed areas, a team of skilled village level workers is required. There is much to be done in this area. Training of workers and their dedication can help the tradition bound farmers to modernise their agriculture.

21. Inadequate Agricultural Research and Education, Training, and Extension

Though enough progress has been made in the field of agricultural research, there is no co-ordination between the farm and research laboratories in the different agro-climatic regions of the country. Hence, gains of new agricultural researches are not reaching the common cultivators, especially the marginal and small farmers. Very little attention is being paid for educating and training farmers for the adoption of new agricultural innovations and techniques to increase their agricultural production.

22. Soil Erosion and Soil Degradation

Soil erosion is a universal phenomenon. It is, however, significantly high in the areas of heavy rainfall with undulating topography and in the areas of scanty rainfall (deserts and semi-desert areas). The indiscriminate felling of trees, cattle grazing, unscientific land use practices have greatly accelerated the rate of soil erosion in the different parts of the country. Although soil conservation programmes were initiated in 1953, their impact has not been very encouraging. The people's awareness and their active participation in the soil conservation is essentially required.

23. Other Characteristics and Problems

There are numerous other problems also which are affecting the agricultural production and rural economy and society adversely. For example, unscientific methods of agriculture, inadequate irrigation facilities, less use of chemical fertilisers, insecticides, pesticides, less remunerative prices of agricultural products, poverty, hunger, and malnutrition of farmers and lack of infrastructural facilities like roads, water, irrigation, electricity, credit, banking, and crop-insurance.

DETERMINANTS OF AGRICULTURE

The agricultural practices, cropping patterns and their productivity are closely determined by the geo-climatic, socioeconomic, and cultural-political factors. In fact, the agriculture of any region is influenced by the following factors:

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

These factors individually and collectively have their impact on the cropping patterns, level of agricultural development and yield of crops in a region. A brief account of these factors has been given below.

Physical Factors

(a) Terrain, Topography, and Altitude

The agricultural patterns are strictly dependent on the geo-ecological conditions; terrain, topography, slope and altitude. While paddy cultivation requires leveled fields, tea plantations perform well in the undulating topography in which water does not remain standing. Orchards of coconut are found at low altitudes, preferably closer to the sea level, while the apple orchards in the tropical and sub-tropical conditions perform well above 1500 metres above sea level. Moreover, cultivation of crops is rarely done 3500 m above sea-level in the tropical and sub-tropical latitudes. The highly rarified air, low-pressure, low temperature, and shortage of oxygen at high altitudes are the serious impediments not only in the cultivation of crops, but also in keeping dairy cattle. The soils of high mountainous tracts are generally immature which are also less conducive for agriculture. The topographical features also affect the distribution of rainfall. Normally, the windward side gets more rainfall than the leeward side. The amount of rainfall received in a region determines the selection of crops to be sown.

Apart from altitude and aspects of slope, the nature of the surface also affects the agricultural activities. The gullied land is least conducive for cropping. The Chambal ravines in Madhya Pradesh, Rajasthan, and Uttar Pradesh have put over thousands of hectares of good arable land out of agriculture.

(b) Climate

Of all the physical factors, climate is one of the most significant determinant of agricultural land use and cropping patterns.

(i) Temperature The crops to be grown, their patterns and combinations are closely controlled by the prevailing temperature and precipitation conditions. The agricultural scientists have proved that each crop has a specific zero temperature below which it can not be grown. There is also an optimal temperature in which the crop is at its greatest vigour. For each stage of crop life, i.e. germination, foliation, blossoming or fructification a specific zero and optimum can be observed in temperature.

The upper limit of temperature for plants growth is 60°C under high temperature conditions, i.e. at over 40°C, crops dry up, if the moisture supply is inadequate. In contrast to this, the chilling and freezing temperatures have a great adverse effect on the germination, growth and ripening of crops. Crops like rice, sugarcane, jute, cotton, chilli and tomatoes are killed or damaged at the occurrence of frost. The minimum temperature for wheat and barley is 5°C, maize 10°C, and rice 20°C.

The impact of temperature on cropping patterns may be seen from the fact that the northern limit of the regions in which date-palm bear ripe fruit coincides almost exactly with the mean annual temperature of 19°C. The essential factor in the limit of grape orchards seem to be temperature. Grapes ripen only in those countries in which the mean temperature from April to October exceeds 15° C. Crops like winter-wheat and barley perform well when the mean daily temperature ranges between 15°C and 25°C. Contrary to this, tropical crops like cocoa, coffee, spices, squash, rubber and tobacco require over 18° C temperature even in the coldest months, while crops like wheat, gram, peas, lentil, potato, mustard, and rapeseed require a temprature of about 20°C during the growth and development, stage and relatively higher (over 25°C) during the sowing and harvesting periods.

(ii) Moisture All crops need **moisture**. They take water and moisture from the soil. This moisture may be available from the rains or from irrigation systems. Within wide temperature limits, moisture is more important than any other climatic factor in crop production. There are optimal moisture conditions for crop development just as there are optimal temperature conditions. The excessive amount of water in the soil alters various chemical and biological processes, limiting the amount of oxygen and increasing the formation of compounds that are toxic to plant roots. The excess of water in the soil, therefore, leads to stunted growth of plants. The problem of inadequate oxygen in the soil can be solved by drainage practices in an ill-drained tract.

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

(iii) Drought **Drought** has devastating consequences on the crops, their yields and production. Soil drought has been described as a condition in which the amount of water needed for transpiration and direct evaporation exceeds the amount of water available in the soil. Drought damages the crops when plants are inadequately supplied with moisture from the soil.

The drought prone areas of India lie in the states of Rajasthan, Gujarat, Madhya Pradesh, Chhattisgarh, Jharkhand, Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu, Odisha, Bundelkhand (U.P.), Uttarakhand, H.P., J&K, south-west Punjab and Haryana. In the areas where the average annual rainfall is less than 75 cm, agriculture is considered a gamble on monsoon. In 2009, the erratic monsoon resulted into drought in more than 200 districts of the country.

The incidence of drought and its intensity can be determined from the annual, seasonal and diurnal distribution of rainfall. Moreover, different plants have different moisture requirements. In the drought prone areas of India, dry farming is practiced, while in the more rainfall recording regions, intensive agriculture of paddy crop is a common practice.

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

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

(c) Soils

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

2. Institutional Factors

The institutional factors include land tenancy, land-tenure, and ownership. These factors have their bearing on field size, field patterns, farming type, crop land use, crop associations, and productivity of crops. A brief account of the institutional factors has been given in the following:

(i) Land Tenure and Land Tenancy

The ownership of agricultural land is determined by the law of land tenure and land tenancy. In the primitive societies like those of the shifting cultivators (*Jhumias*), land belongs to the community. Subsequently, in India, the land ownership rights were vested in the king and the government. During the British period, a new system of land tenancy known as *Zamindari, Mahalwari,* and *Royatwari* was introduced to manage the agricultural land and to collect the land revenue. After independence, the Zamindari system was abolished and the rights of the tillers over cultivated land were restored.

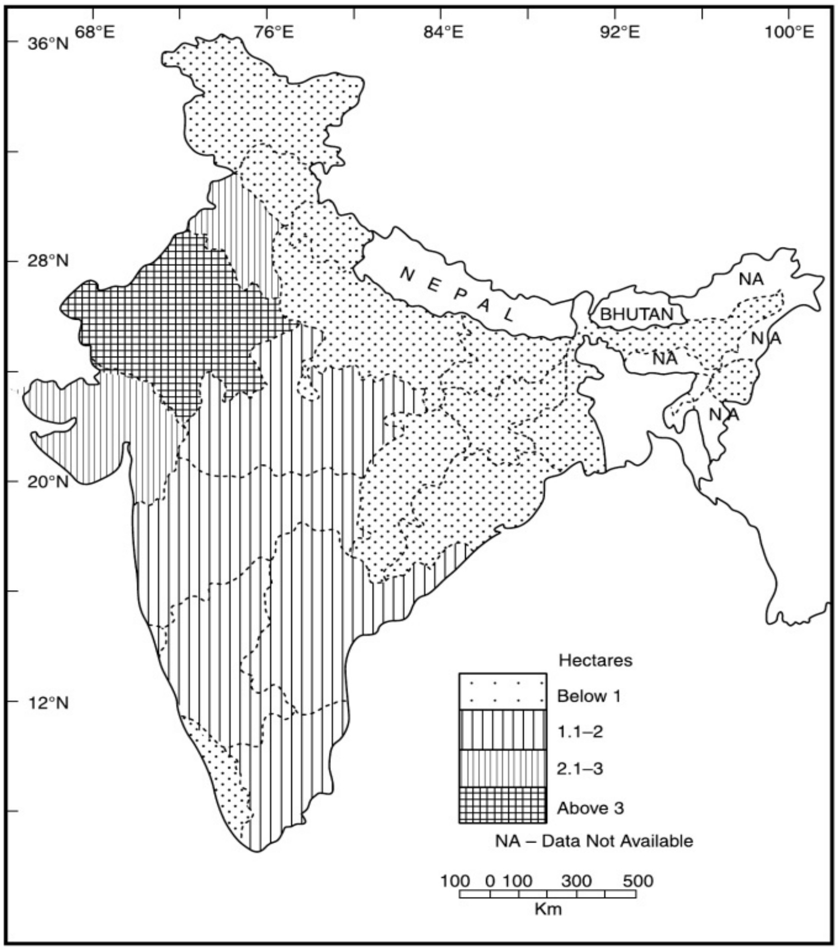


Fig. 9.5 Size of Holdings (2005–06)

After the abolition of Zamindari system, a number of land reform legislations have been passed by the central and state governments, but still there is enough scope to restore the rights of the actual tillers and landless labourers. Still, there are numerous absentee landlords, many of them possessing land more than the ceiling act permits. Only Punjab, Haryana, and Uttar Pradesh are the states in which consolidation of holdings has been completed.

(ii) Land Holding

In India the size of holding is too small. Due to the rapid growth of population during the last few decades and the existing law of inheritance, the agricultural land is divided equally among the male children of the deceased farmer. At present, the per capita available land is only about 0.10 hectare which is much below the world average of about 4.50 hectares. Over 75 per cent of the land holdings are less than one hectare. Such small holdings are not economically viable. In fact, small holdings can not produce enough to meet the costs of irrigation, improved seeds, chemical fertilisers, insecticides, pesticides and farm machinery. The average size of holdings and their percentage share in India have been given in the **Table 9.6** (**Fig. 9.5**).

Table 9.6 *The Average Size of Land Holdings in the Selected States of India, 2005*

State	*Size of holdings (hectares)*	*State*	*Size of holdings (hectares)*
Rajasthan	4.00	Himachal Pradesh	1.15
Maharashtra	2.40	Bihar	0.70
Gujarat	2.85	Assam	1.15
Madhya Pradesh	2.75	Tamil Nadu	1.00
Haryana	2.45	West Bengal	0.80
Karnataka	2.15	Uttar Pradesh	0.72
Punjab	3.45	Jammu & Kashmir	0.75
Andhra Pradesh	1.50	Kerala	0.30
Odisha	1.30	India	1.50

Source: ***Agricultural Statistics of India, 2005***.

An examination of **Table 9.6** shows that the average size holding in India is about 1.50 hectares which is too small for mechanisation and application of modern technology. The largest size of operation holdings is in Rajasthan being 4.00 hectares, followed by Punjab at 3.45 hectares, and Gujarat at 2.85 hectares. The lowest size of land holding is in Kerala, being only 0.3 hectares and Uttar Pradesh 0.72 hectares. In rest of the states, it varies between 0.8 to 2.50 hectares. On the whole, in most of the states, the size of holdings is not economically viable.

LAND REFORMS

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

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

1. Abolition of Intermediaries

During the British period, three categories of land tenure systems, namely, *Zamindari, Mahalwari,* and *Ryotwari* came into existence.

Zamindari System

Under the Zamindari system , which was introduced by Lord Cornwallis in 1793 in Bengal, land was held by one person or at the most by a few joint owners who were responsible for the payment of land revenue (*Malguzari*). Under the Zamindari system of tenure, these revenue collectors were raised to the status of land owners. The Zamindari settlements were of two types: (i) permanent with fixed land revenue in perpetuity, and (ii) temporary in which land revenue used to be assessed for a period ranging between 20 to 40 years and was subject to revision. Thus, between the state and the actual tiller, there grew an intermediary who was interested in land only to the extent of extraction of exorbitant rent. So Zamindari symbolised oppression and tyranny and agriculture was degraded to subsistence farming with low productivity.

Mahalwari System

Under the Mahalwari tenure, the village agricultural lands were jointly held by the village communities, the members of which were jointly and severally responsible for the payment of land revenue. The system was first introduced in Agra and Oudh and later in undivided Punjab. Here, the village *Lumbardar* collected revenue for which he received 5 per cent as commission.

Ryotwari System

Under the Ryotwari tenure, the individual holder was directly responsible to the state for the payment of land revenue. This form of tenure was first introduced in Madras in 1872 and later in Bombay, Berar, and Central India. The Ryot was at liberty to enjoy permanent rights over land and to sub-let it so long as he paid the land revenue to the government.

In order to stop the tyranny and exploitation by Zamindars and to restore tiller's right over the land, measures were taken for the abolition of intermediaries after independence. The Zamindari Abolition Acts were passed in different states of the country between 1948 and 1955. As a consequence, over 260,000 Zamindars were abolished.

Due to several loopholes in the Zamindari Abolition Act, the land could not be transferred to the actual tillers and the landless agricultural labourers. In certain parts of the country, the intermediaries are yet to be abolished, i.e. water rights in Bhagalpur (Bihar), Jotdari in Meghalaya, Communided in Goa, Trust Estate (Zamindari of religious institutions) in Odisha, and Devasthan Enam in Maharashtra.

2. Tenancy Reforms

During the British period, the *Zamindari, Mahalwari*, and *Ryotwari* systems, tenancy cultivation was quite common in India. The small and marginal farmers as well as the landless labourers were interested in doing cultivation in the fields of Zamindars. There were three types of tenants, namely: (i) occupancy or permanent tenants with permanent and heritable rights, (ii) tenants at will or temporary tenants, and (iii) sub-tenants or *Shikmi-kisan*. The condition of temporary and sub-tenants was adhoc and they were subject to ruthless exploitation. Frequent enhancement of rent, eviction on petty grounds and *begari* (free service) were some of the prevalent ways of exploitation. In India about 20 per cent of the agricultural land is devoted to share-cropping (*batai*), where 50 per cent of the produce is the normal rent. On several occasions, the peasant have to forego even two-thirds of the produce as rent. Under the land tenancy reforms, more than 11.5 million cultivators have been given tenancy rights. The tenancy reforms cover the following points:

(i) regulation of rent,
(ii) security of tenure, and

(iii) conferment of ownership on tenants. States have made the following provisions to achieve the third objective:
   (a) All tenants have been given full security of tenure, without giving the owners the right of personal cultivation.
   (b) Owners have been given the right to resume a limited area (not more than a family holding in any case) subject, however, to conditions that a minimum area is left with the tenant.
   (c) A limit has been placed on the extent of land with a land-owner may resume, but the tenant is not entitled to retain minimum area of cultivation in all cases.

3. Rent Control

At the time of independence the rate of rent on agricultural land was 50 per cent or more of the agricultural produce. It was too high for ordinary farmers. Hence, legislation were enacted to bring down the rate of rent to 20 to 30 per cent in Andhra Pradesh, 33 per cent in Punjab and Haryana, and 33 to 40 per cent in Tamil Nadu. Since the Fourth Five-Year Plan, the system of payment of rent in agricultural produce was fully abolished and the same was replaced by the system of cash payment.

4. Ceiling of Landholdings

Under the land reforms programme, it was envisaged that beyond a certain specified limit, all lands belonging to the landlords would be taken over by the state and allotted to small proprietors to make their holdings economic or to landless labourers to meet their demand for land. Ceiling on landholdings is, therefore, an effective measure for redistribution of land and achieving the goal of social justice. The land ceiling limits, both in the irrigated and dry lands, vary from state to state have been given in **Table 9.7:**

Table 9.7 *India—Ceiling Limits on Land Holdings in Hectares*

State	*Irrigated with two crops*	*Irrigated with one crop*	*Dryland*
As Suggested in National Guidelines of 1972	5.05–7.28	10.93	21.85
Actual Ceiling			
Andhra Pradesh	4.05–7.28	6.07–10.93	14.16–21.85
Assam	6.74	6.74	6.74
Bihar	6.07–7.28	10.12	12.14–18.21
Gujarat	4.05–7.28	6.07–10.93	8.09-21.85
Haryana	7.25	10.90	21.80
Himachal Pradesh	4.05	6.07	12.14–28.33
Jammu & Kashmir	3.6–5.06	...	21.85
Karnataka	7.28	10.93	21.85
Kerala	4.86–6.07	4.86–6.07	4.86–6.07
Madhya Pradesh	7.28	10.93	21.85
Maharashtra	7.28	10.93–14.57	21.85
Manipur	5.00	5.00	6.00
Odisha	4.05	6.07	12.14–18.21

(*Contd.*)

(*Contd.*)

Punjab	7.28	10.93	21.85–70.82
Rajasthan	4.86	12.14	24.28
Tamil Nadu	5.06	...	20.23
Sikkim	5.06	...	20.23
Tripura	4.00	4.00	12.00
Uttar Pradesh	7.30	10.95	18.25
West Bengal	5.00	...	7.00

Source: ***Agricultural Statistics at a Glance***—Ministry of Agriculture.

It may be observed from **Table 9.7** that in J&K and Kerala, only 3.6 and 4.86 hectares respectively are the ceiling limits of irrigated agricultural land, while in Uttar Pradesh and Haryana it is about 7.30 hectares. The unirrigated agricultural land ceiling limit is over 24 hectares in Rajasthan, over 20 hectares in Tamil Nadu, about 22 hectares in Jammu and Kashmir state and over 21 to about 71 hectares in Haryana and Punjab, respectively.

5. Consolidation of Holdings

Consolidation of holdings was one of the important steps towards land reforms. It was envisaged with the set objective to increase the agricultural efficiency and production of all category of farmers. Consolidation of holdings means to bring together in compact block, all the fields of land of a farmer which are well scattered in different parts of the village. Under the scheme, all land in the village is first pooled into one compact block and it is divided into smaller blocks called *chaks*, and allotted to individual farmer. This is a useful scheme which helped in overcoming the problem of fragmentation of holdings. But unfortunately, the scheme has not been implemented in all the states of the country. There are many hurdles in the implementation of consolidation of holdings in some of the states. Some points which are coming in the way of implementation of consolidation of holdings are as under.

(i) Farmers are emotionally attached to their ancestral land, and therefore, they are not willing to take advantage of the scheme of consolidation of holding.

(ii) Those farmers who own good quality of land do not like the scheme for fear of getting the inferior and poor quality of land after the consolidation.

(iii) Consolidation of holdings is a cumbersome process. The government officials who implement the scheme are generally slow and often corrupt.

(iv) In general, the scheme did not receive the desired support and co-operation from the farmers.

(v) The scheme has paved way for litigation and court cases, many of which are pending in different courts for a long time. This vitiates the serene atmosphere of the rural areas.

(vi) Under the existing law of inheritance, the fields continue to be smaller and fragmented.

(vii) In every consolidation, about 5 to 10 per cent of the village land is taken out for providing house sites to the weaker sections of society, approach roads (*chak-roads*) and village utility services. Hence, if the process is repeated three or four times, a sizable portion of the agricultural land would go out of agriculture.

(viii) The cost of consolidation is realised from the farmers which has adverse effect on their resources and economy.

(ix) It has been observed that the small farmers are generally allotted inferior quality of land, and due to lack of money power, they are neither able to please the officials nor get justice in the court.

Looking at these drawbacks, efforts should be made to remove these barriers and pitfalls in the scheme of consolidation of holdings to modernise the system of keeping revenue records. In the Seventh Five-Year Plan emphasis was laid on (i) scientific survey of the un-surveyed land, (ii) registering the name of tenant and share cropper in land records, (iii) strengthening the revenue system at the lowest level, and (iv) providing training facility to revenue officials to improve their efficiency. During the Eighth Five-Year Plan, it was decided to use computer and new techniques for keeping and maintaining and updating revenue records, proper recording of land rights, tenancy and causes of rural unrest and restriction on the sale and purchase of agricultural land for non-agricultural purposes. Land reforms also include computerisation of records of rights with maps, and land passbook.

Thus, a number of legislations have been enacted in the country for land reforms after independence, but due to socioeconomic and cultural complexities, loopholes in the land reform laws, laxity in implementation, and political and legal interference, these land reforms have not been able to achieve the desired success.

6. Computerised Land Records

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

INFRASTRUCTURE AND AGRICULTURAL INPUTS

Provision of quality and efficient infrastructure is essential to realise the full potential of agriculture. In other words, infrastructural development is imperative for the agricultural development of a country/region. Infrastructure includes the facilities of irrigation, availability of electricity, roads, marketing credit facilities and crop insurance.

Irrigation

The process of supplying water to crops by artificial means such as canals, tube wells, tanks, etc. is known as irrigation. In greater part of India, agriculture is rain-fed. In the incidence of failure of monsoon, the crop fails. The behaviour of Indian monsoon is highly erratic. Excess rainfall may cause floods, but scanty rainfall may reduce the crop yield substantially, and in acute cases the crop may be a complete failure. This problem may be solved by increasing the irrigated area in the country. Irrigation helps in bringing the new area under cultivation on the one hand, and increases the double and multiple cropping on the other. Moreover, the per hectare yield of the irrigated area is much higher to that of the unirrigated areas. About 84 per cent of the water resources of India is used for irrigation. The irrigation potential of India is about 102 million hectares of the total potential created, however, only about 87 million hectares is actually utilized (India 2010, pp.998–1002).

Sources of Irrigation

Depending on the availability of surface and underground water, slope of the land, nature of the soil and the types of crops grown in a region, a number of sources of irrigation are utilised. The main sources of irrigation used in different parts of the country are: (i) canals, (ii) wells and tube-wells, (iii) tanks, and (iv) other sources (springs, *kuhls*, *swing-basket, dhenkli*, *dongs*, and *bokka*, etc.). The areas irrigated by the different sources have been plotted in **Fig. 9.6** while **Table 9.8** gives the temporal changes in the irrigated area under different sources.

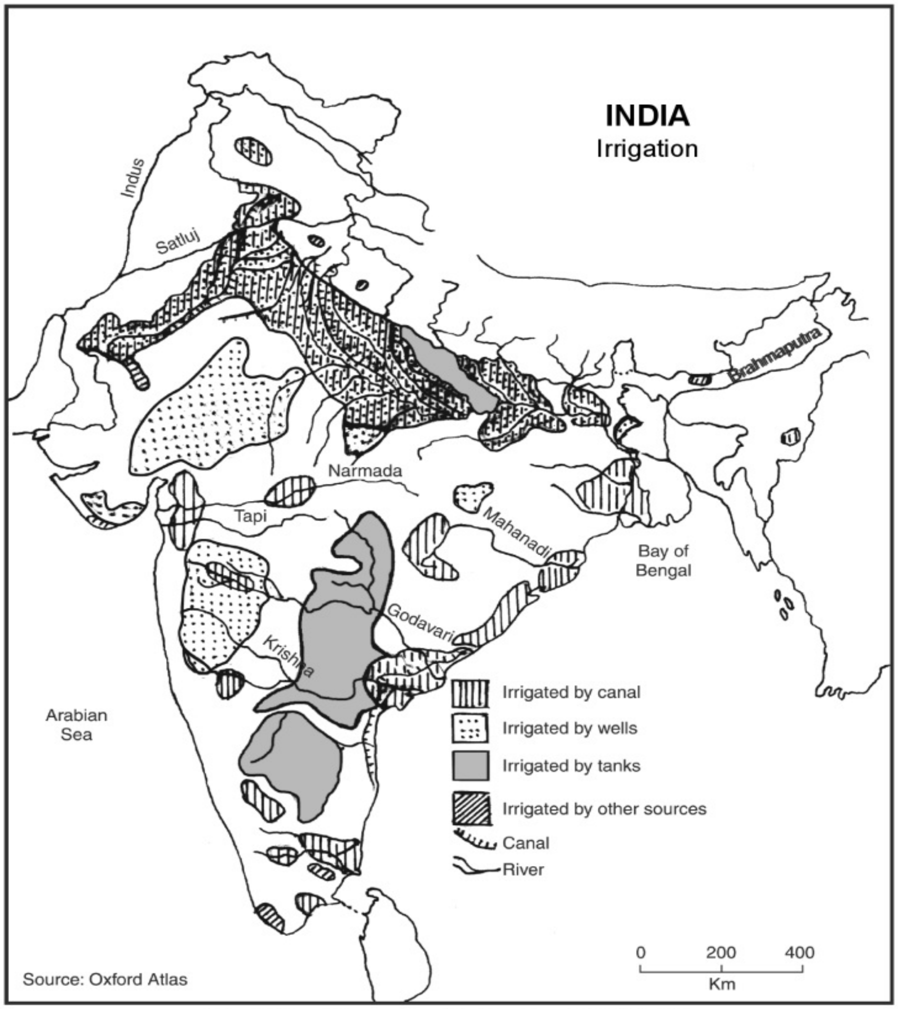


Fig. 9.6 Sources of Irrigation (2005–06)

Table 9.8 *Area and Sources of Irrigation (area in thousand hectares)*

Year	*Canals*	*Wells, including tube-wells*	*Tanks*	*Other sources*	*Total*
1950–51	8295	5980	3610	970	18,855
	(44.0%)	(31.7%)	(19.1%)	(5.20%)	(32.0 %)
1990–91	16,560	34,580	2575	3050	56,765
	(29.17%)	(60.91%)	(4.53%)	(5.37%)	(55.7%)
2000–01	15,790	33,275	2525	2900	54,490
	(28.98%)	(61.07%)	(4.63%)	(5.32%)	(100.00%)

Source: ***Statistical Abstracts of India, 2005–06***.

It may be seen from **Table 9.8** that only 18,855 thousand hectares of the cropped area was under irrigation in 1950–51 which increased to 54,490 thousand hectares in 2000–01, an increase of almost three times. While the canal area has been doubled over the given period, the area under wells and tube-well irrigation has increased by more than ten times. Despite these achievements, a lot of area of the agricultural land of the country is un-irrigated and needs a controlled and assured supply of moisture to the crops through irrigation.

The statewise net sown area under irrigation has been plotted in **Fig. 9.7**. An examination of **Fig. 9.7** shows that Punjab and Haryana have the highest percentage of irrigated area (over 85 per cent) followed by Uttar Pradesh and Tamil Nadu—between 50 to 75 per cent. In the remaining states the irrigated area is below 50 per cent (**Fig. 9.7**).

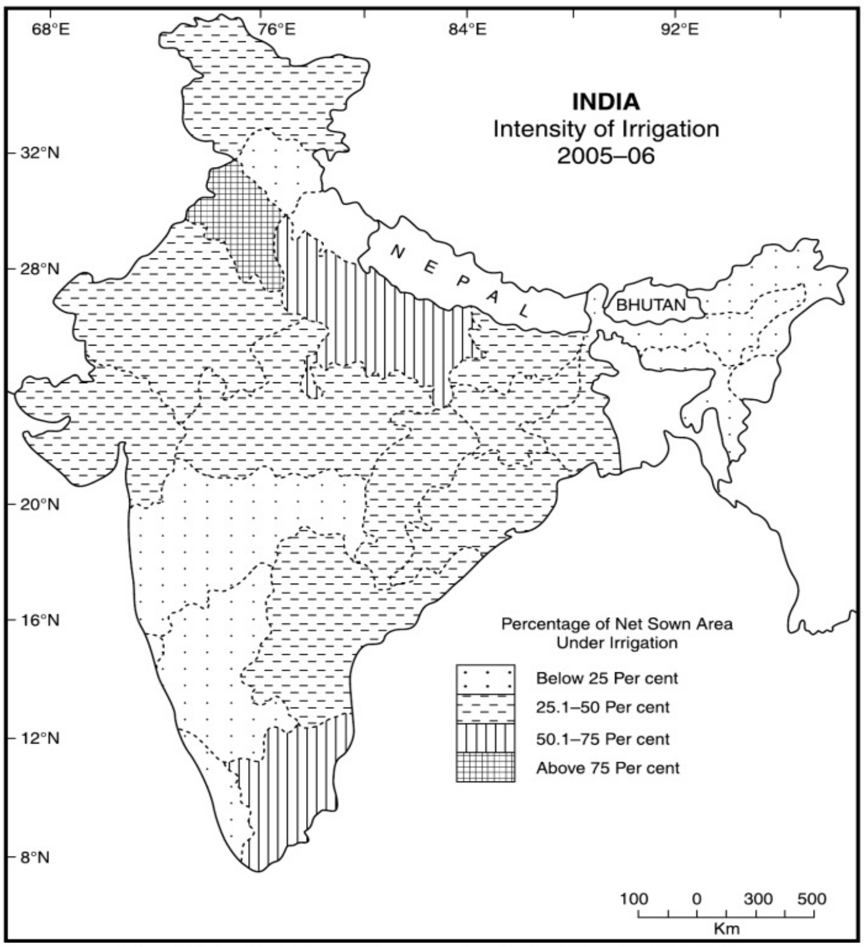


Fig. 9.7 Net Sown Area under Irrigation (2005–06)

Canal Irrigation Canals used to be the main source of irrigation in 1950–51, irrigating almost 50 per cent of the total irrigated area, but in the Third and Fourth Five-Year Plans, there was a tremendous increase in the tube-well irrigated area. Consequently, the percentage of canal irrigated area declined to less than 29 per cent and in 2000–01, wells and tube-wells emerged as the major source of irrigation, covering over 61 per cent of the irrigated area.

Canals are an effective source of irrigation in the areas of low and leveled relief, productive plain areas where perennial source of surface drainage is available. These conditions are ideally found in the Northern Plains of India, Kashmir and Manipur Valleys and the Eastern Coastal Plains of India. The main concentration of canals in India is found in Uttar Pradesh, Punjab, Haryana, and western Rajasthan. After the construction of multi-purpose projects, a number of small canals have been dug in the Damodar, Mahanadi, Godavari, Krishna, Kaveri, Narmada, Tapi rivers, and their tributaries. Some of the important irrigation projects have been shown in **Fig. 9.9**.

Table 9.9 *Net Area under Canal Irrigation—(2000–01)*

S. No.	*State*	*Net area under canal irrigation ('000 hectares)*	*Percentage of canal irrigated area to net irrigated area of the state/country*	*Percentage of canal irrigated area in the state to total irrigated area of India*
1	Uttar Pradesh	3090	25.42	21.33
2	Andhra Pradesh	1650	36.42	10.83
3	Haryana	1475	49.89	9.68
4	Rajasthan	1355	27.59	8.90
5	Bihar	1135	31.34	7.45
6	Maharashtra	1050	35.38	6.89
7	Karnataka	975	36.55	6.40
8	Odisha	875	24.38	5.74
9	Tamil Nadu	830	28.81	5.44
10	Madhya Pradesh	825	19.49	5.41
11	Chhattisgarh	800	68.90	4.25
12	Punjab	675	18.76	4.43
13	Gujarat	495	16.52	3.25
	India	15,230	29.24	100.00

Source: ***Statistical Abstracts of India-2003.***

It may be seen from **Table 9.9** that in India, about a little over 29 per cent of the total irrigated area was under canal irrigation. Uttar Pradesh with 3090 thousand hectares under canals has the first rank in canal irrigation, followed by Andhra Pradesh with 1650 thousand hectares and Haryana with 1475 thousand hectares. The states of Rajasthan and Bihar rank fourth and fifth in canal irrigated area. The rank of Punjab was however, 12^{th} in canal irrigation, followed by Gujarat (**Table 9.9**).

The existing irrigated area and the sources of irrigation are not adequate to meet the growing demand. There are a number of problems Indian agriculture is facing. There is a gap between the developed and utilised irrigation potential. Moreover, in the case of big irrigation projects like canals, there are interstate disputes. There is wastage of water, water-logging in canal command areas and other ecological problems. Hence, there is a need for a judicious and scientific development of irrigation, full utilisation of its potential and rational pricing of irrigation water.

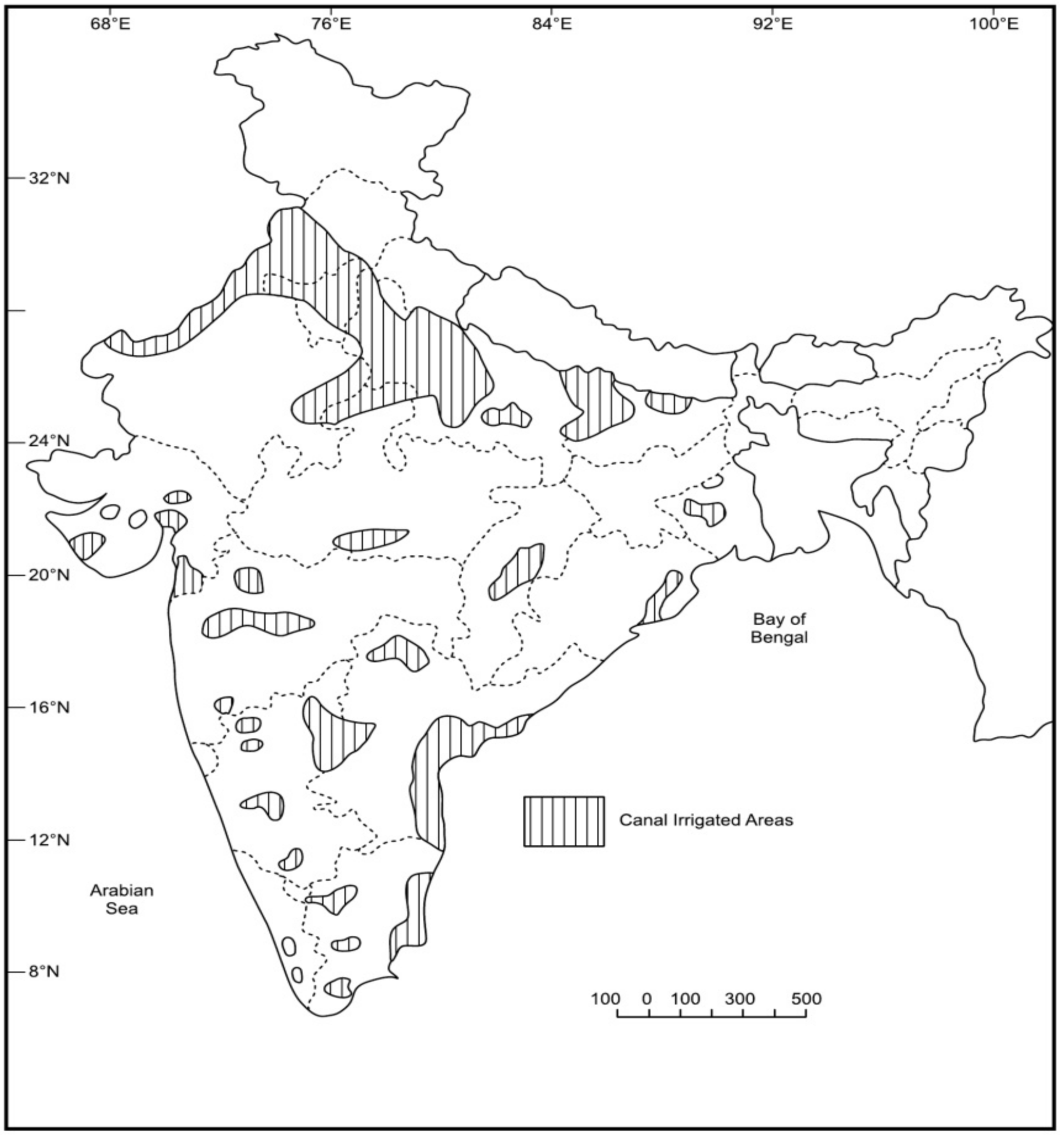


Fig. 9.8 Canal Irrigation (2005–06)

Wells and Tube-Wells This type of irrigation has been practised in India since the time immemorial. The widely used methods for the utilization of underground water are persian-wheel *Rahat*, *Charas*, or *mot* and tube-wells. Out of these, tube-well irrigation is more popular in the Satluj-Ganga plains. Tube-well irrigation accounts for more than 61% of the total irrigated area of the country.

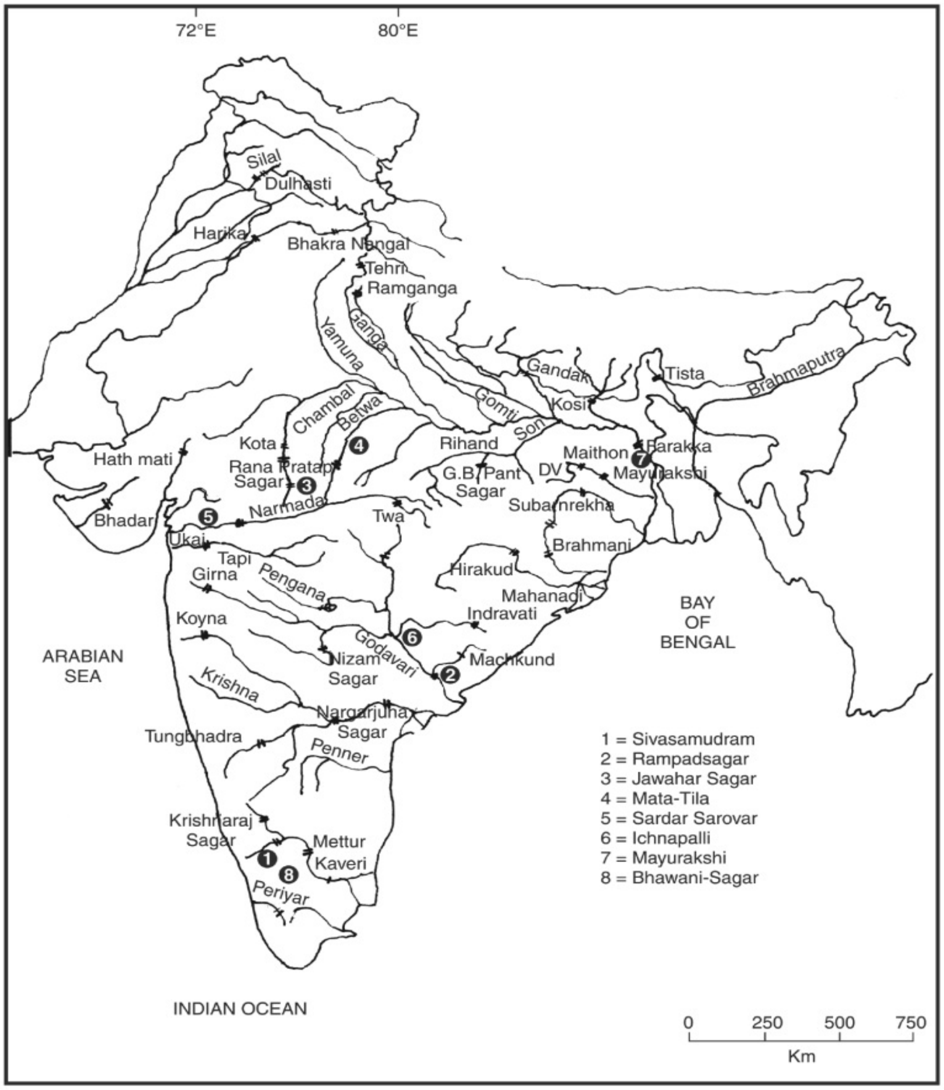


Fig. 9.9 Major Irrigation Projects

Tube-well irrigation is the easiest source of irrigation. It can be installed in a short duration of time. It is however, expensive and diminishes the underground watertable, especially in the years of drought like 2009. The most important problem of tube well irrigation is the high energy costs for pumping groundwater because of farmers dependence on diesel and electricity. The prices of these energy resources have increased rapidly. The largest area under tube-well irrigation is in Uttar Pradesh followed by Rajasthan, Punjab, Madhya Pradesh, Gujarat, Bihar, Andhra Pradesh and Haryana.

Tank Irrigation In some parts of the country, especially in the peninsular India tank is an important source of irrigation. About 4% of the total irrigated area is under tank irrigation. Andhra Pradesh (32%) has the largest area under tanks followed by Tamil Nadu (28%), West Bengal (14%), Karnataka (9.3%), U.P. (7%), M.P. (6.5%), Odisha and Maharashtra. Many of the tanks however, dry up during the summer season when more irrigation is required. It is an expensive and time-consuming technique which can command only small area.

Power Availability of electric power is also an important determinant of cropping patterns and agricultural productivity. In general higher the supply of electricity for irrigation, higher is the yield of crops.

Roads A well knit and co-ordinated network of metalled roads play a significant role in the agricultural development of a region. In India, the road density is the highest in Punjab, Haryana and Kerala these states have higher yields of cereals to that of the national average.

Credit The cultivator needs credit for a variety of purposes and for different periods. Firstly, he needs short-term credit (up to 15 months) for the purchase of requirements of current production. (seeds, fertilisers, insecticides, pesticides, electricity, diesel, cattle-feed, repair of farm implements, wages to hired labourers, etc.) and to meet the consumption needs of his family till the harvest of the crop. Secondly, he requires medium-term finance (up to 5 years) for such purposes as buying cattle and implements, undertaking digging of wells or other minor irrigation works, and effecting substantial improvement to land. Finally, he requires long term finance (for over 5 years) for such purposes as purchase of land, substantial investment in tube-wells, farm machinery and orchards, and the repay of old loans.

In the absence of this facility, the cultivators mostly used to borrow from the private money lenders, traders, commission agents and relatives. The All India Credit Survey 1951–52 showed that of the total rural credit secured by the cultivators, money lenders accounted for almost 70 per cent, relatives 14.2 per cent, traders and commission agents 5.5 per cent, co-operatives 3.1 per cent, government agencies 3.3 per cent, and others 4.2 per cent. This led to a lot of exploitation of the cultivators by money lenders charging exorbitant interest, illegally and fraudulently grabbing the property of the borrower and forcing him to act as bonded labour. At present, farmers are getting agricultural credit facilities through co-operatives, commercial banks and regional rural banks.

The National Bank for Agricultural and Rural Development (NABARD) founded on 2nd July, 1982 took over the functions of the erstwhile Agriculture Credit Development, Rural Planning, and Credit Cell of the Reserve bank of India and Agriculture Refinance and Development Corporations. The NABARD was established for providing credit for promotion of agriculture, small scale industries, handicrafts and other economic activities in rural areas. It has been emphasised that the largest proportion of the agricultural credit should go to marginal and small farmers.

Research and Extension Development of new seeds and extension service also enhance significantly aggricultural productivity. According to agronomists the HYVs become outdated after every three years. The old seeds need to be replaced by new varieties, for which research and extension services are required.

Crop Insurance

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

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

The sum insured is 100 per cent of the crop loan or a maximum of Rs.10,000 per farmer. The insurance premium is 2 per cent of the sum insured for rice, wheat, and millets and 1 per cent for pulses, and oil seeds which is deducted at the time of disbursement of the loan. Small and marginal farmers pay only 50 per cent of the insurance premium, the balance is paid as subsidy by the Centre and the States. The crop insurance policy has however, not paid much dividends to the marginal, small, and medium farmers.

Technological Factors Moderisation of agriculture requires appropriate machiney for ensuring timely field operations, effective application of agricultural inputs and reducing drudgery in agriculture. Traditionally, farmers in Inia have been using manual and animal operated farm equipment but due to increased cropping intensity, this power is no longer adequate to ensure timeliness. The research institutions and industries together have helped the farmers in development suitable farm machinery to mechanised field operations. The farm mechanisation increases cropping intensity, timely operations increases crop productivity and profitability. Technological factors include HYVs, chemical fertilisers, insecticides and pesticides tractors and other agricultural machinery. The use and availability of these inputs also enhance the agricultural productivity of a region.

Green Revolution in India

Green Revolution is a term coined to describe the emergence and diffusion of new seeds of cereals. Norman-e-Burlaug is the Father of Green Revolution in the world, while Dr. M.S. Swaminathan is known as the Father of Green Revolution in India.The new cereals were the product of research work and concentrated plant breeding with the objective of creating High Yielding Varieties (HYVs) of use to the developing countries. New varieties of wheat were first bred in Mexico in the 1950s and that of rice, like IR-8 (miracle rice) at the International Rice Research Institute, Manila, (Philippines in the 1960s). The increase in the yield from the new seeds has been spectacular as during the last forty years, agricultural production, particularly of wheat and rice, has experienced a great spurt and this has been designated as the Green Revolution.

The Green Revolution has been used to mean two different things. Some experts of agriculture use it for referring to a broad transformation of agricultural sector in the developing countries to reduce food shortages. Others use it when referring to the specific plant improvements, notably the development of HYVs. Whatsoever the meaning of Green Revolution may be taken as, the adoption and diffusion of new seeds of wheat and rice has been considered as a significant achievement as it offered great optimism. In fact, these varieties of seeds have revolutionised the agricultural landscape of the developing countries and the problem of food shortage has been reduced.

In India, hybridisation of selected crops, i.e. maize, *bajra* (bulrush millets), and millets began in 1960. The Mexican dwarf varieties of wheat were tried out on a selected scale in 1963–64. Exotic varieties of rice such as Taichung Native I were introduced in India in 1964. The diffusion of HYVs, however, became fully operational in the country in the *Kharif* season of 1965–66. The diffusion of the new seeds was mainly in the Satluj-Ganga Plains and the Kaveri Delta. Subsequently, a number of varieties of wheat and rice were developed by the Indian scientists and adopted by the Indian farmers.

Merits of the High Yielding Varieties

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

1. Shorter Life Cycle

The High Yielding Varieties have shorter life cycle, thereby enabling the farmers to go for multiple cropping. For example, the new seeds of rice and wheat complete their life cycles in about 100 and 110 days respectively. Contrary to this, the traditional varieties of rice and wheat take about 130 to 150 days respectively to harvest. The new seeds thus enable the farmers to economise on land.

2. Economise on Irrigation Water

The High Yielding Varieties need a lot of water for better returns. The yield of these varieties per unit area is significantly high. If it is considered in terms of water required per quintal of wheat and rice, the new seeds require less water as compared to traditional varieties. Thus, the new seeds economise on water also as the crop remains in the field for a shorter period of time.

3. Generate more Employment

The High Yielding Varieties under optimal conditions require more labour per unit area and thus, help in generating more employment. Prior to the introduction of the new seeds, the farmers over greater parts of the country, especially in the Northern Plains of India, were largely dependent for their agricultural operations on the arrival of monsoon. In fact, they used to remain unemployed during the summer months (April to mid-June), i.e. after the harvest of the *rabi* crops (wheat, gram, etc.). But now, the farmers and the dependent labourers get work in various agricultural operations throughout the year.

4. The High Yielding Varieties are Scale Neutral

One of the main advantages of the High Yielding Varieties is that they benefit all category of farmers in the same proportion. In other words, the new seeds are not biased towards the big and the small farmers.

5. Easy to Adopt

The adoption of High Yielding Varieties does not require any special skill for adoption. The farmers of different socioeconomic and cultural backgrounds can adopt the new seeds without any difficulty. Only a minor adjustment in the dates of sowing of wheat is required as the new seeds require relatively cool temperature at the time of sowing. Being short duration, the wheat crop is to be sown late in the month of November and December instead of October.

When the new seeds were diffused in the mid-sixties, it was expected that the problems of food shortage, unemployment, poverty, hunger, malnutrition, undernourishment, and regional inequalities will be largely solved. But these objectives could not be fully achieved. The geographical conditions required for the successful cultivation of High Yielding Varieties have been given in brief in the following section:

Geographical Constraints in the Adoption of New Seeds

The new seeds are undoubtedly land substituting, water economising, more labour using, and employment generating innovations. Nevertheless, they are very delicate and therefore, require a great deal of care for obtaining a successful harvest. For example, the new seeds are less resistant to droughts and floods and need an efficient management of water, chemical fertilisers, insecticides and pesticides. Any lapse on the part of the farmer in the application of these inputs may reduce the production substantially. In order to obtain a satisfactory agricultural return, the farmer should be in a position to arrange the costly inputs on time for which sufficient surplus capital should be available. The conditions required for the good harvest of new seeds have been described below:

1. Irrigation

Irrigation is the most important input required for the successful cultivation of new seeds. The new seeds need copious irrigation. Adoption of High Yielding Varieties and intensification of agriculture in a country like India without the availability of irrigation is not possible. The new seeds need controlled irrigation, i.e. they need irrigation at the specific periods of growth, development and flowering in the prescribed quantity. Over irrigation and under-irrigation, both are injurious to the crop. Thus, the timings of irrigation and the quantity of water supplied are decisive for the satisfactory performance of the crop. In the case of wheat for example, appropriate timing and spacing of irrigation raise the yield as much as 50 per cent even if other inputs (fertilisers, etc.) are not applied. The first irrigation of wheat around the third week of sowing alone raises the yield as much as 30 per cent. Moreover, the associated inputs like chemical fertilisers, insecticides and pesticides also perform satisfactorily only if timely irrigation is provided to the crop. Without irrigation, a surfeit of other inputs would be to no avail. In the absence of controlled irrigation, the farmer may not get even a reasonable return from their fields.

2. Availability of Chemical Fertilisers

The natural fertility of the soil decreases with the passage of time. In a region like the Great Plains of India, in which agriculture is being carried out for the last five thousand years, the soils are generally depleted and are increasingly losing their resilient characteristics. For the recuperation of fertility, the soils need to be rested in the form of fallowing or they have to be enriched by applying manures (cowdung, compost, and green) and chemical fertilisers.

The High Yielding Varieties give rise to short stemmed, stiff-straw plants that respond well to heavy doses of fertilisers. These dwarf varieties are known as the hungry varieties which need more energy in the form of chemical fertilisers. Contrary to this, the traditional varieties, if given heavy doses of fertilisers, get lodged at the occurrence of rains. The lodging of the crop reduces the yield per unit area.

In the areas of controlled irrigation, the recommended dose of chemical fertiliser for the new seeds of wheat and rice in terms of NPK is 90-45-45 kg. per hectare. Some of the well off farmers of Punjab, Haryana, and western Uttar Pradesh are applying the chemical fertilisers to the crop in the prescribed quantity. The all India average fertilizer consumption is 129 kg per hectare per annum in 2009–2010. India is the third largest producer of fertilizer after China and USA and the second largest consumer after China in the world. All India fertilizer consumption in 2010-11 was about 140 kg/ha of NPK nutrients. There is a wide variation in consumption of fertilizer from state to state. It is about

238 kg/ha in Punjab, 225 kg/ha in Andhra Pradesh, 2010 kg/ha in Haryana and 205 Kg/ha in Tamil Nadu. The lowest consumption is in Arunachal Pradesh and Nagaland with 5 kg/ha (2010-11).

3. Plant Protection Chemicals

The new seeds are very delicate and highly susceptible to pests and diseases. The irrigated fields enriched with heavy energy input (fertilisers-NPK) create a micro climate (hot and humid) in the field which helps in the fast growth of plants. The same environment is conducive for the fast growth and multiplication of insects and pests. These insects and pests attack the crop, hamper their growth and reduce the yield substantially. The danger of pests and insects may be reduced by using plant protection chemicals. The problem may be tackled either by developing the disease resistant seeds or by spraying insecticides and pesticides at the appropriate time prescribed or advised for different crops.

The problems of crop disease and pests may also be tackled by timely application of insecticides and pesticides. Thus, the farmer must have adequate knowledge of plant disease and their controlling chemicals. At the outbreak of a disease in the crop, the entire area should be sprayed. If the timely spray of the insecticides and pesticides is not done, the crop of the entire village/region may vanish. Since the plant protection chemicals are quite expensive, and often adultrated, they are generally out of reach of the small and marginal farmers. And if the crops by small and marginal farmers are not sprayed, the insects may creep in the neighbouring fields and the disease may adversely affect the larger area. At present plant protection is available to only 34 per cent of the total cropped area (2009–2010).

4. Capital Constraint

Availability of capital is also a vital constraint in the adoption and successful cultivation of the High Yielding Varieties. The farmer must have sufficient capital for the purchase of seeds, installation of tube-wells, drilling of pumping sets, chemical fertilisers, plant protection chemicals, tractors, harvesters, threshers, sprayers, and other accessories of agriculture. In case the farmer does not possess the operational capital, he should have an easy access to credit. In India, most of the farmers have no surplus over consumption, and therefore, no saving or operational capital at their disposal. The agrarian institutions like banks and co-operative credit societies have great responsibilities. They should advance loans to the farmers at a reasonable rate of interest. Unfortunately, the credit agencies in India, generally, serve the big farmers who are economically well off and politically well connected. The poor and the small farmers are thus deprived of the required inputs, so essential for the successful cultivation of High Yielding Varieties of crops like wheat and rice. Thus, there is a need of strengthening credit disbursting agencies.

5. Mechanisation

Modern farming tools and technology like tractors, leveller, seeder, planter, threshers, harvesters, winnower and sprayers are also imperative for the successful cultivation of the High Yielding Varieties. These varieties require adequate arrangements of controlled irrigation. Raising of two or three crops from the same field is possible only if the modern technology is available to the farmer. The indigenous plough and bullock/buffalo carts are less efficient to complete the agricultural operations on time. Machinery like tractors, threshers, sprayers, tillers, chaff cutters, leveller, pumping sets, etc., are required for the timely operations of sowing, weeding, spraying, and harvesting. The mechanisation of agriculture also helps in the judicious utilisation of complementary inputs like chemical fertilisers, insecticides and pesticides. For example, a farmer with a tractor and blade-terracer manages to grade his field to much better level in the course of time as compared to a farmer not having the similar equipments at his disposal. Among many useful aids which increase the efficiency of the farmers are seed-cum-fertiliser drills, well designed plant protection equipments, dunlop-cart, trolley, threshers, sprayers and tractors. Availability of electric power which is the nucleus of all technological development, is imperative for multiple cropping and intensification of agriculture. As a matter of fact, electric power has a vital role in the development and diffusion of High Yielding Varieties. It supplies the mechanical power to tube-wells, pumping sets, threshers, crushers, grinders and chaff-cutters. Availability of cheap power for agriculture helps in the adoption of new technology. At present in India, tractors are being used for tillage, of 22.78 per cent of total arable area and sowing 21 per cent of total area (2010–2011).

6. Marketing and Storage Facilities

The infrastructural facilities, like roads, marketing and storage facilities are also very crucial for the successful cultivation of High Yielding Varieties. It is the transportation cost which determines the cropping pattern and crop intensity in given region. Once a village is linked with a town/market by a metalled (*pucca*) road, its economy undergoes a remarkable transformation. The farmers can market their produce with ease and are also able to purchase fertilisers, plant protection chemicals, and other agricultural equipments from the neighbouring town. Cultivation of perishable commodities like vegetables, fruits, flowers and dairy products can also be done efficiently and profitably if adequate transport and marketing facilities are available.

7. Extension Service

For the successful adoption and spread of High Yielding Varieties, there should be an efficient extension service which may guide and help the farmers about the various agricultural operations and precautions. The fuller use of inputs may be made only if proper guidance to the farmers is available. The cultivation of delicate and highly sensitive varieties needs the services of qualified and dedicated extension agents. In the tradition bound society of India, the efficiency of extension machinery determines largely the efficiency of the farmers. There should, therefore, be a perfect understanding and co-ordination between farmers, extension agents, farm supervisors, researchers, and agricultural scientists. Any slackness in the work of agricultural machinery may make agriculture a less profitable pursuit. It is a well-established fact that investment in research brings ten times profit to the investor.

8. Human Factor

In the adoption of High Yielding Varieties, the role of human factor is also very important. As a matter of fact, in many cases, man behind the machine becomes more important than the machine itself. Within an agricultural community, individuals vary in their receptivity to innovations and new agricultural techniques. The personal qualities of the farmers, education, progressiveness, attitude towards life, aspirations, life style and family values determine his capacity to adopt the new agricultural technology. There are innovative and progressive farmers within a village who perform better than their orthodox and less progressive brothers. In other words, in all societies, there are rational and irrational farmers. The progressive farmers have largely improved their production and thereby their standard of living, while the conservative and less hard working farmers could not adopt the new agricultural technology successfully and they are in the grip of poverty and undernourishment.

The life style of the farmers and their aspirations for better standard of living also determine their efficiency. It is mainly because of the human factor that the agricultural income of the farmers, having almost the same size of holdings in a village, vary from each other. Human development of cultivators by focusing on education health and skill programmes is required at a priority basis.

Performance of the High Yielding Varieties

Green Revolution performed well in Punjab, Haryana and western Uttar Pradesh where the High Yielding Varieties were adopted first. The introduction of the High Yielding Varieties have increased the production of cereal crops substantially. For example, the total food production in 1950–51 was 97.3 million tonnes which rose to about 241.5 million tonnes in 2010–11. The production of rice was estimated 95.32 million tonnes and wheat 85.93 million tonnes (2010-2011). Thus, there was a substantial increase in the production of wheat and rice after the diffusion of the High Yielding Varieties in Indian agriculture.

Rice is the staple food for about 60 per cent of the total population of India. It is grown under diverse climatic and soil conditions. It, however, does not perform satisfactorily if the temperature falls below 20°C. Availability of moisture either from rains or from irrigation is, however, the main determinant of its cultivation. Rice cultivation is carried on in almost all parts of India except the un-irrigated tracts of Rajasthan, Malwa, Maharashtra and Gujarat. After the adoption of High Yielding Varieties, its cultivation has assumed great significance in the cropping structure of Punjab, Haryana, and western Uttar Pradesh (**Fig. 9.10 and Fig. 9.11**).

A comparison of **Fig. 9.10 and Fig. 9.11** shows that rice cultivation has been diffused substantially in the regions of Punjab, Haryana and Western Uttar Pradesh. Interestingly enough, the highest yields of rice are being obtained by the farmers of Punjab who are doing its cultivation with the help of canal and tube-well irrigation. In fact, controlled irrigation in these regions is helpful in achieving high yields per unit area. The percentage change in the area of rice, wheat and other main crops has been shown in **Table 9.10**.

Table 9.10 *Cropping Pattern in 2010–11*

Crops	*Area in million hectares*	*Percentage*
Rice	45.0	26.43
Wheat	29.25	16.10
Jowar	10.4	6.11
Bajra	8.8	5.16
Maize	6.4	3.76
Gram	6.3	3.70
Pulses	21.1	12.40

Source: ***Government of India, Ministry of Information: Production Division***, India (2012), New Delhi, pp. 71–78.

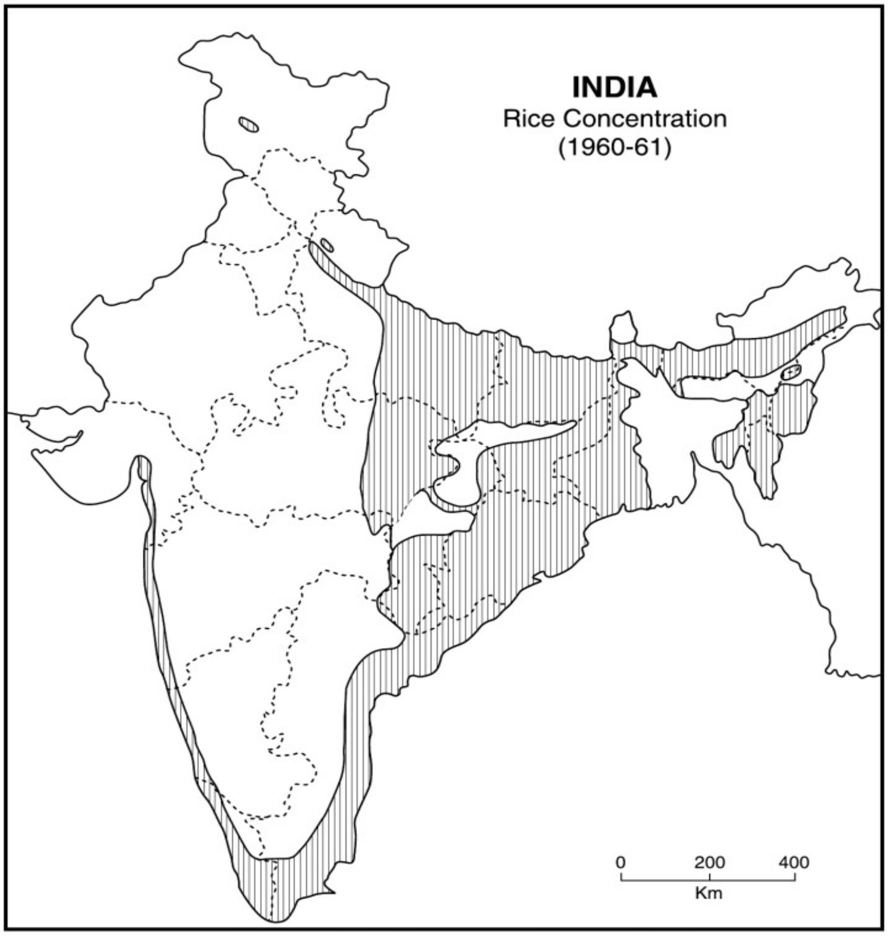


Fig. 9.10 Rice Concentration (1960–61)

It may be seen from **Table 9.10** that over 26 per cent of the total cropped area was under rice and 16 per cent under wheat in 2005–06. *Jowar* (millet), *bajra* (bulrush-millet), and *maize* occupied about 6%, 5%, and about 4% of the total cropped area respectively, while the share of pulses was over 12 per cent.

A comparative picture of cereals production in 1950–51 to 2005–06 has been given in **Table 9.11**:

Table 9.11 *Production of Cereals, 1950–51 to 2010–11 (in million tonnes)*

Crops	*1950–51*	*1970–71*	*2010–11*
Rice	30.8	37.6	95.32
Wheat	9.7	18.2	85.93
Pulses	12.5	13.4	28.0

(*Contd.*)

(*Contd.*)

Coarse-grains	15.5	31.4	30.0
Total cereals	78.2	101.7	341.0
Total food grains	97.3	124.3	241.56

Source: ***Ministry of Agriculture and Economic Survey***, 2010–11, and India 2012.

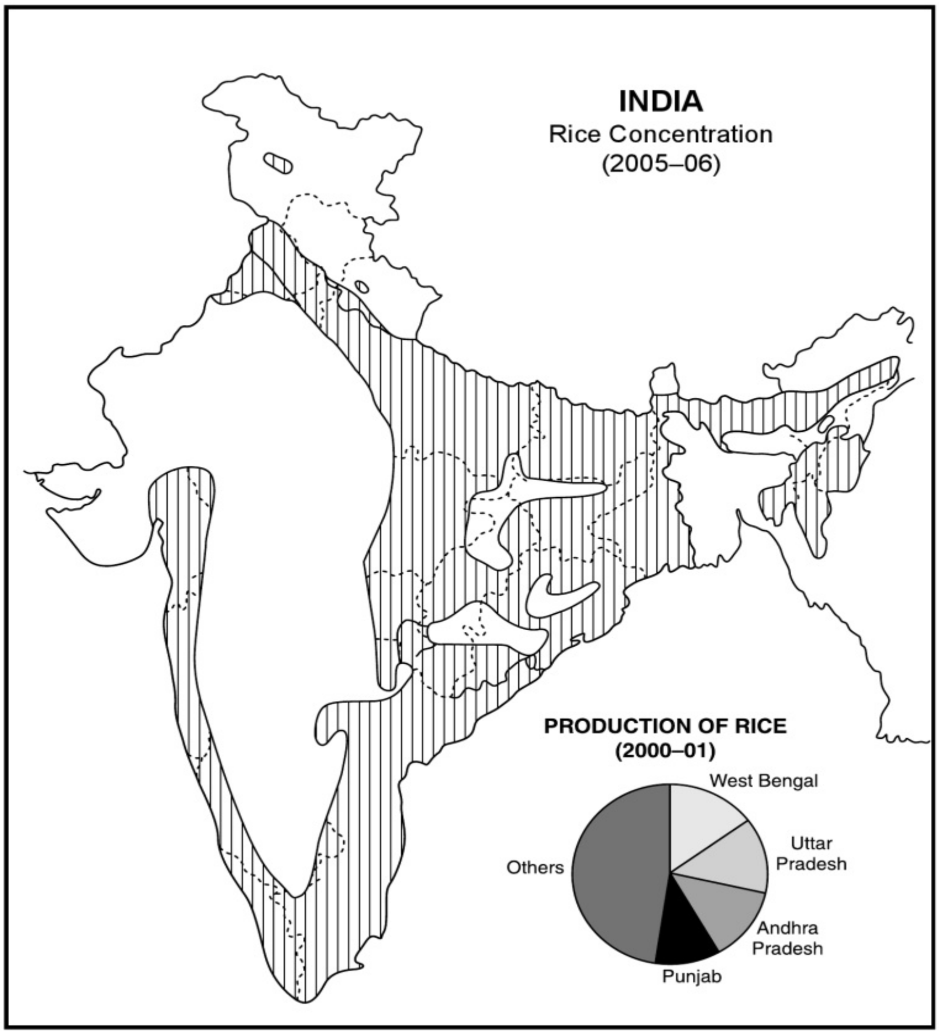


Fig. 9.11 Rice Concentration (2005–06)

It may be seen from **Table 9.11** that the production of rice in the country has increased from 30.8 million tonnes in 1950–51 to about 95.32 million tonnes in 2010–11. Although, the production of rice has increased in all the states of the country, it has recorded a phenomenal increase in the states of Punjab and Haryana, mainly because of the adequate and controlled irrigation which are imperative for its cultivation.

Recently, the Indian Rice Research Institute has discovered new varieties of rice that are capable of producing 6–7 tonnes of rice per hectare. This is about three times the average production of rice per hectare.

Wheat is the second most important staple food in India after rice. It contributes about 34 per cent of the total food grain production in the country. The regional distribution of wheat during the Pre-Green Revolution and Post-Green Revolution periods have been shown in **Fig. 9.12 and Fig. 9.13,** while **Table 9.11** shows the growth of its production.

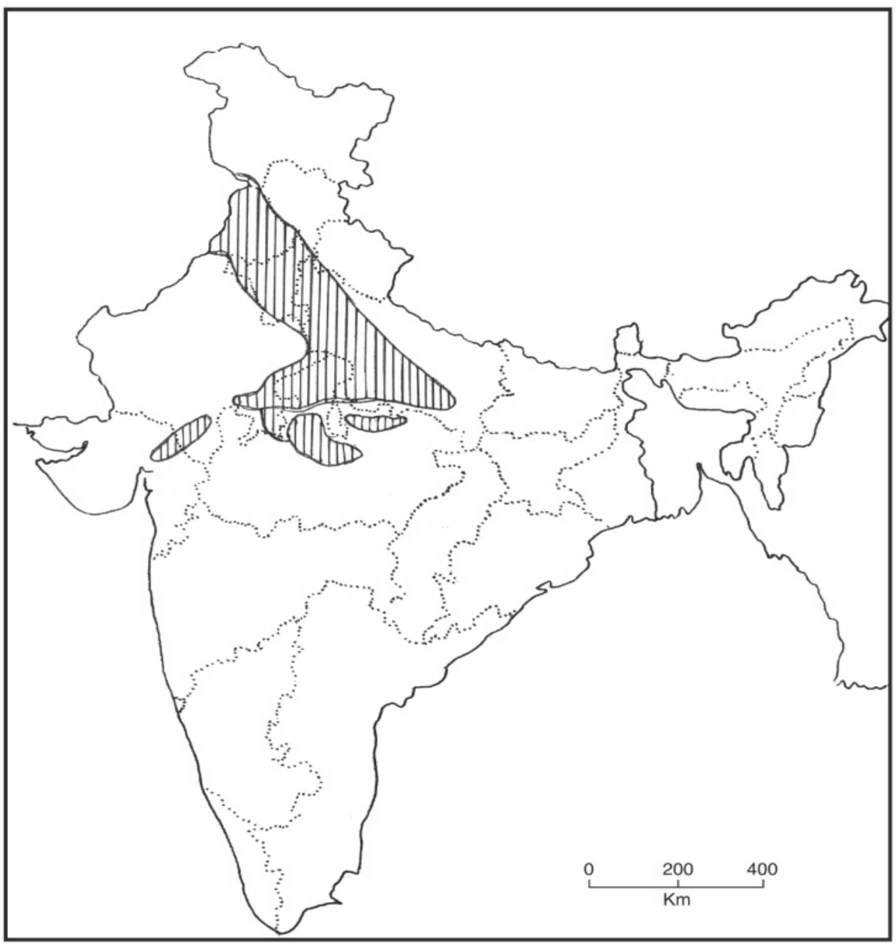


Fig. 9.12 Wheat Concentration (1960–61)

It may be observed from **Table 9.11** that wheat is the only crop in which the production has increased to the maximum. The production of wheat has gone up 85.93 million tonnes in 2010–11 as against only 9.7 million tonnes in 1950–51.

The regional pattern of wheat distribution shows an overall expansion of wheat area from the Ganganagar District of Rajasthan in the west to Dimapur (Nagaland) in the east, and from the Suru and Nubra Valleys (tributaries of the Indus in Ladakh) in the north to Maharashtra, Andhra Pradesh, and even Karnataka in the south **(Fig. 9.12).**

Looking at the spread of wheat and its excellent performance in the Satluj-Ganga Plains, it may be said that Green Revolution is most successful in the case of wheat. It is because of its high production that wheat has become a commercial crop in Punjab, Haryana and Western Uttar Pradesh.

It may be observed from the **Fig. 9.14** that Punjab, Haryana, and western Uttar Pradesh have emerged as the areas of major concentration of rice, while wheat has been diffused in all the directions from its traditional heartland of the north-west India.

Among the other crops, the area yield and production of maize and *bajra* have gone up. The area and production of pulses have, however, could not have any significant impact of Green Revolution.

Green Revolution and Rotation of Crops

In India, rotation of crops is practiced by most of the farmers. The main objective of rotation of crops is to obtain higher agricultural returns on the one hand and to maintain the soil fertility on the other. Thus, rotation of crops helps in making agriculture sustainable. The importance of rotation of crops is more in the areas where the farmers grow two or more than two crops in a year in the same field.

Prior to the Green Revolution most of the Indian farmers were subsistent in character, growing crops mainly for the family consumption. In the areas, where Green Revolution is a success, agriculture has become agri-business and market oriented in which the farmers are concentrating on a few number of crops. Most of the farmers are devoting their lands in the Green Revolution areas to rice in the kharif season and wheat in the rabi season. Both these staple crops are soil exhaustive. The area under leguminous crops has shrunk and the farmers have given up their empirical practice of fallowing to recuperate soil fertility. The rotation of crops of some of the villages from western Uttar Pradesh and Haryana, where Green Revolution is a success have been given in **Table 9.12**.

Table 9.12 *Traditional Rotation of Crops (1960–65) in Banhera (Tanda) Village, District Hardwar*

Year	*Kharif Season (Mid-June to Mid-October)*	*Rabi Season (Mid-October to Mid-April)*	*Zaid Season (April-June)*	*No. of days land left fallow*
1960	Millet/fodder/rice	Gram	Fallow	90
1961	Fallow	Wheat	Fallow	210
1962	Millet/fodder/rice	Gram	Fallow	90
1963	Fallow	Wheat	Fallow	210
1964	Millet/fodder/rice	Gram	Fallow	90
1965	Fallow	Wheat	Fallow	210

Source: ***Field work by the author,*** 1960–65.

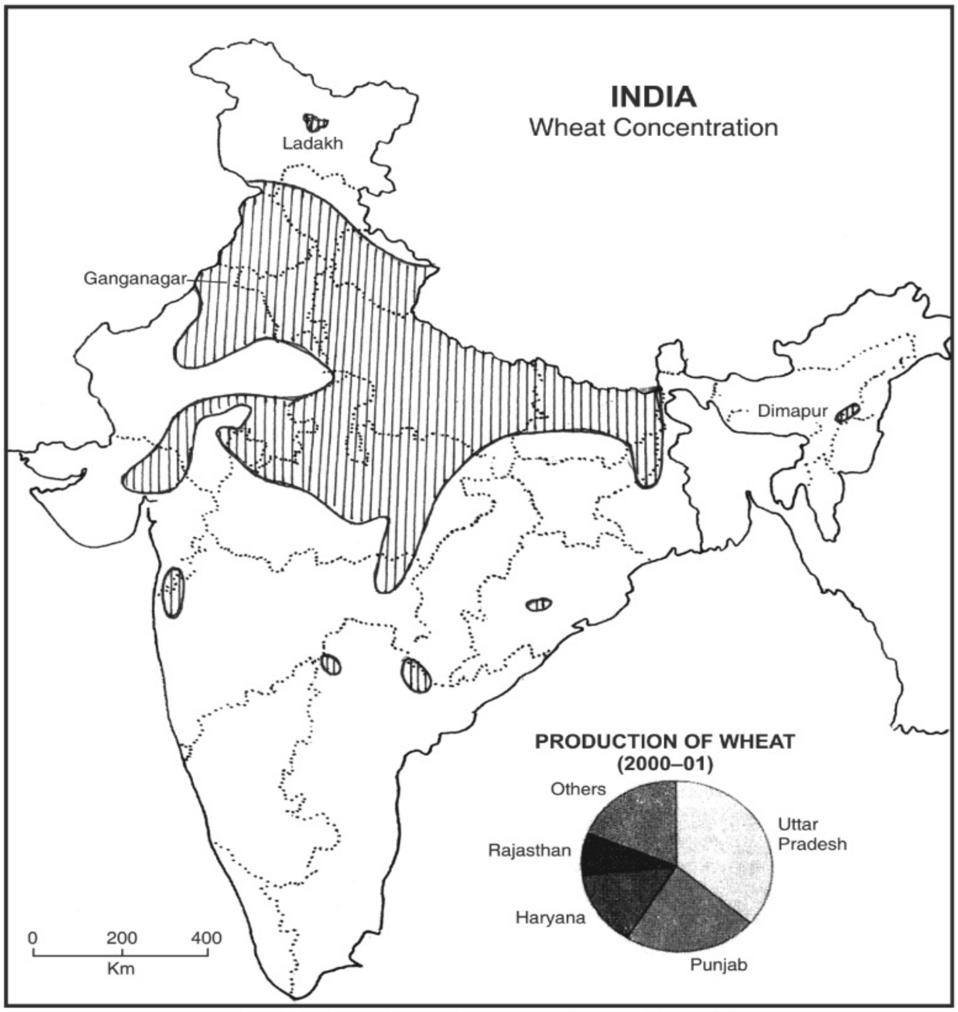


Fig. 9.13 Wheat Concentration (2005–06)

It may be observed from **Table 9.12** that fallowing was an important practice each year in Western Uttar Pradesh before the adoption of the High Yielding Varieties. Moreover, wheat and gram (a leguminous crop) used to be sown in the same field in alternate years. This type of rotation of crops was helpful in maintaining the fertility of the soil.

Under the pressure of growing population on arable land, the adoption of new seeds have resulted in a new pattern of rotation of crops, which has been given in **Table 9.13.**

In the new rotation of crops, the farmers are largely concentrating on the cultivation of High Yielding Varieties of rice and wheat, and depending on the circumstances, they grow a cash crop of sugarcane. All these crops are soil exhaustive. Moreover, the fallowing practice has been abandoned.

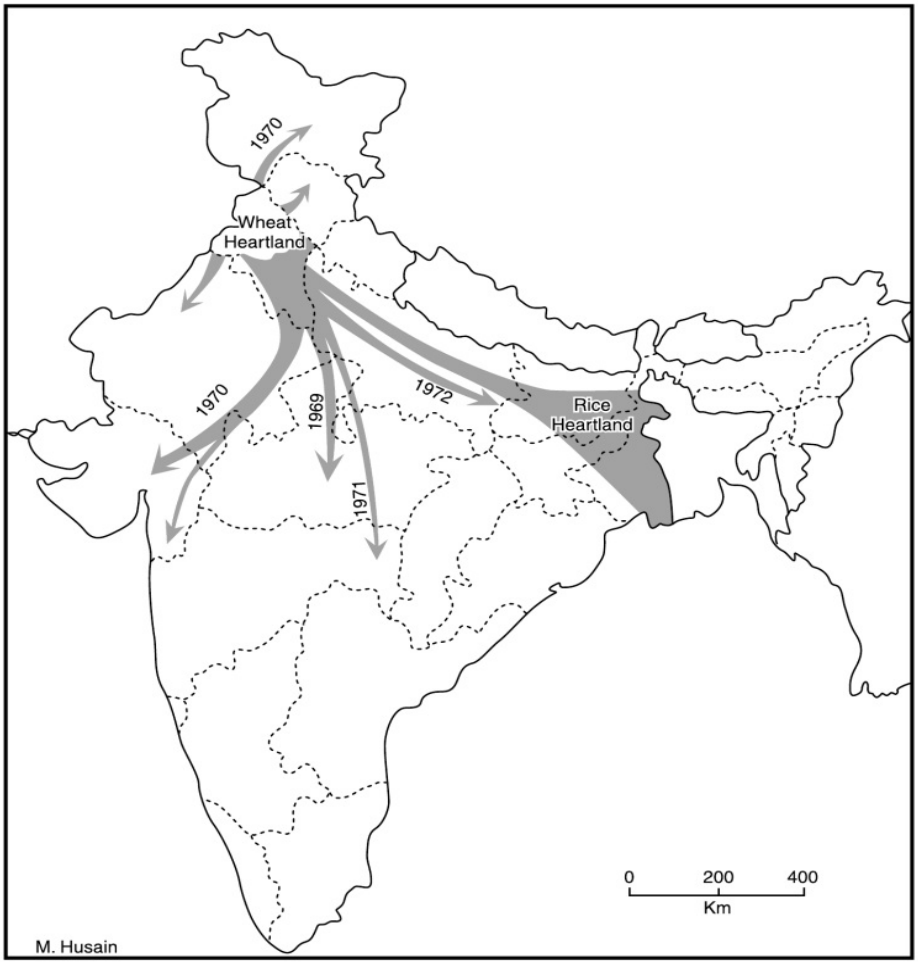


Fig. 9.14 Diffusion of High Yielding Varieties of Rice and Wheat

Table 9.13 *Rotation of Crops in 2005–06 in Village Banhera (Tanda) Village, District Hardwar*

Year	*Kharif*	*Rabi*	*Zaid*	*No. of Fallow Days*
2000	Rice	Wheat	Fodder	20
2001	Rice	Wheat	Fodder	5
2002	Rice	Wheat	Fodder	20
2003	Rice	Wheat	Fodder	5
2004	Sugarcane	Sugarcane	Sugarcane	20
2005	Sugarcane	Sugarcane	Sugarcane	5
2006	Rice	Wheat	Fodder	20

Source: ***Field work by the author,*** 2000–06.

Green Revolution and Regional Inequalities

The High Yielding Varieties adopted under the new agricultural strategy are quite delicate and highly sensitive which require the timely application of costly inputs (water, fertilisers, insecticides, and pesticides). Moreover, they perform better in the areas where infrastructural facilities (electricity, irrigation, and roads) are adequately available. Contrary to this, the areas of extreme climate (precipitation and temperature) where controlled irrigation is not available the new seeds are not performing satisfactorily. This has created regional imbalances in the agricultural development in the irrigated and unirrigated parts of the country.

Intra-Regional Inequalities

The adoption of High Yielding Varieties have created intra-regional inequalities also. All the farmers, even in the states of Punjab, Haryana, western Uttar Pradesh and Kaveri Delta have not been benefited equally. It is the large, progressive and educated farmers who gained much from the High Yielding Varieties. The early adopters reaped much dividends from the new seeds. By the time the majority came to adopt the new seeds, income gains realised by the early adopters generally disappeared. The average, small and marginal farmers could not gain much, while the late adopters gained almost nothing.

Thus, the High Yielding Varieties have had a discriminatory impact in which the large and early adopters were benefited and the small and marginal farmers who adopted these seeds late could not achieve much.

Intercrop Disparities

The production and productivity of wheat, rice, maize and bajra have gone up. There are however, several cereal and cash crops (pulses, small millets, barley, oilseeds) which are not performing satisfactorily. It is in the case of *kharif* pulses where the performance needs much improvement. Development of High Yielding Varieties of pulses for each of the agro-climatic region is the pressing need of the day.

Impact of Green Revolution on Farmers and Landless Labourers

When the package programme for the development of agriculture to increase agricultural production was introduced in the mid-sixties, it was expected that the new seeds will be neutral to the scale. This assumption has, however, been proved wrong as the new seeds are no longer scale neutral.

In India, there are four categories of farmers, i.e. (i) large farmers, (ii) medium farmers, (iii) small farmers, and (iv) marginal farmers. Each one of them has not been equally benefited from the new seeds. It would be worthwhile to examine the impact of Green Revolution on the various categories of farmers and the dependent labourers.

Large Farmers

The definition of large farmer differs from state to state in India. For example, a farmer having 10 acres in Kerala is a large farmer, while in Rajasthan, Punjab and Haryana he falls under the category of medium or small farmer. All the studies conducted in areas where Green Revolution is a success show that the large farmers have been the main gainers of the package programme. In the initial phase of the Green Revolution, the large farmers were able to adopt the High Yielding Varieties easily. The new varieties increased their savings, both to buy machinery that can displace labour and to purchase more land of the marginal and small farmers. This trend increased the income base of those who were already relatively well off and better placed in society. The large farmers, in fact, are in a position to make the best use of tractors, threshers, and sprayers. They installed tube-wells and pumping sets for an effective utilisation of underground water. For the purchase of agricultural machinery and installation of tube-wells and other costly inputs, credit was necessary. Since the large farmers have more risk taking capacity, they could modernise their agriculture easily. Small and marginal farmers being constrained by financial resources could not adopt the High Yielding Varieties in the early phase of their diffusion. Consequently, they lagged behind in the adoption of new seeds.

In general, the complexity of farming increases with multiple cropping as more inputs and timely operations are required for good harvests. Intensification of agriculture and multiple cropping means more risk on the part of the cultivator. The agrarian institutions, credit agencies, and extension service, generally serve the large and powerful farmers as a result of which the small and marginal farmers are deprived of adequate inputs so essential for the successful cultivation of High Yielding Varieties. The big farmers who have close connections with the money economy and influential political persons are able to complete their agricultural operations more easily than the small farmers who rely on family labour for agricultural operations. This process accentuated the income inequalities in the rural society and led to polarisation of rural masses.

Small Farmers

The small farmers generally have less than two acres of land in most of the states of India. These farmers are not well placed technologically and financially. Moreover, they do not have an easy access to the credit agencies. For the irrigation of their crops, they have to depend on the tube-wells of large farmers. It has been observed that at the time of peak irrigation demand, the tube-well owners (large farmers) either do not give water to the small farmers or they charge exorbitantly for the water, which is often beyond the reach of small farmers. In the absence of timely irrigation, the crops of the small farmers suffer adversely. Over a period of time, small and marginal farmers, by taking the advantage of rising land prices, sell out their land and attempt a new start in life.

Moreover, the agrarian institutions which are supposed to assist the small and marginal farmers, are not very helpful. The credit agencies as stated above, are serving largely the big farmers who are economically well off and politically powerful. The big farmers could easily pre-empt for their own use the bulk, if not, the entire supply of costly inputs like electricity, water, fertilisers, insecticides, and pesticides. Thus, the poor farmers have been deprived of enough inputs so essential for the successful cultivation of the High Yielding Varieties of crops.

Tenant Farmers

The diffusion of High Yielding Varieties also affected the tenant farmers adversely. In general, the tenant farmers have a low tendency to adopt the new innovations in their cropping patterns as they are not very sure for how long the land will be available to them for cultivation. The difficulties of tenant farmers have multiplied by the astronomical rise in the value of land in recent decades. The tenants want to lease more land while land owners are reorganising the gains to be achieved by direct management of their fields. Under these circumstances, the landlords are reluctant to get into a position where their tenants might be given title of the land. Numerous evasive tactics have been adopted by the landlords. Some of them have directly evicted their tenants from establishing security of tenure by shifting them frequently. In the absence of more effective land reforms, the prospect is for large number of tenant farmers to join the rank of landless labourers. Compelled by financial constraints, they migrate to big cities in search of employment and to start a new career.

Landless Labourers

One of the assumptions of the High Yielding Varieties that they will generate more employment could also not be achieved. Undoubtedly, the wages of the unorganised agricultural workers have risen by about 20 times. In the areas where Green Revolution is a success, the labourers are finding employment throughout the year, while in many areas the rural employment has declined. The main cause of decline in labour employment is the natural growth of labour and mainly because of the mechanisation of agriculture by the big farmers which displaces labour.

The impact of Green Revolution has been shown in **Table 9.14.** It may be observed from this Table that the large farmers who have better risk taking capacity adopted High Yielding Varieties quickly. They installed tube-wells and pumping sets in their fields and purchased tractors, threshers and harvesters, etc. from the loans they got from the funding agencies and co-operative societies. Consequently, their production and productivity went up substantially. Better income helped them in improving their food and nutrition. Improvements also occurred in their housing. Realising the importance of education, many of them sent their children to the English medium schools of the neighbouring towns and cities. The economic prosperity also made them increasingly conscious about health and sanitation. It was at this stage that some of the big farmers started desiring small families. These steps led to a decline in the fertility rate of big farmers which ultimately reduced their dependency ratio.

Moreover, the economic prosperity and interaction with the well-off urban people inspired them to construct elegant and spacious *pucca* houses. They started consuming more comfort and luxury goods, which in a sense, brought consumerism in the rural society of the regions of successful green revolution.

The traditional farmer became economic farmer who stated thinking all the time in terms of optimising his profit. Being too busy and conscious of the value of his time, he started ignoring the interest of the neighbours and small farmers. On the other hand, he started purchasing the agricultural land of the small and marginal farmers. This broke the well establish reciprocal aid system and *bhai-chara* (brotherhood) in the village community. With better agricultural income, the standard of living of the farmers went up, their longevity increased and life became more enjoyable.

Contrary to this, the small and marginal farmers, having less risk-taking capacity, could not adopt the High Yielding Varieties rapidly as they did not like to mortgage their lands for obtaining loans from the funding agencies and the money lenders. Their production and productivity increased only marginally. Consequently, there was no improvement in their food, nutrition, education, sanitation and health. Being poor, they could not afford to bear the expenses of school education and thought it better to engage their children in agriculture. Realising the importance of additional hands, these farmers have no desire of small families and did not adopt family planning. Being under debt, poor nutrition, and mental stress they could not maintain their health and many of them, unfortunately, committed suicide.

Under the changed socioeconomic conditions, the income gap between the big and small farmers increased. This broke the traditional rural society and divided them into the rich and the poor. The social tension increased leading to the polarisation of the society. The social implications of Green Revolution has been given in a tabular form in **Table 9.14:**

Table 9.14 *Impact of Green Revolution on Big and Small Farmers*

Big Farmers	*Small and Marginal farmers*
Fast adoption of High Yielding Varieties	Slow adoption of High Yielding Varieties
Rapid increase in agricultural productivity and production	Little increase in agricultural productivity and production
Improvement in:	*Little or no improvement in:*
Food and nutrition	Food and nutrition
Housing	Housing
Education	Education
Sanitation	Sanitation
Health	Health
Some of the big farmers went for family planning	No or little desire for smaller family
Decrease in dependency ratio	Little or no family planning
	Increase in dependency ratio
Increase in the consumption of comfortable and luxury goods	Little or no improvement in consumption
Multiplication of immovable assets	Decrease in immovable assets
Better standard of living	Decline in standard of living
Increase in longevity	Little or no increase in longevity
Big farmers became rich	Small farmers became poor
Polarisation of the rural society	Small farmers united
Increase in social tension	Increase in social tension

Source: ***Fieldwork by the author***, 1962-63 and 2011-12.

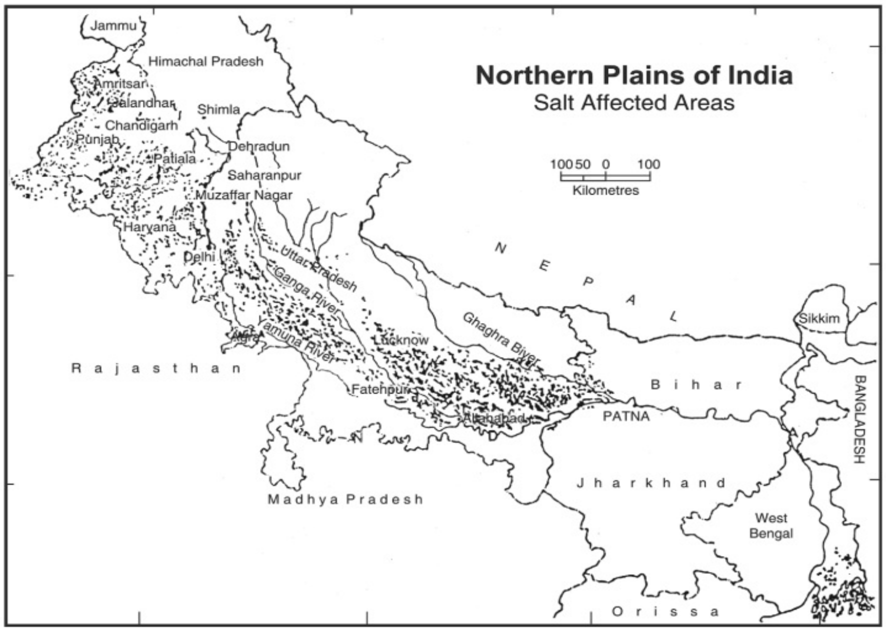
Environmental and Ecological Implications of Green Revolution

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

1. Salination

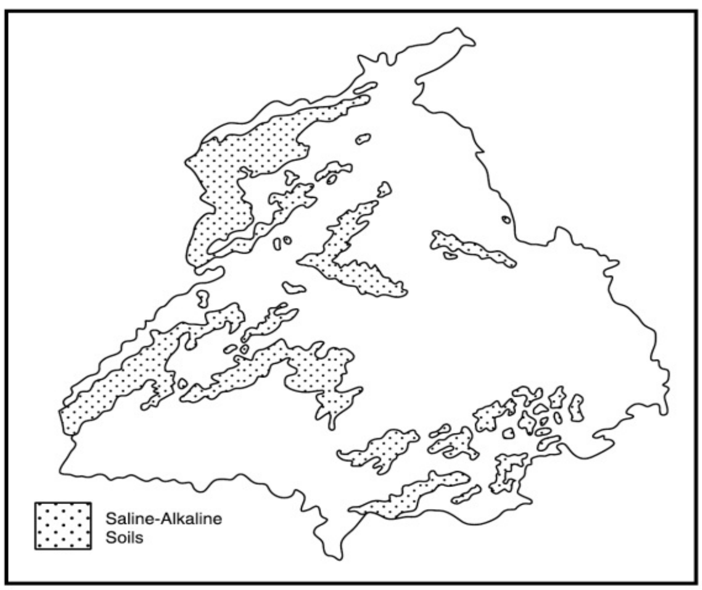
The High Yielding varieties of rice and wheat require several waterings, especially in an area like Punjab and Haryana in which the average annual rainfall is about 65 cm. The continuous supply of moisture through irrigation during the summer and winter seasons have changed the soil chemistry. In the arid and semi-arid areas, owing to capillary action, the soils are becoming either acidic or alkaline. The saline and alkaline affected tracts, locally known as *kallar* or *thur* in Punjab and *kallar* or *reh* in Uttar Pradesh have expanded and increased in area. According to one estimate, about 50 per cent of the total arable land of Punjab and Haryana has been harmed by soluble salts. The saline and alkaline affected areas have been shown in **Fig. 9.15 and Fig. 9.16.**

It may be observed from **Fig. 9.15 and Fig. 9.16** that some of the best agricultural tracts have been adversely affected and rendered useless from the agricultural point of view**.** If the existing pattern of crops and their rotation is not changed more agricultural land may become unproductive.



Source: Waste Land Map of India, 1980–82 Prepared by N.R.S. a Govt. of India

Fig. 9.15 Satluj–Ganga Plain: Salt Affected Land



Source: Punjab Agri Univ. Ludhiana

Fig. 9.16 Punjab—Soil Salinity

The problem of salinity and alkalinity can be solved by use of manure (cowdung, compost, and green manure) and by a judicious selection of leguminous crops in the rotation. Cultivation of salt tolerant crops like barley, sugar-beet, salt grass, asparagus, spinach, and tomato may also help to a great extent and may improve the fertility of such lands.

2. Waterlogging

Water logging is the other major problem associated with over-irrigation. In all the canal irrigated areas of Punjab, Haryana, and western Uttar Pradesh, waterlogging is a serious problem. The Indira Gandhi Canal command area is a recent example in which waterlogging is progressively becoming a serious menace to the arable land. Several thousand acres of productive agricultural land and pastures in the districts of Ganganagar, Bikaner, and Jaisalmer (Rajasthan) have been submerged under water (**Fig. 9.17**). The progressive and ambitious cultivators of the irrigated areas of these districts have changed their cropping patterns and have introduced rice and wheat in place of bajra, pulses, cotton, and fodder. Repeated irrigation of these crops in the summer and winter seasons have resulted into waterlogged condition, especially along the canals.

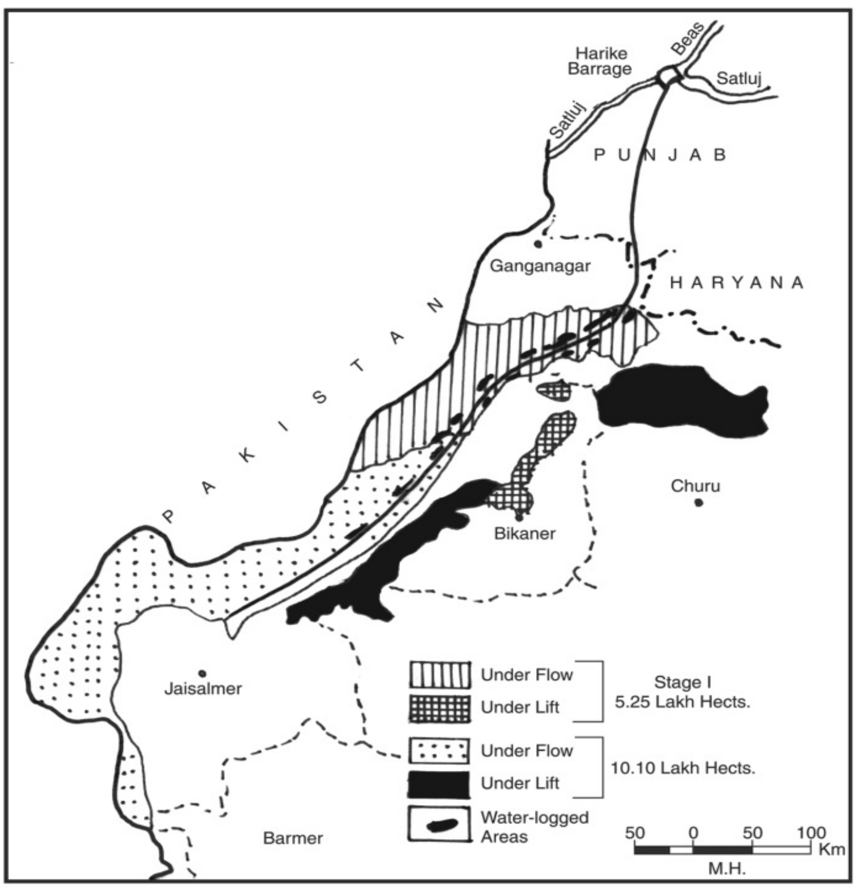


Fig. 9.17 Indira Gandhi Canal Command Area

3. Soil Erosion

Soil erosion is a universal phenomena. It may be observed to some extent in all parts of the country, its intensity, however, is more in the arid, semi-arid, and mountainous areas. The presence of forests reduces the danger of soil erosion significantly. In recent years, the agricultural area has been expanded by indiscriminate felling of trees. The increase in the rate of soil erosion is not only damaging the agricultural lands, it is also affecting adversely the areas where the eroded soil is deposited.

In order to minimise the danger of soil erosion, afforestation is imperative. Moreover, the farmers should apply more manures and develop wind breakers in the desert areas. Development of terraces in the hills, leveling of gullies, and contour ploughing in the hilly areas can also go a long way in reducing soil erosion.

4. Pollution

The High Yielding Varieties perform better if heavy doses of chemical fertiliser, insecticides, and pesticides are applied. Application of heavy doses, of these inputs destroy the micro-organisms which are so necessary to maintain the fertility of the soil. The use of manures in place of chemical fertilisers can go a long way in overcoming the problem of soil pollution.

5. Lowering of the Underground Water-Table

The High Yielding Varieties of rice and wheat are water-relishing crops. Rice, being sown in the low rainfall recording area of Punjab and Haryana, demands several irrigations and same is the case with wheat crop. The continuous lifting of water through tube-wells and pumping sets has lowered the water Table in the eastern districts of Haryana (**Fig. 9.18**). Many farmers have to lower their tube-wells in the years of inadequate monsoon rainfall. If the cropping pattern is not changed, and irrigation of rice and wheat continues at the present level, the underground water-table may not be sufficiently recharged and may get substantially depleted. In opposition to this, the underground

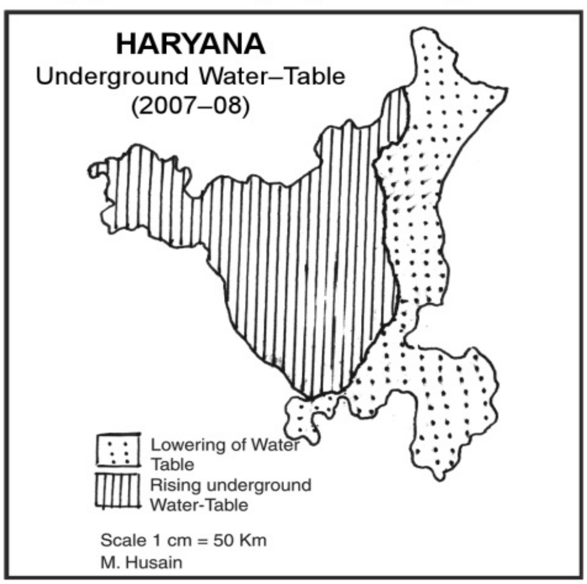


Fig. 9.18 Haryana Green Revolution and Underground Water-Table (2007–08)

water-table in western Haryana is rising as there is a gypsum layer in that part of the state which does not permit the percolation of water through this layer. The watertable in the Jhajjar District of Haryana has risen significantly. The crops of millets, bajra, arhar are damaged. In fact, people in this district pray for drought so that the waterlogged areas may be sown. Consequently, there are water-logged conditions in several tracts in the western parts of Haryana. This rise in the water-table is resulting into capillary action, leading to the occurrence of saline and alkaline formations.

6. Deforestation

There had been heavy felling of trees to bring the forest area under cultivation. In Punjab and Haryana, less than 5 per cent of their area is under forest. This is affecting the environment and ecology adversely.

7. Noise Pollution

The change in the agricultural technology, the use of tractors, terracers, harvesters, threshers, and crushers have increased noise pollution which have disturbed the rural tranquility.

8. Health Hazards

Application of heavy doses of insecticides, pesticides, and chemical fertilisers are health hazards. The application of these poisons on vegetables, fruits and grasses are health hazards. The Indian Council of Medical Research established that traces of lead, zinc and copper are found in the milk and vegetables on which the fertilisers, insecticides, and pesticides are sprayed.

The recurrence of malaria in irrigated tracts of arid and semi-arid regions of Rajasthan and Punjab is the result of heavy irrigation and water-logged tracts along the canal which have become the breeding grounds for mosquitoes (**Fig. 9.19**).

Green Revolution—Achievements

The diffusion of High Yielding Varieties has transformed the rural landscape. The main achievements of Green Revolution may be summarised as under:

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

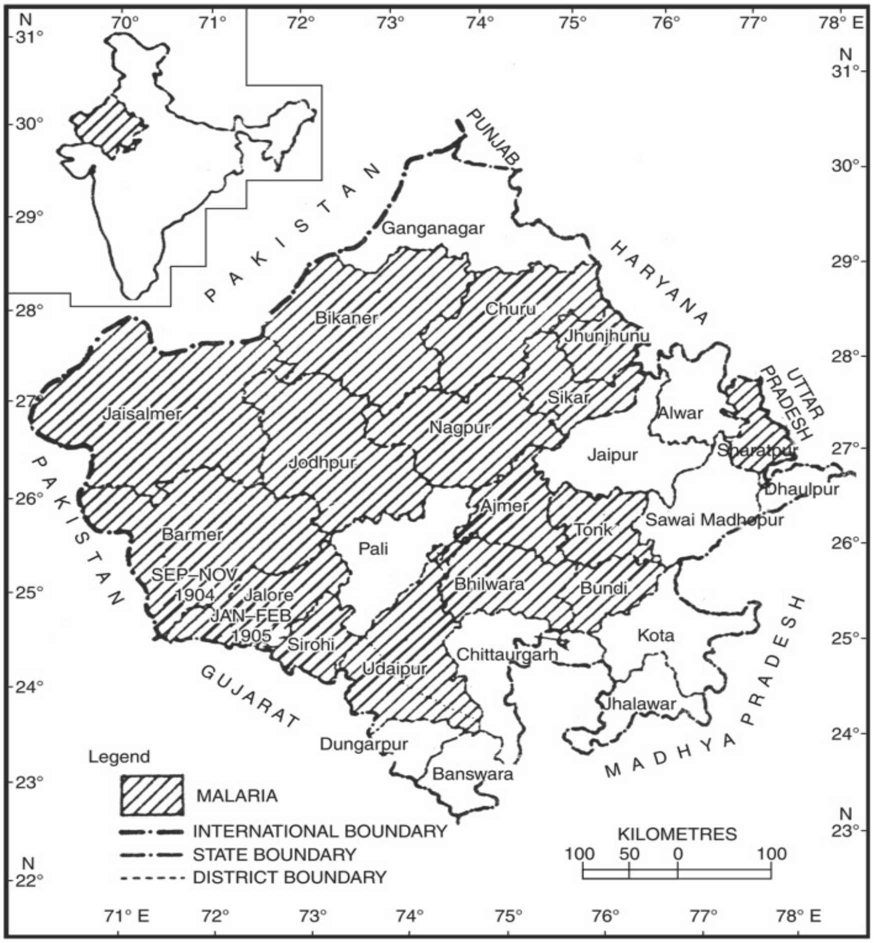


Fig. 9.19 Rajasthan—Malaria Affected Areas

Green Revolution—Problems and Prospects

1. Depletion of soil owing to the continuous cultivation of soil exhaustive crops like rice and wheat.
2. Depletion of underground water table due to over-irrigation of more moisture requiring crops like rice and wheat.
3. Green Revolution has increased the income disparity amongst the farmers.
4. Green Revolution led to polarisation of the rural society. It has created three types of conflicts in the rural community, namely, between large and small farmers, between owner and tenant farmers, between the employers and employees on agricultural farms.
5. Green Revolution has displaced the agricultural labourers, leading to rural unemployment. The mechanical innovations like tractors have displaced the agricultural labour.
6. Agricultural production in the Green Revolution areas is either stationary or has shown declining trend.

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

SECOND GREEN REVOLUTION

The overall production of the cereal and non-cereal crops has reached almost the plateau stage. The growth rate of agricultural sector is only about two per cent. Looking at the growing demand of agricultural produce, there is an urgent need for undertaking agriculture to a higher trajectory of four per cent annual growth rate. In order to achieve these objectives, various governments have undertaken important steps towards agricultural reforms. These reforms aim at efficient use of resources and conservation of soil, water and ecology on a sustainable basis, and in holistic framework. The main objectives of the second Green Revolution are: (i) To raise agricultural productivity to promote food security (ii) More emphasis on bio-technology (iii) To promote substainable agriculture (iv) To become self sufficient in staple food, pulses, oil seeds, and industrial raw material (v) To increase the per capita income of the farmers and to raise their standard of living. The holistic framework, thus, must incorporate financing of rural infrastructure such as irrigation, roads and power.

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

1. Doubling the rate of growth of irrigated area.
2. Improving water management, rainwater harvesting, and watershed development.
3. Reclaiming degraded land and focusing on soil quality.
4. Bridging the knowledge gap through effective extension.
5. Diversifying into high value outputs, e.g. fruits, vegetables, flowers, herbs and spices, medicinal plants, bamboo, bio-diesel, but with adequate measures to ensure food security.
6. Providing easy access to credit at affordable rate of interest.
7. Improving the incentive structure and functioning of markets, and
8. Refocusing on land reforms issues.
9. Laying emphasis on the cultivation of pulses. With the limited availability of pulses overseas, development of hybrid varieties becomes a pre-requisite for increasing domestic production.
10. Focusing on the development of area specific seeds and their application.
11. Attention has to be focused on areas such as rainfed, drought-prone crops, and drought resistant crops, and those amenable to biotechnological application.

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

WHITE REVOLUTION

The package programme adopted to increase the production of milk is known as White Revolution in India. The White Revolution in India occurred in 1970, when the National Dairy Development Board (NDDB) was established to organise the dairy development through the co-operative societies. Prof. Verghese Kuerin was the father of White Revolution in India. The dairy development programme through co-operative societies was first established in the state of Gujarat. The co-operative societies were most successful in the Anand District of Gujarat. The co-operative societies are owned and managed by the milk producers. These co-operatives apart from financial help, also provide consultancy. The increase in milk production has also been termed as ***Operation Flood***. Varghese Kurien (1921-2012) who is considered as the 'Father of White Revolution in India' was one of world's great agricultural leaders of the 20th century.

Objectives

1. The main objectives of the co-operative society is the procurement, transportation, storage of milk at the chilling plants.
2. To provide cattle feed.
3. The production of wide varieties of milk products and their marketing management.
4. The societies also provide superior breeds of cattle (cows and buffaloes), health service, veterinary treatment, and artificial insemination facilities.
5. To provide extension service.

The technology of White Revolution is based on an extensive system of co-operative societies. Milk, after being collected at a village collection centre, is promptly transported to the dairy plant at the milk chilling centre. Timing of collection is rigidly maintained by the village society, truck operators, and the quick transport to the dairy plants. Milk tankers, each, normally carry 14,000 litres of milk. The chilling centres are managed by producers' co-operative unions to facilitate the collection of milk from producers who live at some distance from the chilling centres and thus, the middlemen are eliminated.

Phases of the White Revolution

The White Revolution may be examined under the following three phases:

Phase I (1970–81)

During this period, the dairy development programme was set up in ten states to provide milk to the cosmopolitan cities, i.e. Mumbai, Kolkata, Delhi, and Chennai. The important step in this phase was the setting up of 4 Mother Dairies in Mumbai, Kolkata, Delhi, and Chennai.

Phase II (1981–85)

During this phase, the dairy development programme was extended in the states of Karnataka, Madhya Pradesh, and Rajasthan. In this phase, within 25 contiguous milk-shed areas (in 155 districts) a cluster of milk producers' union was established. The Research Institute at Hyderabad developed a vaccine called 'Raksha' to control cattle diseases. The programme also involved the improvement in milk marketing in 144 more cities of the country. The Dairy Co-operative societies were set up in 35,000 villages and the membership exceeded 36 lakhs.

Phase III (1985–2000)

A number of co-operative societies were set up in most of the major states of the country and the number of co-operatives went up by 1,35,439 with a membership of 14 million. The following table 9.16 shows the spurt in milk production in India.

Table 9.15 *The Phenomenal Increase in Milk Production in India—1950–51 to 2005–06*

Year	*Milk Production in million tonnes*	*Per capita availability grams/day*
1950–51	17.0	124
1960–61	20.0	126
1970–71	22.0	128
1980–81	31.6	128
1990–91	53.9	176
2000–01	80.6	220
2005–06	97.1	241
2009–10	112.54	263

Source: ***Govt. of India, India 2012***, p. 109.

Achievements

White Revolution is as important to dairy development as Green Revolution has been to grain production. Its outcome is based on the improvement in cattle breeding and adoption of new technology.

Today, India has earned the first position in milk production in the world. In 2009–10, livestock sector produced 112.54 million tonnes of milk as compared to 54 million tonnes in 1990-91. (**Table 9.15**). Dairying has become an important role in providing employment and income generating opportunities. The contribution of milk alone in 2005–06 was over 1.25 trillion, which is much higher than that of paddy (0.75 trillion). The statewise distribution of milk production has been shown in **Fig. 9.20**. It may be observed from this figures that Gujarat, Maharashtra, U.P., Punjab, Haryana, Madhya Pradesh, Rajasthan, West Bengal, Andhra Pradesh, Karnataka, and Tamil Nadu are the main milk-producing states of the country.

Some of the important achievements of the White Revolution are as under:

1. The White Revolution made a sound impact on rural masses and encouraged them to take up dairying as a subsidiary occupation.
2. India has become the leading producer of milk in the world. The milk production that was about 17 million tonnes in 1950–51 rose to over 112 million tonnes in 2009–10. The production of milk has gone up by more than six times when compared with that of the Pre-Independence situation.
3. The per capita availability of milk per day at present is about 263 gm as against 125 grams before the White Revolution.
4. The import of milk and milk production has been reduced substantially.
5. The small and marginal farmers and the landless labourers have been especially benefitted from the White Revolution. About 14 million farmers have been brought under ambit of 1,35,439 village level dairy co-operative societies. At present (2012), there are 200 million litres across India producing 20 million litres of milk every day.
6. To ensure the success of Operation Flood Programme, research centres have been set up at Anand, Mehsana, and Palanpur (Banaskantha). Moreover, three regional centres are

functioning at Siliguri, Jalandhar, and Erode. Presently, there are metro dairies in 10 metropolitan cities of the country, beside 40 plants with capacity to handle more than one lakh litres of milk.

7. Livestock Insurance Scheme was approved in February 2006 and in 2006–07 on a pilot basis in 100 selected districts across the country. The scheme aims at protecting the farmers against losses due to untimely death of animals.
8. To improve the quality of livestock, extensive cross breeding has been launched.
9. For ensuring the maintenance of disease-free status, major health schemes have been initiated.
10. The government implemented livestock insurance on pilot basis in 2005–06.

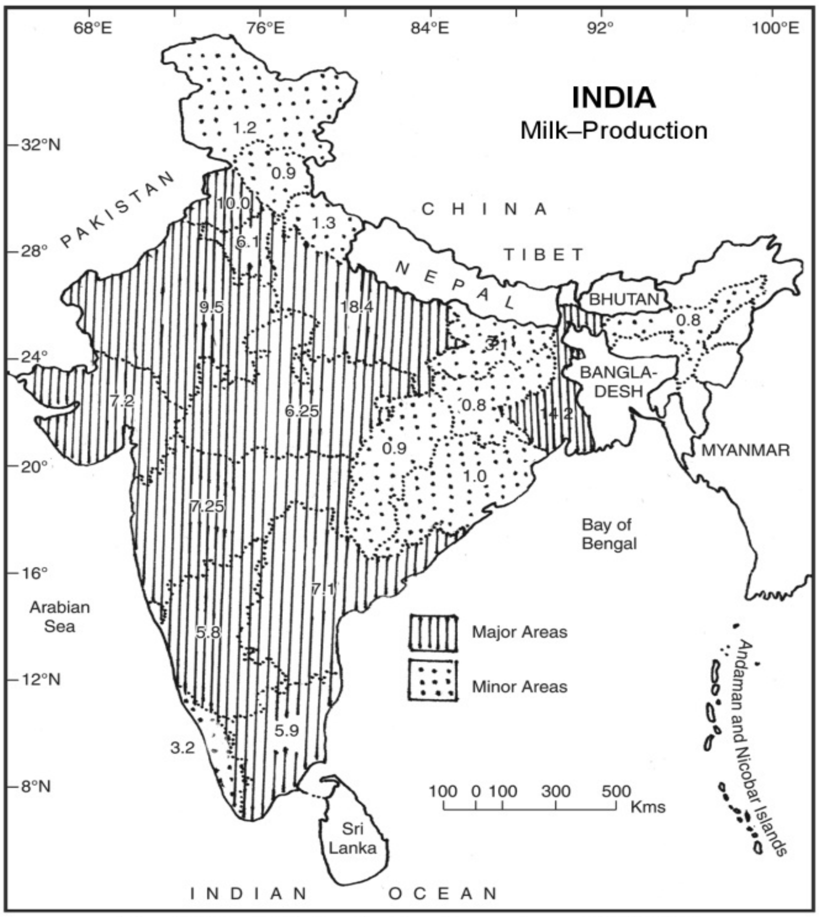


Fig. 9.20 Milk Production Percentage (2007–08)

The All India Summary Reports of the 17th Livestock Census released in July 2006 points out that India possesses the largest livestock population in the world after Brazil. It accounts for about 56 per cent of the cattle population of the world's buffalo population and 14 per cent of the cattle population. It ranks first in respect of buffalo and second in respect of cattle population, second in goat population and third in respect of sheep in the world.

Problems and Prospects

Some of the important problems of the White Revolution are as under:

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

In India, dairy development has a great future. It should take the advantage of liberalisation in the global trade and should try to capture international market. Many corporate sector firms like Indana (plants at Nagpur, Hyderabad, and Bangalore), The Sheel International and Milk and Food, and the Amrut Industries are taking advantage of the existing situation of liberalisation and globalisation. The government has constituted Technology Mission for dairy development and Amul Model Co-operatives are being promoted to cover about 60 per cent of the total area of the country.

BLUE REVOLUTION

Blue Revolution means the adoption of a package programme to increase the production of fish and marine products. The Blue Revolution in India was started in 1970 during the Fifth Five-Year Plan when the Central Government sponsored the Fish Farmers Development Agency (FFDA). Subsequently, the Brakish Water Fish Farms Development Agency were set up to develop aquaculture. The Blue Revolution has brought improvement in aquaculture by adopting new techniques of fish breeding, fish rearing, fish marketing, and fish export. Under the Blue Revolution programme, there had been a tremendous increase in the production of shrimp. Andhra Pradesh and Tamil Nadu have developed shrimp in a big way. The Nellore District of Andhra Pradesh is known as the '**Shrimp Capital of India**'.

There are more than 1800 species of fish found in the sea and inland waters of India, of which a very few are commercially important. The important sea fish include catfish, herring, mackerels, perches, mullets, Indian salmon, shell fish, eels, anchovies, and dorab. Similarly, the main fresh water fish include catfish, loaches, perches, eels, herrings, feather backs, mullets, carps, prawns, murrels, and anchovies. The production of fish in the country has been shown in **Table 9.16**, while **Fig. 9.21** shows the statewise percentage– production of fisheries.

Table 9.16 *India—Fish Production (production in million tonnes)*

Year	*Marine Fish*	*Inland Fish*	*Total*
1950–51	0.535	0.240	00.75
1970–71	10.86	6.75	17.56
1990–91	23.00	15.36	38.36
2000–2001	28.11	23.23	56.75
2010–2011	29.89	48.62	78.51

Source: ***India 2012,*** pp 118-119.

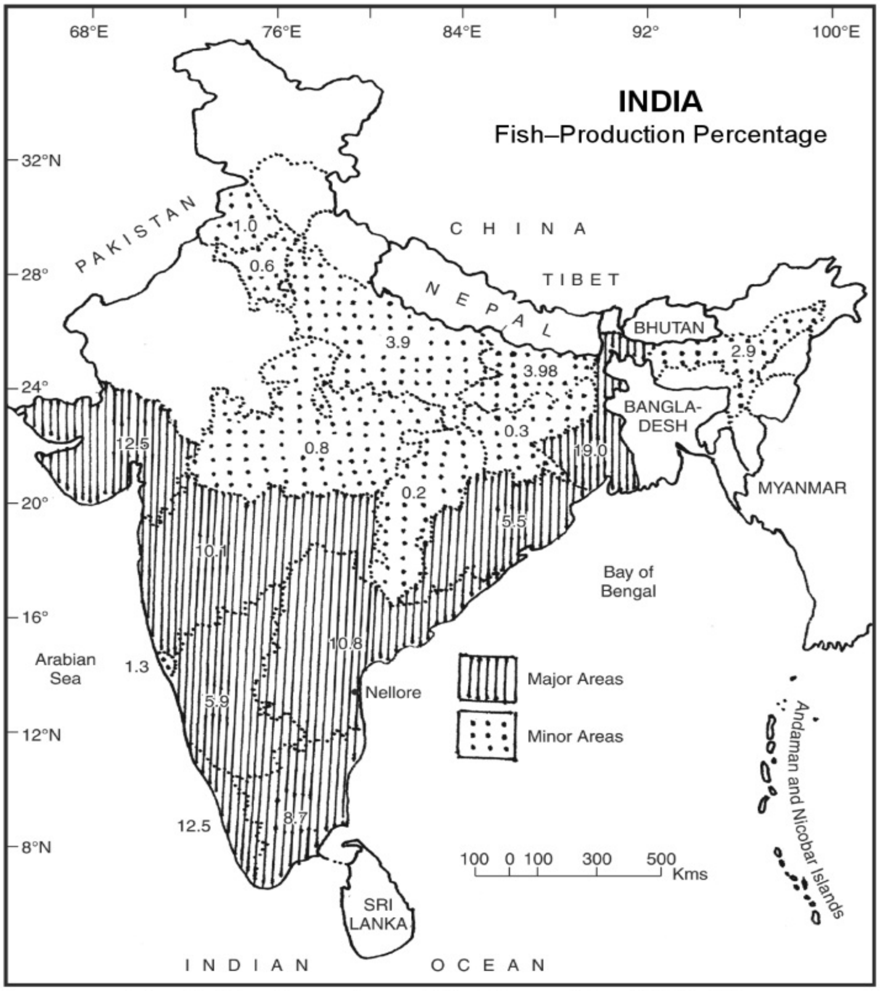


Fig. 9.21 Percentage of Fish Production (2005–06)

It may be observed from **Table 9.16** that the fish production in the country has increased from 0.75 million tonnes in 1950–51 to 68.69 million tonnes in 2006–2007. Fishing, aquaculture and a host of allied activities, a source of livelihood to over 14 million people as well as a major foreign exchange earner, in 2005–06 contributed about one per cent of the total GDP and 5.3 per cent of the GDP from agriculture sector.

The geographic base of Indian marine fisheries has 8118 km coastline, 2.02 million sq of Exclusive Economic Zone including 0.5 million sq km of continental shelf, and 3937 fishing villages. There are 189 traditional fish landing centres, 59 minor fishing harbours, which serve as bases for about 2,80,000 fishing craft consisting of 1,81,000 non-motorised traditional craft and 54,000 mechanised boats. Out of 180 deep sea fishing vessels, only 60 are in operation at present.

About 50 per cent of the country's total fish production comes from the inland fisheries including the freshwater fisheries like ponds, tanks, canals, rivers, reservoirs, and fresh water lakes.

Marine fisheries contribute about 50 per cent of the total fish production of the country. Kerala is the leading producer followed by Maharashtra, Karnataka, Gujarat, and Goa. The fishing season extends from September to March. The higher fish production in the Arabian Sea is due to the broader continental shelf. The important fish varieties include sardines, mackerel and prawn.

The East Coast contributes about 28 per cent of the total production of marine fish in the country. The fishing activity along the East coast is mainly carried on from Rameswaram in the south to Ganjam in the north, with fishing season from September to April along the Coromandal Coast.

The National Fisheries Development Board has been set up to realise the untapped potential of fishery sector with the application of modern tools of research and development including biotechnology.

Strategies for the Fisheries Development

1. The Indian Council of Agricultural Research has established eight fisheries research institutes. These institutes are developing strategies for the exploitation of various aquatic resources.
2. Refrigeration and cold storage facilities have been provided in Chennai, Cuddalore, Kochi, Kollam, Kozhikode, Mumbai, Pune, Ratnagiri, and Thiruvananthapuram.
3. Training centres for fishermen have been established at Satpati (Maharashtra), Veraval (Saurashtra), and Kojan and Tutukandi (Tamil Nadu).
4. Fishing farm docks have been established at Cuddalore, Royapuram (Tamil Nadu), Kandla, Veraval (Gujarat), Vijinjam (Kerala), and Port Blair.
5. Various programmes have been launched by the government for the development of inland fisheries. Over five hundred fish farms have been established by the central government in collaboration with the state governments.
6. The Indian Council of Agricultural Research (ICAR) has established 422 district level Fish Farms in different parts of the country with due emphasis on development.
7. Under the Jawahar Rozgar Yojna, village panchayats have been authorised to carry out fisheries development programmes in respective villages.
8. Under the programme of Development of Model Fishermen Villages, basic civic amenities such as housing, drinking water and construction of community halls for fishermen villages are provided.
9. Brackish Fish Farmers Development Agencies (BFDA) functioning in the coastal areas of the country are providing a package of technical, financial and extension support to shrimp farmers.
10. Insurance facilities have been extended to fishermen for the insurance and security of their life.
11. The government is collecting data on the micro-climates of various water bodies to promote fisheries in the country.
12. Development of Fishing Harbours: Six majors fishing harbours (Cochin, Chennai, Vishakhapatnam, Roychowk, Paradwip and Mumbai), 62 minor fishing harbours and 194 fish landing centres have been constructed in various coastal states (India, 2012, p. 120).

Problems and Prospects

Despite tremendous success in the development of fisheries in the country during the last four decades, pisciculture is facing a number of problems.

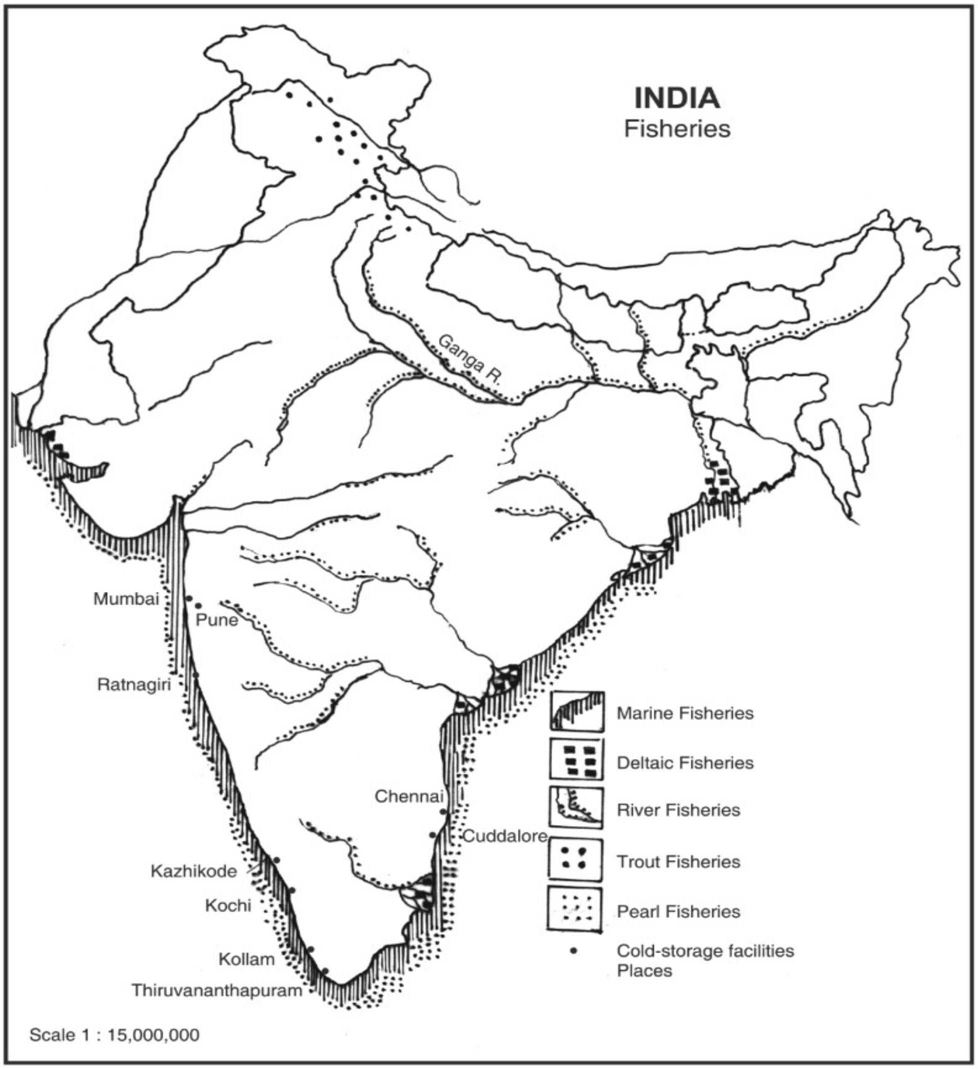


Fig. 9.22 Inland and Marine Fisheries

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

5. Unpredictable nature of monsoon as a result of which the inland fisheries suffer adversely.
6. Problem of marketing, storage, and transportation.
7. Inadequacy of research and extension service facilities.
8. There is need of Pink Revolution (Prawns) in the coastal regions of the country.

AQUACULTURE

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

Growth and Development of Aquaculture

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

Types of Aquaculture

1. Algaculture

Algaculture is a form of aquaculture involving the farming of species of algae.The majority of algae that are intentionally cultivated fall into the category of microalgae, also referred to as phytoplankton, microphytes, or planktonic algae.

Macroalgae, commonly known as seaweed, also have many commercial and industrial uses, but due to their size and the specific requirements of the environment in which they need to grow, they do not lend themselves as readily to cultivation on a large scale as microalgae and are most often harvested wild from the ocean.

2. Fish Farming

Fish farming is the principal form of aquaculture, while other methods may fall under mariculture. It involves raising fish commercially in tanks or enclosures, usually for food. Fish species raised by fish farms include salmon, catfish, tilapia, cod, carp, trout, and others.

Increasing demands on wild fisheries by commercial fishing operations have caused widespread overfishing. Fish farming offers an alternative solution to the increasing market demand for fish and fish protein.

3. Freshwater Prawn Farming

A freshwater prawn farm is an aquaculture business designed to raise and produce freshwater prawn or shrimp for human consumption. Freshwater prawn farming shares many characteristics with, and many of the same problems as, marine shrimp farming. Unique problems are introduced by the development life cycle of the main species (the giant river prawn, *Macrobrachium rosenbergii*).

4. Integrated Multi-Trophic Aquaculture

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

5. Mariculture

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

6. Shrimp Farming

A shrimp farm is an aquaculture for the cultivation of marine shrimp for human consumption. Commercial shrimp farming began in the 1970s, and production grew steeply, particularly to match the market demands of the US, Japan, and Western Europe.The total global production of farmed shrimp reached more than 1.8 million tonnes in 2005, representing a value of nearly 9,500 million US dollars. About 75% of farmed shrimp is produced in Asia, in particular in China and Thailand.The other 25% is produced mainly in Latin America, where Brazil is the largest producer.The largest exporting nation is Thailand. Shrimp farming on modern lines is being done in Andhra Pradesh (Nellore District), a state of India (see Blue Revolution)

APICULTURE (BEEKEEPING) OR GOLDEN REVOLUTION

Apiculture is the science and culture of honeybees and their management. Beekeeping (or apiculture, from Latin *apis*, a bee) is the practice of intentional maintenance of honey bee colonies, commonly in hives, by humans. A beekeeper (or apiarist) may keep bees in order to collect honey and beeswax, or for the purpose of pollinating crops, or to produce bees for sale to other beeskeeper. A location where bees are kept is called an apiary.

History of Beekeeping

Globally, there are more than 20,000 species of wild bees, many of which are solitary or which rear their young in burrows and small colonies, like mason bees or bumblebees. Beekeeping, or apiculture, is concerned with the practical management of the social species of honey bees which live in large colonies of upto 100,000 individuals.

Wild Honey Harvesting

Robbing honey from wild bee colonies is one of the most ancient human activities and is still practiced by aboriginal societies in parts of Africa, Asia, Australia, and South America.

Domestication of Wild Bees

At some point humans began to domesticate wild bees in artificial hives made from hollow logs, wooden boxes, pottery vessels, and woven straw baskets or '*skeps*'.

Invention of the Moveable Comb Hive

Early forms of honey collecting entailed the destruction of the entire colony when the honey was harvested.The wild hive was crudely broken using smoke to suppress the bees, the honeycombs were torn out and smashed up, along with the eggs, larvae, and honey they contained.The liquid honey from the destroyed brood nest was crudely strained through a sieve or basket.This was destructive and unhygienic but for honey-gathering societies this did not matter since the honey was generally consumed immediately and there were always more wild colonies to exploit.

Traditional Beekeeping

Fixed Frame Hives

There are considerable regional variations in the type of hive in which bees are kept.A hive is a set of rectangular wooden boxes filled with moveable wood or plastic frames, each of which holds a sheet of wax or plastic foundation. The bees build cells upon the sheets of foundation to create complete honeycombs. Foundation comes in different sizes: 'worker foundation' which enables the bees to create small, hexagonal worker cells, and 'drone foundation' which allows the bees to build much larger cells—the drone cells for the production of male bees.

The bottom box, or brood chamber, contains the queen and most of the bees ; the upper boxes, or supers, contain just honey.Only the young nurse bees can produce wax flakes which they secrete from between their abdominal plates; they build honeycomb using the artificial wax foundation as a starting point, after which they may raise brood or deposit honey and pollen in the cells of the comb.These frames can be freely manipulated and honey supers with frames full of honey can be taken and extracted for their honey crop.

Modern Beekeeping

Movable Frame Hives

In the USA, the Langstroth hive is commonly used. The Langstroth was the first successful top-opened hive with movable frames, and designs of hive have been based on it. Langstroth hive was, however, a descendant of Jan Dziezon's Polish hive designs. In the United Kingdom, the most common type of hive is the British National Hive, but it is not unusual to see some other sorts of hive(Smith, Commercial, and WBC, rarely Langstroth). Straw skeps, bee gums, and unframed box hives are now unlawful in most US states, as the comb and brood cannot be inspected for diseases. However, straw skeps are still used for collecting swarms by hobbyists in the UK, before moving them into standard hives.

Top Bar Hives

A few hobby beekeepers are adopting various top bar hives of the type commonly found in Africa. These have no frames and the honey-filled comb is not returned to the hive after extraction, as it is in the Langstroth hive. Because of this, the production of honey in a top bar hive is equal to only about 20% of the production of a Langstroth hive, but the initial costs and equipment requirements are far lower. Top-bar hives also offer some advantages in interacting with the bees and the amount of weight that must be lifted is greatly reduced. Top Bar Hives are being widely used in developing countries in Africa and Asia as a result of 'Bees For Development' programme.

Types of Beekeepers

Beekeepers generally categorise themselves as:

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

The Colony of Bees

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

The production and consumption of honey in some of the selected countries of the world has been given in **Table 9.17**

Table 9.17 *World Honey Production and Consumption in 2005*

Country	*Production (1000 metric tonnes)*	*Consumption (1000 metric tonnes)*
Russian Federation	52.13	54
United States of America	79.22	163
Argentina	93.42	3
China	299.33	238
Turkey	82.34	66
India	52.23	45

Source: ***Food and Agriculture Organisation of the United Nations.***

It may be seen from the **Table 9.17** that China is the largest producer and consumer of honey in the world with a production of about 300 thousand metric tonnes annually. Argentina stands second with an annual production of 93.42 thousand metric tonnes, followed by Turkey, USA, and India. India produced over 52 thousand metric tonnes in 2005.

SERICULTURE

Sericulture or silk farming is the rearing of silkworms for the production of raw silk. Although there are several commercial species of silkworms, *Bombyx mori* is the most widely used and intensively studies. According to Chinese records, the discovery of silk production from *mori* occurred about 2700 BC making the start of history of silk. Today, China and Japan are the two main producers, together manufacturing more than 50 per cent of the world production each year. India has a unique distinction of producing all the five known varieties of silk viz. mulberry, Oaktsar, tropical tsar, eri and muga.

Production

Silkworm larvae are fed on mulberry leaves and after the fourth molt, they climb a twig placed near them and spin their silken cocoons. The silk is a continuous-filament fibre consisting of fibroin protein, secreted from two salivary glands in the head of each larva, and a gum called *sericin*, which cements the two filament together. The sericin is removed by placing the cocoons in hot water, which frees silk filaments and readies them for reeling. The immersion of cocoons in hot water also kills the silkworm larvae.

In India, silk worms thrive on the leaves of mulberry, *mahua, sal, ber,* and *kusum* trees. India ranks third among the silk producing countries of the world. In India, about 4.5 lakh hectares of area is under mulberry cultivation. Silk production is mainly confined to areas between 15° and 34° N latitudes. About 55 lakh people are engaged in this industry.

The state of Karnataka is the largest producer of raw silk (65%) follwed by Andhra Pradesh (17%) West Bengal (8%), Tamil Nadu (5%), Assam (2.5%) and Jammu & Kashmir (1.2%), Limited quantity of mulberry silk is also produced in Arunachal Pradesh, Chhattisgarh, Himachal Pradesh, Jharkhand, Kerala, Madhya Pradesh, Maharashtra, Manipur, Odisha, Punjab, Tripura, Uttarakhand and Uttar Pradesh.

The growth pattern of mulberry cultivation has been given in **Table 9.18.**

Table 9.18 *Trend in Raw Silk Production*

Year	*Silk (lakh kg.)*
1950–51	52.50
1960–61	78.32
1970–71	231.90
1980–81	459.30
1990–91	114.85
2000–01	165.00
2005–06	167.00

Source: ***Statistical Abstracts India***, 2005–06.

It may be seen from the Table 9.18 that in 1950–51 the raw silk production was 52.50 lakh kg. which rose to 167 lakh kg. in 2005–06. Silk production has a great future in India.

POULTRY FARMING (SILVER REVOLUTION)

Poultry farming is the practice of raising poultry, such as chickens, turkeys, ducks, geese, as a subcategory of animal husbandry, for the purpose of farming meat or eggs for food. It requires small capital and provides additional income and job opportunities to a large number of rural population in the shortest possible time. The vast majority of poultry are farmed using factory farming techniques; according to the Worldwatch Institute, 75 per cent of the world's poultry meat, and 70 per cent of eggs are produced in this way.

The contrasting method of poultry farming in free range and friction between the two main methods, has led to long term issues of ethical consumerism. Opponents of the factory farming argue that it harms the environment and creates health risks, as well as abuses animals. In contrast, proponents of factory farming highlight its increased productivity, stating that the animals are looked after in state-of-the art confinement facilities and are happy; that it is needed to feed the growing global human population; and that it protects the environment.

Poultry Farming in India

Poultry farming in India is quite old. At present, more than three million people are directly or indirectly employed in poultry farming. It produced around 2.4 million tonnes of chicken meat in 2010–11. Between the 1970 and 2011, the annual per capita availability of eggs has quadrupled from 10 to 45, while the corresponding increase in chicken meat has been faster from, 145 grams to 1.6 kgs. India produces more than 59.84 billion eggs per year (India 2012, p. 109).

Poultry sector besides employment generation and subsidiary income increase provides nutritional security especially to the rural poor. Further, landless labourers derive more than 50 per cent of their income from livestock, especially poultry.

While India's share of world trade in the poultry and poultry production continues to be very small in the last decade the value of such exports has increased from 11 crore in 1990–91 to Rs. 350 crore in 2010–11. Exports of products such as live poultry, eggs, hatching eggs, frozen eggs, egg powder, and poultry meat to countries including Bangladesh, Sri Lanka, South West Asia, Japan, Denmark, Poland, USA, and Angola augurs well for industry. The value of output from poultry sector is nearly Rs. 20,000 crore.

In India, there are over 260 million hens in the country which laid down about 30 billion eggs during 2010–11. The largest number of poultry population is in Andhra Pradesh followed by Bihar, West Bengal, Tamil Nadu, Maharashtra, Assam, Karnataka, Kerala, Odisha, Madhya Pradesh, Uttar Pradesh, Punjab, and Haryana. Most of the important poultry farms are being developed around almost all the important urban centres like Mumbai, Kolkata, Delhi, Chennai, Hyderabad, Bangalore, Pune, Nagpur, Shimla, Bhubaneshwar, Ajmer, Chandigarh, and Bhopal.

Uninterrupted supplies of feed as well as *avian influenza* are critical for the continued robust growth of the poultry sector. The first outbreak of avian influenza occurred in India in the state of Maharashtra in the Nandurbar district on 18th Feb. 2006. The Government of India initiated immediate steps to control and contain the outbreak.

The Central Poultry Development Organisation has been playing a pivotal role in the implementation of the policies of the Government with respect to poultry as a tool for alleviating nutritional hunger and palliating the impecuniosities of the resource-poor farmers, especially the women. The mandate of the Central Poultry Development Organisation has been specifically revised, by restructuring all poultry units of this Department to focus on improved indigenous birds, which lay on an average 180–200 eggs per annum and have a vastly improved FCR ratio in terms of feed consumption and weight gain. The Central Poultry Development Organisations have been entrusted with the responsibility of producing excellent germplasm in the form of day-old chicks and hatching eggs of these varieties like Nierbheek, Hitkari, Vanaraja, Shyama, Cari, Chabro, etc. Besides, these organisations are also playing a crucial role in analysing feed samples.

These Organisations, besides conducting the activities stated above, also work for scaling-up of diversification of other avian species like Ducks/Turkeys/Guinea fowl/Japanese Quail, and upgrading of Training Unit into International Tropical Avian Management Institutes in which private-public partnership is envisaged. Presently these Organisations are also supporting and hand-holding the Centrally-sponsored Schemes related to assistance to state poultry farms.

A new Centrally-sponsored scheme called Assistance to State Poultry, is being implemented during the Tenth Plan where one time assistance is provided to suitably strengthen the farms in terms of hatching, brooding, and rearing of birds with provision for feed mill and their quality monitoring and in-house disease diagnostic facilities.

A new scheme, Dairy/Poultry Venture Capital Fund, has been launched during the 2004–05, wherein there is a provision to grant subsidy on interest payment. The nodal agency for the implementation of this scheme is NABARD through nationalised commercial bank. In 2005–06, a total of 49 poultry units involving 2.17 crore was approved.

HORTICULTURE

Horticulture is a branch of agriculture relating to the cultivation of fruits, vegetables and ornamental plants. Horticulture is a capital and labour intensive agriculture. India is bestowed with varied agro-climates, which is highly favourable for growing large number of horticultural crops such as fruits, vegetables, spices, root tuber, ornamental, aromatic plants, medicinal species and plantation crops like coconut, arecanut, cashew and cocoa. Presently, horticulture crops occupy about 10 per cent of the gross cropped area of the country, producing about 160 million tonnes. India is the second largest producer of fruits and vegetables. The total production of fruits has been estimated at about 63 million tonnes from 5.7 million hectares. Vegetables occupy an area of 7.8 million hectares with a production of 125 million tonnes (India 2009, p. 183). India's share in world fruit and vegetable production is 10 per cent and about 13.25 per cent respectively.

Fruits

Indian climate favours the development of a large range of varieties of fruits. Indians' share in the total fruit production of the world is 10 per cent. Mango, banana, citrus, pineapple, papaya, guava, sapota (*cheekoo*), jackfruit, litchi, and grapes, among the tropical and subtropical fruits; apple, pear, peach, plum, apricot, almond, walnut, among the temperate fruits; and aonla, ber, pomegranate, fig, phalsa, among the arid fruits are important. India leads the world in the production of mango, banana, sapota (*cheekoo*) and nimboo (*acid lime*), and in productivity of grapes per unit land area.

India is the largest producer of mango, banana, sapota, and acid-lime. About 40 per cent of world's mango and 23 per cent of world's banana are produced in the country. In grapes, India has recorded the highest productivity per unit area in the world. The overall production of the horticulture crops registered an increase of 8 per cent during 2004–05 as compared to 2003–04, while the percentage increase in fruit production has been about 1.5 per cent during the same period.

Vegetables

More than 40 kinds of vegetables are grown in India. Important vegetable crops grown in the country are potato, tomato, onion, chillies, carrot, raddish, turnip, beans, ladiesfinger, guard, letuce, brinjal, cabbage, cauliflower, spinach, okra, and peas.

India is next only to China in area and production of vegetables, and occupies the first position in the production of cauliflower, second in onion, and third in cabbage in the world. The area and production of major vegetables during 2004–05 is estimated at 6.30 million hectares with a production of 93 million tonnes and average productivity of 14.8 tonnes per hectare.

Flowers

Though flower cultivation has been practised in India since times immemorial, floriculture has blossomed into a viable business only in recent years. The increased growing of contemporary cut-flowers like rose, gladiolus, tuberose, carnation, etc. has led their use for bouquets and arrangements for gifts, as well as decoration of both home and workplace. A growing market, as a result of improvement in the general level of well-being in the country and increased affluence, particularly among the upper and the middle classes, has led to transformation of the activity of flower growing into a well developed industry. Availability of diverse agro-climatic conditions in the large country, facilitates production of all major flowers throughout the year in some part or the other, and improved transportation facilties, have increased the availability of flowers all over the country.

India has made noticeable advancement in the production of flowers. Floriculture is estimated to cover an area of 1.14 lakh hectares with a production of 670,000 million tonnes of loose flowers and 13,010 million tonnes of cut flowers.

A major programme, namely National Horticulture Mission (NHM) was launched in the country during the Tenth Five Year Plan with effect from 2005–06. The main objectives of the Mission are to enhance horticulture production through area based regionally differentiated strategies to improve nutritional security and income support to farm households, and to promote and disseminate technologies.

DRY FARMING

The spread of the dry farming is in the regions where the average annual rainfall is less than 75 cm and irrigation facilities are not available. About 60% of the net-cultivated area is under dryland and rainfed cultivation in India, which contributes 40% of the total agricultural production. In these areas the rainfall is scanty and uncertain, where hot and dry conditions prevail. It is not only that the average annual rainfall is low, the variability of rainfall in these areas varies between 25 to 60 per cent. Agriculture in the dry farming regions belongs to fragile, high risking and low productive agricultural ecosystem. The areas in which more than 75 cm of average annual rainfall is recorded are known as the areas of rain-fed agriculture (**Fig. 9.23**).

In India dry-lands cover about 32 million hectares or about 60 per cent of the net arable land. The dry farming areas cover the greater parts of Rajasthan and Gujarat. Moreover, there are small tracts of dry land farming in Punjab, Haryana, Maharashtra, Andhra Pradesh, Karnataka, Himachal Pradesh, Jammu and Kashmir, Jharkhand, Odisha, Uttarakhand, Uttar Pradesh, West Bengal and Tamil Nadu. These areas having scanty rainfall and high variability of rainfall are adversely affected by erratic precipitation, frequent droughts, high temperature, and high wind velocity resulting in soil erosion.

Significant Features of Dry Farming

Dry farming in India is characterised by the following:

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

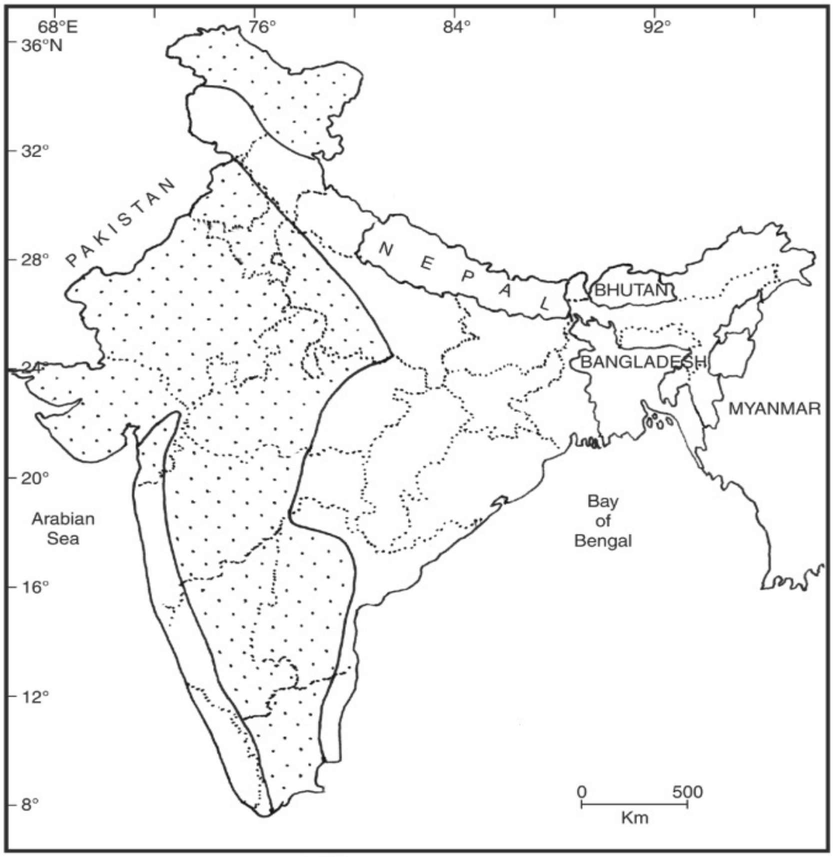


Fig. 9.23 Dry Farming Areas

7. Where ever possible, thrifty use of water.
8. Development and efficient use of solar energy.

Crops

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

The cropping patterns and their combinations in the dry-farming regions of India have been given in **Fig. 9.24.**

Main Problems of Dry Farming

The main problems of dry farming agriculture are as under:

1. Scarcity of precipitation, erratic occurrence of rains leading to famines, droughts, and floods.
2. The soils, being sandy, lack in humus and organic nutrients.

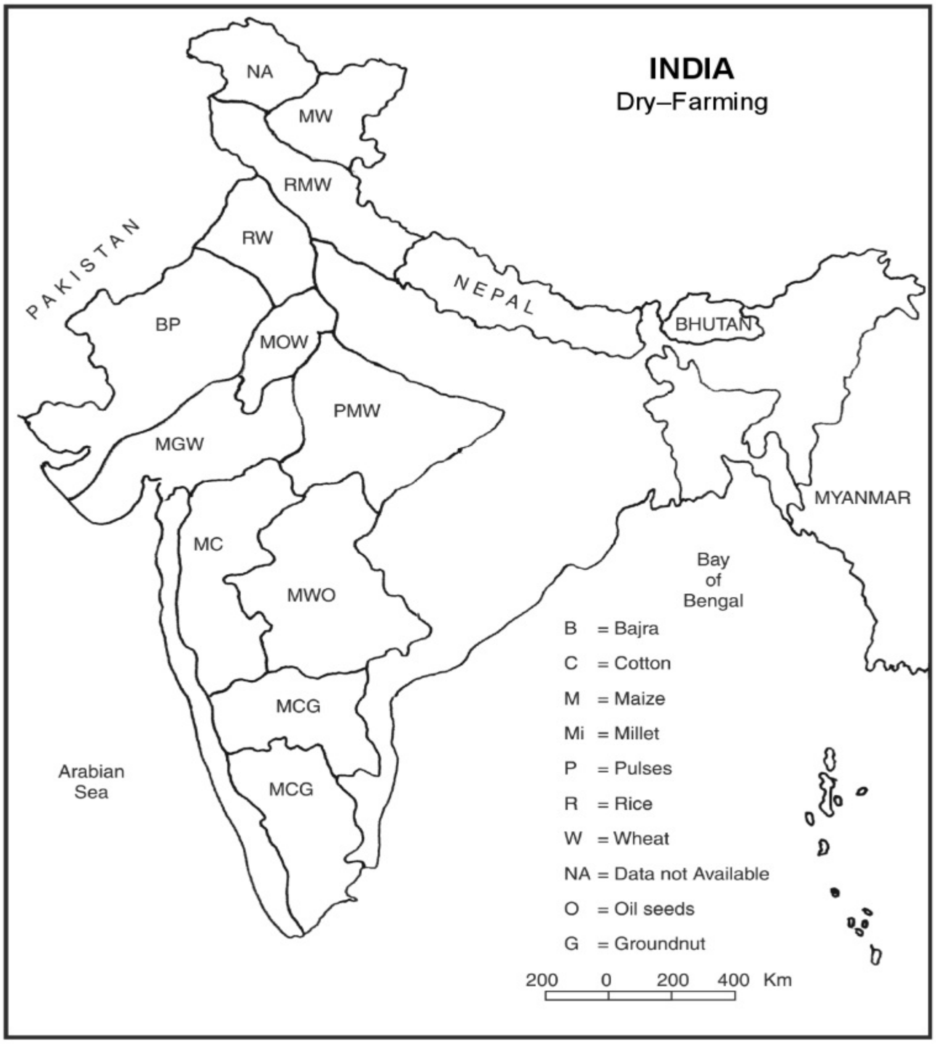


Fig. 9.24 Dry Farming Areas Crop Combination (2005–06)

3. The dry farming areas are highly vulnerable to soil erosion.
4. These are low yields per unit area.
5. In the absence of moisture and irrigation, the use of High Yielding Varieties and new technology is not possible.
6. Most of the farmers in the dry farming regions being poor, are not able to apply the new costly inputs.
7. These areas are not having the basic irrigation and other infrastructural facilities, like roads, marketing and storage.

Strategy for Development

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

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

In addition to these, there are many other practices like contour-ploughing, contour-bunding, and field-bunding that help water conservation measures. Practice like mulching prevents evaporation from the soil. Deep placement of manures and fertilisers would help the roots to penetrate deep layers. This, along-with weed control, will help in increasing the yield. The latest advance technology of dry farming is to lay stress on soil moisture and its conservation. It should be noted that in the dry areas, soils suffer from nutrient deficiency, particularly nitrogen. Band placement of fertilisers in sub-soil layers is a good method of helping the roots to go deep for exploiting the conserved moisture. The World Congress on Conservation Agriculture was organised in February 2009 at New Delhi in order to address the issues of improving efficiency, equity and environment in which the problems and prospects of dry farming were also discussed.

AGRIBUSINESS

Agribusiness means agriculture for commercial purpose. Johnston and colleagues have defined agri-business as farming organisation applying modern management techniques and accounting methods with the aim of maximising final profit. The concept is applied differently in USA and Western Europe. In USA, agribusiness has grown as a result of increased involvement by food processing companies in the actual production of their own raw material inputs. Such companies have purchased farms and run them as subsidiary elements within their overall production system, while in Western Europe such integration of farm production with processing is less common. In Western Europe and also in some developing countries like India, agribusiness constitutes large farming companies independent of food processors. But there are certain characteristics which are common to all agribusiness. More specifically, that part of modern national economy devoted to production, processing, and distribution of food and fibre products and by-products falls under the category of agribusiness.

Characteristics of Agribusiness

Agribusiness essentially has the following characteristics:

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

In highly industrialised countries, many activities essential to agriculture are carried out at places away from the farm. These include the development and production of equipment, fertilisers, and seeds. In some countries, the processing, storage, preservation, and delivery of agricultural products have also been separated from basic farming. In consequence, farming itself has become increasingly specialised and business-like. Some business firms even raise crops, as in the case of winery, that operates its own wine-yards, or large commercial producers who maintain their own farms. Many of these farms are extensively mechanised with computer technology to increase production.

In recent years, conglomerate companies that are involved in non-agricultural business have entered into agri-business by buying and operating large farms. Some food processing farms that operate farms have begun to market fresh produce, under their land resources.

India has recently entered into agribusiness, which consists of processed and unprocessed agricultural products. In the processed category are processed fruits and vegetable juices, meat, and meat and fish products, sugar and molasses, coffee and tobacco, spices, and wheat, tea, and rice. Entry into agribusiness requires polishing and parboiling. Commodities like fruits, vegetables, and eggs are sorted out according to size, shape, and colour. Canning of fruits and vegetables constitute an important part of agribusiness. However, there is need in India to develop facilities for research to evolve new techniques and standardised recipes and methods of manufacture of fruits and vegetable products.

It is also necessary to develop sophisticated allied industries such as manufacture of containers and closures (covers) equipments and machinery used by fruits and vegetable processing. Further, grant of subsidies and incentives like the removal of duty on tin plates, sugar, and railway freight to processors is necessary to encourage exports.

India can have good agribusiness in mango products and other processing industries based on fruits like apple, pineapple, oranges, lemon, lime, *aonla* (*Phyllanthus emblica sp.*), and guava, and vegetables like peas, tomato, and potatoes (canned). Other fruits and vegetables which are exported to some extent in the processed form are apricot, *bel* (*Aegle marmelos*), peach, plum, strawberry, ladies finger, brinjal, cabbage, carrot, *karela* (bitter gourd), *tinda* (*citrullus volgaris*), mustard green, *parwa*l, spinach, turnip, chillies, and ginger.

NATIONAL COMMISSION ON FARMERS

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

1. Assest reforms covering land, water, livestock, and bio-resources
2. Farmer-friendly support services covering extension, training and knowledge
3. Credit and insurance

4. Assured and remunerative marketing
5. Inputs and delivery services
6. Bringing agriculture in Concurrent List of the Constitution
7. Setting up of a National Food Security and Sovereignty Board
8. Universalisation of Public Distribution System
9. Setting up of an India Trade Organisation
10. Launch of a Rural-Non-farm Livelihood Initiative (when implemented would be able to absorb higher number of people dependent on agriculture)

INDIAN AGRICULTURE—CHALLENGES AND PROSPECTS

Agriculture, the dominant economic activity of India, faces a number of challenges on various fronts. Some of the important challenges Indian agriculture is facing at present are given below:

1. **Stunted Yield:** The yield of most of the crops has not improved substantially and in some cases (wheat, gram, pulses, sugarcane, and bajra) fluctuated downward. Therefore, there is a need to focus on improving productivity. At the same time there is a need to speed up the growth of allied activities.
2. **Dry Farming:** Agriculture in the dry-farming areas is highly vulnerable to drought. In such areas, micro-irrigation system needs to be developed. Watersheds management, water harvesting and participatory approach can be of great importance in such areas.
3. **Inadequate Marketing Facilities:** In the greater parts of the country, including the areas of Green Revolution, the farmers are not getting remunerative prices. There is a need to narrow the gap between producer prices and consumer prices through proper marketing support. The development of marketing infrastructure and storage and cold-chains and spot markets that are driven by modern technology may go a long way in providing good returns to the farmers.
4. **Inadequate Formal Sources of Credit:** As per the report of the committee on Financial Inclusion (January 2008), more than 73 per cent of the farmer households have no access to formal sources of credit. Under the debt pressure of private money lenders, thousands of farmers have committed suicide. To exempt the full or part of the loan of the marginal, small, and medium farmers is an immediate need of the hour.
5. **Mismanagement of Public Distribution System:** The Public Distribution System is not working satisfactorily. The weaker section of the society, especially the people below the poverty line, should be provided sufficient quantity of food at a highly subsidised rate.
6. **Sustainability of Agriculture:** After the diffusion of the High Yielding Varieties, especially in Punjab, Haryana, and western Uttar Pradesh, the farmers have adopted rice and wheat crop combination. Both these crops, however, are soil exhaustive, damaging the soil fertility and degrading the environment.
7. **Soil Erosion:** Soil erosion, water-logging, reduction in underground watertable are some of the serious problems of Indian agriculture. These problems are causing ecological imbalances. In brief, while the challenges faced by the agriculture and the allied sector are numerous, the possibilities for new investment, the use of new technologies are imperative. These issues of the meso and micro levels deserve to be addressed immediately.

NEW NATIONAL AGRICULTURAL POLICY

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

(i) Efficient use of resources and technology.
(ii) Timely and adequate credit is to be provided to farmers.
(iii) Private sector investment in agriculture would be encouraged.
(iv) To protect the farmers against the adverse effects of implementation of WTO agreement.
(v) To protect the farmers against fluctuations in agricultural prices.
(vi) The restrictions on the movement of agricultural commodities throughout the country would be removed.
(vii) Excise duties on agricultural machinery, fertilizers, etc. will be reduced.
(viii) Package insurance policy for the farmers.
(ix) Rural electrification, rural roads and development of irrigation to be encouraged.
(x) Strengthening agriculture marketing infrastructure.
(xi) Remunerative prices for agricultural products.
(xii) Focus on horticulture, floriculture, animal husbandary and fisheries.

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Chapter 10

Spatial Organisation of Agriculture

CROPPING PATTERNS

Cropping pattern means the proportion of area under different crops at a given point of time. The crop statistics published by the government are used to denote the cropping patterns. Cropping pattern is however, a dynamic concept as it changes in space and time. The cropping patterns of a region are closely influenced by the geo-climatic, socioeconomic, and political factors. In any region, the prevalent cropping patterns are the cumulative results of the past and present decisions of individuals, communities or government and their agencies. These decisions are usually based on experience, tradition, expected profit, personal preferences and resources, social and political pressure.

The physical environment (physiography, climate, soils, water, etc.) imposes limits on the growth and distribution of plants and animals. The role of man in the cultivation of certain crops in a region is also important. Man, by his technological advancement can ameliorate the physical limits. The cultivation of rice in Punjab, Haryana, and Ganganagar District (Rajasthan) testifies this fact. Nevertheless, in different parts of the world, the physical environment reduces the choice of crops, either by prohibiting the growth of certain crops or by reducing their yield per unit area.

Depending on the geo-ecological conditions and availability of irrigation, the cropping patterns vary from region to region. In those regions where the physical diversity is less, the cropping patterns are less diversified and vice versa. For example, in the rainfall deficient areas of Rajasthan (Thar Desert) the farmers grow *bajra* (bulrush-millet), while in the fertile valley of Brahmaputra, rice has the status of monoculture. Contrary to this the soils of the Indo-Gangetic plains are suitable for the cultivation of numerous crops.

In addition to physical environment, the land ownership, the land tenancy, land tenure, size of holding and fields also influence the cropping patterns. A farmer with small holding prefer the cultivation of *labour intensive* crop, while a large holding farmer goes for the *capital intensive* agricultural practices. Cropping patterns are also affected by the infrastructural, institutional and technological factors (see Chapter 9)

The cropping patterns of a region are determined on the basis of area strength of individual crop. The first, second and third ranking crops of an areal unit may be called as the *dominant crops* of that unit. These crops, if occupying more or less the same percentage of the total cropped area, shall be competing with each other and the farmer will decide which crop may fetch him more profit. In general, for the demarcation of cropping patterns of a region, the minor crops (crops occupying less than one per cent of the total cropped area) are ignored.

The *relative yield index* and the *relative spread index* for the determination of suitability of crop may be calculated with the help of the following formula:

$$\text{Relative Yield Index} = \frac{\text{Mean yield of the crop in a component areal unit}}{\text{Mean yield of the total area}} \times 100$$

$$\text{Relative Spread Index} = \frac{\text{Area of the crop expressed as percentage of the total cultivated area in the areal unit}}{\text{Area of the crop expressed as percentage of the total cultivated area}} \times 100$$

On the basis of these indices the suitability of crop grown in a region may be ascertained. If the relative yield is below 90 per cent, then it may be an inefficient crop and therefore, should not be sown in more area of the cultivated land.

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

(i) High yield, high spread
(ii) High yield, low spread
(iii) Low yield, high spread
(iv) Low yield, low spread

On the availability of an alternative, more efficient crop than the existing ones is preferred which leads to new cropping patterns. The cropping patterns may be intensified with the help of short duration *High Yielding Varieties*. Any cropping sequence to be adopted by the cultivator, however, should be flexible. The suitability of a crop and cropping pattern may be judged on the basis of the following:

1. The crop should not accentuate certain diseases as a result of a fixed continuous rotation.
2. The crop should not exhaust on some plant specific nutrients from a particular part of the soil.
3. The crop should be fertility-building and soil-improving.
4. The crop should fetch handsome return to the cultivator and should provide the cultivator employment all the year round.
5. The crop should ensure the optimum utilisation of his resources, particularly inputs like irrigation water, chemical fertilisers, insecticides, pesticides, equipments, power and family labour.

Excluding the areas where Green Revolution is a big success and the areas in which plantation agriculture is being done, Indian farming by and large is subsistence type in character. Consequently food crops occupy over 72 per cent of the total cropped area. Among the cereals, rice and wheat rank first and second in area respectively. The subsistent cropping patterns of India are based on the utilisation of inherent fertility of the soil without much use of modern inputs and technology.

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

CROP CONCENTRATION

Crop concentration means the variation in the density of any crop in a region at a given point of time. The concentration of crops in an area largely depends on its terrain, climate, and soils and agricultural practices of the farmers. Each crop has a maximum, minimum and optimal temperature. The crops have a tendency to have high concentration in the areas of ideal agro-climatic conditions and the density declines as the geographical conditions become less conducive. It is because of these factors that rice has high concentration in east Indian states, wheat in Punjab and Haryana, cotton in black earth region, and *Bajra* in Rajasthan (**Fig. 10.1**).

A number of statistical techniques have been used by agricultural geographers for the demarcation of crop concentration regions. The location quotient method is, however, more reliable as it gives a reliable picture of the relative density of crops.

The Location Quotient Method of Crop Concentration

In the location quotient technique, the regional character of distribution is investigated and determined, first by comparing the proportion of sown area under different crops and ranking them, and secondly, by retaining the crop density in each of the component areal units of the region/country to the corresponding density of the region/country as a whole. This approach makes it possible to measure the regional concentration of the crops objectively. It also helps to identify and differentiate areas that have some significance with regard to the crop distribution within the region.

The location quotient technique may be expressed as under:

$$\text{Crop Concentration Index} = \frac{\text{Area of } x \text{ crop in the component areal unit}}{\text{Area of all crops in the component area unit}} \Bigg/ \frac{\text{Area of } x \text{ crop in the entire region/country}}{\text{Area of all crops in the entire region/country}}$$

By adopting the above technique, if the index value is greater than unity, the component areal unit accounts for a share rather than it would have had if the distribution were uniform in the entire region, and, therefore, the areal unit has a concentration of greater significance. After ascertaining the index values for the crops in the component areal unit, they are arranged in an ascending or descending order. The index scale is calculated by dividing the array into three equal parts to distinguish the high, medium and low concentration. In general, higher the crop concentration index, higher is the level of interest in the production of that crop.

The main advantage of the location quotient technique for the demarcation of crop concentration lies in the fact that it enables the geographers and planners to understand the areas of specialisation of different crops grown in the region at a given point of time. The continuous cultivation of a particular crop in a unit or region, however, leads to progressive reduction in yield. This leads to the depletion of soil fertility as the particular crop exhausts certain nutrients from the soil. Rotation of crops with diverse choice in which leguminous crops are included needs to be practiced by the farmers. A scientific rotation of crops not only makes agriculture more remunerative and dignified occupation, it also makes the agro-ecosystem more resilient and sustainable.

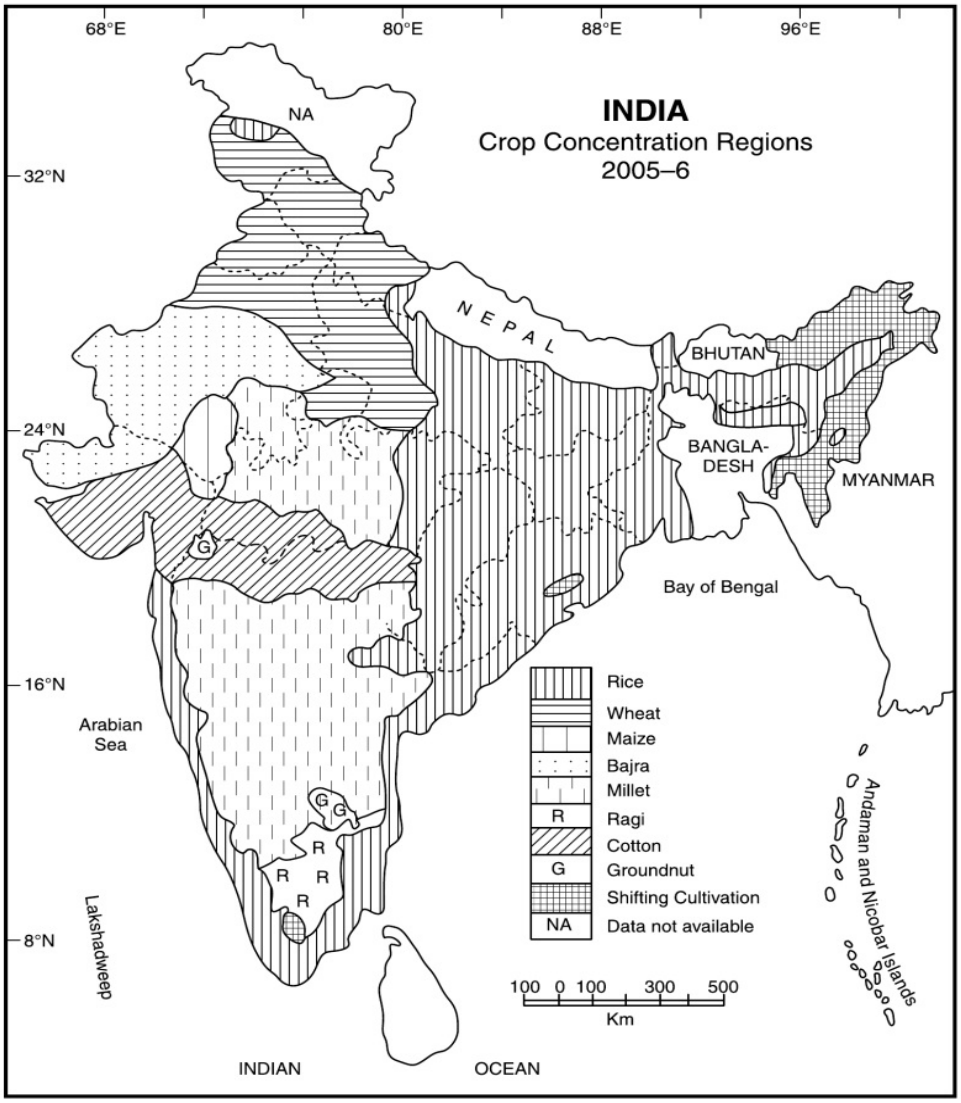

Fig. 10.1 Crop Concentration Regions (2005–06)

AGRICULTURAL PRODUCTIVITY

Agricultural productivity is a synonym for agricultural efficiency. The *yield per unit area* is known as agricultural productivity. Agricultural productivity is generally the result of the physical, socio-economic, and cultural factors. It is also affected by the managerial skill of the farmer. Agricultural productivity, however, is a dynamic concept which changes in space and time.

Agricultural productivity of a region is closely influenced by a number of physical (physiography, terrain, climate, soils, and water), socioeconomic, infrastructural institutional, and organisational factors. Agricultural productivity also depends on the managerial skill of the farmer, his attitude, and aspirations for the better standard of living.

The delineation of agricultural productivity has great significance in the planning of agriculture of a region. The main advantages are:

(i) It helps in ascertaining the relative productivity of the component areal units of a region.
(ii) It helps in identifying the weaker areas which are lagging behind in agricultural productivity.
(iii) The existing patterns of agricultural productivity is a reliable index to assess the agricultural development of the past.
(iv) It provides a sound base for the agricultural development planning.

Agricultural geographers and economists have developed a number of methods for the measurement of agricultural productivity. Some of the important methods used by the geographers are given as under:

1. Output per unit area.
2. Production per unit of farm labour.
3. Agricultural production as grain equivalent (Buck, 1967).
4. Input-output ratio (Khusro, 1964).
5. Ranking Coefficient Method (Kendall, 1939, Stamp, 1960).
6. Carrying capacity of land in terms of population (Stamp 1958).
7. Determining a productivity index on the basis of area and yield (Enyedi, 1964, Shafi 1972).
8. Determining an index of productivity with the help of area and production under various crops in the areal units and converting them in a uniform scale.
9. Converting total production in terms of money (Husain, 1976)
10. To assess the net income in Rupees per hectare of the cropped area (Jasbir Singh, 1985).
11. Assessing net income (farm business income) in Rupees per hectare of cropped area or per adult male unit of farm work-force (Tiwari, Roy, and Srivastava, 1997).

Each of the methods and techniques adopted by the agricultural geographers has its own merits and demerits. None of the techniques, however, gives satisfactory results at the national and/or global level. Some of the techniques are cumbersome and time-consuming to apply for the delineation of agricultural productivity regions. The Kendall's technique of ranking coefficient used by many of the leading geographers for the demarcation of agricultural productivity regions has been illustrated below.

Ranking Coefficient Method of Agricultural Productivity

The ranking coefficient method adopted by Kendall is quite simple and easy to apply. In this technique, the component areal units are ranked according to the per hectare yield of crops and the arithmetical average rank, called the *ranking coefficient* for each of the component areal units is obtained. It is obvious that a component areal unit with relatively high yields will have low ranking coefficient, indicating a high agricultural productivity. In other words, if a component areal unit (district in India) was at the top of every list of crops, it would have a ranking coefficient of one and thus having the highest agricultural productivity. Opposite to this if the areal unit was at the bottom of every list, it would have a ranking coefficient equal to total number of units considered, showing the lowest agricultural productivity among the constituent units.

The ranking coefficient method can be illustrated with the help of an example. Suppose, in a region, there are 80 component areal units (district/tehsil). In a district 'x', on the basis of average yields, wheat ranks 5th, rice 12th, gram 20th, cotton 21st, barley 24th, and sugarcane 38th, pulses 40th and mustard 54th. The average rank, called the ranking coefficient of the district x' would be:

$$\text{Agricultural Productivity} = \frac{5+12+20+21+34+38+40+54}{8 \text{ crops}} = 28$$

The average ranked position of all the units of the region is, thus, calculated and arranged in an ascending order or descending array. The array is divided into three equal parts to ascertain the low, medium and high agricultural productivity. With the help of the index scale, the agricultural productivity of each unit can be ascertained and plotted. The Kendall's technique was applied to determine the agricultural productivity of India at the district level. The agricultural data for each of the districts were computed for the years 2003 to 2006. The ranking coefficients thus obtained were plotted in **Fig. 10.2.**

High Agricultural Productivity

It may be observed from **Fig. 10.2** that high agricultural productivity is found in the Satluj-Ganga Plain, the Brahmaputra Valley, the delta regions of Godavari, Krishna, and Kaveri rivers. In these areas either the irrigation facilities are well developed or there is adequacy of rainfall over greater part of the year. Wheat, rice, maize, pulses, sugarcane, and oilseeds are the main crops grown in the high agricultural productivity regions. The farmers, especially that of Punjab, Haryana, and western Uttar Pradesh are no longer subsistent as most of them are doing agriculture as agri-business.

Medium Agricultural Productivity

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

Low Agricultural Productivity

The regional patterns of agricultural productivity plotted in **Fig. 10.2** show that the state of Jharkhand, Chhattisgarh, parts of Madhya Pradesh, Andhra Pradesh, Gujarat, Maharashtra, Rajasthan, parts of Kerala, Jammu & Kashmir, hilly areas of Uttarakhand, western Rajasthan, northern Gujarat, and the north-eastern hill states have low agricultural productivity. These areas are deficient in irrigation and characterised with low rainfall conditions. In fact most of these areas are susceptible to droughts or floods, and are the less rainfall recording areas. The main crops of these areas are rice, maize, coarse grains, pulses, and oilseeds. The intensification of agriculture in these states is low. Agriculture is mainly rain-fed practiced to meet the family requirements. It is in these areas where the agrarian community is generally at a low level of subsistence and many of them are committing suicides. Special programmes need to be launched to enhance the agricultural productivity of the farmers of these regions.

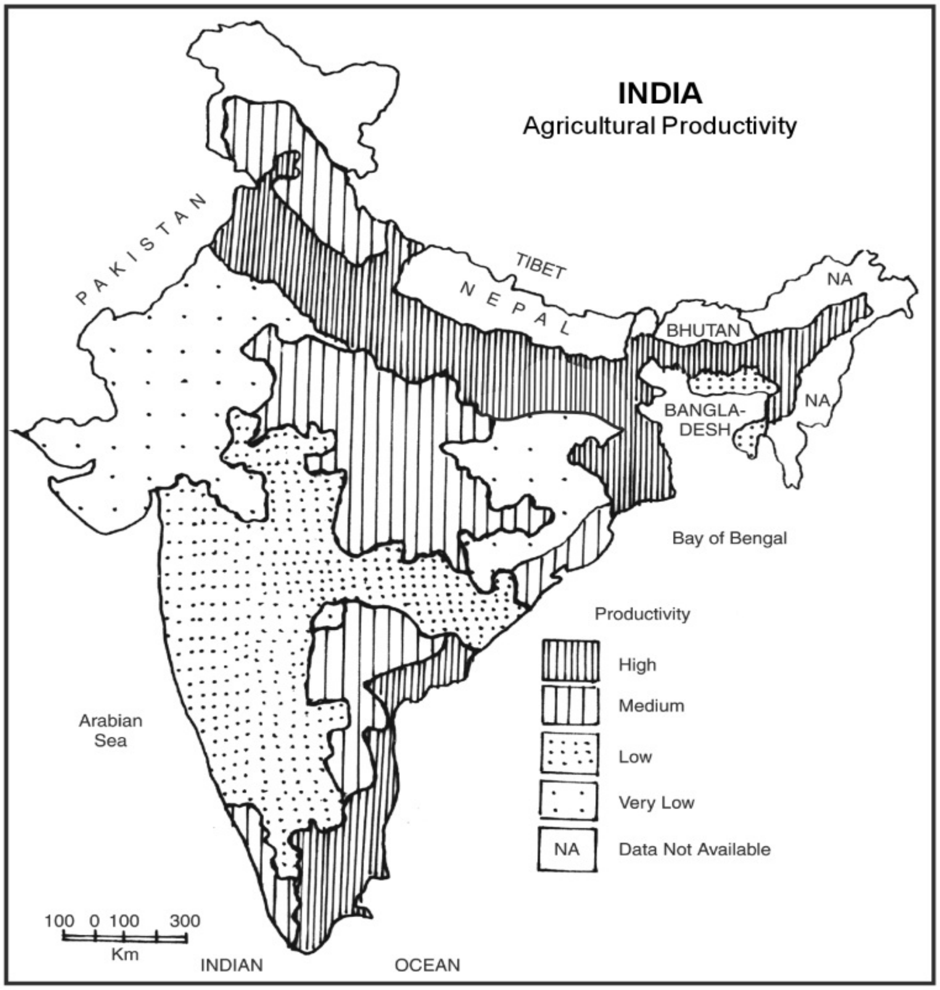

Fig. 10.2 Agricultural Productivity (2003–06)

Very Low Agricultural Productivity

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

AGRICULTURAL INTENSITY

Cropping intensity has been defined as the ratio between the net sown area and the gross or total cropped area. The double and multiple cropped area added into the net cultivated area gives the

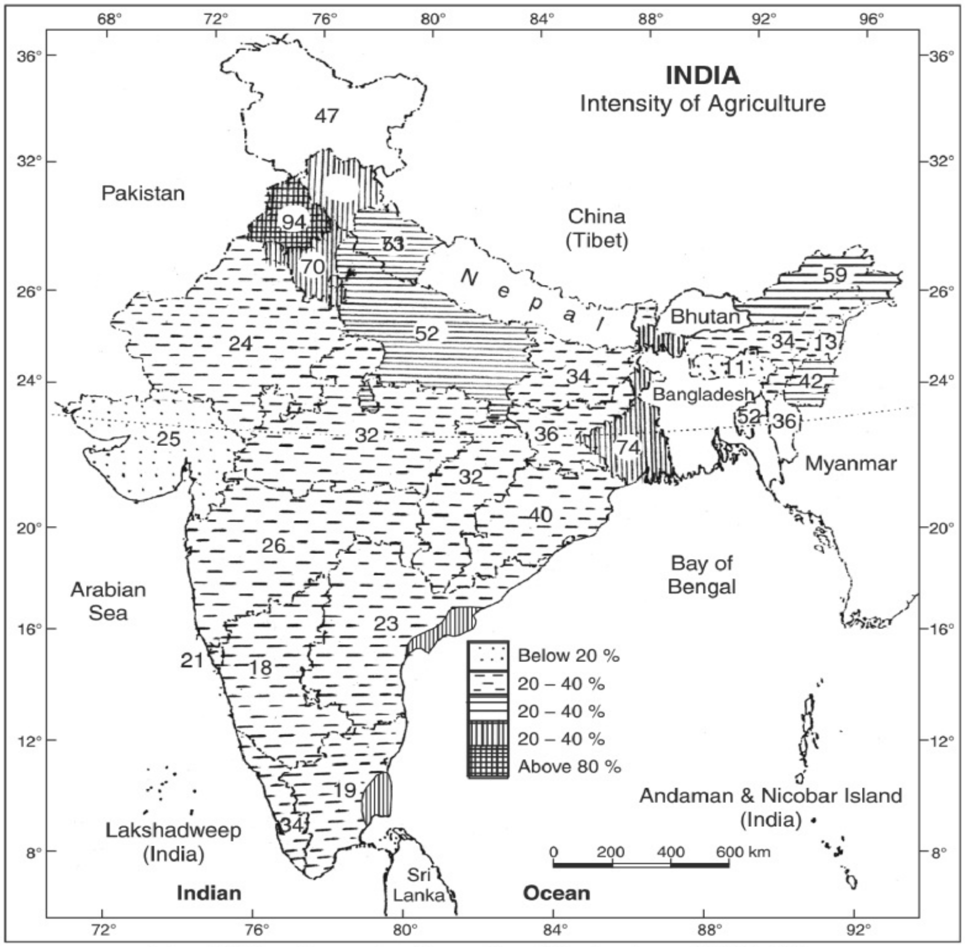

Fig. 10.3 Statewise Intensity of Agriculture (2005–06)

In the arbitrary choice method, the first two or the first three crops in the area are included and the rest of the crops are excluded from the combination. This is an unscientific method as the crops are excluded from the combination without any consideration of their percentage area and their monetary value.

The second method is known as the *statistical method*. This method being based on statistical formula is more scientific and reliable for the objective grouping of crops. In the field of agricultural geography, Weaver (1954) was the first to use statistical technique for the demarcation of crop combination regions of the Middle West (USA).

In his attempt to demarcate the agricultural regions of the Middle West (USA), Weaver based his analysis on acreage statistics. Weaver computed the percentage of total harvested cropland occupied by each crop that held as much as one per cent of the total cultivated land in each of the 1081 counties covered in his research work. He devised a rigorous approach that would provide total cropped area. The Department of Agriculture, Government of India, developed the following formula for the measurement of agricultural intensity:

$$\text{Agricultural Intensity} = \frac{\text{Gross (total) cropped area}}{\text{Net cultivated area}} \times 100$$

The formula may be illustrated with the help of the following example:

Suppose the net cultivated area in a village is 1000 hectares and the total cropped area is 1500 hectares (800 hectares in the *kharif* and 700 hectares in the *rabi* season)

The agricultural intensity in this village would be:

$$\frac{800 + 700}{1000} \times 100 = 150\%$$

The agricultural intensity depends on the geo-climatic, pedological, socio-cultural, and infrastructural factors. Thus, the agricultural intensity is generally high in the well irrigated alluvial plains like Punjab, Haryana, and western Uttar Pradesh. Contrary to this, the agricultural intensity is low in the less rainfall recording areas, e.g. western Rajasthan, in which only one crop (*kharif*) is obtained during the season of general rains.

The agricultural intensity of India for 2005–06 has been plotted in **Fig. 10.3.** It may be observed from **Fig. 10.3** that the agricultural intensity for the country as a whole is 132 per cent (2005–06). The highest agricultural density is in Punjab being 165 per cent, followed by Haryana 160 per cent and Uttar Pradesh 150 per cent. The main cause of high agricultural intensity in these states is the diffusion of short duration High Yielding Varieties of rice and wheat, availability of controlled irrigation, better accessibility to the market, storage facilities, and the progressive nature of the farmers who adopt the new innovations quickly and want to achieve a high standard of living. Contrary to this, the agricultural intensity is low in Rajasthan, north-western Gujarat, Hill states of North East India, Chhattisgarh, Jammu & Kashmir, Himachal Pradesh, and Uttarakhand (excluding its plain districts). In all these regions agriculture is rain-fed, the average annual rainfall is less than 60 cm. and irrigation facilities are not adequately available.

CROP COMBINATIONS

The study of crop combinations constitutes an important aspect of agricultural geography. In fact, it provides a good basis for agricultural regionalisation and helps in the formulation of strategy for agricultural development.

Crops are generally grown in combinations and it is rarely that a particular crop occupies a position of total isolation. The distribution maps of and their concentration are interesting and help in knowing the density and concentration of individual crops, but it is even more important to view the integrated assemblage of the various crops in a region. For example, the demarcation of India into rice or wheat region does not explain the agriculturally significant fact that very often the wheat/rice region also has mustard, gram, pulses, and maize. For a comprehensive and clear understanding of the agricultural mosaic of a region, a systematic study of the crop combinations has great planning significance. The methods applied for the demarcation of crop combination regions may be summed up under two categories:

1. The arbitrary choice method, and
2. The statistical method

an objective, constant and precisely repeatable procedure and would yield comparable results for different years and localities. In his work, Weaver calculated deviation of the real percentages of crops (occupying one per cent of the cropped area) for all the possible combinations in the component areal units against a theoretical standard. The theoretical curve for the standard measurement was employed as follows:

Monoculture = 100 per cent of the total harvested crop land in one crop
2-crop combination = 50 per cent in each of the two crops
3-crop combination = 33.3 per cent in each of the three crops
4-crop combination = 25 per cent in each of the four crops
5-crop combination = 20 per cent in each of five crops
10-crop combination = 10 per cent in each of 10 crops

For the determination of the minimum deviation the standard deviation method was used:

$$SD = \sqrt{\frac{\Sigma d^2}{N}}$$

Where '*d*' is the difference between the actual crop percentage in a given county (areal unit) and the appropriate percentage in the theoretical curve and '*n*' is the number of crops in a given combination.

As Weaver pointed out, the relative, not absolute, value being significant, square roots were not extracted; so the actual formula used was as follows:

$$d = \frac{\Sigma d^2}{n}$$

To illustrate Weaver's technique an illustration can be given from the Gorakhpur district where the percentage share of crops in the total harvested area in a year was as follows: rice—48 per cent, wheat—23 per cent, barley—15 per cent, sugarcane—6 per cent, and pulses—5 per cent.

$$\text{Monoculture} = \frac{(100-48)^2}{1\text{ crop}} = 2704$$

$$\text{2-crop combination} = \frac{(50-48)^2 + (50-23)^2}{2\text{ crops}} = 366.5$$

$$\text{3-crop combination} = \frac{(33.3-48)^2 + (33.3-23)^2 + (33.3-15)^2}{3\text{ crops}} = 216$$

$$\text{4-crop combination} = \frac{(25-48)^2 + (25\ 23)^2 + (25-15)^2 + (25-6)^2}{4\text{ crops}} = 248$$

$$\text{5-crop combination} = \frac{(20-48)^2 + (20-23)^2 + (20-15)^2 + (20-6)^2 + (20-5)^2}{5\text{ crops}} = 248$$

The deviation of the actual percentage from the theoretical curve is seen to be the lowest for a 3-crop combination. This result established the identity and the number of crops in the basic combination for the district of Gorakhpur as rice-wheat and barley.

Weaver's technique when applied at the district level for the data of 2003–06 gives the following eight-crop combinations to India which have been plotted in **Fig. 10.4.**

An examination of **Fig. 10.4** show that the lower Brahmaputra Valley, West Bengal, Odisha and coastal Andhra Pradesh has the monoculture of rice while in Western Rajasthan, *Bajra* is the dominant single most important crop. In Punjab and Haryana rice and wheat enter into combination and in western Uttar Pradesh wheat, rice, and sugarcane constitute the combination. In the remaining parts of the country crop combinations vary between four to eight. In these combinations, wheat, rice, maize, gram, barley, ragi, pulses, oilseeds, cotton, sugarcane, *bajra*, and millets form different crop associations.

Weaver's method has admirably been accepted and applied for the demarcation of crop combination regions as its application results into suitable and accurate grouping of crops. The technique, however, gives most unwieldy combinations for the units of high crop diversification. This method, however, suffers from the setback of laborious calculations.

LAND CAPABILITY

Land capability survey was devised by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) for the demarcation of land capability regions of Australia. Subsequently, the land capability survey was widely applied in the European and Anglo-American countries and in some of the Third World countries.

Land capability survey helps in ascertaining the usefulness of land, its utility for agriculture, forest, industry, tourism, and other land use purposes.

For the delineation of land capability regions, only *physical parameters* are taken into consideration. The demarcation of these regions in fact is on the basis of texture, structure of soil, terrain, slope, run-off, temperature, and precipitation. Thus, in the land capability survey, there is a heavy reliance on the results of soil survey and pedological conditions.

In general each soil group has its own physical and chemical properties. These properties determine the land capability and land suitability. For example, the *regur* soil is good for the cultivation of cotton, sugarcane, and citrus fruits, while the alluvial soil is utilised for wheat, rice, maize, sugarcane, pulses, and oilseeds.

In India, the basic objective of the Soil Survey was to achieve the land capability classification. The All India Soil and Land Use Survey Organisation attempted the land capability survey in 1960 which identified eight land use capability classes given below.

Land Suitable for Cultivation

Class I: Very good arable land with no specific difficulty in farming. It is nearly levelled, well–drained, easily worked soil. These soils are very productive.

Class II: Good cultivable land which needs protection from erosion or floods, drainage improvement and conservation of irrigation water. It has gentle, slope, less than ideal slope.

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

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

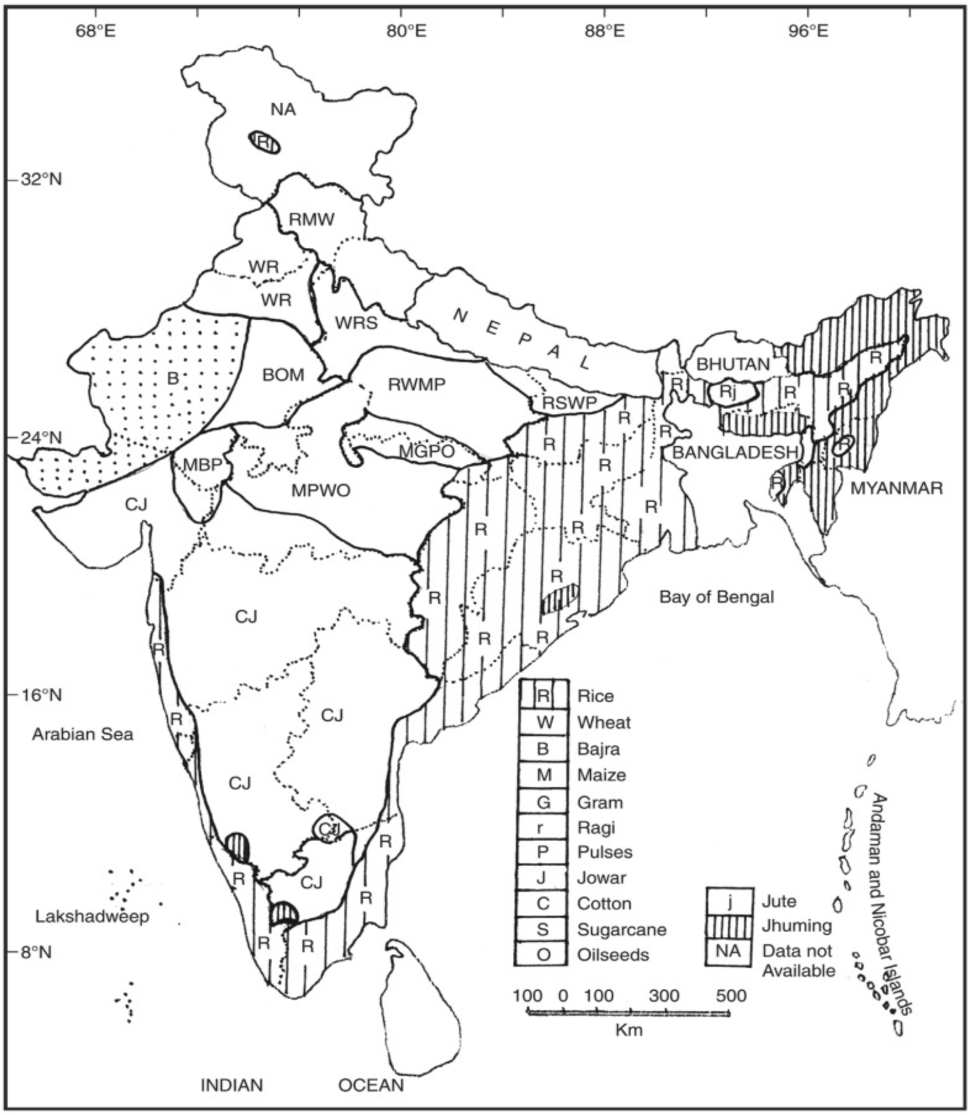

Fig. 10.4 Crop Combination Regions (2005–2006)

Land not Suitable for Cultivation

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

Class VI: Well suited for grazing and forestry but not for cultivation of crops. It has a moderate carrying capacity of livestock. This land has steep slope, severe erosion, stoniness,, poor moisture retaining capacity, sainity and severe climate.

(iii) Multi-element (Statistical) Technique
(iv) Quantitative-cum-Qualitative Technique

(i) Empirical Technique: It is largely based on the experience of the farmers and the observed facts. Von Thunen was the 1st scholar who adopted the empirical technique and prepared the first agricultural land use and crop intensity models.

The empirical technique gives a generalised picture of the cropping pattern and agricultural regions. By adopting the empirical technique Symons, Munton and Morgan demarcated the agricultural regions of the different parts of the world. This technique, has, however, been criticised as it is not objective and scientific.

(ii) Single-Element Technique: This is an arbitrary technique in which only the first ranking crops in respect of area are plotted for the purpose of demarcation of agricultural regions. Baker was the first geographer who adopted the single-element technique for the demarcation of agricultural belts of U.S.A. This technique has however been criticized as it is not scientific and objective (Fig. 10.5). On the basis of this technique, the first ranking crops of India in the different districts in 2005–06 have been plotted in **Fig. 10.1** which show the rice, wheat, maize, bajara, ragi, millets, cotton, and groundnut regions.

The main weakness of this technique is that it conceals the position and importance of other crops grown in the region. In fact, in most of the districts of India, crops are grown in combination and not in isolation. A combinational analysis is more important from the agricultural planning point of view than that of the single dominant crop.

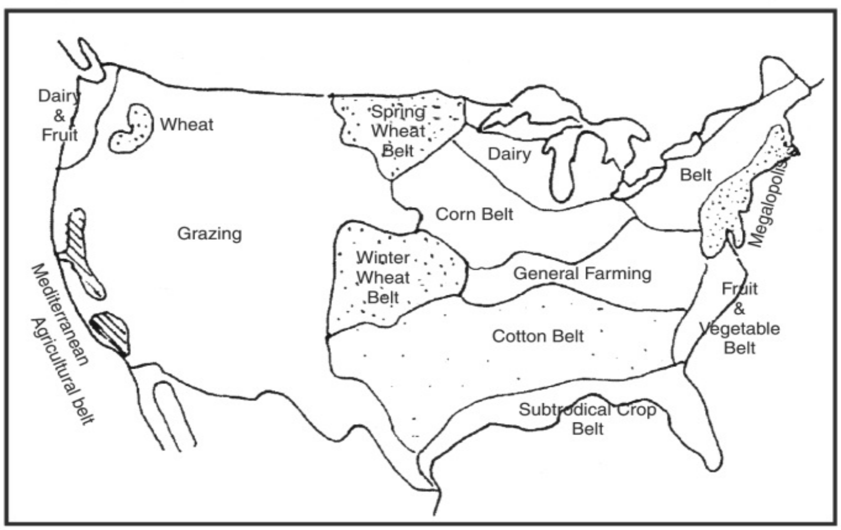

Fig. 10.5 Agricultural Belts of USA (After Baker)

(iii) Multi-Element or Statistical Technique: The multi-element technique is more objective and scientific. In the statistical techniques more than one elements (crops, etc.) are taken into consideration. The crop combination regions demarcated by Weaver, Doi, Coppock, Shafi, Jasbir Singh, Aiyer, Husain, Sapre, and Deshpande, Tiwari etc., were based on the Standard Deviation Technique. This technique is free from bias and subjectivity.

Class VII: Fairly well suited for grazing or forestry with little carrying capacity of livestock.

Class VIII: Suited only for wildlife. This land has severe climate, wet soil, stones, bad lands, sandy beaches, marshes, deserts, and nearly barren lands.

CONTRACT FARMING

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

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

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

(i) The sale of their produce is assured.
(ii) They earn higher price than the price in the open market.
(iii) The capital requirements of the farmers are reduced as the contract often agreed for advance payment.
(iv) Very often, the companies also provide specialised knowledge and expertise.

Contract farming also leads to certain disadvantages:

(i) If a farmer has produced quality products, he could get a higher price than offered by the contracts in the open market.
(ii) The farmer acts mechanically and loses his independent status.
(iii) The bargaining power is tilted in favour of companies as they are financially more powerful.

AGRICULTURAL REGIONALISATION

Region is one of the basic concepts in geography. It has been defined differently by different geographers. A widely accepted definition of region is ‘an area that is differentiated from other areas according to a specific criteria.’ In other words, ‘region is a differentiated segment of the earth surface. (Whittlesey, 1936)

Agricultural region is an uninterrupted area having some kind of homogeneity with specifically defined outer limit. It is an area which depicts homogeneity in respect of agricultural land use, agricultural practices, and cropping patterns. Agricultural region, in fact, is a device for selecting and investigating regional groupings of the complex agricultural phenomena found on the earth’s surface. In other words, any segment or portion of the earth surface possessing a distinctive form of agriculture is an agricultural region. Agricultural region is a dynamic concept which changes in space and time.

The main characteristics of agricultural regions are: (i) they have location; (ii) they have transitional boundaries; (iii) they may be either formal or functional; and (iv) they may be hierarchically arranged.

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

(i) Empirical Techniques
(ii) Single-element Technique

In the multi-element or statistical techniques, the agricultural regions may be demarcated with the help of the following:

(i) Cropping patterns, crop concentration, and crop diversification
(ii) Crop combination
(iii) Regional patterns of agricultural productivity

Some of the studies made with the help of the multi-element techniques gave very reliable agricultural regions. In the developing countries the non-availability of reliable data is a limiting factor in the application of this technique.

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

The non-availability of reliable data and the quantification of cultural-cum-religious values are the limiting factors in the delineation of agricultural regions with the help of this technique.

Many of the scholars have attempted to delineate the agricultural regions of India. The divisions of India into climatic divisions made by L.D. Stamp (1958), M.S.A. Randhawa (1958), O.H.K. Spate and A.T.A. Learmonth (1960), P. Sengupta and G. Sdasyuk (1967), R.L. Singh (1971) and Jasbir Singh (1975) are important. A brief account of some of the important agricultural regionalisations of India have been given in the following section.

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

On the basis of geo-climatic variations, crop characteristics and animals, Randhawa has identified five main agricultural regions of India (**Fig. 10.6**).

1. The Temperate Himalayan Region

The Temperate Himalayan region includes the states of Jammu and Kashmir, Himachal Pradesh, and Uttarakhand in the west, and Arunachal Pradesh and Upper Assam in the east. It has two sub-divisions:

(i) The eastern part comprising Arunachal Pradesh, Sikkim, Nagaland, Tripura, and Upper Assam records heavy rainfall and are covered with thick forests. Here rice and tea are the dominant crops.
(ii) The western temperate Himalayan region consists of Jammu and Kashmir, Himachal Pradesh and Uttarakhand. This region is characterised by horticulture (apples, cherries, pears, peach, almond, apricot, and walnut). Other crops grown are maize, rice, wheat, and potatoes.

2. The Northern Dry (Wheat) Region

This region stretches over Punjab, Haryana, western Uttar Pradesh, north-western Madhya Pradesh, and irrigated parts of Rajasthan. The average annual rainfall in this region is less than 75 cm. Parts of it are adequately irrigated by canals and tube wells. The main crops of this region are wheat, maize, cotton, mustard, gram, rice, sugarcane, and millets.

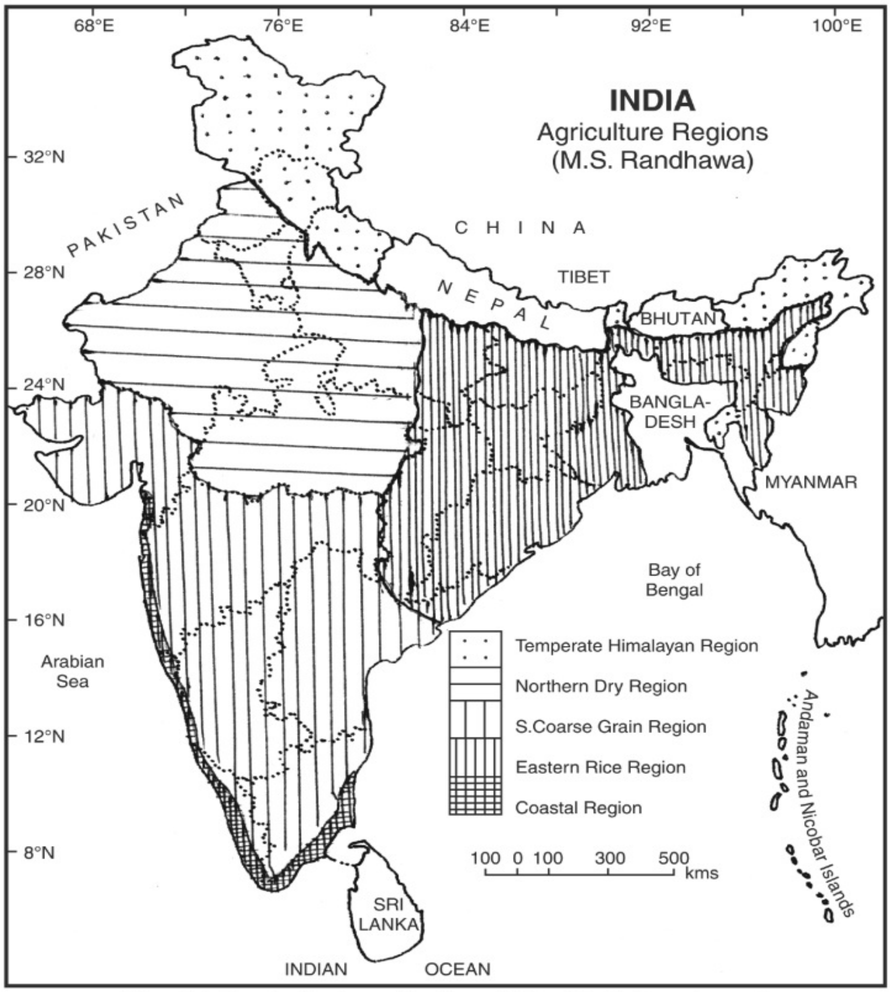

Fig. 10.6 Agriculture Regions (after M. S. Randhawa)

3. The Eastern Wet (Rice) Region

It includes the greater parts of the states of Assam, Meghalaya, Manipur, Mizoram, West Bengal, Jharkhand, Bihar, Chhattisgarh, eastern Uttar Pradesh, Odisha, and coastal Andhra Pradesh. This region records more than 150 cm of rainfall. Rice, jute, pulses, oil seeds, tea, and sugarcane are the main crops of this region.

4. The Western Wet (Malabar) Region

This region stretches over from Maharashtra to Kerala. The average annual rainfall in this region is over 200 cm. Rice is the main food crop although coconut and plantation crops (rubber, coffee, spices, cashew nut, etc.) are the main cash crops.

5. The Southern Coarse (Cereals) Region

This agricultural region sprawls over Gujarat, Madhya Pradesh, southern Uttar Pradesh (Bundelkhand), eastern Maharashtra, western Andhra Pradesh, Karnataka, and western Tamil Nadu. These areas record rainfall between 50 to 100 cm. Millets, *Bajra*, cotton, groundnut, oilseeds, and pulses are the main crops.

2. P. Sengupta and G. Sdasyuk's Classification of Agriculture

Miss P. Sengupta and Galina Sdasyuk (1968) presented a three-tier classification of India's agricultural regions.

(i) Climatic characteristics : 4 macro regions.
(ii) Physiographic characteristics: 11 meso regions.
(iii) Crop combinations : 60 micro regions.

These agricultural regions have been plotted in **Fig. 10.7** to **Fig. 10.8.**

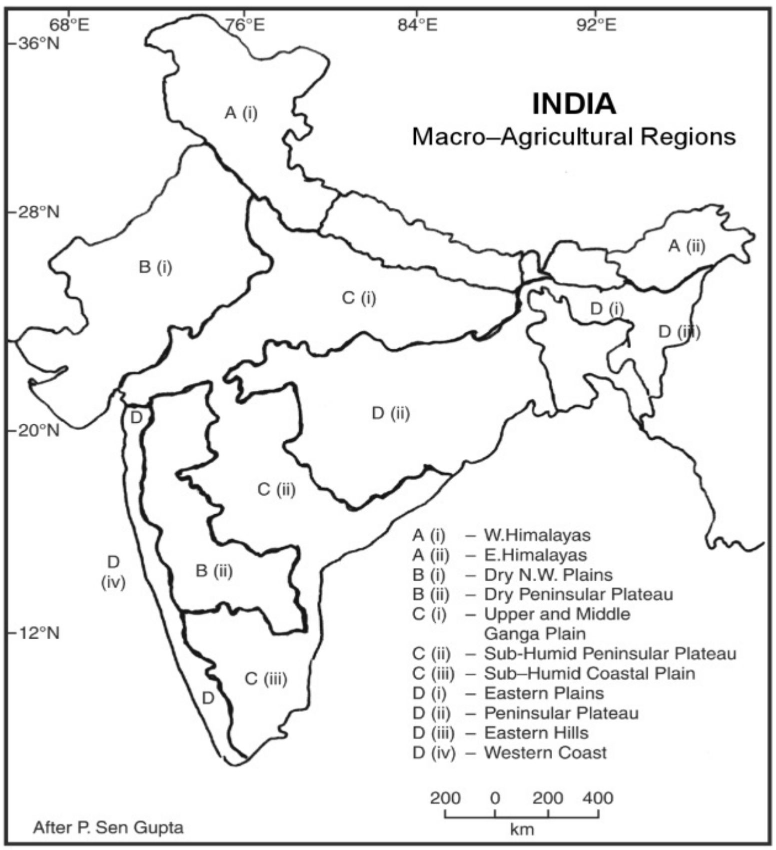

Fig. 10.7 Major Agricultural Regions

A. Himalayan Agricultural Belt

This belt sprawls over Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Darjeeling District of West Bengal, Sikkim, Arunachal Pradesh, and Assam Himalayas. The mean annual rainfall in this belt varies between 125 to 250 cm. Being mountainous, the percentage of arable land is low. Rice, wheat, maize and orchards are the main crops in the Western Himalayas, while rice, tea, and maize are the main crops in the Eastern Himalayas. It has 2 meso and 4 micro regions. Rice, maize, and wheat the significant crops of this region.

B. The Dry Agricultural Belt

The dry agricultural belt stretches over Rajasthan, western Uttar Pradesh, Haryana, and the leeward side of the Western Ghats (Sahaydris). This region records less than 75 cm of average annual rainfall.

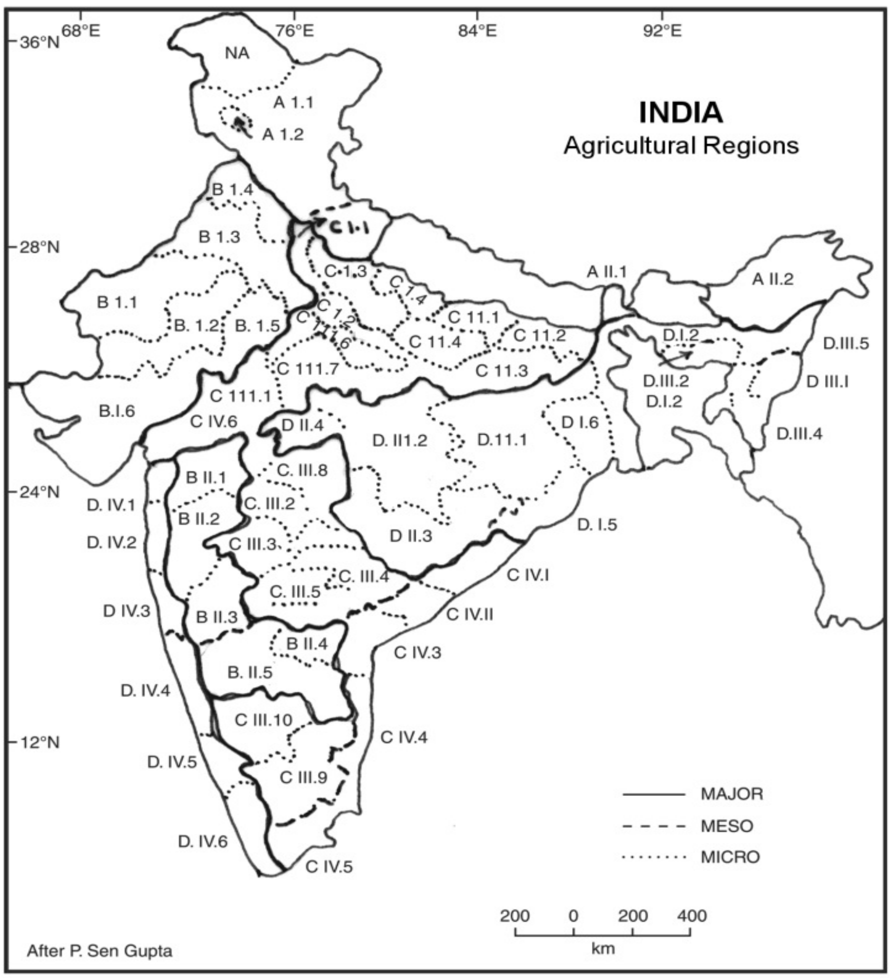

Fig. 10.8 Agricultural Regions

In Punjab, Haryana, and western Uttar Pradesh, irrigation by canals and tube wells is adequately available. The main crops of this region are wheat, rice, sugarcane, maize, pulses, oilseeds, millets, and *bajra*. It has 2 meso and 11 micro agricultural regions.

C. The Sub-Humid Belt

The sub-humid belt stretches over the Upper and Middle Ganga Plains and a narrow central belt running from Bundelkhand Andhra Pradesh to Tamil Nadu Plateau and the Eastern Coastal plain. The average annual rainfall in this region varies between 75 cm to 100 cm. The main crops are wheat, rice, sugarcane, gram, maize, millets, cotton, groundnut, oilseeds, and tobacco. It has three mesodivisions and 24 micro-agricultural regions.

D. The Wet Belt

The wet belt sprawls over West Bengal, Jharkhand, Meghalaya, Assam, Manipur, Nagaland, Mizoram, and Tripura. It receives 100 to 200 cm average annual rainfall. The main crops are rice, jute, tea, oilseeds, wheat, rubber, spices, and oilseeds. It consists of 4 meso and 21 micro-level agricultural regions. Rice, jute, oil seeds, maize, coconut, sugarcane are the dominant crops in this region.

AGRO-CLIMATIC REGIONS OF INDIA

India has great variations in the geo-climatic, socioeconomic, and agricultural practices. The variations in the geo-ecological and socioeconomic conditions have closely influenced the agricultural activities. For the planning of agriculture, the Planning Commission and the National Remote Sensing Agency (NRSA) have divided the country into 15 agro-climatic regions (**Fig. 10.9**). The main objectives of agro-climatic regions are

(i) to optimise agricultural production
(ii) to increase farm income
(iii) to generate more rural employment
(iv) to make a judicious use of the available irrigation water
(v) to reduce the regional inequalities in the development of agriculture.

These agro-climatic regions are as under:

1. The Western Himalayan Region
2. The Eastern Himalayan Region
3. The Satluj-Yamuna Plain
4. The Upper Ganga Plain
5. The Middle Ganga Plain
6. The Lower Ganga Plain
7. The Eastern Plateau and Hills
8. The Aravalli Malwa Upland
9. The Plateau Maharashtra
10. The Deccan Interior
11. The Eastern Coastal Plain
12. The Western Coastal Plain
13. The Gujarat Region
14. The Western Rajasthan
15. The Islands (Andaman and Nicobar and Maldives)

Fig. 10.9 Agro-Climatic Regions

1. The Western Himalayan Region

The western Himalayan region stretches over the states of Jammu and Kashmir, Himachal Pradesh, and Uttarakhand. There is great variation in its topography. The average temperature of July varies between 5°C and 30°C, while the January temperature reads between 15°C to –5°C. The mean annual rainfall varies between 75 cm to 150 cm except Ladakh where it is below 20 cm. The valley of Kashmir, Kullu, and Dun have thick alluvial soils while the hills and mountains have thin cover of brown soils. This region has perennial rivers, some of which are utilised for irrigation and hydel-power generation.

Rice, maize, wheat, barley, oilseeds, pulses, potato, and vegetables are the main crops of this region. Temperate fruits like apples, peach, pears, almond, apricot, walnut, etc. are the source of cash for the cultivators. Though the geographical conditions of this region are well suited for orchards and plantation crops, there is a need of improvement in the old less productive varieties of fruits.

A more judicious land use planning is required for the region. Land should be rationally allotted for cultivation of crops, horticulture, pastures, and forestry. Better quality of seeds and planting materials should be made available for growing fruits, vegetables, flowers, saffron, ginger, and potato.

2. The Eastern Himalayan Region

This region sprawls over Arunachal Pradesh, Hills of Assam, Nagaland, Meghalaya, Manipur, Mizoram, Tripura, Sikkim, and Darjeeling District of West Bengal. It has rugged topography. The temperature of July varies between 25°C to 30°C and of January between 10°C and 20°C. The soil is red-brown and less productive. About 33 per cent of the total cultivated area is under *Jhuming* (shifting cultivation).

Rice, maize, potato, tea, and orchards (pineapple, lime, litchi, oranges, etc.) are the main crops. Shifting cultivation should be controlled by developing terrace farming. Soil erosion is another important problem which needs immediate attention of the planners.The region needs marked improvement in infrastructural facilities to accelerate the pace of agricultural development. Moreover, a long term quality seed production suitable for the region needs to be implemented.

3. The Satluj Yamuna Plain

It stretches over Punjab, Haryana, Chandigarh, Delhi, and the Ganganagar District of Rajasthan. The climate has the semi-arid characteristics with July's mean monthly temperature between 25°C and 35°C and that of January between 10°C and 20° C. The average annual rainfall varies between 65 cm and 125 cm. The soil is alluvial which is highly productive. Apart from the canals, there are lakhs of tube wells and pumping sets installed by the cultivators and the governments. The intensity of agriculture (165 per cent) is the highest in the country.

Wheat, rice, sugarcane, cotton, maize, gram, millets, pulses, oilseeds, and orchards are the main crops. The farmers of this region are most innovative and progressive. The High Yielding Varieties of rice and wheat were adopted first by the farmers of this region which led to Green Revolution. At present contract farming has been started by the corporate sector in some of the districts of this region.

Development of saline and alkaline patches, water-logging, and soil erosion are the main problems of the region.

Agriculturally, this is the most developed part of the country. Agriculture may be made more productive and sustainable if the following steps are taken:

(i) Less area be devoted to rice as it is depleting the underground water table and the fertility of soil. Nearly 5 per cent of the rice and wheat area may be diverted to pulses, oilseeds, maize, fodder, vegetables, flowers, and orchards.
(ii) Pests and disease resistant seeds of rice and wheat need to be developed.
(iii) Horticulture should be promoted.
(iv) Emphasis should be made on the cultivation of vegetables.
(v) High quality fodder crops should be developed.
(vi) Steps should be taken for the diversification of agriculture.

4. The Upper Ganga Plain

The Upper Ganga Plain stretches over the western Uttar Pradesh and the Hardwar and Udham-Singh Nagar districts of Uttarakhand. The July temperature varies between 25°C and 35°C and that of January between 10°C and 25°C. The soil varies from sandy loam to clayey loam. Adequate facilities of irrigation by canals and tube well are available. Agriculture is well developed and Green Revolution is a big success in this region also.

Wheat, rice, sugarcane, maize, millets, pulses, oilseeds, and vegetables are the main crops. Mango and guava orchards are also quite significant in the agricultural landscape.

In order to make agriculture more productive and sustainable there should be emphasis on mixed cropping, horticulture, floriculture, judicious use of irrigation water, lining of canals, reclamation of saline/alkaline soils.

5. The Middle Ganga Plain

It sprawls over the greater parts of Uttar Pradesh and Bihar. The July temperature varies between 25° C and 35° C and that of January between 10° C and 25° C. The average annual rainfall varies between 100 cm and 150 cm. The soil is alluvial and there is great potential of underground water.

Rice, wheat, barley, maize, millets, pulses, mustard, sugarcane and oilseeds, are the main crops. Agriculturally, these plains are less developed than the Upper Ganga Plains.

Agriculture can be made more productive and sustainable to improve the input delivery system and diversification of crops by giving more area to vegetables, fruits, and floriculture. Dairying, silviculture, agro-forestry, and pisciculture can also go a long way in improving the income of the farmers.

6. The Lower Ganga Plains

This region stretches over the Brahmaputra Valley, West Bengal (excluding the Darjeeling District) and eastern Bihar. The July temperature varies between 25°C and 35°C and that of January between 10°C and 25°C. The mean annual rainfall varies between 100 cm and 200 cm. The soil is alluvial and highly productive.

Rice is the main crop. From the same field the farmers obtain three successive rice crops (*Aman, Aus, and Boro*) in a year. Jute, maize, pulses, and potato are the other important crops of the region.

Development of horticulture (banana, mango, and citrus fruits), pisciculture, poultry, and livestock can enhance the income of the cultivators substantially.

7. The Eastern Plateau and Hills

The Chotanagpur Plateau, stretching over Jharkhand, Odisha, Chhattisgarh, and Dandakarnaya are included in this agro-climatic region. The mean monthly temperature of July ranges between 25°C and 35°C and that of January between 15°C and 25°C. The mean annual rainfall ranges between 75 cm and 150 cm. Soils are red and yellow.

The agriculture in this region is mainly rain-fed The main crops are rice, maize, millets, *ragi*, oilseeds, gram, and tobacco.

The cultivation of high value crops like oilseeds, pulses, vegetables can increase the income of the farmers. Water-harvesting and watershed development as well as soil conservation practices can make the agriculture more remunerative.

8. The Aravalli–Malwa Upland

This region includes Bundelkhand, Baghelkhand, Mahabharat Plateau, Malwa Plateau, and Vindhyachal Hills. This region is characterised by semi-arid climatic conditions. The mean July temperature reads between 25°C and 35°C, while the mean January temperature ranges between 15°C and 25° C. The soil is mixed yellow, red, and black. It has scarcity of water, both surface and underground.

Millets, wheat, gram, pulses, oilseeds, cotton, and sunflower are the main crops. Agriculture returns can be improved by farming, sprinkle irrigation, water-harvesting, dairy development, and poultry farming.

9. The Plateau of Maharashtra

It stretches largely on Deccan Plateau. This is a region of *regur* soil (black earth soil). The July temperature ranges between 25°C and 35°C, while the mean monthly temperature in January ranges between 15°C and 25° C. The average annual rainfall varies between 50 cm and 75 cm.

Wheat, gram, millets, cotton, pulses, groundnut, and oilseeds are the main crops in the rain-fed areas, while in the irrigated areas, sugarcane, rice, and wheat, are cultivated.

In place of coarse grains, value crops like pulses and oilseeds need to be cultivated. About 5 per cent of the cotton area may be transferred to oilseeds. Dairy development, poultry farming, and social forestry are the other aspects of agricultural landscape which deserve immediate attention.

10. The Deccan Interior

The Deccan interior sprawls over the greater parts of Karnataka, Andhra Pradesh, and Tamil Nadu uplands from Adilabad District in the north to Madurai District in the south. The mean monthly temperature of July varies between 25°C and 35°C, and the mean January temperature reads between 15°C and 20°C. This region records rainfall between 50 cm and 100 cm.

This is essentially a dry-farming area where millets, pulses, oilseeds, groundnut, coffee, tea, cardamom, and spices are the main crops. The area under millets and *bajra* can be devoted to pulses. Development of horticulture, poultry, and dairy-farming can help the farmers in the augmentation of their income.

11. The Eastern Coastal Plain

This region sprawls over the Coromandal and northern Circar coasts of Andhra Pradesh and Odisha. The mean July temperature ranges between 25°C and 35°C and the mean January temperature varies between 20°C and 30°C. The mean annual rainfall varies between 75 cm and 150 cm. The main crops of this region are rice, jute, tobacco, sugarcane, maize, millets, pulses, groundnut, and oilseeds. Area from coarse grains need to be shifted to high value crops like pulses and tobacco. Development of dairying, poultry, fisheries, and social forestry deserve more attention and investment.

12. The Western Coastal Plains

This region stretches over the western fringes of the states of Maharashtra, Karnataka, and Kerala. In the north, it is known as the *Konkan coastal plains* and in the southern parts as the *Malabar coastal plains.* The mean July temperature varies between 25° C and 30° C and mean January temperatures between 18° C and 30° C. The mean annual rainfall is more than 200 cm.

Rice, oilseeds, sugarcane, millets, pulses, cotton, and coconut are the main crops. Moreover spices are raised along the hill slopes of the Western Ghats.

Raising of high value crops (pulses, spices, and coconut) should get more agricultural area. Development of infrastructural facilities and promotion to prawn culture in brackish water should get preference.

13. The Gujarat Plains and Hills

This region consists of the hills and plains of Kathiawar, and the fertile valleys of Mahi, and Sabarmati rivers. It is an arid and semi-arid region where the July temperature reads about 30°C and that of January about 25°C. The mean annual rainfall varies between 50 cm and 100 cm.

Groundnut, cotton, rice, maize, millets, oilseeds, wheat, pulses, and tobacco are the main crops. It is an important oilseeds producing area. The major thrust of development in the region should be on canal and ground water management, rain-water harvesting, agro-forestry in the region, and brackish/backwater aquaculture in coastal areas.

14. The Western Region

This region stretches over Rajasthan west of the Aravalli mountains, and northern Gujarat. The mean July and January temperatures vary between 40°C and 15°C respectively. The mean annual rainfall is less than 25 cm.

Bajra, pulses, and fodder are the main crops. Livestock contributes greatly to the desert ecology. Rain water harvesting horticulture of date-palm, water-melon, and plums deserve more attention.

15. The Islands Region

This region includes Andaman-Nicobar, and Lakshadweep which have marine equatorial climates. At Port Blair, the mean July and January temperatures read 30°C and 25°C, respectively. Rice, maize, millets, *bajra*, pulses, arecanut, turmeric, and cassava are the main crops. The main thrust in the development of agriculture should be on crop improvement, water management, and fisheries. Brackish water prawn culture should be promoted in the coastal areas.

AGRO-ECOLOGICAL REGIONS OF INDIA

The concept of 'agro-ecological region' is a modification and improvement on agroclimatic regions. The concept of agro-ecological region is perhaps hazy to our scientific communities. People generally confuse these two terms (agroclimatic and agro-ecological) and use them in more or less the same way. But there is a distinct difference between these two terms. According to FAO (1983), agro-climatic region is a land unit in terms of major bioclimate and length of growing period and which is climatically suitable for certain range of crop cultivation. But agro-ecological region is the land unit carved out of agro-climatic region when superimposed on land form and soil condition that acts as modifier of the length of growing period. Therefore, within an agro-climatic region there may be a few agro-ecological regions depending on soil condition. This approach has been used in delineating agro-ecological regions of India.

Methodology

The methodology used in the delineation of agro-ecological region is given below:

(i) Mean monthly temperature and mean monthly precipitation.
(ii) Type of soil.
(iii) Length of growing period.

In order to prepare an agro-ecological region map, the soil-scap (soil-map) was superimposed on bio-climatic map. On the resultant map, the growing period was incorporated, using GIS technology.

In the demarcation of agro-ecological regions of India, the agro-climatic regions of India have been sub-divided on the basis of soil type. In the meso-regions thus obtained, the length of growing period (LGP) has been superimposed. This method has resulted into 20 agro-ecological regions and 60 agro-ecological sub-regions. The 20 agro-ecological regions of India have been plotted in **Fig. 10.10.**

The agro-ecological regions of India are:

1. Western Himalayas, cold arid eco-region with shallow soil and length of growing period less than 90 days.
2. Western Plain, Kachchh, and part of Kathiwara Peninsula, hot and arid ecoregion with desert and saline soils and growing period less than 90 days.
3. Deccan Plateau, hot arid region with red and black soils and growing period of less than 90 days.
4. Northern Plain and Central Highlands including Aravallis, hot semi-arid ecoregion, with alluvium-derived soils and growing period between varying between 90–150 days.
5. Central Malwa Highlands, Gujarat Plains, and Kathiawar Peninsula, hot semi-arid ecoregion with medium and deep black soils and growing period varying between 90 to 150 days.
6. Deccan Plateau, hot semi-arid ecoregion, with shallow and medium black soils and growing period varying between 90 to 150 days.
7. Deccan (Telengana)Plateau and Eastern Ghats, hot semi-arid ecoregion with red and black soil and growing period from 90 to 150 days.
8. Eastern Ghats, Tamil Nadu Plateau and Deccan (Karnataka), hot semi-arid ecoregion with red-loamy soils, and growing period of 90–150 days.
9. Northern Plain, hot sub-humid (dry) ecoregion, with alluvium soils, and growing period of 150–180 days.
10. Central Highlands (Malwas, Budelkhand, and Eastern Satpura), hot subhumid ecoregion, with black and red soils, and growing period 150–189 days.
11. Eastern Plateau (Chattisgarh), hot sub-humid ecoregion, with red and yellow soils, and growing period of 150–180 days.
12. Eastern (Chotanagpur) Plateau and Eastern Ghats, hot subhumid ecoregion, with red and lateritic soils, and growing period of 150–180 days.
13. Eastern Plain, hot sub-humid (moist) ecoregion, with alluvium soils, and growing period of 180–210 days.
14. Western Himalayas, warm sub-humid to humid with inclusion of perhumid ecoregion, with brown forest and podzolic soils, and growing period of 180–210 days.
15. Bengal and Assam Plain, hot sub-humid (moist) to humid (inclusion of perhumid) ecoregion with alluvial soils, and growing period 180 to 210 days.

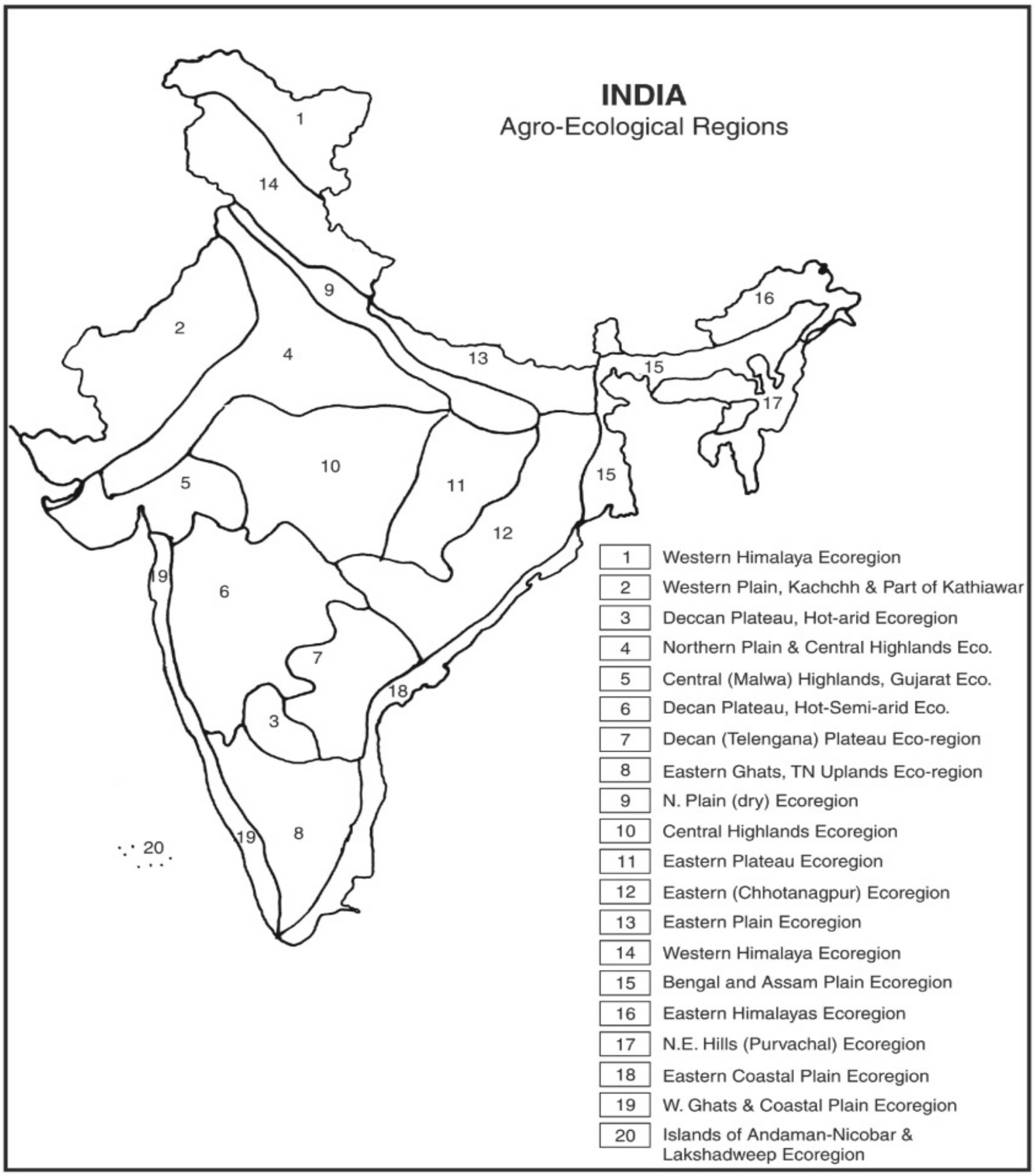

Fig. 10.10 Agro-Ecological Regions

16. Eastern Himalayas, warm perhumid ecoregion with brown and red soils, and growing period over 210 days.
17. North-Eastern Hills (Purvanchal), warm perhumid ecoregion with red and lateritic soils, and growing period over 210 days.

18. Eastern Coastal Plain, hot sub-humid to semi-arid ecoregion with coastal alluvium soils, and growing period varying from 90 to 210 days.
19. Western Ghats and Coastal Plain, hot humid per humid ecoregion, with red lateritic and alluvium soils, and growing period varying from 90 to 210 days.
20. The Islands of Andaman and Nicobar and Lakshadweep, hot humid to perhumid island ecoregion, with red loamy and sandy soils, and growing period over 210 days.

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Chapter 11

Industries

EVOLUTION OF INDUSTRIES

Industrial development is considered as one of the important indicators of socioeconomic and human development. Before the rise of modern industries, India was known all over the world for its cottage and household industries. Indian muslin, silk goods, and artistic pottery were in great demand the world over. The arrival of English resulted in the decay of traditional handicrafts. The East India Company developed a policy of export of raw material from India to Britain and the import of finished products to India from Europe. It was because of this policy that no industry could be developed in India before 1854. In the later part of the 19^{th} century the growth and development of industries in India was stunted and slow.

The industrial development in India started after 1854 when some cotton and jute mills were established by the British in Mumbai and Calcutta (Kolkata) respectively. The beginning of modern industrial phase may be traced back to the establishment of the first iron and steel charcoal plant at Port-Navo (Tamil Nadu). This mill was closed down in 1886. The first cotton textile factory was established at Mumbai in 1854, followed with the opening of a jute mill at Rishira near Calcutta (Kolkata) in 1855. The cotton textile industry expanded during 1870s when there was civil war in America. The number of cotton mills grew to 275 before the First World War. The progress in jute industry was, however, not satisfactory.

The beginning of iron and steel industry was even more delayed. The first iron and steel mill was established by Bengal Iron Works Ltd. at Kulti in 1874. It resulted in a failure and was shut down in 1881. The real development of iron and steel industry started in 1908 when a steel plant was established at Jamshedpur.

The first successful paper mill started at Ballygunj Circular Road in Kolkata in 1870. Two more paper mills in Kolkata and one in Lucknow (1879) started in 1905. It was in 1870, when the woollen textile mills were established in Bangalore (1886) (Karnataka), Dhariwal (1881) (Punjab), and Kanpur (1876) (Uttar Pradesh).

After the First World War, the Indian industries got a good boost as India became the main supplier of cotton and woollen textiles and liquors. The government gave protection to some of the industries. The period during the Second World War was a time of crisis as India got involved into war. After the Second World War, the production fell down due to decreasing demand for industrial products, lack of capital, political unrest, transport bottlenecks, and labour strikes. The partition of the country in 1947 gave a severe blow to jute and cotton textiles as the raw material producing areas of jute and good quality cotton went to Pakistan.

As stated above, the post Second World War period was characterised by industrial turmoil. Production in most of the industries declined. The condition of cotton textiles, cement, paper, iron and steel industries, and consumer goods was worst due to the non-availability of raw material.

After Independence, the Government of India realised the importance of an appropriate industrial policy, which led to the Industrial Policy Resolution, 1948. According to this policy, the concept of mixed economy was introduced in which the state and the private enterprise were allowed to co-exist and co-prosper in the fields demarcated for them. This resolution divided the industries between public and private sectors.

INDUSTRIAL DEVELOPMENT DURING THE FIVE-YEAR PLANS

The real growth and development of the industrial sector in India started during the period of Five-Year Plans.

First Five-Year Plan (1951–56)

The main thrust of the First Five-Year Plan was on agricultural development. Therefore, the emphasis was on increasing capacity of the then existing industries rather than the establishment of new industries. Cotton, woollen and jute textiles, cement, paper, newsprint, power-looms, medicine, paints, sugar, *vanaspati* (vegetable oil), chemical and engineering goods, and transport equipments showed some progress.

Second Five-Year Plan (1956–61)

Great emphasis was laid on the establishment of heavy industries during the Second Five-Year Plan. The second industrial policy was announced in 1956. The main thrust of industrial development was on iron and steel, heavy engineering, lignite projects, and fertiliser industries. Moreover, there was emphasis on the expansion of existing steel plants, like Jamshedpur, Kulti-Burnpur, and Bhadravati. Three new iron and steel plants were located at Bhilai, Durgapur, and Raurkela. The Chittranjan Locomotive Workshop, the Hindustan Ship-building Yard (Vishakhapatnam), the Sindri Fertiliser Factory, and Hindustan Machine Tools Ltd. (HMT) at Bangalore were expanded. Many of the targets, however, could not be achieved because of the war with China in 1962 and the failure of monsoon over greater parts of the country.

Third Five-Year Plan (1961–66)

There was emphasis on the expansion of basic industries like iron and steel, fossil-fuel, power, and machine building. The Ranchi Machine Tool and three more HMT units were established. Machine building, locomotive and railway coach making, ship-building, air-craft manufacturing, chemicals, drugs, and fertiliser industries also made steady progress.

Fourth Five-Year Plan (1969–74)

The period between 1966 and 1969 was the period of annual plans. The industrial period could not make much progress during the annual plans period. During the fourth Five-Year Plan there was much emphasis on the agro-based industries such as sugar, cotton, jute, *vanaspati*, metal-based, and chemical industries. It was during this plan when much progress was made in alloys, aluminium, automobile-tyres, electronic goods, machine tools, tractors, and special steel. Efforts were also made to accelerate the process of industrial dispersal.

Fifth Five-Year Plan (1974–79)

The main stress in this plan was on rapid growth of steel plants, export-oriented articles, and goods of mass consumption. The steel plants at Salem, Vijaynagar, and Vishakhapatnam were proposed to create additional capacity. The Steel Authority of India (SAIL) was constituted. Moreover, drug manufacturing, oil refining, chemical fertilisers, and heavy engineering industries made steady progress.

Sixth Five-Year Plan (1980–85)

The main emphasis in the Sixth Five-Year Plan was on producing goods to exploit the domestic and international markets. To achieve this objective industries like aluminium, automobiles, electric equipments, thermostatics were given the priority. Production targets were achieved in industries like commercial vehicles, drugs, T.V. receivers, automobiles, cement, coal, jute industry, non-ferrous metals, textiles, railway wagons, sugar industry, etc.

Seventh Five-Year Plan (1985–90)

The main thrust of the Seventh Five-Year Plan was on 'high tech' and electronic industries. Industrial dispersal, self employment, exploitation of local resources, and proper training were the preference areas of the plan.

Eighth Five-Year Plan (1992–97)

The period between 1990 and 1995 was the period of annual plan. There was a major change in the industrial policy of the Government of India which was initiated in 1991. The policy of liberalisation was adopted for the investment of foreign multi-nationals. Emphasis was given on the removal of regional imbalances and encouraging the growth of employment in small and tiny sectors.

Ninth Five-Year Plan (1997–2002)

The main emphasis during this plan was on cement, coal, crude oil, consumer goods, electricity, infrastructures, refinery, and quality steel products.

Tenth Five-Year Plan (2002–07)

During the Tenth Five-Year Plan, the main emphasis was on:

(i) the modernisation, technology upgrading, reducing transaction costs, and increased export;
(ii) to enhance export and to increase global competitiveness; and
(iii) to achieve balanced regional development.

To achieve these objectives and reduce the regional inequalities Special Economic Zones (SEZs) policy has been adopted. Moreover, industrial packages have been given to Himachal Pradesh, Jammu and Kashmir, and Uttarakhand. In addition to these, production of basic foods, capital goods, intermediate goods, and consumer goods has been encouraged.

Eleventh Five Year Plan (2007–12)

The 11th plan document entitled "Towards Faster and More Inclusive Growth" gave priority to: agriculture, irrigation, and water resources, education, health, infrastructure, and employment, along with programmes for SCs/STs, other backward classes, minorities, women and children. Government has realised that in recent years although economic growth has accelerated but it has failed to be 'inclusive'. In other words benefits of growth have not reached all sections of population particularly small farmers, landless labourers and persons working in unorganised sector have remained beyond the benefits of development. Eleventh plan stresses that benefits of development should reach all sections of population. This plan emphasizes on social justice. Eleventh plan recognizes that we need a growth process that brings faster reduction in poverty, generate employment and ensures essential services such as health, and education to all sections of the society.

INDUSTRIAL POLICY

The first industrial policy was announced by the government of India on April 6, 1948. In this policy both the public and private sectors were involved towards industrial development. Accordingly, the industries were classified into four broad categories:

1. **Exclusive State Monopoly**: This includes the manufacturing of arms and ammunition; production and control of atomic energy; and the ownership and management of railways.
2. **State Monopoly for New Units**: This category included coal, iron and steel, aircraft manufacturing, ship-building, manufacturing of telephone, telegraph and wireless apparatus (excluding radio receiving sets), and mineral oil. New undertakings in this category could, henceforth, be undertaken only by the state.
3. **State Regulation**: This category included industries of such basic importance like machine tools, chemicals, fertilisers, non-ferrous metals, rubber manufactures, cement, paper, newsprint, automobiles, electric engineering, etc. which the central government would feel necessary to plan and regulate.
4. **Unregulated Private Enterprise**: The industries in this category were left open to the private sector, individual as well as co-operative.

Industrial Policy, 1991

A major shift in the industrial policy was made by the Congress Government, led by P.B. Narasimha Rao on July 24, 1991. The main aim of this policy was to unshackle the country's industrial economy from the cobwebs of unnecessary bureaucratic control, induced liberalisation with a view to integrate the Indian economy with the world economy, to remove restrictions on direct foreign investment and also to free the domestic entrepreneur from the restriction of MRTP (Monopolies and Restrictrive Practices Act). Moreover, the policy aimed at shedding the load of public enterprises which have shown a very low rate of return or incurred losses over the years. The salient features of the 1991 industrial policy were:

1. Except some specified industries (security and strategic concerns, atomic energy, coal, social reasons, environmental issues, railways, atomic minerals, hazardous projects, and articles of elitist consumption), industrial licensing would be abolished.
2. Foreign investment would be encouraged in high priority areas upto a limit of 51 per cent equity.

3. Government would encourage foreign trade companies to assist Indian exporters in export activities.
4. With a view to inject desired level of technological dynamism in Indian industries, the government would provide automatic approval for technology agreements related to high priority industries.
5. Relaxation of MRTP (Monopolies and Restrictive Practices Act) which has almost been rendered non-functional.
6. Dilution of Foreign Exchange Regulation Act (FERA) making Rupee fully convertible on trade account.
7. Disinvestment of Public Sector Units' shares.
8. Closing of such public sector units which are incurring heavy losses.
9. Abolition of C.C.I. and wealth tax on shares.
10. General reduction in custom duties.
11. Provide strength to those public sector enterprises which fall in reserved areas of operation or in high priority areas.
12. Constitution of special boards to negotiate with foreign firms for large investments in the development of industries and import of technology.

COTTON TEXTILE INDUSTRY

Textile industry includes cotton, jute, wool, silk, and synthetic fibre textiles. India is one of the leading producers of textile goods. It is one of the largest and most important sector in the economy in terms of output, foreign exchange earning, and employment in India. Its contributioin forms 20 per cent of the industrial production, 10 per cent of the excise collection, 18 per cent of employment in the industrial sector, 20 per cent of the country's total export earning and 4 per cent of the GDP. At present, India is the *third* largest producer of silk, *fifth* largest producer of synthetic fibres, and has the *largest* loomage and spindles in the world.

India enjoyed monopoly in the production of textile goods from 1500 BC to 1500 AD. Indian cotton and silk textiles were in great demand all over the world. It was the arrival of the British in India and the Industrial Revolution in Britain in 1779 which led to the downfall of the Indian manufacturing. The British after the consolidation of their rule in India encouraged the export of raw material from India to Britain and import of manufactured goods from Britain to India. The first textile mill was established in 1854 in Mumbai by C.N. Dewar. The fast growth of cotton textile occurred in 1870 when there was much demand of Indian goods in the wake of American Civil War. Before the First World War the number of Indian textile mills rose to 271. The demand for cloth during the Second World War led to further progress of the textile industry.

The industry suffered a setback in 1947 as good quality cotton growing area went to Pakistan. Consequently, India had to import cotton from the African countries.

Cotton being a pure raw material provides a chance to establish textile mill either in the areas of raw material or in the market. In India, most of the textile mills are in the cotton growing areas or in the neighbouring cities and towns. The location of cotton textile industry is mainly affected by: (i) raw material, (ii) proximity to market, (iii) moist weather, (iv) capital, (v) skilled and cheap labour, (vi) transport, (vii) sea-port, (viii) export facility and the domestic and international markets. The trend of growth in cotton textile industry has been given in **Table 11.1**.

Table 11.1 *Growth of Cotton Textile Industry in India 1950–2006*

Year	*Cotton cloth (million sq. metres)*
1950–51	4215
1960–61	6738
1970–71	7602
1980–81	8368
1990–91	15,431
2000–01	19,718
2005–06	19,250

Source: ***Economic Survey 2005–06.***

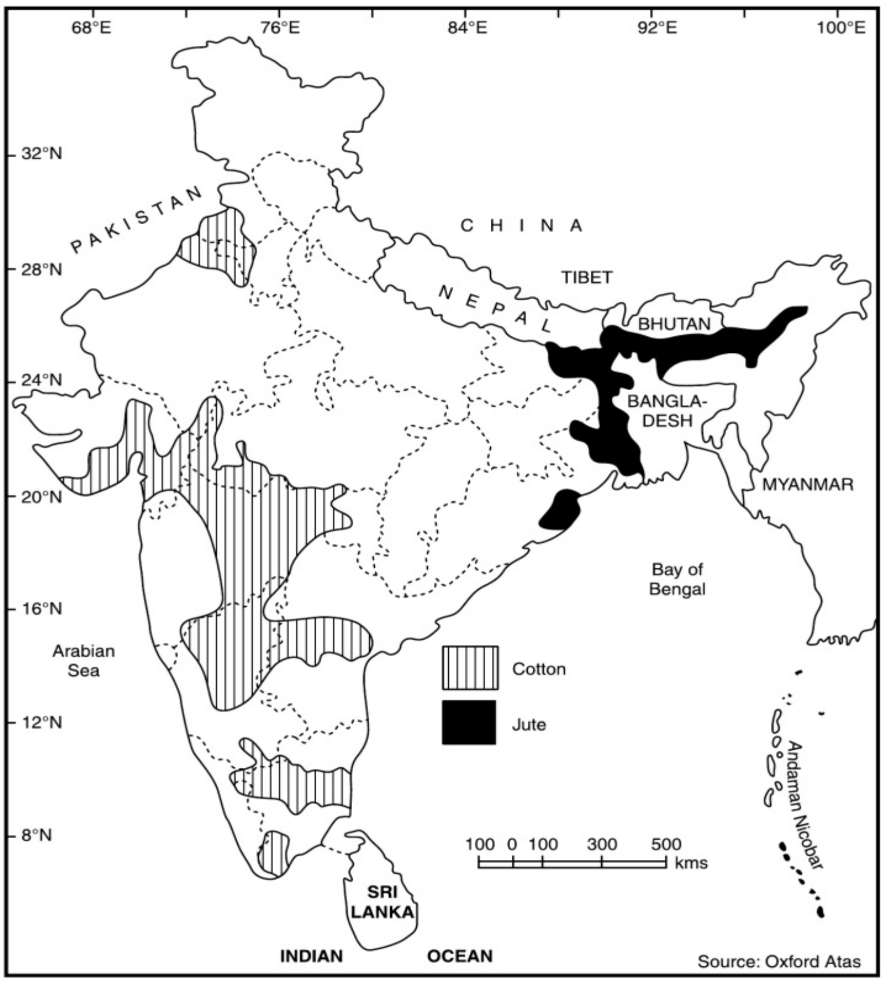

Fig. 11.1 Concentration of Cotton & Jute (2009–2010)

(i) **Cotton mills and factories:** In the earlier days of its development, mills were the main producers of cotton goods. For example, in 1950–51 over 80 per cent of the total cotton goods production was from the mills and factories, which dropped to only about 10 per cent in 2005–06. The production and employment is increasing steadily in the powerloom sector.

(ii) **Powerlooms:** The decentralised power-loom sector played a vital role in meeting the clothing needs of the country. The powerloom industry produces a wide variety of cloth with intricate designs and accounts for almost 83 per cent of the total cloth production.

(iii) **Handlooms:** The handloom sector provides over 12 per cent of the total production.

Most of the cotton mills and factories are located in the cotton producing regions of the country. The main cotton producing areas of the country have been shown in **Fig. 11.1.**

Distribution and Production of Cotton Goods State-wise

The cotton textiles production in India between 1980 to 2006 has been shown in **Fig. 11.2**. It may be seen from **Fig. 11.2** that the total production of cotton textile in 1980–81 was only about 8 million tonnes which rose to about 26 million tonnes in 2006.

The statewise distribution and production of cotton textile have been shown in **Table 11.2**. It may be seen from **Table 11.2** that Maharashtra is the leading producer of cotton textile, followed by Gujarat and Tamil Nadu. During 2010-11, the production of fabric was 61.81 billion sq. mtrs as compared to 49.58 billion sq. mtrs in 2005-06.

India's textile and clothing industry is one of the main stays of the national economy. It is also securing a 7 per cent share in the global textile trade (2011-12).

Table 11.2 *State-wise Production of Cotton Cloth in India*

State/Union Territory	*Production in sq metres*	*Percentage of All India Production*
1. Maharashtra	400,550	38.89
2. Gujarat	355,745	34.54
3. Tamil Nadu	65,850	6.40
4. Punjab	56,850	5.53
5. Madhya Pradesh	48,500	4.70
6. Uttar Pradesh	32,850	3.20
7. Rajasthan	28,880	2.80
8. Pondicherry	25,250	2.45
9. Karnataka	8,500	0.82
10. Kerala	6,850	0.67
Total	10,29,825	100.00

Source: ***Data Computed from Statistical Abstract, 2007***.

Maharashtra

The state of Maharashtra is the largest producer of cotton goods. The locational factors in the high concentration of cotton mills in the state of Maharashtra are:

(i) *Availability of raw material:* The state of Maharashtra is one of the leading producers of cotton.

(ii) *Climate:* The city of Mumbai where most of cotton mills are located has a mild climate with enough moisture in the air; so the thread does not break frequently.

(iii) Mumbai is close to Egypt, Sudan, and east African countries from where the long staple cotton is imported for the production of good quality of cloth.
(iv) *Labour:* Cheap skilled labour is available in the state.
(v) *Electricity:* Cheap electricity is available and there is not much power breakdown in the state.
(vi) *Market:* There is a large market of cotton products, both in India and abroad.

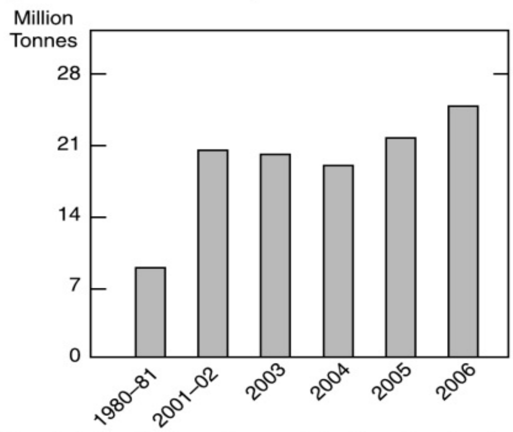

Fig. 11.2 India—Cotton Textiles Production

(vii) *Seaport:* The seaport of Mumbai is well connected by rails and highways.
(viii) *Investment:* There is no dearth of money investment in this industry.
(ix) *Entrepreneurs:* Mumbai being the commercial capital of the country enjoys the presence of entrepreneurs who are always willing to invest in this industry.
(x) *Early Start:* The state of Maharashtra and the city of Mumbai got the advantage of an early start in cotton textile industry.

With 122 cotton textile mills in Maharashtra, this industry contributes about 39 per cent of the total cloth production of the country. The city of Mumbai with 63 cotton mills is the largest producer of cotton in the country. The bulk production is in the form of light textured cloth, long cloth, shirting, domestics, sheets, *dhotis*, and coloured clothes. Due to the high concentration of cotton mills Mumbai is called the 'Cottonopolis of India'.

In Maharashtra, Sholapur is the second largest producer of cotton goods. It lies in the cotton growing area of south Maharashtra. Pune, Nagpur, Jalgaon, Akola, Sangli, Miraj, Kolhapur, Kalyan, and Thane are the other important cotton goods producing centres (**Fig. 11.3**).

Gujarat

Gujarat has 118 mills producing about 35 per cent of the total cotton goods of the country. The city of Ahmedabad is the second largest cotton producing centre after Mumbai in the country. It specialises in the production of fine qualities of *dhotis* and *saris* and a large variety of bleached, coloured, or printed fabrics. In addition to this Bhavnagar, Bharuch, Kalol, Kadi, Kelot, Khambat, Nanded, Porbander, Rajkot, Surat, Vadodra, and Viramgam are the other important cotton producing centres of Gujarat.

Tamil Nadu

Tamil Nadu has the largest number of cotton mills in the country. It is the third largest producer of cotton textile in the country. The largest number of mills are, however, in the city of Coimbatore which has over 200 small and big factories. Tamil Nadu's mills are however, smaller in size. This state produces about 45 per cent of the total yarn of the country. Chennai, Madurai, Perambur, Salem, Tiruchirappalli, Tirunelveli, and Tuticorin are the other important cotton textile centres in the state.

Fig. 11.3 Cotton Textile

Uttar Pradesh

Kanpur is the most important cotton textile centre of Uttar Pradesh. In addition to this, cotton textile industry is located in the cities of Agra, Aligarh, Bareilly, Etawah, Lucknow, Mirzapur, Modinagar, Modipuram, Moradabad, Saharanpur, and Varanasi.

West Bengal

Kolkata is the most important cotton textile producing centre of West Bengal. Cotton goods are also produced in Haora, Hugli, Murshidabad, Panihar, Sirampur, and Shiampur.

In addition to these, Ajmer, Beawar, Bhilwara, Ganganagar, Kishangarh, Jaipur, Kota, Pali, and Udaipur in *Rajasthan*; Amritsar, Ludhiana, and Phagwara in *Punjab*; Bhopal, Dewas, Gwalior, Indore, Jabalpur, Ratlam, and Ujjain in *Madhya Pradesh*; East Godavari, Guntur, Hyderabad, Secunderabad, and Udaygiri in *Andhra Pradesh*; Gaya, Bhagalpur and Patna in *Bihar*; Bhiwani, Hissar and Rohtak in *Haryana*; Bangalore, Belgaum, Chennapatnam, Chitradurga, Gulbarga, Mangalore, and Mysore in *Karnataka*; Alleppey, Alwaye, Kollam, Thiruvananthapuram, and Trichur in *Kerala* are the important cotton textile centres in the country.

In India, cotton goods are produced in the following three types of sectors: (i) Mills, (ii) Powerlooms, and (iii) Handlooms. The production of different sectors of cotton textile has been given in **Table 11.3**.

Table 11.3 *Production of Fabrics (in millions of sq metres)*

Sector	*2005–06*
1. Mills	1,656 (3.3 %)
2. Powerlooms including Hosiery	41,044 (82.8 %)
3. Handlooms	6,108 (12.3 %)
4. Others	769 (1.6 %)
5. Total	49,577

Source: ***Economic Survey, 2006-07***.

It may be observed from **Table 11.4** that in 1950–51 the total production of cotton textile was only 4225 million sq metres which increased to 55,000 sq metres in 2008–09 recording an increase of over 130 per cent.

Table 11.4 *Production of Cotton Cloth*

Year	*Production in million sq. metres*
1950–51	4225
1960–61	6750
1970–71	7600
1980–81	8400
1990–91	15,500
2000–01	19,700
2008–09	55,000

Source: India 2010, p. 643.

Problems of the Cotton Textile Industry

The cotton textile industry is suffering from many serious problems. Some of the problems of the cotton textile industry have been briefly presented here:

1. Shortage of Raw Material

There is a shortage of raw material especially of good quality cotton to meet the growing demand of the Indian textile industry. The fluctuating prices and uncertainties in the availability of raw material lead to low production and sickness of the mill. Consequently, long staple cotton is imported from Egypt, Sudan Kenya, Peru, Tanzania, Uganda, and USA. There is a need of Silver Fibre Revolution in the country.

2. Obsolete Machinery

Most of the Indian textile mills are working with obsolete machinery. According to one estimate 70 per cent of the spindles are more than 30 years of age. The outdated machinery cannot compete with the machinery of countries like China, Japan, South Korea, Taiwan, and USA which have the latest sophisticated machinery in their textile mills.

3. Erratic Power Supply

Power supply to most of the factories is inadequate and erratic which adversely affects the production of goods.

4. Strikes and Lockouts

The cotton textile industry suffers seriously because of frequent strikes by the workers. Occasionally the owners lockout the mills which decreases the production of goods.

5. Competition in Foreign Market

The Indian cotton goods are facing a stiff competition in foreign markets, especially from China, Egypt, Japan, South Korea, and Taiwan.

6. Heavy Excise Duties

The cotton textile industry suffered because of heavy excise duties. The high rate of duty on imported cotton has increased the cost of production of clothes which has created problems in selling the cloth in the international market.

7. Competition with Synthetic Fibres

The poor people of the country prefer to use synthetic fibre clothes which are more durable and attractive.

8. Sick Mills

In India more than 130 mills are sick. The machinery of these mills is obsolete which can only be replaced with heavy investment. The slow pace of modernisation, outdated machinery, and old technology are some of the long-term problems which need to be addressed.

JUTE TEXTILE

India is the largest producer and second largest exporter of jute goods in the world, contributing about 35 per cent of the total output of the world. It is a labour intensive industry which directly and indirectly provides job to more than 4 lakh people. The industry is, however, facing a tough competition from synthetics and its export market is shrinking.

The first jute factory in India was established at Rishira, about 20 km north of Calcutta in 1854. The industry made tremendous progress in the later part of the 19^{th} century. Subsequently, the industry was boosted by the two world wars. The industry suffered a serious setback in 1947 due to the partition of the subcontinent. After partition about 80 per cent of the jute growing areas went to East Pakistan (Bangladesh), while nearly 90 per cent jute mills remained in India. In 1959, the international demand of jute products decreased substantially as a result of which 112 jute factories were closed down. At present there are only 79 jute producing mills in India. Most of these mills are along the Hugli river, especially to the north of Kolkata. Out of total 79 jute mills, 62 are located in West Bengal, 3 each in Bihar and U.P., seven in Andhra Pradesh and one each in Assam, Odisha, Tripura and Chhattisgarh.

The jute mills are integrated units consisting of both spinning and weaving units. The main products of jute industry are gunny bags, canvas, pack-sheets, cotton-jute, paper-lined Hessians, Hessian cloth, carpets, carpet-backings, rugs, cordage, and twines.

Jute industry is mainly a raw material based industry. Most of the jute mills are in the jute producing areas of the country. West Bengal alone accounts for 85 per cent of the total jute production of the country (**Fig. 11.1 and Fig. 11.4**). The high concentration of Jute mills in West Bengal (**Fig. 11.5**) is because of the following factors:

1. *Availability of raw material:* Jute cultivation needs highly productive, well-drained soils and hot and humid climate. These conditions are ideally available in many tracts of West Bengal and Lower Assam.
2. Cheap and skilled labour is available in West Bengal, one of the most densely populated state of the country.
3. Cheap water transport through the Hugli river.
4. Availability of coal from the Raniganj coal-mines.
5. Export facility through the port of Kolkata and Haldia.

In addition to West Bengal, jute mills are also located in Eluru, Guntur, Ongole and Vishakhapatnam (Andhra Pradesh); Darbhanga, Gaya, Katihar and Samastipur (Bihar); Kanpur (Uttar Pradesh); and Raigarh (Chhattisgarh). The jute mills outside the Hugli belt are generally smaller in size. The total production from these 25 mills is only about 3 per cent of the total production of jute goods.

Jute industry in India is essentially export-oriented. India stands second after Bangladesh in the export of jute and jute products. Jute goods are exported to USA (30 per cent), Russia (25 per cent), UAE ((10 per cent), and UK, and Germany (2 per cent each). Among the other importers of Indian jute goods, Argentina, Australia, CIS, Cuba, Indonesia, Japan, Myanmar, Malaysia, Singapore, Sudan, and Thailand are important.

Problems of the Jute Textile Industry

The jute industry of India is confronted with many problems. Some of the important problems of jute industry are given here:

1. Shortage of Raw Material

Despite expansion of jute growing area and intensification of its cultivation, India is not self-sufficient in the supply of raw material. To meet the growing need of the industry, raw material is imported from Bangladesh, Brazil, and Philippines. There is a need of Golden Fibre Revolution in the country.

2. Obsolete Machinery

Most of the machinery in jute mills is more than 25 years old. These machinery are outdated and lead to low production.

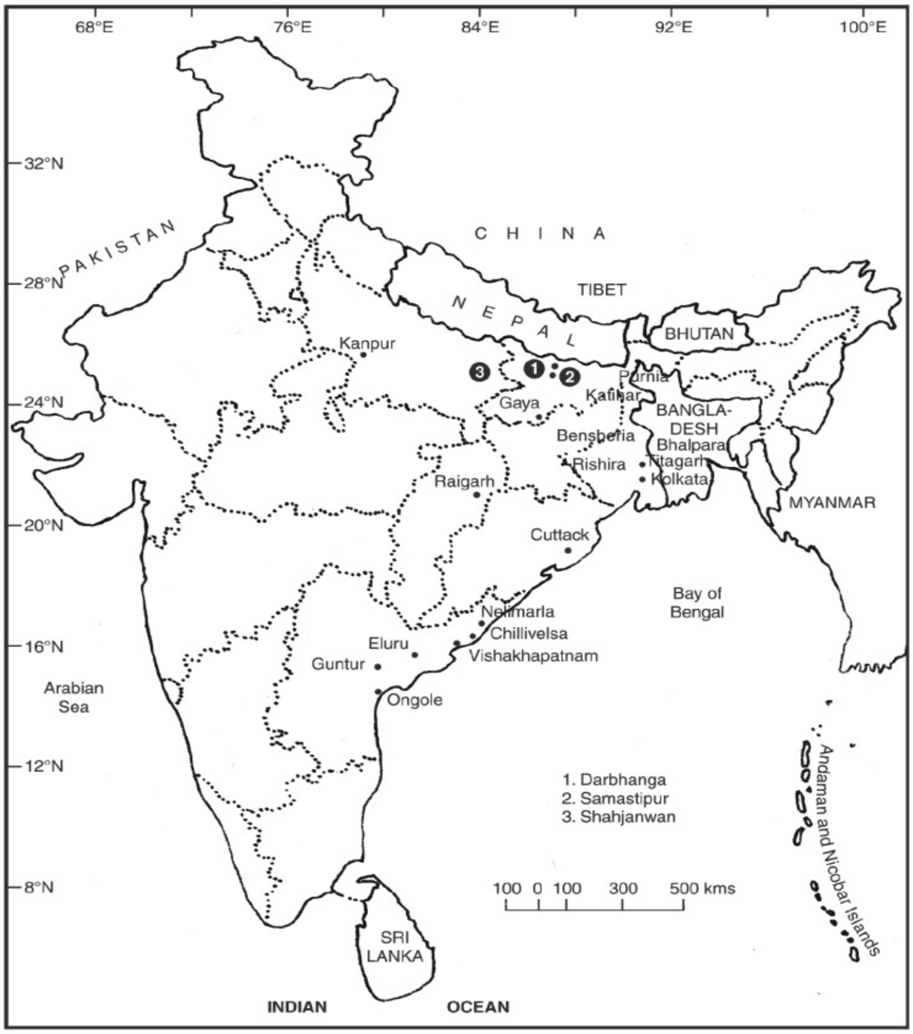

Fig. 11.4 Jute Industrial Centres

3. International Competition

India is facing a tough competition from Bangladesh, Brazil, Japan, Philippines, and South Korea.

4. High Prices

The high price of raw material is making the jute products expensive. Consequently, a number of jute mills are becoming sick units.

5. Decrease in the Demand of Jute Products

The overall demand of jute products is steadily decreasing in the international market.

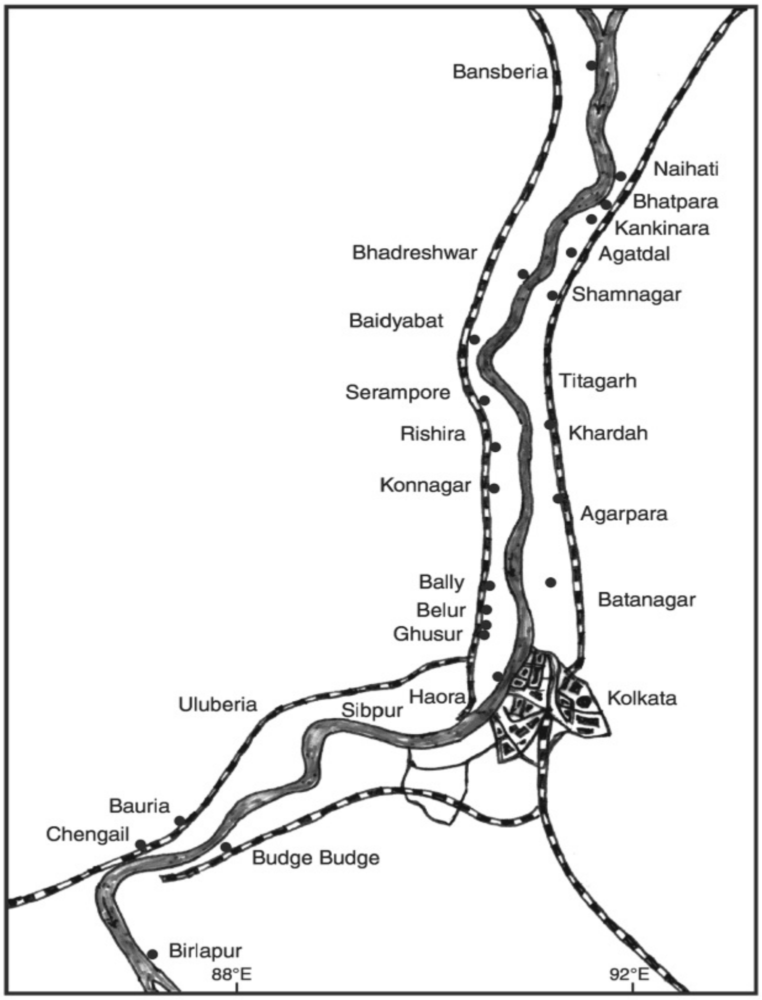

Fig. 11.5 Hugli Valley Jute Mills

6. Strikes and Lock-outs

The trade unions frequently go on strike which hamper the routine production of jute goods.

7. Competition from Substitutes

Jute industry is facing a tough competition from synthetic bags.

WOOLLEN TEXTILES

Woollen textile is one of the oldest industries of India. During the ancient and medieval periods woollen clothes were manufactured at the cottage industry level. The modern woollen textile industry started with the establishment of '*Lal Imli*' at Kanpur in 1876. It was followed by the setting up of '*Dhariwal*' at Punjab in 1881. Subsequently woollen mills were established in Mumbai (1882) and Bangalore (1886). The industry made tremendous progress after Independence. At present there are 625 big and small woollen textile factories in the country.

The main concentration of woollen textile industry is found in Punjab, Maharashtra, and Uttar Pradesh. Other states which are producing woollen goods are Gujarat, Jammu and Kashmir, Karnataka, and West Bengal (**Fig. 11.6**).

In Punjab, there are more than 260 small and big mills which are located mainly in Amritsar, Dhariwal, Kharar and Ludhiana. In Maharashtra, Mumbai is the leading producer having 45 woollen factories. In Uttar Pradesh, woollen factories are located at Kanpur, Agra, Mirzapur, Modinagar,

Fig. 11.6 Woollen Textile

Shahjahanpur, and Varanasi. In Gujarat, Ahmedabad, Jamnagar, Kalol, and Vadodra are the main producers of woollen goods. In Haryana, Bahadurgarh, Faridabad, Gurgaon, and Panipat are the centres of woollen textile production. In Rajasthan, Alwar, Beawar, Bikaner, Bhilwara Jaipur, Jodhpur, Sikar and Nagaur are the important woollen textile centres. Bangalore, Kolkata, Haora, Srinagar, Kullu (Himachal Pradesh), Salem and Chennai are the other woollen textile centres. This industry provides employment to 27 lakh workers in the wide spectrum of activities (India 2012, p. 726).

India is not self sufficient in quality wool production. Good quality wool is, however, imported from Australia. The important items of export are blankets, caps, carpets, cardigans, druggets, gabbas, hosiery, jerseys, mufflers, *Namdas*, pullovers, shawls, and socks. These goods are exported to USA, UK, Australia, Belgium, Canada, Denmark, France, Germany, the Netherlands, Russia, South West Asian, and African countries.

Problems of the Woollen Textile Industry

The woollen textile industry is facing the problems of:

(i) Shortage of quantity and quality of wool
(ii) Obsolete machinery
(iii) Competition with more advanced countries
(iv) Competition with synthetic fibres
(v) Shortage of power
(vi) Low quality of goods
(vii) Lack of market
(viii) Strikes by the workers

SILK TEXTILE

India's position in silk production is number two in the world after China, contributing 18% of the total silk production of the world. India has the monopoly in the production of *muga* silk, produced in Assam and Bihar. Silk textile was essentially a household industry in the early stage of its development. The Mughals were very much fond of silk clothes. The cotton goods used to be exported to the countries of south-west Asia and Europe. The first silk mill was, however, located at Haora by the East India Company in 1832. The industry made tremendous progress after Independence.

Distribution

The states of Andhra Pradesh, Assam, Bihar, Jammu and Kashmir, Karnataka, Tamil Nadu, Uttar Pradesh, and West Bengal are the leading producers of silk textile goods. The silk manufacturing centres have been shown in **Fig. 11.7**.

The state of Karnataka is the largest producer of silk textile. Bangalore, Belgaum, Gokak, Kolar, Mandya, Mysore, and Tumkur are the main producing centres. Channapatna and Mysore are the main centres of silk textile in the state. Silk yarn from these centres is exported to Arani, Dharmavaram, Kancheepuram, Kumbakonam, Surat, and Varanasi.

In West Bengal, the main centres of silk textile are Basawa, Bishenpur, Chak-Islampur, Kolkata, and Madhu-Ghat (Maldah District). In Andhra Pradesh, silk textile is concentrated in Anantapur, Chittor, Karimnagar, Vishakhapatnam, and Warangal. In Bihar, Bhagalpur; in Jharkhand, Hazaribagh and Ranchi; in Assam, Barpeta, Goalpara, Kamrup, Nalbari, and Naogaon are known for silk textile. In Tamil Nadu, Coimbatore, Dharmapuri, Kancheepuram, Nilgiri, Salem, and Tirunelveli; while in Madhya Pradesh, Balghat, Bastar, Bilaspur, Raigarh, and Surguja are the silk textile centres. Silk textile is also concentrated in Anantnag, Baramulla, Doda, Jammu, Riasi, Srinagar, and Udhampur in Jammu and Kashmir.

India is one of the important exporters of silk textile. Silk and silk products are exported to USA, UK, Kuwait, Russia, Oman, Saudi Arabia, Singapore, and UAE.

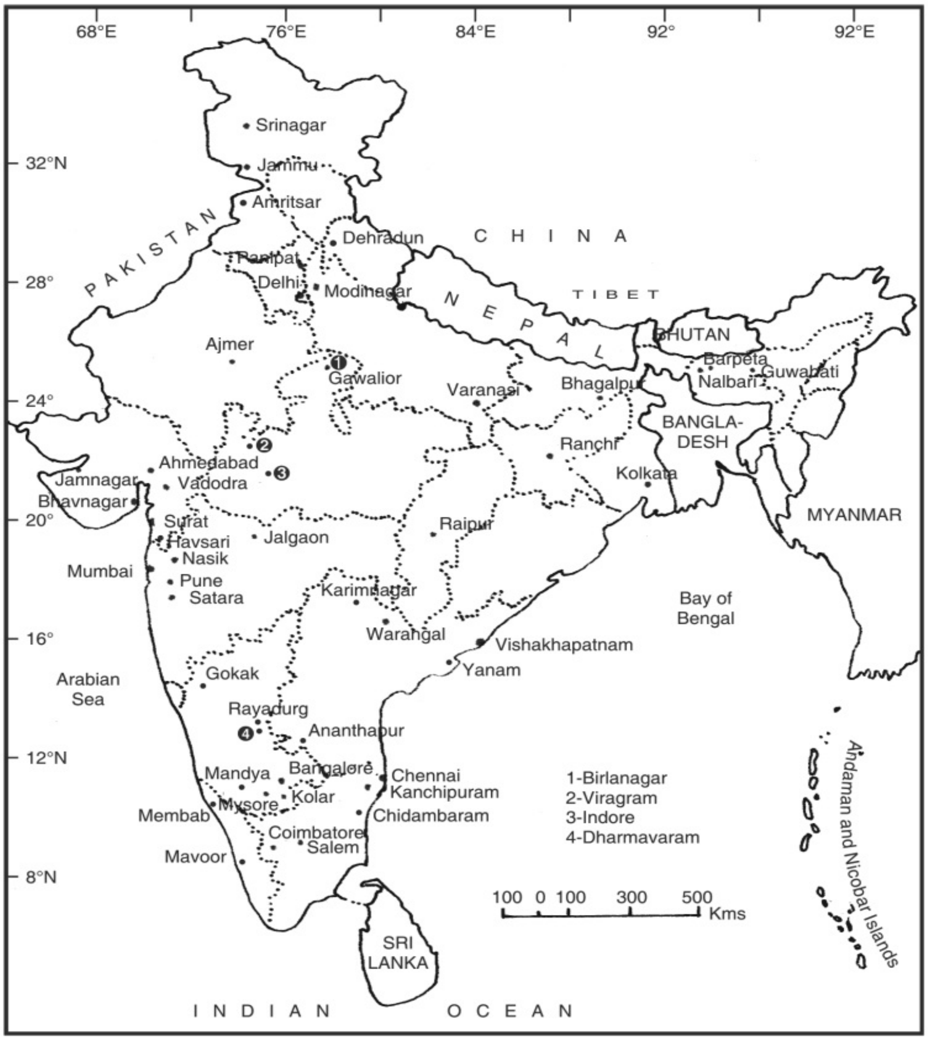

Fig. 11.7 Silk Textile

IRON AND STEEL INDUSTRY

The history of iron and steel industry in India is nearly 4000 years old. The famous iron pillar near Qutab Minar is dating back to 350 AD. The first attempt to produce iron and steel on modern lines was made in 1830 at Porto Nova, near Chennai (Tamil Nadu). But it was not successful as the smelting used to be done with the help of charcoal. Pig-iron was produced in 1874 for the first time by the Bengal Iron Works. The real progress in the iron and steel industry was made in 1907 when J.N. Tata established the smelting factory at Sakchi (the former name of Jamshedpur). Subsequently, the Indian Iron and Steel Company Ltd. (IISCO) was set up at Hirapur in 1918, and the Visveswaraya Iron and Steel Limited (VISL) at Bhadravati in 1923.

It was in the Second Five-Year Plan 1956–61, when tremendous progress was made by the iron and steel industry. It was during this plan, when integrated iron and steel plants were established at Bhilai, Durgapur, and Raurkela. The Bokaro Iron and Steel Plant was established with the help of Russian government in 1964. The Steel Authority of India (SAIL), was set up in January 1973. In the Fifth Five-Year Plan, it was resolved to set up four new iron and steel plants at Paradwip, Salem, Vijaynagar, and Vishakhapatnam. At present India is the 5th largest producer of crude steel in the world.

Locational Factors

The raw material used in the iron and steel industry are iron ore, manganese, flux, limestone, fuel (coking coal), and fire-clay. It consumes heavy quantity of coal and iron-ore. Both these minerals are weight-losing. Consequently, it is located either at the site of coal mines or near the iron-ore deposits. All these raw materials including water, bauxite, dolomite, etc. and coal are found in the Chotanagpur Plateau. The state of Bihar, Chhattisgarh, Jharkhand, Karnataka, Madhya Pradesh, Odisha, Tamil Nadu, and West Bengal are rich in the raw material required for the smelting of iron-ore.

Iron and Steel Plants in India

There are twelve important iron and steel plants in India (**Fig. 11.8**). Except TISCO, all the big integrated plants are in public sector. The steel plants under public sector are supervised by the Steel Authority of India Limited (SAIL). A brief description of the main steel plants of India has been given in the following:

1. The Tata Iron and Steel Company (Jamshedpur)

TISCO Plant is located at the confluence of Subernrekha and Kharkai rivers about 240 km north-west of Kolkata in the Singhbhum District of Jharkhand. It was established in 1907; the production of pig-iron started here in 1908 and that of steel in 1911.

The Jamshedpur Steel Plant has an ideal location at which the transportation cost is the least (**Fig. 11.9**). It obtains the supply of iron-ore from Badam-Pahar (Mayurbhanj-Odisha), Noamundi (Singhbhum District of Jharkhand); coking coal from Jharia and Bokaro, manganese from Keonjhar (Odisha); limestone and fire-clay from Sundargarh District (Jharkhand), and fresh water from the Subernrekha and Kharkai rivers. Being situated in the tribal belt, cheap labour is also available and the finished products can be exported through the port of Kolkata.

TISCO produces pig iron, high grade steel, acid steel for making railway wheels, axles, bars, bolts, corrugated-sheets, nails, nuts, rods, sheets, steel-casting, tinplates, tyres, and wires. Special alloy steel produced by the plant is used for making bullet-proof armour plates and for armour-piercing bullets.

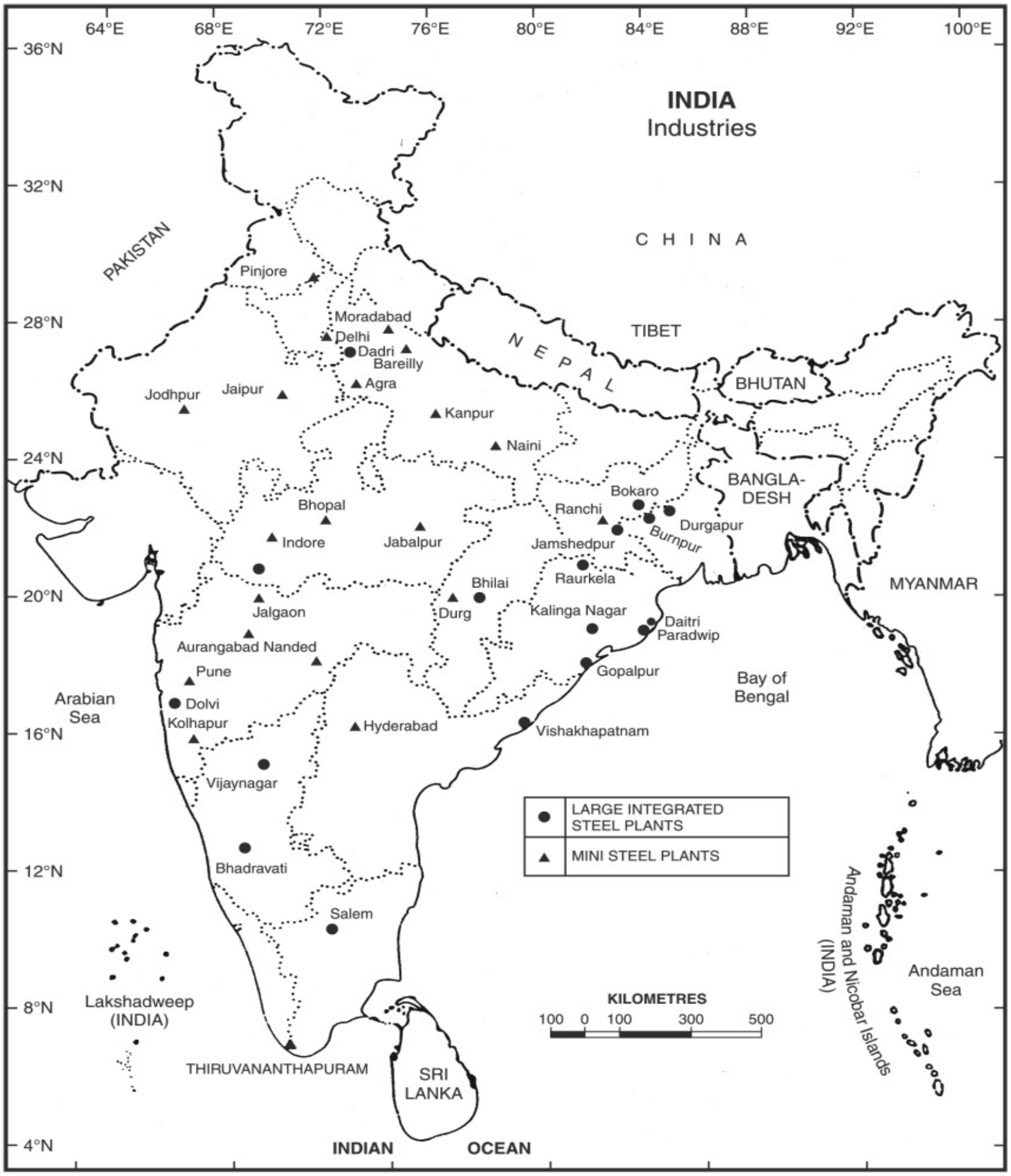

Fig. 11.8 Iron and Steel Industry

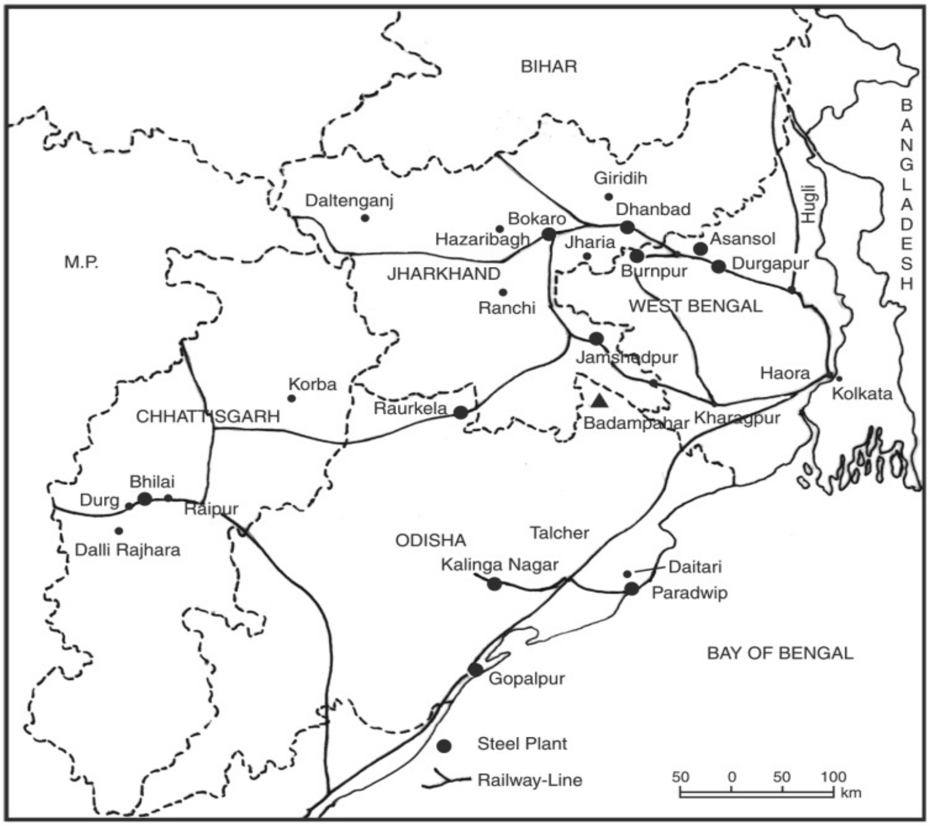

Fig. 11.9 Chotanagpur Plateau Iron and Steel Plants

2. Burnpur, Indian Iron and Steel Company (IISCO)

The Indian Iron and Steel Company, founded in 1918, and the Steel Corporation of Bengal, founded in 1927, were merged under the former name in 1952. It has three separate plants at Burnpur (about 5 km south-west of Asansol), Hirpur (about 6 km south of Asansol) and Kulti (about 16 km west of Asansol). The management of these steel plants was taken over by the government in 1972.

These steel plants obtain iron ore from their mines at Goa. The coal is obtained from Ramnagar mines of Jharia, which is only about 3 km from Kulti. Manganese is obtained from Bihar, Jharkhand, Madhya Pradesh, and Odisha; fire-clay from Singhbhum. Moreover, cheap hydro-electricity is available from the Damodar Valley Corporation (DVC) and water from the Damodar river. Cheap labour is available from within the tribal belt of the region and Bihar, while the seaport of Kolkata helps in the export of the finished product.

3. The Bhadravati Iron and Steel Plant (VISL)

The Visveswaraya Iron and Steel Limited at Bhadravati, formerly known as Mysore Iron and Steel Limited was established in 1823. The plant was taken over by the Central Government in 1962. It obtains iron ore from Kudermukh, Baba Budan Hills (Chikmaglur District of Karnataka). Manganese, limestone, dolomite, and fire-clay are also available within a distance of 50 km, electricity from the Jog and Shravati Power Projects.

This plant is one of the major producers of alloy and special steel in the country. It also produces casting iron, ferro-silicon, mild-steel and, spun-pipes.

4. Bhilai Iron and Steel Plant (HSL)

The Bhilai Iron and Steel Plant was established with the technical co-operation of Russain Government (erstwhile Soviet Union) in the Durg District of Chhattisgarh in 1959. It obtains its iron ore from the Dhalli-Rajhara mines about 95 km south of the plant, coal from Korba (Chhattisgarh), Bokaro and Jharia (Jharkhand), manganese from Balaghat and Bhandara, limestone from Nandani mines only 18 km from Bhilai, water from Tandula Canal and Reservoir, electricity from the Korba Thermal Power Station. As it is located in the tribal belt of Chhattisgarh, cheap labour is locally available. The finished products are exported through the port of Vishakhapatnam.

Bhilai steel plant specialises in the production of pig-iron, crude-steel, and plates for ship-building industry. The plant also produces byproducts like ammonium sulphate, benzol, coal-tar, and sulphate-acid.

5. Raurkela Iron and Steel Plant (Hindustan Steel Limited)

The Raurkela Steel Plant is located in the Sundargarh District of Odisha along the Kolkata-Nagpur railway line. It was built with the technical co-operation from the German firm, Krupps and Demang in 1959. The plant obtains its iron-ore from Mayurbhanj; coal from Bokaro, Jharia, Talcher, and Korba; manganese from Sundargarh; water from the Sankha and Koel rivers (tributaries of Brahmani); and hydro-power from the Hirakud Dam. Cheap labour is available from the Jharkhand and densely populated Bihar state.

It specialises in the production of flat products. The main products of this steel plant are cold-rolled-sheets, hot-rolled-sheets, galvanised sheets and electrical steel plates. The plant also releases large quantity of nitrogen as by-product of fertilisers and various chemicals like anthracite-oil, benzole, crude-anthracite, crude-phenol, naphtha, naphthalene, and wash-oil.

6. Durgapur Iron and Steel Plant (HSL)

The Durgapur Iron and Steel Plant was established with the help of British companies in 1956; production started in 1962. The city of Durgapur is located along the Damodar River. It obtains iron-ore from Singhbhum (Jharkhand), and Kendujhar (Odisha), coal from Raniganj, manganese from Balaghat (M.P.), and water from the Damodar river. It produces ingot steel.

7. Bokaro, Bharat Steel Limited (BSL)

The Bokaro Steel Plant was located with the help of the Soviet collaboration in 1964. It obtains its iron ore from Keonjhar District; coal from Bokaro, Jharia, and Kargali coal mines; lime from Daltonganj in Palamu District; dolomite from Bilaspur District; and water from the Tenu Dam across the Damodar river.

Bakaro is essentially a flat product plant, and the hot and cold rolling mills are its main production units. Its sludge and slag are being used in making fertilisers at Sindri.

8. Salem Steel Plant

This steel plant was commissioned in 1982. It obtains iron-ore from the neighbouring areas, manganese, dolomite and limestone are also available within a distance of 60 km. Cheap power and labour and enormous market are the added advantage. It produces iron and steel of special grade.

9. Vijayanagar Steel Plant

This steel plant is located near Hosepet in the Bellary District of Karnataka. It obtains iron-ore from Hosepet; coal from Kanhan valley (Chhattisgarh)and Singareni (Andhra Pradesh); limestone and dolomite are also available within a distance of 150 km; water from the Tungbhadra Reservoir (about 35 km); and cheap hydel-power from the Tungbhadra Project. In this plant steel is produced with the Corex process which makes use of non-coking coal.

10. Vishakhapatnam Steel Plant

The foundation of this steel plant was laid in 1971 and the actual production was commissioned in 1992. This steel plant was established by the Rashtriya Ispat Nigam Limited (National Steel Corporation Ltd.). This is the only steel plant of India which has a coastal location. It obtains iron-ore from Bailadila (Chhattisgarh); coal from Bokaro, Raniganj, and Jharia; limestone and dolomite from Bastar (Chhattisgarh), Madhya Pradesh, and Odisha. It specialises in the production of steel and the quality of its steel can be compared to global standards.

11. Daitari Steel Plant

A steel plant has been located at Daitari near Paradwip in Odisha. Initially it was to be established in collaboration with the British and South Korean companies. Its responsibility has, however, been given to the Tata Group. It has a capacity of 2.6 million tonnes.

12. Dolvi Steel Plant

A new steel plant is being set up by the Ispat Industries Limited at Dolvi in the Ratnagiri District of Maharashtra. This steel plant is equipped with the latest technology in steel manufacturing. It requires less space, less energy, high labour productivity, and less cost of production. The plant is capable of producing strips as thin as 1.00 mm. Its annual capacity is 3 million tonnes.

13. Tata Steel, Kalinganagar

This steel plant has been undertaken by the Tata Steel Company. The first phase of the project was completed in 2005.

14. Pasco Steel, Paradwip

The Pohang Steel Company of South Korea has agreed with the Odisha Government to establish an iron and steel plant at Paradwip. The project is likely to be commissioned in 2016. It is one of the biggest foreign direct investment (FDI) in India. When complete, it will require over 600 million tonnes of iron-ore for the production of iron and steel.

15. Mini-Steel Plants

In addition to these, there are more than 225 mini-steel plants with a capacity of 10,000 tonnes to 5 lakh tonnes. The main factors responsible for the growth and establishment of mini-steel plants are:

(i) Heavy demand for iron and steel
(ii) Lower cost of production
(iii) Controlled price of the steel
(iv) Easy availability of scrap at lower prices from home and abroad
(v) Lower capital investment
(vi) Shorter gestation period

The production of steel in India between 1980 and 2006 has been shown in **Fig. 11.10** while **Table 11.5** gives the production of pig-iron and steel. It may be observed from Table 11.5 that the production of finished was only about one million tonnes in 1950–51 which rose to 32.50 million tonnes in 2005–06

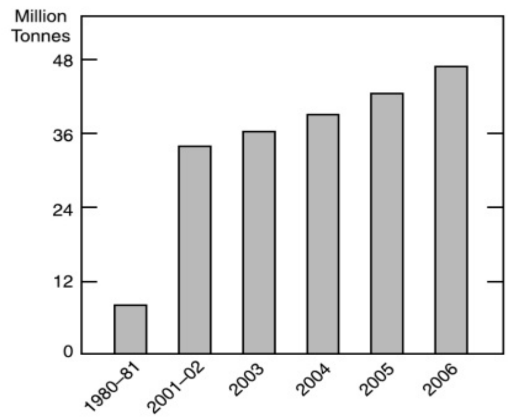

Fig. 11.10 India—Production of Steel

Table: 11.5 *Trends in the Production of Iron and Steel in India (in million tonnes)*

Year	*Pig iron*	*Steelingots*	*Finished steel*
1950–51	1.69	1.47	1.04
1960–61	4.31	3.48	2.39
1970–71	6.99	6.14	4.64
1980–81	9.55	10.33	6.82
1990–91	12.15	11.10	13.53
2000–01	03.39	25.88	29.27
2005–06	04.25	28.35	32.50

Source: ***Indian Economic Survey, 2005–06 and India 2007***.

Problems of Iron and Steel Industry

The Iron and Steel Industry of India is facing the following problems:

1. Heavy Investment

The establishment of iron and steel industry requires huge amount of capital. Moreover, the plant has a long gestation period. Construction of iron and steel plants is a difficult proposition, and therefore, most of the steel plants are in the public sector.

2. Obsolete Technology

The iron and steel plants established during the Second Five-Year Plan are not working to the full capacity as the machinery is outdated. Moreover, the high cost of coking coal has affected the industry adversely.

3. Inefficient Public Sector

Most of the iron and steel plants in public sector are incurring heavy losses mainly due to poor management and under-utilisation of capacity.

4. Controlled Prices

The government has fixed price for iron and steel which leaves very little margin of profit for the manufacturers.

5. Sickness of Mini-Steel Plants

Due to the inadequate supply of power and sharp increase in the raw materials, many of the small iron and steel plants are either experiencing sickness or are being closed down.

6. Inadequate Supply of Coking Coal

India's coking coal deposits are confined largely to the Raniganj and Jharia coal mines. These coal mines have become fairly deep and the cost of product of coal has gone up. Consequently, the input cost of energy is going up, affecting the output and margin of profit adversely.

7. Competition in the International Market

In the international markets, it is becoming increasingly difficult to compete with the steel of Australia, Brazil, France, Germany, Japan, Canada, Sweden, UK, and USA.

ALUMINIUM INDUSTRY

Aluminium is the second most important metallurgical industry of the country. It plays a very vital role in the overall industrial development of the country. Its elasticity and good conductivity of electricity and heat, and capacity to be moulded into any desired shape has made it a universally accepted metal. It is widely used in the generation and distribution of electricity, manufacturing of aeroplanes, railway coaches, defence and nuclear accessories, utensils, packing, and for making coins. It is a cheaper substitute of steel, copper, zinc, lead, etc. in a large number of industries.

Locational Factors: Availability of *bauxite* (raw material) and hydro-electricity are the basic requirements for the establishment of aluminium industry.

The production of one tonne of aluminium requires approximately six tonnes of bauxite. About 30 to 40 per cent of the production cost of aluminium is accounted for electricity alone. Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Maharashtra, Odisha, Rajasthan, and Tamil Nadu are the major producers of bauxite in India.

Development: The aluminium industry was started in India during the Second World War at Alupuram (Alwaye) by the Aluminium Company in 1938. It was later on converted into a public sector company in 1944. Another company, namely Aluminium Corporation of India started production of alumina in 1942 at Jaykaynagar (West Bengal). At the time of Independence, there were only two plants in the country with a total installed capacity of 4000 tonnes of ingots. During the Second Five-Year Plan two new aluminium plants were established at Hirakud (INDAL) and Renukoot (HINDALCO). Another plant was established in the Third Five-Year Plan at Mettur (MALCO) in 1967. The INDAL established a new plant at Belgaum in 1970. Later on the Bharat Aluminium Plant was established at Korba. Consequently the annual production increased to more than three lakh tonnes in 1979. At present, there are seven major aluminium producing plants in the country. The location of aluminium plants have been shown in **Fig. 11.11.** A brief account of the important aluminium plants has been given here:

Important Aluminum Plants

1. The Indian Aluminium Company Ltd. (INDAL), Hirakud

This company started production in 1938 as a private company and was converted into a public company in 1944. It is an integrated plant having three units at five different places for the production of alumina and aluminium sheets. The plants for the extraction of alumina from bauxite are located at Muri (Jharkhand), near the bauxite mines. Its three smelting units are located at Alupuram (Alwaye in Kerala), Hirakud (Odisha), and Belgaum (Karnataka). The rolling mill at Belur (West Bengal)

Fig. 11.11 Aluminium Industry

manufactures aluminium sheets, rod, aluminium paste, electrical conductors, and domestic utensils. The plant gets bauxite from the Bagru Hills near Lohardaga, coal from Damodar valley, and hydro-electricity from Hirakud. The plant has an installed capacity of one lakh tonnes of aluminium ingots.

2. The Aluminium Corporation of India, Jaykaynagar (near Asansol)

The production from this plant was started in 1942. The plant gets bauxite from Ranchi (Jharkhand) and Unchera (M.P.). It has its own coal-mine, a thermal power plant and an alumina plant, a reduction plant, a sheet rolling plant and a utensils producing plant. It has a capacity of producing 90,000 tonnes of aluminium ingots annually.

3. The Hindustan Aluminium Corporation Ltd. (HINDALCO), Renukoot

This plant was set up at Renukoot, about 160 km south of Mirzapur, in 1958. It obtains bauxite from Lohardaga (Jharkhand and Amarkantak region of Madhya Pradesh), and power from the Rihand Dam. Its installed capacity is 1.26 lakh tonnes of ingots per annum, manufacturing mainly aluminium sheets and wires.

4. The Madras Aluminium Company Ltd. (MALCO), Mettur

This company set up its plant at Mettur near Salem in 1965. It obtains bauxite from the Shevaroy Hills and electricity from the Mettur Hydel Project. Its installed capacity is 25,000 tonnes of aluminium ingots.

5. The Bharat Aluminium Company Ltd. (BALCO), Korba

This is a public sector company which set up its plant at Korba (Bilaspur District, Chhattisgarh) in 1965. It obtains bauxite from the Amarkantak (Shahdol District of Madhya Pradesh) and electricity from the Korba Thermal Power Plant. The plant has an installed capacity of 2.00 lakh tonnes of ingots per year. The government has recently disinvested its share to a private company namely, Sterlite Industries, India (March 2001).

6. The National Aluminium Company Ltd. (NALCO), Koraput

Located at Koraput, it is the largest aluminium plant of the country. The Company was incorporated in 1981. It obtains bauxite from the bauxite mines at Panchpatmali (District Koraput). It has an installed capacity of 1.6 million tonnes of ingots per year. There is an alumina refinery at Damanjodi (District Koraput) and alumina smelter at Angul. It obtains hydro-electricity from the Angul Power Plant and the port facilities from the Vishakhapatnam for export of alumina and import of caustic soda. It has a capacity of production of alumina of 8 lakh tonnes per annum. The Central Government has disinvested about 45 per cent of NALCO's shares.

The Government has approved the second phase expansion of NALCO's Integrated Aluminium Complex in 2004 at the outlay of Rs. 4,091.51 crore to be completed by 2008. With this expansion, capacity of Bauxite Mines Refinery, Smelter, and Captive Power Plant will increase from 4.8 million tonnes per year to 6.3 million tonnes per year.

Table 11.6 *India: Trends of Aluminium Production (000 tonnes)*

Year	*Production*
1950–51	4.0
1960–61	18.5
1970–71	169.0
1980–81	199.00
1990–91	450.00
2000–01	560.00
2005–06	585.00

The aluminium industry has made a commendable progress during the planned period. It may be seen from **Table 11.6** that the total production of aluminium was only 4 thousand tonnes in 1950–51 which rose to 585 thousand tonnes in 2005–06. Despite appreciable progress in the production of aluminum, India is not self-sufficient in matter of aluminium.

Trade

India is almost self-sufficient in the matter of aluminium. Except some high quality aluminium which it imports from the foreign countries. The demand for good quality of aluminium is on the increase and consequently, India is importing aluminium and its products from the developed countries.

Problems

The major problem of the aluminium industry is international competition. India has the best grade of bauxite but unfortunately, the quality of products are not at par to that of the countries like Australia, Canada, France, Germany, Japan, UK, and USA.

Non-availability of power at a cheaper rate, strikes, and labour unrests are the other problems this industry is facing.

AUTOMOBILE INDUSTRY

Automobile indusry in india is one of the largest in the world and one of the fastest growing globally. India manufactures over 11 million vehicles (including 2 wheeled and 4 wheeled) and exports about 1.5 million every year. By 2050, India is expected to top the world in cars number with 600 million on the nation's roads.

The automobile industry of India made a steady progress after independence. It was in 1947 when the Premier Automobiles Ltd. was established at Kurla (Mumbai). In 1948, the Hindustan Motors Ltd. Uttarapara was established near Kolkata. Within a short period of about fifty years, automobile industry in India has made a tremendous progress. At present, there are 17 manufacturers of passenger cars, 9 manufacturers of commercial vehicles, 16 producers of two and three wheelers and 14 producers of tractors, besides 5 manufacturers of engines. In 2010-11, India produced about 3 million passenger vehicle, 7.5 lakh commercial vehicles, 8 lakh three wheelers, 13.38 million two wheelers. The percentage growth rate in 2010-11 was 27.45. (India 2012, p. 704)

The automobile industry was delicensed in July 1991 with the announcement of the New Industrial Policy. The passenger car was, however, delicensed in 1993. At present 100% Foreign Direct Investment

(FDI) is permissible in automobile industry. The auto industry directly or indirectly employ 12.5 million people and contributes 5 per cent of national GDP (India 2012, p. 704).

The automobile industry is mainly located near the iron and steel producing centres as steel is the basic raw material used in the industry. The automobile industry is also located near the markets and the seaports. Some of the automobile industries have been located in the under-developed areas of isolation and relative isolation (**Fig. 11.12**).

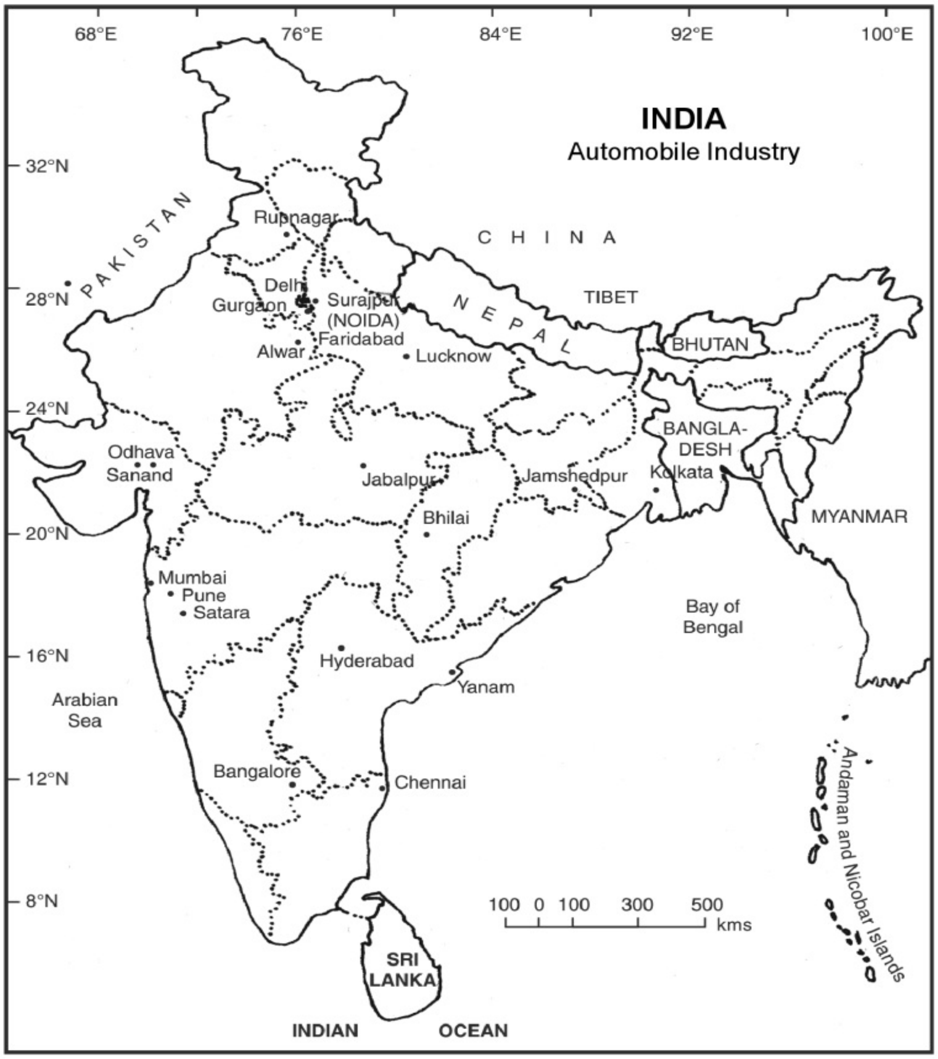

Fig. 11.12 Automobile Industry

The main automobile producing centres are: Chennai, Delhi, Gurgaon, Jabalpur, Jamshedpur, Kolkata, NOIDA (U.P.) and Mumbai. Motorcycles are produced at Faridabad and Mysore. Scooters are manufactured at Akurdi (near Pune), Lucknow, Odhav (near Ahmedabad), Panki (near Kanpur), and Satara in Maharashtra.

The commercial vehicles are produced by Tata Engineering and Locomotive Co. (TELCO). It produces over 70 per cent of the total commercial vehicles. Its four plants are located at Hyderabad, Pithampur (Madhya Pradesh), Rupnagar (Punjab), Surajpur (NOIDA—Uttar Pradesh). The Premier Automobiles and Mahindra and Mahindra are located at Mumbai; Ashok Leyland Ltd. and Standard Motors at Chennai; Hindustan Motors Ltd. at Kolkata, and Bajaj Tempo Ltd. at Pune. Moreover, Shaktiman Trucks are manufactured under the Ministry of Defence and Nissan Jeeps at Jabalpur in collaboration with the Nissan Company of Japan.

Table 11.7 *Production of Vehicles in 2005–06*

Category	*Production in numbers in 2005–06*
Passenger Car	10,45,881
Multi-Utility Vehicles	2,63,032
Commercial Vehicles	3,91,078
Two Wheelers	76,00,801
Three Wheelers	4,34,424
Total	**97,35,216**

Source: ***India, 2007,*** pp.550–551.

Passenger Cars

The demand of passenger cars has increased tremendously during the last two decades (**Fig. 11.12**). There are a number of companies producing passenger cars. Some of the important car manufacturers are: (i) Maruti Udyog Limited, Gurgaon (Haryana); (ii) Hindustan Motors (Chennai and Kolkata); (iii) Premier Automobiles, (Mumbai); (iv) Standard Motor Products, Chennai; (v) Hyundai Motors India: Surajpur (NOIDA-Uttar Pradesh); (vi) Daewoo Motors India Ltd. near Pune; (vii) Honda City (Uttar Pradesh); (viii) The collaboration between Mahindra and Ford has introduced the Ford Escort; (ix) Mercedes Benz of Germany in collaboration with Telco is producing expensive E220 and 250D; and (x) the Premier Automobiles in collaboration with Fiat-Ind-Auto Limited has introduced Fiat Uno car.

Jeeps

The entire production of jeeps is contributed by Mahindra and Mahindra, Mumbai. It has a capacity to produce 15,000 jeeps annually.

Two and Three Wheelers

There is an increasing demand of two and three wheelers all over the country. In fact, the two-wheeler industry has a great future. The two-wheeler industry comprises moped, scooters, and motorcycles. Mopeds are produced mainly by TVS-Suzuki, scooters by Bajaj Auto and LML at Mumbai, Pune, New Delhi, and Kanpur. Public sector units are located at Alwar, Bangalore, Hyderabad, Lucknow, and Satara. The motorcycle producing units are located at Chennai, Delhi, and Mysore.

FERTILISER INDUSTRY

Fertiliser industry has made a tremendous progress after independence. The first fertiliser plant was established in India in 1906. The five decades of planning and development of fertiliser industry have brought India to the frontline of fertiliser producing countries. India today is the third largest producer of nitrogenous fertilisers in the world after China and USA. The domestic production of urea in the year 2010–2011 was about 164 lakh tonnes which is 85% of the urea requirement of the country, while the per hectare consumption was about 129 kg. per hectare.

The public sector has been playing a dominant role in the fertiliser industry. The first state-owned fertiliser unit was set up in 1951 at Sindri in Bihar (Jharkhand) which was followed by another plant at Nangal in Punjab. At present, there are, 57 fertiliser units manufacturing a wide range of nitrogenous and complex fertilisers, 29 units producing urea, and 9 units producing ammonium sulphate as a by-product. Besides there are 68 medium and small scale units in operation producing single superphosphate.

For a fertiliser industry, the basic raw materials are neptha, rock-phosphate, sulphur gypsum, and smelter gases. In case gas is not available, the plant may be operated with the help of coke and coke-oven-gas. In India, we have coal based fertiliser plants at Bhilai and Korba (Chhattisgarh), Durgapur (West Bengal), Ramgundam (Andhra Pradesh), Jamshedpur and Sindri (Jharkhand), and Rourkela and Talcher (Odisha). Neyveli is based on lignite while Hazira (Gujarat) and Thal (Maharashtra) use natural gas from the Bombay High. Most of the fertiliser plants are located close to the petroleum refineries. Plants near sea are based on imported material. Some of the fertiliser plants have, however, been located near the consumer centres. The maximum number of fertiliser plants are in the state of Gujarat and Tamil Nadu **(Fig. 11.14)**.

Fertiliser Units in India

At present, there are 70 fertiliser producing units in the country. The Fertiliser Corporation of India (FCI), the National Fertilser Limited, the Hindustan Fertiliser Corporation, the Rashtriya Chemicals and Fertiliser Limited (RCF), the Fertilisers and Chemicals Travancore Limited (FACT), the Madras Fertiliser Limited, the Paradwip Phosphate Limited (PPL), and the Projects and Development Limited India are some of the important public sector undertakings.

1. The Fertiliser Corporation of India Limited (FCI)

The FCI was established in 1961 to take over the management of Sindri and Nangal (Punjab) fertiliser factories. Now the Fertiliser Corporation of India has four units, one each at Sindri (Jharkhand), Gorakhpur (UP), Talcher (Odisha), and Ramagundam (Andhra Pradesh). The Gorakhpur plant has remained closed since 1990 due to obsolete technology.

2. The National Fertilisers Limited (NFL)

The NFL was established in 1974. It has its units at Bhatinda, Nangal, Panipat, and Bijaipur. It specialises in the production of calcium ammonium nitrate.

3. The Hindustan Fertiliser Corporation Limited (HFC)

It was established in 1978. It has five operation units one at each at Barauni (Bihar) and Durgapur (West Bengal), and three at Namrup (Assam).

7. The Paradwip Phosphate Limited (PPL)

This was established in 1981. Its first plant was commissioned in 1986 and the second phase of the project was completed in 1992 to produce phosphoric acid and sulphuric acid.

Co-operative Sector

There are a number of fertiliser plants in the co-operative sector out of which, the Indian Farmers Fertiliser Co-operative Limited (IFFCO) is the most important. IFFCO has six production units one each at Aonla—two units (Bareilly), Kalol and Kandla (Gujarat), and Phulpur—two units (Allahabad). The KRIBHCO has a gas based urea-ammonia plant at Hazira in Gujarat.

India is not self sufficient in the matter of chemical fertilisers. About 50 per cent of the country's requirement is met by import.

The consumption, indigenous production, and imports of fertilisers in terms of fertiliser nutrients (NPK) during the period 2000–2001 and 2005–2006 are given below:

Table 11.8 *Consumption, Production, and Imports of Fertilisers (lakh tonnes)*

Year	*Consumption*	*Production*	*Imports*
2000–01	167.02	147.04	20.91
2007–08	225.70	147.06	77.56

Source: ***India, 2010***, p. 667.

It may be seen from **Table 11.8** that the consumption of chemical fertilisers in 2007–08 was 220 lakh tonnes out of which 190 lakh tonnes was produced indigenously and the remaining 30 per cent was imported.

Aonla: Situated in the District of Bareilly, the Aonla Chemical Fertiliser Plant was established by the Indian Farmers Fertilisers Co-operative Limited. The plant was commissioned in 1974. It meets the requirements of the farmers of the Rohilkhand Division of Uttar Pradesh.

Hazira: Situated in the state of Gujarat, Hazira is a modern chemical fertiliser plant. The smelting in this plant is done with the help of natural gas obtained from the Bombay High.

Kalol: Situated in the state of Gujarat, Kalol is one of the important petro-chemical complex of India. In addition to refinery it produces nitrogenous and phosphoric fertilisers. The natural gas for the production of fertilisers is obtained from the Gulf of Khambat.

Sindri: The first chemical fertiliser plant of India in public sector was established at Sindri in 1951 in the state of Jharkhand (erstwhile Bihar). The chemical fertilisers are produced with the help of coking coal. It is the main supplier of chemical fertilisers to the states of Bihar, Jharkhand, and West Bengal.

PAPER INDUSTRY

Paper industry is one of the core industries. It is a unique product which helps in the preservation of information and propagation of noble ideas and thoughts. In fact, the paper industry has a vital role to play in socioeconomic development of the country. It has great social and cultural significance. The per capita consumption of paper is considered as a bench mark of a country's modernization.

Paper making in India as a cottage industry was started during the Medieval Period, but the first paper mill was set up in 1832 at Serampore (West Bengal). It, however, resulted in a failure.

Problems of Paper Industry

Some of the important problems of paper industry are:

(i) Shortage of raw material
(ii) Inadequate supply of chemicals
(iii) Heavy investment
(iv) Strikes and lockouts
(v) Tough competition with the foreign paper producers
(vi) Obsolete machinery

Fig. 11.15 Paper Industry

(vii) High cost of basic inputs
(viii) Quality and environmental concern

PHARMACEUTICAL INDUSTRY

The drugs and pharmaceutical industry has made a phenomenal progress in India during the last four decades. The country now ranks 3rd in terms of volume of production (10% of global share) and 14th largest by value. Indian exports are destined to various countries around the globe including USA, Europe, Japan and Australia (2011-12). There are five Central Public Sector Undertakings and five joint Sector Undertakings in the pharmaceutical Industry Sector under the administrative control of the Department of Chemicals and Petrochemicals. Besides, there are two wholly-owned subsidiaries. A brief profile of these organisations is given in the following paragraphs.

1. Indian Drugs and Pharmaceuticals Limited (IDPL)

It was incorporated in 1961. The company has presently three manufacturing plants one each at Rishikesh in Uttarakhand, Hyderabad (Andhra Pradesh) and Gurgaon (Haryana). IDPL has two wholly owned subsidiaries, namely IDPL (Tamil Nadu) Ltd., Chennai in Tamil Nadu and Bihar Drugs and Organic Chemicals Limited at Muzaffarpur (Bihar). In addition, IDPL has two joint sector undertakings, promoted in collaboration with the respective State Governments. These are Rajasthan Drugs and Pharmaceutical Limited (RDPL), Jaipur and Odisha Drugs and Chemicals Ltd. (ODCL), Bhubaneshwar (**Fig. 11.16**).

2. Hindustan Antibiotics Limited (HAL), Pimpri (Pune)

It was incorporated in 1954. This was the first public sector company in drugs and pharmaceuticals. It has its plant located at Pimpri. There are three joint sector units promoted by HAL in collaboration with the respective State Governments. These are Karnataka Antibiotics and Pharmaceuticals Ltd. Bangalore (Karnataka), the Maharashtra Antibiotics and Pharmaceuticals Ltd. (MAPL) at Nagpur (Maharashtra), and Manipur State Drugs and Pharmaceuticals Ltd. (MSDPL) at Imphal (Manipur). The company produces a wide range of pharmaceutical formulations including agro-vet products.

3. The Bengal Chemicals and Pharmaceuticals Limited (BCPL)

It was incorporated in 1981. The company has four manufacturing units located at Maniktala (Kolkata), Panihati (24 Parganas West Bengal), one in Mumbai and one at Kanpur.

Most of the drugs and pharmaceutical units in India are located in Delhi, Gujarat, Maharashtra, Madhya Pradesh, Rajasthan, Tamil Nadu, Uttarakhand, Uttar Pradesh, and West Bengal. The important centres are Ahmedabad, Delhi, Hyderabad, Indore, Kanpur, Kolkata, Jaipur, Mumbai, Muzaffarpur (Bihar), Pune, Rishikesh (Uttarakhand), and Vadodra. The Surgical Instruments Plant at Chennai produces different types of surgical instruments, while the Bengal Chemicals and Pharmaceutical Limited (BCPL) with four manufacturing units is the largest producer of anti-snake venom in India.

Although it is producing a large variety of drugs and is meeting 75 per cent of its requirements by indigenous products. India is importing expensive life saving drugs from Australia, France, Germany, Italy, Japan, Russia, Singapore, Spain, UK, and USA.

4. Measures to give further impetus to R & D in the drug sector:
   (a) Newly developed drugs would be put outside price control for a period of 10 years;
   (b) Department of Chemicals and Pharmaceuticals to set up inter-ministerial group to decide, within a set time frame, on measures to give further impetus to R & D in the drug sector; and
   (c) Ministry of Health and Family Welfare to take suitable steps for the quick clearance of new drug application, especially those developed through indigenous R & D.
5. The system of price control would be operated through a single list of price-controlled drugs, selected on the basis of transparent and objective criteria as laid down in the modification in drug policy 1986.
6. In case of basic manufacture, the rate of return would be higher by four per cent over the existing rates which are 14 per cent on net worth or 22 per cent on capital employed.
7. To achieve uniformity in prices of widely used formulations there should be ceiling on prices for commonly marked standard pack-sizes of price-controlled formulations.
8. The National Pharmaceutical Pricing Authority to entrust with the task of price fixation/ revision and other related matters.
9. Government to keep a close watch on the prices of medicines which are taken out of price control.
10. A National Drug Authority to be set up to look after the quality control aspects, national use of drugs, and related matters.
11. To provide better focus to all matters relating to developing and promotion of indigenous and other systems of medicines, a separate department would be created by the Ministry of Health and Family Welfare.

Pharmaceutical Policy, 2002

The government of India announced the New Pharmaceutical Policy 2002. The salient features of the policy are:

(i) Industrial licensing for all bulk drugs to be cleared by Drug Controller General of India.
(ii) Foreign direct investment upto 100 per cent will be permitted subject to the stipulations laid down from time to time.
(iii) Automatic approval for foreign technology agreement.
(iv) Ceiling price may be fixed for any formulation.
(v) Government will keep a close watch on the prices of medicines.
(vi) Price fixation by the Pharmaceutical Pricing Authority, an independent body of experts.

COTTAGE INDUSTRIES

The production of finished goods by a worker, sometimes together with his family, at home is known as cottage industry. The products may be sold directly to the public by the worker, or to an entrepreneur who pays according to number of goods produced. Cottage industry has a long history in India. It exists in almost all the states and regions of the country. Thus, the cottage industry involves the family labour and with the minimum investment the family attempts to increase its income. Some of the important cottage industries in India are *Bidi*-making, sports goods, basket-making, lac industry, manufacture of crackers, paper machie, perfumery, needlework on shawls, and wearings.

The main raw materials used in the *bidi* are *tendu* leaves (*Diospyros melanoxylon*) and *kachnal* (*Bauhinia racemosa*), found in the forests of Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha, and Western and Eastern Ghats. Inferior tobacco which is an important ingredient of *bidi*-making is obtained from Andhra Pradesh, Bihar, Chhattisgarh, Madhya Pradesh and Uttar Pradesh. The annual production of *bidi* is more than 1000 crores. India exports *bidi* to the Asian, African, and European countries.

India produces the entire equipments for athletics goods: basket-ball, cricket, tennis, badminton, baseball, billiard, carrom, chess, dart, football, golf, gymnastics, squash, volleyball, and water-polo. Many of these products are produced in the cottage industry.

Bidi-making

This is a popular cottage industry. It is mainly produced in Bastar, Belgaum, Bhandara, Bhind, Gondia, Hyderabad, Jabalpur, Jagdalpur, Kamptee, Kheda, Mangalore, Nagpur, Nasik, Pune, and Vadodra.

Sports-goods

Sports goods making is a traditional cottage industry in the country. The raw materials used in sports goods are fine quality of wood, leather, cloth, rubber, and metal. These are locally available. Some of the finer quality of raw materials are, however, imported. Sports goods cottage industry, mainly concentrated in the rural and urban areas of Jalandhar, Ludhiana, Ahmedabad, Ambala, Chennai, Delhi, Jammu, Kolkata, Ludhiana, Meerut, Modinagar, Moradabad, Mumbai, Mysore, Nainital, Pune, Saharanpur, Shimla, and Srinagar.

Basket-making

This is generally confined to the hilly and mountainous areas of the country. The important raw materials used in the basket-making are bamboo, cane, and willow. The main producers of baskets are Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Maharashtra, Manipur, Meghalaya, Mizoram, Nagaland, Odisha, Sikkim, Tripura, and Uttarakhand.

Lac Industry

Lac is a natural resin secreted by an insect (*Cerria lacca*). This insect thrives on *babool, bargad, pipal, kusum,* and *palash.* The important products produced with the help of lac as a raw material are adhesives, electrical insulators, gramophones records, nail-polish, and printing ink.

This cottage industry is concentrated in the districts of Assam, Chhattisgarh, Gujarat, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Meghalaya, Mizoram, Nagaland, Odisha, Sikkim, Tripura, Uttar Pradesh, Uttarakhand and West Bengal.

India is the third most important lac producing country in the world after Thailand and Malaysia. About 85 per cent of the total production of lac is exported to France, Germany, Italy, Japan, Russia, UAE, UK, and USA.

Others

Needlework on cloths, especially on shawls is a speciality of the cottage industry in Kashmir, while Lucknow is famous for needlework on *kurtas* and wearings. In Tamil Nadu, cracker-making is an important cottage industry which has a great future.

INDUSTRIAL REGIONS OF INDIA

Delineation of industrial regions empirically has been attempted by a number of geographers. The parameters used by them, however, differ from each other. It was Trewartha and Burner (1944) who divided India into industrial regions. Subsequently, P.P. Karan and W.M. Jenkrins (1959) demarcated the industrial regions of India. Industrial regions of India were also delineated by Spencer and Thomas (1968), R.L. Singh (1971), B.N. Sinha (1972), M.R. Chaudhry (1976), and the Centre for Monitoring Indian Economy (1971, 1982) CMIE. These scholars adopted one or more than one of the following indicators for the demarcation of industrial regions of India:

1. Number of registered factories in a region.
2. Number of industrial workers.
3. Population engaged in the secondary activities.
4. Percentage of industrial workers to the total workers.
5. Gross industrial output.
6. Production in terms of money.

In the demarcation of industrial regions, most of the experts divided India into six major and six minor industrial regions. A brief description of the industrial regions of India as demarcated by Prof. R. L. Singh has been given here (**Fig. 11.17**).

The Major Industrial Regions

1. The Mumbai-Pune Industrial Region

This is the most important industrial region of the country (**Fig. 11.17** and **Fig. 11.18**). The region developed after the arrival of British in India who developed the Mumbai Seaport. After the opening of Suez Canal in 1869 the sea-route between India and Europe was reduced substantially. The development of this industrial region is closely connected with the history of development of cotton textile industry in India. The humid climate, natural port facilities, availability of hydro-power, skilled labour, and a vast hinterland producing cotton became the main factors in the development of this industrial region.

There are more than 8000 registered factories only in the Greater Mumbai, out of which 350 belong to cotton textile. The other industries of the region are engineering goods, chemical industries, food-processing industries, leather goods, pharmaceutical, and film industries. In Mumbai, the bulk of the production is light textured fine and super fine cotton cloths. Over 15 lakh people are engaged in the industrial sector of this region.

Pune is the second most important industrial centre of the region. It has more than 1200 registered factories. Its industries are producing metallurgical, chemical, engineering, and automobile goods. Pune has two factories producing scooters and mopeds.

In addition to Mumbai and Pune, the industrial centres of this region are: Ambarnath, Andheri, Bhandup, Ghatkopar, Hadapsar, Jogeshwari, Kalyan, Kirkee, Kolhapur, Kurla, Nashik, Sholapur, Thane, Trombay, Ulhasnagar, and Vikroli.

This industrial region has almost reached the saturation level. Some of the important problems of this industrial region facing are:

(i) Inadequate supply of power
(ii) Obsolete and outdated machinery

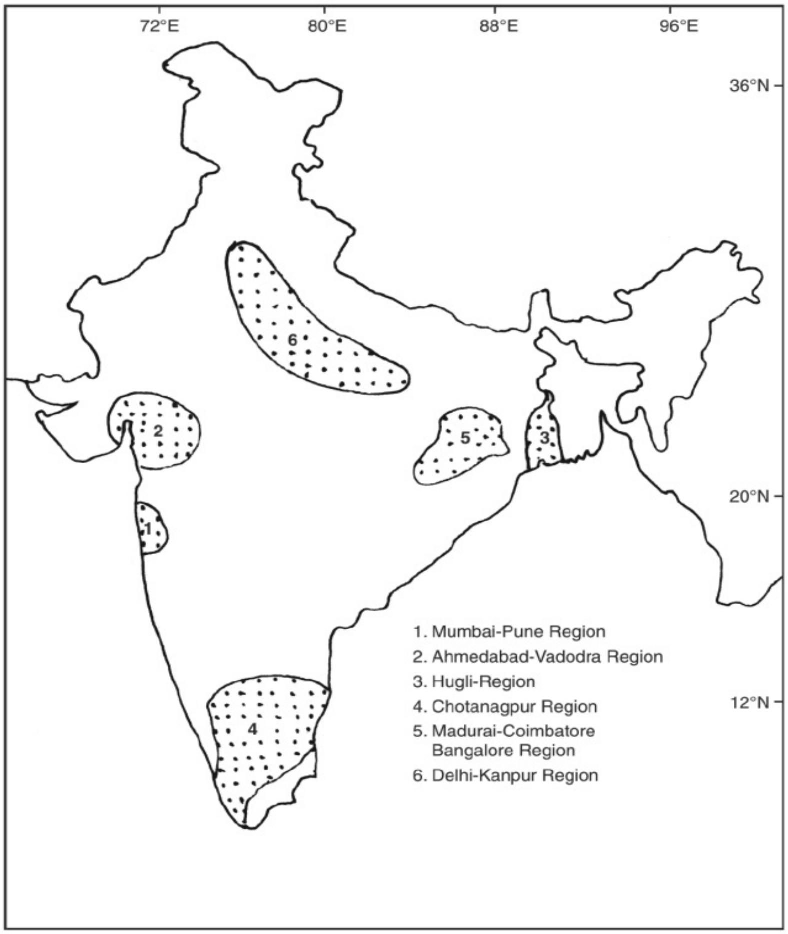

Fig. 11.17 Industrial Regions

(iii) High cost of land and high rent of commercial space
(iv) Labour unrest
(v) Increasing regionalism
(vi) High rate of crime
(vii) Increasing environmental pollution

2. The Kolkata-Hugli Industrial Region

The Kolkata-Hugli industrial region is located along the banks of the Hugli River. The availability of agro-raw material (jute, indigo, and tea), nearness of coal mines (Raniganj and Jharia), abundance of water, cheap labour, and facilities of export are the main factors which helped in the fast growth of this industrial region. Moreover, Kolkata was the capital of British India from 1773 to 1911. Being the capital, Kolkata attracted many of the industrialists to locate their industries in this region.

There are over 10,000 registered industrial factories in this region in which over 20 lakh people are engaged. This belt specialises in the production of jute, silk, cotton textiles, engineering, electrical goods, automobiles, chemicals, pharmaceutical, transport equipments, leather-footwear, iron and steel and food processing, light machine, locomotives, iron and steel, and spare goods for different types of machines.

The main industrial cities and towns of this region are Bansbeia, Naihati, Bhatpara, Kankinara, Jagatdal, Shamnagar, Bhadreshwar, Krishnanagar, Baidyabati, Serampore, Titagarh, Rishira, Konnagar, Agarpara, Baranagar, Ghusuri, Chunchra, Kolkata, Haora, Budge Budge, Bauria, Chengail, and Birlapur.

The main problems of this industrial region are:

1. Paucity of space and traffic jams
2. Shortage of drinking water, insanitation and lack of infrastructural amenities
3. Silting of the Hugli River resulting in the silting of Kolkata port
4. Obsolete machinery
5. Naxalites movement and political unrest
6. Strikes and lockouts
7. Shortage of power supply

In order to overcome these problems the government of West Bengal is pursuing the policy of liberalisation and inviting domestic and foreign entrepreneurs to invest in the region. Some progress has been made in this direction in recent years.

3. The Ahmedabad-Vadodra Industrial Region

This is the third largest industrial region of the country (**Fig. 11.18**). The main cause for the development of this industrial region is the availability of cotton in the hinterland, availability of cheap land, cheap skilled and unskilled labour, port facilities, and nearness of petroleum (Kioli), thermal (Dhuvaran), Hydel (Ukai Project), and nuclear power station (Kakrapara).

There are over 11 thousand registered factories in this region engaging over 15 lakh workers.

It is the second largest cotton textile industrial centre in the country. It also specialises in chemical industries, engineering goods, and pharmaceutical products. Vadodra is an important centre of woollen textile and petrochemical goods. Surat is well known for silk textile and diamond cutting. The other important industrial centres of this region are Anand, Ankleshwar Bhavnagar, Bharuch, Godhra, Himmatnagar, Jamnagar, Kalol, Kheda, Nadiad, Navsri, Rajkot, and Surendernagar.

Scarcity of water and shortage of good quality of cotton are some of the important problems of the region. For the last few years, communal tension has adversely affected the investment in industries in this region.

4. The Madurai-Coimbatore-Bangalore Industrial Region

Stretching over the State of Tamil Nadu and the southern parts of Karnataka is an important industrial centre which made great progress after independence. This region is mainly the cotton producing area of the country. The good climate, disciplined skilled and unskilled labour, regular supply of power (from the Mettur, Papanasam, Pykara, Savitri and Sivasamudram), and the nearness of Chennai, Kochi, Mangalore, and Tuticorin seaports have contributed in the fast development of this industrial region (**Fig. 11.18**).

About 60 per cent of the workers are engaged in the textile industry followed by engineering at 18%, and food-processing at about 12 per cent.

5. The Chotanagpur Industrial Region

This industrial region stretches over Jharkhand, Odisha, southern Bihar, and western parts of West Bengal. Having a large concentration of iron and steel industry, it is often called as the '*Ruhr* of India'. This region is rich in the fossil fuel, and metallic and non-metallic minerals. Power is available from the Damodar Valley Corporation. There is enormous supply of cheap labour from the states of Bihar, Jharkhand, Odisha, Uttar Pradesh, and West Bengal (**Fig. 11.18**).

The main iron and steel producing centres of the region are Asansol, Bokaro, Burnpur, Durgapur, Kulti, Jamshedpur, and Raurkela. The other important industrial centres of the region are Sindri for fertiliser, Chittranjan for locomotives, Khalari for cement, Ranchi for HMT, and Ramgarh and Bhurkunda for glass industry. The main problems of the region are shortage of power supply, and political unrest like those caused by Naxalites. The labour unrest has deterred many of the investors in this region.

6. The Agra-Delhi-Kalka-Saharanpur Industrial Region

This industrial region emerged mainly after independence. Being in and around the national capital and in the vicinity of the Indira Gandhi International Airport it has a more peaceful industrial environment, largely free from the labour unrest and Naxalite movement. It is located in the most productive part of the country providing enough raw material for the agro-based industries. The nearness of market and availability of hydro-power from Bhakra Nangal and thermal power from Badarpur, Faridabad, Harduaganj, and Indraprastha (Delhi) have helped largely in the development of this industrial region.

The main industries of this region are engineering, electronics, chemical, glass, textile, sugar, and food-processing and agricultural machinery (**Fig. 11.18**). The main industrial centres are Agra (textile, tourisms), Ambala (scientific instruments), Chandigarh (electronic and strategic goods), Delhi (textile, chemicals, drugs, pharmaceutical, light machine, electronic goods, food processing), Faridabad (engineering), Ghaziabad (synthetic fibre, chemicals, electronics, pharmaceuticals, agricultural equipments, iron & steel, cycle tyre and tubes), Gurgaon (automobiles), Kalka (HMT), Mathura (petrochemicals), Meerut (sugar and textile), Modinagar (textile, engineering goods, and paper), Modipuram (textiles), Mohannagar (brewery, alcohol), Moradnagar (ordinance), NOIDA (automobile, electronics, etc.), Panipat (textile, chemical and food processing), and Saharanpur (paper, wood-work, sugar, textile and food-processing).

High price of land, traffic jam, and high rate of crimes are the main problems of this region.

Minor Industrial Regions

Apart from the industrial regions described above there are several minor emerging industrial regions in the country. Some of them are as under:

(i) **Kanpur-Lucknow Industrial Region:** Cotton, woollen and jute textiles, leather goods, fertilisers, chemical, drugs, pharmaceuticals, electric goods, and light machinery.

(ii) **Assam Valley Industrial Region:** This region has the industries of petro-chemical, jute and silk textiles, tea-processing industry, paper, plywood, match, and food processing industries. Important industrial centres are: Bongaigaon, Dibrugarh, Digboi, Guwahati, Noonmati, and Tinsukia (**Fig. 11.19**).

(iii) **Darjeeling-Siliguri Industrial Region:** Tea-processing industry and tourism.

(iv) **North Bihar and Eastern Uttar Pradesh Industrial Region**: Sugar, cement, glass, jute, fertilisers, locomotive, paper, and food processing are the main industries of this region. The main industrial centres are Allahabad, Dalmianagar (Bihar), Gorakhpur, Patna, Sultanpur, and Varanasi.

(v) **Indore-Ujjain Industrial Region:** Main industries are cotton textile, chemicals, drugs, electronic and engineering goods, and food processing.

(vi) **Amritsar-Jalandhar-Ludhiana Industrial Region:** Sports goods, cotton and woollen, textiles, hosiery, food-processing, and tourism are the main industries of this region.

(vii) **Nagpur-Wardha Industrial Region:** Textiles, engineering, chemicals, and food processing are the main industries of this region.

(viii) **Godavari-Krishna Delta:** Main industries are iron and steel, ship-building, fertiliser, rice-milling, cotton textile, sugar, fish processing, engineering, and chemicals. Main industrial centres are Guntur, Machlipatnam, Rajamundry, and Vishakhapatnam.

(ix) **Dharwar-Belgaum Industrial Region:** Cotton textile, chemicals, spices packing, and food processing are the main industries.

(x) **Kerala Coast Industrial Region:** Main industries of this region are coconut-oil extraction, rice-milling, fish packing, paper, coir-matting, ship-building (Kochi), petroleum refining (Kochi), and chemical and electronic goods.

MULTINATIONALS

A firm which owns or controls production facilities in more than one country through direct foreign investment is known as a multinational or multinational corporation (MNC). These are also called the Transnational Corporations. During the colonial period, the East India Company, the Dutch East Indonesian Company, the Royal African Company, and the Hudson Bay Company were such multinational companies.

Although multinationals grew most rapidly in the 1960s, the foundations were laid in the inter-war period, notable examples being Ford, Vauxhall, and Phillips. In the mid-1980s, multinationals accounted for 14% of UK employment and 30 per cent of UK exports. The corresponding figures for France were 24% and 32% respectively. Multinationals are made possible by improved international communications which provide rapid containerised transshipment and foreign travel, easy communications of information, and international mobility of capital. When one market is saturated, the multinational can rapidly develop others, since foreign investment cuts transport costs, and makes possible a rapid response to local markets. It also eases tariff barriers. Moreover, multinationals can compare costs at different locations, and can switch activities to different areas as appropriate.

Multinational corporations are probably the major force affecting world wide shifts in economic activity, since the largest MNCs have a turnover greater than the GNP of many less developed countries. Although a developing country may benefit from the construction of a plant for a multinational corporation in terms of jobs and markets, it has been argued that the price is loss of local control.

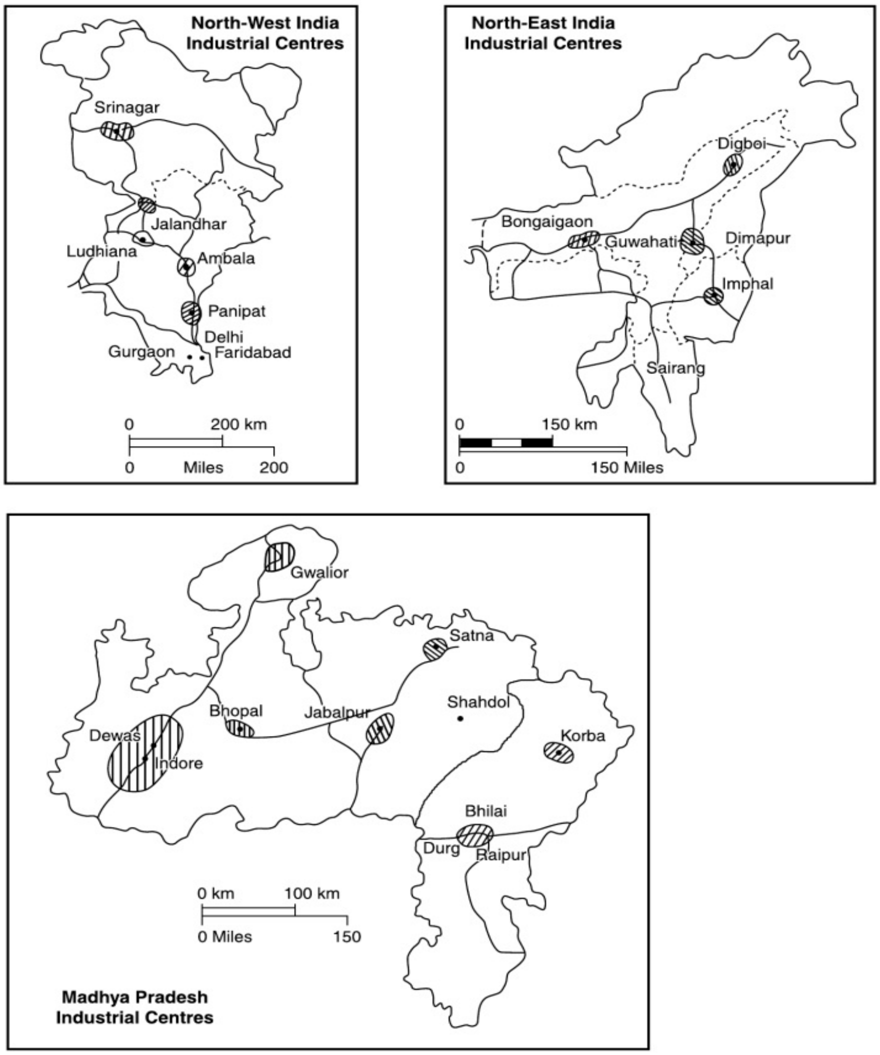

Fig. 11.19 India—Emerging Industrial Regions

Impact of Multinational Corporations

The multinationals have affected the Indian economy, society and ecology favourably and adversely. Some of the important impacts of multinationals have been presented here:

1. **Replacement of Technology:** The obsolete and outdated technology performing below the capacity has been replaced by the latest and more efficient technology by the multinationals.
2. **Damage to Cottage and Small Scale Industries:** The traditional cottage industries as well as small scale industries are not able to compete with the large-scale production of the

multinationals. These industries may disappear completely, unless special steps are taken to promote their interest.

3. **Heavy Remittance Abroad:** According to the Reserve Bank of India, the average rate of profit to the multinationals varies between 20 to 25 per cent. This is a huge profit remitted outside of the country.
4. **Low Foreign Investment:** Most of the foreign subsidiaries have raised financial resources from within India, and the transfer of capital from the parent company has been marginal.
5. **Change in the Initial Activities of the Multinational Corporation:** A number of foreign companies in India are acquiring the character of multi-product and multi-industry enterprises. For example, the Imperial (now India) Tobacco Company (ITC) has diversified its activities to hotel industry, constructing a chain of hotels all over India.
6. **Transfer of Technology—A Myth:** The assumption that the entry of multinational corporation would ensure transfer of latest sophisticated technology to developing countries has not been found valid in practice.

LIBERALISATION

Liberalisation in India is a reform adopted to accelerate the industrial growth and socioeconomic development of the country. The main objective of liberalisation is to permit Indian and foreign entrepreneurs to enter the power, road, and communication as well as in the petroleum sector so that the Central and State governments can lay greater emphasis on the social and economic development programmes. The salient features of the policy of liberelisation are as under:

1. Under liberalisation the new Industrial Policy, July 1991, was adopted to remove the bureaucratic control, which was a barrier in the industrial development of the country. In fact, liberalisation means deregularisation of the industrial sector by cutting down the minimum administrative interference in the operation, instead, letting the market forces operate through the profit motive of the producers and free competition among them to regulate and guide the future development of the sector.
2. Under the policy of liberalisation, the requirement of industrial licensing has been abolished for all industries except for 16 products, namely, (i) aerospace equipments, (ii) alcohol, (iii) asbestos, (iv) chamois leather, (v) coal and lignite, (vi) consumer electric goods, (vii) defence equipments, (viii) electric equipments, (ix) drugs and pharmaceuticals, (x) fur-skin, (xi) hazardous chemicals, (xii) industrial explosives, (xiii) paper and pulp, (xiv) petroleum and natural gas, (xv) plywood, and (xvi) sugar.
3. The liberalisation has opened the economy to direct foreign investment with 51 per cent equity, and started with the process of reducing government subsidies.
4. Abolition of restrictions on most import and export items.
5. Substantial reduction in import tariffs and almost complete removal of restrictions on foreign investments.
6. Disinvestment of shares of public undertakings to reduce government share holding to 51 per cent. This will improve the efficiency of the public sector as the decision-making process will be efficient and prompt.

differentiated economic management like relaxation in certain basic restrictions applicable to the rest of the economy; and free inflow of foreign capital.

Objectives of Special Economic Zone

The main objectives of SEZs are:

(i) To provide a conducive structure to increase foreign and domestic investment in industries.
(ii) To promote foreign trade.
(iii) To generate more employment.
(iv) To develop the relatively less developed areas.
(v) To accelerate the process of industrialisation and urbanisation.
(vi) To reduce the regional inequalities in socioeconomic development.

Historical Perspective

According to Robert C. Hayword, Director World Economic Processing Zones Association the concept of free economic zones dates back to 300 BC. The author notes that such enclaves were found in the Phoenician city of Tyre in the Greek island of Delos. The city became wealthy as a result of such policies and was viewed as a challenger to the centralism of the Roman Empire.

One of the earliest and most famous Special Economic Zones were founded by the government of China under Deng Xiaoping in the early 1960. Following the Chinese example, Special Economic Zones have been established in several countries including Brazil, India, Iran, Jordan, Kazakhstan, Pakistan, Philippines, Poland, Russia, and Ukraine.

Conditions for Ideal SEZ

If the SEZ policy is to provide a real economic impetus especially in the form of creation of world class infrastructure, the minimum size should be 1000 hectares or a minimum investment at Rs.10,000 crore.

Special Economic Zones of India

In order to enhance foreign investment and promote exports from the country and to provide liberal facilities to the foreign and domestic investors, the Special Economic Zones were created in India. The Government of India had in April 2000 announced the introduction of Special Economic Zones policy in the country, deemed to be foreign territory for the purpose of trade operations, duties, and tariffs. As of 2007, more than 500 SEZ have been proposed, 220 of which have been created. India passed Special Economic Zone Act in 2005.

The policy provides for setting up of SEZs in the public, private, joint sector or by state governments. It was also envisaged that some of the existing Export Processing Zones would be converted into Special Economic Zones. Accordingly, the government has converted Export Processing Zones located at: (i) Kandla and Surat in Gujarat, (ii) Cochin (Kerala), Santa Cruz, (Mumbai–Maharashtra), Falta (West Bengal), Chennai, Ilandaikulam, Nanguneri and Tirunelveli (Tamil Nadu), Vishakhapatnam (Andhra Pradesh), NOIDA (Uttar Pradesh), Rajiv Gandhi Info Tech Park, Hinjewadi, Pune-Maharashtra, and Indore (Madhya Pradesh).

At present, India has 81 units in operation in 8 functional SEZs, each with an average of 200 acres. Eight Export Processing Zones (EPZs) have been converted into SEZs. These are fully

The sustenance, prosperity, and development of the private sector and the rest of the economy today is closely dependent on how well the public sector functions. Castigating the public sector, however, is futile. The public sector, thus, has come to stay as an essential component of the economy. What is required is an objective analysis of what ails the public sector in India and the formulation and enforcement of remedial strategy.

Remedial Strategy

The future of a company or a corporation depends upon its profitability. If it has to depend on state subsidisation, its future is bleak.

Firstly, the unit should yield a surplus and profit.

Secondly, the unit should build such a surplus from one year to another. A viable public sector unit should generate a wholesale net annual or periodical surplus to be ploughed partly back towards expansion, modernisation, and development.

The public sector has come to such a sorry pass due to the spread of the unfortunate *civil service culture*. In such a culture, routine, red tape, and financial indiscipline rule at the cost of professionalism and profitability. In the opinion of experts:

(i) There should be freedom from red tapism, and financial and administrative recklessness.

(ii) Such freedom and decision-making levels can be useful and pragmatic only where it is matched by appropriate accountability in terms of productivity and profitability and does not proliferate a civil service culture.

(iii) Bureaucratic inroads into professionalism should be curbed and the reins of public sector should be entrusted to the hands of technologists, economists, and specialists. These experts can improve the viability and profitability of the unit.

(iv) The principle of *autonomy with accountability* is to be followed strictly.

TOURISM

Making a holiday involving an overnight stay away from the normal place of residence is known as tourism. This is in contrast to recreation which involves leisure activities lasting less than twenty-four hours. This holiday may be based on cultural, historic, and social attractions of an urban centre, or on the appeal of different environment.

Tourism is based on the tertiary sector, providing services to the tourists. It is one of the most important emerging industry of India. Tourism in India is an important foreign exchange earner. Tourism not only fetches foreign exchange, it has great potential to provide employment to the trained, skilled, and unskilled workers. Tourism is recognised as a powerful engine for economic growth and employment generating in the country. The contribution of tourism to the country's GDP and total jobs was 5.92 per cent and 9.24 per cent respectively during 2007-08. More importantly, tourism frames massive and continuous flows of people to more and more places of the country which ultimately leads to national integration and promotes international brotherhood.

India, a place of infinite variety, is fascinating with its ancient and complex culture, dazzling contrasts, and breathtaking physical beauty. Tourism in India is growing fast because of its cultural exuberance, and physical diversity. In fact, India is a vast country of great natural beauty and cultural diversity. India has a rich cultural heritage as superbly manifest in many of the architectural wonders like tombs, forts, palaces, temples, mosques, etc. With the great potential available and the development initiatives taken by the government, inbound tourism has shown a substantial growth in the last two decades. In terms of visitors, at present, India is the 10^{th} among Asia-Pacific countries. India's share in international tourist arrival was 5.6 million in 2010, constituting only 0.50% of the world tourists. The World Travel and Tourism Council has identified India as one of the foremost growth centres in the world in the coming decades. Domestic tourism is estimated to be much higher than that of international tourism which has been rising rapidly.

Tourism in India

In India tourism has emerged as an instrument of employment generation, poverty alleviation and sustainable human development. During 2008–09, direct imployment in the tourism sector was estimated to be over 50 million. Tourism promotes national integration and international understanding and gives support to local handicrafts and cultural activities.

Tourism in India may be examined under the following headings:

1. Nature Tourism and Hill Stations

India has great geographical diversity, which resulted in varieties of nature tourism. Its snow-covered peaks, waterfalls, valleys, gorges, high altitude lakes, and cliffs, provide enough attraction for the nature-loving tourists. India has numerous waterfalls in the Himalayas, Chotanagpur Plateau, and Western Ghats, including Jog Falls (the highest in India). The backwaters of Kerala, hill stations, national parks, natural vegetation in wilderness, and biosphere reserves are also fascinating and attract tourists in large numbers.

2. Hill Stations

The mountainous and hilly areas of India are dotted with places of tourist interest. The most famous hill stations have been shown in **Fig. 11.20**. Several of these hill stations have served as summer capitals of Indian provinces, princely states, or, in the case of Shimla, of British India itself. Since Indian Independence, the role of these hill stations as summer capitals has largely ended, but many hill stations remain popular summer resorts. Most famous hill stations of India are: Almora, Abu, Amarnath, Amarkantak, Chamba, Dalhousie, Darjeeling, Dharamshala, Gangtok, Gulmarg, Kasauli, Kodaikanal, Kullu, Mahabaleshwar, Lavasa, Manali, Matheran (Maharashtra), Mussoorie, Nainital, Ooty (Tamil Nadu), Pahalgam, Panchmarhi, Ranchi, Ranikhet, Shillong, Shimla, Sonmarg, Udhagamandalam, Yeusmarg, etc.

3. Historic Monuments and Archaeological Sites

India has a large cultural heritage. Its cultural, historical, and archaeological centres are of great interest for the domestic and international tourists. Places like Ajanta, Ellora, and some of the important historical monuments like Taj Mahal (one of the seven wonders of the world), Golden Temple, Qutab Minar, Red Fort, Jama Masjid, Humayun's Tomb, Char-Minar, Birla Mandir, the Victoria Terminus (Mumbai), Rashtrapati Bhavan, Gateway of India, India Gate, Lotus Temple (New Delhi), etc., attract a list of tourists.

4. Cultural and Religious Tourism

The main places of cultural tourism have been shown in **Fig. 11.21**. Places of cultural tourism include Allahabad, Ajmer, Amarnath, Ayodhya, Badrinath, Bhadrachalam, Bhubaneshwar, Bodh Gaya, Dwarka, Gangotri, Guwahati, Hardwar, Kanchipuram, Kedarnath, Kochi, Madurai, Mahabalipuram, beach temples of Mahabalipuram, (vii) beaches of Andaman and Nicobar Islands, (viii) beaches in Mumbai, (ix) Gopalpur (Odisha) (x) beaches of Lakshadweep, and (xi) beaches of Diu.

6. Adventure Tourism

India has enormous potential for adventure tourism. For example: (i) river rafting and kayaking in Himalayas, (ii) mountain climbing in Himalayas, (iii) rock climbing, (iv) skiing in Gulmarg and Auli, (v) boat racing in Kerala, (vi) paragliding in Maharashtra, etc.

Tourism in India has great relevance to regional economic development. Since Independence, Indian tourism, especially the number of foreign tourists, has grown considerably as given in **Table 11.9**.

Table 11.9 *Foreign Tourists in India*

Year	*Number of Foreign tourists*
1951	16,830
1961	140,000
1971	301,000
1981	1,280,000
1991	1,670,000
2001	2,540,000
2010	5,580,000

Source: *India 2012,* p. 147

It may be observed from **Table 11.9** that in 1951 the total number of foreign tourists was only 16,830 which grew to 2,450,000 in 2006, an increase of more than about 150 times. Most of the foreign tourists who visited India were from West European countries (30%), South Asia (26%), North America (20%), South East Asia (6%), East Asia (5%), West Asia (4%), Africa (4%), Australia (3%), and East-European countries (2%).

Problems of Indian Tourism Industry

The tourism industry in India is confronted with many problems: Some of the problems of the tourist industry are given below:

- (i) Lack of adequate infrastructure (transport, banking, and hotels)
- (ii) Complex visa formalities
- (iii) Multiplicity of taxes
- (iv) Problem of law and order in some of the regions of the country like Jammu and Kashmir, and the states of North East India
- (v) Safety and security of the tourists
- (vi) Inadequacy of qualified tourist guides
- (vii) Absence of participation of the people

Despite all these shortcomings and problems, India has great potential for tourism development. The World Tourism and Travel Council (WTTC) has estimated that India's travel and tourism potential can provide a substantial resource to economy (Rs. 500,000 crores to GDP) by 2010. The World Tourism and Travel Council has suggested the following four-fold plan of action to achieve the potentials of tourism:

ECO-TOURISM

Eco-tourism, also known as ecological tourism, is a form of tourism that appeals to the ecological and socially-conscious individuals. *Generally, eco-tourism focuses on volunteering, personal growth, and learning new ways to live on the planet, typically involving travel to destinations where flora, fauna, and cultural heritage are primary attractions.*

Much of what goes on in the name of eco-tourism is business as usual, albeit with a few peripheral changes like notices in your room requesting you to re-use the towel. Some visits are called eco-tourism simply because they take tourists to ecologically interesting areas, such as national parks. Most principles of genuinely sensitive tourism, developed internationally over the last years, are ignored.This includes carrying out assessments of the ecological impact of tourism and whether it actually benefits the local people or not.

According to some experts, eco-tourism is responsible tourism. Responsible eco-tourism includes programmes that minimise the negative aspects of conventional tourism on the environment, and enhance the cultural integrity of people. Therefore, in addition to evaluating environmental and cultural factors, an integral part of eco-tourism is in the promotion of recycling, energy efficiency, water conservation, and creation of economic opportunities for the local communities.

Ideally, eco-tourism should satisfy several criteria, such as:

(i) Conservation of biological diversity and cultural diversity through ecosystem protection.
(ii) Promotion of sustainable use of biodiversity, by providing jobs to local populations.
(iii) Sharing of socioeconomic benefits with local communities and indigenous people by having their informed consent and participation in the management of eco-tourism enterprises.
(iv) Tourism to unspoiled natural resources, with minimal impact on the environment being a primary concern.
(v) Minimisation of tourism's own environmental impact.
(vi) Affordability and lack of waste in the form of luxury.
(vii) Local culture, flora and fauna being the main attractions.

For many countries, eco-tourism is not simply a marginal activity to finance protection of the environment but a major industry of the national economy. For example, countries like Costa Rica, Ecuador, Kenya, Madagascar, and Nepal represent eco-tourism as a significant industry adding good revenue to their gross domestic product by playing a major role in their economic activity.

Growth and Development of Eco-tourism

Eco-tourism, responsible tourism, and sustainable development have become prevalent concepts since the late 1980s, and eco-tourism has experienced arguably the fastest growth of all sub sectors in the tourism industry. The popularity represents a change in tourist perceptions, increased environmental awareness, and a desire to explore natural environments. Such changes have become a statement affirming one's social identity, education, sophistication, and disposable income as they are about preserving the Amazon rainforest or the Caribbean coral reef for posterity.

With its great potential for environmental protection, the United Nations celebrated the International Year of Eco-tourism in 2002.

10. The Krisloskars

A highly reputed and amongst the oldest industrial houses in India, this establishment has enough contributions in the areas of heavy and light machine tools industries, with speciality in the areas of locomotion. It is credited to produce the first and the reputed 'diesel pump sets' in the country. It has played an important role in farm mechanisation by producing the 'first' and the most trusted 'tractors' in India. The company produces farm implements also. It has entered the fast-growing automobile industry with Toyota, the second largest car-maker in the world.

11. The Firodias

Being one of the oldest industrial houses of the country, the company has made important contributions in the areas of automobile, two-wheelers, generator sets, etc.

12. The UB Group

This group is amongst the oldest and the leading industrial houses of India with its traditional interest in the alcoholic drinks sector. Of late, it has also started diversifying in the areas such as airlines, infrastructure, hospitality, and real estate segments.

13. The Sarabhais

This is one of the important industrial houses in the country. The company has led the drug and pharmaceutical industries in India with a reputation well-established around the world.

14. The Jagatjit Group

This is amongst the oldest industrial houses of India and its focus remains the liquor industries.

15. The Godrejs

Amongst the top, oldest, and reputed industrial houses of the country, this organisation has contributed in the areas of detergents, refrigeration, almirahs, furniture, air-conditioning, and lock industries providing highest of the standards.

16. The Reliance Group

Though the group is now divided between two brothers, the industrial house is considered a rags-to-riches story, and represents the rise of a new entrepreneurial class in the country. It has paraffin and synthetic yarn as its traditional interests; today it has diversified in more than a dozen traditional and new industrial areas such as power, petroleum, textile, garments, hospitality, telecommunication, pharmaceuticals, software, banking, insurance, etc.

17. The Wipro Group

The doyen of sunrise industries in the country, the group functions in the areas of software development and export including the production of computer peripherals. This is one of the leading companies in the areas of business process outsourcing (BPO) and is also seriously involved in social work. This company is amongst the top names in the software around the world.

conservation-supporting, and environmentally-educated. The tourist industry and governments, however, focus more on the product aspect, treating eco-tourism as equivalent to any sort of tourism based in nature. As a further complication, many terms are used under the rubric of eco-tourism, and others have been used in literature and marketing. Although they are not necessary synonymous with eco-tourism.

The problems associated with defining eco-tourism have led to confusion among tourists and academics alike. Definitional problems are also subject of considerable public controversy, a trend towards the commercialisation of tourism schemes disguised as sustainable, nature-based, and environmentally-friendly eco-tourism. *According to McLaren, these schemes are environmentally destructive, economically exploitative, and culturally insensitive at its worst.* They are also morally disconcerting because they mislead tourists and manipulate their concerns for the environment. The development and success of such large scale, energy intensive and ecologically unsustainable schemes are a testament to the tremendous profits associated with being labelled as eco-tourism.

The Native and Psycho-Social Impact of Eco-tourism

Some of the negative impacts of eco-tourism are:

1. Commercialisation

Eco-tourism is a trend towards commercialisation of tourism throughout the nation. This trend has become one of the fastest growing sectors of tourism industry growing annually 10–15 per cent worldwide. Many of the eco-tourism projects are, however, not meeting these standards. Even if some of the guidelines are being executed, the local communities are still facing other negative impacts. For example, South Africa is reaping significant economic benefits from eco-tourism, but negative effects including physical displacement of persons, gross violation of fundamental rights, and environmental hazards far out weight the medium-term economic benefits.

2. Direct Environmental Impact

Eco-tourism operations typically fail to live up to conservation ideals. It is often overlooked that eco-tourism is a highly concentrated activity, and that environmental conservation is only means to further economic growth.

3. Problem of Garbage and Pollution

Apart from environmental degradation with tourist infrastructure, population pressure from eco-tourism also leaves behind garbage and pollution associated with the Western lifestyle. Although eco-tourists claim to be educationally sophisticated and environmentally concerned, they rarely understand the ecological consequences of their visits and how their day-to-day activities have physical impacts on the environment. The eco-tourists rarely recognise the great consumption of non-renewable energy required to arrive at their destination, which is typically more remote than conventional tourism destinations. For instance, an exotic journey to a place 10,000 km away consumes 100 litres of fuel per person.

4. Impact on Fauna and Flora

The eco-tourists disturb fauna and flora. Eco-tourists believe that because they are only taking pictures and leaving footprints, they keep eco-tourism sites pristine, but even harmless sounding activities such as a nature hike can be ecologically destructive. Where the eco-tourism activity involves wildlife viewing, it can scare away animals, disrupt their feeding and nesting sites.

Now as the economy is going for a process of reforms, many of these problems are being attended by the government with differing levels of success. As the process of economic reforms gets success, we may hope for the success of the industrial complexes in India, too.

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Chapter 12 Transport, Communications and Trade

TRANSPORT

Provisions of quality and efficient infrastructure services are essential to realise the full potential of growth impulses surging through the economy. In fact, a well-knit and coordinated system of transport plays an important role in the sustained economic growth of a country. The present transport system of India comprises several modes of transport including (i) road, (ii) rail, (iii) inland waterways, (iv) coastal shipping (coastal and international), and (v) airways. Transport has recorded a substantial growth over the years both in the spread of its network and in the output of its system. The Ministry of Transport is responsible for the formation and implementation of policies and programmes for the development of various modes of transport except the railways and the civil aviation.

Roads

India has one of the largest road networks in the world with an aggregate distance of 4.1 million kilometers (India 2012, p. 1079). Roads in India connect village to village and village to urban centres. Moreover, roads offer door-to-door service and their construction can be undertaken even in areas of difficult terrain and steep slopes. The movement of goods is safer through road transport. They help the farmers to move their perishable commodities (flowers, fruits, milk, and vegetables) to the urban markets. The role of roads in the economic development and regional planning cannot be underestimated.

The country's road network consists of: (i) Expressways, (ii) National Highways, (iii) State Highways, (iv) Major District Roads, (v) Other District Roads, and (vi) Village Panchayat Roads. The road network comprises 70,934 km of National Highways, 128,000 km of State Highways, 470,000 km of Major District Roads, and about 2,650,000 km of other District and Rural Roads.

Out of these, the National Highways and State Highways together account for about 195,000 kilometres length. Though, the National Highways—the construction and maintenance of which is the responsibility of the Central Government—has about 66,590 km of length and comprises only about 2 per cent of the total length of roads, they, however, carry over 40 per cent of the total traffic across the country.

About 65 per cent of freight and 80 per cent of traffic is carried by the roads. The pressure on the road network is increasing day by day. The number of vehicles have been growing at a rapid pace of 10.50 per cent per annum over the last five years. The rapid expansion and strengthening of the road network, therefore, is imperative both to provide for present and future traffic, and for improved accessibility to the hinterland. In addition, road transport needs to be regulated for better energy efficiency, lesser pollution, and enhanced road-safety.

Border Roads Organisation (BRO) The Border Roads Organisation was established in 1960 for the development of roads of strategic importance in the northern and north-eastern borders of the country. The Border Roads Organisation has not only linked the border areas of the North and North-East with the rest of the country, but has also developed the road infrastructure in Bihar, Maharashtra, Karnataka, Rajathan, Andhra Pradesh, Andaaman and Nicobar, and Chhattisgarh. It has also constructed roads and air fields in Tajikistan, Afghanistan, Bhutan and Myanmar. So far it has constructed more than 32,000 km of roads and surfaced 40,500 km of roads. The Zojila–Kargil and Manali–Leh roads were completed in 1998. The Pathankot–Jammu–Srinagar National Highway is also maintained by the Border Roads Organisation.

Highways and Roads

1. National Highways The Central Government is responsible for the development and maintenance of the National Highways System. The National Highways of India have been shown in **Fig. 12.1.** The total length of the National Highways in 2010 was 70,548 km. The Ministry is carrying out development and maintenance work of the National Highways through three agencies: (i) the National Highways Authority of India (NHAI), (ii) the State Public Works Department (PWD), and (iii) the Border Road Organisation (BRO).

In order to give boost to the economic development of the country, the Government has embarked upon massive National Highways Development Projects (NHDP) being implemented by the National Highways Authority of India (NHAI). Some of the important National Highways Projects under progress are given below:

Golden Quadrilateral (GQ) The National Highways Development Project (NHDP) has taken up a massive programme of road building in the country. Launched in January 1999, the Golden Quadrilateral Project is perhaps one of the largest projects of road building in the country **(Fig. 12.2).** The project is being implemented by the National Highways Authority of India (NHAI). The National Highways Development Project has the following components:

(i) Phase I—Golden Quadrilateral: This phase comprises connecting Delhi-Mumbai, Chennai, and Kolkata-Delhi by six-lane super highways. It has a total length of 5846 km. The four sides of the quadrilateral have varying length. The side of the quadrilaterals between Delhi and Mumbai is 1419 km long, Mumbai to Chennai 1290 km long, Chennai to Kolkata 1684 km long, and Kolkata to Delhi 1453 km.

(ii) Phase II—

(i) *The North South Corridor*: This corridor aims to connect the National Highways from Srinagar (J & K) to Kanniyakumari including Kochi–Salem; and

(ii) *The East West Corridor:* This corridor aims to connect the National Highways from Silchar in Assam to Porbandar in Gujarat (**Fig. 12.2**).

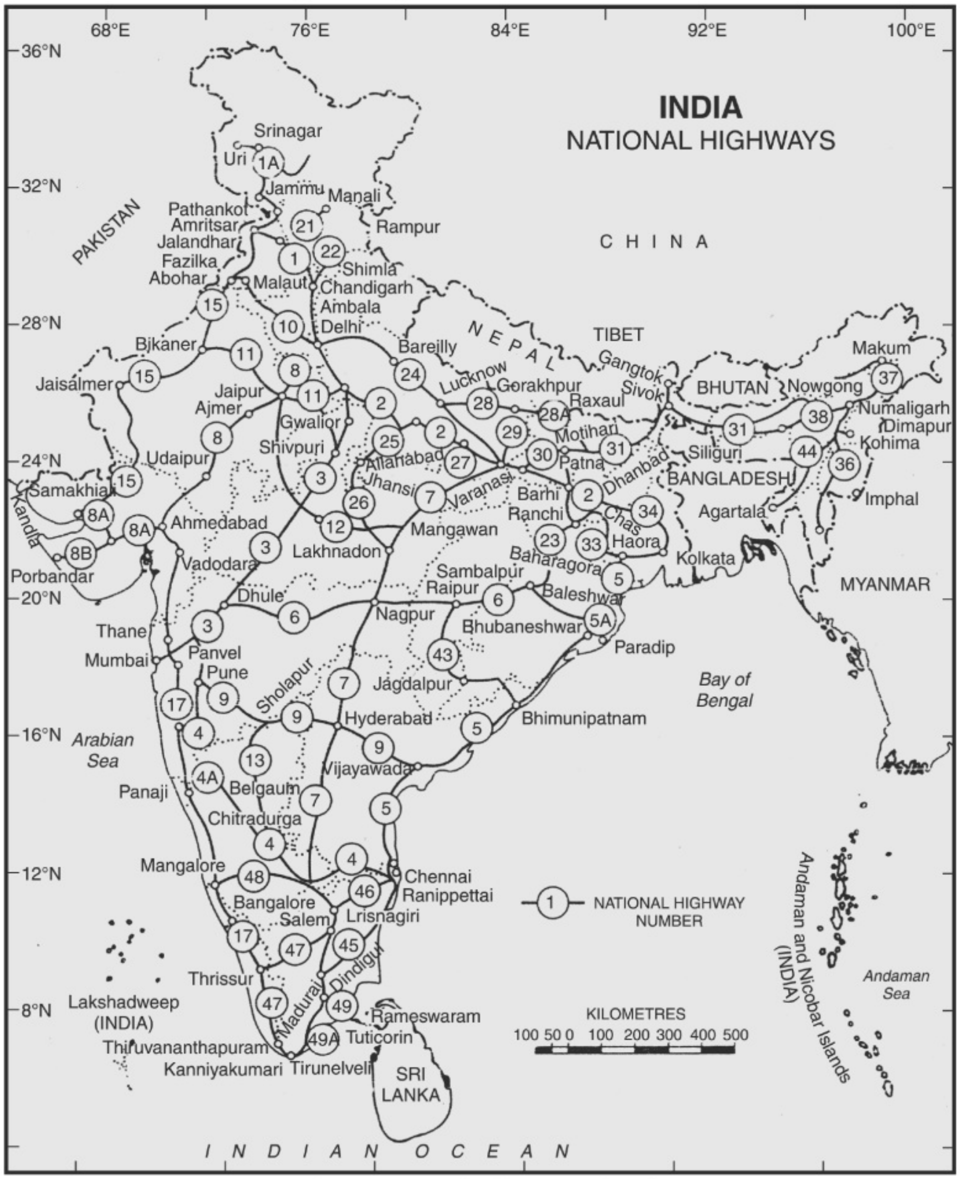


Fig. 12.1 Network of National Highways

(iii) Phase III—Phase three comprises widening of the existing National Highways to 4/6 lane standard. Thus to connect state capitals, seaports, and the important tourist locations with the Golden Quadrilateral.

Traditionally, the road projects used to be financed by the government. But in the last decade after the liberalisation or globalisation, a significant contribution is being made by the private sector. To encourage the private sector, several steps, given below, have been taken by the government.

1. Declaration of the road sector as an industry.
2. Provision of capital subsidy up to 40 per cent of the project cost to make project commercially viable.

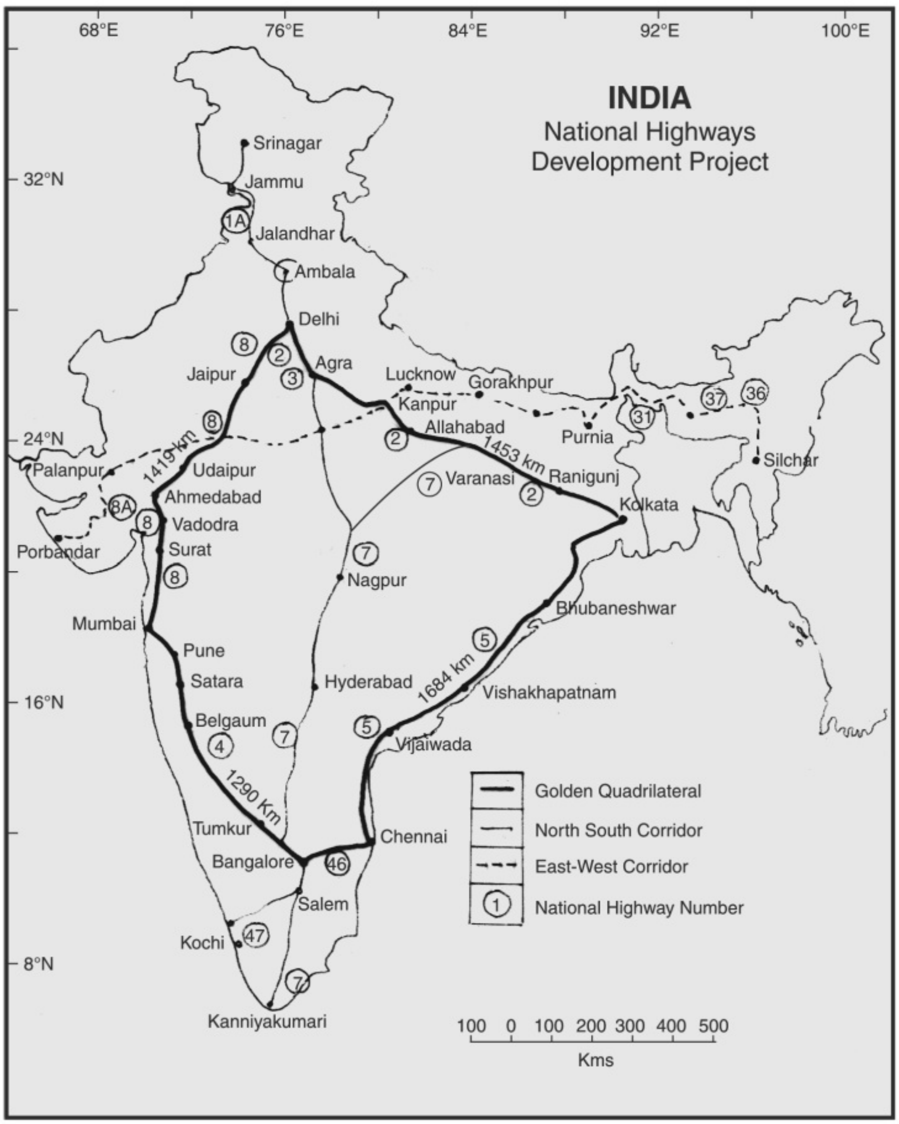


Fig. 12.2 National Highways Development Project

3. Full (100 per cent) tax exemption in any consecutive 10 years out of the first 20 years of the project.
4. Provision of encumbrance free site work, i.e., the Government shall meet all expenses relating to land and other pre-construction activities.
5. Foreign direct investment upto 100 per cent in road sector.
6. Easier external commercial borrowing norms.
7. Higher concession period (upto 30 years).
8. Right to collect and retain toll.

2. State Highways The length of state Highway is 128,000 Km (2010). The State Highways and Rural Roads are developed and maintained by the various agencies of the state and union territories. The funds, however, are also provided by the Central Government for the development of roads under the following schemes.

(a) **Improvement of State Roads from the CRF**: The funds from the CRF are provided for improvement of state roads other than the rural roads.

(b) **Economic importance and Inter State Connectivity Scheme**. To promote inter-state facilities and also to assist the state governments in their economic development through construction of roads bridges of inter-state and economic importance, the Central Government provides 100 per cent grant for inter-state connectivity projects and 50 per cent for projects of economic importance.

(c) **Rural Roads:** Roads are also being developed in rural areas under the *Pradhan Mantri Gram Sadak Yojna* (PMGSY). The objective of this scheme is to link all the villages with a population of more than 500 with all weather roads by the end 2007.

3. District Roads These roads mostly connect the towns and large villages with one another and with the district headquarters. The construction and maintenance of roads is the responsibility of the Zila Parishad and the PWD. The length of major district roads is 4,70,000 km.

4. Village Roads Village roads are constructed and maintained by the *village panchayats*. These roads are generally, narrow and zig-zag. They are generally not suitable for heavy mechanised traffic. The length of rural roads is 26,50,000 km.

5. International Highways Under the agreement with the Economic and Social Commission on Asia and Pacific (ESCAP) some of the country's highways linking neighbouring countries have been declared international highways. These highways are of two types:

(a) **The Main Arterial Routes**, linking the capitals of the neighbouring countries like (i) Lahore–Amritsar–Delhi–Agra–Kolkata–Golaghat–Imphal–Mandalay (Myanmar), (ii) Agra–Gwalior–Hyderabad–Bangalore–Dhanushkodi, and (iii) Barhi–Kathmandu;

(b) **The routes joining the main cities, seaports, and industrial centres with the arterial road-network**, like (i) Agra–Mumbai Road, (ii) Delhi–Multan Road, (iii) Bangalore–Chennai Road, and (iv) Golaghat–Ledo Road.

The World Bank provides funds for the maintenance of these roads.

6. Express Highways These are multi-lane well-paved highways used for movement of goods and traffic. Some of the important express highways are (i) Kolkata–Dum–Dum Airport Highway, (ii) Durgapur–Kolkata Express Highway, and (iii) Mumbai–Pune Express Highway.

Some of the important National Highways have been shown in **Fig. 12.1 and Fig. 12.2** while **Table 12.1** gives their routes and length in kilometres.

Table 12.1 *India—Some of the Important National Highways and their Lengths*

NH No.	*Route*	*Length*
1.	Delhi–Ambala–Jalandhar–Amritsar	456
1A.	Jalandhar–Madhopur–Jammu–Srinagar–Baramulla–Uri	663
1B.	Batote–Doda–Kishtwar–Khanabal	274
2.	Delhi–Mathura–Agra–Kanpur–Allahabad–Varanasi–Barh–Kolkata	1465
3.	Agra–Gwalior–Shivpuri–Indore–Dhulia–Nashik–Thane–Mumbai	1161
4.	Thane–Pune–Belgaum–Hubli–Bangalore–Ranipet–Chennai	1533
4A.	Belgaum–Anmode–Ponda–Panaji	153
5.	Baharagora–Cuttack–Bhubaneshwar–Vishakhapatnam–Vijaiwada–Chennai	1533
6.	Hajira–Dhule–Nagpur–Raipur–Sambalpur–Bhargora–Kolkata	1949
7.	Varanasi–Rewa–Jabalpur–Nagpur–Hyderabad–Bangalore–Madurai–Kanniyakumari	2369
8.	Delhi–Jaipur–Ajmer–Udaipur–Ahmadabad–Vadodra–Mumbai	1428
9.	Pune–Sholapur–Hyderabad–Vijaiwada–Machlipatnam	841
10.	Delhi–Fazilka	403
11.	Agra–Bharatpur–Jaipur–Bikaner	582
12.	Jabalpur–Bhopal–Kota–Bundi–Jaipur	890
13.	Sholapur–Chitradurga–Mangalore	691
14.	Beawar–Sirohi–Radhanpur	450
15.	Pathankot–Bhatinda–Bikaner–Samakhiali (Jaisalmer)	1526
16.	Nizamabad–Samkhiyali–Jagdalpur	460
17.	Panvel–Mangalore–Edapally (Kochi)	1269
18.	Kurnool–Nandyal–Cuddapah–Chittor	369
21.	Chandigarh–Ropar–Mandi–Kulu–Manali	323
22.	Ambala–Kalka–Shimla–Narkanda–Rampur–Shipki La	459
24.	Delhi–Bareilly–Lucknow	438
28.	Barauni–Muzaffarpur–Gorakhpur–Lucknow	570
47.	Salem–Coimbatore–Thiruvananthapuram–Kanniyakumari	640
49.	Kochi–Madurai–Dhanushkhodi	440
58.	Delhi–Mana Pass	538
150.	Aizawl–Imphal–Kohima	700

Roads and Rural Development Plan

This includes construction of roads under Minimum Needs Programme (MNP), Rural Landless Employment Guarantee Programme (RLEGP), *Jawahar Rozgar Yojana* (JRY), and Command Area Development (CAD) to connect all villages having a population of 500 or more with all-weather roads and those having less than 500 with the link roads.

Density of Roads

The state-wise density of roads has been shown in **Fig. 12.3**. It may be observed from this figure that the density of roads is the highest in the states of Goa, Kerala, and Punjab, followed by Maharashtra, Tamil Nadu, Haryana, and Uttar Pradesh. The density of roads is however, very low in Bihar, Chhattisgarh, Jammu & Kashmir, Jharkhand, Madhya Pradesh, and the states of North-

East India.

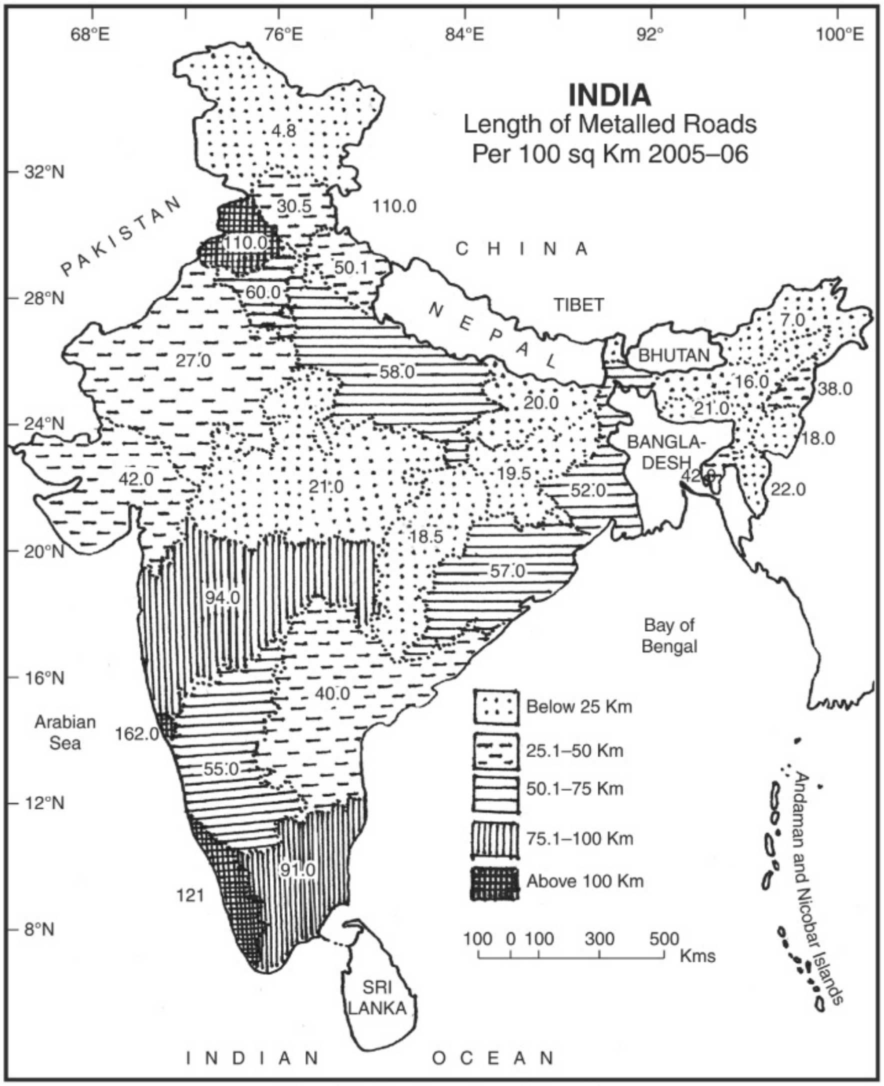


Fig. 12.3 Density of Roads

Transformation of Roads

With the new policy of globalisation of our national economy and emphasis on promotion of exports of agricultural and industrial products, a dense and efficient road network is a must. The Government has opened up road construction and its maintenance to private sector including joint venture with foreign collaboration. One of the policies is to invite private parties to 'build', 'operate', and 'transfer' (BOT) roads decided upon by the Government. The parties would bear cost of construction, operate roads for stipulated period, collect road taxes from users and return the roads to the

Government at the end of the contracted period. Various International Agencies have given funds for this specific purpose.

Main Problems of Road-Transport

Although India has one of the longest road networks in the world, it is facing a number of problems. Some of the important problems of road transport are given here:

1. Unmetalled Roads and their Improper Maintenance About 40 per cent of the roads are not metalled. Moreover, the roads are not properly maintained which accentuate the problems, especially during the rainy season.

2. Mixed Traffic Mixed traffic is a serious problem of Indian road transport. In fact, over greater parts of the country including the megacities, the same road is used by cars, trucks, two-wheelers, tractors, harvesters, animal driven carts, cyclists, rickshaws, and pedestrians. This increases travel time, congestion, pollution, tension, and road accidents.

3. Multiple Check Posts There are multiple check posts, toll tax, and octroi duties collection points on the roads which bring down the speed of the traffic, waste time, and causes irritation. Moreover, the rate of road tax varies from state to state and in the different regions of the same state.

4. Inadequate Side Amenities Along the roads, repair shops, first-aid centres, telephones, toilets, restaurant, rest-places, and cheap hotels are not adequately developed.

5. Shortage of Funds There is shortage of funds for the construction and maintenance of roads. Unfortunately, there is insignificant participation of the private sector as a result of which capital for development, extension, and maintenance of roads is not adequately available.

6. Unstable Road Policy There is not a stable policy for the construction, extension, and maintenance of roads. The road policy in the states, generally changes with the change of government. This leads to poor maintenance of roads.

Rail Transport

India has the fourth largest rail network in the world after USA (224,792 km), China(98,000 km), and Russia (81,157 km). Railways connect different parts of the country. The total length of Indian Railways presently is around 64,000 kms. Indian railway carries two crore people on 18,000 trains daily.

Indian Railways have grown into a vast network of 7030 stations spread over a route length of 63,974 km with a fleet of 8,593 locomotives, 51,030 passaenger service vehicle, 6,505 other coaching vehicles and 2,19,931 wagons as on 31st March, 2010 (India - 2012, p. 1076).

About 30 per cent of the route kilometer, 41 per cent of running track kilometer and 41 per cent of total track kilometre is electrified. About 85 per cent of the total railway route is in broad gauge, 11.3 per cent in meter gauge and only 3.70 per cent in narrow gauge.

Passengers originating had risen from 1284 million in 1950-51 to 7246 Million in 2009-2010. Despite constraing of resources, the railways have been able to cope with increasing demand of passenger traffic. Railways are the premier mode of passenger transport both for long distance and suburban traffic.

Revenue freight traffic has increased from 73.2 million tonnes in 1950-51 to 888 million tonnes in 2009-10 (India-2012, p. 1079). They provide the principal mode of transportation for freight and passengers. Thus, they unite people from the farthest corner of the country and make possible the conduct of business, sight seeing, pilgrimage, and education. It has also played an important role during the periods of droughts, floods, wars, epidemics, and natural calamities. The process of industrialisation and economic development has also been accelerated with the help of railways.

The railway system started in India in 1853 when the first railway line between Mumbai (Bombay) and Thane (a distance of 34 km) was inaugurated. This was followed by the opening of another railway line between Kolkata (Calcutta) and Raniganj in 1854 , and Chennai (Madras) and Arkonam in 1856. The railway development was, however, quite fast after 1900 and a tremendous progress in the development of railway network was made after Independence (1947). Originally the railways were operated by private companies owned by the British; but in 1950, the entire railway management was taken over by the Central Government.

Main Features of Indian Railways

Railway Gauges There are four different types of gauges of the Indian railways. They are: (i) Broad Gauge (width 1.676 metres), (ii) Metre Gauge (width one metre), (iii) Narrow Gauge (width 0.762 metre), and (iv) Lift Gauge (width 0.610 metre). These gauges were designed during the colonial period keeping in mind the volume of traffic and goods movement. The major port cities were connected by Broad Gauge to facilitate the export of raw materials from India to Britain and the Commonwealth countries.

After Independence, the Government of India decided to convert all the gauges into Broad Gauge to facilitate the traffic and transport of goods. Prior to Independence, the whole railways system was under steam traction. Since it had poor efficiency and caused great environmental pollution the diesel engines were introduced in 1950s. At present, Diesel Locomotive Works (DLW), Varanasi (UP), Chitranjan Locomotive Works (West Bengal), and Mihijam and Tat Engineering and Locomotive Works, Jamshedpur (Jharkhand), are producing diesel engines for railways. The diesel engines were also the cause of environmental pollution; therefore, in order to overcome the pollution problem and to cope with the growing pressure of traffic and goods, a decision was taken to switch over to electric traction all the important routes. In the electrification process, priority was given to high density sections of railway lines. Of the two main segments of the Indian Railways, ((i) freight and (ii) passenger), the freight segment accounts for about 66 per cent of the revenues. Within the freight segment, bulk traffic accounts for nearly 95 per cent, of which more than 45 per cent is coal.

Distributional Pattern The distributional pattern of railway network is closely influenced by the terrain, topography, density of population, minerals, fertility of land, and arid and semi-arid climatic conditions The railway network of the country has been shown in **Fig. 12.4** while **Table 12.2** shows the density of railway-line per 1000 sq km of area in the major states **Table 12.2 (Fig. 12.5).** It may be observed from the **Fig. 12.5** that the density of roads is significantly high in the Northern Plains of India while in the hilly states their density is very low.

Table 12.2 *Length of Railways in Major States—2007*

States	*Railway length per 1000 sq km area*
1. Punjab	42.78
2. West Bengal	41.85
3. Bihar	30.82
4. Uttar Pradesh	30.20

(*Contd.*)

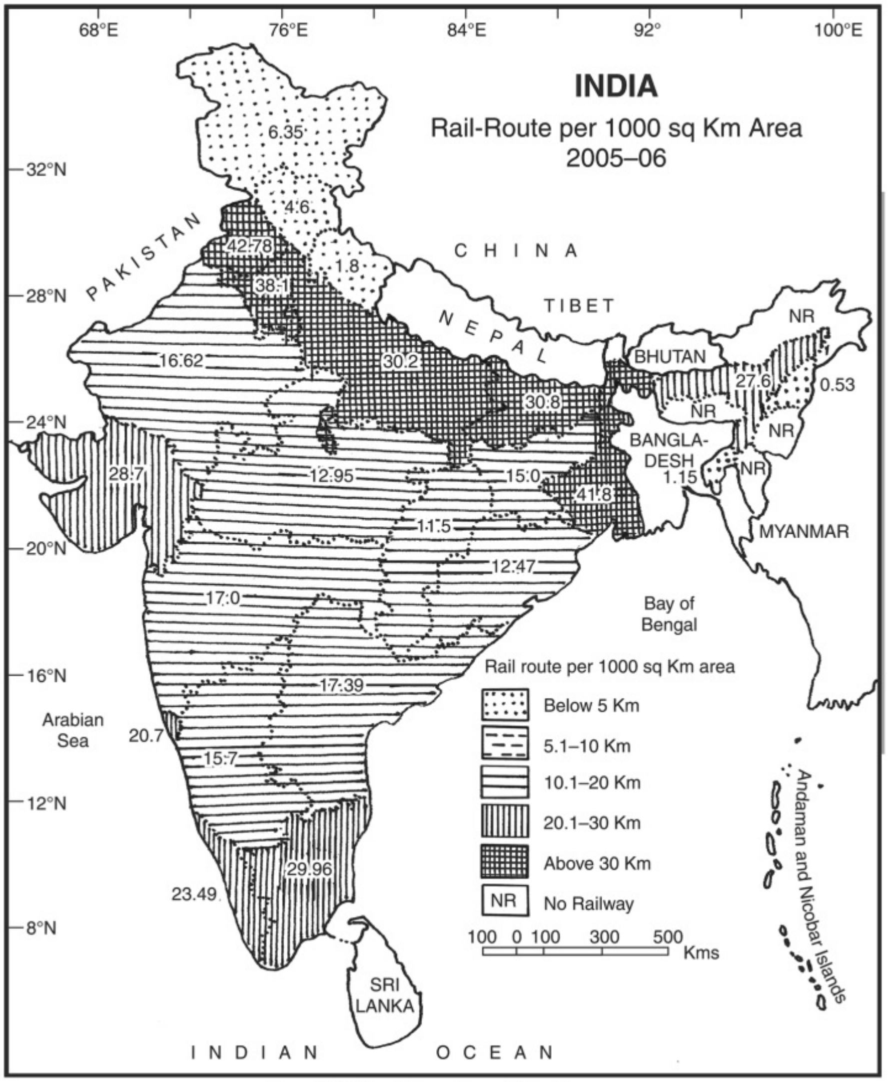


Fig. 12.5 Density of Railways

Railway Management The entire railway system is managed by the Railway Board. The railway network has been divided into 16 railway zones which are subdivided into divisions (**Table 12.3**). These divisions are the basic operating units for the Indian railways.

Table 12.3 *India—Railway Zones*

Zones	*Date of Formation*	*Headquarters*
1. Southern	14.4.1951	Chennai
2. Central	05.11.1951	Mumbai (CST)

(*Contd.*)

(*Contd.*)

3.	Western	05.11.1951	Mumbai (Churchgate)
4.	Northern	14.04.1952	New Delhi
5.	North-Eastern	14.04.1952	Gorakhpur
6.	South Eastern	01.08.1955	Kolkata
7.	Eastern	01.08.1955	Kolkata
8.	North-Eastern Frontier	15.01.1958	Maligaon (Guwahati)
9.	South-Central	02.10.1966	Secunderabad
10.	East Central	01.10.2002	Hajipur
11.	North-Western	01.10.2002	Jaipur
12.	East Coast	01.04.2003	Bhubaneshwar
13.	North Central	01.04.2003	Allahabad
14.	South-East Central	01.04.2003	Bilaspur
15.	South Western	01.04.2003	Hubli
16.	West Central	01.04.2003	Jabalpur
17.	Metro Railway, Kolkata	31.12.2010	Kolkata

Impact of Railways on Economy and Society

The impact of development and expansion on the economy and society is enormous. The construction and expansion of the railways have improved the economy of the country appreciably. Railways have played a significant role in the development of cotton textile industry in Maharashtra and Gujarat; jute industry in Hugli Basin; coal industry in Chhattisgarh, Jharkhand, Maharashtra, Odisha, and West Bengal; tea-plantation and petro-chemical industries in Assam and West Bengal. In the post-Independence period, railways have helped substantially in setting up of industries in the under-developed and backward areas (Bhilai, Bokaro, Durgapur, Raurkela, etc.), of isolation and relative isolation. Railways have played an important role in the transportation of grains, and chemical fertilizers in the regions of Punjab, Haryana and Western Uttar Pradesh where Green Revolution is a success.

Merits of Railway Transport

Some of the important merits of railway transport are as under:

1. Easy Mode of Travel Railways provide the cheapest and the most convenient mode of passenger transport, both for short and long distances. Railways are particularly suited for long distance journeys.

2. Accelerates Industrialisation Railways have played a vital role in the process of economic development, industrialisation, and urbanisation of the country.

3. Agricultural Development Railways have played a significant role in the development and intensification of agriculture. In fact, the farmers can sell their perishable and non-perishable commodities to long distant market at a remunerative price. The fertiliser used in the High Yielding Varieties is also generally transported to the farmers in different parts of the country by the railways.

4. Connects Remote Cultures Railways connect people from the areas of isolation and relative isolation with the urban centres and thus accelerate social interaction and national integration and help in the diffusion of new ideas and innovations.

5. Helps in the Maintenance of Law and Order At the time of communal tension and socio-political turmoil, railways play a significant role

10. Miscellaneous Problems Late running of trains, filthy trains, choked toilets, lack of passenger facilities, cleanliness at railway stations, lack of security arrangements on the railways result into frequent thefts, robberies, and dacoities.

Looking at the above problems, it will be decades before India gets close to Japan's superfast and clean trains.

Water Transport

Prior to the development of railway network, waterways were the main mode of transportation in India. Waterways are the cheapest means of transportation. Moreover, they are the most suitable for carrying heavy and bulky goods. Despite all these merits, water transport in India at present provides only about one per cent of the total transport of the country.

Ports

There are 12 major and 200 minor ports in India. Ports not only play a crucial role in facilitating international trade, they also act as fulcrums of economic activity and development in their surrounding areas. India has about 7517 km of main coastline spread over 13 states/union territories, and studded with 12 major ports and 200 non-major ports (minor and intermediate). Of the non-major ports, around 60 are handling traffic. The major ports are under the jurisdiction of the Central Government, while the minor and intermediate ports are managed and maintained by the respective state governments. The number of cargo vessels handled at major port is about 16,500 per annum.

The total traffic carried by both the major and minor ports during 2005–06 was estimated at around 570 million tonnes. The 12 major ports carry about 75 per cent of the total traffic with Vishakhapatnam as the top traffic handler in each of the last six years (2000–01 to 2006–07).

Major Seaports of India The major seaports of India are: (i) Chennai, (ii) Cochin, (iii) Ennore, (iv) Jawaharlal Nehru Port (Nhava Sheva), (v) Kandla, (vi) Kolkata/ Haldia, (vii) Mormugao, (viii) Mumbai, (ix) New Mangalore, (x) Paradwip, (xi) New Tuticorin, and (xii) Vishakhapatnam **(Fig. 12.6).** The salient geographical features of the major seaports of India have been described briefly here:

1. Chennai Situated along the northern coast of Tamil Nadu, it is an artificial seaport. It spreads over an area of about 80 hectares with an average depth of about 16 metres. The harbour has an entry from the north. It can accommodate 22 vessels. The main exports from the Chennai port are food-grains, hides and skins, iron-ore, mica, oil-cake, sugar, turmeric, timber, and tobacco. The port imports chemicals, coal, cotton, cotton-goods, edible-oils, fertilisers, iron and steel, machinery, metals, and petroleum.

2. Ennore Situated about 20 km to the north of Chennai, Ennore is a natural harbour. It was developed to ease the pressure of the Chennai-seaport. Ennore exports hides, machinery, mica, rice, and sugar. The principal imports are cement, cotton, edible-oils, fertilisers, machinery, and petroleum products.

3. Jawahar Lal Nehru (Nhova Shiva) Port Situated about 14 km to the south of Mumbai, this seaport was developed to ease the pressure of the Mumbai seaport. It is a world-class port equipped with all the modern facilities. The seaport is connected by a four-lane Highway with the hinterland. India's largest container port is Jawaharlal Nehru Port.

4. Kandla Located at the head of the Gulf of Kutch, Kandla seaport was developed after Independence to take up the place of Karachi which went to Pakistan. It is a tidal harbour in the Kandla Creek with an average depth of 10 metres. The port has a vast hinterland in the states of Gujarat, Rajasthan, Haryana, Punjab, Himachal Pradesh, and Jammu and Kashmir. Its main imports are petroleum, fertilisers, phosphates, and sulphur, while the export includes bones, cotton, food-grains, naptha, salt, and sugar.

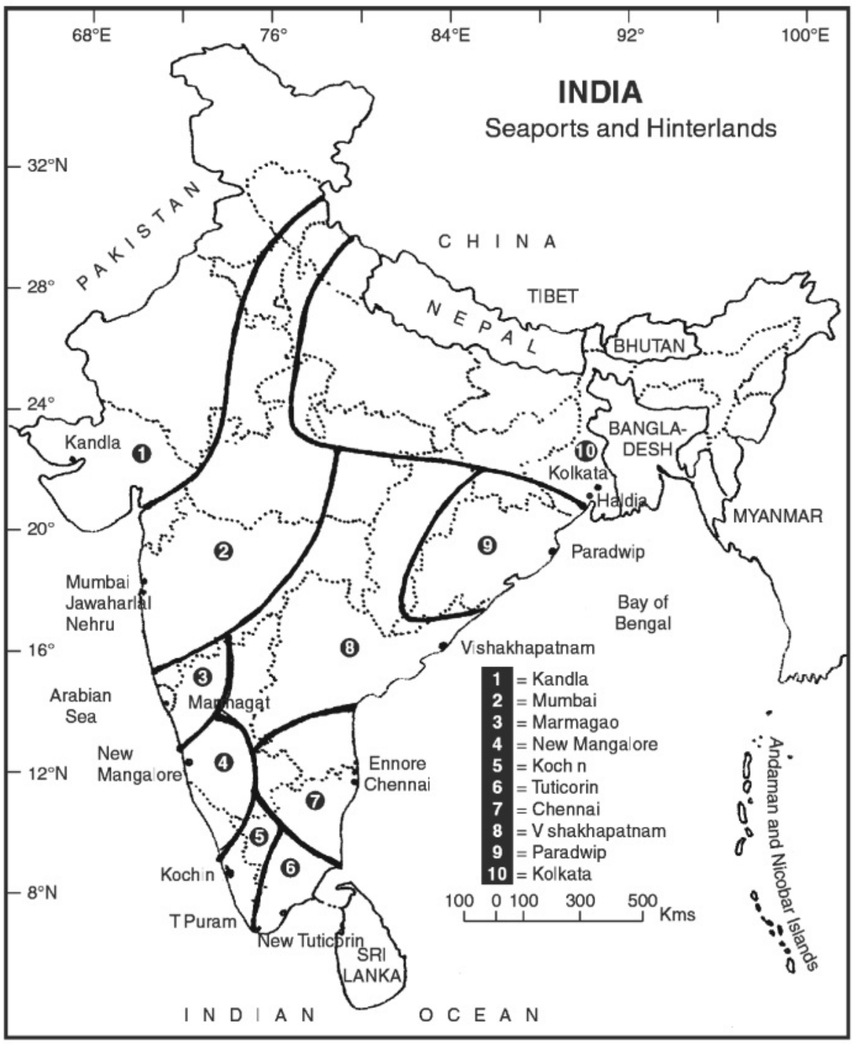


Fig. 12.6 Major Seaports and their Areas of Influence

5. Kochi Situated along the coast of Kerala, Kochi is a natural seaport and the largest shipyard in the country. The indigenous Aircraft Carrier for the Indian Navy is also presently under construction in the shipyard. It remains open for cargo traffic throughout the year. Being situated close to the Suez–Colombo route, it has great commercial and strategic importance. The main items of export

Coastal Shipping Coastal shipping is an energy efficient, environmental-friendly, and economical mode of transportation in Indian transport network. It is a crucial component for the development of domestic industry and trade. Coastal shipping involves movement of goods and passengers from one port to another port within the country**.** India's coastal Shipping Tonnage in December 2005 was 470 vessels with 8,04,612 GRT.

Coastal shipping has many advantages as given below:

1. It reduces the pressure on rail and road transport systems.
2. It is relatively pollution free.
3. It is less capital intensive.
4. It provides large employment.
5. It is the cheapest mode of transport.
6. It promotes coastal base industries such as fisheries and corals collection.
7. It promotes tourism.

Problems some of the important problems of the Indian ports are given below:

1. Indian ports are the most congested.
2. The ports are not adequately connected with the hinterland.
3. There is heavy pressure on container traffic. The largest container port in the world is Singapore which handles 23.19 million TEUs (twenty foot equivalent units). In comparison to this India's largest container port handled roughly 2.67 million TEUs in 2005–06.

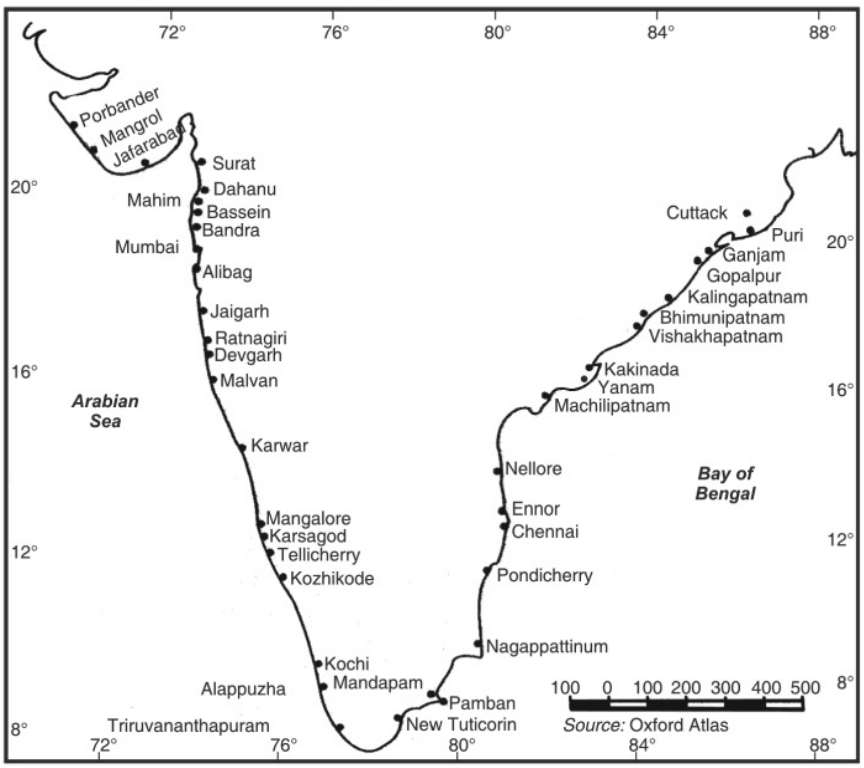


Fig. 12.7 Major Fishing Ports

Inland Water Transport

India has about 14,500 km of navigable waterways which comprise rivers, canals, lakes, backwaters, and creeks. About 45 million tonnes of cargo is being moved annually by Inland Water Transport. It is a fuel-efficient and environment-friendly mode of transportation. Its operations are currently restricted to a few stretches in the Ganga–Hugli rivers, the Brahmaputra, the Barak river (Assam), the rivers in Goa, the backwaters of Kerala, inland waterways in Mumbai, and the deltaic regions of the Godavari–Krishna rivers. Besides the organised operations by mechanised vessels, country boats of various capacities also operate in various rivers, lakes, and canals. Data of cargo and passenger-movement in unorganised sector (i.e., by country boats, etc.) has not been compiled, but it is a fact that substantial quantum of cargo and passengers are transported in the unorganised sector as well.

The Central Water Transport Corporation (CIWTC) Constituted in 1967, it has its headquarters at Kolkata. It is mainly engaged in the transportation of goods by inland waterways in the Ganga, Brahmaputra, Hugli, and Sundarban regions. It is operating regular cargo service between Kolkata and Karimganj (Assam), Kolkata and Bangladesh, and Haldia and Patna.

Inland Waterways Authority of India (IWAI) The Inland Waterways Authority of India came into existence on October 27, 1986 for the development and regulation of inland waterways for shipping and navigation. The Authority primarily undertakes projects for development and maintenance of IWT infrastructure on national waterways through grant received from the Ministry of Shipping, Road Transport and Highways. The head-office of the Authority is located at NOIDA (UP near Delhi). The authority also has its regional offices at Guwahati, Kochi, Kolkata, and Patna and sub-offices at Allahabad, Bhagalpur, Farakka, Kollam, and Varanasi. The National Inland Navigation Institute is located at Patna.

National Waterways Following are National Waterways in India:

1. The Ganga between Allahabad–Haldia (1620 km).
2. The Sadiya–Dhubri stretch of the Brahmapputra (891 km).
3. The Kollam–Kottapuram stretch of West Coast Canal along Champakara and Udhyogmandal Canalas (205 km) in Kerala.

Factors Affecting Inland Waterways The following factors have a close bearing on the development and maintenance of inland waterways:

1. Fluctuation Regime of Rivers Many of the rivers are seasonal. Even in the perennial rivers, like Brahmaputra, Ganga, Gandak, Kosi, and Yamuna, the discharge of water decreases substantially during the summer and winter months, while during the rainy season they are in floods. Both the conditions are not conducive for navigation.

2. Natural Obstacles Presence of waterfalls, cataracts, and rapids in the course of rivers hinder the development of inland navigation.

3. Silting of River Beds Silting of river bed reduces the depth of water and creates problems of navigation.

4. Water for Irrigation Diversion of water for irrigation reduces the quantity of water in the river channel.

5. Economically Unviable The demand for waterways is not adequate as the people want fast movement of their commodities. This makes river transport economically unviable.

Shipping

Managing about 95% of the country's trade volume is carried by shipping (2012). India has a long history of shipping. The Scindhia Steam Navigation Co. was set up in 1919 on modern lines. At the time of Independence, there were only 59 ships with less than 2 lakh tonnes of Gross Registered Tonnage (GRT). Since Independence, India has made a significant progress in shipping and the shipping fleet had 872 ships (282 overseas and 590 coastal vessels (India 2010)). Coal, crude oil and natural gas are mainly transported by ship.

At present, shipping plays a significant role in the transport sector of the country's economy. Nearly 95 per cent of the total trade volume is moved by sea making shipping the backbone of trade and economic growth. Today India has one of the largest merchant shipping fleet in the developing world. The major international sea routes of India have been shown in **Fig. 12.8.**

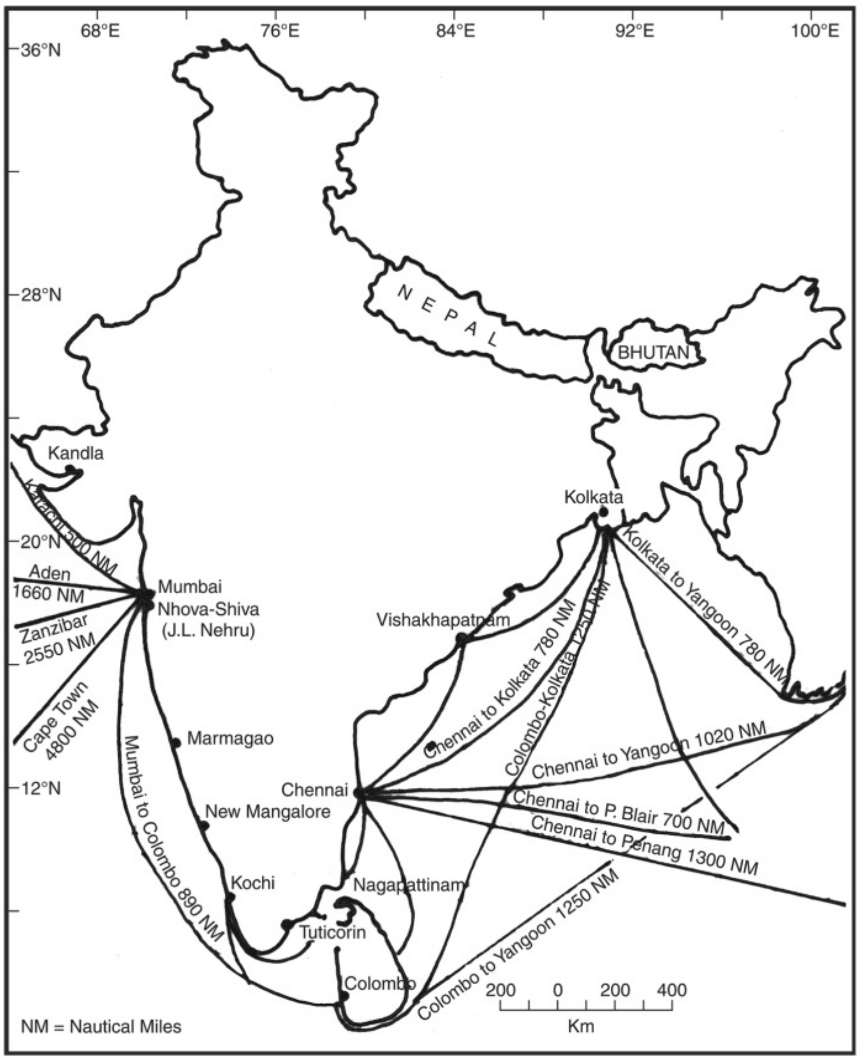
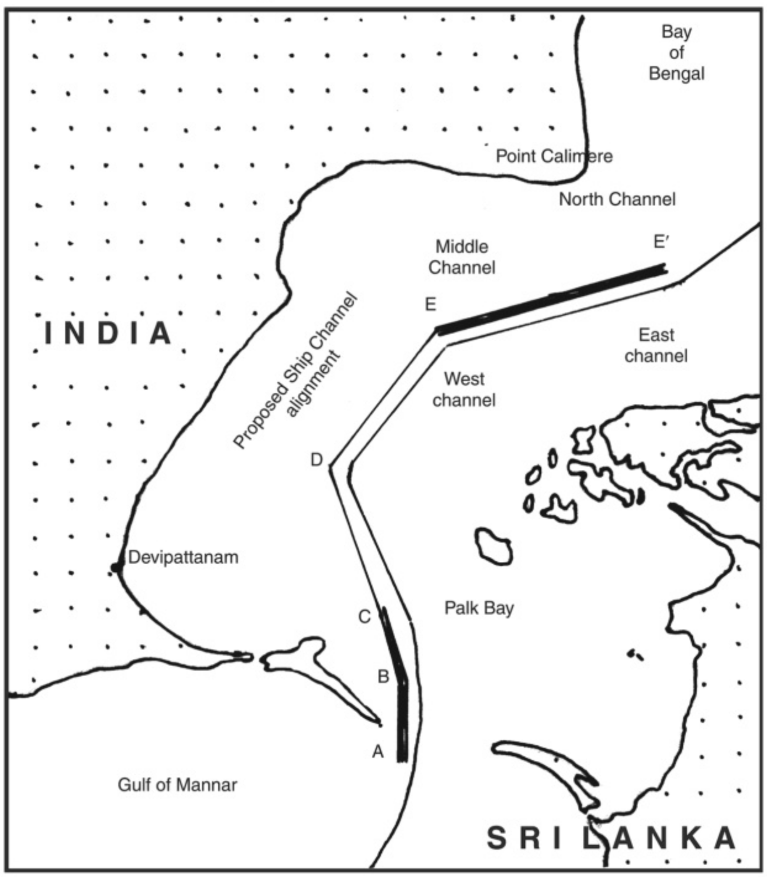


Fig. 12.8 Major Sea-routes

Adam's Bridge (Ram Sethu)

The Adam's Bridge or Ram Sethu is a discontinuous chain of sandbars dotting 30 km stretch in the east-west direction between the southern tip of Rameswaram Island in India and Talaimannar in north-western Sri Lanka. It creates a geological divide between the Palk-Bay and the Gulf of Mannar which form part of the southern Kaveri Basin in the Bay of Bengal (**Fig. 12.8**).

The Sethu-Samudram Ship Channel Project (SSCP) of the Government of India envisages the dredging of the shallow ocean region in the Bay of Bengal to create an artificial 167 km long 300 m wide and 12 m deep channel like passage for (10,000–12,000 gross tonnage) ships across the island formations called Adam's Bridge or *Ram Sethu.*



AB (17.3 Km) North Adam's Bridge.
BC (13.38 Km) North Adam's Bridge
CD (37.44 Km) Palk Bay
DE (40.48 Km) Palk Bay
EE′ (54.25 Km) Palk Strait

Total 167.22 Km

Fig. 12.9 India—Ram Sethu Project

The proposal for channel linking the Palk-Strait and the Gulf of Mannar goes back to the British in 1860 and since then several proposals have been made and six distinct alignments for the passage

Dr. Ram Mohan a leading geomorphologist and oceanographer, in his research paper entitled 'Geological Evolution of Adam's Bridge' opined that Adam's Bridge consists of sand-bars and coral formations. The possibility of formation of shoals in the shallow continental shelf as barrier bars (sandbars) appear to be the most plausible explanation for the evolution of Rameswaram and Adam's Bridge.

Thus all the scientific studies about the Ram Sethu suggest a consistent picture of natural process that led to the formation of Adam's Bridge. It is not a man-made structure . It is merely a sand and coral formation. The reduction in the distances between Tuticorin and Chennai, Ennore, Vishakhapatnam, and Haldia/Kolkata, etc. has been given in **Fig. 12.10.**

Air Transport

India has bilateral Air Service Agreement with 103 countries. Recently, new Air Services Agreement have been signed with Mexico and Chile. Air transport is the fastest mode of transport. It has reduced geographical distances, making the world a village.

The main advantages and disadvantages of the air transport are:

1. With the help of air-transport one can easily reach the remote and difficult terrains, like mountains, deserts, thick-forests, deserts, and marshy lands.
2. It is the fastest mode of transportation.
3. Air-transport plays a vital role at the time of emergency like a war situation and in the event of natural calamities like earthquakes, cyclones, famines, floods, droughts, epidemics, etc.
4. Air-transport is, however, adversely affected at the occurrence of fog, mist, and stormy weather.

Civil Aviation

The Airport Authority of India (AAI), constituted on 1st April 1995, operates 127 airports including civil enclave and defence airfields for Commercial Airlines operations. The Ministry of Civil Aviation is responsible for the formulation of national policies and programmes for the development and regulation of civil aviation and for the devising and implementing of schemes for an orderly growth and expansion of civil air transport. Its functions also extend to overseeing the provision of airport facilities, air traffic services, carriage of passengers and goods by air, safeguarding civil aviation operations, regulation of air transport services, licensing of aerodromes, air carriers, pilots, and aircraft maintenance engineers.

Airports There are 450 airports in the country in various stages of development. Out of these Ahmadabad, Amritsar, Bangalore, Chennai, Delhi, Guwahati, Hyderabad, Jaipur, Kochi, Kolkata, Mumbai, Panaji, Srinagar and Thiruvananthapuram are the international airports.

The improvement in the infrastructural facilities at the airports need heavy capital investment which the government cannot afford of its own. Therefore, private domestic and foreign investors including Non-Resident Indians have been encouraged to participate in the process of improvement of the Indian Airlines.

Cargo In order to help the Indian exports to make their exports more competitive, the Government had introduced in April 1992 an '*Open Sky Policy*' for cargo. Under this policy, foreign airlines or association of exporters can bring any number of freighters to the country for upliftment of cargo. The Government has also permitted market forces to determine cargo traffic with IATA rates as the floor rates.

Air Services India has bilateral Air Services Agreement with 101 countries. A revised Air Service Agreement between India and USA was signed in 2005 replacing earlier Agreement, signed in 1956. The revised agreement grants unlimited access to the designated airlines to any point of call in the territory of the other country as against four airports under the earlier agreement.

Air India The Air India was constituted in 1947, after which the Air India International launched its first service to London via Cairo and Geneva on June 8, 1948 with Constellation aircraft. In 1952, the Planning Commission recommended the nationalisation of Air Transport Industry which was effected in March 1953 with the creation of nationalised Corporations—Air India International Limited, which retained its identity and international flag carrier status; and the Indian Airlines, to operate domestic services.

Fleet Air India owns a fleet of 16 aircrafts consisting of six B747-400, two B747-300, and eight A-310-300. In addition, Air India has inducted six B747-400, eleven A310-300, and four B777-222 on dry lease basis, taking the total number of aircrafts in Air India to 37. Additionally, B737-800 have been leased for Air India Express.

Air India operates 173 flights per week serving 59 stations (45 international and 14 domestic). Air India also has code-share agreements with 12 airlines to offer its passengers more destinations and convenient connections.

Indian Airlines Indian Airlines was set up under the Air Corporation Act, 1953 with an initial capital of Rs. 3.25 crore with its Headquarters at Delhi. The India Airlines is the major domestic air carrier of the country. The Indian Airlines operates to 55 domestic stations alongwith its wholly-owned subsidiary Airlines, Allied Services Ltd. (Alliance Air). Besides Indian Airlines also operates to 18 international stations.

The Indian Airlines presently has a fleet of 73 aircrafts comprising 03 Airbus, A-300s; 48 Airbus, A-320s, 5 Airbus, A-319s; 11 Boeing 737s; 18 Dornier DO-228; and 04 ATR-42-320. All B-737 and ATR aircrafts are operated by Alliance Air.

In addition to Air India, there are: Jet Airways, Kingfisher Airlines, Deccan Aviation Co; Jet-lite, Paramount Airways, MDLR Airways, Jagson Airlines and Go-Air airlines.

Pawan Hans Helicopters Limited The Pawan Hans Helicopters Ltd (PHHL) 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.

Private Companies In addition to these, five companies are providing services in India : out of these Jet Airways and Air Sahara are operating on domestic as well as international air-routes, while Air Deccan, Kingfisher, and Spice-Jet are operating on domestic routes only.

Problems

The air transport of India is facing the following main problems:

1. Running in Loss Both the Air India and the Indian Airlines are incurring constant losses. Some better airlines like Singapore and Lufthansa have shown willingness to join with Air India.

2. Strikes Strikes have become regular feature in the air-transport industry. For example, the September/October 2009 strike of pilots created great inconvenience to the passengers and heavy losses to the Indian Airlines.

Offices. All the categories of Post Offices retain similar postal services, while delivery function is restricted to specified offices. In terms of management control, accounts are consolidated progressively from Branch Post Offices to Sub Post Offices and finally in Head Post Offices.

The Department has about 2.47 lakh departmental employees and about 2.93 lakh Gramin Dal Sevaks as on March 31, 2005.

Mail System

First class mail, viz., post cards, inland letters, and envelops are given airlift wherever found advantageous, without any surcharge, between stations connected by air. Second class mail, viz., book packets, registered newspapers, and periodicals are carried by surface transport, i.e. trains and road transport.

International Mails

India is a member of the Universal Postal Union (UPU) since 1876 and of the Asian Pacific Postal Union (APPU) since 1964. These organisations aim at extending, facilitating, and improving postal relations among other countries. India exchanges mail with more than 217 countries by air and surface.

Money can be remitted from selected foreign countries to India by way of money orders and postal orders. India has money order service with 27 countries. India has two-way money order service with Bhutan and Nepal wherein money orders can be sent to and received from these countries. With the remaining 25 countries, only inward service is available where money orders booked in these countries can be paid in India. British Postal Orders and Irish Postal Orders are encashable in India at selected post offices.

International EMS, which started in 1986 with five countries, has now been extended to 97 countries. With a view to facilitate export and import to and from foreign destinations, principal foreign offices of exchanges have been set up at Chennai, Delhi, Kolkata, and Mumbai. In addition, six sub-foreign post offices have been established at Ahmadabad, Bangalore, Cochin, Jaipur, NOIDA, and Srinagar. Export Extension Windows have also been made operative at Guwahati, Kanpur, Ludhiana, Moradabad, Surat, and Varanasi to cater to the needs of the exporters, tourists in these areas.

Telecommunication

India's telecom sector has been one of the biggest success stories of market-oriented reforms, and India is now amongst the fastest growing telecom markets in the world. The total number of telephones has increased to 190 million in December 31, 2006.

The announcement of the New Telecom Policy, 1999 was a watershed event in telecommunications in India. Other policy milestones include the opening of the long-distance market in 2002. As a result, telecom tariffs which were among the highest in the world less than four years ago have now dipped among the lowest. The growth of wireless services has been phenomenal, with wireless subscribers growing at a compound annual growth rate of above 90 per cent per annum since 2003.

The total number of telephone has increased from 54.63 million on March 31, 2006 to 189.92 million on December 31, 2006. About five million subscribers are added every month. With this growth, the number of telephones is expected to reach 250 million by the end of 2007. Today the wireless subscribers are not only much more than the fixed subscribers in the country, but also increasing at a much faster pace. The share of wireless phones has increased from 24 per cent in March 2003 to 79 per cent in December, 2006.

Internet

As on December 31, 2006, there are 400 licenses for provision of Internet Services out of which 128 have signed Licenses for Provisions of Internet Services (including Internet Telephony). Based on reports received from Internet Service Providers till March 2006, there are approximately 12.00 million Internet subscribers in India (India 2010).

Manufacturing of Telecom Equipments

The Indian telephone industry manufactures a complete range of telecom equipments using state of the art technologies designed specifically to match the diverse terrain and climatic conditions. Production of telecom equipments has increased from Rs.16,090 crore in 2004–05 to Rs. 17,833 crore in 2005–06. There is heavy demand of the mobile phones from domestic and international markets. It is expected that within the next decade, India is expected to become a manufacturing hub for telecom equipments.

Telegraph and Telephone Service

Telegraph services were introduced at Calcutta in 1851 and a telephone service began also at Calcutta in 1851–82 soon after their invention in the United States of America. Today there are over 45,000 telegraph offices. There are over 25,000 telephone exchanges in the country by 2005–06. Ours is the largest telecom network in Asia.

Radio, Television, and Cinema

Radio, television and cinema (films) are the electronic media of mass communication, unlike postal, telegraphic, telephone, and telex services which are essentially of personal nature. Unlike telephone, radio is a means of wireless communication. It is a very powerful medium to transmit and receive useful information, news and variety of entertainment programmes including sports.

At the time of Independence, there were six radio (Akashwani) stations. At preset All India Radio is accessible to almost 98.5 per cent of the total population of the country.

Doordarshan is the national television service of India. It started in 1959. It is one of the largest and essential networks in the world with over 900 transmitters. Its programmes are watched by over 500 million viewers in their homes. Its commercial advertisements brought in a huge revenue of over Rs.10,000 million in 2005–06. Now under the open skies policies a large number of private parties registered in India. It manages radio and television channels and have been assigned to private parties registered in India. It manages radio and television services under the supervision of parliamentary Committee.

Cinema is the most popular means of entertainment in India. It is the largest producer of feature films in the world. Hindi films by far is the most dominant section. Almost all the regional languages bring out their own films almost continuously. Personal computers and Internet services have brought about a new revolution in the age of explosion of information technology.

Print Media

The total number of newspapers and periodicals being published was over 42,000 on December 31, 2006. Hindi publication has the largest share of over 40 per cent of the total. Books are an equally important means of communication for preserving and propagating knowledge, information and entertainment to posterity.

INTERNATIONAL TRADE

A flow of commodities from producers to consumers is known as trade. It is an important tertiary sector of economy which is carried out at the local, regional, national, and international levels.

India has a long tradition of trading with countries located far and near. Today we are living in a fast shrinking world mainly because of tremendous advances in both transport and communications. We are living in an economically interdependent world, where the world itself has turned into a global village with a self-contained economy. Because of fast means of transport and communications, India conducts international trade with about 200 countries with an endless list of around 8000 commodities. The share of trade in the GDP is about 15 per cent, which engages 7.3 per cent of work force in the country.

There was a time when commodities were imported only for domestic consumption. But now more and more countries including India, have been importing certain raw or semi-processed materials, not for their own domestic consumption, but to process them further and export them after value addition. *Indirectly, what the country exports are items of human skills*. For example, Japan exports cotton and woollen textiles although it imports all its requirements of raw materials from other countries. The same is true of mineral based industries. India imports raw cashewnuts only to re-export them after they are further reprocessed. India imports crude diamonds and other precious stones only to process them further and re-export them as highly finished fine products at a considerable upward margin. India also imports gold and silver and exporting them in the form of attractive and expensive ornaments. International or foreign trade has played a crucial role in India's economic growth.

During the colonial days India used to export almost entirely agricultural raw materials. India's traditional exports consisted of jute, cotton, tea, spices, hides, skins, oil-seeds, especially groundnut. At present, instead of exporting raw materials, India is exporting jute-packing materials (gunny-bags, linen, and carpets). In place of cotton, India exports quality yarn, cotton fabrics, including hosiery, readymade garments and skilled and semi-skilled workers. India also exports silk woollen, and synthetic textiles, processed marine products, manufactured leather goods, sports goods (cricket bats, hockey sticks, etc.) engineering goods like fans, sewing machines, bicycles, three-wheelers, scooters, cars, commercial vehicles, chemicals and allied products, carpets, rice, processed food, medicines, electric goods, books and films.

Table 12.4 shows India's total export, import, total value of foreign trade and balance of trade from the year 1990–91, 2000–01, and 2005–06.

Table 12.4 *India's Foreign Trade (in Rupees crore)*

Year	*Exports*	*Imports*	*Total trade*	*Trade deficit*
1950–51	606	608	1214	–2
1960–61	642	1122	1764	–480
1970–71	1535	1634	3169	–99
1980–81	6710	12,549	19,259	–99
1990–91	32,558	43,193	75,751	–10,635
2000–01	20,3571	2,30,873	4,34,444	–27,302
2008–09	696,498	870,399	15,66,897	–173,901

Source: ***India 2010***, p.148.

An examination of **Table 12.6** vividly shows that about 34 per cent of the total import consists of crude oil, petroleum and allied products. Capital goods constituting 12.1 per cent of the total import ranks second, while electric goods and gold and silver rank third and fourth in the list of import respectively. Other important items of import are chemicals, pearls and precious stones followed by metal scraps and coke.

Table 12.7 *India's Major Trading Partners (2005–06)*

Country	*2005–06*
1. USA	12.5
2. United Arab Emirates	5.6
3. China	5.4
4. UK	4.5
5. Belgium	4.2
6. Germany	4.0
7. Hong Kong	3.5
8. Japan	3.5
9. Switzerland	2.8
10. Malaysia	2.5
11. Russia	2.4

Source: ***The Economic Survey, 2005–06***

At present India's largest international trade partner is USA, followed by UAE, China, UK, Belgium, Germany, Hong Kong, and Japan (**Table 12.7**). There is, however, enough scope to increase the import and export with the India's adjacent countries.

Salient Features of Foreign Trade

Following are the salient features of the Indian foreign trade:

1. Unfavourable Balance of Trade

India is importing enormous quantity of crude-oil, petroleum, petroleum products, precious stones, gold, silver, copper, machinery, cashewnuts, fertilisers, and mainly exporting agro-based products, engineering goods, commercial automobiles, etc. The balance of trade and balance of payment are still unfavourable as import exceeds the export. India's balance of payment in the post-reform period (1991) is growing from strength to strength.

2. More Export of Manufactured Goods

India is exporting nearly 8000 commodities, and the number of exports of finished commodities is increasing appreciably.

3. Worldwide Trade

India exports its products to 200 countries and imports from 150 countries.

4.Change in Import

Earlier India used to import almost all types of machinery, precision instruments, surgical equipments, automobiles, and electrical goods. Now India is exporting all sorts of machinery including vehicles, electronic, and chemical goods, and importing raw materials like diamonds, precious stones, gold, cashew-nuts, jute, mineral ores, and raw and semi-processed raw materials.

5. Maritime Trade

About 96 per cent of our foreign trade is carried out through sea routes. Trade through land routes is limited either because of the physical barriers of Himalayas or the less friendly relations with the neighbours.

6. Trade through Selected Ports

India has only 12 major international seaports which handle about 92 per cent of foreign trade. The remaining seaports handle insignificant amount of the foreign trade.

7. Insignificant Position in the International Trade

India has almost 17 per cent of the total population of the world but unfortunately, its share in the International trade is less than one per cent.

8. State Trading

Over 95 per cent of the overseas trade is done in public sector by the state agencies. There is insignificant trade done by the private undertakings.

9. Increasing Import of Raw Material

India is importing cashew-nut, cotton, gems, jute, mineral ores, pearls, precious and semi-precious stones, and raw silk.

10. Increasing Import of Capital Goods

Goods like manufactures of metals, electrical and non-electrical machinery, transport equipments, chemicals, and new technology are being increasingly imported.

Export Processing Zones (EPZ)

In order to promote International trade, the government of India has created seven Export Processing Zones. The zones and their headquarters are as under:
1.Chennai (Tamil Nadu), 2. Falta (West Bengal), 3. Kandla (Gujarat), 4.Kochi (Kerala), 5. NOIDA (Uttar Pradesh), 6. Santa Cruz (Maharashtra), and 7. Vishakhapatnam (Andhra Pradesh).

Each zone provides the basic infrastructural facilities in addition to whole range of fiscal incentives. Customs clearance facilities are offered within the zones. However, EPZs were not able to emerge as effective instruments for export promotion on account of multiplicity of controls and clearances, absence of world class infrastructure, and an unstable fiscal regime.

General Agreement on Tariff and Trade (GATT)

The General Agreement on Tariff and Trade (GATT) was established in 1948 in Geneva to pursue the objective of free trade in order to encourage growth and development amongst all member countries of the world. The main objective of the GATT was to ensure competition in commodity trade through the removal or reduction of trade barriers. The first seven rounds of negotiations conducted under GATT were aimed at stimulating international trade through reduction in tariff barriers and also by reduction in non-tariff restricts on imports imposed by the member countries.

BALANCE OF TRADE AND BALANCE OF PAYMENT

The exports and imports of a country should be roughly equal in value, since the foreign exchange earned by exports is necessary to finance imports, but such a balance is rarely achieved. This is partly because trade passes through the hands of many different companies working independently, and thus an exact balance can never be reached, but is also due to fluctuations in markets leading to changes in import and export values over a period of years. The difference in value between imports and exports is referred to as the balance of trade. If exports exceed imports a country is said to have a *favourable balance of trade*, while if imports exceed exports it has an *adverse balance of trade*. These terms are relics of an earlier trading era, when if a country exported goods in large quantities they were paid for in gold. Thus, an excess of exports brought an addition to gold reserves. A country which has consistent adverse balance of trade, as Britain has done for more than a century, can enjoy great prosperity, while a favourable balance of trade is often characteristic of underdeveloped countries today, which often have great financial difficulties notwithstanding.

The balance of trade only takes account of visible trade or the value of actual goods transferred from one country to another. But there are many other ways in which foreign exchange can be earned or spent. These are collectively called *invisible trade* which accounts for a quarter of all transactions with foreign countries can be worked out. This is called the *balance of payments*.

Transactions which bring money into the country are called invisible exports and can be of several kinds.

1. **Payment for financial services** including insurance, banking, brokage, and other services carried out on behalf of foreigners.
2. **Payment of transport services** such as shipping or air transport of passengers or freight. Britain and certain other European countries have large invisible earnings in these two fields because of their importance in trade and financial dealings.
3. **Expenditure by foreign tourists**. This is often an extremely important source of foreign exchange.
4. **Interest and dividends on foreign investments**. India is earning a substantial amount in the form of interest and profit on foreign investment, annually.
5. **Remittance from emigrants.** Many emigrants send money to their families and thus countries like India, which have supplied large number of emigrants, may receive considerable foreign exchange in this way.
6. **Loans and aids** from foreign countries or international organisations. Many underdeveloped countries receive aid or loans to finance development, while other countries may obtain loans to cover balance of payments deficits.

Transactions which take money out of the country are called *invisible imports*. Payment for services, payment of interest on investments, remittances of immigrants, repayment and interest of foreign loans, or deficit on tourism, may all be greater than invisible exports in the same fields.

When these invisibles, both exports and imports, are brought into account, many countries which would have an unfavourable balance of trade are found to have a more favourable balance of payments. It is much more important that the total payments and receipts rather than the visible trade, should be well balanced as long-term loans may have to be obtained, which may lead to future difficulties when they have to be repaid; or gold reserves may be reduced; or overseas assets may be sold so that longer-term invisible exports are reduced; or currency values may be changed by devaluation or revaluation to alter the relative value of exports and imports and thus balance total transactions more nearly.

All these measures may have detrimental effects on the economy in the long term but have to be resorted to by many countries. Other ways of balancing transactions are to increase visible or invisible exports, or to apply trading restrictions in order to cut down on imports. Countries may also reduce the mobility of money, restrict tourism, or confiscate foreign property to reduce the outflow of money.

(ix) Revitalising the Board of Trade by redefining its role, giving it due recognition and inducting experts on Trade Policy.

(x) Activating our Embassies as key players in our export strategy and linking our Commercial Wings abroad through an electronic platform for real time trade intelligence.

INDIA—SPACE PROGRAMME

History: India's experience in rocketery began in ancient times when fireworks were first used in the country, a technology invented in neighbouring China, and which had an extensive two-way exchange of ideas and goods with India, connected by the Silk Road. Military use of rockets by Indians during the Mysore War against the British inspired William Congreve to invent the Congreve rocket, predecessor of modern artillery rockets, in 1804. After India gained Indepenedence from British occupation in 1947, Indian scientists and politicians recognised the potential of rocket technology in both defence applications, and for research development. Recognising the fact that a country as demographically large as India would require its own independent space capabilities, and recognising the early potential of satellites in the fields of remote sensing and communication, these visionaries set about establishing a space research organisation.

Phase I: 1960–70

Dr. Vikram Sarabhai was the founding father of the Indian space programme, and is considered not only a scientific visionary by many but also a national hero. After the launch of Sputnik in 1957, he recognised the potential that satellites provided. India's first Prime Minister, Pt. Jawaharlal Nehru, who saw scientific development as an essential part of India's future, placed space research under the jurisdiction of the Department of Atomic Evergy in 1961. The DAE Director Homi Bhabha, who is regarded as the father of India's atomic programme, then established the Indian National Committee for Space Research (INCOSPAR) with Dr. Sarabhai as Chairman in 1962.

From its establishment in 1962, the Indian space programme began establishing itself with the launch of sounding rockets, which was complemented by India's geographical proximity to the equator. These were established from the newly-established Thumba Equatorial Rocket Launching Station (TERLS), built near Thiruvananthapuram in south Kerala. Subsequently, India developed indigenous technology of sounding rockets called *Rohini Family* of sounding rockets.

Recognising the need for indigenous technology, and possibility of future instability in the supply of parts and technology, the Indian space programme endeavoured to indigenise every material supply route, mechanism, and technology. As the Indian Rohini Programme continued to launch sounding rockets of greater size and complexity, the space programme expanded and was eventually given its own government department, separate from the department of Atomic Energy. In 1969, the India Space Research Organisation (ISRO) was created and finally the Department of Space was established in 1972.

Phase II: 1970–80

Sarabhai had taken part in an early study with NASA regarding the feasibility of using satellites for applications as wide as direct television broadcasting. India started designing and creating an independent launch vehicle. Meanwhile, India also began development of satellite technology, anticipating the remote sensing and communication needs of the future. India's first foray into space began with the launch of its satellite Aryabhata in 1975 by a Soviet booster. By 1979, the SLV was ready to be launched from a newly-established second launch site, the Sriharikota Rocket

Launching Station (SRLS). The first launch in 1979 was a failure, attributed to control failure in the second stage. By 1980, this problem had been worked out. *The first indigenous satellite launched by India was called Rohini.*

Phase III: 1980–90

Following the success of the SLV, ISRO was keen to begin construction of a satellite launch vehicle that would be able to put truly useful satellite into polar orbit. The Augmented Satellite Launch Vehicle (ASLV) was tested in 1987, but this launch was a failure. After minor corrections, another launch was attempted in 1988, and this launch again failed.

Phase IV: 1990–2000

It was not until 1992 that the first successful launch of the ASLV took place. The first successful launch took place in 1994., and since then, the PSLV has become the workhorse launch vehicle, placing both remote sensing and communications satellites into orbit, creating the largest cluster in the world, and providing unique data to Indian industry and agriculture.

Phase V: 2000–2010

In 2001, the first development flight of the GSLV took place. India is developing a project to send unmanned probe to the moon in 2008, as the first attempt at exploration of solar system.This project is called *Chndrayaan.*

ISRO has entered the lucrative market of launching payloads of other nations upon its rockets from Indian soil. ISRO is planning a mission to Mars early in the next decade.

Major Events

1962: Indian National Committee for Space Research (INCOSPAR), formed by the Department of Atomic Energy, and work on establishing Thumba Equatorial Rocket Launching Station (TERLS) near Trivendrum began.
1963: First sounding rocket launched from TERLS on November 21, 1963.
1965: Space Science & Technology Centre (SSTC) established in Thumba.
1967: Satellite Telecommunication Earth Station set up at Ahmedabad.
1972: Space Commission and Department of Space set up.
1975: First Indian Satellite, Aryabhatt launched (April 19, 1975).
1976: Satellite Industrial Television Experiment (SITE) conducted.
1979: Bhaskara-1, an experimental satellite, launched. First experimental launch of SLV-3 with Rohini satellite on board failed.
1980: Second experimental launch of SLV-3; Rohini satellite successfully placed in orbit.
1981: Bhaskara II launched on November 20.
1982: INSAT-1A launched (April), deactivated in September.
1983: Second launch of SLV-3; RD-D2 placed in orbit. INSAT-1B launched.
1984: Indo-Soviet manned space mission (April). Rakesh Sharma became the first Indian to reach space.
1987: ASLV with SROSS-1 satellite on board launched.
1988: First Indian Remote Sensing Satellite, IRS-1A launched.
1990: INSAT-1D launched successfully.
1991: Launch of second operational Remote Sensing Satellite, IRS-1B (August).

1992: Third developmental launch of ASLV witth SROCC-C on board (May). Satellite placed in orbit. First indigenously built satellite, INSAT-2A, launched successfully.

1993: INSAT-2B launched in July successfully. First developmental launch of PSLV with IRS-1E on board fails.

1994: Fourth developmental launch of ASLV successful (May). Second developmental launch of Polar Satellite Launch Vehicle (PSLV) with IRS-P2 successful (October).

1995: INSAT-2C launched in June.

1996: Third developmental launch PSLV with IRS-P3 successful in (March).

1997: INSAT-2D launched in June and became inoperational in October. Arabsat-1C, since renamed INSAT-2DT, acquired in November. First operational launch of PSLV with IRS-1D successful (September).

1998: INSAT system capacity augmented with readiness of INSAT-2DT aquired from Arabsat (January).

1999: INSAT-2D the last satellite in the multi-purpose (INSAT-2D series), launched by Ariane from Kourou French Guyana (April 3, 1999). IRS-P4 (OCEANSAT), launched by Polar Satellite Launch Vehicle (PSLV-C2).

2000: INSAT-3B was launched on March 22, 2000.

2001: Geosynchronous Satellite Launch Vehicle-D1 (GSLV-D1), the first developmental launch of GSLV V with GSAT-1 on board, partially successful.

2002: INSAT-3 CGSLV-D2 launched successfully by Ariannespace (January); launch of KALPANA-1 (September).

2003: GSLV-D2, the second developmental launch of GSLV with GSAT-2, successful (May).

2004: First operational flight of GSLV (F02) unsuccessfully launches EDUSAT (September).

2005: Launch of CARTOSAT and HAMSAT by PSLV-C6 from the second launch pad (Universal Launch Pad) (May 1). ISAT-4A launched successfully on July 10, 2006. GSL V-F02 carried INSAT-4C.

2006: Second operational flight of GSLV (F02) unsuccessful July 2006.

2007: Successful launch of CARTOSAT-2, SRE-1, LAPAN-TUBSAT and PEHUENSAT-1 on PSLV V C7 on January 10, 2007.

2008:
- PSLV-C11 successfully launches CHANDRAYAAN-1 from Sriharikota (October 22, 2008).
- PSLV-C9 successfully launches CARTOSAT-2A, IMS-1 and 8 foreign nano satellites from Sriharikota (April 28,2008).
- PSLV-C10 successfully launches TECSAR satellite under a commercial contract with Antrix Corporation (January 21, 2008).

2009:
- PSLV-C14 successfully launches Seven Satellites - OCEANSAT-2, FourCUBESAT Satellites and Two RUBIN-9 from Sriharikota (Sept. 23, 2009).
- PSLV-C12 successfully launches RISAT-2 and ANUSAT from Sriharikota (April 20, 2009).

2010:
- GSLV-F06 launched from Shriharikota (Dec 25, 2010). GSAT-5P could not be placed into orbit as the GSLV-F06 mission was not successful.
- Successful launch of advanced communication satellite HYLAS (Highly Adaptable Satellite), built by ISRO on a commercial basis in partnership with EADS-Astrium of Europe, by Ariane-5 V198 from Kourou French Guiana (November 27, 2010).
- PSLV-C15 successfully launches Five Satellites - CARTOSAT-2B, ALSAT-2A, two nanosatellites-NLS-6.1 & 6.2 and a pico-satellite- STUDSAT from Sriharikota (July 12, 2010).
- GSLV-D3 launched from Sriharikota (Apr 15, 2010). GSAT-4 satellite could not be placed in orbit as flight testing of the Indigenous Cryogenic Stage in GSLV-D3 Mission was not successful.

2011:
- PSLV-C18 successfully launches Megha-Tropiques, Jugnu, SRMSat andVesselSat-1 from Sriharikota (October 12, 2011).
- PSLV-C17 successfully launches GSAT-12 from Sriharikota (July 15, 2011).
- Successful launch of GSAT-8 by Ariane-5 VA-202 from Kourou French Guiana, (May 21, 2011).
- PSLV-C16 successfully launches Three Satellites - RESOURCESAT-2,YOUTHSAT, X-SAT from Sriharikota (April 20, 2011).

2012:
- Successful launch of GSAT-10 by Ariane-5 VA-209 from Kourou French Guiana (September 29, 2012).
- ISRO's Polar Satellite Launch Vehicle, PSLV-C21 successfully launchesSPOT 6 and PROITERES from Sriharikota (September 09, 2012).
- PSLV–C19 successfully launches RISAT-1 from Sriharikota (April 26, 2012).

2013:
- PSLV – C25 successfully launches Mars Orbiter Mission Spacecraftfrom Sriharikota (Nov 05, 2013).
- Successful launch of GSAT-7 by Ariane-5 VA-215 from Kourou French Guiana (August 30, 2013).
- Successful launch of INSAT-3D by Ariane-5 VA-214 from Kourou French Guiana (July 26, 2013).
- PSLV – C22 successfully launches IRNSS-1A from Sriharikota (Jul 01, 2013).
- PSLV – C20 successfully launches SARAL and six commercial payloadsfrom Sriharikota (Feb 25, 2013).

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Chapter 13

Cultural Setting

ORIGIN OF MANKIND

There is no direct evidence to show when the first man appeared on the earth and at which place he was born. In fact, the origin of man is shrouded in mystery. But the protagonists of the 'Theory of Evolution' believe that man is the last product of slow evolution of life on the earth. The anthropologists opine that the ancestors of the first man were born in the region to the east of the Victoria Lake in east Africa. The oldest fossils of the ancestors of *Homo Sapiens* (Modern Man) are found in that part of Africa. From this region, modern man migrated and entered into Asia, Europe and the Subcontinent of India around one million years back **(Fig. 13.1).**

Subdivisions of the Human Species

Race

It is difficult to give a precise definition of race. Man is one of most variable tool-making animals, and each man is a distinct individual, differing in greater or lesser degree from each of his fellows. But just as all men have sufficient general resemblance to be classified as human, to a lesser degree, certain groups of man have enough characteristics in common to be classed, somewhat arbitrarily, as races.

In the opinion of Kroeber, 'A race is a valid biological concept; a breed of genetic strain or sub-species. It is not a valid socio-cultural concept'. In the opinion of J.B. Birdsell, 'A race is an interbreeding group whose gene pool is different from other populations.' Haddon considers 'Race as a biological breed based on a combination of physical traits which are transmitted.'

Ethnic Group

An ethnic group is a distinct category of the population in a larger society whose culture is usually different from that of the society. The members of such a group are, or feel themselves, or are sought to be, bound together by common ties of race or nationality or culture. In other words, a group of people having common racial, religious, linguistic, or national characteristics is known as an ethnic group.

The cultural elements, i.e. language, religion, faith, belief, nationality, customs, and traditions that have been passed on from one generation to another are of paramount importance in the division of mankind. In fact, division of mankind can be most accurate and precise when based on ways of living and thinking.

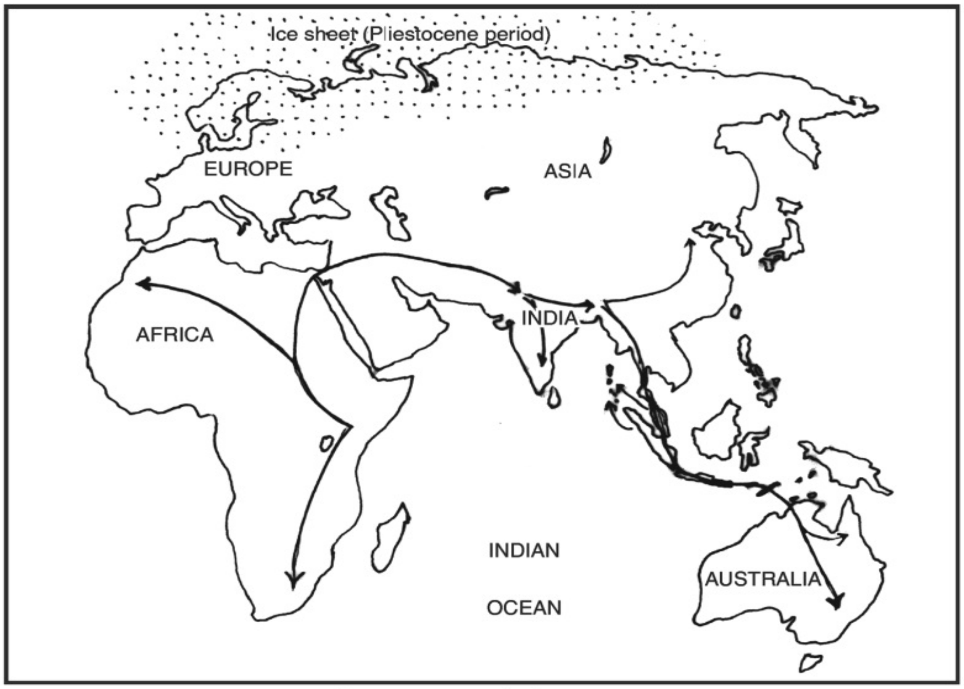

Fig. 13.1 Dispersal of Homosapiens

HISTORICAL PERSPECTIVE OF INDIAN SOCIETY

Indian society is one of the oldest in the world. India's social structure and cultrural pattern are characterised by unity as well as diversity. Historically, India has been hospitable to numerous groups of immigrants from different parts of Asia, Africa, and Europe, but the culture of each group has undergone enough change over the centuries to become an integral part of the Indian mosaic. The institution of caste may be mentioned as a typical example of the paradox that is Indian society. Each caste stands for a way of life that is to some extent distinctive, but at the same time the castes of a region form part of a single social framework. It is important to note that caste is found not only among the Hindus but also among Muslims, Christians, Jews, Sikhs, Buddhists, and Jains. Caste is ubiquitous, and this has resulted in an ideology tolerant of diversity.

Factors making for diversity are apparent even to the casual observer. The population of India is racially and ethnically diverse, containing elements from six main racial types: (i) Negrito, (ii) the Proto-Australoid, (iii) the Mongoloid, (iv) the Mediterranean, (v) the Western Brachycephals, and (vi) the Nordic. All the great religions of the world are represented in this country. The tribal groups enjoy varying degrees of contact with one or the other of the great religions. The major literary languages alone number fourteen. Diversity is seen in the patterns of rural as well as urban settlements, community life, forms of land tenure, and agricultural operations. In kinship, marriage rites and customs, inheritance, and general mode of living, there are striking differences between groups.

Diversity is, however, only one side of the picture. There are underlying factors as well. India is a political entity, every part of which is under the same constitution. The process of unification developed as several great rulers—Asoka, Samudragupta, Akbar—brought large parts of the country under their power; but it was only during the British rule that India became for the first time a single political entity.

The concept of unity of India is inherent in Hinduism. There are sacred centres of Hindu pilgrimage in every corner of the country. India is a sacred land not only of the Hindus but also of Sikhs, Jains, and Buddhists. The Muslims and Christians too, have several sacred centres of pilgrimage in India. The institution of caste cuts across diverse religious groups and gives them all common social idiom.

The declaration of India as a Secular state provides one more evidence of the tolerance of diversity which has been characteristic of Indian history from its beginning. The process of economic development ushered in the Five-Year Plans and the spread of egalitarian ideals have brought about revolutionary changes in the Indian pattern of social life. A single government and a common body of civil and criminal law, a developing economy, and a secular approach to public life and problems are now providing substance and reality to India's claim to be a nation.

THE CASTE SYSTEM

The first literary traces of the caste system are to be found in the Rig Veda, where three groups are mentioned: *Brahma* (priests), *Ksatra* (kings and rulers), and *Vis* (common people). The *Purusasukta hymn*, however, mentions of four classes originating from four parts of the body of the Creator (God). These four classes—*Brahmana*, *Rajanya*, *Vaisya*, and *Sudra*—are referred to in later literature as *Chaturvarna*.

The post-Vedic period saw the growth and consolidation of the power of Brahmins. Brahmin writers continually discussed and defined the duties and rights of each caste amidst its place in the hierarchy. Justifications and rationalisations of the hierarchy were also produced during this period. In the *Bhagavad Gita*, for instance, the caste system is sought to be justified on the basis of the ideas of *Guna*, *Karma*, and *Dharma*.

The 6th century BC. saw the rise of Buddhism, which is believed to have questioned the basis of the caste system itself. Some scholars, however, have said that Buddhism on its social and political side was chiefly a *Ksatriya* movement against Brahmanical supremacy.

The Bhakti Movement with its long history contained elements which ran counter to caste ideology. The Bhakti saints came from all castes, including Harijans. The movement was more or less continuous in Indian history, and it spread right across the subcontinent. The movement attracted converts from all castes including Harijans. The followers of Kabir (Kabirpanthi) also became a caste. Caste even survived conversion to Christianity and Islam. During the last century, there came into existence the Arya Samaj in the Punjab and Brahmo Samaj in Bengal. These movements, as well as the Ramakrishna Mission, represented a shift towards the liberalisation of castes.

Main Features of Castes

The main features of caste prevailing through the past centuries may be described under nine heads: hierarchy, endogamy, and hypergamy; occupational association; distinction in custom, dress, and speech; pollution; ritual, other privileges, and disabilities; and caste organisation and caste mobility.

Caste and Village Community

The caste living in a village or a group of neighbouring villages, are bound together by economic ties. Generally peasant castes are numerically predominant in villages and they need carpenter, blacksmith, barber, water-man, watch-man, washer-man and leather worker castes to perform agricultural work. Servicing castes such as priest (Brahmin as well as non- Brahmin), barber, washerman, and water carrier cater to the needs of everyone except Harijans. Artisan castes produce goods which are wanted by everyone. Most Indian villages do not have more than a few of the essential castes and depend on neighbouring villages for certain services, skills, and goods.

In rural India, with its largely subsistent economy, the relationship between the different caste groups in a village takes a particular form. The essential artisan and servicing castes are paid annually in grain at harvest. In some parts of India, the artisan and servicing castes are also provided with free food, clothing, fodder, and residential site. On such occasions as birth, marriage, and death, these castes perform extra duties for which they are paid a customary sum of money and some gifts in kind. This type of relationship is found all over India and is called by different names: *Jajmani* in the North, *Mirasi* in Madras, *Bara Balute* in Maharashtra, and *Adade* in Mysore. The relationship between the *Jajman* and his *Kamin* is unequal, since the latter is regarded as inferior. The right to serve is hereditary, transferable, saleable, mortgageable, and partible.

The Jajmani system bound together the different castes living in a village or a group of neighbouring villages. The caste-wise division of labour and the consequent linking up of different castes in enduring and pervasive relationships provided a pattern of alliances which cut across the ties of caste. The modern 'caste problem' is to some extent the result of the weakening, in the last sixty years or more, of these vertical and local ties and consequent strengthening of horizontal ties over whole area.

The relationship between landowner and tenant, master and servant, creditor and debtor, may all be subsumed under a single category—patron and client. This relationship is widespread and crucial to the understanding of rural India. Voting at elections, local and general, is influenced by the patron-client tie.

Ritual occasions like life-cycle ceremonies, festivals and fairs, require the co-operation of several castes. Certain rituals which are common for all the castes occur at birth, girls puberty, marriage, and death.Several castes are also required to cooperate in the performance of calender, festivals, and festivals of village deities.

The functioning of the village as a political and social entity brought together members from different castes. Every village had a headman usually belonging to the dominant caste. The accountant was always Brahmin in South India. Every village had a watchman and messengers. In the irrigated areas, there was always a man to look after and regulate the flow of water in the canals feeding the fields. The headman and accountant collected the land taxes with the aid of Harijan village servants.

The village council performed a variety of tasks, including the maintenance of law and order, settling of disputes, celebrations of festivals and construction of roads, bridges, and tanks.

of race is visible. In the opinion of Prof. Aijazuddin Ahmad, "Those who managed to drift into the isolated and remote parts of the subcontinent could preserve their original ethnic traits which remained by and large unaffected by the fresh waves of incursions witnessed along the main corridor of movement connecting the Kabul Valley with the North Indian Plain". The Indian population has been classified by a number of scholars. Some of the important classifications are as follows:

Risley's Classification of Indian Races

Sir Herbert Risley, the Census Superintendent of India, 1901, made a pioneering effort and classified the Indian races into seven groups as follows:

1. Indo-Aryans

The Indo-Aryan tribes migrated into India from Central Asia. They are presently found in Jammu and Kashmir, Punjab, Haryana, Himachal Pradesh, Uttar Pradesh, Uttarakhand and Rajasthan. Their main physical traits are tall stature, fair complexion, long arms, broad shoulders and heavy to slim bodies. Their representative communities are the Rajputs, Khatris, and the Jats of northern India.

2. Dravidians

They are found particularly in South India (Andhra Pradesh, Karnataka, Kerala and Tamil Nadu), Chhattisgarh, Jharkhand, southern Madhya Pradesh, Odisha, and southern Rajasthan. Their representatives are the Santhals of Chotanagpur Plateau, the Todas of Nilgiri, the Juangs of Odisha, the Gonds of Bastar, and the Bhils of Rajasthan. They were probably the ancient people of India, but have been influenced by the admixture of Aryans, the Scythians (Ukrainians) and Mongoloid people. They are characterised by short stature, dark complexion, hairy bodies, curly hair, long heads, and broad nose.

3. The Mongoloids

They are found in the Himalayan and sub-Himalayan regions stretching from Ladakh (Jammu and Kashmir) to Sikkim, Arunachal Pradesh and the Hill states of North East India. They are of short stature, yellow in complexion, have medium broad nose, flat face, and oblique eyes with an epicanthic fold. Their representatives are the Kinnets of Lahul-Spiti and Kullu, the Lepchas, and Bhutias of Sikkim, and the Tharus of the Tarai region of Uttar Pradesh and Uttarakhand.

4. Aryo-Dravidian

It is an amalgamation of the Aryans and the Dravidians. This group is found in parts of Rajasthan, Uttar Pradesh and Bihar. Their elements are present in both the lower and the upper castes of Brahmins and the Scheduled Castes. Their complexion varies from light brown to black and they have long head, short stature, and medium to broad nose.

5. The Mongolo-Dravidians

They are an intermixture of the Mongoloids and the Dravidians. They are mostly found in West Bengal and Odisha (Brahmins and Kayastha). Their characteristics include broad head, dark complexion, flat nose, short to medium stature, and plentiful hair on face.

6. The Scytho-Dravidians

They are an admixture of the Scythians and the Dravidians. Some of the anthropologists hold that the Sakas belong to the Scythian race which came to India from Central Asia. They settled in the

Sind Province of Pakistan, Gujarat, Maharashtra, Karnataka, Rajasthan, and Uttar Pradesh. The Scythian features are pronounced in higher castes, while the Dravidian features are associated with the lower strata of society. The Marathas are considered to be the representatives of the Scythian-Dravidian race. Their main features are low stature, long head, moderate nose, light brown to fair complexion, and scanty body hair.

7. The Turko-Iranian

They are found in Baluchistan and Afghanistan. Their representatives are the Pathans who are found in some parts of north-west India as a minority group. They are well built, tall statured, with fair complexion, long head, and moderate to narrow nose.

Risley's classification of Indian races is largely based on languages rather than on physical traits. It does not recognise the Negrito element in Indian population which has been duly recognised by J.H. Hutton, A.C. Haddon and B.S. Guha.

Huttons's Classification

J.H. Hutton has also based his racial classification of India on the Census findings. However, he does not recognise India as the cradle land of humanity and holds that all the races of India are constituted by foreign immigrants. On the basis of chronological order, he has recognised the following seven races in India:

1. The Negritoes

In the opinion of Hutton, the Negritoes were the oldest inhabitants of India, but have left virtually no trace on the main land of the subcontinent. Some of the representatives of the Negritoes are found in Andaman and Nicobar Islands and among some of the Nagas.

2. The Proto-Australoids

They came in large numbers and spread in different parts of the country. Their representatives are found in the aboriginal peoples of India.

3. The Early Mediterraneans

The Early Mediterraneans reached South India where their representatives are still found in Karnataka and Tamil Nadu. They are also found in the tribal belt stretching from Gujarat to West Bengal. They have medium stature, brown to black complexion, and slight built.

4. The Advanced Mediterranean

They are the early Dravidian people who were associated with the Indus Valley Civilisation. They were the Pre-Aryan people who mingled with the Aryans. They were taller and fairer than the Early Mediterraneans. They spread over Punjab, Haryana, Uttar Pradesh, and Bihar.

5. The Alpines or the Pre-Vedic Aryans

The Pre-Vedic Aryans are found in both Gujarat and West Bengal.

6. The Nordics or the Vedic Aryans

They came to India during the second millennium BC. Their elements are found in Jammu and Kashmir, Punjab, Haryana, Rajasthan, and western Uttar Pradesh among the higher castes. Their main physical traits are fair complexion, tall stature, and sharp nose.

1. The Negritoes

Most probably, the Negritoes were the earliest arrivals in India. These are characterised by short stature (150 cm), frizzy-hair, bulbous forehead, flat nose, slightly protruding jaws, small chin, black skin colour, weak hands, and long arms. Their representatives are the Andamanese, Nicobaris, and the Irulas, Kadars, Kanikkars, Muthaiwans, Paniyans, Puliyans, Uralis living in the hills of Tamil Nadu, Kerala, and Karnataka. The Angami-Nagas have also been considered as having some of the traits of the Negritoes. Their arrival in the Andaman and Nicobar Islands (Jarawa, Ongs, Sentinelese, Shompen, etc.) is believed to be from the Peninsula of Malaysia. In appearance, culture, and traditions, they are very close to the Semangs and Sakais tribes of Malaysian Peninsula.

2. Proto-Australoids

After the Negritoes, the Proto-Australoids entered the Subcontinent of India, most probably from Australia. Their representatives are found among the Bhils, Chenchus, Hos, Kurumbas, Mundas, Santhals, and Yeruvas. Their common physical traits are dark brown to black-brown complexion, broad nose, wavy to curly hair, short stature, and thick everted lips.

3. Mongoloids

The Mongoloids reached India from China, Mongolia, Tibet, Malyasia, Thailand, and Myanmar in about the first millennium BC. They occupied the Ladakh Division of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, the Himalayan and sub-Himalayan belts, and the North Eastern states of India.

Dr. B.S. Guha has recognised two sub-groups of Mongoloids: (a) Palaeo-Mongoloid and (b) Tibeto-Mongoloid. The Palaeo–Mongoloid are the most primitive type which have long heads, medium stature, light brown colour, medium nose, oblique eyes, and scanty hair on body. Their representatives are found in the sub-Himalayan region, particularly Arunachal Pradesh, Assam, and Indo-Myanmar (Burma) border districts. Their representatives are Daflas, Garos, Kacharis, Khasis, Kuki-Nagas, Lalung, Machi, Miris, and Tipperas.

The Tibeto-Mongoloids are found in Bhutan, Himachal Pradesh, Ladakh, Nepal, Sikkim, and Uttarakhand. Their typical features are long stature, light yellow colour, hairy body, oblique eyes, long nose, and flat face. The Bhutias, the Gorkhas, the Ladakhis, the Kinnauris, the Tharus are the representatives of the Tibeto-Mongolid racial group.

4. The Mediterraneans

They came to India in successive waves from the Mediterranean region. Dr. Guha has identified three sub-groups of the Mediterraneans, namely, (i) Palaeo-Mediterranean, (ii) Mediterranean, and (iii) Oriental Type.

(i) Palaeo-Mediterraneans The oldest group is the Palaeo-Mediterranean. They are characterized by medium stature, long and narrow head, long face, short and medium nose, and brown complexion. Perhaps they entered the subcontinent during the Neolithic Period and were pushed into the area south of the Vindhyan Mountains in areas of isolation and relative isolation.

(ii) The Mediterraneans The Mediterraneans have medium stature, olive brown complexion, long head and long-broad open eyes. They are found in Haryana, Punjab, Uttar Pradesh, Maharashtra, and Kerala.

The distribution of each of the minorities in the country is highly unequal. For example, the Muslims constitute 5 to 25% of the population in most of the states except Arunachal Pradesh (1.9%), Chhattisgarh (2.0%), Himachal Pradesh (2.0%), Mizoram (1.1%) and Nagaland (1.8%). The overall percentage of population of Muslims is 13.4 per cent (2001). The literacy level and per capita income of the Muslims is much below the national average. Most of them are below the poverty line.

Christians constitute about 2.3 per cent of the total population of the country. Their percentage, however, is significantly high in Nagaland (90%), Mizoram (87%), Meghalaya (70%) and Goa (27%). Their density, however, is insignificant in the states of north and west India.

Sikh minority is largely confined to Punjab (60%), Haryana (5.5%), and Uttarakhand (2.5%). Their presence is small in the greater parts of the country. The Sikhs are progressive, hardworking and forward-looking people, who perform superbly in all spheres of life. The proportion of Budhists in the total population of the country is only 0.8 per cent—Sikkim (28%) and Arunachal Pradesh with a density of 13 per cent have the largest concentration followed by Mizoram (8%) and Maharashtra (6%). The Parsis are confined to the cities of Mumbai, Navsari, Udvada, Surat and Ahmedabad. Essentially Parsis are industrialists and businessmen.

For the development of minorities, Rs. 1000 crore have been earmarked. For the development of education of minorities, three scholarships have been launched, with a total provision of Rs. 305 crore in 2008–09. The issues of education, skill development, employment, sanitation, housing, drinking waters, etc., in the minority concentration districts have been addressed. The corpus of Maulana Azad Education Foundation (MAEF) has been enhanced significantly. Several self-employment schemes have been financed. Numerous other economic ventures among backward sections of the minority community have been designed and implemented.

SCHEDULED TRIBES

The tribal people of India, who come under the category of 'Scheduled Tribes' in term of the provisions of the Constitution of India, number 84.3 million, constituting about 8.20 per cent of the population of the country (Census 2001). According to the Census 1961, there were 365 Scheduled Tribes. Their number has however, gone up as some new ethnic groups have also been included in the category of Scheduled Tribes. At present, there are more than 425 Scheduled Tribes in the country. Many more ethnic groups and communities have applied to the government for being included into the list of Scheduled Tribes.

The Scheduled Tribes of India belong to the differential racial, ethnic, linguistic and religious groups. They are mostly occupying the areas of isolation and relative isolation in the hilly and forested areas.

The Scheduled Tribes comprise the indigenous people. They have often been termed as the people of the *'Fourth World'*. The Scheduled Tribes are the people who cherish their own culture. They are the victims of past and present colonialism. They have maintained a close relationship with land. In their societies, there exists a co-operative attitude of give and take, a respect for the earth and life it supports. Their philosophy of life is: '*From everybody according to his capacity, to everyone according to his needs.*'

In terms of percentage and absolute population, the population of Scheduled Tribes is highly unevenly distributed. Their main areas of concentration of tribals are, however, in three regions as given in **Table 13.2.** The main concentration of the tribal population has been shown in **Fig. 13.5.**

Table 13.2 *Main Areas of Concentration of Tribal Population*

1. The North Eastern Region (NER)	Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura.
2. The Central Tribal Belt	Andhra Pradesh, Bihar, Chhattisgarh, Dadar & Nagar Haveli, Daman and Diu, Gujarat, Jharkhand, Madhya Pradesh, Maharashtra, Odisha, Rajasthan, and West Bengal.
3. Other States and Union Territories	Andaman and Nicobar Islands, Himachal Pradesh, Jammu and Kashmir, Karnataka, Kerala, and Tamil Nadu.

Source: ***Census of India, 2001.***

The tribal communities live in about 15 per cent of the country's area in varying ecological and geo-climatic conditions; mountains, hills, forests, plains and inaccessible areas. They have their presence in almost all the states and Union Territories of the country except Chandigarh, Goa, Delhi, Haryana, and Punjab (**Fig. 13.6**).

An interesting feature of the tribal population is that it is growing at a faster pace. The temporal change in the growth of population has been shown in **Table 13.3**.

It may be observed from **Table 13.3** that the total population of the Scheduled Tribes in 1951 was only 225 lakhs accounting for 6.23 per cent of the total population of India. Their growth rate is however, higher than the national average. Consequently, in 2001 the tribal population became 843 lakhs or 8.20 per cent of the total population of the country. The lower standard of living of over 95 per cent of the tribal population may be the main cause of their high birth and high growth rate. The higher growth rate of the tribal population is also because of the inclusion of new tribes in the list of Scheduled Tribes.

According to the Census of 2001, about 87 per cent of the main workers from these communities were engaged in primary activities. A majority of Scheduled Tribes continue to live below the poverty line. They have poor literacy rates, suffer from malnutrition, undernourishment, water-borne diseases, and are vulnerable to displacement.

The Central and the State Governments have been implementing schemes/programmes, Centrally Sponsored Schemes, etc. However, a lot more is required to be done to achieve the desired developmental goals for Scheduled Tribes.

Table 13.3 *India: Growth of Scheduled Tribe Population, 1951–2001*

Year	*Total Population of Scheduled Tribes in Lakhs*	*Percentage of Scheduled Tribes to Total Population*
1951	22.5	6.23
1961	302	6.87
1971	380	6.94
1981	538	6.94
1991	678	8.08
2001	843	8.20

Source: ***Census of India, 2001***.

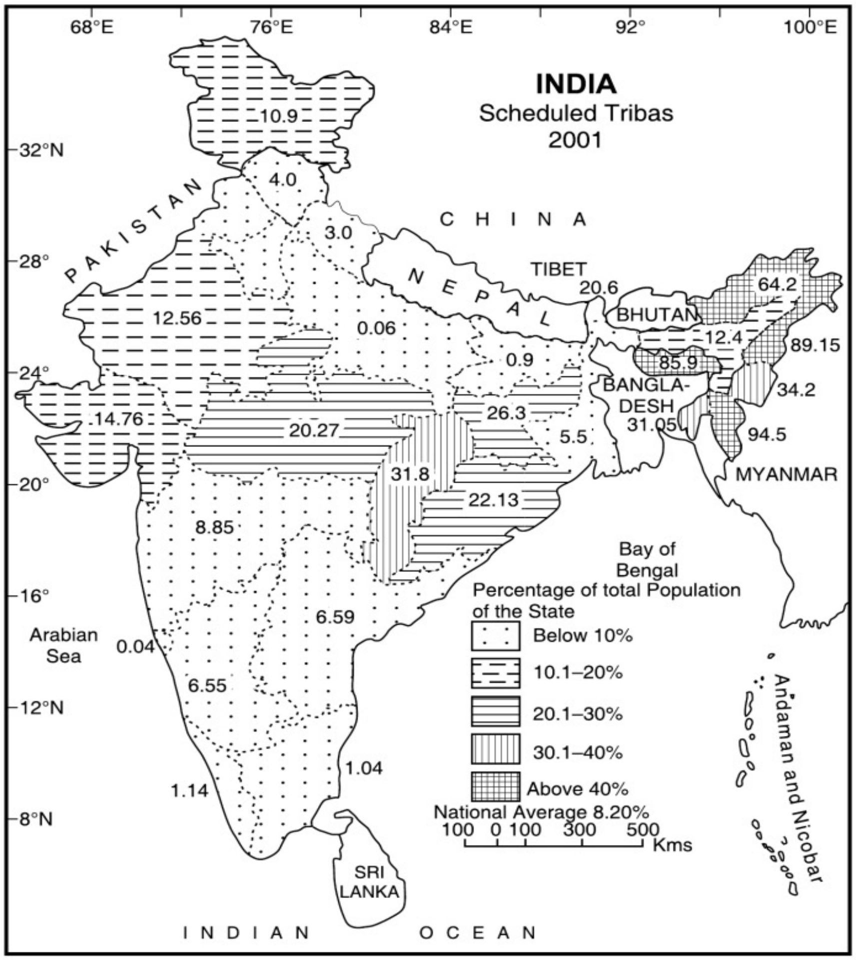

Fig. 13.5 Density of Scheduled Tribes, 2001

The Main Scheduled Tribes

The number of Scheduled Tribes in India is quite large. Some of the main tribes of India are as under:

1. North East India

Bodo, Kachari Miri, Xaxa (Assam), Angami, Ao, Chang, Konyaks, Kuki, Lotha, Mikir, Sema (Nagaland), Apatani, Dafla, Mishmi (Arunachal Pradesh), Garo, Khasi, Jaintia (Meghalaya), Lushai (Mizoram), Bhutia, Lepcha, Serpa (Sikkim), Chakmas and Orang (Tripura).

2. Bihar, Jharkhand, and West Bengal

Asur, Birja, Birhor, Bhuiya, Gond, Ho, Khaira, Maler, Malpaharia, Munda, Oraon, Pakiha Pantaram, and Santhal.

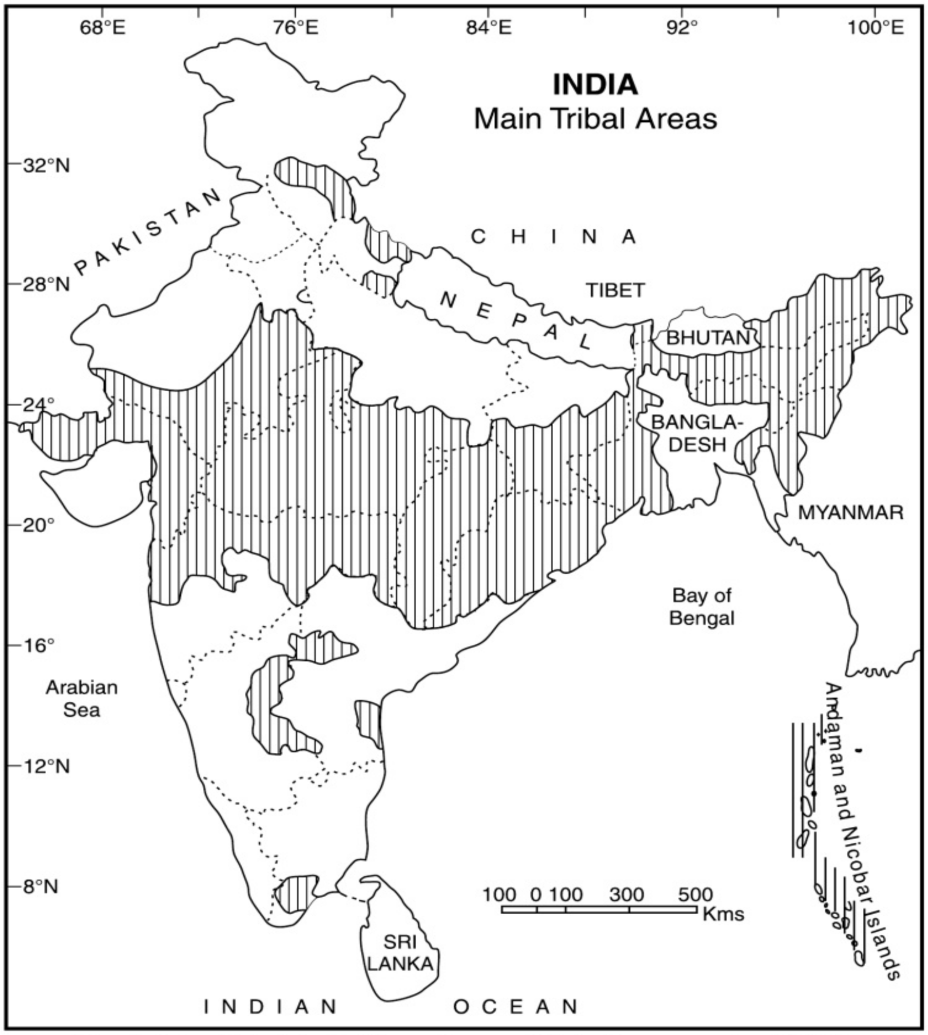

Fig. 13.6 Scheduled Tribes—Areas of Main Concentration (2001)

3. Andhra Pradesh, Chhattisgarh, Madhya Pradesh, and Maharashtra

Akha, Bhil, Bhilara, Chenchu, Dabla, Dandami, Gadaba, Godwa, Gond, Kol, Kadar, Ketkari, Kotku, Koya, Korva, Maler, Mariya, Mauriya, Lambadi, Paradh, Paliyan, Pariya, Rajgond, Todia, Turi, Yaruba, and Yendi.

4. Odisha and Tamil Nadu

Bagda, Birhor, Khond, Gond, Juang, Kanikkar, Kol, Lambadi, Munda, Santhal, Savara, etc.

5. Gujarat

Bhil, Bhila, Dafar, Dhanka, Garsaya, Dubala, Koli, Patelia, Raibari, Todia, Varali, etc.

6. Rajasthan

Bherat, Bhil, Bhila, Dhanka, Garasiya, Meena, Mira, Rawat, Saha, Sahariya, etc.

7. Kerala

Arandan, Chenchu, Gadaba, Irula, Kadar, Kochu, Malapandaram, Malkurvan, Mallayan, Muthuwan, Paniyan, Paniyan, Sholiga, Sumali, Toda, Yurali, etc.

8. Uttar Pradesh and Uttarakhand

Badkol, Bhotiya, Bhoksa, Bhuiya, Chero, Jaunsaries/Khasa (Chakrata Tehsil, Dehra Dun), Khoha, Manhi, Raji, Tharu, Viyar, etc.

9. Himachal Pradesh and Jammu and Kashmir

Bholia, Bakkarwal, Gujjar, Gaddi, Kinnar, Laholi, Laddakhi, Pangwal, etc.

10. Andaman and Nicobar Islands

Andamani, Aong, Jarawa, Nicobarese, Onges Sentinelese, Shompen, etc.

Economy

The Scheduled Tribes are essentially dependent on hunting, food-gathering, fishing, shifting cultivation, lumbering, sedentary agriculture, and animal husbandry.

1. Hunting, Fishing, and Food Gathering

The main tribes which are dependent on these economic activities are Chenchu and Yanadi in Andhra Pradesh; Hill-Maria in Chhattisgarh; Bhil, Garasia in Gujarat and Maharashtra; Bhil, Garasia, and Sahariya in Rajasthan; Birgias, Birhor, Kharia, Korwa, Pariha in Jharkhand; Ao, Angami, Changs, Konyak, Kuki, Lotha, Mikir, Sema in Nagaland; Juang in Odisha; Kadar, Koya, Paliyan, Reddi in Tamil Nadu and Raji in Uttar Pradesh.

2. Shifting Cultivation

Bagola, Khond, Kurumba, Saora in Andhra Pradesh; Bhil and Garasia in Gujarat and Madhya Pradesh; Asur, Korwa in Jharkhand; Kathodia in Rajasthan; Baiga, Dhora and Gond in Chhattisgarh and Madhya Pradesh; Chakmas (Tripura), Garo, Khasi, Jaintia, Lushai, Nagas in North Eastern Hill States; Gond, Khond, Kurumba, and Muduwan in Tamil Nadu; Bhutias, Korias, Kharwar and Saharia in Uttar Pradesh and Uttarakhand practice shifting cultivation.

3. Sedentary Cultivation and Animal Husbandry

Badaga, Kota, Koya, Irula in Andhra Pradesh; Baija, Bhatra, Gond, and Parja in Chhattisgarh and Madhya Pradesh; Bhil, Barali, Dubla, Koli, Raiwari in Gujarat and Maharashtra; Bhila, Ho, Korwa, Munda, Oraon, Tamaria and Santhali in Jharkhand; Bhil, Garasiya and Meena in Rajasthan; Badaga, Irula, Malydi and Praga in Tamil Nadu; Bhoksa, Bhotias, Khasa, Kol, and Tharus in Uttar Pradesh and Uttarakhand; Bhumji, Polia and Santhali in Bihar, Jharkhand, West Bengal are engaged in sedentary cultivation and animal husbandry.

Polygamous Tribes—Baiga, Gond (Chhattisgarh, M.P.), Lushai (Mizoram), Mon (Nagaland), Toda (Kerala, Tamil-Nadu).

Polyandrous Tribas—Kota, Khasa, Jaunsari (U.P., Uttarakhand), Ladakhi, Bota (Ladakh), Nayar and Todas (Kerala, Tamil-Nadu).

Tribal Development

The human development of the Scheduled Tribes of India is quite low. Most of them are living below the poverty line. The Central and the state governments have taken a number of measures over the years to improve the condition of Scheduled Tribes and for their development.

The Tribal Sub-Plan (TSP)

The innovative strategy of the Tribal Sub-Plan (TSP) for Scheduled Tribes was launched during 1974. This special strategy was expected to ensure that all the general development sectors earmark funds for Scheduled Tribes in proportion to their population so that adequate benefits from all the concerned sectors flow to this disadvantaged group. The Tribal Sub-Plan strategy has been extended to the following states and Union Territories:

1. Andhra Pradesh, 2. Assam, 3. Bihar, 4. Chhattisgarh, 5. Gujarat. 6. Himachal Pradesh, 7. Jammu and Kashmir, 8. Jharkhand, 9. Karnataka, 10. Kerala, 11. Madhya Pradesh, 12. Maharashtra, 13. Manipur, 14. Odisha, 15. Rajasthan, 16. Sikkim, 17. Tamil Nadu, 18. Tripura, 19. Uttar Pradesh, 20. Uttarakhand, 21. West Bengal, 22. Andaman and Nicobar, and 23. Daman and Diu.

The ultimate objective of extending the Tribal Sub-Plan is to boost the demand based income generation programmes, and thus raise the economic and social status of tribals in the sectors of agriculture, horticulture, land reforms, watershed development, soil moisture conservation, animal husbandry, ecology and environment, development of forests/forest villages, and development of entrepreneurship.

The main focus of the Tribal Sub-Plan is to make an integrated development effort to develop their agriculture, animal husbandry, irrigation, forestry, education, health, and employment. There is emphasis on preparing a broad policy framework for tribal development and defining a suitable administrative strategy for its implementation.

In addition to these, the Central Ministers/Departments have to take the following steps for the socioeconomic development of the Scheduled Tribes:

(a) to formulate appropriate need-based programmes for tribal areas;
(b) suitably adapt the ongoing programmes to the specific requirements of Scheduled Tribes.
(c) provide sufficient quantity of funds for tribal areas under Central Ministries programmes; and
(d) earmarking of senior officer dedicated exclusively for the welfare of Scheduled Tribes.

The Tribal Research Institutes

The Tribal Research Institutes are engaged in the work of providing planning inputs to the State Governments, collection of data and conducting research and evaluation studies on problems relating to the tribes living in respective states. The Tribal Research Institutes also conduct training, coaching,

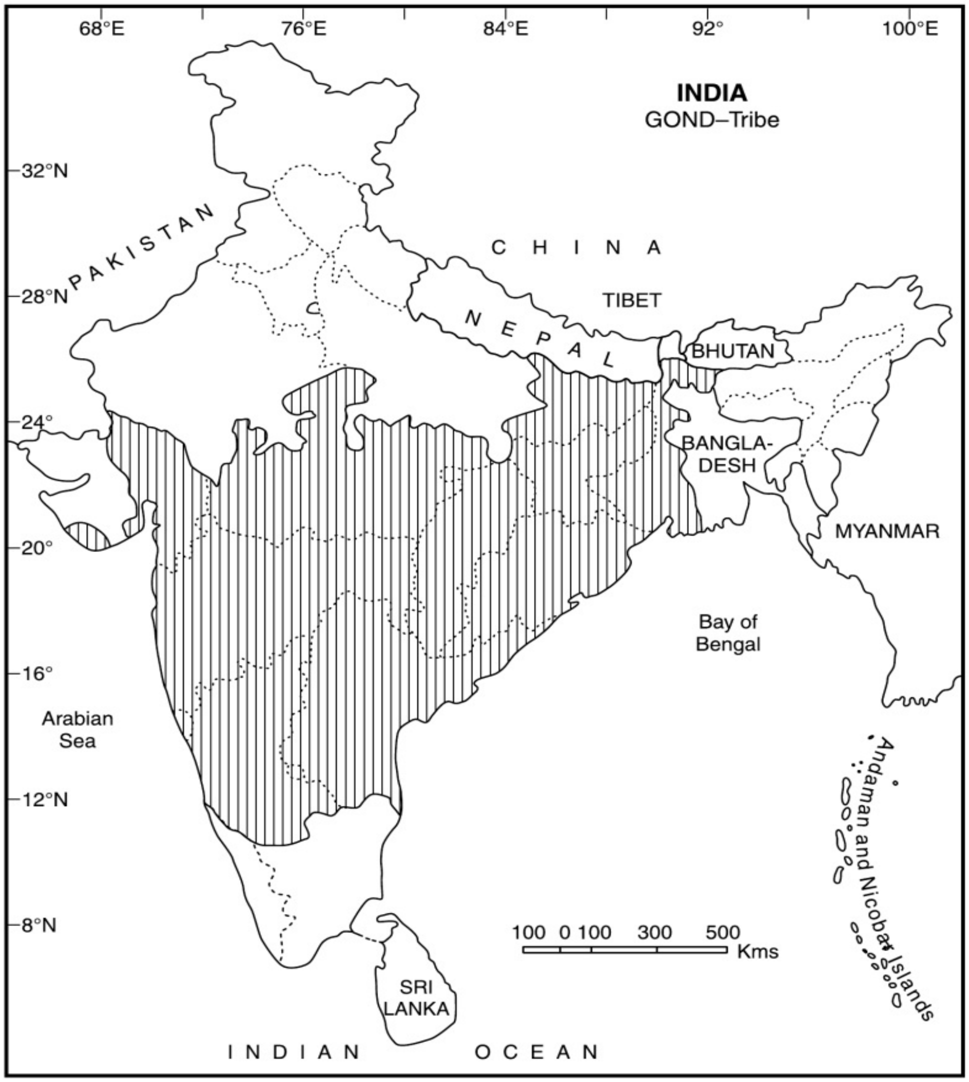

Fig. 13.7 Distribution of Gonds (2001)

The Bhils

The total population of Bhils is over six million (2001). They are distributed over a vast territory extending from Rajasthan, Madhya Pradesh, Chhattisgarh,Gujarat, Maharashtra, Andhra Pradesh, and Karnataka (**Fig. 13.8**).

The habitat of the Bhils is characterised by varied terrain features of plains, hills, plateaus and forested areas. They are generally living in the areas of isolation and relative isolation.

and guidance seminars and workshops for the cause of tribal development. At present, there are 16 Tribal Research Institutes in the country situated in different states.

The respective state governments have constructed Girls Hostels, Boys Hostels, Ashram Schools, Vocational Training in Tribal Areas, Post-Matric Scholarship for Scheduled Tribes Students, National Overseas Scholarships for Scheduled Tribes Students (Non-Plan). In addition to these, the National Scheduled Tribes Finance and Development Corporation, and Tribal Co-operative Marketing Development of India are providing useful service and relief to the Scheduled Tribes.

The National Tribal Policy

The Ministry of Tribal Affairs has formulated the draft of a National Tribal Policy covering various issues such as alienation of tribal land, tribal forest interface; displacement; rehabilitation and resettlement; enhancement of human development index; creating critical infrastructure; violent manifestations; conservation and development of particularly vulnerable tribal groups; adoption of Tribal Sub-Plan strategy; empowerment; gender equality; enlisting support of non-government organisations, tribal culture and traditional knowledge; administration of tribal areas; the Regularity and Protective Regime; scheduling and descheduling of tribes, etc. The Ministry has received an enthusiastic response from the various stakeholders and it is in the process of examining of the same and hopes to finalise the draft National Tribal Policy at the earliest.

Some Important Tribes of India

A brief description of some of the important tribes of India has been given in the following:

The Gonds

The Gonds with a population of about 8 million constitute the largest tribal group of India. The spatial distribution of Gonds has been shown in **Fig. 13.7** They are spread over Chhattisgarh, Jharkhand, Madhya Pradesh, Andhra Pradesh, Karnataka, Gujarat, Maharashtra, Bihar, and West Bengal. Their main concentration is in forest and hilly areas between the Vidhyans and Satpura. Their physical traits are dark complexion, flat nose, thick lips, straight hair, and short stature. Their language is Gondi which belongs to the Austric family. They live in small villages of 20–30 families and build their houses along the east west street on both sides. Most of them are agricultural labourers or marginal sedentary farmers. Some of them like Dhimar and Kewats are dependent on fishing, while the Rawats are cattle keepers.

The Gonds maintain Ghotals (youth-house). They practice and participate in music and dance. They also provide security to the village in the night. It is like a club, where both unmarried boys and girls sleep in separate apartments at night and carry on love affairs which culminate in matrimonial relationship. Such affairs are kept secret till their marriage materialises. But it is common knowledge that hardly any girl remains virgin before she is locked in nuptial bond. In fact, the pre-marital sex relations are condoned by the community, but after marriage, sexual fidelity is strictly observed by both husband and wife. They practice endogamous marriage. Polygamy is also in use. Divorce is quite common. They believe in the animistic religion and worship their family deity.

The Gonds are hard working, honest and treat theft as a serious crime. They are, however, superstitious and believe in sorcery and black magic.

Among the Bhils marriage is not only universal, but also compulsory and the unmarried men and women are looked down upon by the society. There is ample freedom for marriage; boys and girls can choose their partners and later on get social approbation by the village community. However, the Thakur Bhils of Nimar do not permit such liberty and prefer prior engagement in matrimonial relations.

Divorce can be sought by either party with the consent of the village Panchayat. Child marriage is conspicuous by its absence.

Bhils are animists by nature as reflected in their folk music and art. They believe in rebirth and migration of soul. They stress on good conduct for their salvation, they also believe in evil spirits, ghosts and black magic. The services of Badva (magician) are sought for riddance from disease. They also believe in superstitions. The ladies do a lot of tatooning. They decorate the walls of houses with folk pictorial designs/sketches. They take great interest in dance and music and arrange *Nautanki* for community celebrations.

The society is basically patriarchal. The families have great reverence for gods and goddesses. They also believe in Hindu gods like Hanuman, Ram, and Shiva besides,'Baba Deo' and 'Ghata Deo'.

They generally live in small hamlets and construct their houses with bamboos. The Bhils make pretentious houses and take care in their maintenance for nuclear families.

The Santhals

Having a population of over 6 millions, the santhals constitute one of the largest tribal groups in India. The anthropological evidence confirms their Dravidian origin which is corroborated by their Austric language (Santhali language and Col Chika script). The Santhal scholars claim that it was the santhals who had developed the Indus Valley Civilisation. The geographical distribution of the Santhals has been shown in **Fig. 13.9.**

It may be seen from Fig. 13.9 that their present habitat is mainly in the Rajmahal Hills and Chotanagpur Plateau in the state of Bihar, Jharkhand, Odisha, and West Bengal. Tripura also has the Santhal Tribes and they can also be found working in tea gardens of Assam and West Bengal. They are a dominant majority in Santhal Pargana, Giridih, Bankura, Bardhaman, and Birbhum while in more than 16 districts they have a majority. Their demographic growth is about 1.75 per cent per annum.

The Santhals are basically agriculturists (68%). They own landed property and hardly any Santhali is landless. Their subsidiary occupations include hunting, fishing, and collecting forest products. With increasing literacy and cultural contacts, they are also engaged in service, trade and contracting business. Their demand is for a Greater Jharkhand which extends over the Santhal areas in West Bengal and Odisha.

The Santhals have a great cultural heritage and have a well defined social order. Widow remarriage is permissible. The Santhal society is patriarchal. The Santhal woman is deemed a strong labour force and contributes to the family income. She participates in the agricultural operations and decorates her house before the Bandana festival.

The Santhals live in permanent settlements. The village settlement generally has a rectangular plan and houses are arranged along the main street of the village. They have their own Panchayats and a well developed penal system.

Karma is the only festival of the women in the month of Bhadon. It takes place in Manjhithan girls with music and dance with unmarried girls participating. Their other important festivals are Bandhan or Sohrai (in winter after harvest).

has a cold winter and moderately hot and humid summer. They have adopted English as the official language of Nagaland. It has helped their cultural and political unification.

Their villages are located at the top of ridges for reasons of security. They use hill slopes for terraced cultivation. Where the development of terraces is difficult, they practice shifting cultivation.

The village has a *Morung* (communal dormitory) for the bachelors, where both boys and girls stay at night. It functions as a youth club where the youths are initiated into tribal traditions and art of community living. They also receive sex education and often their pre-marital sex relations consummate in marriage with the consent of the village community.

The Nagas are by and large agriculturists (85%). They practice Jhuming (shifting cultivation). The Angami tribe around Kohima has developed beautiful terraces for paddy cultivation. They grow rice, pulses, coarse cereals, vegetables and cotton.The Nagas are known for their artistic handicrafts, particularly weaving and wood carving.

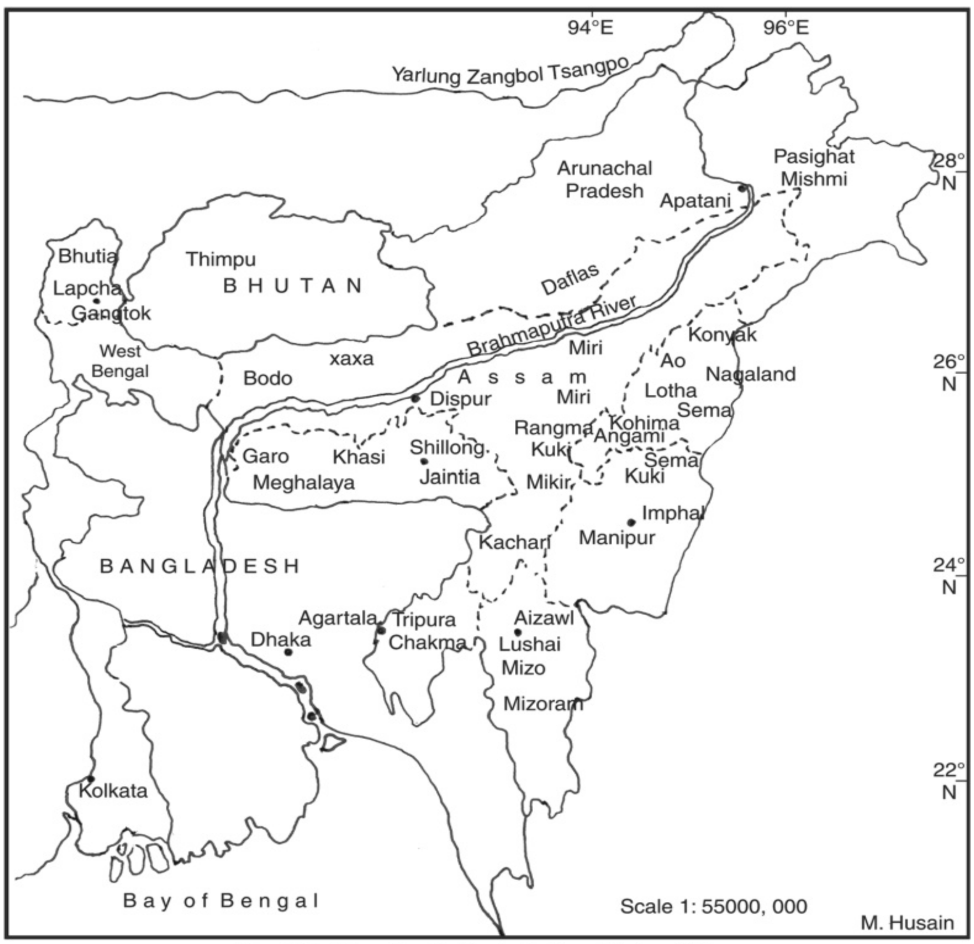

Fig. 13.10 North-East India—Major Tribes

doctrine of purity and pollution.

The anthropological evidence suggest their varied origin from an admixture of aboriginal/tribal population with the successive waves of invaders.

According to the Census 2001, the population of Scheduled Castes in India was 66,636 million accounting for 16.20 per cent of the total population, while that of the Scheduled Tribes population was 8.20 per cent. They constitute the socially and economically deprived caste group of the Indian society. They consist mainly of agricultural labourers, marginal cultivators, artisans, landless labourers, and industrial workers. They include the Malls of Andhra Pradesh, the Meghs of Gujarat, the Mahars of Maharashtra, the Adi-Davidas of Tamil Nadu, the Chamars of Uttar Pradesh and Uttarakhand, and Balais of West Bengal.

Geographical Distribution

The geographical distribution and density of the Scheduled Castes has been shown in **Fig. 13.11**. The state of Uttar Pradesh has the largest number of Scheduled Castes population, accounting for about 21 per cent of the total Scheduled Caste population of the country, followed by West Bengal (11.1%), Bihar (7.83%), Andhra Pradesh (7.4%), Tamil Nadu (7.12%), Maharashtra (5.93%), Rajasthan (5.8%) and Madhya Pradesh (5.49%). In opposition to this, the state of Nagaland, and the Union Territories of Andaman and Nicobar Islands and Lakshadweep have no Scheduled Caste population **(Fig. 13.11)**.

The highest percentage of Scheduled Caste population is found in Punjab (28.85 %), followed by Himachal Pradesh (24.72%), West Bengal (23.02%) and Uttar Pradesh (21.15 %). The states of Arunachal Pradesh, Goa, Mizoram, Meghalaya, Nagaland, Andaman, Nicobar, and Lakshadweep do not have Scheduled Caste population **(Fig. 3.11)**.

The percentage of the Scheduled Castes is low in the areas of Schedued Tribes, Muslims, and Christians dominate regions/districts. The north-eastern states of India, except Tripura have a very low percentage of the Scheduled Caste population. Similarly, the percentage of Sheduled Caste population is low where the percentage of Muslim and Christian population is high. Another important feature about the spatial distribution of the Scheduled Tribes is that they are mainly concentrated in the rural areas. Despite reservation and special programmes for their upliftment, over 90 per cent of them maintain a very poor standard of living.

Table 13.4 *Scheduled Castes: Geographical Distribution, Census 2001*

State	*Total Population ('000)*	*Scheduled Caste Population ('000)*	*Percentage of Scheduled Caste to Total Population in the State*
1. Andhra Pradesh	76,210	12,339	16.19
2. Arunachal Pradesh	1,098	6	0.56
3. Assam	26,656	1,826	6.85
4. Bihar	82,999	13,049	15.72
5. Chhattisgarh	20,834	2,419	11.61
6. Goa	1,348	24	1.77
7. Gujarat	50,671	3,593	7.09
9. Haryana	21,145	4,091	19.35

(*Contd.*)

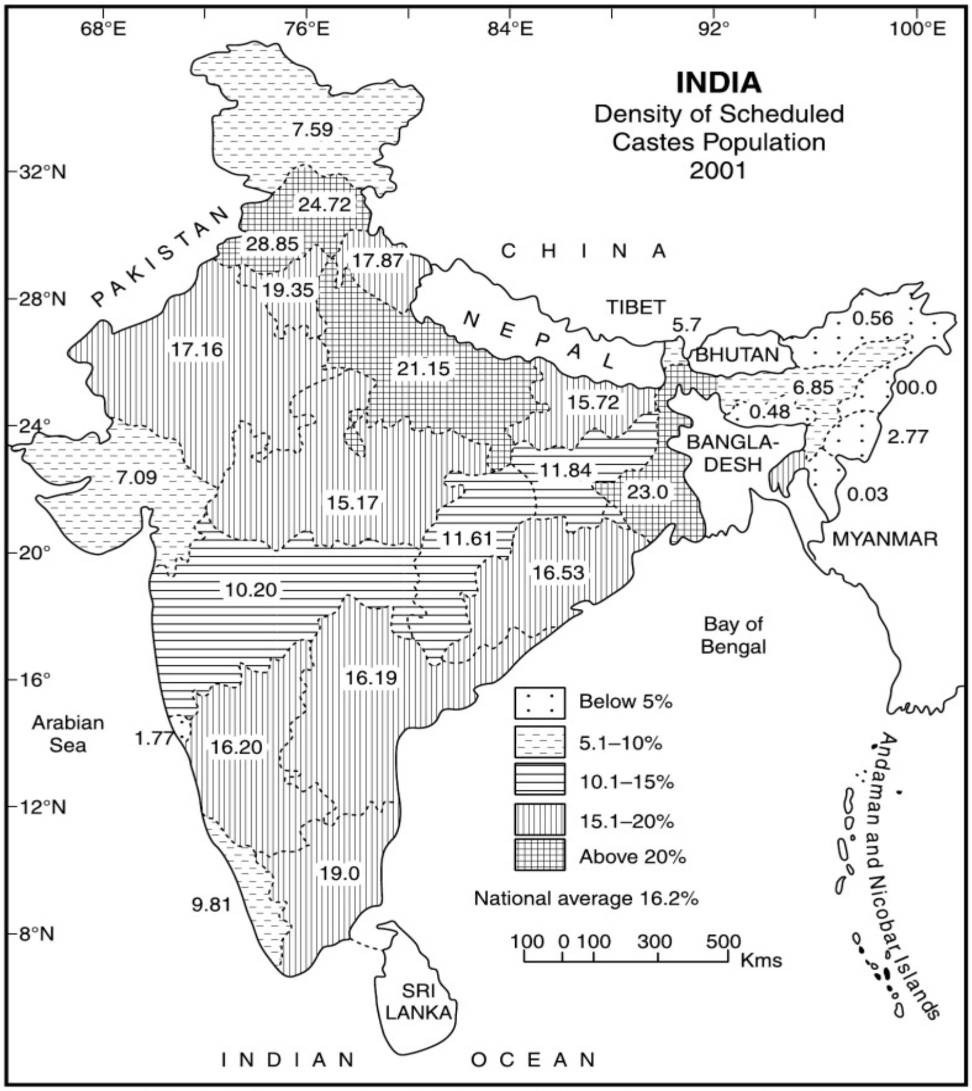

Fig. 13.11 Density of Scheduled Caste Population, 2001

(*Contd.*)

10. Himachal Pradesh	6,078	1,502	24.72
11. Jammu & Kashmir	10,144	770	7.59
12. Jharkhand	26,946	3,189	11.84
13. Karnataka	52,851	8,564	16.20

(*Contd.*)

a common heritage. The sense of cultural identity is most pronounced in a micro-region and becomes diffused in a macro-region.

Cultural Regions of India

Language, religion, customs, and traditions are some of the important elements of culture. Cultural regions may be delineated on the basis of these cultural traits.

Language as a Determinant of Cultural Region

India is a multi-ethnic, multi-lingual and multi-religious country. According to anthropologists and historians, the Indian population comprises of the people who came here from the Mediterranean region, central Asia, south-west Asia, south-east Asia, Mongolia, Tibet, and China. Each of the racial and ethnic groups has its own language. After coming to India, the cultural mixing led to the mixing of their languages also. These languages have their core and peripheral areas. This broad linguistic regional identity formed the basis for the demarcation of Indian States in 1956. According to the Census of 1961, there were 187 languages spoken by different sections of the Indian society. Of these, 94 were spoken by less than 10,000 people. According to Vadodra-based Bhasa Research and Publication centre, the country had 1100 languages in 1961, but nearly 220 of them disappeared in the past 50 years. The lost languages were spoken mostly by nomads. At present, there are 780 languages in India (Times of India-August 8, 2013). The fifteen main languages, as mentioned in the Eighth Schedule of the Indian Constitution, are spoken by over 92 per cent of the total population of the country. The geographical distribution of the main languages of India has been shown in **Fig. 13.12**.

The Indian languages belong to the following four linguistic groups:

1. The Indo-European family (Arya)
2. The Dravidian family (Dravida)
3. Austric family (Nishada)
4. Sino-Tibetan family (Kirata)

1. The Indo-Aryan language This is the most important group of Indian languages spoken by most of the people of northern India. Its core area is known as the *Khari Boli* region, comprising of Haryana and western Uttar Pradesh. Going away from the core, it has different shades and dialects. Prof. A. Ahmad has given a diagrammatic representation of the diffusion of ***Khari-Boli*** (Hindi) in different directions from the core area. **(Fig. 13.13).** Offshoots include Dardi, Kohistani,Kashmiri, Lahnda, Sindhi, Kachhchi, Gujarati, Marathi, Odiya, Bengali, Assamese, Bihari, Avadhi, Bagheli, Chhattisgarhi, Hindi, Punjabi, Rajasthani, Nepali, and Pahari.

Hindi (the National language) is the principal language of the Indo-European Family spoken by over 40 per cent of the total population of the country. It is mainly spoken in Bihar, Delhi, Haryana, Himachal Pradesh, Madhya Pradesh, Rajasthan, Uttar Pradesh, and Uttarakhand. Urdu is closely akin to Hindi and is popular in Bihar, Delhi, Hyderabad, J&K, M.P., Uttar Pradesh, Uttarakhand and in most of the places of urban India.

2. The Dravidian Family The Dravidian Family of the Indian languages is mainly spoken in Andhra Pradesh (Telgu), Karnataka (Kannada), Kerala (Malayalam), and Tamil Nadu (Tamil). These four languages are spoken by more than 22 per cent of the total population of India.

3. The Austric Family The Austric languages are spoken by the tribal groups of Chhattisgarh, Jharkhand, Madhya Pradesh, Meghalaya, Odisha and West Bengal. These languages belong to

Religion, like language, is a symbol of group identity and a cultural rallying point. All societies have value systems, common beliefs, understandings, and expectations which unite their people. Religion plays a crucial role in the socioeconomic life of the people and even their utilisation of natural resources is closely controlled by the religion of the people. Geographers are concerned with the interaction between religion and landscape (resources). Thus, religion provides a good basis for the demarcation of cultural regions.

India is a multi-religion country. It is the birth place of Hinduism, Buddhism, Jainism, and Sikhism. Subsequently, the successive waves of people of other religious faiths came to India. They maintained their religious identity. For example, the Syrian Christians appeared on the west coast of India in the first century AD. They are still found in Kerala. The Muslims came to India from South-West Asia and Central Asia and maintained their religious identity.

Concentration of Religious Groups

Hindus According to the Census 2001, about 82 per cent of the total population of India is Hindu by faith. They are predominantly distributed throughout the country, but in a few areas, like the Kashmir Valley, Punjab, Mizoram, Meghalaya, Nagaland, and parts of Kerala, they are in minority **(Fig. 13.14)**.

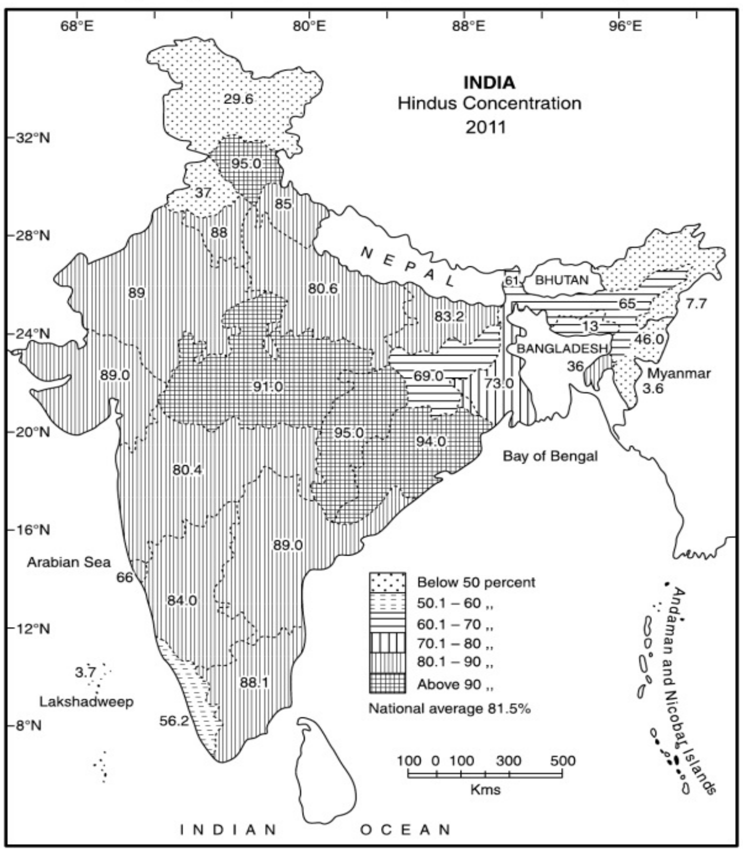

Fig. 13.14 Hindu Population (2011)

was established in Kerala. The largest number of Christian population is in the state of Kerala—about 29% of the total population. Christians number more than one million in the states of Andhra Pradesh, Meghalaya, Nagaland and Tamil Nadu. Their proportion is significantly large in the states of Mizoram, and Goa. Nagaland (90%) and Mizoram (87%) have the largest percentage in population. **(Fig. 13.16).**

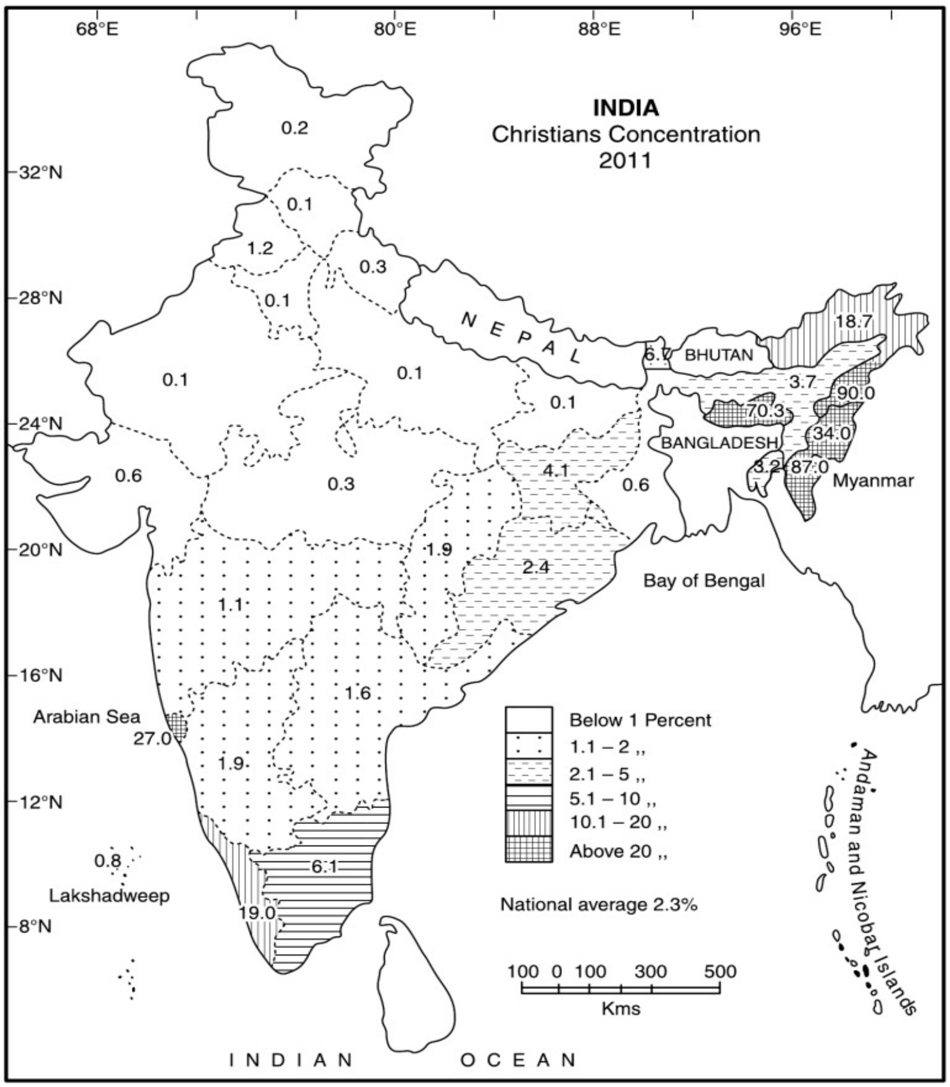

Fig. 13.16 Christian Population (2011)

Sikhs The religion of Sikhism was founded by Guru Nanak Sahib in the fifteenth century. The Sikhs constitute about 2 per cent of the total population of the country (Census, 2001). Sikhism attempted to create social harmony by removing the Hindu caste system and permitting widow remarriage. But for a long time it remained confined to Punjab and has accepted Gurmukhi as its language. Nearly 79 per cent of the total population of Sikhs is concentrated in the state of Punjab (**Fig. 13.17**). In addition to Punjab, Sikhs are found in Haryana, Chandigarh, Delhi, Rajasthan and the Terai region of Uttar Pradesh and Uttarakhand (Udham Singh Nagar). At present, Sikhs have spread in all parts of the country and have acquired international presence in U.K., Canada, U.S.A., Australia, New Zealand, Kenya, Pakistan, Afghanistan, Singapore and Hong Kong.

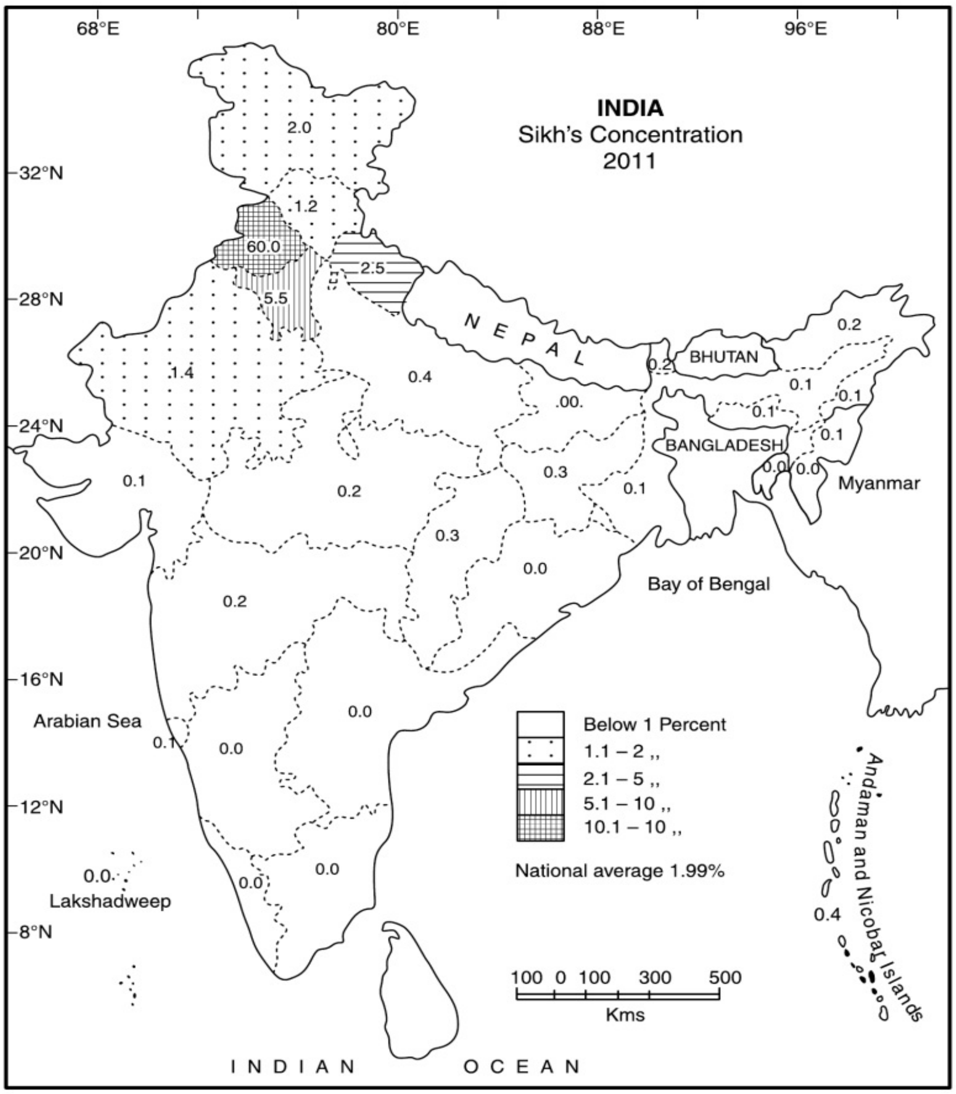

Fig. 13.17 Density of Sikh Population (2011)

Buddhism Buddhism was founded by Gautam Buddha (563–483 BC) in North India. The Buddhists constitute less than one per cent of the total population of the country. Nearly 80 per cent of the Buddhists live in Maharashtra. The traditional pockets of Buddhism are Ladakh, areas of Jammu and Kashmir, Himachal Pradesh, Sikkim, Arunachal Pradesh, and Tripura (**Fig. 13.18**).

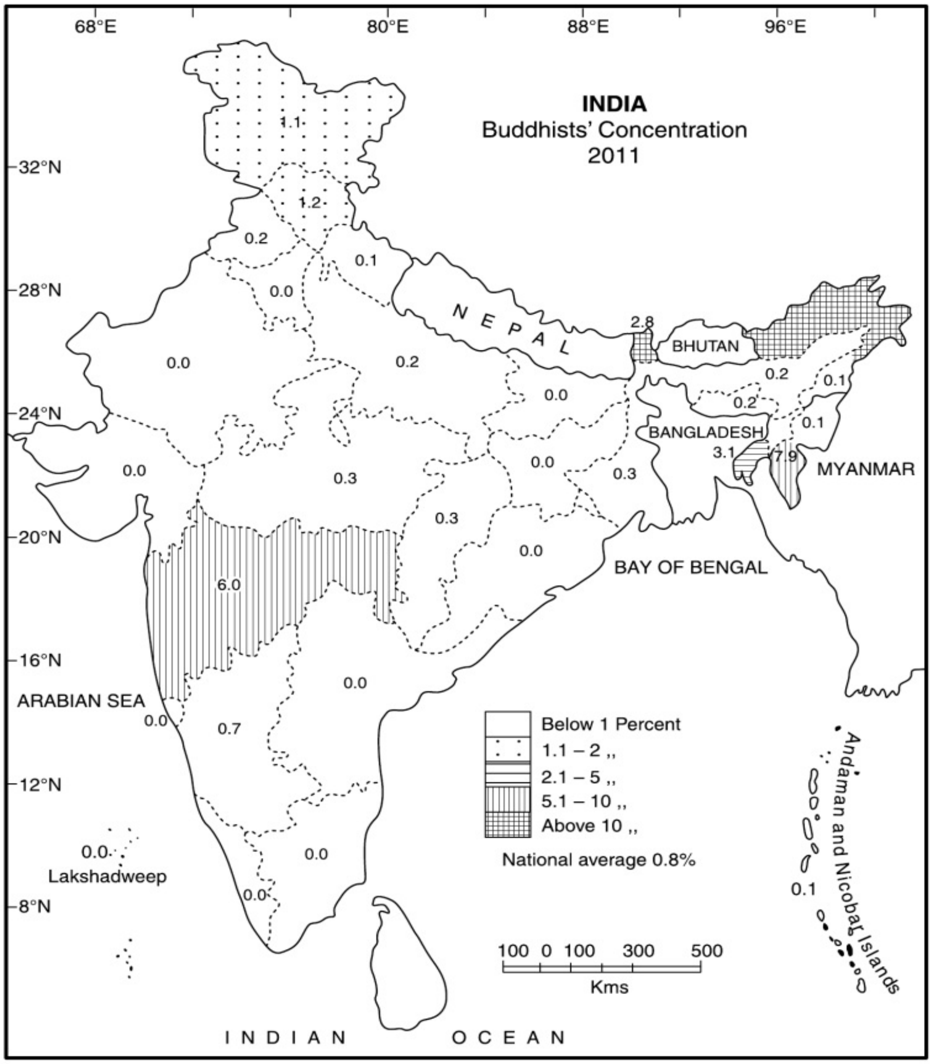

Fig. 13.18 Density of the Buddhist Population (2001)

Jainism India is the homeland of Jainism which is a minority religion (0.4%) and has no perceptible following in other countries. Its followers are found in Maharashtra, Rajasthan, Gujarat, Madhya Pradesh, Uttar Pradesh, Uttarakhand, and Karnataka, particularly in urban areas. The Jains have an important influence in business and politics.

Zoroastrianism The Parsis (population about 1.67 lakh) are the followers of Zoroastrianism (2011). It was a dominant religion in the days of the Old Persian Empire. The essence of its ethics is well summed up in three words: *Humata* (good thoughts), *Hukhta* (good words), and *Huvarshta* (good deeds). Their religious book is *Dinkart.* They first reached Diu in 766 A.D. and shifted their colony to Mt. Bharhat (1490). From there they spread to Navsari and ultimately to Udvada. They have been influenced by the Hindu customs, but they do not advocate celibacy, and permit remarriage. About 80 per cent of the Parsi population is concentrated in Greater Mumbai and the rest in Navsari, Udvada, Surat, and Ahmadabad.

Religious Regions of India The cultural regions of India based on religion have been plotted in **Fig. 13.19.**

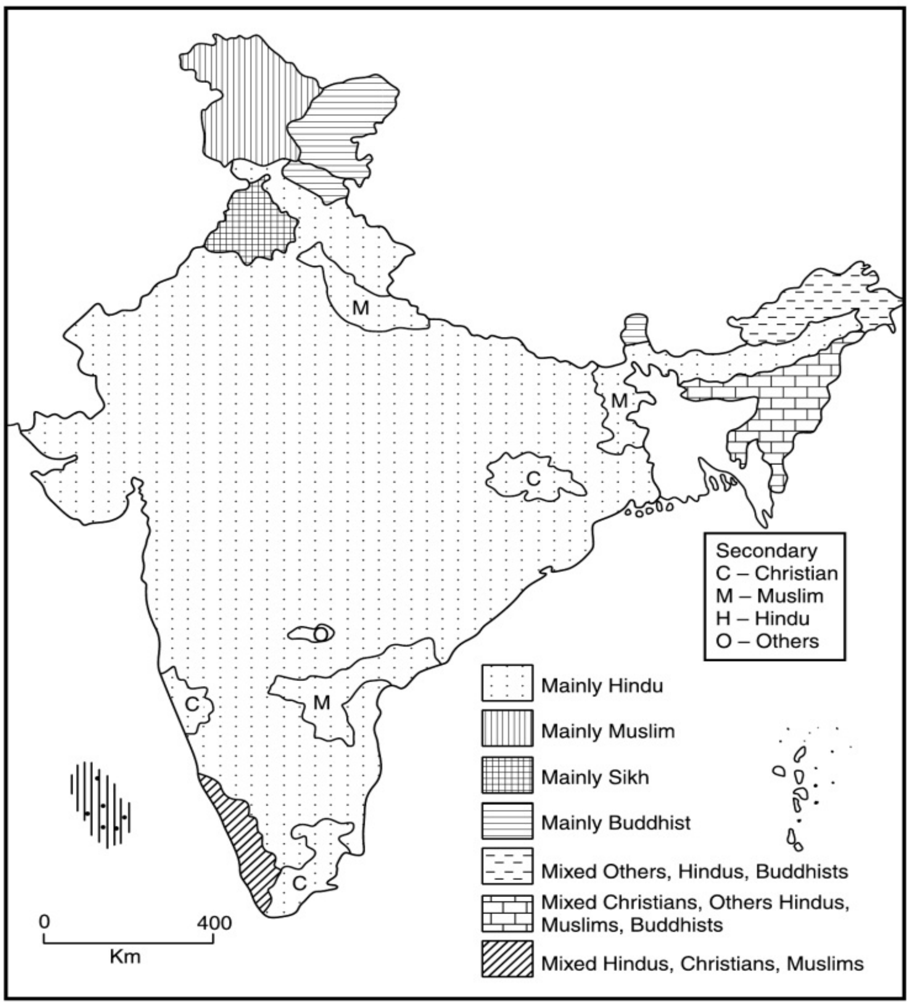

Fig. 13.19 Religious Regions 2011

It may be seen from **Fig. 13.19** that the greater part of the country has a dominance of Hindu religion and culture with sprinkled populations of Muslims, Christians, Sikhs, Buddhists, and tribals. The hill states of north east India are however, characterised by the mixed population of Christians, Tribals, Hindus, and Muslims. The Muslim dominated regions are the Kashmir Division and Kargil District of Jammu and Kashmir state. Muslims are quite significant in northern Kerala and in Agra, Meerut, Lucknow, Rohilkhand, and Saharanpur divisions of Uttar Pradesh. Ahmadabad, Bhopal, Hydarabad, Kolkata and Mumbai, Surat. The state of Punjab and the Union Territory of Chandigarh are the Sikh dominated parts of the country **(Fig. 13.19).**

Customs Customs are a very important component of cultural geography. A custom is a frequent repetition of the same act to the extent that it becomes characteristic of the group of people performing the act. Habit is a similar word which is adopted by an individual, while custom is the act which has been adopted by most of the people of an ethnic group or society. There is a positive correlation between the customs and utilisation of environment (resources). In fact, the tradition bound society has many oral folk traditions. In the delineation of cultural regions, customs (folk dance, folk lore, folk medicine, etc.) are also important indicators.

Cultural regions of India based on Language, Religion and Customs The cultural regions of India based on language, religion, and traditions have been plotted in **Fig. 13.20.**

It may be seen from **Fig. 13.20** that on the basis of language, religion, customs, and traditions, India may be divided into the following ten cultural regions:

1. The Ladakhi-Buddhist Cultural Region
2. The Kashmiri-Muslim Cultural Region
3. The Sikh-Gurumukhi Cultural Region
4. The Kinnauri-Dev-Bhumi Cultural Region (Himachal Pradesh and Uttarakhand)
5. The Hindu-Hindi Cultural Region
6. The Mixed Cultural Region of north east India
7. The Bengali Cultural Region
8. The Tribo-Hindu Cultural Region of Chotanagpur
9. The Marathi Hindu Cultural Region
10. The Dravido-Cultural Region (comprising of Telugu, Kannada, Tamil, and Malyalam)

1. The Ladakh Cultural Region: It has the dominance of Buddhists and Ladakhi language. There are Gompas and monasteries in this region. Leh and Dhramshala are the important sacred and cultural centres of this region.

2. The Kashmiri-Muslim Cultural Region: Stretching over the valley of Kashmir and northern parts of Jammu (Doda district, etc) and southern parts of Ladakh (Kargil) divisions, it is a predominantly Muslim dominated region in which Kashmiri is the main language. Hindus and Sikhs though in minority, speak Kashmiri and follow the Kashmiri cultural traditions.

3. The Sikh-Gurmukhi Cultural Region: Stretching over the state of Punjab and the Union Territory of Chandigarh, this region has the majority of Sikhs who speak Punjabi language. The Hindus are in minority. This region is characterised by Gurudwaras in almost all the villages and towns. The Golden Temple situated in the city of Amritsar is a sacred place and an important pilgrimage centre for religious people.

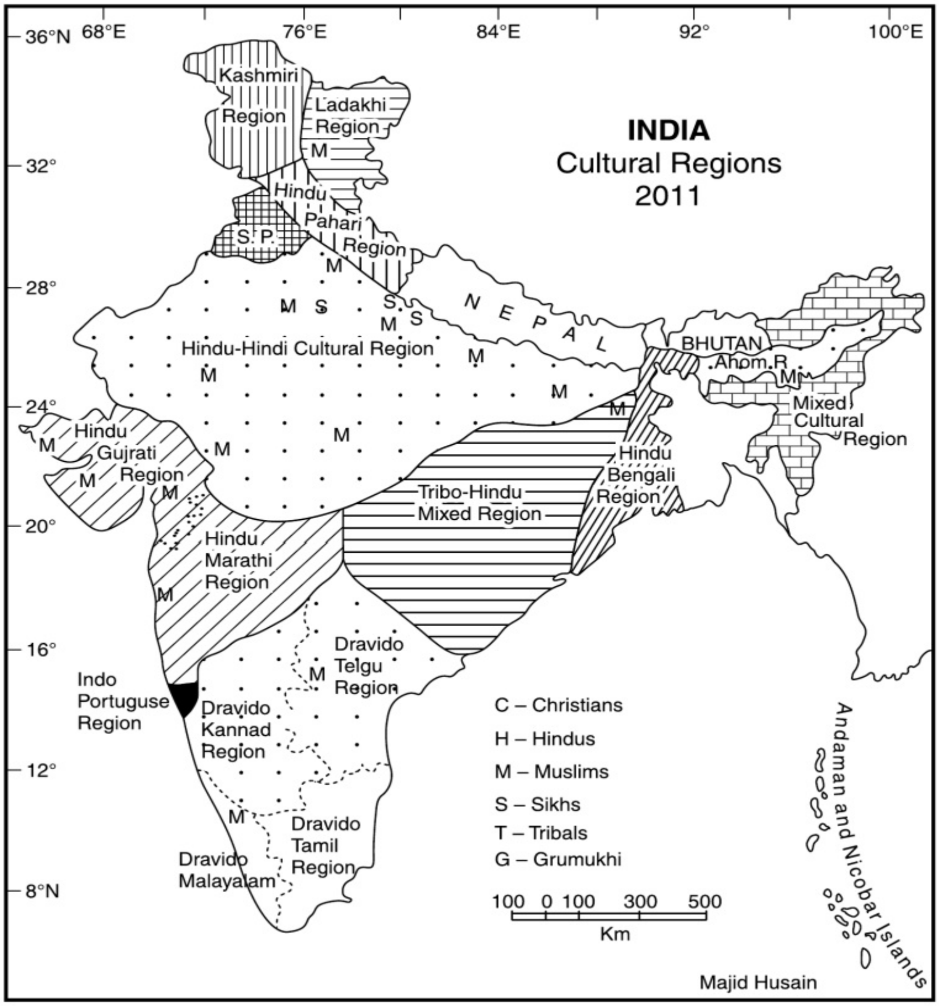

Fig. 13.20 Cultural Regions based on Religion, Language, and Traditions 2011

4. The Kinnauri-Dev Bhumi Cultural Region: This region sprawls over the mountainous parts of Himachal Pradesh and Uttarakhand. It is called the Dev-Bhumi in which there are many religious shrines (Kedarnath, Badrinath, Hardwar, Paonta Saheb, etc.). In the region of Himachal Pradesh, Kinnauri is the dominant language, while in Uttarakhand Hindi is the language of the masses.

5. The Hindu-Hindi Cultural Region: This region covers the states of Bihar, Haryana, Madhya Pradesh, Rajasthan, southern parts of Uttarakhand and Uttar Pradesh. It is the Hindi Heartland with dominance of Hindu religion. In western Uttar Pradesh and in urban centres, Muslims consititute a significant minority. Sikhs and Christians are also sprinkled, mainly in the urban areas like Delhi, Kanpur, Lucknow, Varanasi, Meerut, Agra, and Allahabad.

6. The Mixed Cultural Region of North East India: Stretching across the states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura, it is a region of mixed culture in which there are areas of dominance of Hindus, Christians, Muslims and Tribal religion. There is a great diversity in the languages, religion, customs, folk-dances, music, and folk medicine.

7. The Bengali-Cultural Region: Spreading over West Bengal and the adjacent regions of Odisha, Jharkhand and Bihar, this region has the dominance of Bengali speaking people. The main religion of the people is Hinduism, while Muslims constitute a significant minority in isolated pockets.

8. The Tribo-Hindu Cultural Region: This cultural region spreads over Chotanagpur plateau. Most of the people belong to Hindu religion, while Christians are also significant in number. Most of the people speak Hindi language.

9. The Marathi-Hindu Cultural Region: Stretching over Maharashtra, parts of Gujarat, Goa and the adjacent regions of Andhra Pradesh and Karnataka, this region has a dominance of Marathi language and Hindu population. Concentration of Muslims and Buddhists is in isolated pockets.

10. The Dravido-Cultural Region: This region sprawls over Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu. The people belong to the Paleo-Mediterranean race and speak Dravidian language. The major languages are Tamil, Malyalam, Telgu, and Kannad (**Fig. 13.20**).

DEMOGRAPHIC CHARACTERISTICS OF INDIAN POPULATION

The spatial variations in the distribution, density, composition, sex-ratio, literacy rate, migration, and growth of population have a direct bearing on the utilisation of resources and the levels of development of a region/country. It is, therefore, an important concern of geographers. The distribution, density, composition, growth, and migration of population is directly or indirectly controlled by the physical, socio-cultural, economic, and political factors.

India has only about 2.4 per cent of the total area of the world but supports over 17.64 per cent of the total population of the world. Indian population has its own peculiar characteristics which have been precisely presented here.

India—Demographic Transition and Population Growth

Demographic transition is the transition from a stable population with high mortality and fertility to stable population with low mortality and fertility. During the transition population growth and changes in the age structure of the population are inevitable.

In India, the demographic transition has been relatively slow but steady. As a result the country was able to avoid adverse effects of too rapid changes in the number and age structure of the population on social and economic development.

Growth of population is the rate in the number of people living in a particular area between two given points of time. The net change between the two points of time is expressed in percentage and is described as the growth rate of population.

The patterns of growth changed between 1901 and 2001 have been plotted in **Fig. 13.21** and the relevant data has been given in **Table 13.6.**

Table 13.6 *India—Growth of Population 1901–2011*

Census Year 1	*Population* 2	*Absolute* 3	*Decadal growth rate* 4
1901	23,83,96,327	—	—
1911	25,20,93,390	1,36,97,063	5.75
1921	25,13,21,213	-7,72,177	0.31—Year of Demographic Divide
1931	27,89,77,238	2,76,56,025	11.00
1941	31,86,60,580	3,96,83,324	14.22
1951	36,10,88,090	4,24,27,510	13.31
1961	43,92,34,771	7,81,46,681	21.64
1971	54,81,59,652	10,89,24,881	24.80
1981	68,33,29,097	13,51,69,455	24.66
1991	84,64,21,039	16,30,91,942	23.87
2001	1,02,87,37,436	18,23,16,397	21.54
2011	1,210,195,000	18,14,57,564	17.64

Source: ***Census of India, 2011.***

As stated at the outset, India has the second largest population in the world after China. The population of India, according to the census of 2011 was 1210.19 million. It is growing at a faster pace. On an average, Indian population is being increasing at a growth rate of over 1.76 per cent per annum as against 1.3 per cent for the world as a whole and 0.57 per cent for China (2001–2011).

The population of India as recorded at each decennial census from 1901 has grown steadily except for a decrease during the decade of 1911–21. The year 1921 is known as the year of demographic divide in the demographic history of India when mortality started to decline leading to acceleration in the rate of population growth. The decadal growth of population of India has been given in **Table 13.6.**

It may be observed from **Table 13.6** that the total population of India in 1901 was about 238 million which rose to 361 million in 1951 and became 1210.19 million in 2011.

It may also be seen from **Table 13.6** that there have been significant turning points in the Census Years of 1921, 1951, and 1981. Thus, the temporal changes in the population growth of India during the 20th century may be classified under the following four phases (**Fig. 13.21** and **Fig. 13.22**).

1. Period of Stagnant Population—1901–21
2. Period of Steady Growth—1921–51
3. Period of Rapid Growth—1951–81
4. Period of High Growth with Declining Trend—1981–2011

1. Period of Stagnant Population

The first two decades (from 1901 to 1921) was the period of stagnant or stable population. During this period, the birth rate and the death rate were high. Consequently, the population showed a stagnant phase of population growth. It may be termed as the first phase of demographic transition in India. There was high mortality during this period because of epidemics like, cholera, influenza, malaria, plague, small-pox, etc. Food shortage caused severe droughts in the years of 1911, 1913, 1915,1918 and 1920. Moreover, thousands of Indian soldiers lost their lives during the First World

War (1914–18). Interestingly enough, the population showed a declining trend between 1911 and 1921. The Census year of 1921 is termed as the year of *'demographic divide'* in the demographic history of India.

2. Period of Steady Growth of Population (1921–51)

The period between 1921 and 1951 is known as the period of steady growth of population. The birth rate during this period remained high but the death rate started to show the declining trend. Moreover, some of the epidemic diseases like cholera, malaria, plague, small pox were significantly controlled. The problems of scarcity of food were also controlled with the help of the expansion and improvements in the roads and railways networks.

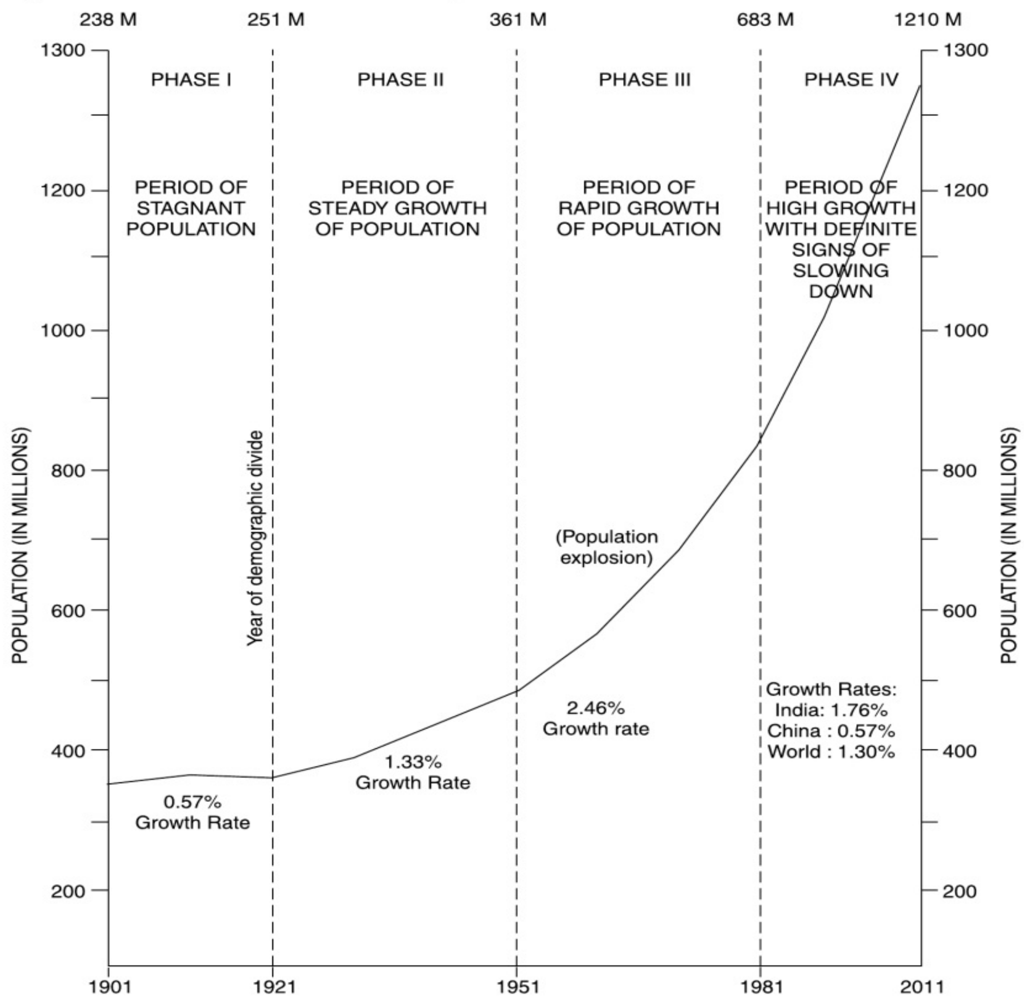

Fig. 13.21 India: Demographic Transition (1901–2011)

Table 13.7 *India—Birth Rate, Death Rate, and Natural Growth Rate of Population (1911–2011)*

Census Year	*Crude Birth Rate*	*Crude Death Rate*	*Natural Growth Persons Per Thousand of Population*
1911	49	43	6
1921	48	47	1
1931	46	36	10
1941	45	31	14
1951	40	27	13
1961	42	23	19
1971	37	15	22
1981	34	12	22
1991	31	11	20
2001	26	9	17.7
2011	23	5.4	17.6

Source: ***Census of India, 2011.***

It may be seen from **Table 13.7** that the natural growth rate of population was the highest between 1961–71 and 1971–81, being 22 persons per thousand of population. In 2001, the natural growth of population declined to 17 persons per thousand which is an encouraging factor for the demographers and population planners. In fact, 2001–2011 is the first decade (with the exception of 1911–1921) which has actually added lesser population compared to the previous decade. The absolute growth of population is still significantly high being about 20 million per year which is mainly because of the large base (over one billion) of population of India.

At present India is in a state of rapid fertility transition with the pace of decline having accelerated in recent years. India's population is in the late expanding stage in which birth rate is falling, death rate is also falling and population continues to grow. This is because of: (i) family planning, (ii) lower infant mortality, (iii) changing status of women and (iv) increase in standard of living. The pace of decline varies from state to state and experiences of Andhra Pradesh, Nagaland, Goa, Tamil Nadu, W. Bengal, Assam, Tripura, Odisha, and Kerala indicate that the Crude Birth Rate (CBR) can go much below the replacement level of fertility. The rural urban differential in fertility tend to narrow down as fertility declines. In Nagaland, Kerala, Tamil Nadu, Andhra Pradesh, and Goa, the rural urban birth rates are almost the same. There is greater homogeneity in the Crude Birth Rate in urban areas compared to rural areas. Surprisingly, among the larger high fertility states of north India, Bihar has exhibited a comparatively rapid decline in the Crude Birth Rate during the last ten years, probably as a result of relatively greater acceptance of family planning methods. Interestingly enough, Nagaland recorded the lowest growth rate of 0.47 per cent during the decade of 2001–2011.

Distribution of Population

The distribution of population in any country/region is closely influenced by the physical (terrain, topography, climate, natural vegetation, minerals, and soils), socioeconomic (religion, customs, education, awareness, per capita income, and standard of living), and political factors (government policy towards population). The parts of the country having good climate, fertile soils, adequate availability of water, minerals, good connectivity by roads and railways have a high concentration of population.