316

SENIOR SECONDARY COURSE

# GEOGRAPHY

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National Institute of Open Schooling

316

Senior Secondary Course

# GEOGRAPHY

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NATIONAL INSTITUTE OF OPEN SCHOOLING

(An autonomous institution under Ministry of Education, Govt. of India)

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# A Word with You

Dear learner,

You often observe that how the world is changing around yourself. Sometimes these changes happens due to various events related to earthquakes, volcano, floods, drought etc. while sometimes human intervention make relevant changes. These natural phenomena as well as human interventions attracts our attention and encourage our curiosity to be familiar with our environment. Geography is a subject which gives you such information with their societal concern.

The subject matter of Geography is very extensive. At one side, it is related to physical phenomena i.e earth's movements, distribution of ocean and continent, earth's surface, climate etc while at another side it analyses natural resources and human population. Geography provides facts and also analyse the relationship between humans and their environment.

The National Institute of Open Schooling's course of Geography at Senior Secondary level tries to cover various branches of Geography. It provides an opportunity to connect geographical knowledge with of our surrounding. The whole course has been divided into 10 modules and a practical manual. The first book includes 6 modules (Module 1 to 6). Second book includes remaining 4 Modules (Module 7 to 10) and Practical Manual.

In this Self Learning Material, we have covered six modules. First module- The study of geography as a discipline, gives you a synaptic view about nature and scope of geography. The module two, three, four and five deal with four realm of the earth surface - land, water, air and space for living organism. Module six gives an overview of the physical geography of India.

The Self Learning Material has been designed to equip you for self learning. It also includes assessment items i.e. Intext Questions and Terminal Questions. I hope you will enjoy reading the self learning material. In case of any difficulty do not hesitate to write to us.

Happy Learning!

Best of luck.

Course Team - Geography

# How to use the Learning Material

Congratulations! You have accepted the challenge to be a self-learner. NIOS is with you at every step and has developed the material in Geography with the help of a team of experts, keeping you at the focal point. A format supporting independent learning has followed. You can take the best out of this material if follow the instructions given. The relevant icons used in the material will guide you.

**Title:** will give a clear indication of the contents within. Do read it.

**Introduction:** This will introduce you to the lesson linking it to the previous one.

**Objectives:** These are statements that explain what you are expected to learn from the lesson. The objectives will also help you to check what you have learnt after you have gone through the lesson. Do read them.

**Notes:** Each page carries empty space in the side margins, for you to write important points or make notes.

**Intext Questions:** Very short answer self check questions are asked after every section, the answers to which are given at the end of the lesson. These will help you to check your progress. Do solve them. Successful completion will allow you to decide whether to proceed further or go back and learn again.

**What You Have Learnt:** This is the summary of the main points of the lesson. It will help in recapitulation and revision. You are welcome to add your own points to it also.

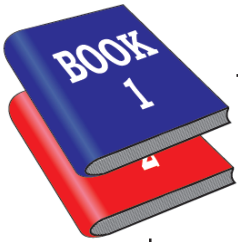
**Terminal Exercises:** These are long and short questions that provide an opportunity to practice for a clear understanding of the whole topic.

**Do You Know:** This box provides additional information. The text in boxes is important and must be given attention. It is not meant for evaluation, but only to improve your general knowledge.

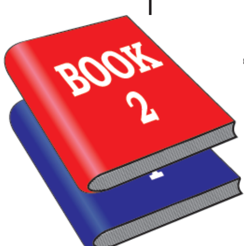
**Answers :** These will help you to know how correctly you have answered the questions.

**Activities:** Certain activities have been suggested for better understanding of the concept.

# COURSE OVERVIEW




| MODULE | | LESSON |
|---|---|---|
| 1. The study of Geography as a discipline | 1. | Nature and subject matter of Geography |
| 2. Dynamic and Geomorphic Processes of the Earth | 2. | Endogenic Forces |
| | 3. | Exogenic Forces and their resultant landforms |
| | 4. | Running water, moving ice, wind and sea waves |
| 3. The domain of the water on the earth | 5. | Hydrological Cycle and Ocean |
| 4. Dynamics of Atmosphere | 6. | Structure and composition; Insolation |
| | 7. | Atmospheric pressure and winds |
| | 8. | Humidity and precipitation |
| | 9. | Climate and Climate Change |
| 5. Biogeography and Biodiversity | 10. | Biosphere, Biomes and Biodiversity |
| 6. Physical Geography of India | 11. | Physical Settings |
| | 12. | Climate |
| | 13 | Natural Hazards and Disasters |




| MODULE | | LESSON |
|---|---|---|
| 7. Natural resources, Utilisation and Management | 14. | Land and Soil Resources |
| | 15. | Forests and Biodiversity |
| | 16. | Water Resources |
| 8. Economic Geography of India | 17. | Agriculture and Food Security |
| | 18. | Mineral and Energy Resources |
| | 19. | Major Industries and Industrial Complexes |
| | 20. | 20 Foreign Direct Investment (FDI), Transport, Communication and Trade |
| 9. Human resource development in India | 21. | Population Growth and Distribution |
| | 22. | Population Composition |
| | 23. | Human Development |
| 10. Contemporary Issues and Challenges | 24. | Sustainable Development Goals (SDGs) |
| | 25. | Environment, Health and Sanitation |

PRACTICAL MANUAL

1. Maps: Types and Elements; Toposheets
2. Geospatial Technologies
3. Data and Statistical Diagrams

# CONTENTS



**Note:** The syllabus has been bifurcated into two sections -

(i.) Lessons for the Tutor Marked Assignment (TMA)

(ii.) Lessons for public examination question paper

The details of the different sections are on the next page.

# National Institute of Open Schooling

## Bifurcation of Syllabus in Geography - 316

## Sr. Secondary

**Total no. of Lessons=25**

| MODULE (No. & name) | I. TMA (40%) (No. of lessons -9) | II. Public Examination (60%) (No. of lessons -16) |
|---|---|---|
| 1. The study of Geography as a discipline | | L-1: Nature and subject matter of Geography |
| 2. Dynamic and Geomorphic Processes of the Earth | L-2 : Endogenic Forces<br>L-4: Running water, moving ice, wind and sea waves | L -3: Exogenic Forces and their resultant landforms |
| 3. The domain of the water on the earth | | L-5 : Hydrological Cycle and Ocean |
| 4. Dynamics of Atmosphere | L-6 Structure and composition; Insolation<br>L-8 : Humidity and precipitation | L-7 : Atmospheric pressure and winds<br>L-9: Climate and Climate Change |
| 5. Biogeography and Biodiversity | | L-10 : Biosphere, Biomes and Biodiversity |
| 6. Physical Geography of India | L-13 : Natural Hazards and Disasters | L-11 : Physical Settings<br>L-12 : Climate |
| 7. Natural resources, Utilisation and Management | L-14 : Land and Soil Resources | L-15 : Forests and Biodiversity<br>L-16 : Water Resources |
| 8. Economic Geography of India | L-19 : Major Industries and Industrial Complexes | L-17 : Agriculture and Food Security<br>L-18 : Mineral and Energy Resources<br>L-20 : Foreign Direct Investment (FDI), Transport, Communication and Trade |
| 9. Human resource development in India | L-21 : Population Growth and Distribution | L-22 : Population Composition<br>L-23 : Human Development |
| 10. Contemporary Issues and Challenges | L-25 : Environment, Health and Sanitation | L-24 : Sustainable Development Goals (SDGs) |

# MODULE -1

## The Study of Geography as a Discipline

1. Nature and Subject Matter of Geography

1

# NATURE AND SUBJECT MATTER OF GEOGRAPHY

Geography is one of the oldest earth sciences and its roots date back in the works of the early Greek scholars. The word 'geography' was first used by the Greek scholar Eratosthenes in the third century B.C. Geography is made of two words 'Geo' and 'Graphy'. Geo means "Earth" and Graphy means "to describe". Thus, the literal meaning of geography is to describe the earth's surfaces. In other words "Geography is the study of the interaction of all physical and human phenomena and landscapes created by such interactions." It is about how, why, and where human and natural activities occur and how these activities are interconnected. In simple words, the object of geography is to know the earth in its total character including physical, biological and human phenomena interacting with each other. Geography has undergone changes in its approach. The earlier geographers were descriptive geographers. Later, geography came to be developed as an analytical science. Integration of heterogeneous phenomena needs analysis as well as synthesis of multiple factors. Today the discipline is not only concerned with descriptions but also with analysis, synthesis as well as prediction.

In this lesson you will learn how important geography is in everyday life. This study will encourage you to understand your surrounding environment with greater interest. You will also study various approaches, methods and branches to Geography.

## OUTCOMES

After studying this lesson, learner:

- describes the use of Geography in daily life;
- traces development of Geography as a discipline;
- explains human-environment relationships and their impacts on each other;
- illustrates the systematic and regional approaches of Geography;

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- explains various analytical techniques in Geography; and
- identifies the different branches of Geography and its scope.

## 1.1 GEOGRAPHY IN DAILY LIFE

One pertinent question is why should there be such a field as geography? The answer is that this is the only living planet, universe or world in which we live and can directly experience. You must have noticed that the earth's surface is ever changing. In general, the natural features like mountains, rivers, lakes etc. change slowly while the cultural elements like buildings, roads, crops, change fast. Traveling-from one place to another you notice that the number and types of trees change from area to area. All this is because of the changes in factors governing the growth of trees such as climate, soil and terrain and the continuous interaction between the environment in which we live in and the way we use it. The study of Geography is about observing such patterns.

Another aspect of geography is to understand the factors or reason behind the areal differentiation, how social, cultural, economic and demographic factors change our physical landscape and create new or altered landscapes by human interventions. For example, human settlements are the transformation-of forest or barren lands for living purposes by human beings. The features of the earth have a different significance for peoples of different cultures, of different times and of different groups and individuals within the same time and culture.

Geography is often thought of as the art of making and studying maps. Maps give us a much more correct and graphic view of the way the Earth's surface looks compared to a picture of drawing. As earlier, even today geographical information about an area is available through reports, travel diaries and gazetteers. At present maps can be drawn by using satellite images using Geographic Information Systems (GIS) tools. Computers easily convert the information from satellite images into maps to show what changes development can bring about. Such information is of benefit to society. Such mapmakers are in great demand today. Nowadays geographers, engineers, environmental scientists, city planners, social scientists, and many others learn to use GIS to understand the Earth better.

Geography not only investigates what is on the Earth, but also why it is there. Geographers study the location of the activities, carefully identify patterns using maps and find out the reasons for these patterns. The areas are then described based on the distribution of landforms , population, house type and agriculture. They discover the linkages and movements between places and are able to infer the spatial processes that are working in an area.

Today, all over the world there are problems related to providing food security, health, effective energy use and environmental conservation. Equally important are equality issues and sustainable development. All these can be achieved by using our resources in sustainable ways. Study of geography is, therefore, necessary to learn more about environmental processes and to understand how land use planning can help us to overcome problems.

Geographical thinking and concepts affect our daily decisions in a number of ways– For example when urban master plans are made or rural development strategies are considered, it is important to understand the physical structure, climatic conditions and availability of resources in an area. The decision to shift industries from city areas would require the extension of industrial land use into farming areas. This would displace farmers and their source of income. Similarly, the construction of a railway line or highway causes ribbon development. Many economic activities concentrate along such corridors. Thus, knowledge of geography plays a crucial role in identification of suitable sites for different types of projects with minimum collateral damage to the surrounding environment as well as to the local community. Nowadays, the need to provide relief material to all affected persons after a flood or an earthquake requires a good understanding of the geography of the area. Distribution of relief is functional and related to the needs of people, according to climate or terrain.

## Basic Concepts

Geography has been defined differently through different periods of its history. Geographical work in ancient Greece had followed two distinct traditions. One was the mathematical tradition which was focused on fixing the location of places on the earth's surface, and the other was gathering geographic information through travels and field work. According to them, the purpose of geography was to provide a description of the physical features and conditions in different parts of the world. The emergence of regional approach in geography also emphasized the descriptive character of geography. According to Humboldt, geography is the science related to nature and it studies and describes all material things found on earth. The word KOSMOS was used by Humboldt to describe the nature of outer space and earth. He imparted a unifying perspective to the studies of science, nature and mankind. Another important school of thought defined geography as the study of man-environment relationships. The concept of "Erdkunde" by Carl Ritter, "Chorology" by Hettner and "Areal differentiation" by Hartshorne emphasized the regional approach to study geography. It was only after Carl Saur - Hartshorne debate that the use of quantitative methods in geography increasingly accepted and popularized due to which spatial analysis became possible. Subsequently, welfare approach, radical approach, humanistic approach, modernism and postmodernism approaches enriched the studies in geography.

## INTEXT QUESTIONS 1.1

1. What is geography?

2. Why is the earth's surface changing?

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3. Who has coined the term 'Geography"?

4. Which are the two distinct traditions followed by Greeks?

## 1.2 DEVELOPMENT OF GEOGRAPHY

### Ancient Period

The earliest records illustrate the interests of scholars in understanding the physical domain of the earth by making maps and astronomical measurements. The Greeks are given the credit of being the earliest geographers, prominent among them being Herodotus, Thales, Aristotle and Eratosthenes.

### Pre-Modern Period

This period starting from the middle of 15th century and continuing with the 18th century provides us with enormous information about the physical and cultural nature of the world by the travels and explorations of early geographers. The early seventeenth century witnessed the beginnings of a new scientific geography. Christopher Columbus and Vasco de Gama, Ferdinand Magellan and Thomas cook were important explorers and travelers among those. Varenius, Kant, Humboldt and Ritter led the geographers of this period. They contributed in the development of cartography and discovering new lands, and developing geography into a scientific discipline.

### Modern Period

Ritter and Humboldt are frequently referred to as the founders of modern geography. Generally, the latter half of the nineteenth century is considered a period of modern geography. The first modern geographer in the true sense was Ratzel who built the structure of modern geography on the foundations laid down by classical geographers.

### Recent Period

The development of geography during the post Second World War period has been very rapid. The American and European geographers such as Hartshorne have contributed the most during this phase. Harthshorne described geography as a science dealing with areal differentiation. The present day geographers look upon regional approach and systematic approach as complementary rather than contradictory.

### Scope of Geography

Geography has now acquired the status of science that explains the arrangements of various natural and cultural features on the earth surface. Geography is a holistic and interdisciplinary field of study engaged in understanding the changing spatial structure from past to the future. Thus, the scope of geography is in various disciplines, like armed services, environment

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management, water resources, disaster management, meteorology and planning and various social sciences. Apart from that, a geographer can help in day to day life like tourism, commuting, housing and health related activities.

## 1.3 APPROACHES FOR STUDY OF GEOGRAPHY

Today, geography is the only discipline that brings all natural and human sciences on a common platform to understand the dynamics of the spatial configuration of the earth surface. There are two main approaches in geography:

A. Systematic

B. Regional

### Systematic Approach

A study of specific natural or human phenomenon at world scale that gives rise to certain spatial patterns and structures on the earth surface is called systematic study. This approach was given by Humboldt, a German geographer (1769-1859). Ordinarily, systematic geography is divided into three main branches. Additionally, philosophy of the subject and use of quantitative techniques helps in understanding the subject and analysis and synthesis of the phenomena respectively.

Main branches of systematic geography;

- Physical geography
- Human geography
- Biogeography, including environmental geography
- Methods and Techniques in Geography

### a. Physical geography

It deals with earth systems like atmosphere (air), the hydrosphere (water), the lithosphere (earth solid rock) and biosphere, which encompasses all of earth's living organisms. Astronomy, geomorphology, climatology, oceanography, hydrology, water resources and soil geography are the sub-branches of physical geography. Let us discuss some of the branches in brief.

### b. Human geography

It describes population and dynamics of social, economic, and political aspects of space. The Sub branches includes; Population geography, Settlement geography, Economic geography, Resource geography, Agriculture geography, Industrial geography, Social and cultural geography, Geography of health, Political geography, Transport geography and Historical geography.

### c. Biogeography and environment geography

It focuses on evolution and distribution of plants (flora) including grasslands and forest and animals (fauna), ecosystems and environment. Focus is on processes, types, distribution, human- nature relationships and the quality of the living environment including the elements of water, air and noise pollution, solid waste and waste water management.

### d. Geographical methods and techniques

It deals with methods and techniques for field studies, qualitative, quantitative and cartographic analysis and use of Geographic Information System (GIS), Global Positioning system (GPS) and remote sensing for mapping, modeling and spatial analysis.

## Regional Approach

Vidal de la Blache, Carl Ritter, Alfred Hettner and Richard Hartshorne were the prominent geographers who advocated a regional approach in geography. Unlike systematic approach, regional approach starts with the spatial imprints of one or all the systematic geographic processes discernible as regions of different sizes. Regions could be based on a single factor like relief, rainfall, vegetation, per capita income etc. They could also be multifactor regions formed by the association of two or more factors. Administrative units like states , districts, tehsils also can be treated as regions. The main sub branches of regional geography are:

- Regional studies
- Regional planning
- Regional development
- Regional analysis

**Regional studies:** It refer to the study of a region. It comprises Macro or large scale like the whole world or a country, Meso or medium scale like a region such as Chota Nagpur Plateau and Micro or small scale like a village, tehsil or a district.

**Regional planning:** It is planning of a region at different scales, country/ rural or urban.

**Regional development:** It is the execution of regional plan i.e development of a region at different scale/size.

**Regional analysis:** It refers to description, analysis and synthesis with a regional approach to understand the spatial disparities in development.

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## INTEXT QUESTIONS 1.2

1. Which are the main branches of systematic geography?
2. Name the main branches of regional geography.

## 1.4 METHODS AND TECHNIQUES OF GEOGRAPHY

Each branch of systematized knowledge has certain methods / tools and techniques on which it depends to further its basic objectives. Geography too has its tools, techniques and methods. Important among them are globes, maps, diagrams, relief models and spatial analytical methods. Cartography is concerned with preparation of maps and diagrams to show distribution of geographical phenomena. Important methods in geography are deductive and inductive in nature. Various statistical techniques and models are used for regional analysis and to understand spatial distribution and interaction.

### a. Cartography

Most of us are fascinated with maps. "Cartography" is the study and practice of making maps and diagrams. It represents the earth with maps and abstract symbols. Maps have traditionally been made using pen, ink and paper, but computers have revolutionized cartography and with GIS methods one can prepare maps and diagrams with greater choice and efficiency.

Spatial data is obtained from measurement and other published sources and can be stored in a database, from which it can be extracted for a variety of purposes. Current trends in this field are moving away from drawing with ink or paper type methods of map making towards the creation of increasingly dynamic, interactive maps that can be manipulated digitally. Most commercial quality maps are now made with map making software that falls into one of three main types; Computer aided data management (CAD), Geographic Information Systems (GIS) and Global Positioning Systems (GPS).

Cartography has grown from a collection of drafting techniques into an actual science. Cartographers must understand which symbols convey information about the Earth most effectively, and make such maps that will encourage everyone to use the maps to find places or use it for their daily work. A cartographer must learn geodesy and fairly advanced mathematics to understand how the shape of the Earth affects the distortion of map symbols projected onto a flat surface for viewing.

**"Geographic Information Systems"** deals with the storage of information about the Earth for automatic retrieval by a computer in an accurate manner. In addition to other sub disciplines of geography, GIS specialists must understand computer science and database systems. Maps have traditionally been used to explore the Earth and to exploit its resources. GIS technology, as an expansion of Cartographic science, has enhanced the efficiency and analytic power of traditional mapping. Now, as the scientific community recognizes the environmental consequences of human activities, GIS technology is becoming an essential tool in the effort to understand the process of global change. Various map and satellite information sources can combine in ways that recreate the interactions of complex natural systems. Such visualization can help to predict what will happen to an area if it is repeatedly flooded, or what changes are expected if a particular industry is located or developed in an area.

Survey of India, inherited from the British Ordnance Survey, the NATMO is a premier organization for mapping in India. Its maps of one million series are well known. The organization of the Cartographic Unit in the 1960s at the French Institute, Pondicherry, brought a significant impact on the development of Geography in India. Its publication of Vegetation and Soil maps at the scale of 1:100000 were very well received for their cartographic appreciation and resource mapping. This Unit was upgraded in 1995 as a Genetics Laboratory with an emphasis on computer cartography and GIS.

### b. Quantitative methods in Geography

These aspects of geographical techniques deal with numerical methods most commonly found in geography. In addition to spatial analysis, you are likely to find methods like cluster analysis, discriminant analysis in geographic studies. These statistical techniques are useful in finding patterns and identifying relationships between space and the activities that are performed in them.

### c. Field Survey and Methods

Geographic research is based on both secondary and primary data. There are different types of surveys based on questionnaire or schedule and focused group discussion. Survey can cover all the inhabitants of the area (Census) or a small part of the total (sample survey).

## 1.5 BRANCHES OF GEOGRAPHY

Branches of Geography can be categorised in two broad groups:

### Physical Geography

a. **Astronomical Geography:** It studies the celestial phenomena which concern the Earth's surface particularly Sun, Moon and Planets of the Solar System.

b. **Geomorphology:** It is concerned with the study of the landforms on the Earth's surface. It includes origin and development of landforms through erosional, transportational and depositional processes of water, wind and glaciers.

c. **Climatology:** Climatology is the study of the atmospheric conditions and related climatic and weather phenomena. It includes the study of atmospheric composition, climatic regions, seasons, etc.

d. **Oceanography:** It is concerned with the study of various types of Oceanic components and processes related to ocean floor depths, currents, coral reefs, and continental drifts etc.

e. **Soil Geography or Pedology:** It studies various soil forming processes, their physical, chemical and biological constituents, their color and types, texture, distribution and carrying capacity etc.

f. **Hydrology and water resources:** It comprises the study of all water bodies such as sea/oceans, rivers, lakes and elements of rainfall and snowfall (precipitation), and glaciers.

g. **Biogeography and environment geography:** It focuses on evolution and distribution of plants (flora) including grasslands and forest and animals (fauna), ecosystems and environment. Focus is on processes, types, distribution, human- nature relationships and the quality of the living environment including the elements of water, air and noise pollution, solid waste and waste water management.

### Human Geography

a. **Anthropogeography:** It largely deals with racial phenomena in their spatial context.

b. **Cultural geography:** It focuses on the origin, components and impact of human cultures, both material and non-material over space. It comprises landscape characteristics, in terms of caste, race, religion, dialect and language, art and craft, literature, folk dance and music, cuisine and social norms and behaviors; its pattern and diffusion.

c. **Social geography:** It is the analysis of social phenomena in space. Poverty, health, education, livelihood are some important fields of study in social geography.

d. **Geography of Health:** It is a sub-branch of social geography which deals with issues related to mortality, morbidity (disease), and immunization etc. in its spatial context.

e. **Population geography:** It is the study of various dimensions of population such as demographic (population distribution, density, composition, fertility, mortality, migration) and socio-economic characteristics.

f. **Settlement geography:** It is the study of Rural/Urban settlements, their size, distribution, functions, hierarchy, and various other parameters of the settlement system. Nowadays, urban geography and rural settlement are taught as separate branches of human geography.

g. **Economic geography:** It refers to the study of the location and distribution of economic activities at the local, regional, national and world scale. Economic geography can be studied under the following heads: resource geography, agricultural geography, industrial and transport geography.

h. **Resource geography:** It is defined as the study of the distribution and characteristics of resources, which distinguish one region from another, with interest focused on utilisation,

i. **Agriculture geography:** It focuses on cropping pattern, production and trade, input of agriculture, irrigation and marketing of products.

j. **Industrial geography:** It studies types of industries, their growth, spatial pattern, input and production and industrial policies.

k. **Transport geography:** It studies the transport network, accessibility and related issues.

l. **Political geography:** It is the study of political phenomena such as boundaries, geopolitical issues, delineation of constituencies and electoral issues in their spatial context. Main focus remains for creation and transformation of political and administrative regions

m. **Historical geography:** Spatial and temporal trends of geographical phenomena are studied in historical context.

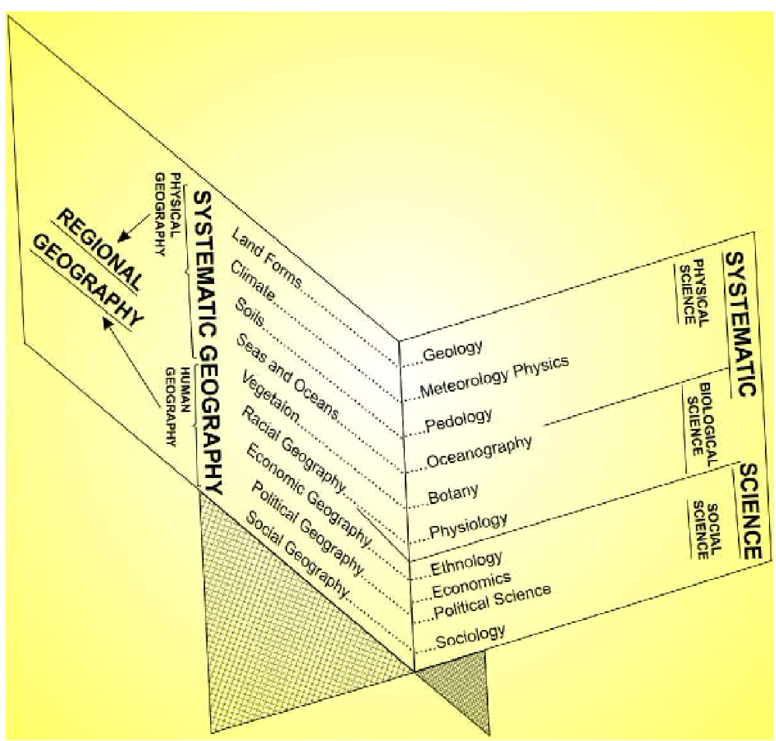



Fig. 1.1 Geography as an integrating science (Based on Hettner and Hartshorne)

## 1.6 GEOGRAPHY AS AN INTEGRATING DISCIPLINE

Geography is a peculiar discipline in the sense that it focuses on the integration of heterogeneous phenomena. Geography has its strong relation with mathematics, natural sciences, and social sciences. Geomorphology is closely related to geology and geophysics; oceanography and water resources with meteorology and hydrology; soil geography with agronomy; economic geography with economics, social/cultural geography with sociology; anthropogeography with anthropology, political geography with political science, environment geography and biogeography with botany and zoology. While other sciences deal with distinctive types of phenomena, geography studies several kinds of phenomena, each already studied by other sister disciplines. In an integrated manner thus, geography has firmly established itself as a discipline of synthesis. Fig. 1.1 gives the idea of integrating science

## INTEXT QUESTIONS 1.3

1. What are the two branches of geography?
2. Name the tools and techniques of geographical study?
3. What is Anthropogeography?
4. What is the difference between social and cultural geography?
5. Why is geography considered an integrating discipline?

## WHAT YOU HAVE LEARNT

- Geography is a science of space. Geography is both a natural and social science as it studies both the environment and the people. It is concerned with the different ways in which resources are used. It connects the physical and cultural world. Physical geography studies the earth systems that create natural environments.
- Earlier geography merely described places. Even though this is still a part of geography, the pattern of description has changed a lot in recent years.
- Geographical phenomena and processes are generally described by two approaches viz. (i) regional and (ii) systematic. Regional approaches are characterized by understanding the formation and characteristic of regions.
- Systematic approach is organized in terms of particular phenomena of general geographic significance. Each phenomena is studied in terms of the relations of its areal differentiations with the others.

- Geography has two main branches: Physical and human. Physical geography is further subdivided into several other branches namely geomorphology, climatology, oceanography, soil and biogeography.
- Human Geography is also subdivided into other branches like, cultural, population, social, economic and political.

## TERMINAL QUESTIONS

1. Define the term 'Geography'.
2. Why geography is called the mother of all sciences?
3. What are the two basic approaches in geography?
4. What are the four phases of development of geography?
5. Define the terms physical and human geography.
6. Why is human geography an important part of geography? Explain with suitable examples.
7. Distinguish between the followings:
   - i. Systematic and regional geography.
   - ii. Physical geography and human geography.
   - iii. Population and economic geography.
   - iv. Discuss the techniques of geographical studies.

## ANSWERS TO INTEXT QUESTIONS

**1.1.**

1. Geography is largely the study of the interaction of all physical and human phenomena and landscapes created by such interactions.
2. The Earth's surface is changing because of the continuous interaction between the environment in which we live in and the way we use it.
3. Eratosthenes

Notes

4. (a) Mathematical tradition,

   (b) Geographic information through travel and field work.

**1.2**

1. (i) Physical Geography

   (ii) Human Geography

   (iii) Biogeography

   (iv) Geographycal methods and teaching

2. (i) Regional studies

   (ii) Regional analysis,

   (iii) Regional development and

   (iv) Regional planning.

**1.3**

1. (i) Physical

   (ii) Human

2. (i) Quantitative methods

   (ii) Remote sensing/ GIS/GPS

   (iii) field survey methods

3. It deals largely with racial phenomena in their spatial context.

4. While other sciences deal with distinctive types of phenomena, geography studies several kinds of phenomena, each already studied by other sister disciplines. Thus in an integrated manner, geography as a discipline, analyses and synthesizes knowledge from diverse fields.

# MODULE -2

**Dynamic and Geomorphic Processes of the Earth**

# 2

# ENDOGENIC FORCES

You have already studied about the development of geography, its themes as well as different branches. This lesson belongs to the branch – Geomorphology. Your book laying on the table will remain there until you or someone else remove or shift it by applying some force. Only then the book's position will change. Its position may also change when the table itself is moved by any force. Movement of tables is caused due to internal mechanisms. Your hand is an external force which removes the book. Therefore, there are two types of forces – Internal and External. All the features observed on earth's surface are the results of the balance between these two types of forces. These forces are dependent upon numerous factors. Hence, it is necessary to understand the interior of the earth and internal forces in operation. Due to internal forces, the surface with sizable thickness is always on move. In this context, we will study the continental drift and its improvised version of plate tectonics. Its results like folds, faults and earthquakes are also there to study in this lesson.

## OUTCOMES

After studying this lesson, learner:

- explains changing temperature, rocks density, and state of matter in the interior;
- identifies endogenic forces shaping the earth;
- explains continental drift and mechanism of plate movement;
- describes fold, fault, their types their formation, and
- explains the causes, occurrences and spatial distribution of volcanoes and earthquakes.

## 2.1 EARTH'S INTERNAL FORCES

The features seen on earth's surface are the result of two types of forces – Endogenic (internal) and Exogenic (external). The forces which are generated from below the earth's surface are termed as endogenic forces. Forces which are operational on or above the earth's surface are known as exogenic forces. In this lesson, we are going to discuss Endogenic forces, while the exogenic forces will be covered in the next lesson.

You might be knowing that the temperature in the interior goes on increasing if we go from the earth's surface. Increase in temperature leads to expansion among rock molecules. Heat is transferred from the higher temperature to lower temperature areas. Since the temperature towards surface is lower in comparison to the internal parts, the dissipation of heat is possible only towards surface. In the process of heat transport, conventional current is produced. Once convection currents are created, it causes numerous changes.

## 2.2 EARTH'S INTERIOR

You might have watched volcanic eruptions on television or in movies. Huge amounts of molten material, dust particles, smoke and flame come out from the mouth called crater. In that way, we receive some internal materials on the earth surface. Beyond the depth of volcanic origin, there is no availability of materials on the earth surface for direct observation and analysis. The average radius of the earth is about 6371 km. Our reach in the interior is confined to the depth of mining and drilling. The material from that depth is available to us for study. Therefore, to know the interior, we have to take the help of different sources.

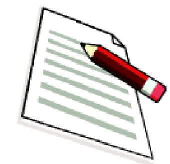
### A. Sources to Study Earth's Interior

Primarily, there are two types of sources by which we try to know the interior. They are Direct sources and Indirect sources.

**a. Direct Sources:** It is that source in which we get the materials from the interior into our hands. The material from the interior is available through mining, drilling or volcanic eruption.

i **Mining** : For a very long time, mining has been done at several places all over the globe. In mining, we dig the earth surface and extract ores or needed matter. Hence, we get the matter from below the surface into our hands. But the mining is confined to a little skin depth of earth's interior. Gaut gold mine of South Africa is the deepest. Its depth is around 3.8 km from the surface. With respect to the earth's radius, it is negligible.

ii. **Drilling :** Further deep materials are also brought to the surface by drilling. The deepest drilling has been recorded at north-eastern part of the Scandina-



Notes

vian landmass on Kola Peninsula in Russian territory. Its depth is more than 12.2 km from the surface. It is also very small in depth and not able to tell about the deep internal parts.

iii. **Volcanic Eruption :** Volcanic erupted materials are ejected from a much deeper part of the earth's interior. The exact deepest origin of the volcano is not known but it is also not very significantly deep in comparison to the earth's radius. Hence, it is also not of great importance to know the deep interior.

b. **Indirect Sources** The meaning of the term 'indirect' is quite obvious. It includes those sources which are studied based on certain scientific principles and investigations. The study of rock density, pressure and temperature at different depths are included. Let us study these sources.

i. **Density :** A rock is composed of a mineral or many minerals. The characteristics of minerals determine the nature of rock. The density of the rock is the property of rock's compactness. Density is defined as the relationship between the mass of the rock and how much volume it occupies. Thus, a rock with greater mass and lesser volume will become denser, whereas less mass with greater volume will lead to lesser density.

ii. **Pressure :** The rock of the interior is more compressed due to overlying rocks. Initially, it was believed that rocks of the interior are denser due to compression. But it is also scientifically proved that the density of the rock cannot be increased simply by compression or pressure beyond a certain limit.

iii. **Temperature :** It is observed that the temperature is increasing in the interior. The increase is about $3^{o}$ Celsius per 100 meter (or about 30 degree Celsius per km) of depth in the top layer only. This rising trend of temperature is not maintained for much deeper. On the basis of recent experiments, geo-scientists have calculated the temperature of the core to be around $5000^{o}$ Celsius with a variation of around $500^{o}$ Celsius.

## Relationships of Density, Pressure and Temperature with Depth

From the discussions made above, it is quite clear that all the three components are increasing with increasing depth. Their increase is not uniform continuously but with changing rates. Their relationships can be seen in given Figure.

**Relationships of Density, Pressure and Temperature with Depths in the Earth's Interior**

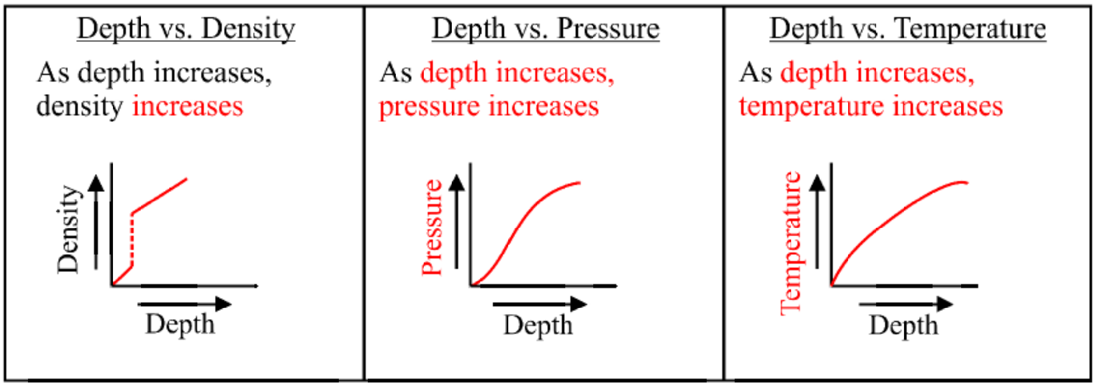



Fig. 2.1: Density, Pressure and Temperature with Depths

## INTEXT QUESTIONS 2.1

1. The sources to know about the earth's interior are: (a)............... (b) .............

2. The temperature increase in the upper crust is ............... C. Per Km.

## B. Seismology and Earth's Interior

Seismology is a branch of scientific knowledge to study the earthquake and its waves propagated through different parts and depths of the earth. An earthquake is a sudden vibration or shake of the ground of an area due to abrupt movement of landmass. This leads to earthquake waves. They are recorded by an instrument commonly known as seismograph.

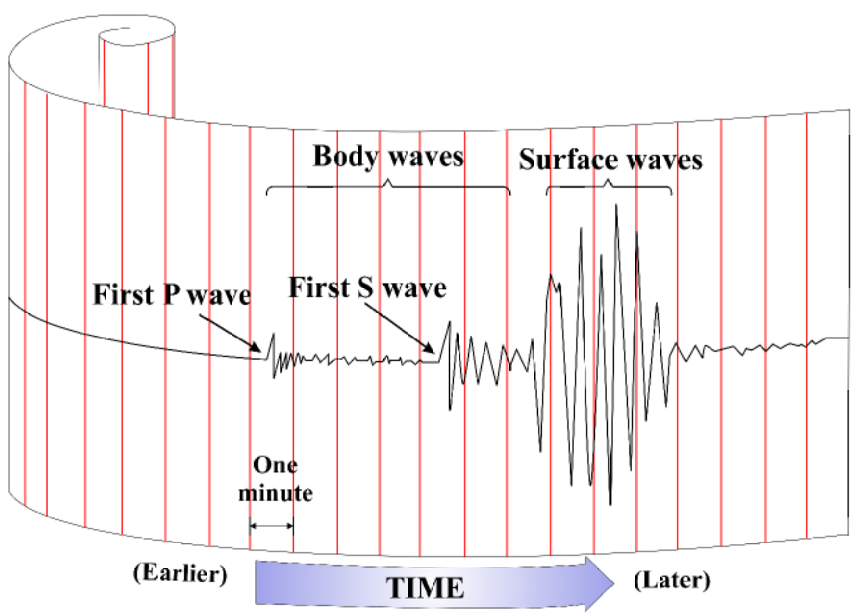



Fig. 2.2: An Ideal Seismograph

Notes

It is important to mention here that seismology is the only source by which the entire earth could be scanned. The scanning provides authentic and complete information about all parts and depths of the earth. Earthquakes originate from a depth below the earth surface. This depth could be anything from a few meters to hundreds of km.

The point from where the earthquake originates is known as focus (Figure 2.3). The shortest distance from focus to earth's surface (perpendicular distance exactly above from focus), is referred to as epicenter. Epicenter, being the closest place on the earth's surface, experiences the earthquake first. It is recorded later to places away from the epicenter. Principally, there are three types of seismic waves – Primary (P), Secondary (S) and Surface (L) waves which are recorded one after the other by the instrument.

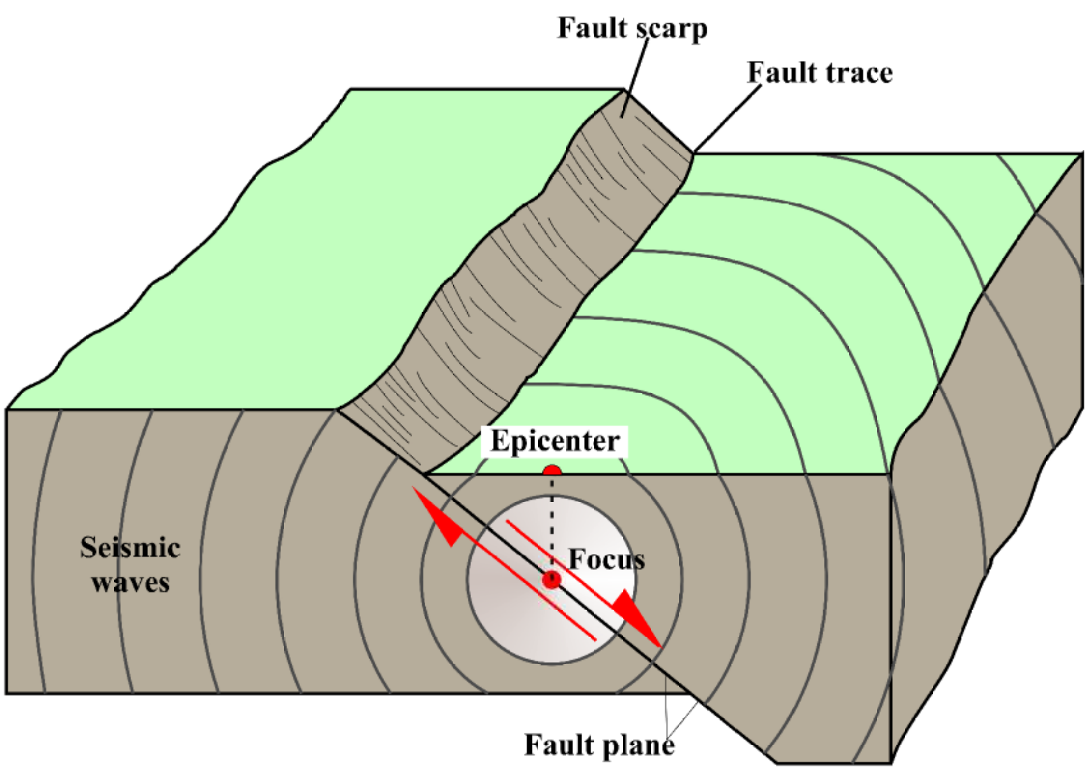



Fig. 2.3: Diagrammatic Presentation of Seismic Wave Propagation

### Primary (P), Secondary (S) and Surface/Long (L) Waves

Primary (P) waves are known as compressional waves. They are also termed as push and pull waves. It is like sound waves that we hear. Secondary (S) waves are known as transverse waves. These waves travel at right angles to the direction the wave propagation. These waves seem to be like the light waves. Surface waves travel through the earth's surface with a large distance. Hence, they are also known as long (L) waves. In fact, surface waves are a combined display of the P and S waves. The characteristics of these waves are given in Table 2.1.

Notes

Table 2.1: Characteristics of Seismic Waves

| Primary (P) Waves | Secondary (S) Waves | Surface/ Long (L) waves |
|---|---|---|
| Fastest wave and reaches first at the surface.<br><br>Travels in solid, liquid and gas medium of matters.<br><br>High velocity is in solid, becomes less in liquid and very slow in gas state of matter.<br><br>Increase in density of rocks, velocity increases and vice versa.<br><br>Change in the state of matter from solid to viscous or liquid, its velocity decreases even if the density is more.<br><br>Velocity of P waves varies from 5.5 km per second at or near the surface to 13.0 km per second in the deep interior. | Its velocity is lesser than Primary (P) waves. So it is recorded after P waves on the seismograph.<br><br>Travels only through the solid state of matter.<br><br>Increase in density of rocks, velocity increases and vice versa.<br><br>Once the state of matter changes from solid to viscous, its velocity is reduced. But when the rocks are melted, it disappears completely.<br><br>Velocity of S waves varies from 3.25 km per second at or near the surface to 7.0 km per second in the interior. | Its velocity is lesser than P and S waves. So, it is recorded after P and S waves on the seismograph.<br><br>Travels only through the solid state of matter.<br><br>Velocity varies from 2.0 to 4.4 km per second. |

## a. Seismology and Constitution of the Earth's Interior

The waves generated at the time of the earthquake radiate in all directions. They are along curved paths. Curvature of the paths is due to changing density from the earth's surface to the core. Due to refraction of the waves, S waves are not found beyond an angular distance of $105^0$ from the epicenter of the earthquake. In the same way, P waves are not traceable from $105^0$ to $140^0$ from the epicenter of the earthquake. These are known as shadow zones.

The interior of the earth is revealed by the nature of the propagation of P and S waves. Approximately at an average depth of 40 km, there is sudden increase in the velocity of both waves which suggests sudden increase in density of rocks.

At a depth of around 100 to 250 km, the velocity of both waves starts declining and after around 700 km velocity again becomes higher. Decreasing velocity between these depths indicate that the matter of rocks is semi-solid. Because of this the velocity of both waves declines. This low velocity zone is known as the nosphere. It is also named as the transition zone.

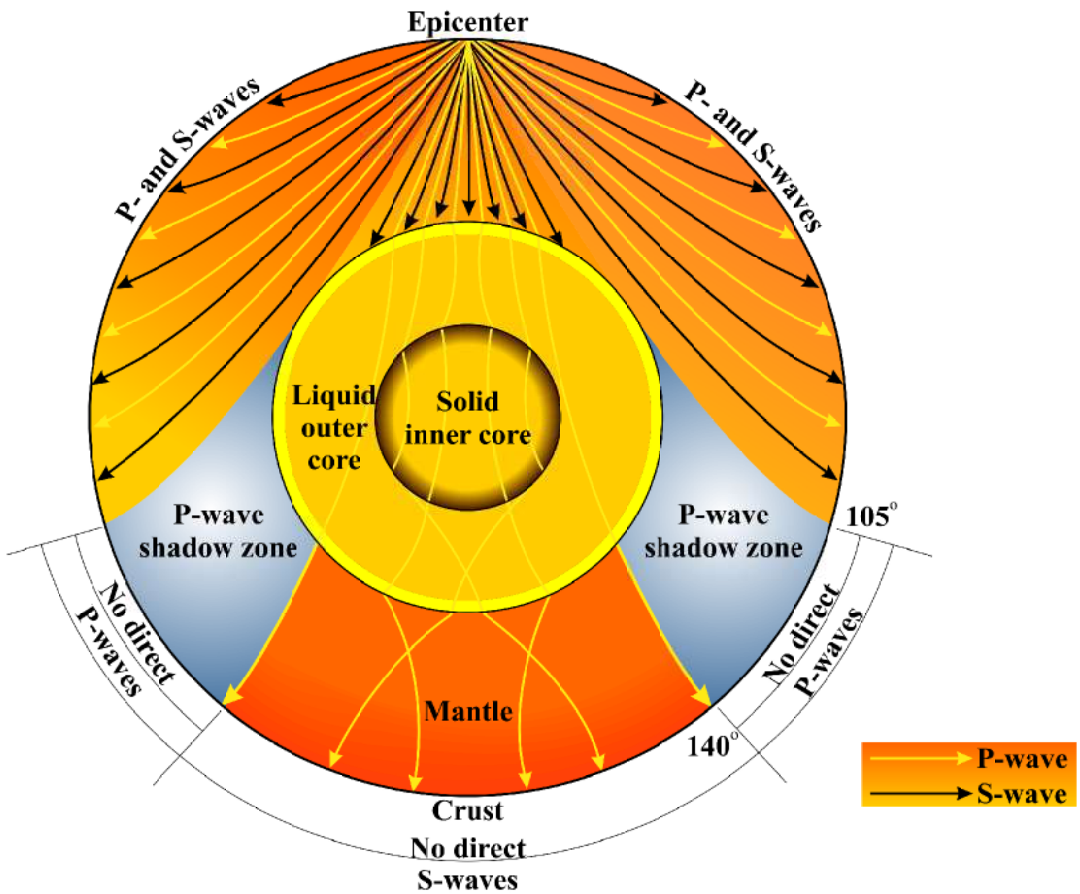



Fig. 2.4: Propagation of P and S Waves in the Interior

Further the velocity of both waves increases continuously until a depth of 2900 km. Increasing velocity shows that the density is higher and the state of the rocks is solid. From 2890 km to 2900 km, the rocks are again almost in a plastic state, i.e., neither solid nor liquid. It is termed as Gutenberg discontinuity.

Beyond the depth of 2900 km, there is no trace of S waves and the velocity of P waves declines very drastically. The rock at this depth is melted and the S wave does not travel in liquid. Reduction in the velocity of P waves is also due to the changing state of the matter or rocks. At around 5150 km depth, the velocity of the P waves increases. This is proof that the rocks become solid again.

## INTEXT QUESTIONS 2.2

1. Name the earthquake measuring instrument.
2. 'P' waves travel in .................. layer/layers and 'S' waves travel in ................ layer/layers.

### b. Chemical Composition of the Earth

There are three major and almost concentric layers in the earth. These are explained by Swiss and they are SIAL, SIMA and NIFE.

**SIAL:** It is the topmost layer of the earth found just below the sedimentary thin cover of the crust. Silicon (Si) and Aluminum (Al) are the two very important elements found in abundance in this layer and so they are named as SIAL. The average density of this layer is 2.75 to 2.90 g/cm$^3$ and its average depth is 40 km. It is very thin below the oceanic bed (5 to 10 km) but below the mountains, it is very thick (up to 70 km). The main rock occupying here is of granite types.

**SIMA:** It is the second layer after SIAL from the surface. It is named after Silicon (SI) and Magnesium (MA) as both of these elements are very much abundant in this layer. It is a very thick layer which goes almost up to 2900 km depth. Below the continents, it starts from an average depth of 40 km while below the oceans, it is found at about 0 to 5 km depth. Its average density varies from 2.90 g/cm$^3$ to 4.75 g/cm$^3$. The main rocks in this layer are silicates of magnesium and iron. This layer is largely composed of basalt.

**NIFE:** It is the innermost layer of the earth. This layer is made up of Nickel (NI) and Ferrous (FE) and so it is named as NIFE. It is just below the SIMA from a depth of 2900 km to the earth's centre. Nickel and Ferrous are very heavy and dense elements and therefore this layer has higher density. Its density is about 11 to 12 g/cm$^3$.

### c. Earth's Internal Structure

The study of the propagation of seismic waves in the interior enabled the scientists to theorize about its structure. Based on the abrupt changes in the paths of seismic waves, the structure of the earth has clearly been demarcated into three zones. They are Crust, outer and a very thin layer including our earth surface; Mantle, an intermediary layer thick with large volume of rocks below the crust; Core, the innermost layer which is spread all-around the center of the earth.

i. **The Earth's Crust:** The earth's crust is the outermost and the thinnest layer with an average depth of 5 km below oceans and 40 km below the continents. Its depth reaches about 70 km below the mountains. Apart from a very thin sedimentary layer on the continental crust and adjoining ocean floors, it is primarily composed of igneous and metamorphic rocks. The density of the crust at the surface is 2.7 g/cm$^3$ and at the bottom limit, it is 2.9 g/cm$^3$. The demarcating limit is known as Mohorovicic (Moho) discontinuity from where mantle starts.

ii. **The Mantle :** Just after the upper layer, i.e., crust, the density of the mantle at the boundary increases to 3.0 g/cm$^3$. It extends from the base of the crust to about 2900 km below the surface and occupies over 80% of the earth's volume and 65% of the total mass. Mantle is composed of ultramafic rocks which are igneous in nature and very rich in minerals constituting magnesium and iron with very low silica content. Roughly up to a depth of 100 to 250 km from the surface of the earth, the rocks are firm, solid and rigid. It is termed as lithosphere. Below this depth, the state of the matter is partially molten and plastic in behaviour. This plastic and semi-solid belt extends about a depth of 700 km. It is known as the asthenosphere from this depth to about 2900 km. the state of rock is rigid and solid. It is termed as mesosphere.

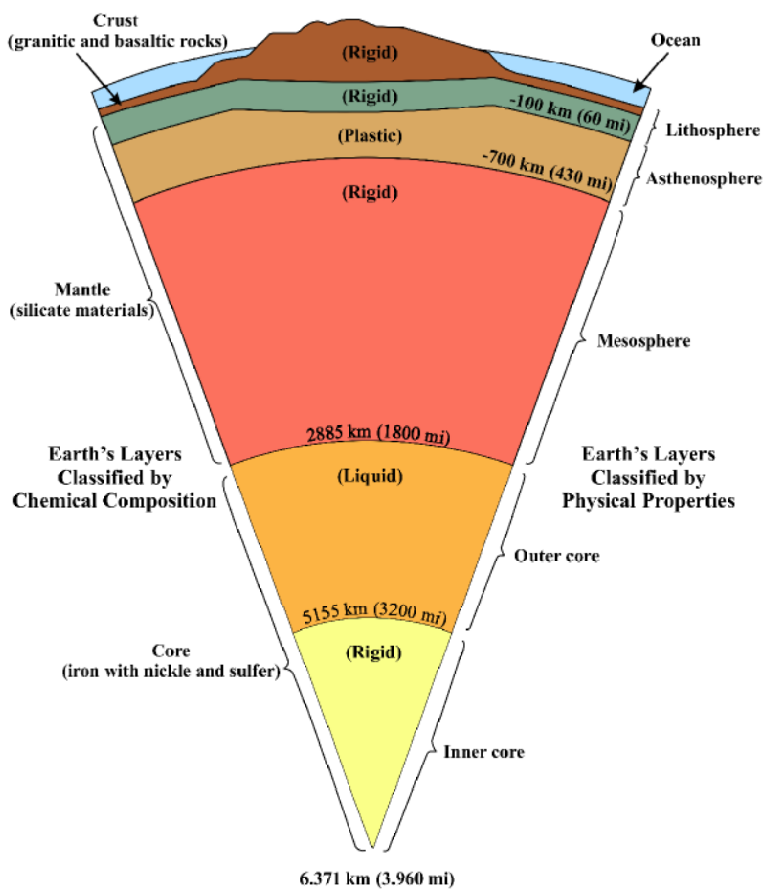



Figure 2.5: Earth's Internal Structure

*Notes*

Notes

**iii. The Core** : It is the innermost layer of the earth starting from 2900 km to the centre (6371 km). It has a volume of only 17% of the earth but it contains 34% of the mass. It is because of the very high dense materials lying over there. The density of the core at the outer boundary is about 10 $g/cm^3$ and in the innermost part it is 13$g/cm^3$. The core is made up of iron and nickel. It is divided into layers upper and lower.

## INTEXT QUESTIONS 2.3

1. Name different layers of earth explained by Swiss.
2. Earths core starts from .................. km.

## 2.3 CONTINENTAL DRIFT

As the term itself is self-explanatory – "continental drift". It means continents are drifting or shifting their positions with passage of time.

Alfred Wegner was first to introduce the concept of Continental Drift in a detailed and comprehensive manner in 1912. He was a German meteorologist and geophysicist and was studying the distribution of plants over the globe. During his study, he was trying to study the plant's fossils underlying in the sedimentary rocks of the east and west coasts of the Atlantic Ocean. He came across the similarity between the two coasts in terms of plant fossils and geology. On the basis of this study, he proposed the concept of continental drift.

According to Alfred Wegener, the entire landmass of the globe was together about 200 million years ago. He termed it Pangea, a super continent of the beginning. The huge water body surrounding the Pangea was known as Panthalasa. About 135 million years ago, Pangea was broken latitudinally into northern and southern parts known as Laurasia (Angaraland) and Gondwanaland, respectively. Both of them drifted away and in between a shallow sea emerged by filling up the water from Panthalasa. It was known as Tethys Sea. Later on Laurasia and Gondwanaland were rifted and finally drifted to form the present day distribution of land and water on the earth.

Notes

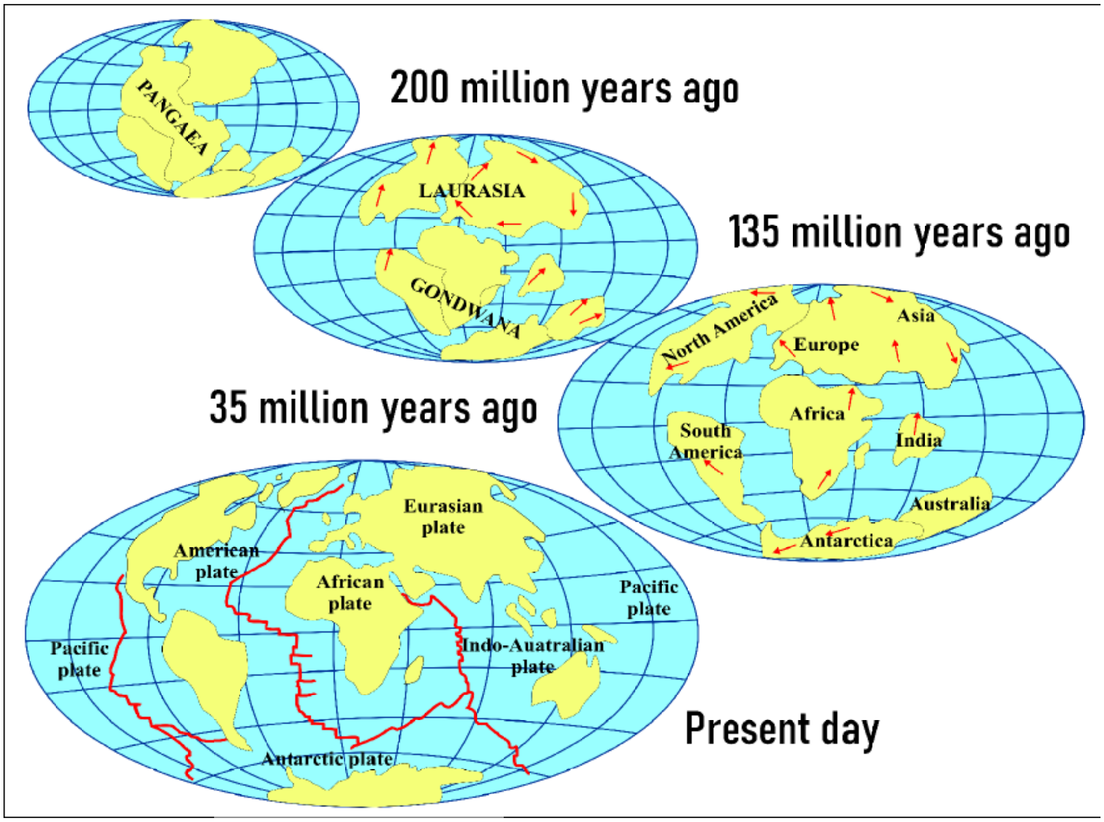



Fig. 2.6: Continental Drift through Time

## Evidences of Continental Drift

While proposing his hypothesis, Wegener presented several pieces of evidence of continental unification a long time back which later on drifted away. The evidence was- quite convincing and it was widely accepted. They are:

**Jig-saw-fit:** Both coasts of the Atlantic with South America and Africa are identical and fit very well. This fitting is said to be a jig-saw-fit. It means, as a piece of wood cut in a zigzag way can be jumbled together and that fits as well to form one unit. In the same way, continents broken by endogenic forces are dragged in different directions and could easily be matched.

**Geological Matching:** There is a very high degree of similarity in terms of the mountain systems of South America and Africa. The mountain system of South Africa is continuing in Argentina of South America. The geological characteristics found in the Appalachian region of North America are found continuing in the British Isles and Scandinavia of Europe.

Notes

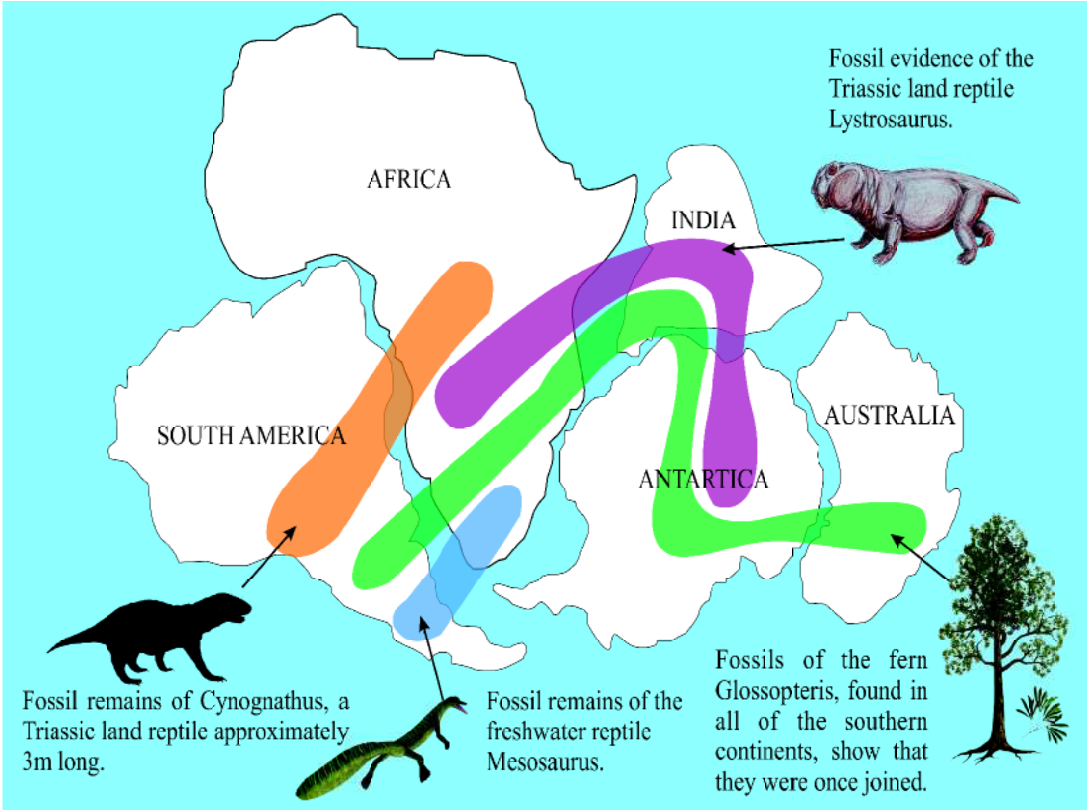



Fig. 2.7: Jig-Saw-Fitting of the Continents

**Coal and Vegetation evidence:** The distribution of coal and vegetation over South America, Africa, India and Australia proves that they were together in the geological past. The classical glacial deposits during the carboniferous period over these landmasses resemble each other which tell the story of togetherness. Today they lie in different climatic zones.

## 2.4 PLATE TECTONICS

Continental drift was well accepted for about 50 years from Wegner's proposal in 1912. During this period, numerous scientific studies were conducted like convectional current theory, sea-floor spreading and paleomagnetism. These studies help the scientists to propose the theory of plate tectonics.

According to plate tectonic theory, the earth surface is composed of several plates. Plates are the solid and rigid upper part above the asthenosphere segmented into several blocks. Those blocks are known as lithospheric plates.

Notes

## A. Major and Minor Plates

There are seven major plates. They are: Eurasian, African, Indo-Australian, Pacific, North American, South American and Antarctic Plates. Apart from above seven major plates, there are about 20 minor plates. A few important among them are: Arabian, Caribbean, Scotia, Nazca, Cocos, Juan De Fuca, Philippine, Caroline, Bismarca, Fiji etc.

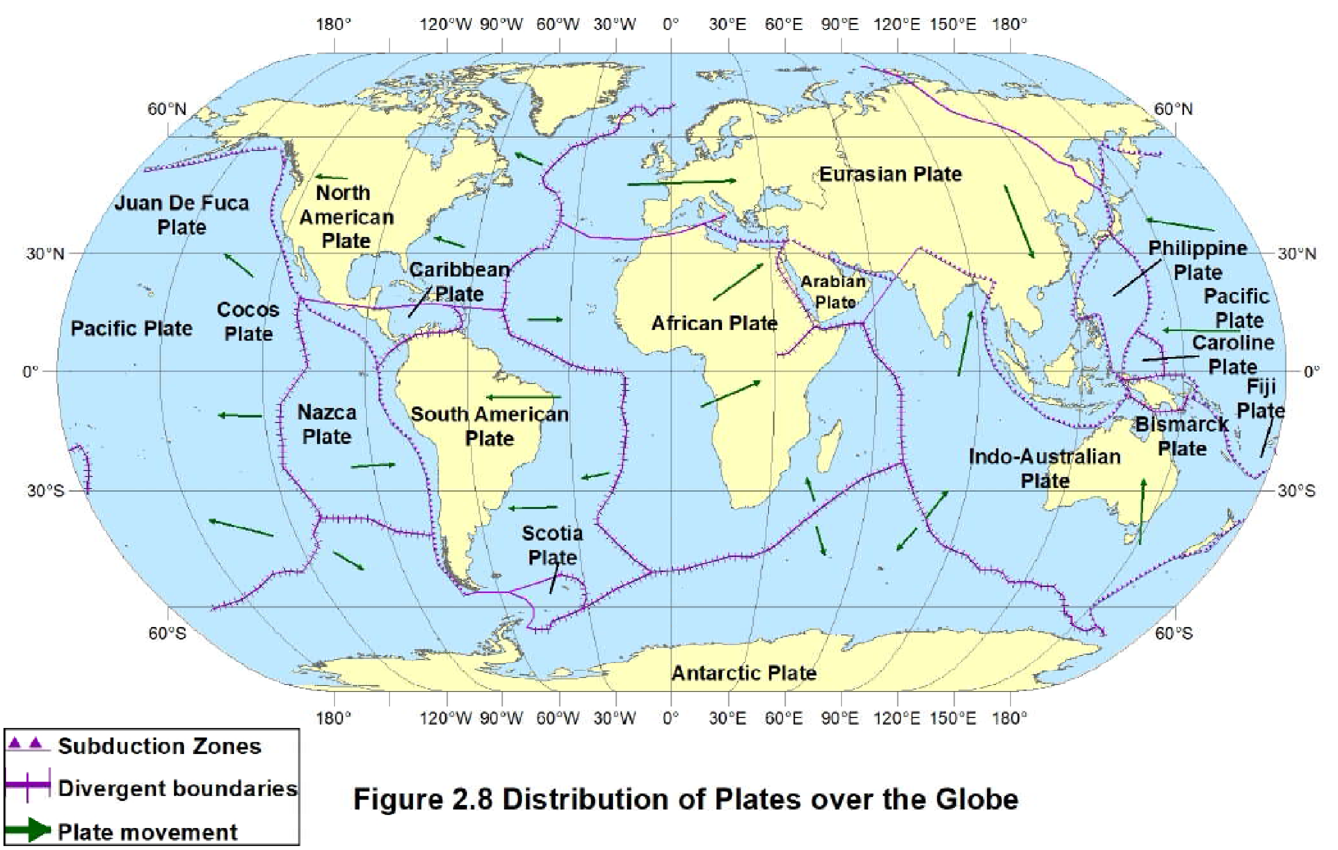



Figure 2.8 Distribution of Plates over the Globe

Fig. 2.8: Distribution of Plates over the Globe

Plates constitute the entire surface of the earth. Plate's thickness is about 100 to 250 km deep from the surface. Below it, the state of the matter is viscous/semi-solid over which plates are moving.

## B. Mechanism of Plate Movement and Associated Features

British geologist Arthur Holmes proposed the existence of convection currents underneath the lithosphere. It is getting generated from the asthenosphere by the excessive

Notes



heat available there. The excessive heat is dissipated towards the surface.The convection currents are classified into two rising and falling with divergence and convergence actions respectively.

**Divergent Plate Boundary**: With rising convection currents, transport of hot and viscous rock material is brought to the surface by splitting it. The molten material penetrates into the split. Hence, a new surface is created and the mammoth sized plate is pushed apart. It happens below the mid-oceanic ridge. It is called a divergent plate boundary. It is also termed as a constructive boundary.

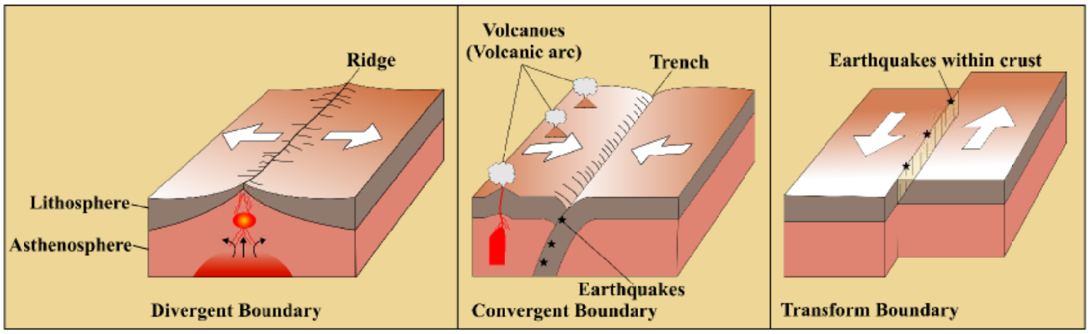



Fig. 2.9: Types of Plate Boundaries

**Convergent Plate Boundary**: When two sets of convection currents bring two plates together, it is called convergent plate boundary. At this boundary, subduction of plate or formation of mountain is seen. Because of this process, the surface area is reduced or destroyed. Hence, it is termed as a destructive plate boundary.

**Transform Plate Boundary**: Sometimes plate boundary and plate margin are used as synonymous. But for practical purposes, boundary is a thin line separating the plates whereas margin is an area or zone along the plate boundary. The earth's surface is of two types – land and water. In the same way, the boundary of the plate is also of two types – oceanic and continental.

Due to differential magma ejection along the divergent plate boundary, the differential departure of the plate segment is also observed. This boundary is known as the transform boundary. Along this boundary, neither surface is created or destroyed. Therefore, it is also termed as conservative boundary.

## C. Plate Boundaries and Associated Features

Plate boundaries and activities along them are explained above. Due to different actions, different types of features are formed. They are given in Table 2.2:

Table 2.2: Characteristics of Plate Boundary and Feature Resulted

| **Activities** | | **Types of Boundaries** | |
|---|---|---|---|
| | **Divergent** | **Convergent** | **Transform** |
| Movement | Plates going apart | Plates coming closer | Lateral sliding |
| Zone known as Effects | Constructive<br>New surface creation | Destructive<br>Surface loss, lowering of plate into the interior, mountain formation | Conservative<br>Side by side sliding of plates |
| Features formed | Fault, mid ocean ridge | Trench formation, volcanic islands | No major feature |
| Volcanism | Yes | Yes | No |
| Earthquake | Yes | Yes | Yes, but minor |

## INTEXT QUESTIONS 2.4

1. Who introduce the concept of continental drift.

2. Name any two pieces of continental drift.

   (a)...................... (b) ..........................

3. Plate boundaries are:

   (a) ................. (b) ................ and (c) ......................

## 2.5 FOLDS AND FAULTS

Folds are formed when flexible rocks are subjected to compression due to endogenic forces. faults are caused when tough or rigid rocks are broken due to endogenic forces.

### A. Folds

Fold is that surface of the earth which is wavy and undulating. Wavy or undulating structure is formed because of compression. Generally, the folding occurs in sedimentary rocks. In folds, there are several layers from surface to inner side. Surface layers are newest in terms of formation while the inners are older by age.

Folds are upward and downward in appearance. Upward formation is known as anticline while the downward shape is termed as syncline; both the limbs are called hinge zones. When an imaginary line is drawn to separate the fold into two parts, it is called the axial plane. This description is very well understood from Figure.

**Types of Folds:** Depending on the appearance of the fold and its angle, folds are put into following types:

a. **Symmetrical Fold**: Both sides are similar in terms of length and angle of inclination.

b. **Asymmetrical Fold**: Both sides are dissimilar in terms of length and angle of inclination. One limb is smaller than the other. Smaller side is steeply sloped while the longer side is gently sloped.

c. **Overfold**: When the greater force of compression is operational from one side the fold keeps on turning to the other side and thus inclination is observed. In this fold the turning of the side is more than 90 degrees, and the overturned fold becomes visible.

d. **Recumbent Fold**: When overfold is further intensified, the greater - turned side overlies the other side. In this way, the layer becomes almost horizontal.

e. **Overthrust Fold**: Further intensification of force causes to overthrusting of the overlaying limb. In this case, due to more and more compression, the layer is so stretched that it is about to break but not broken. But when it is broken, it no longer remains a fold, but becomes faulty. It is called nappe which is dealt under fault.

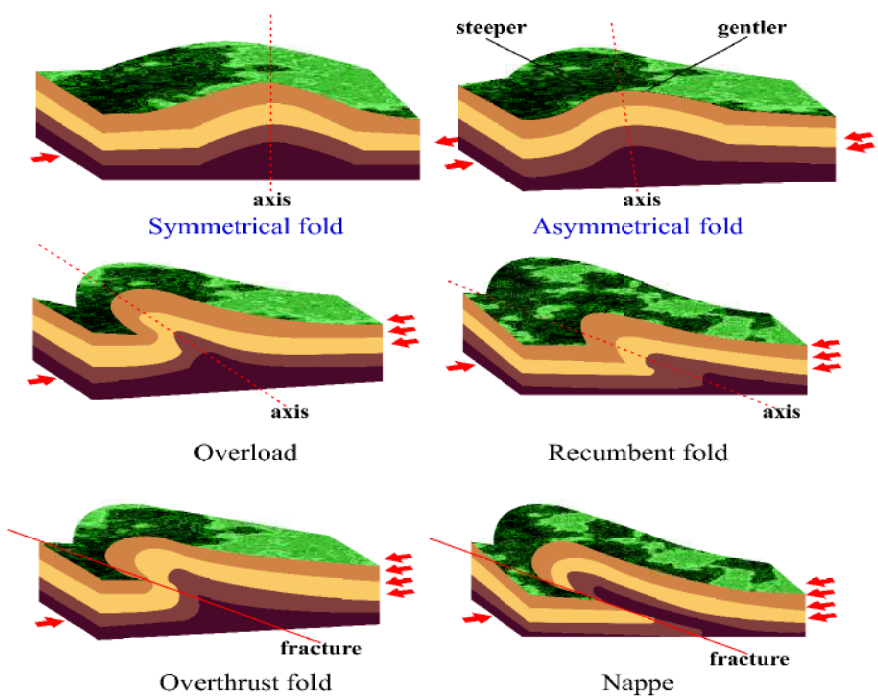



Fig. 2.10: Types of Folds

Notes

**Features formed by Folds:** Fold Mountains are formed by the process of folding. Most of the mountains found on the globe belong to this category. The surface area is reduced when folds occur because of the inclination of the crust. In terms of plate tectonics, it is called the zone of convergence or the zone of reduction of the horizontal distance of the crust.

## B. Faults

Due to internal forces, when the earth's crust bends, a fold is formed, but when it cracks or gets separated, it is called a fault. In this process, minor to significant displacement of crust is resulted. Faults occur due to tension as well as compression both.

### Types of Faults

According to the way of formation of the faults, they are grouped under the following types:

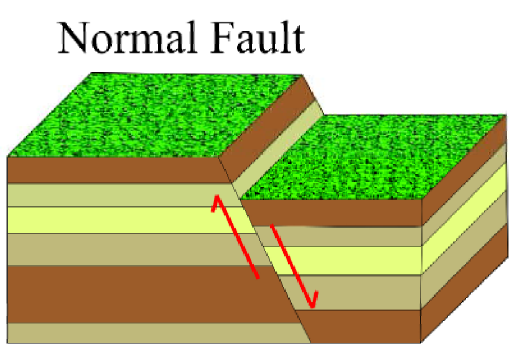
a. **Normal Fault**: Normal fault is formed due to tensional force caused from the interior. In this fault, there is an increase in the surface area.

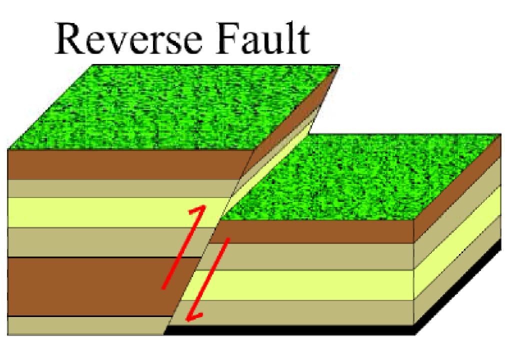
b. **Reverse Fault**: Reverse fault is formed due to compressional force caused from the interior. In this fault, there is shortening in the surface area.

c. **Strike-slip Fault**: In strike-slip fault, the crustal block/mass slips past one another. It is also called a lateral fault.

d. **Oblique Fault**: In oblique fault, the crustal mass is shifted not only away like the normal fault but also gets rotated by sideways movement. For this, just compare the movement in normal fault and oblique fault shown in Figure.

e. **Nappe**: Refer to Figure 2.14. Because of excessive force, when the limb of the fold is broken, it gets detached and thrown away from its original position. This breaking no longer remains a fold but it turns into a fault known as nappe.



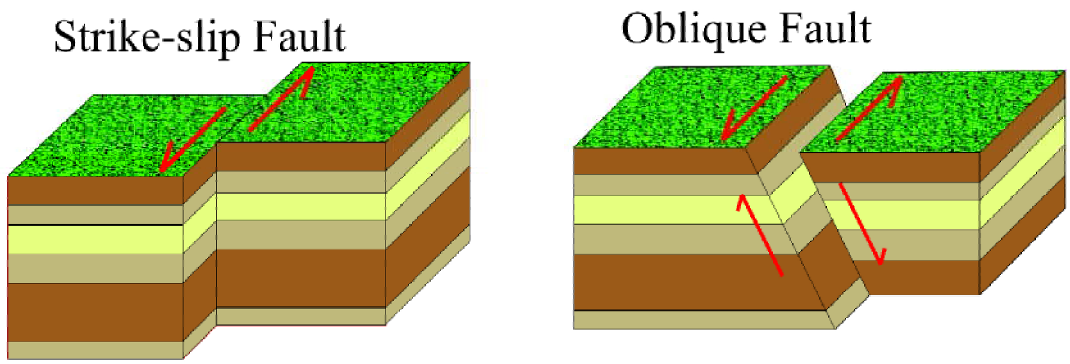



Fig. 2.11: Types of Faults

### Features formed by Faults

Two types of features are formed due to faulting. One is depressed called graben or rift valley and the other is elevated called horst. When there is normal faulting, the downthrown side with respect to other forms the graben through which rivers generally occupy. When the widening of the depressed/ downthrown side gets widened, it becomes a rift valley. When there is an upthrown-side with respect to other forms, horst. Horst is also sometimes known as Block Mountain if the height is more.

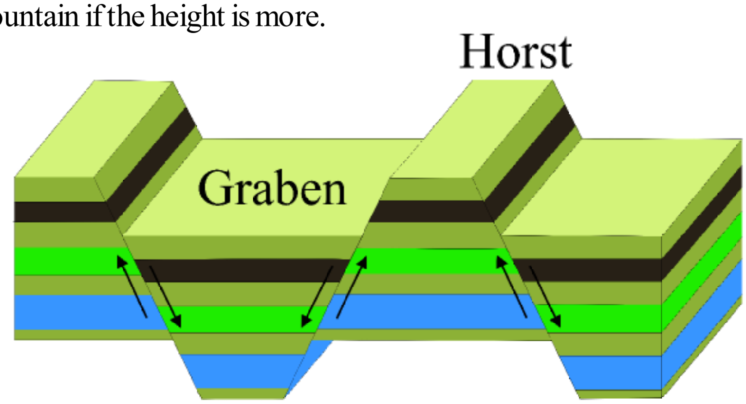



Fig. 2.12: Graben and Horst

## INTEXT QUESTIONS 2.5

1. Upward formation of fold is ................ and downward is...............

2. Name any three types of fold.

   (a) .................. (b) ...................... and (c) .........................

3. Name any three types of fault.

   (a) .................. (b) ...................... and (c) .........................

Notes

## 2.6 VOLCANOES

A volcano is a vent or an opening in the earth's crust through which molten rock material, rock fragments, ash, steam and other hot gases are emitted slowly or forcefully. These materials are thrown out from the hot interior of the earth to its surface. Such vents or openings occur in those parts of the earth's crust where rock strata are relatively weak.

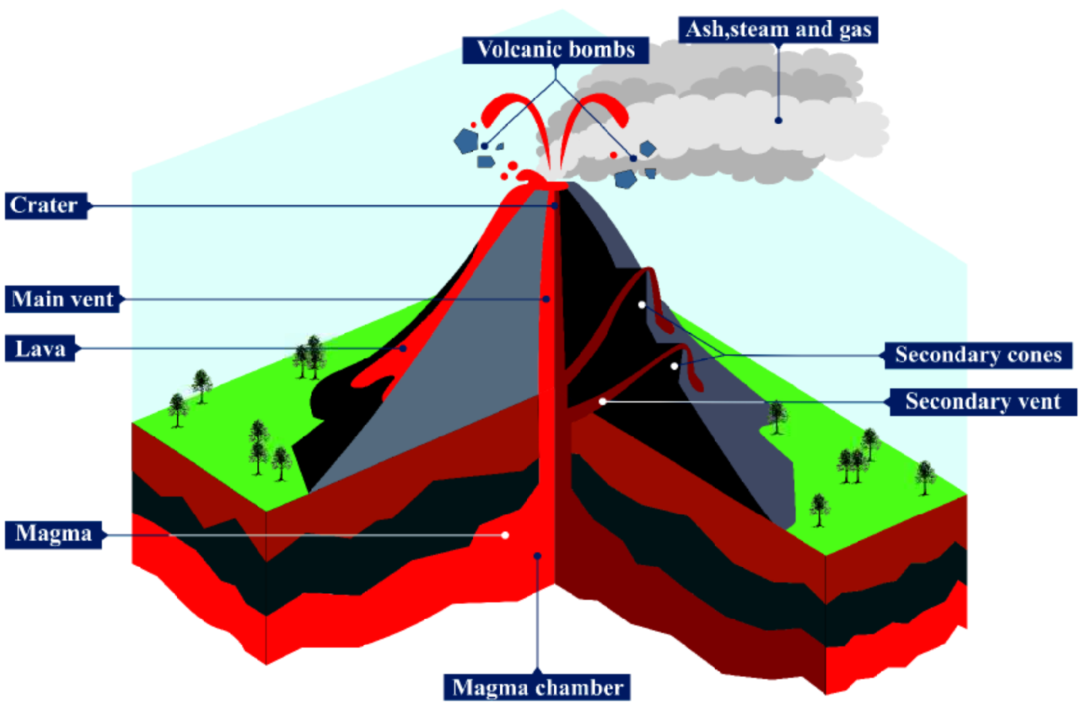



Fig. 2.13: Volcanoes

You may be wondering why such eruptions take place. Hot and molten rock material beneath the solid outer crust is known as magma. When this magma is thrown out to earth's surface, it is known as lava. The tremendous force created by magma and gases break the crust. Magma appearing on the surface is termed as lava. The process by which solid liquid and gaseous materials escape from the earth's interior to the surface of the earth is called volcanism. The volcanic materials gets accumulated around the opening or hole and form a cone. The top of the cone has a funnel shaped depression. It is called its crater.

**Types of Volcanoes:** Volcanoes are classified on the basis of the nature of volcanism . It includes frequency of eruption, mode of eruption or fluidity and the manner in which volcanic material escapes to the surface of the earth.

### A. On the basis of the frequency of eruption, volcanoes are of three types

a. **Active**: This category of volcanoes erupts frequently or has erupted recently.

Important among these include Stromboli in Mediterranean, Krakatoa in Indonesia, Mayon in Philippines, Mauna loa in Hawaii Islands and Barren Island in India.

b. **Dormant**: The volcanoes which have not erupted in recent times are known as dormant volcanoes . They are termed as such the 'sleeping volcanoes'. Important among these are Vesuvius of Italy, Cotopaxi in South America.

c. **Extinct**: Contrary to these two, there are volcanoes which have not erupted in historical times. They are called extinct volcanoes. Mount Popa of Myanmar and Kilimanjaro of Tanzania are important extinct volcanoes.

## B. On the basis of mode of eruption

a. **Central Eruption**: When the eruption in a volcano takes place from a vent or a hole, it is called a central type of volcano. Different types of domes or conical hills are formed by this type of eruption depending on the nature of erupted materials. The other characteristics of this mode of eruption are marked by violent explosions due to sudden escape of gases and molten rocks. Visuvious and Fuji-yama belong to this group of volcanoes.

b. **Fissure Eruption**: Sometimes, deep elongated cracks develop due to endogenic forces discussed above in plate tectonics. In this process, magma is expelled through long fissures. Therefore, it is termed as fissure eruption. When lava is spread over a large area, it is called lava plateaus. Deccan Traps of India is one example of fissure type of eruption.

## C. On the basis of the fluidity of lava

a. **Volcanoes of acid lava**: Acid lava is rich in silica and has a relatively high melting point. Therefore, it is highly viscous and solidifies quickly. Hence, the acid lava volcanoes cause the formation of usually higher domes with steeper slopes.

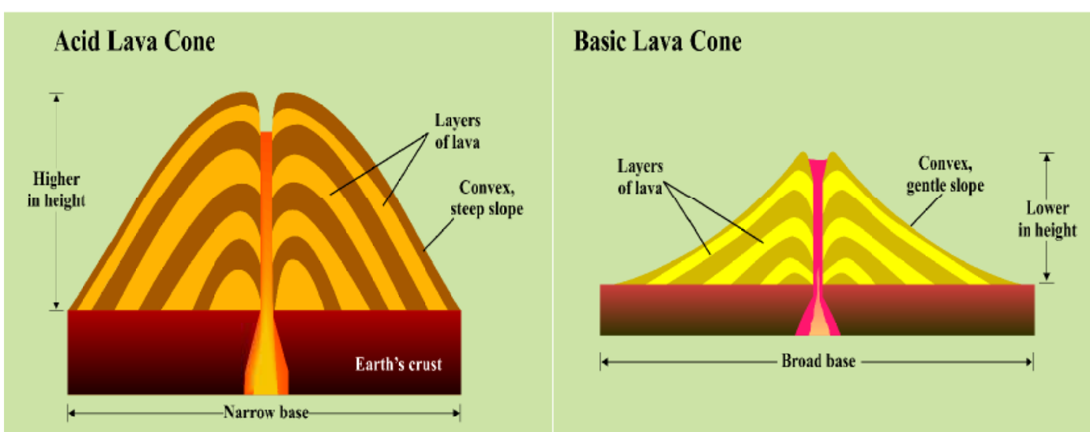



Fig. 2.14: Acidic and Basic Lava Cone

b. **Volcanoes of basic lava**: Since the basic lava is rich in metallic minerals and has a low melting point, it has greater fluidity. In this type of eruption, lava flows far and wide quietly with greater speed and spreads out in thin sheets over a large area. Thus, it leads to the formation of shields and lava domes. The shield volcano of Hawaii Island in the Pacific Ocean is one of these volcanoes.

**Distribution of Volcanoes:** Most of these volcanoes are found in three well defined belts. First, the Circum-Pacific region has the greatest concentration of volcanoes.That is why; it is called the- 'Pacific Ring of Fire'. This ring extends along the Andes Mountains of South America to Alaska and from the Aleutian Islands to Japan, Philippines, and Indonesia to New Zealand. The Mid-world mountain belt occupies the second position with regard to the numbers of volcanoes. It runs from the Alps in Europe to the western parts of South west Asia. The African rift valley region ranks third.

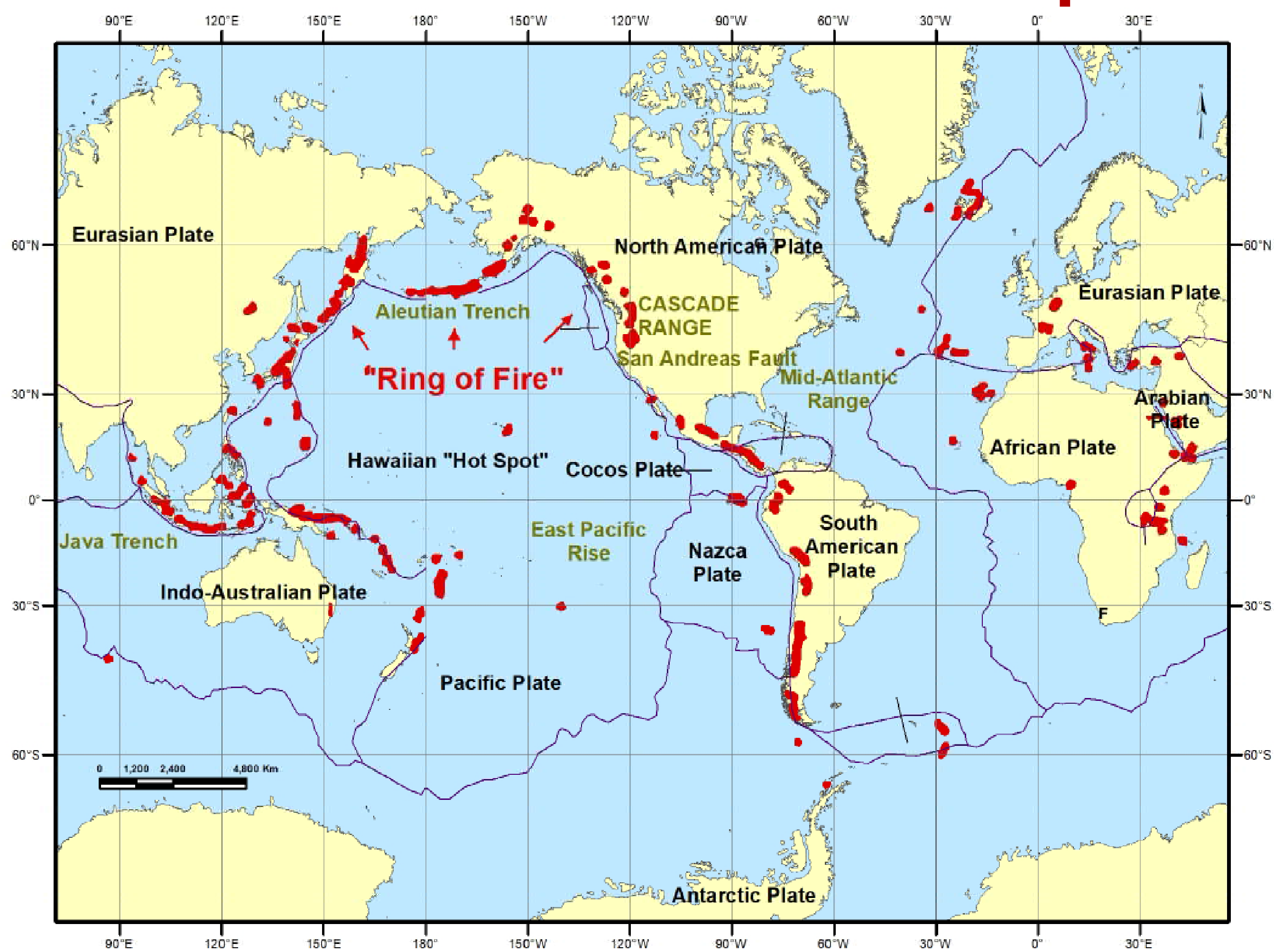



Fig. 2.15: Distribution of Volcanoes and Earthquakes

## 2.7 EARTHQUAKES

An earthquake is a sudden shaking of the ground surface, ranging from a faint tremor to a wild motion. The frequency of earthquakes varies largely from place to place. The network of seismographic stations all over the world records hundreds of earthquakes every day. But, occurrences of severe earthquakes are limited. The intensity is the highest at or near the epicentre. That is why the maximum destruction occurs at and around the epicentre.

**Causes and Effects of Earthquakes** : Endogenic forces are the main cause of earthquakes. It results in folding and faulting. Sudden shift or movement in the crust causes the surface to shake. The second important cause is volcanic eruption. The violent volcanic eruption causes vibrations in the earth's crust. The earthquakes are limited to the areas of volcanic activity.

Violent earthquakes are very disastrous. They may themselves cause land-slides, damming of river courses and occurrence of floods. It changes the drainage system of an area as was witnessed in Assam after its 1951 earthquake. The sea waves caused by earthquakes prove most catastrophic in coastal regions. Such tidal waves are called Tsunamis. These waves may wash away coastal cities. Buildings and bridges collapse causing the death of thousands of people. Lines of transport, communication and of electric transmission get disrupted.

**Distribution of Earthquakes** :The occurrence of earthquakes is a phenomenon in almost every part of the world. But, there are two well-defined belts where they occur more frequently. These belts are the Circum-Pacific belt and the Mid-world mountain belt.The Circum Pacific belt comprises the western coast of North and South America; Aleutian Islands and island groups along the eastern coasts of Asia such as Japan and Philippines. As it encircles the Pacific Ocean, it is named so. The earthquakes in this belt are associated with the convergence boundary of the plates. It is estimated that about 68 percent of earthquakes of the world are occurring in this belt alone.

The second belt extends from the Alps with their extension into the Mediterranean the Caucasus and the Himalayan region and continues to Indonesia. About 21 percent of total earthquakes of the world originate in this belt. Remaining 11 percent occurs in the other parts of the world.

### INTEXT QUESTIONS 2.6

1. Krakatoa is a/an ..................volcano and Kilimanjaro ss a/an .................... volcano.
2. Acidic lava forms ................ cone while basic lava
3. Name any two effects of earthquake.

Notes

## WHAT YOU HAVE LEARNT

- The interior of the earth is studied based on two types of sources – direct and indirect.
- Study through mining, drilling and volcanic eruptions comes under direct sources while knowing interior by the study of density, pressure and temperature is grouped under indirect sources.
- Seismology is another indirect source which scans the entire earth and tells about it completely.
- Seismic waves are recorded by seismograph in detail and studies by seismologist.
- There are three types of seismic waves - 'P', 'S' and 'L' waves.
- 'P' and 'S' waves are known as body waves as they travel in the interior while 'L' wave are termed as surface waves as they travels in the top layer of the earth surface.
- Based on the chemical characteristics of the rocks found at different depths, earth is divided into three layers SIAL (silicon and aluminium), SIMA (silicon and magnesium) and NIFE (nickel and ferrous).
- Based on the change in the seismic waves velocity in the interior, earth is divided into three layers.
- They are crust – top thin solid later, mantle – top solid, intermediary viscous and again solid denser rocks and core- highly sense rocks with outer liquid and inner solid and abundance of nickel and ferrous.
- The top layer of around 100 to 250 km depth, continents are mobile and it has been proposed by Alfred Wegner with sound evidence.
- Later on it was modified into plate tectonics based on newer researche conducted after the continental drift proposition.
- There are seven major plates such as - Eurasian, African, Indo-Australian, Pacific, North American, South American and Antarctic Plates.
- Apart from them, about 20 minor plates are there with which the surface of the earth is composed of.
- Due to magma coming out along the mid-oceanic ridges, divergence and convergence of plates are eminent.

*Notes*

- At both the boundaries – convergence and divergence, different types of features are formed. Due to divergence and convergence of plates folds and faults are resulted and different types and faults are seen.

## TERMINAL QUESTIONS

1. Describe the interior of the earth on the basis of seismic evidence.
2. Explain seismic wave propagation with changing density and state of rocks in interior.
3. Illustrate the characteristics of seismic waves.
4. Examine the chemical composition of the earth's interior.
5. Evaluate the concept of continental drift by giving approprate evidences.
6. What is a plate? Explain its mechanism, and features formed at plate margins.
7. What is fold and how are they formed? Describe the types of fold.
8. What is the fault and how are they formed? Describe the types of fault.
9. Explain the distribution of earthquakes with respect to plate tectonics.

## ANSWERS TO INTEXT QUESTIONS

**2.1**

1. a. Direct

   b. Indirect

2. 10 degree

**2.2**

1. Seismograph
2. All (crust, Mantle and core), top two (crust and mantle)

**2.3**

1. a. SIAL b. SIMA and c. NIFE
2. 2900 km

*Notes*

**2.4**

1. Alfred Wegner
2. Any two
   a. Jig-saw
   b. Geological Matching
   c. Coal and vegetation endemics
3. a. Divergent
   b. Convergent
   c. Transform

**2.5**

1. Anticline and syncline
2. Any three
   a. Symmetrical
   b. Asymmetrical
   c. Overfold
   d Recumbent
   e. Overthrust.
3. Any three
   a. Normal
   b. Revere
   c. Strike slip
   d. Oblique
   e. Nappe

**2.6**

1. Active and Extinct
2. Sleep and Flat

*Notes*

3. Any two

   a. Landslide

   b. Jamming of river course

   c. Occurrence of floods

   d. Damage to life and property

   e. Any relevant effects.

3

# EXOGENIC FORCES AND THEIR RESULTANT LANDFORMS

You have learnt in the previous lesson that the vertical irregularities on the earth's surface are the result of interplay between endogenic (internal) and exogenic (external) forces. The significant endogenic processes include diastrophic (slow) and catastrophic (sudden) processes. Endogenic processes are considered as constructional processes as these produce surface irregularities in the form of mountains, plateaus, depressions, faults, folds, etc. on the earth's surface. In contrast to this, exogenic processes are called as gradational or plantation processes because these are continuously engaged in wearing down vertical irregularities created by endogenic processes through denudational mechanisms (including both weathering and erosion) and depositional processes. So, the endogenic and exogenic processes are considered competing forces which are engaged in continual conflict and this continuous interactions between endogenic and exogenic processes produces complex sets of physical landscapes on the surface of the earth. These landforms are not only the physical features of the earth's surface but also the cornerstones of human civilization. The major (second order) landforms found on the earth's surface are mountains, plateaus and plains. In this lesson, we will study the exogenic forces and resultant landforms on the surface of the earth and their socio-economic importance for us.

## OUTCOMES

After studying this lesson, learner

- classifes exogenic forces shaping the earth surface;
- describes weathering and gradation and their effects on landforms;
- differentiates between aggradation and degradation processes and agents;
- classifies mountains, plateaus and plains, and
- elaborates the socio-economic significance of major landforms.

## 3.1 EXOGENIC FORCES: DEFINITION AND TYPES

The forces which derive their energy from the earth's exterior or originate within the earth's atmosphere are called exogenic forces (also termed as exogenetic forces) or external forces. The action of exogenic forces results in wearing down and hence they are considered as land wearing forces. The processes which occur on the surface of the earth in the influence of exogenic forces are termed as exogenic processes or exogenic geomorphic processes. The energy and material of exogenous processes are held as pools of detention and retention storage at or near the surface of the earth. The two sources of energy which power the various exogenic processes are solar radiation and the potential energy arising from the gravitational attraction of the Earth. In the absence of sufficient resisting forces, gravitational attraction of the Earth causes the downslope movement of water, ice and particles of rock and soil. Solar radiation acts in a different way, providing the energy for the evaporation of water, biological activity, and the functioning of the Earth's atmospheric circulation. Exogenic processes, including the action of water, ice and wind, predominantly involve denudation, that is, the removal of material, and thus generally lead to a reduction in elevation and relief. An exception is the localised deposition of material, to form sand dunes for instance, which causes an increase in relief.

### Types of Exogenic Processes

The gradational or plantation work of the earth's surface irregularities is accomplished through (i) Degradation and (ii) Aggradation. Under the Degradation the upstanding landmass is lowered down by weathering (disintegration and decomposition and consequent downslope transfer of weathered materials), mass movement and erosional activities. This mechanism of plantation is termed as level down. In parallel to this, Aggradation is the deposition of the weathered and eroded material and this mechanism of plantation is called level up.

Notes

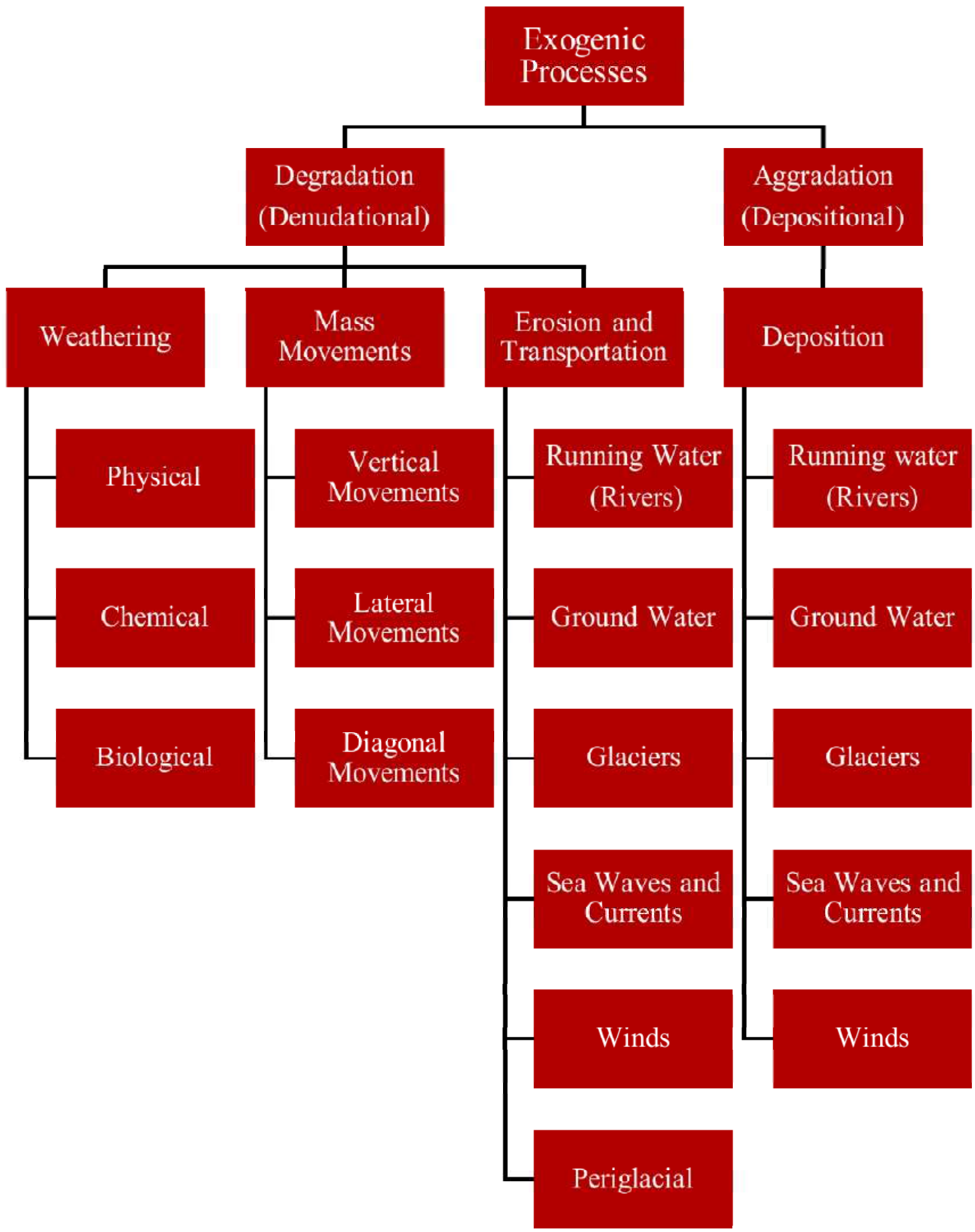



Fig. 3.1 Classification of Exogenic Processes

## 3.2 MECHANISM OF EXOGENIC PROCESSES

The mechanism of exogenic geomorphic processes is controlled by a number of factors. As there are different physio-climatic regions owing to variations in thermal gradients created by latitudinal, seasonal, and land-use spread on the surface of the earth, the exogenic geomorphic processes vary from region to region. The type, density and distribution of vegetation which largely depend upon precipitation and temperature also exert influence indirectly on exogenic geomorphic processes. Along with this, there may be local variations due to altitudinal differences, aspect variations and the variation in the amount of insolation received by north and south facing slopes as compared to east and west facing slopes. Further, due to differences in wind velocities and directions, amount and kind of precipitation, its intensity, the relation between precipitation and evaporation, daily range of temperature, freezing and thawing frequency, depth of frost penetration, the geomorphic processes vary within any climatic region. Climatic factors being equal, the intensity of action of exogenic geomorphic processes depends upon the type and structure of rocks. The term structure includes such aspects of rocks as folds, faults, orientation and inclination of beds, presence or absence of joints, bedding planes, hardness or softness of constituent minerals, chemical susceptibility of mineral constituents; the permeability or impermeability. Finally, it boils down to one fact that the differences on the surface of the earth though originally related to the crustal evolution continue to exist in some form or the other due to differences in the type and structure of earth materials, differences in geomorphic processes and in their rates of operation. Some of the exogenic geomorphic processes have been dealt with in detail here.

## 3.3 WEATHERING AND MASS WASTING

Weathering is the action of elements of weather and climate over earth materials. There are several processes within weathering which act either individually or together to affect the earth materials in order to reduce them to fragmental state. It is an in-situ or on-site process, as very little or no motion of materials takes place in weathering. The process of weathering is conditioned by many complex geological, topographic, climatic, and vegetative factors. Climate played the most vital role. There are three major groups of weathering processes:

i. Physical or Mechanical

ii. Chemical and

iii. Biological weathering processes.

Notes

| Weathering | | | |
|---|---|---|---|
| Processes | Physical or Mechanical | Chemical | Biological |
| Agents | Water Moisture<br>Frost Insolation<br>Wind | Oxygen<br>Carbon dioxide<br>Hydrogen | Vegetation<br>Animals<br>Micro-organisms |
| Types | Block Disintegration<br>Granular Disintegration<br>Exfoliation<br>Shattering<br>Spalling<br>Flaking<br>Sheeting | Oxidation<br>Carbonation<br>Solution<br>Hydration<br>Chelation<br>Hydrolosis | Plant weathering<br>Animal weathering<br>Biochemical weathering<br>Anthropogenic weathering |
| Resulted Landforms | Exfoliation Domes, Block fields,<br>Flutes, Rills, Runnels, Gutters<br>Rock-basins Tafoni<br>Alveoli, etc. | | |

Fig. 3.2 Weathering: Processes, agents, and types

Generally, the process of weathering is the complex result of all these phenomena. It is very rare that these processes ever operate completely by itself, but dominance of one process can be seen quite often. Physical or mechanical weathering can be considered as the disintegration of rock masses into blocks, boulders, cobbles and pebbles, sands, and silts due to variation in temperature, frost action, wind action and unloading of superincumbent pressure. Chemical weathering is the disintegration and decomposition of rock masses due to chemical responses. Oxidation, solution, hydration, carbonation, chelation, and hydrolysis, etc. are the most recognized chemical reactions which affect the chemical composition of the rock masses. Apart from the mechanical and chemical reactions, biological agents also affect the rock's structure which includes floral (physical and chemical both), faunal (burrowing animals, worms and other organisms), and anthropogenic (mining, blasting of hills for road and dam construction, quarrying for building and industrial material, deforestation, agriculture and many more).

Fig. 3.3 Weathering products: Landforms.

## Mass Movements

Disintegrated and fragmented material due to the mechanism of weathering processes (mechanical, chemical, or biological) is called debris or rock-wastes. Generally, movement of this waste material down the hill slope under the influence of gravity is called mass movement or mass wasting. The sliding or flowing of weathered materials ranging from very fine (soils) to very coarse and large sized rock materials (boulders) is due to their position and to gravitational forces, but mass movement is accelerated by presence of water, ice, and air.

Table 3.1

**Classification of Mass movements**

| **Direction of movement** | **Vertical** | | **Lateral** | | **Diagonal** | | |
|---|---|---|---|---|---|---|---|
| Type of movement | Fall | Subsidence | Slide | Spread | Creep | Slide | Flow |
| Presence of transporting agent | No | No | Minor in basal layer | Moderate in basal layer | Minor | Minor to mod-erate | Major |
| Type of mass movement | Rock fall, Earth-fall, Topple | Collapse settlement | Block slide | Spread camb-ering | Soil creep, Rock creep, Talus creep | Rock slide, Debris slide, Soil slip, Slump | Solifluction, Mudflow, Rock Glacier, Rock avalanche |

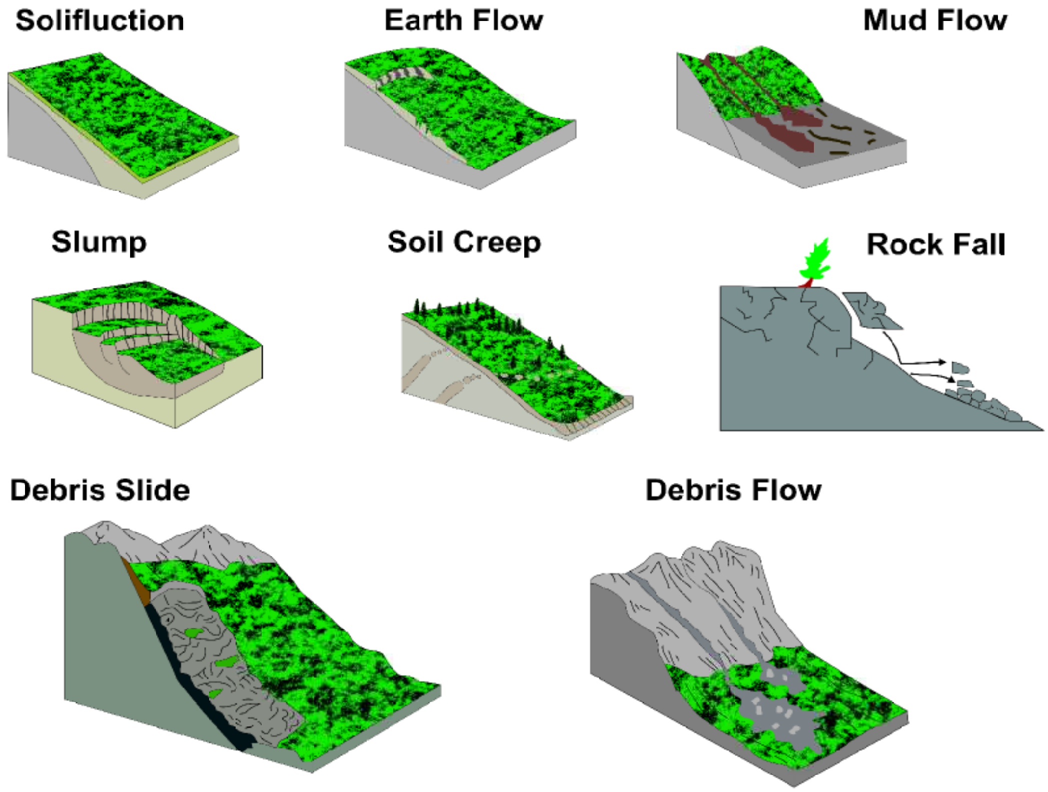



Fig. 3.4 Different types of Mass movements

## 3.4 EROSION, TRANSPORTATION AND DEPOSITION

Exogenic processes are generally called erosional processes which perform three-phase work i.e. erosion, transportation and deposition. Erosion is the acquisition and transportation of rock debris by geomorphic agents like running water, the wind, waves, glaciers, etc. Though weathering aids erosion, it is not a precondition for erosion to take place. (i.e., erosion can take place in unweathered conditions also). The deposition is a consequence of erosion, as erosional agents lose their velocity and energy on gentle slopes and materials carried by them start to settle themselves.

The erosional work by different processes is performed through the mechanism of:

a. Corrasion or Abrasion

b. Corrosion or solution

c. Attrition

d. Hydraulic action

e. Deflation

f. Periglacial erosional processes (Nivation, Congelifraction, etc.)

a. Corrasion or Abrasion involves the removal of loosened materials of the rocks by different erosional processes in different manner. Erosion tools refer to all those solid materials (boulders, cobbles, pebbles, sands etc.) with the help of which erosional agents attack and abrade the rocks. The degree of abrasion depends on a host of variables, e.g. nature of erosional agents such as rivers, groundwater, sea-waves, glacier, wind etc., nature of erosion tools, nature of geomaterials, force of erosional processes, gradient etc.

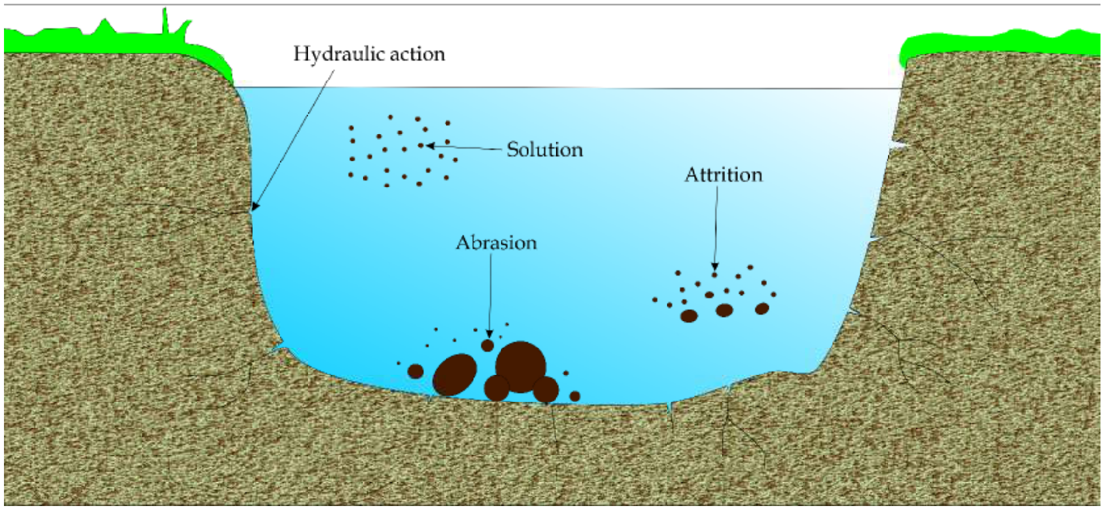



Fig. 3.5 Types of erosional processes

b. The mechanism of corrosion involves dissolution of the soluble materials through the process of disintegration and decomposition of carbonate rocks, which is effectively corroded by running water, groundwater and sea waves.

c. Attrition refers to mechanical tear and wear of erosion tools suffered by themselves. The boulders, cobbles, pebbles etc. while moving downstream with water collide against each other and thus are fragmented into smaller and finer pieces in the transit. Attrition by wind involves mechanical breakdown of rock particles while they are transported by wind through the processes of saltation and surface creep.

d. The breakdown of rocks due to pressure exerted by water currents of the rivers and sea waves is termed as Hydraulic action. It is the mechanical loosening and removal of materials of rocks by water alone without the help of erosion tools. The rivers erode their valley walls through hydraulic action.

e. Deflation is the process of removing, lifting and blowing away dry and loose particles of sands and dust by winds. It happens in semi-arid or arid regions. Congelifraction (frost weathering), Congelifluction (soil creep), nivation (snow patch erosion), etc. are significant weathering and transportation mechanisms performed by periglacial agents.

Notes

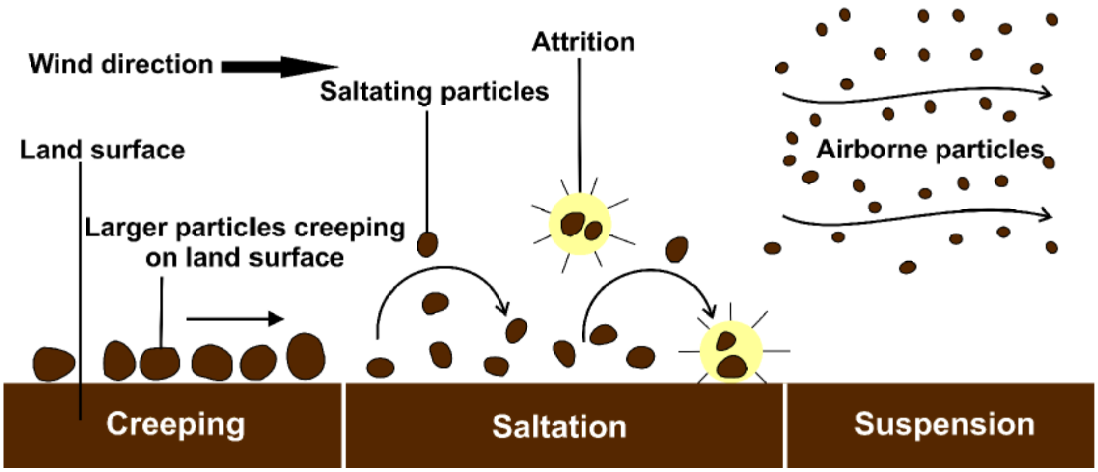



Fig. 3.6 The process of erosion and transportation by wind

The transportation work by different geomorphic processes is accomplished through flotation, suspension, traction, saltation, solution etc. such as running water (rivers) transports sediments through traction, saltation, suspension and solution. The mechanism of saltation is extremely slow, involves the transport of load with water currents wherein coarse load moves downward by leaping and jumping through valley floors. The downstream movement of loose materials on the valley floor is called traction. The bed-load being transported by traction method consists of gravels, pebbles, cobbles and boulders. The materials of medium size are suspended in water due to buoyancy.

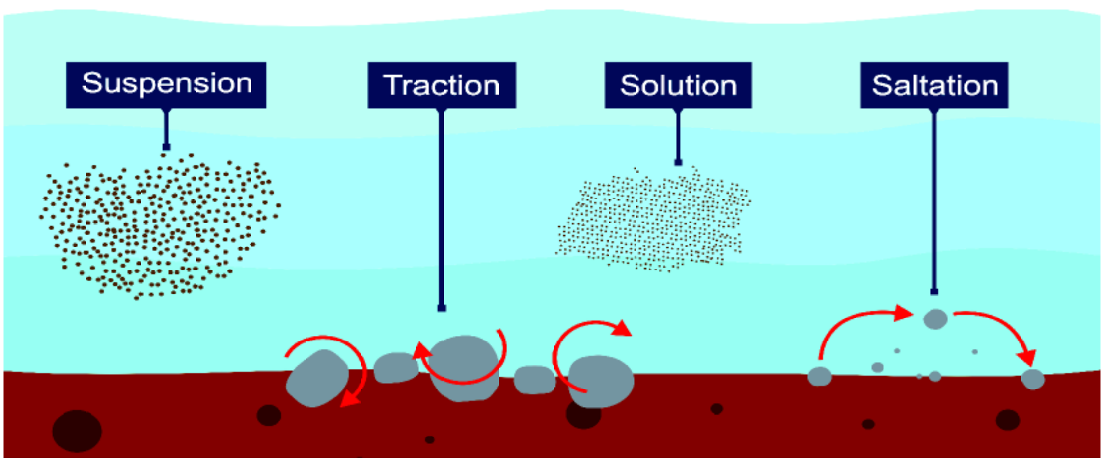



Fig. 3.7 Four ways of transportation in a river

The transportation by streams is unidirectional (downstream). The soluble materials are dissolved in water and become invisible and are transported downstream in solution, which is prominent in groundwater transports. The transportational work of sea waves varies significantly from other agents of erosion and transportation. For example, the backwash (towards sea) currents pick up the eroded materials and transport them seaward but the up rushing breaker waves or surf currents pick up these materials and bring them again to the coasts and beaches. The transportational work of wind differs significantly as wind-transportation is multi-directional. Wind transport involves entrainment of loosened grains of sands and dust in the air and their movement to new locations. Only very fine materials are transported to greater distances in one step while coarser materials are transported in stages and steps by rolling, leaping and jumping. Glacial sediments (glacial drifts) are transported along the sides and floors of the glacial valleys and snouts of the glaciers. The debris falling directly into the glacier is transported without touching the bottom of the glacier while the debris falling onto the surface of a glacier is transported down slope with the moving ice mass.

The process of transportation of eroded material is followed by the depositional work which is affected by a variety of factors depending on the agents of erosion and material eroded. For example, the deposition of load carried by the streams is affected by decrease in channel gradient, decrease in stream velocity, obstruction in channel flow, increase in sediments load, etc. Depositional work by groundwater takes place when solvent (water) becomes oversaturated. As the chemical erosion of carbonate rocks continues, the groundwater or say solvent receives more and more solutes and becomes saturated with dissolved sediments and it cannot transport enough sediments. Thus, chemical erosion and sedimentation (deposition) take place together. Deposition by marine processes (sea waves or currents) is most variable and temporary in character because breakers or surf currents abrade the coasts and backwash currents and rip currents bring them seaward and deposit at the lower segments of wave-cut platforms. These sediments are again picked up by surf currents and breakers and are brought to the coasts. Thus, marine sediments are reworked by sea waves again and again.

Depositional work by wind is geomorphologically very important because significant features like sand dunes and loose arcs are formed. Deposition of windblown sediments occurs due to marked reduction in wind speed and obstructions caused by bushes, forests, marshes and swamps, lakes, big rivers, walls etc. The debris carried by glaciers arc collectively called as glacial drifts which include till, ice-contact stratified drift, outwash etc. The unsorted and unstratified glacial drifts are called tills which are further divided into (i) basal till and (ii) ablation till. The glacial deposition is generally called moraine.

## INTEXT QUESTIONS 3.1

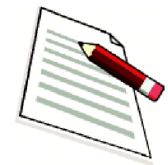
1. Name the two major sources of energy which empower the various exogenic processes.

   (i) ________________________ (ii) ________________________

2. Classify the degradational or denudational exogenic processes.

   (i) ________________________

   (ii) ________________________



Notes

(iii) ____________________

3. By which process rivers erode their valley walls?

____________________

4. Name the process of removing, lifting and blowing away dry and loose particles of sands and dusts by winds, in semi-arid or arid regions.

____________________

5. Name the debris carried by glaciers.

____________________

## 3.5 RESULTANT MAJOR LANDFORMS

The mechanism of the endogenic and exogenic operations (erosional and depositional work) is different from one another and hence the landforms produced by each process may be differentiated. Thus, on the basis of dimension and scale, the relief features of the earth's surface may be grouped in three broad categories of descending order. On the smallest scale and covering the largest area is world geomorphology which includes consideration of continents and ocean basins. The consideration and interpretation of worldwide erosion surfaces requires the description and analysis of the characteristics and evolution of continents and ocean basins. Thus, continents and ocean basins become the relief features of the first order. The structural forms developed over a continent or ocean basins as mountains, plateaus, plains, lakes, faults, rift valleys etc. constitute the category of relief features of the second order. These forms owe their genesis mainly to endogenetic forces, particularly diastrophic forces but shaped and developed through exogenic forces. Micro-level landforms developed on these second order relief features by exogenic degradational and aggradational processes originating from the atmosphere dominate in this category, called third order landforms. These landforms may be erosional (e.g. river valley, glacial valley, karst valley, terraces, cirques, canyons, sea cliffs, etc.), depositional (e.g. flood plains, bars, eskers, delta, sea beaches, sand dunes, stalactites, stalagmites, tufa, etc.), residuals (e.g. inselbergs) and sometimes minor tectonic features (by endogenetic forces).

The micro-level landforms will be discussed in the next lesson. In this lesson, the major landforms (second order) of the earth surface, mountains, plateaus, and plains will be explained in detail.

## 3.6 MOUNTAINS

Mountains are the most awe-inspiring landform on the surface of the earth. A mountain is an elevated portion of the Earth's crust, generally with steep sides that show significant exposed bedrock, which covers around 27% of the total earth's surface. A mountain differs from a plateau in having a limited summit area, and is larger than a hill. A few mountains are isolated summits, but most occur in mountain ranges. There is no universally accepted definition of a mountain. Elevation, volume, relief, steepness, spacing and continuity have been used as criteria for defining a mountain. According to the Oxford English Dictionary, a mountain is defined as "a natural elevation of the earth surface rising more or less abruptly from the surrounding level and attaining an altitude which, relative to the adjacent elevation, is impressive or notable."

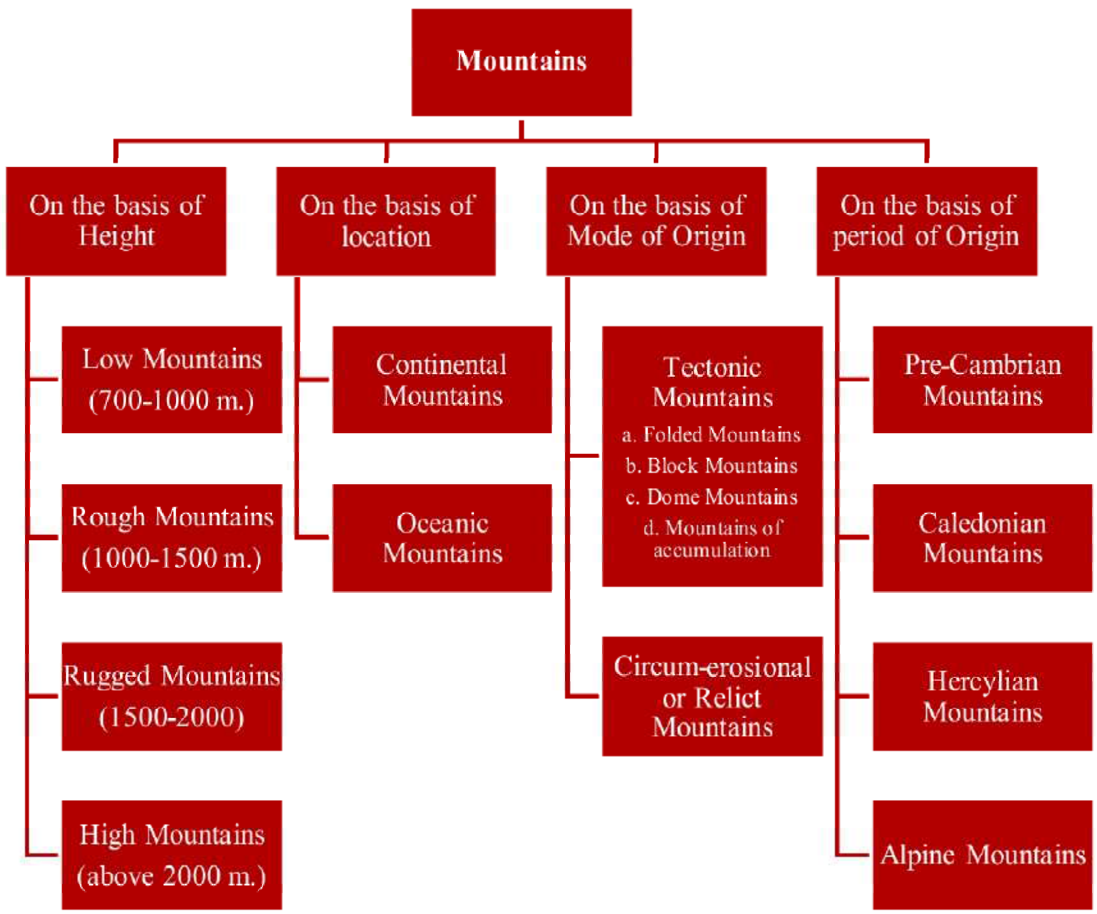



Fig. 3.8 Classification of Mountains

On the basis of their mode of origin, the mountains have been classified as:

### a. Folded Mountains

Folded mountains are formed due to folding of crustal rocks by compressive forces generated by endogenetic forces coming from within the earth. These are the highest and most extensive mountains of the world and are found in all the continents. Rockies, Andes, Alps, Himalayas, Atlas etc. are the examples of folded mountains.

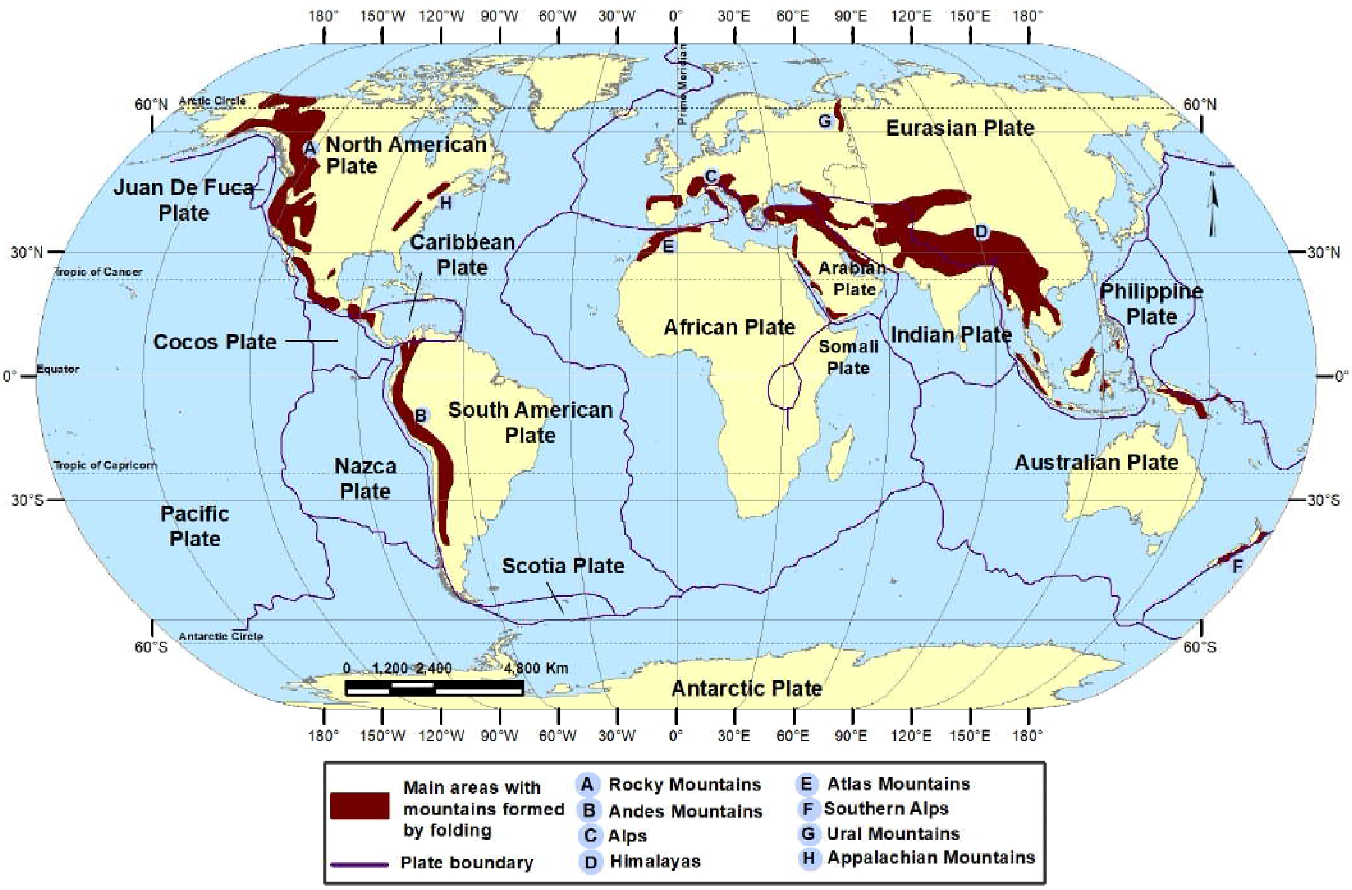



Fig. 3.9 Distribution of Important Fold Mountains of the World

### Block Mountains

Block mountains are the result of faulting caused by tensile and compressive forces motored by endogenetic forces coming from within the earth. Block mountains represent the upstanding parts of the ground between two faults or on either side of a rift valley or a graben. Essentially, block mountains are formed due to faulting in the ground surface. They are also called horst mountains. The Vosges in France, Black Forest Mountains in Germany are the typical examples of block mountains.

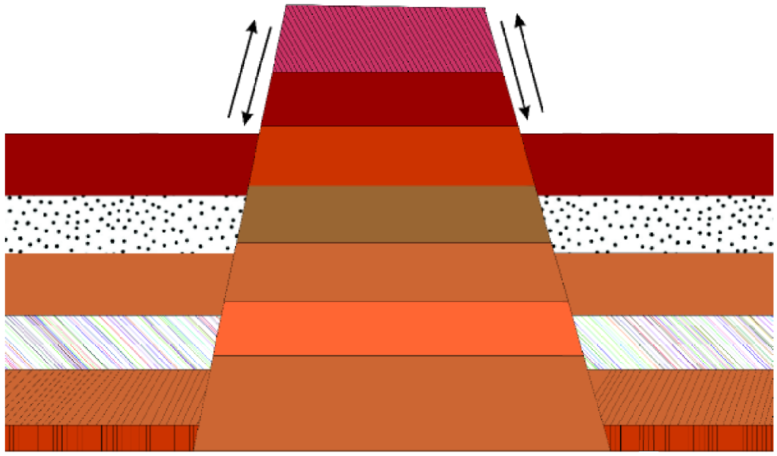


Fig.3.10 (a) Formation & Block Mountains

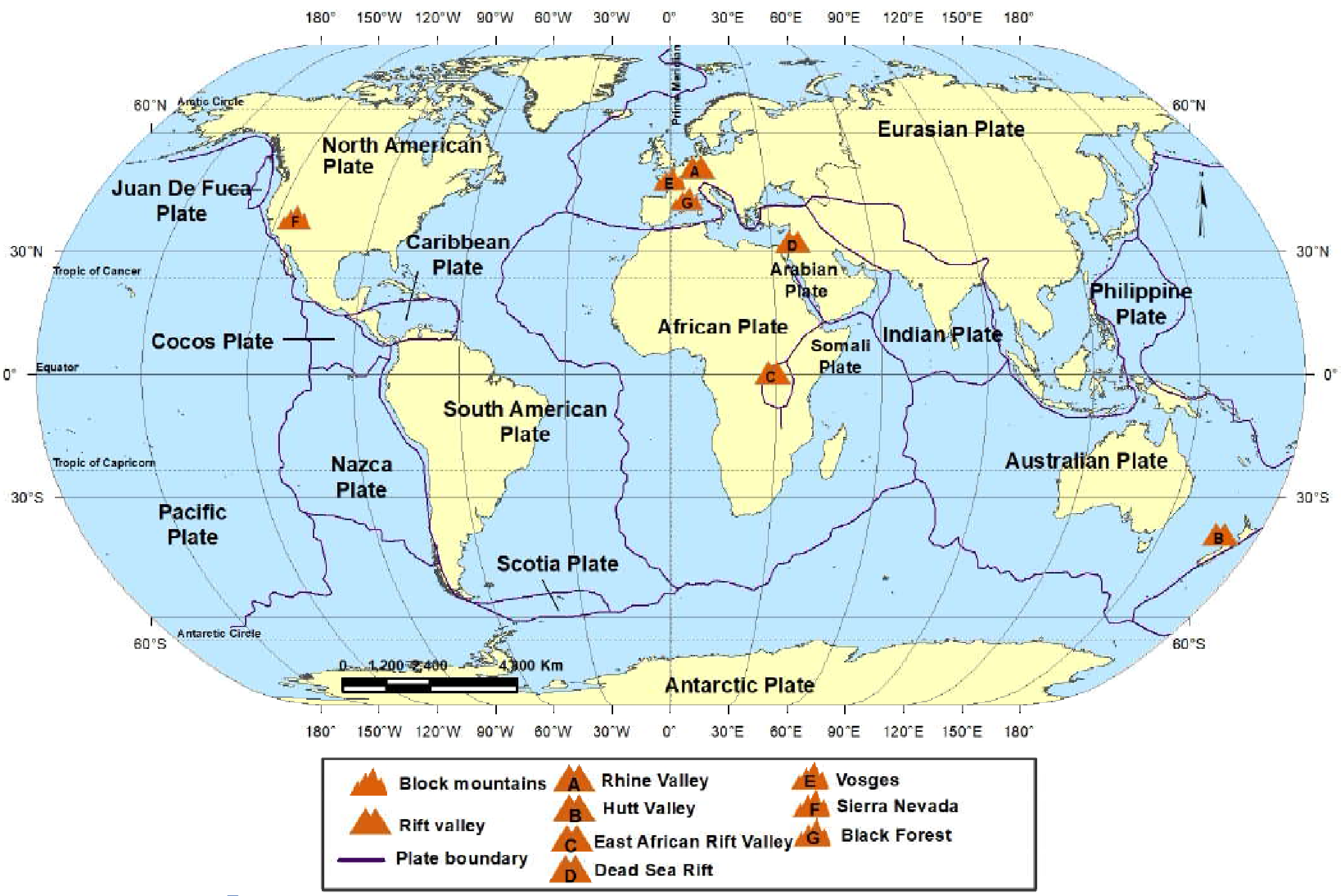



Fig.3.10 (b) Formation of Block Mountains

## b. Dome Mountains

These mountains are originated by magmatic intrusions and upwarping of the crustal surface. Examples: normal domes, lava domes, batholithic domes, laccolithic domes, salt domes etc. Typical example of domed mountain is Weald in southeast England.

Notes

### c. Mountains of Accumulations

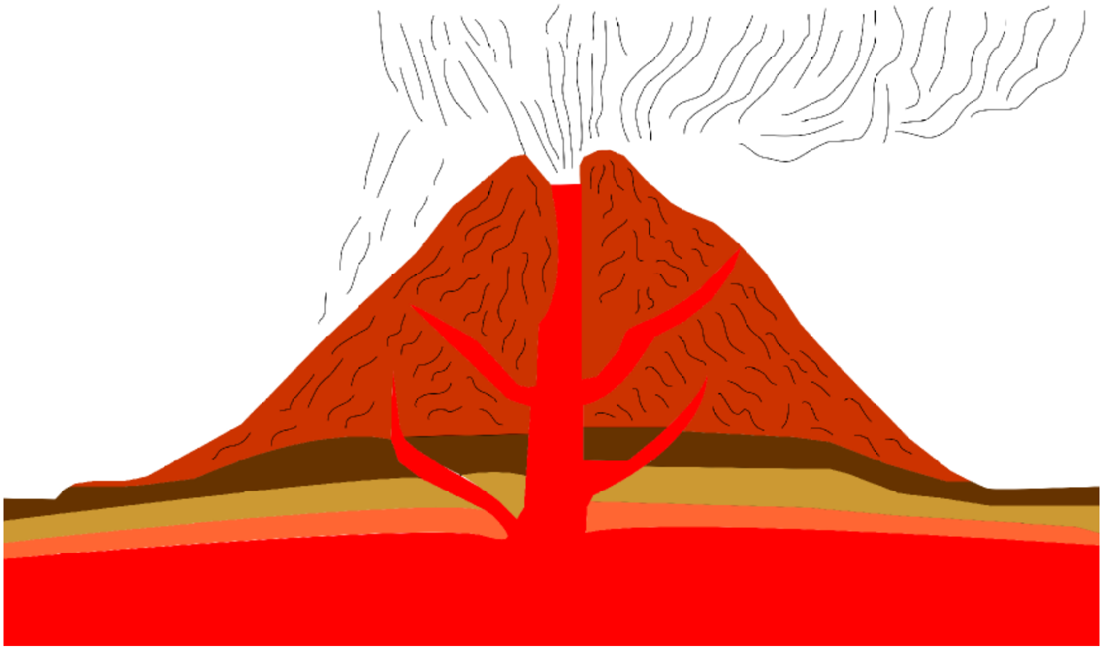


Fig. 3.11 Formation of Volcanic Mountains.

These mountains are formed due to accumulation of volcanic materials. Thus, these are also called volcanicc mountains. Different types of volcanic cones (e.g. cinder cones, composite cones, acid lava cones, basic lava cones etc.) come under this category. Mount Mauna Loa in Hawaii Islands, Mount Popa in Myanmar, Vesuvius in Italy, Cotopaxi in Ecuador and Fuji Yama in Japan are examples of volcanic mountains.

### d. Circum-erosional or Relict or Residual Mountains

Fig.3.12 Aravalli Range, India

As soon as an elevated mountain range appears on the earth's surface due to internal forces, the agents of gradation begin their work of levelling it down. To a large extent, the process of wearing down depends on the shape and structure of the rocks. After thousands of years, soft rocks are worn down into sand and the hard rocks are left standing up in the area that has been reduced in height. These are called relict or residual mountains. Hills like the Nilgiris, the Parasnath, the Rajmahals and the Aravallis in India are examples of residual mountains.

**The Significance of Mountains:**

Mountains are useful to us and nature in the following ways:

**a. Storehouse of Resources**

Mountains are the storehouse of natural resources. Large resources of minerals are found in mountains. The Appalachian range in the United States is well-known for coal and limestone deposits. We get timber, lac, medicinal herbs and wood for making pulp from the forests of the mountains. Tea and coffee plantations and some fruit orchards have been developed on mountain and hill slopes of Himalayas and western ghats in India.

**b. Abundant Sources of Water**

Perennial rivers rising in the snow fed or heavily rain fed mountains are the important source of water. They help in promoting irrigation and provide water for many other uses. For example, The Himalayas is the source of many perennial rivers in India and adjoining nations like Ganga, Yamuna, Brahmaputra, Indus, Sutlej, etc.

**c. Generation of Hydro-electricity**

Hydro-electricity is generated from the waters of perennial rivers in the mountain regions. The mountainous countries like Japan, Italy and Switzerland, which suffer from the shortage of coal have developed hydro-electricity.

**d. Formation of Fertile Plains Downstream**

The rivers that originate in the high mountain region bring silt along with water to the lower valleys. This helps in the formation of fertile plains. The great alluvial plain of northern India has been formed by the rivers Ganga, Sutlej and the Brahmaputra and their tributaries.

**e. Hotspots for Biodiversity**

As half of the world's biodiversity hotspots are concentrated in mountains and mountains support approximately one-quarter of terrestrial biological diversity. Mountains are home to rare animals such as gorillas, snow leopards and the majestic tahr as well as strikingly beautiful plants such as orchids and lobelias.

Notes

### f. Home of numerous Indigenous people

As many mountain areas host ancient indigenous communities that possess and maintain precious knowledge, traditions and languages. Mountain peoples have developed remarkable land use systems and have a wealth of knowledge and strategies accumulated over generations on how to adapt to climate variability. For example, Bakarwals, Bhotias, Tharu, Lepchas and Mishmis of Himalayas.

### g. Natural Political Frontiers

The mountain ranges do act as natural political frontiers between countries and protect them from invasions to some extent. The Himalaya has formed a political frontier between India and China.

### h. Influence the Climate

Mountainous areas have lower temperatures. They serve as a climatic divide between two adjoining regions. The Himalaya for example forms a barrier to the movement of cold winds from Central Asia towards the Indian subcontinent. They also force the South West Monsoons to ascend and cause rainfall on their southern slopes.

### i. Major Tourist Attractions

Mountains are also becoming recreational refuges from crowded cities for the tourists. The pleasant climate and the beautiful scenery of the mountains have led to their development as centres of tourist attraction. The tourist and hotel industries get additional encouragement in such regions. Shimla, Nainital, Mussoorie, Gangtok Srinagar etc are some of the important hill stations of India which attract tourists all over the world.

### j. Sacred landforms on the Earth

For more than one billion people, mountains are sacred places. Their soaring summits, the clouds and thunder that swirl about their peaks, the life-giving waters that flow from their heights, these and other characteristics imbue them with an aura of mystery and sanctity. Mount Kailash, Mount Fuji etc are some of the examples which are important for different religion.

## 3.6 PLATEAUS

Plateau or Plateaus is an extensive area of flat upland usually bounded by steep slopes on all sides but sometimes enclosed by mountains. The essential criteria for plateaus are low relative relief and some altitude. It covers about 18% of the earth's surface. This landform has a large elevated area on its top unlike a mountain and has nearly an even surface out there. Very often rivers or streams cut out deep valleys and gorges in a plateau region which transforms its original smooth topography into a dissected plateau. The vertical expansion is normally 600 metres above sea level, but there are also plateaus of Tibet and Bolivia, more than 3600 metres above sea level. On the basis of their geographical location and structure of rocks, the plateaus can be classified as:

a. Intermontane Plateaus

b. Piedmont Plateaus

c. Continental Plateaus

### a. Intermontane Plateau

The plateau which are bordering the fold mountain range or are partly or fully enclosed within them are the intermontane plateaus. Vertical movements raise this extensive landform of nearly horizontal rocks to thousands of metres above sea level. The extensive and over 4500 metres high plateau of Tibet is one such example. It is surrounded by folded mountains like Himalaya, Karakoram, Kunlun, Tien Shan on its two sides. The plateau of Colorado is another well-known example, over one km high into which rivers have cut the Grand Canyon and a series of gorges. The plateau of Mexico, Bolivia and Iran are all other examples of this type & platines.

### b. Piedmont Plateau

The plateaus that are situated at the foot of the mountains and are bounded on other sides by a plain or an ocean are called piedmont plateau, The plateau of Malwa in India, Patagonia facing the Atlantic Ocean and the Appalachians situated between the Appalachian Mountain and the Atlantic Coastal Plain in U.S.A are their examples. In their case, the areas once high have now been reduced by various agents of erosion. For this reason, these are also called the plateaus of denudation.

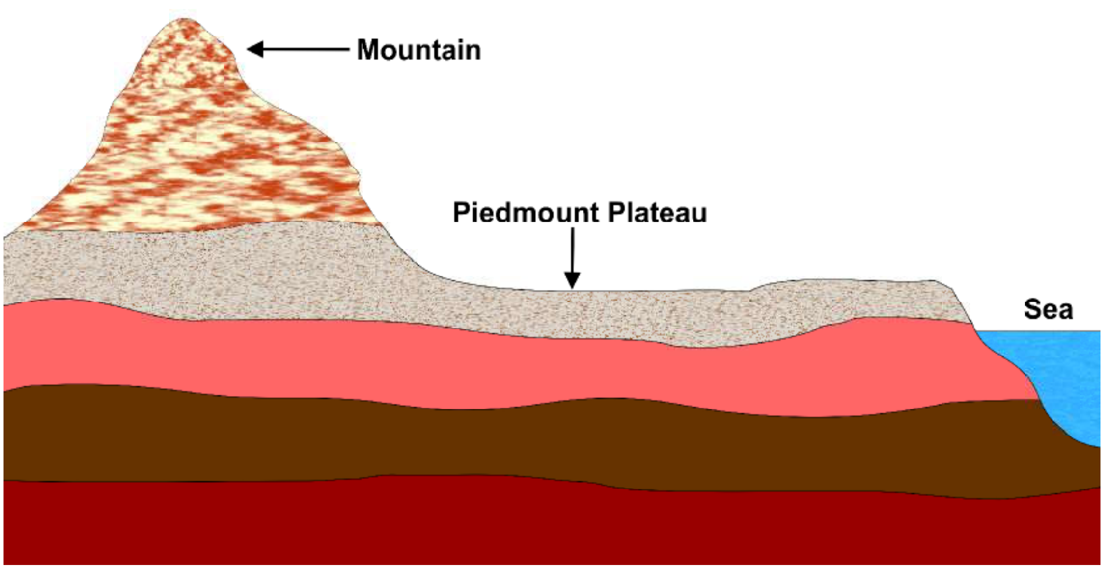



Fig.3.14 Piedmont Plateau

### c. Continental Plateau

Notes

These are formed either by an extensive continental uplift or by the spread of horizontal basic lava sheets completely covering the original topography to a great depth. The volcanic lava covered plateau of Maharashtra in India; Snake River Plateau in North West USA are the examples of this type. These are also called the plateau of accumulation. All continental plateaus show an abrupt elevation in contrast to the nearby lowland or the sea. As compared to others, these plateaus cover a vast area like the Great Indian Plateau and those of Arabia, Spain, Greenland, Africa and Australia. They may be tilted on one side without any disturbance in the horizontal nature of underlying rock strata as in the case of the Great Indian plateau.

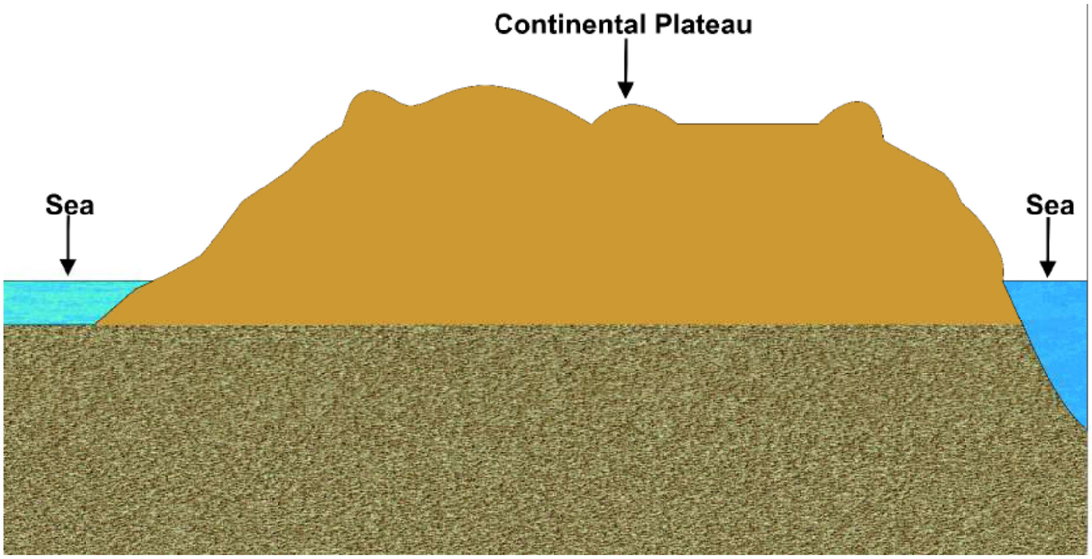



Fig.3.15 Continental Plateau

## The Significance of Plateaus

### i. Storehouse of Minerals

Most of the minerals in the world are found in the plateaus. Besides, the extraction of minerals is relatively easier on plateaus. These minerals are indispensable as raw material for our industries. We get gold from the Plateau of Western Australia; copper, diamonds and gold from the Plateaus of Africa and coal, iron, manganese and mica from the Chota Nagpur Plateau in India.

### ii. Birthplace of various waterfalls

Plateaus are also the source of several waterfalls. These waterfalls provide ideal sites for generating hydel-power. In India, two important waterfalls in the plateau regions are Hundru falls in the Chota Nagpur plateau on the river Subarnarekha and the Jog falls in Karnataka on the river sharavati.

### iii. Cool Climate

The higher parts of the plateaus even in tropical and subtropical regions have cool climates. Hence, they have attracted Europeans to settle there and develop their economy e.g. South and East Africa.

### iv. Useful for Agriculture and Animal-rearing

The lava plateaus that are formed due to volcanic eruptions have black fertile soil, which is suitable for cultivation. Plateaus have large grassland areas suitable for animal-rearing specially sheep, goat and cattle. They provide a variety of products such as wool, milk, meat and hide or skin.

### v. Tourist attraction

Most plateaus have scenic spot-like features which act as tourist attraction sites. The grand cannons, as well as the numerous waterfalls which are found in most high plateaus, are the perfect examples of tourist attraction features on plateaus. With the attractions, the residents of such areas can earn foreign revenues from the sites.

## 3.7 PLAINS

Plains are the most important landforms found on the earth's surface. A low-lying relatively flat or slightly rolling land surface with very gentle slope and minimum local relief is called a plain. Plains occupy about more than one-third of the earth's surface. Most of the plains have been formed by the deposition of sediments brought down by rivers. Besides rivers, some plains have also been formed by the action of wind, moving ice and tectonic activity. Plains have an average height of less than 200 metres.

On the basis of their mode of formation, plains can be classified into the following types:

a. Structural plains

b. Erosional plains

c. Depositional plains.

### a. Structural Plains

These plains are mainly formed by the uplift of a part of the sea-floor or continental shelf. These are located on the borders of almost all the major continents. The south eastern plain of the United States formed by the uplift of a part of the Gulf of Mexico is an example of this type of plain. The structural plains may also be formed by the subsidence of areas. One such plain is the central low-lands of Australia.

Notes

**b. Erosional Plains**

These plains are formed by the continuous and a long-time erosion of all sorts of upland. The surface of such plains is hardly smooth. These are therefore also called peneplains which means almost a plain. The Canadian shield and the West Siberian plain are examples of erosional plains.

**c. Depositional Plain**

Fragments of soil, regolith, and bedrock that are removed from the parent rock mass are transported and deposited elsewhere to make an entirely different set of surface features–the depositional landforms. The type of depositional plains depends on the geomorphic agents of deposition. Plains formed by river deposits are called riverine or alluvial plains. The Indo-Gangetic plain of the Indian subcontinent, the Hwang-Ho Plain of North China and the Ganga-Brahmaputra Delta Plain in Bangladesh are examples of alluvial plains. Deposition of sediments in a lake gives rise to a lacustrine plain or a lake plain. The Valley of Kashmir and that of Manipur are examples of two most prominent lacustrine plains in India. When plains are formed by glacial deposits, they are called glacial or drift plains. Plains of Canada and North-Western Europe are examples of glacial plains. In the semi-arid and arid regions Loess plains are the results when wind is the major agent of deposition. Loess plains of North- Western China are formed by the deposits of loose air-borne fine dust particles.

## The Significance of Plains

The plains have influenced the human life in the following ways:

**a. Most Fertile Soil**

The plains generally have deep and fertile soil. Since the plains have a flat surface, the means of irrigation are easily developed. Both these factors have made the plains agriculturally so important that they are often called ‘food baskets of the world’.

**b. Improved transport and communication system**

Being a level or flat land, plains are ideal for constructing roads and railways. Waterways (rivers) can also be used as a mode of transport, thereby leading to a developed system of transport and communication.

**c. Favourable climate**

Compared to mountains and plateaus, the climate is quite pleasant in the plains. Temperature is not extreme here and rainfall is also suffecient at many plain.

### d. Development of industries

Flat land, pleasant climate, developed transport and communication system, availability of labour (the plains being a densely populated area), availability of raw materials, etc., have all contributed to the development of industries in the plains.

### e. Centres of Civilizations

The flat land, fertile soil, developed transport and communication system, conducive climate, opportunities of employment, etc., have all led to the growth of settlements followed by civilizations. The major river valley civilizations of the world have flourished in the plains only. Hence, they are aptly referred to as the cradles of civilization. For example, there are the civilizations of the Indus and the Nile Valley.

## INTEXT QUESTIONS 3.2

1. Name the three major landforms of second order found on the earth's surface.

   (i)　　　　　　(ii)　　　　　　(iii)

2. Block mountains are the results of which processes?

3. Write the type of the following mountains:

   (a) The Black Forest

   (b) The Himalayas

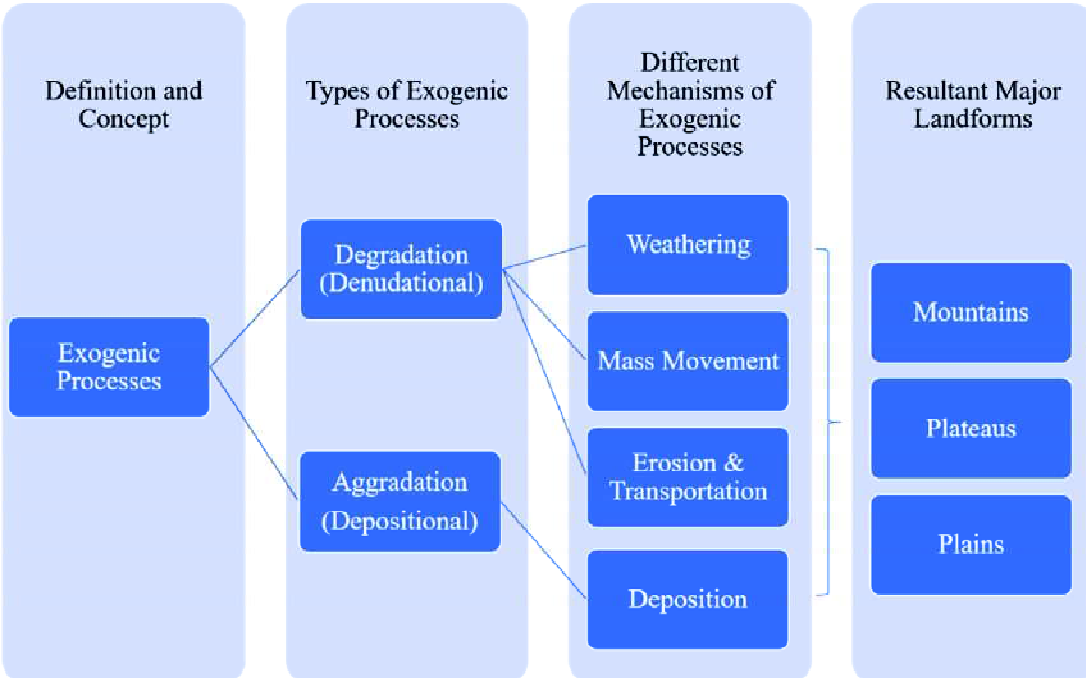
   (c) The Aravalli

   (d) The Fuji Yama

4. Which mountains have surrounded the plateau of Tibet, an intermontane plateau?

5. The Indo Gangetic plain of the Indian sub-continent and the Hwang-Ho Plain of North China are examples of which type of plain?

## WHAT YOU HAVE LEARNT




## TERMINAL QUESTIONS

1. Define the exogenic processes?
2. Describe the mechanism of erosion, transportation and deposition by various geomorphic agents?
3. Why are plains significant for human beings ?
4. Why are the Mountains called 'Sacred landforms on the Earth'?
5. Distinguish between the following:
   (i) Degradational and Aggradational processes.
   (ii) Intermontane and Continental plateaus.
   (iii) Corrasion and Corrosion.
6. Locate and label the following on the outline map of the world.
   (a) Rockies and Andes Mountains
   (b) Tibetan Plateau

*Notes*

(c) Himalayas

(d) Indo-Gangetic plain

(e) Mount Fuji Yama

## ANSWERS TO INTEXT QUESTIONS

**3.1**

1. (i) Solar radiation

   (ii) Potential energy arising from the gravitational attraction of the Earth.

2. (i) Weathering

   (ii) Mass Movements

   (iii) Erosion and Transportation.

3. Hydraulic action.

4. Deflation.

5. Glacial drifts.

**3.2**

1. (i) Mountains

   (ii) Plateau

   (iii) Plains

2. Block mountains are the result of faulting caused by tensile and compressive forces motored by endogenetic forces.

3. (a) Block Mountain

   (b) Folded Mountain

   (c) Relict or Residual Mountain

   (d) Volcanic Mountain

4. Himalaya, Karakoram, Kunlun, Tien Shan.

5. Depositional Plains.

4

# RUNNING WATER, MOVING ICE, WIND AND SEA WAVES

In the previous lesson, we have discussed many geological processes which are active on the surface and contribute to shaping the earth. These exogenous (external- over earth's surface) and endogenous processes result in ultimate gradation and reducing the uneven earth into level surface. The land features very rarely remain in their original form, shape, size, texture and to some extent its colour also continiouslly changes. These agents of gradation have a major role in erosion, transportation and deposition of weathered rocks. These forces play a vital role in modifying the land features.

The gravity and gradients (slope of an area) plays an important role in shaping various landforms through agents of gradation. The most important geological agents capable of eroding, transporting and depositing the mass from one place to the other are: Running Water (Fluvial landforms by rivers and streams); Glaciers (Glacial landforms by glaciers); Wind (Aeolian landforms by wind) and Sea Waves (Marine landforms by waves). In this lesson we will learn about various erosional and depositional landforms formed by various different of gradation.

## OUTCOMES

After studying this lesson, learner:

- describes the importance of various erosional and depositional features produced by action of running water;
- explains the important erosional and depositional features produced by glaciers;
- explains the erosional and depositional features formed by the wind;
- explains the various erosional and depositional features formed by sea waves and
- evaluates significance of running water, moving ice, wind and sea waves for humans.

## 4.1 FUNCTIONS OF RUNNING WATER: EROSION, TRANSPORTATION AND DEPOSITION

Rivers play a significant role in shaping the landscape. Rivers transport water by gravity from source of origin to ocean on its journey. The river passes through three courses- upper, middle and lower course during this journey and creates many erosional and depositional features.

### Courses of River

The path or route in which a river flows from its point of origin known as 'mouth of river' to its destination i.e. sea or ocean is called the course. The river course can be broadly divided into three sections:

i. The upper course or the stage of youth or the youthful stage or mountain course.

ii. The middle course or the stage of maturity or mature stage

iii. The lower course or the stage of old age or old stage

Table 4.1

**Courses of river valley**

| **Features** | **Upper Course** | **Middle Course** | **Lower Course** |
|---|---|---|---|
| Source | Glacier or underground (karst) | | |
| Slope gradient | Very steep | Open gently sloping valley | Almost flat or shallow gradient. Gentle slope with floodplains with flat and wide |
| Discharge of water | Less amount as single stream initially | Large amount as many tributaries join the main river | Very large |
| Depth of river bed/bed load | Shallow / heavy bedload | Deeper / more suspended sediment | Deep |
| Velocity | Very high velocity water gushes down from steep valleys | Moderate | Low and slow movement of water |

Notes

| | | | |
|---|---|---|---|
| Channel and valley shape | Narrow channels with steep valley | Flat and moderate steep sides. Wider and deeper channels | Flat floor with gently sloping sides. Very wide and deep channels. |
| Major landforms created | Rapids, waterfalls, canyons, gorges, 'V' shaped valleys | Meanders, oxbow lakes, floodplains, levees, river cliffs, slip off slopes | Deltas, distributaries |

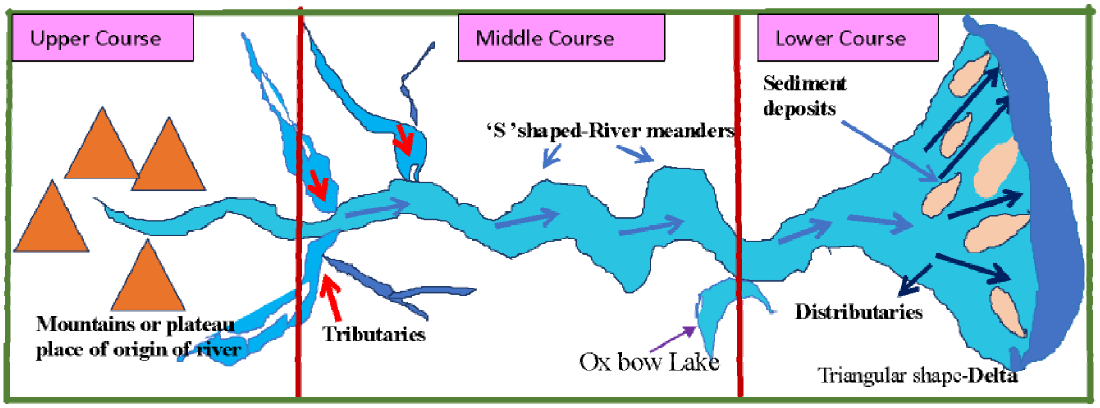



Fig. 4.1 Courses of River Valley

## 4.2 RUNNING WATER: LAND FROMS

### a. EROSION

The cutting and removal of rock debris by the river is called river erosion.

### Erosional Landforms

Many erosional landforms are made by running water. They are -

i. **'V' shaped valleys-** The valleys are created by erosional action of rivers in the upper course. At this stage vertical erosion is more dominant compared to lateral erosion. The fast-flowing rivers with steep gradients create this valley. As the river flows downhill at high speeds it removes maximum sediments from the bottom as compared to the sides of the river channel. This process is called down cutting. Weathering helps in widening a valley at the top giving it a typical 'V' shaped cross section. The valley has very steep walled sides along with a narrow floor.

Fig. 4.2 'V' shaped valley by river Zanskar in Ladakh, India

ii. **Gorge and Canyons-** Hard and resistant bedrock hinder the widening of the valley at the top but down cutting process continues with the vigour of the river which can lead to formation of gorge. A river valley with almost vertical walls is called a gorge. For i.e. Indus gorge, Pakistan Kali Gandaki Gorge, Nepal and the gorge of Gandikota formed by Pennar river in the state of Andhra Pradesh whereas a canyon is very deep gorge with vertical walls and steep sides can stretching for hundreds of kilometres i.e. Grand Canyon created by river Colorado in the USA Fish River Canyon, Namibia and Laitlum canyon, Meghalaya.

Deep gorges also develop in limestone regions in plateau regions and in rocks lying in dry climates. The narrow and very deep gorge or the canyon with vertical walls is also known as 'I' shaped valleys.

iii. **Waterfalls and rapids-** A waterfall is a steep descent made by a river over rocky slopes or ledges . The rivers fall with great velocity and lateral erosion predominates and plunge pools are formed at the base of waterfalls. The streams flow from soft rock to hard rocks. Both lateral and vertical erosion takes place. In most cases the soft rocks (like limestone or sandstone) get eroded and the water falls from a hard ledge of granite or other hard rocks. Waterfalls are also called cascades. For eg. Niagara Falls at the USA and Canada border. Jog falls, India. Victoria falls, Zambia etc. Rapids formed in areas of shallow fast-flowing water in younger streams. There are many tiny waterfalls created within the stream. Adventure sports like water rafting are very common in zones where there are rapids in river channels. For e.g. white water rafting in Rishikesh, India.

Fig. 4.3 Waterfall

Notes

## b. TRANSPORTATION

River carries rock particles from one place to another. This activity is known as transportation of load by a river. The load is transported in four ways- (a) Traction (b) Saltation (c) Suspension (d) Solution actions as discussed in previous lesson. It helps in transporting various types of sediments and debris load from one place to other by running water.

## c. DEPOSITION

When the stream comes down from hills to a plain area, the surface slope becomes gentle. The decrease in energy hampers transportation; as a result, part of its load starts settling on its own. This activity is known as deposition. Deposition takes place either due to decrease in slope or due to fall in the volume or velocity of river water. Deposition takes place usually in plains and low lying areas. When the river joins a lake or sea, the whole of its load is deposited.

### Depositional landforms

(i) **Alluvial fans-** When rivers flow down the steep mountain slopes into the valleys they drop their load of coarse - sand and gravels as their sudden decrease in velocity. The load deposited generally acquires a fan-like shape; therefore they are called alluvial fans.

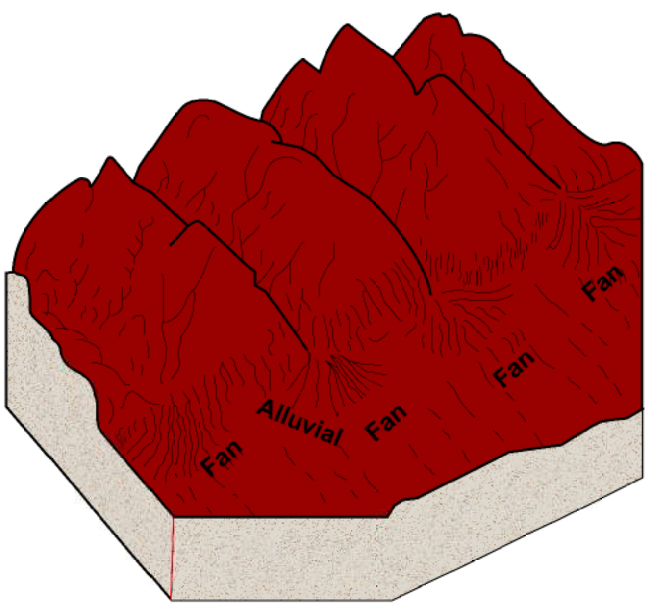



Fig. 4.4 Alluvial Fans

ii. **Meanders-** The term is derived from River Meanders in Turkey which makes winding paths while flowing downstream. When the river is flowing in a relatively plain area even small obstructions on the way forces the river to swing in loops to go around the obstacles. These "S" shaped loops are called meanders.

iii. **Floodplains and Levees-** Vertical erosion has almost ceased in the lower course and in this stage the river is carrying heavy loads of debris and many tributaries join the main river. In this course the river is rich with large volumes of water and sediments that are brought down from upper and middle courses. The work of the river is totally depositional and it is building up its bed and floodplains. Annual flooding causes spreading of large quantities of sediments over the low- lying areas adjacent to the banks of the river channel building a fertile floodplain.

A raised ridge of coarse material is formed along the river banks of the river. Such ridges are called levees.

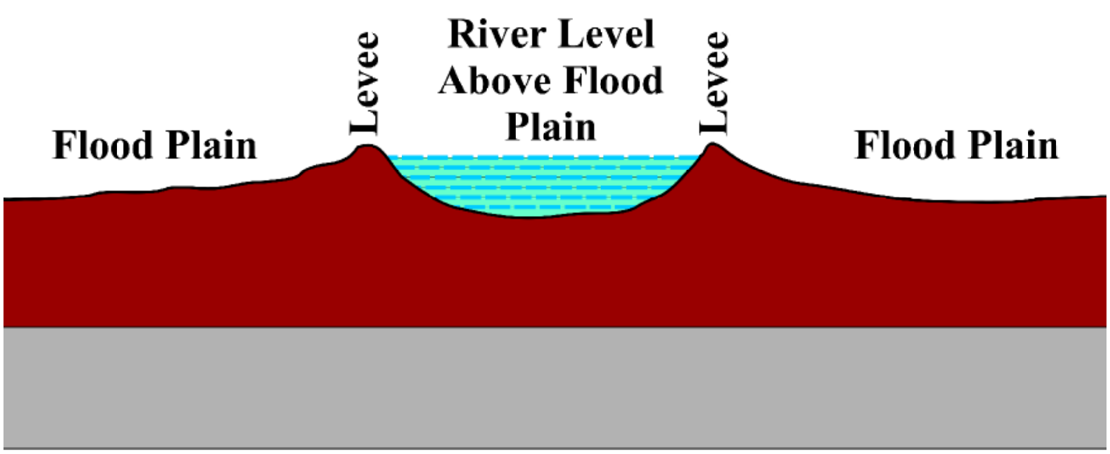



Fig. 4.5 Floodplain and Levees

iv. **Braided streams-** Large sheets of material both fine and coarse are deposited on the level bed and the river splits into a maze of channels. Such stream is called a braided stream.

v. **Ox- bow lakes-** In the lower course of the river the meanders are becoming very pronounced. The outer part or the concave bank is rapidly eroding so that the meander becomes a circle. A time comes when the river changes its course and the river cuts through the narrow neck of the meander. The now cut off portion of the meander looks like a crescent shape (half-moon or bow shape) and initially it has some water so called as Ox Bow Lake. Over the time it becomes a swampy and marshy area and slowly gets totally dried up as the river channel is now far away and recharge of water is not present.

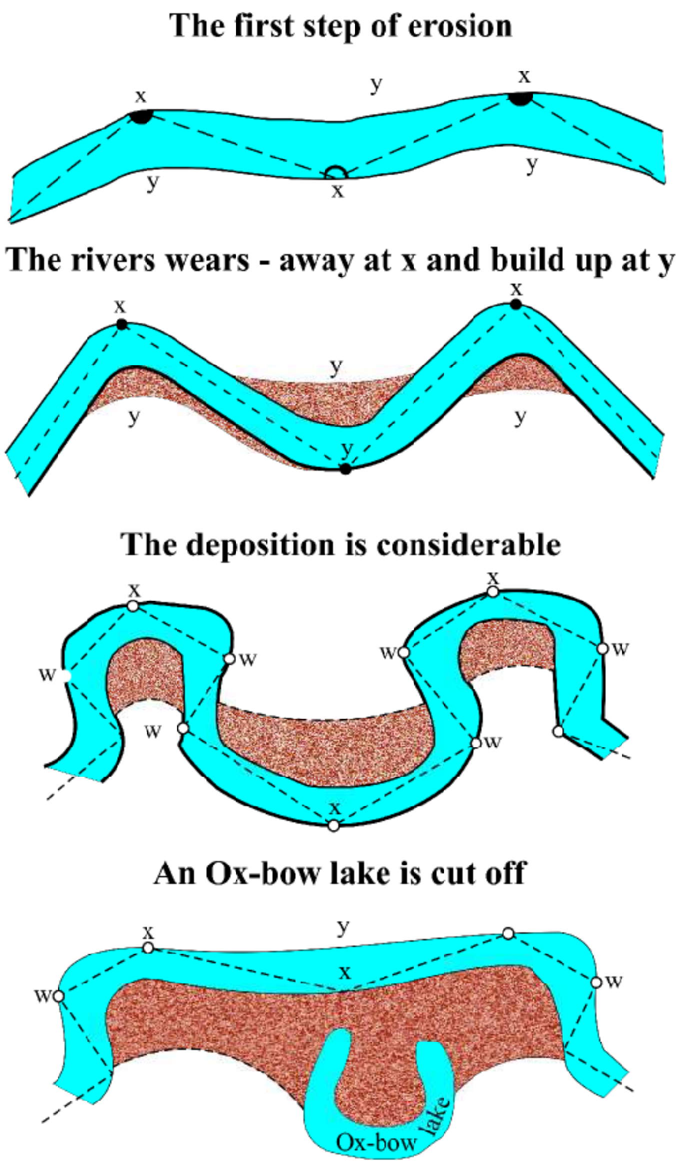



Fig 4.6 Meander and Ox bow lake (formation and shape)

**vi.** **Delta-** The word delta originated from Greek letter (△) which has great resemblance to river Nile delta. Delta is a triangular feature with its apex pointing up stream and has a fan shaped area of fine alluvium. The world's largest delta is made by river Ganga and river Brahmaputra known as Sundarban delta

**Favourable conditions for the formation of Deltas**

i. There should be active lateral and vertical erosion in the upper course of the river to provide large amounts of sediments.

ii. Shallow sea water adjoining the delta.

iii. Tideless and sheltered coast.

Notes

iv. There should be no strong current at the river mouth which may wash away the sediments.

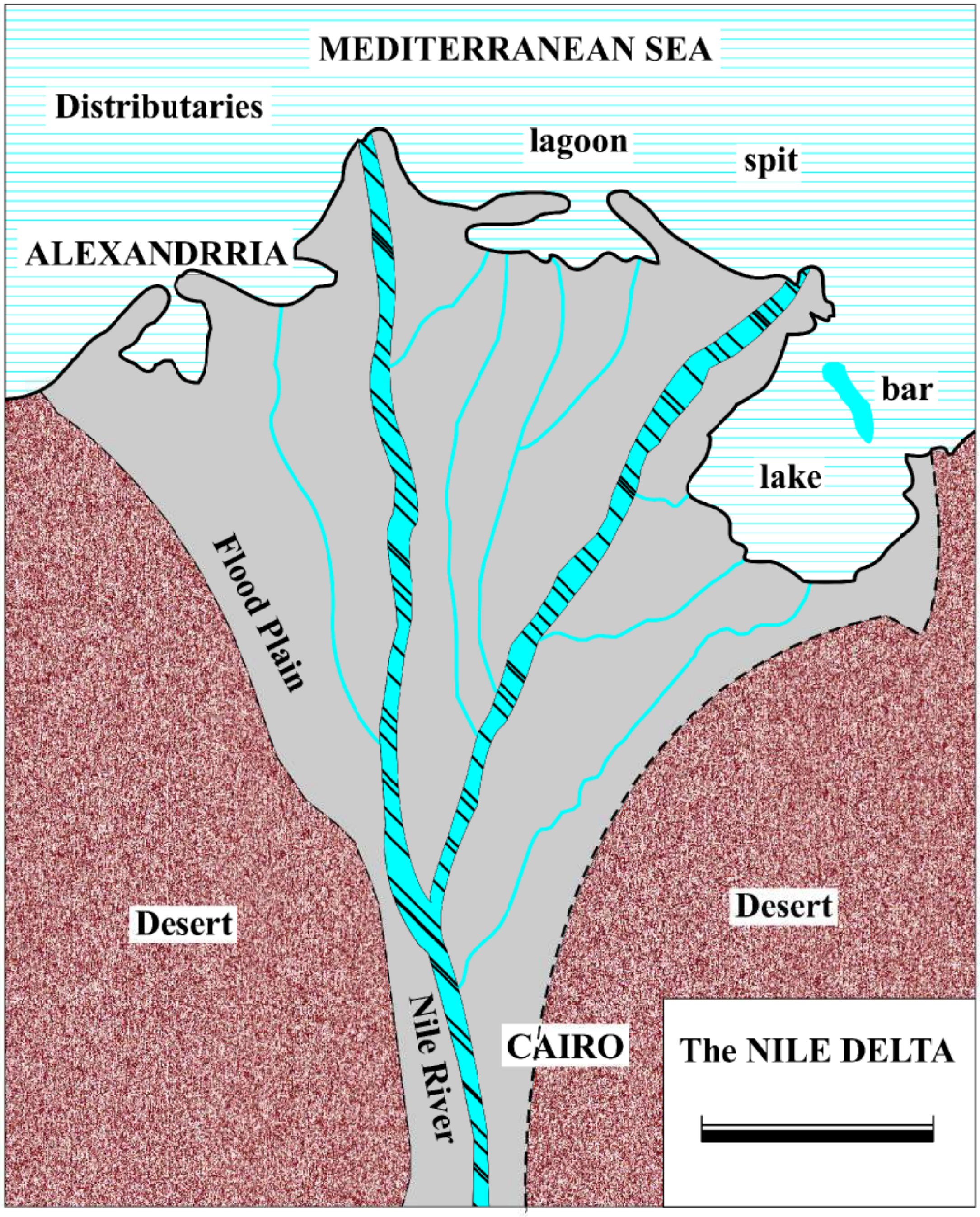



Fig . 4.7 Delta

**Distributaries-** In the delta region the river has deposited large loads of alluvium at the mouth of the sea. These sediments act as barriers for straight flow of river water and rivers that split into numerous channels in the delta region are called **distributaries.**

Some rivers fall from cliffs and high ridges before meeting the sea or ocean. As there is not enough flat area so rivers fall like waterfalls and form estuaries instead of deltas. **Estuaries**

Notes

are funnel shaped channels from which rivers fall into the sea and make small deposit of sediment at the beach. Two west flowing rivers Narmada and Tapi as they fall from western ghats makes estuaries before joining Arabian sea.

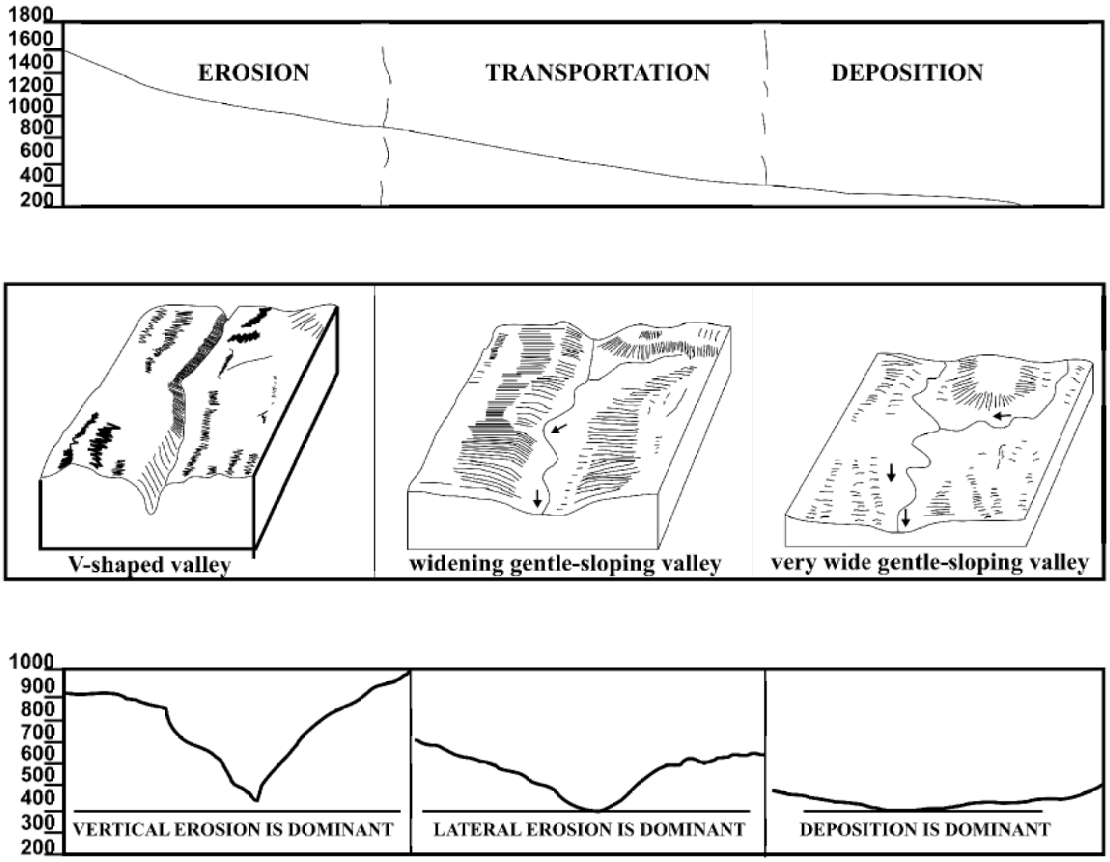



Fig. 4.8 Course of River

## Significance of running water

- Rivers provide a source of freshwater.
- River water gets replenished within a short timeframe.
- Rivers carry water and nutrients from one place to another.
- Rivers play an important role in the water cycle.
- Seventy five percent of earth's surface water is drained by rivers.
- Rivers provide habitat for plants and organisms.
- River water is used for drinking, domestic, agriculture, trade and transportation, recreation and other commercial and industrial uses.
- Rivers play an important role as a renewable source of energy for e.g. Hydro power.

## INTEXT QUESTIONS 4.1

1. Which are the three courses of the river?

   (i) ……………. (ii) …………………(iii) ……………….

2. Name four ways by which river erosion takes place.

   (i) ……………. (ii) …………………(iii) ………………. (iv)……………..

3. Name three erosional landforms.

   (i) ……………. (ii) …………………(iii) ……………….

4. Name four ways by which river transports its load.

   (i) ……………. (ii) …………………(iii) ………………. (iv)……………..

5. Fill in the blanks

   (i) The triangular shaped depositional feature formed by the river is called………....

   (ii) The meanders cut off from the main river forms a lake known as ……….........

   (iii) River Narmada and Tapi forms ………………at the west coast of India instead of a delta.

   (iv) The river splits into numerous channels at the delta are called………….........

## 4.3 GLACIAL EROSIONAL AND DEPOSITIONAL LANDFORMS

**Glaciers** are thick masses of moving or flowing ice sometimes also called rivers of ice. The glaciers originate on land with favourable climatic conditions and compaction and recrystallization of snow where seasonal accumulation is more than seasonal melting.

**Snow fields -** In the regions where the temperature always remains below freezing point precipitation occurs in the form of snowfall. It's a region that displays a net annual accumulation of snow surpassing net melting rates. Wherever the rate of snow melting or its evaporation is lower than the rate of snowfall in a year the snow accumulates in great masses of ice. Permanently snow-covered areas of this type are called snow fields. Snow fields are found above the snow line and their height varies from location to location. Snowline is an imaginary line which defines the limits of snow accumulation in the snowfield above which there is continuous and positive snow cover.

**DO YOU KNOW?**

Snow line is the lowest limit of permanent snow cover. Various factors influence the location of snow line altitude, latitude, amount of rainfall, direction of wind, slope of the land and exposure to sunlight

In regions experiencing snowfall, the snow keeps on accumulating in the layer one above the other. Its overlying pressure makes the lower layer more granular, hard and compact. The layers of snow under pressure start turning into ice and this pressure of the overlying layers makes the solid mass of ice mobile or moving ice under its own weight is called a Glacier. Movement or velocity of the glacier is very slow and it moves from a few centimetres to few metres in a day.

The glaciers are divided into two major types according to their location or area of origin-

- Polar
- High altitude mountain areas.

Glaciers can be broadly divided into two broad categories

(i) Continental glaciers

(ii) Mountain or valley glaciers

i. **Continental glaciers -** Thick ice sheets covering vast areas of land are called as a **continental glaciers.** It is a massive accumulations of ice that covers large areas of continents and regions in polar areas. The thickness of ice in such areas can go up to thousands of metres. The glaciers of this type are built up at the centre and move outward in all directions. Continental Glacier is mainly found in Greenland (1.7 million sq. km), Antarctica (around 18.8 million sq. km) and the Arctic circle (around 15.6 million sq km). The precipitation in this region occurs in the form of snowfall each year which accumulates over these regions because the amount of melting is very less or slow as compared to the amount of snowfall received thereby covering large continental areas by glaciers. 10 percent of the land area is covered by glacial ice, ice caps and ice sheets.

ii. **Mountain or Valley Glacier** When a mass of ice from a high mountain region starts moving down in the existing valleys it is called a **valley glacier or mountain glacier**. The slope and width of the valley has an impact on the size of the glaciers. Where the valley is broad the glaciers spread outwards and where the valley is narrow glacier contracts. Fedchenko glacier situated in Central Asian Pamirs range in central Tajikistan is the world's largest valley glacier found outside polar regions. It is about 70 kms long. Longest Glacier in India is Siachen glacier in Karakoram range which is 172 km long. Gangotri Glacier, Uttarakhand is 25.5 km long. There are many small glaciers in other parts of Himalaya and their length varies from 5 to 10-kilometres. Some of the major river of India i.e. Ganga and Yamuna originate from Gangotri and Yamunotri. Many glaciers are found in Swiss alps, Canadian Rockies and Andes Mountain ranges.

### Types of landforms produced by Glaciers

Like other agents of gradation, glaciers also do the work of erosion, transportation and the deposition as glaciers require certain physical and climatic conditions for their occurrence. Most of the features created by them are found in areas affected by glacial action.

### a. Erosional work of glacier

As glaciers move over the land, it drags rock fragments, gravel and sand along with it. These rock fragments become effective erosive tools. With their help glacier scraps and scours the surface rocks with which they come in contact. This action of glaciers leaves scratches and grooves on the rocks. Some of the important landforms created by glaciers are-

i. **Cirques or corrie** – Snow accumulates at the upper end of arm-chaired or bowl-shaped depressions formed at the head of the glacial valley are called cirques. The structure of the cirque has steep walls on three sides with one side open on the valley front. The cirques are like a cradle of the glacier where it is formed by plucking rock and intense freezing and thawing (causing frost shattering) from the side. It makes steep walls and scoop out at the base of the glacier in which snow accumulates and ice formations flowing away from the cirque. In certain areas the deepest part of these cirque hollows is filled with water called as cirque lakes or tarn.

ii. **"U" shaped valley-** The Glaciers do not carve out a new valley like a river but deepens and widens the pre existing valley by smoothening the irregularities. In this process the glaciers broaden the sides of the valley. The shape of the valley formed in this manner resembles the letter "U". Such a valley is relatively straight, has a flat floor and nearly vertical sides. The glacial valleys are flat bottom and steep walls caused by shear stress and glacial erosion along valley walls.

iii. **Hanging Valley**- Just like tributaries of rivers there are tributary glaciers also which join the main glaciers carve U-shaped valleys. However, they have less volume of ice than the main glaciers thus their rate of erosion is also less rapid. As a result, their valleys are not as deep as the main glacier. Due to this difference in deepening the valley of the tributary glacier is left at a higher level than the main

Notes

glacier. The valley of the tributary glacier just looks like hanging downwards at the point of its confluence with the main valley. This type of topographical feature is called hanging valley. This feature is visible when ice has melted in both the valleys. When the ice in the hanging valley melts, a waterfall is formed at the point of confluence of this stream with the main river.

iv. **Crevasses –** These are cracks which appear on the top of the glaciers and head walls of cirques.

v. **Aretes, Cols and Horns-**Aretes are saw – toothed ridges in which there are multiple ridges in series and rows and they divide two cirques. Cols are shallow passes between two high points of the mountain. They have sharp edge passes or saddles between two adjacent cirques. Horn is pyramid shaped mountain peaks which is formed by erosion on three sides by 3-4 cirques on each side of the peak. Example: Matterhorn in Switzerland.

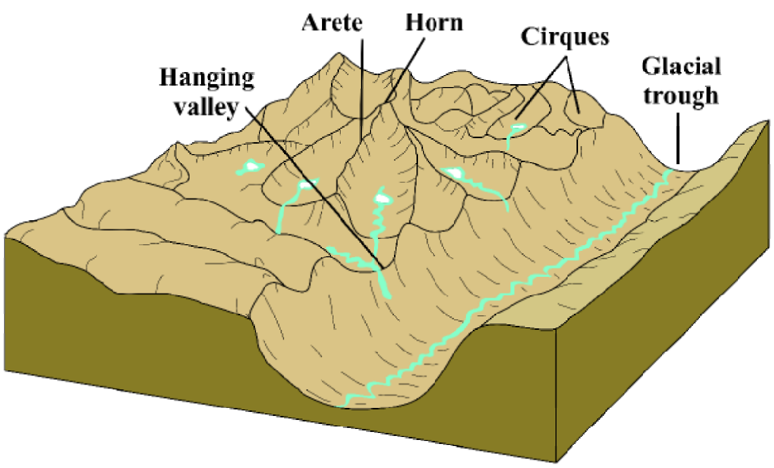



Fig. 4.9 Various glacial erosional landforms

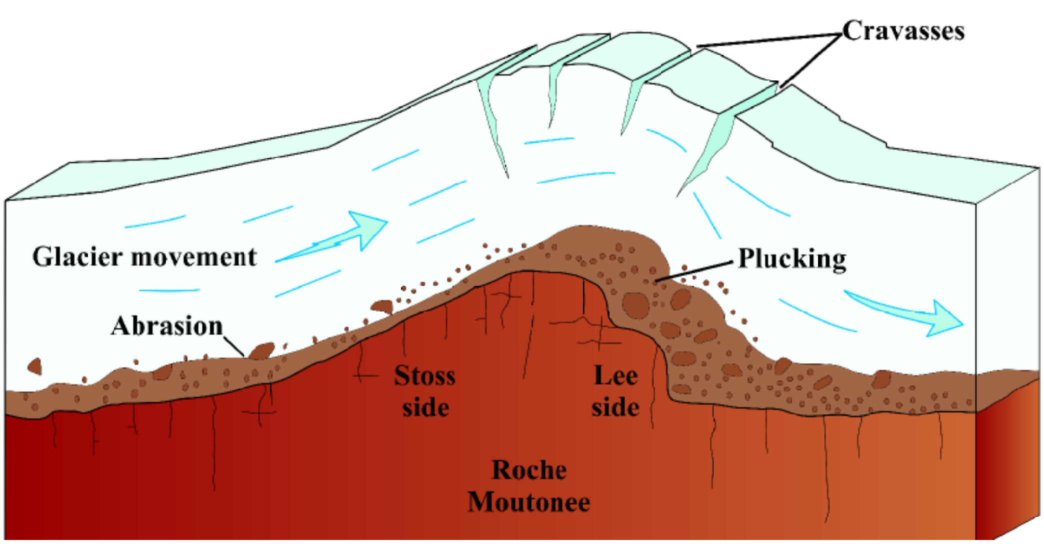



Fig. 4.10 Erosional processes of glaciers and crevasses

Notes



Fig. 4.11 Valley glacier in Sonmarg, Jammu and Kashmir, India

**b. Transportation work of glaciers**

Although glaciers move very slowly, it drags with it large boulders and rock fragments. Glaciers get its material from mountain slopes, valley bottom and from air. This material is called the load of glaciers.

**c. Depositional work of glaciers**

Eroded debris gets deposited when glacial ice melts and the sediments get deposited by moving glaciers or melt water flowing away from the glaciers. All deposits derived from glacial processes are called glacial-drifts.

**Types of debris-**

i. **Till**- Debris deposited directly from glacial ice constitutes poorly sorted materials like boulders, rocks and even rock flour**.**

ii. **Outwash**- Sorted and stratified debris which is deposited by melt waters. When glaciers melt or retreat, it deposits its load to different parts. The debris is directly deposited by ice, which is not sorted or layered marked by mixed of material and lack of stratification. This type of debris deposited in its glaciers is called moraines or till.

Depending upon their location in the valley moraines are of four types-

- **Terminal moraine** – This type of moraine is found along the front of the glacier and has a ridge-like structure which acts like a dam. Water accumulates between the front of the glacier and forms lakes. When the glacier melts, the debris is deposited at the end of the valley glaciers in the form of a ridge. It is called terminal moraine. The moraine material ranges from fine clay to large angular boulders.

- **Lateral moraine-** The moraine which is deposited on either side of a glacier is called lateral moraine. It is formed along the sides of the ice stream chiefly from material which are contributed from the valley sides above the glaciers by weathering, snow slides, avalanches or other types of mass wasting. Lateral moraines are frequently patchy and may and may not be present in both sides of a trough

- **Medial moraine-** When two glaciers join each other their lateral moraine also joins. Moraines thus formed on the confluence of two glaciers are called medial moraines.

- **Ground moraine-** It consists of deposits left behind in areas once covered by glaciers. It is seen only after the glacial ice has disappeared by melting.

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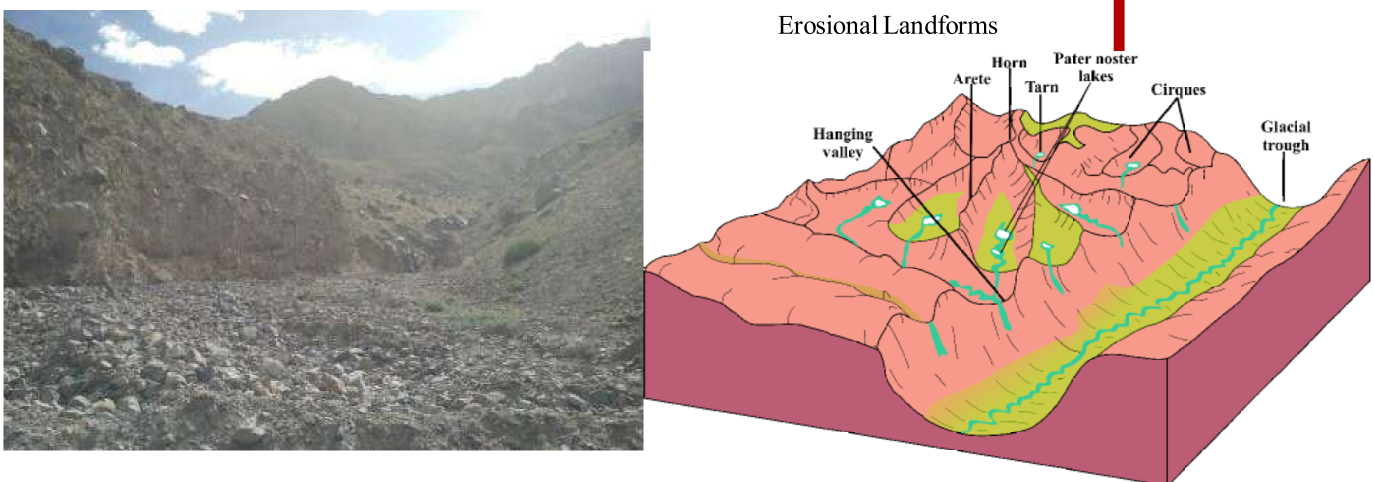



Fig. 4.12 Erosional and Depositional landforms

**DO YOU KNOW?**

**Sea ice, Iceberg and Glacial drift**

**Sea ice-** The floating ice of the oceans is formed by direct freezing of ocean water due to extremely low temperatures in polar areas.

**Iceberg-** They are mass of glacial ice floating in the ocean that has broken off a glacier and the block of ice has drifted into tidal waters. Nearly 5/6$^{th}$ of iceberg is submerged in water, only a very small part is visible over oceans.

**Glacial drift-** It is a general term for all varieties and forms of rock debris deposited by ice sheets.

### Significance of Glaciers for humans

- Glaciers ice have shaped and created many landforms in middle and high latitudes.
- Glacial ice sheets affect global climate.
- Glaciers reflect sunlight.
- Volume of ice caps and melting rate of glaciers has impacts on the sea level.
- Glacial ice affects global heat transport on earth.
- Glaciers are giant freshwater reservoirs and support life systems on the earth and also influence our day to day lives either directly or indirectly. Three quarters of all freshwater in the world is in the form of glaciers.
- They provide drinking water. Many rivers in the world originate from glaciers and snow melts. Himalayan rivers have a glacial origin.
- Melting glacial water is used for irrigation of crops.
- The cold runoff from glaciers also affects the downstream water temperatures

## INTEXT QUESTIONS 4.2

1. Write two types of Glaciers on the bases of location.

   (i) ……………………. (ii) ……………………….

2. Fill in the blanks

   (a) The moving mass of ice and snow are called …………………….

   (b) The region permanently covered by snow and ice is called …………………..

   (c) Lowest limit of permanent snow is known as…………………………………

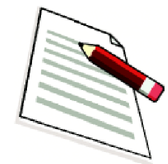
3. Identify and categorise erosional and depositional landforms made by glaciers from the given list-

   Cirques, medial moraines, 'U' shaped valley, crevasses, till, ground moraines

4. Mark as True or false

   (a) Glaciers are small reservoirs of freshwater.

   (b) Glacier lakes are made by moraines.





(c) Glacier runoff affects the downstream water temperature.

(d) Glacier melt has impact on the sea level rise.

(e) Crevasses are deposits made by glaciers.

## 4.3 WORKING OF SEA WAVES

The coastal zone is the part of the land surface influenced by marine processes and formed by the sea waves near by the sea. It extends from the landward limit of tides, waves, and windblown coastal dunes, and seaward to the point at which waves interact significantly with the seabed.

There are atmospheric processes including temperature variation, precipitation and winds, while the major marine processes are waves and tides, together with water temperature and salinity. The coast also supports rich ecosystems, including salt marshes, mangroves, sea grass, and coral reefs. The diverse coastal ecology is favoured by the shallow waters, abundant sunlight, terrestrial and marine nutrients, tidal and wave flushing and a range of habitat types.

There are three processes active in the Oceans; out of these the following modify the coasts:

1. Tides
2. Waves
3. Currents

Let us understand the role played by sea waves in shaping the coastline.

### Erosional work of sea waves

Like rivers and glaciers sea waves also play a vital role in eroding and creating land features. Distinct processes like corrosion, abrasion, attrition and hydraulic action plays an important role in the erosion process by sea waves.

### Factors affecting sea wave erosion

- **Influence of waves-** The volume of water has a great influence on the waves. Larger the volume of water, the bigger the waves created.
- **Characteristics of the coast-** Factors such as height of cliffs near the coast, their rock structure, vertical and horizontal alignment of the coast, quantity of debris along the coast on the beach also affects the sea erosion.

### Coastal Processes and Landforms

Erosional and depositional landforms of coastal areas are the result of the action of ocean waves.

Erosional Coastal Landforms are formed along rugged, high-relief, tectonically-active coastlines. It includes sea cliffs, sea caves, and sea arches.

## Erosional landforms

Coastal erosion is dependent on wave size, angle and frequency. They are focused where waves contact the coast.

### i. Sea cliffs

They are a very distinctive feature of marine erosion. Steep rocky coast rising almost vertically above sea water is called sea cliff. The steepness of a true-vertical cliff depends on variation in geological structure, lithology relative rate of subaerial weathering and erosion of cliff face. The maximum impact of the sea waves is observed on the lower part of the cliff specially. If it is made up of soft rocks like limestone, rocks eroded more rapidly than the upper part. Most of the time upper parts are made of harder rocks and the upper part of the rock is thus left projecting out towards the sea. After some time, due to the weight of the projecting part it falls into the sea leaving behind a vertical wall which is called a cliff. Number of cliffs can be seen in Konkan coast of India.

### ii. Sea caves

Waves crash into headlands eroding weaker parts such as cracks. In areas where the lower part of the coastal rock is made up of softer material and whereas the upper part is made up of harder rocks. Due to differential erosion a hollow is created in the lower part of the rock. The wave pounds against the hollow and air present inside the hollow gets compressed. When the wave comes out of the hollow air is also released and it expands. The continuous compression of the air in the hollow, the rocks are subjected to a great pressure. The crack or the hollow starts to widen in the lower part and it keeps on enlarging. With passage of time, they attain the form of a sea cave. It can be undercut causing the roof to collapse due to lack of support for the roof. This helps the cave get larger. The formation of sea caves depends upon the nature of the coastline and the force of waves.

### iii. Blow hole

As the cave gets larger, waves start to hit into its back wall and on impact are sent crashing into the roof of the cave where erosion occurs.

The erosion of the cave roof can lead to a blowhole, where waves continue to erode upwards and through the top of the headland. This is quite rare and needs a vertical crack line to be exploited.

Notes

### iv. Sea Arches, Stack and Needle

They are natural openings through the mass of boulder clay or limestone. Over time the waves continue to widen the walls of the arch leaving less support for the roof, leading to its collapse. This leaves a new headland on the landward side of the arch and the old wall still standing on the seaward side. This old wall is called a stack or a pillar and is also subject to erosion by the sea. As it erodes it gets thinner at its base and parts of it collapse leaving a narrower pillar called a needle.

### v Wave cut Platform

Wave-cut platforms are horizontal benches in the tidal zone extending from the sea cliff out into the sea. If the sea level relative to the land changes over time (becoming lower with respect to the land due to uplift), multiple wave-cut platforms (terraces) are the result. There are emergent Coastlines Tectonic forces lift coastlines faster than sea level rises. Therefore, cliffs and marine terraces tower above the sea.

## Transportation

**Coastal Transportation** - Wave action creates strong currents parallel to shore. Large waves move beach sand offshore. Small waves push it back on shore. The eroded material is transported by sea waves. The materials transported by sea waves are gravels, silts, cobbles and pebbles. Sometimes boulders and other marine products like minerals and plankton etc can also be transported.

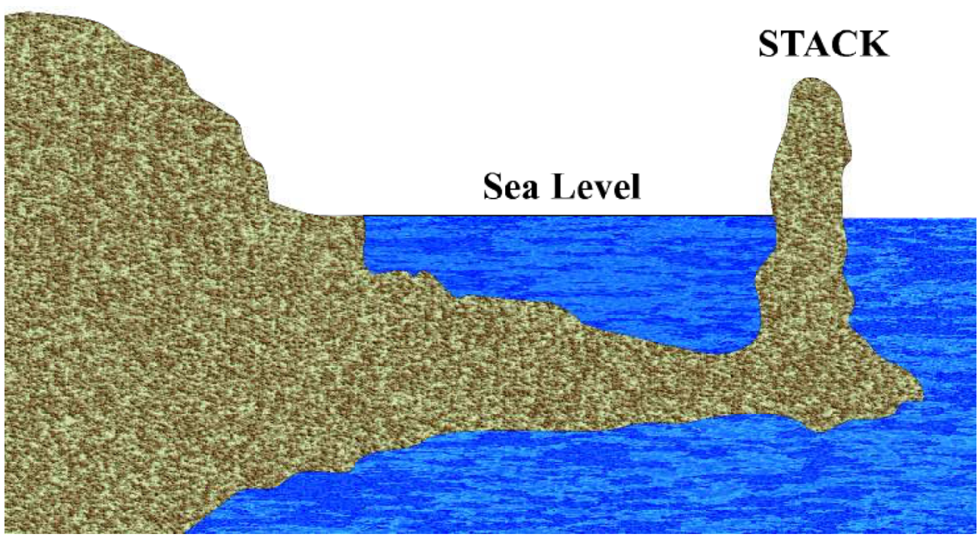



Fig. 4.13 Stack

Notes

## Depositional Landforms

### i. Beaches

Beaches act as natural barriers between waves and upland features, such as dunes. A beach is a narrow, gently sloping patch of land that lies along the ocean or sea. It is also found near river and lakes. They are composed of erodible, unconsolidated sand, gravel, rocks and seashells which may be moved by waves and wind. The wider and higher the beach, the more wave energy is dissipated before reaching the shoreline. Gentle, long period waves found in calmer weather, known as swells, tend to move sediment onshore, building up the beach. Steep waves associated with storms and strong winds tend to transport sediment offshore, eroding the beach. If the shore is gently sloping, wave energy can be dissipated over a longer distance, causing less erosion. Wind blowing across the beach can move finer grained particles, shaping, and, in some cases, eroding the beach. Windblown sediment will continue to move until it reaches a barrier, such as vegetation, which reduces the wind speed and causes sediment to be deposited. It is this accumulation that forms dunes. Radhanagar Beach, Havelock island, Andaman and Nicobar island; Agonda beach Goa, Marina Beach, Chennai, are a few famous beaches of India Seminyak beach, Bali, Indonesia; Santa Monica Beach, California, USA etc. are some more examples.

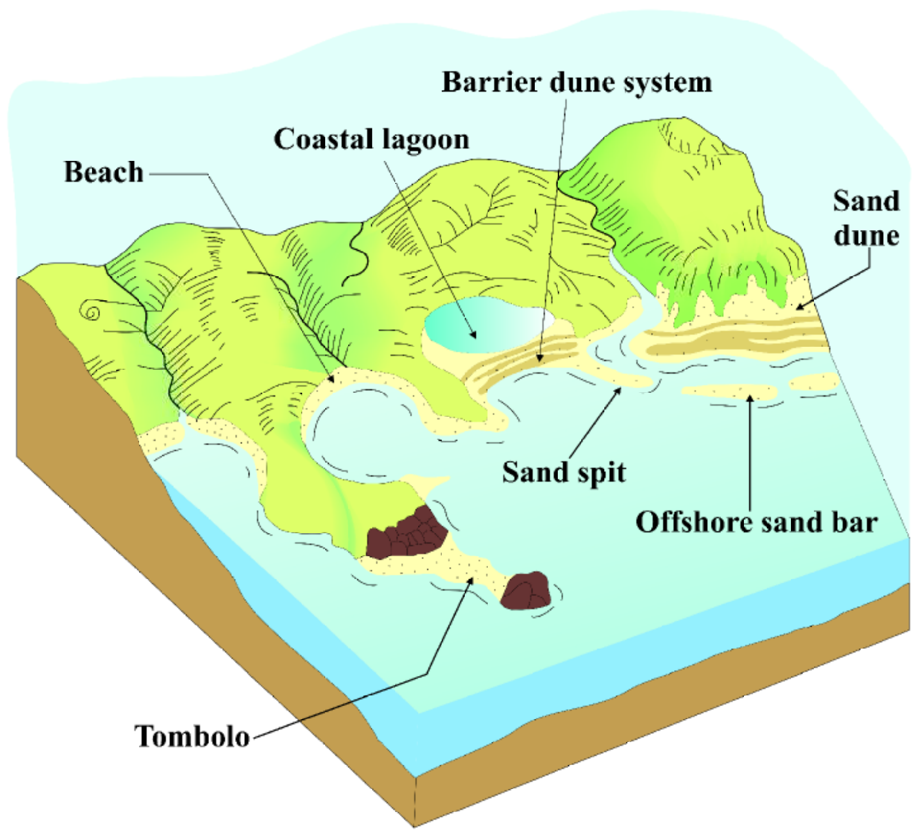
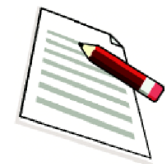



Fig. 4.14 Depositional landforms by Sea waves



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### ii. Offshore Bars

Offshore bars are underwater deposits of sediment that form parallel to the shoreline. They can act as wave barriers, if large enough, by forcing waves to break farther offshore than they normally would. This reduces the amount of wave energy that reaches the shore. Bars are formed from deeper water sediment, or from material carried away from a beach during times of high wave activity or higher-than-normal water levels. Spits are formed when one end of the bar is attached to the coast and the other end extends to sea. It is composed of sand and gravel brought by waves. Lagoons are formed by deposition of sediments by waves and currents on both ends of the bars thereby enclosing a part of sea water between the bar and coast. This enclosed region is filled with saline water and called Lagoon. The lagoon has a narrow passage through which it is connected by sea. Vembanad lake in west coast and Chilka and Pulicat in east coast are examples of lagoons in India.

### iii. Dunes

Dunes are mounds or ridges of sand deposited by the wind immediately landward of the beach. Primary dunes are closest to the beach and are usually lightly vegetated with grasses, while secondary dunes are farther landward and may have a denser vegetation cover that can include shrubs and trees. Vegetation can trap and hold windblown sand on dunes. If large enough, primary dunes can provide protection from flooding and wave action for the upland area, and may replenish some sand to eroded beaches. If a primary dune is breached, secondary dunes (if present) provide erosion and flooding protection to landward areas.

### Significance of Waves for humans

- The motion created by waves plays a vital role in transporting energy all around the globe.
- Also helps shape the coastlines.
- Ocean waves are an important element in the mechanism that controls heat balance of the planet.
- They are part of delicate balance of nature of movement of offshore and onshore by waves,
- Waves are very important for weather forecasting and for climate modelling.
- Provides resources and other benefits for the coastal communities.
- Helps in shipping industry and offshore industries,

- The waves hitting the beaches and seashores keeps earth's crust cool, especially areas which have molten lava.
- Waves also have influence on creating high and low tides which is very useful for fishing,
- Waves are useful for recreational activities like surfing etc.

## INTEXT QUESTIONS 4.3

1. Factors affecting erosion by ocean and sea waves

   (i)……………………(ii)……………….

2. Fill in the blanks

   (a) …………………..are underwater deposits of sediment that form parallel to the shoreline.

   (b) …………………….are horizontal benches in the tidal zone extending from the sea cliff out into the sea.

   (c) Waves are very important for weather ……………..and for ……………….modelling.

3. Rearrange the following relief features made by depositional and erosional action of sea waves-

   Sea caves, Bars, Beaches, Sea cliffs, Arches, Sea stacks, coastal dunes

## 4.4 WORKING OF WIND OR AEOLIAN

Wind is a powerful geological agent to create and destroy landforms. Wind is capable of eroding, transporting and depositing the surface materials. Aeolian landforms are features of the Earth's surface produced by either the erosive or constructive action of the wind. The word "Aeolian" is derived from "Aeolus", in Greek meaning, the god of the winds. In deserts, semi-arid and along sandy shorelines areas of the world where wind action moves sand and mineral particles when they are dry and the areas are without much vegetation or barriers.

### Wind and its Features

Circulation of air over the earth's surface cause the wind to blow. Wind has the ability and force to lift the earth's loose particles laying on the ground surface may be lifted in air by the mechanisms like - a) Deflation b) Abrasion c) Saltation d) Deposition (as introduced in lesson 3) the turbulent eddy actions and by sandblasting of windborne particles helps in creating new Aeolian landforms.

### Winds adopt three mechanisms for eroding the mass -

- Lift
- Bombardment and
- Drag

The **Lift** results from a combination of wind velocity and turbulence. There is a threshold (critical) velocity which is a function of particle size and cohesion and turbulence which changes in wind speed & direction. As turbulence increases, susceptibility of particles to lift increases.

**Bombardment** is the collision of moving particles with stationary ones or with solid surfaces. It has abrasion. In this process there is also collision with the solid surfaces. **Drag** also initiates sliding and rolling. It doesn't lift particles off the ground. The power of wind to erode surface particles is controlled primarily by two factors: wind velocity and surface roughness. Erosive force increases exponentially with increases in wind velocity. The power of wind to erode surface particles is controlled primarily by two factors: wind velocity and surface roughness. Erosive force increases exponentially with increases in wind velocity.

### Desert environments are characterised to assist in wind erosion by following ways -

a. Very low mean annual rainfall of less than 50 mm

b. Absence of vegetation

c. Very high daily and annual range of temperature

d. Dust storms

e. High velocity winds and

f. Dominance of sands

### Erosion by Winds

Winds are the most widespread geomorphic agents in the deserts, arid and semi-arid regions. Wind erosion generally takes place above the ground and thus wind velocity plays a major role in determining the degree of Aeolian erosion. Wind erosion is effective only up to 180 cm above the ground surface. Maximum wind erosion occurs at short distances. Unlike rivers and glaciers, winds erode the rocks from all sides because of their variable directions.

Some of the erosional landforms of the wind are:

#### i. Blow Outs or deflation basins

Rocks that are exposed to the sand blasting of prevailing winds become pitted, grooved, and polished. Deflation basins, called blowouts, are hollows formed by the removal of

*Notes*

particles by wind. Sand grains are rolled and the entire bed is lowered, in some cases up to one metre, resulting in shallow depressions called blowouts. This depression may be a few metres to as much as a kilometre across. Depressions are formed in the deserts due to removal of sands to a greater extent. The size of the depressions varies from small hollows to big hollow deeps. A desert pavement is a typical desert surface. It is covered with closely packed, interlocking angular or rounded rock fragments of pebble and cobble size, formed by the gradual removal of the sand, dust and other fine grained material by the wind and intermittent rain. The Qattara Depression of Egypt is the best example.

### ii. Yardangs

Yardangs are elongated ridges formed wind oriented with the prevailing winds. Yardangs are larger hill-sized features sculpted by the wind. Yardangs are composed of cohesive silts and clays, sandstone, or limestone. They develop in regions with strong unidirectional winds.

### iii Mushroom rock

When the composition of rock is mixed where there are alternate layers of soft and hard rock the rock is subjected to wind abrasion with differential erosion results. More sediment load is carried by wind at lower heights so erosion is more at the base or near base of the rock. The upper blowing winds carry less sediment load as it becomes heavy to carry so erosion at the upper part of the rock is less. This gives the mushroom rock its famous shape of top and base thin. These rocks resemble rock pillars shaped like mushrooms. Such types of formation can be seen in Sahara Desert in Africa and Thar desert in India.

## Features made by deposition

Aeolian or wind deposits are distinguished from other continental deposits by a number of specific features. They are:

a. Irregular cross-bedding

b. Gentle dipping

c. Steep and

d. Orienting in different directions making different shapes.

The grains of Aeolian sands are generally well-rounded due to prolonged transportation by wind. Sometimes, they are well-polished. The depositional landforms of wind are:

Notes

### i. Ripple marks

Ripple marks are very small features produced in unconsolidated sediments or sand dunes at right angles to the wind direction. They stretch laterally for long distances. Ripple marks are produced where there is some irregularity on the surface. Sand ripples develop transverse to the wind direction. Their wave-length is hardly 1 metre. When there are stronger winds blowing the ripple marks can vanish.

### ii. Sand dunes

Landform is created by the movement of sand by wind. The dunes are like small mounts, ridges or hills. Sand dunes are a very prominent feature of desert areas. The coarser materials are deposited in drifts in the shape of crest or definite summit or hills or ridges, called dunes. An ideal dune has a long windward slope rising to a crest and a much steeper leeward slope. A sand dune may be defined as a mound or ridge of wind-blown sand, rising to various heights up to 50 m. It is found in hot deserts and above high-water mark on low-lying coasts where sand is constantly renewed by onshore winds blowing across the sandy beaches. Desert sand dunes are generally characterised by the absence of natural vegetation.

For dune formation certain conditions are necessary such as,

(i) a fairly continuous sand supply;

(ii) a constant wind strength and direction; and

(iii) an obstacle or series of obstacles to trap the sand.

### Types of Sand dunes

Some of the major types of sand dunes are;

a. **Barchan -** They are crescent (half-moon) or arc-shaped, appear convex in shape and are primarily formed by wind from one direction. Most common type of sand dune and found in sandy deserts all over the world. Two "horns" face downwind on this type of dune, with the steeper slope known as the slip face facing away from the wind.

b. **Transverse dunes-**Transverse dunes are asymmetrical in shape, and from where light to moderate winds blow from a constant direction. These dunes take the shape of a series of crests and troughs whose peaks are perpendicular to the direction of prevailing winds. These dunes appear like sea waves.

c. **Seif or longitudinal dunes-** They are long narrow ridges that are parallel to the direction of prevailing winds. The winds come from different directions. The winds blow straight along the corridors between the lines of sand dunes and sweep the corridors clear of sand. Narrow rows elongated which could be many hundred kms long but their troughs the lower portion is almost without sand and some can reach height up to 100 mts. Such types are commonly seen in the Sahara Desert, North Africa, Arabia and can also be seen in western part of the Thar desert of India.

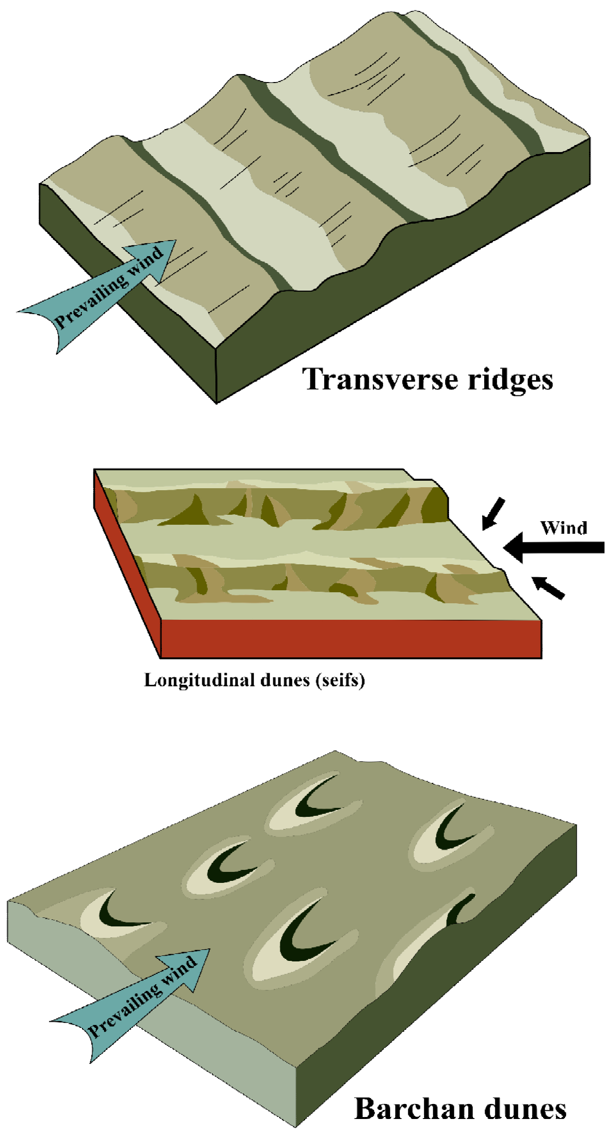



Fig. 4.15 Types of Dunes

### iii. Loess

It primarily located close to desert floor or crust. The word originated from German word Loess which means loose or un- consolidated. The particles are silt-sized and yellow in colour the deposits are very thick and have homogenous unstratified silt deposits. They are made up of fine loamy soil with high contents of lie. They are very porous and very cohesive and water seeps in the subsurface very rapidly and the top surface is always dry. The loess areas are very soft so when roads are constructed in these areas witness frequent sinking of the soil and roads also sink with it. For eg extensive deposits in northwest plateau region of China the thickness can be 30 m deep commonly but can reach up to 100 m. The material is so loose that it is picked up my winds from central Asia to far flung regions in South and Southeast regions.

### Significance of Wind for humans

- Wind increases the turbulence in atmosphere.
- Movement of water vapour, clouds and various forms of precipitation so winds allow humidity to occur.
- Winds also helps in circulation of various gases for example providing supplies of carbon dioxide resulting in greater rates of photosynthesis and oxygen movement for direct consumption by the humans.
- Winds also help in generating renewable sources of energy in the form of wind energy through wind mills. Wind energy is used for various purposes like electricity, milling grains, water pumping etc.
- Winds also help in sailing ships and aeroplanes.
- Winds provide sea breezes (winds move from sea to land) and land breezes (winds move from land to sea.
- Winds help in plants pollens to move from one place to other and also assists in flight of birds.

*Notes*

## INTEXT QUESTIONS

1. Name three mechanism of wind erosion.

   (i) ....................... (ii)..................... (iii)...........................

2. Name major erosional landforms created by action of wind.

   (i) ....................... (ii)..................... (iii)...........................

3. Name major depositional landforms created by action of wind.

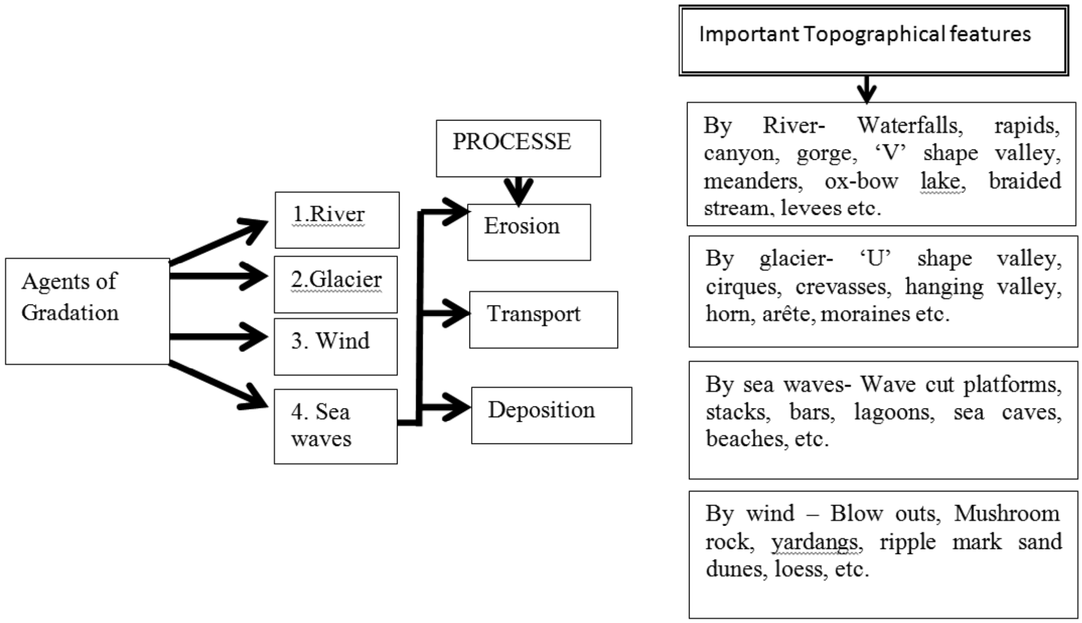
   (i) ....................... (ii)..................... (iii)...........................

Notes

4. In which regions of the world maximum deposits of loess found?

..........................................................................................................................

## WHAT YOU HAVE LEARNT




## TERMINAL QUESTIONS

1. Explain any three topographical features made by erosional work of rivers.
2. What is the difference between estuary and delta?
3. Differentiate between following
   (a) 'U' shaped and 'V' shaped valleys
   (b) Flood plain and braided streams
   (c) Lagoon and bars.
4. With the help of diagrams explain ox-bow lake, delta and natural levee.
5. Define glaciers. Distinguish between continental and valley glaciers.
6. What is a hanging valley? How are hanging valleys different from 'U' shaped valleys ?
7. What are moraines? Elaborate various types of moraines.

8. Explain two major factors affecting sea wave erosion.
9. Discuss formation of beaches and give two examples of beaches in India.
10. Describe favourable conditions in the desert environment assisting in wind erosion.

## ANSWERS TO INTEXT QUESTIONS

**4.1**

1. (i) Upper course
   (ii) Middle course
   (iii) Lower course
2. (i) Abrasion or corrasion
   (ii) Corrosion or solutions
   (iii) Hydraulic action
   (vi) Attrition
3. (i) 'V' shaped valley
   (ii) Waterfalls and rapids
   (iii) Gorges and canyons
4. (i) Traction
   (ii) Saltation
   (iii) Suspension
   (iv) Solution
5. (a) Delta
   (b) Ox-Bow Lake
   (c) Estuaries
   (d) Distributaries

**4.2**

1. (i) Valley or mountain glaciers

   (ii) continental glaciers

2. (a) glaciers

   (b) snow- field

   (c) snow-line

3. Erosional features-cirques, 'U' shaped valley, crevasses
   Depositional features- medial moraines, till, ground moraines

4. (a) False

   (b) False

   (c) True

   (d) True

   ( e) False

**4.3**

1. (i) ) Influence of waves

   (ii) Characteristics of the coast

2. (a) Offshore bars

   (b) wave-cut platform

   (c) forecasting, climate

**4.4**

1. Name three mechanism of wind erosion

   (i) Bombardment

   (ii) Drag

   (iii) lift

Notes

2. Name major erosional landforms created by action of win

   (i) Mushroom rock

   (ii) Blowouts

   (iii) Yardangs

3. Name major depositional landforms created by action of wind

   (i) Dunes

   (ii) Loess

   (iii) Ripple marks

4. In which regions of the world maximum deposits of loess found-
   Extensive deposits in northwest plateau region of China

# MODULE -3

**The Domain of the Water on the Earth**

5. Hydrological Cycle and Ocean

5

# HYDROLOGICAL CYCLE AND OCEAN

Water is the most important life supporting element of planet earth. Without water, survival in the entire earth is not possible. Almost 72% of the earth's surface is covered with water. The water on earth is present as solid form (ice), liquid and gas (water vapor). In the present scenario across the globe, the consumption of freshwater and underground water has increased to the greater extent due to the large population. Water is the crucial element of our domestic, agricultural and industrial economy.

In previous lesson we came across the significance of running water, moving ice wind and sea waves for humans. In this lesson we will discuss hydrological cycle, water budget, ocean relief, temperature and salinity, waves, tides and currents.

## OUTCOMES

After studying this lesson, learner:

- explains the importance of oceans, the hydrological cycle and water budget on the earth;
- differentiates various relief features;
- analyses the vertical and horizontal distribution of temperature and salinity and its determining factors and
- describes the three types of ocean movements-waves, tides and ocean currents;

Notes

## 5.1 IMPORTANCE OF OCEAN IN LIFE

Oceans are responsible for producing half of the world's oxygen. It also absorb more than 50 percent of carbon dioxide of our atmosphere. Oceans regulate climate. It covers 70 percent of the Earth's surface thus transporting heat from equator to the poles. It provides home to number of species

## 5.2. HYDROLOGICAL CYCLE

Hydrology is the scientific study that deals with the movement of water on earth surface and its beginning can be traced at any of the processes i.e. evaporation, condensation, precipitation, interception, infiltration, percolation, transpiration, runoff, and storage.

It is well evident that there is a cyclical process of different physical formations on Earth surface. Water also undergoes such cyclical processes. The water cycle is the journey that water makes in its life. Water changes from one state to the other that is from solid to liquid, liquid to gaseous state and vice versa. Water is the cyclical resource of earth surface. It not only changes its form but also from one place to another that is ocean to land or land to ocean etc. There is no starting point as the word 'cycle' suggests. This means that there is no beginning and no end and no fixed path.

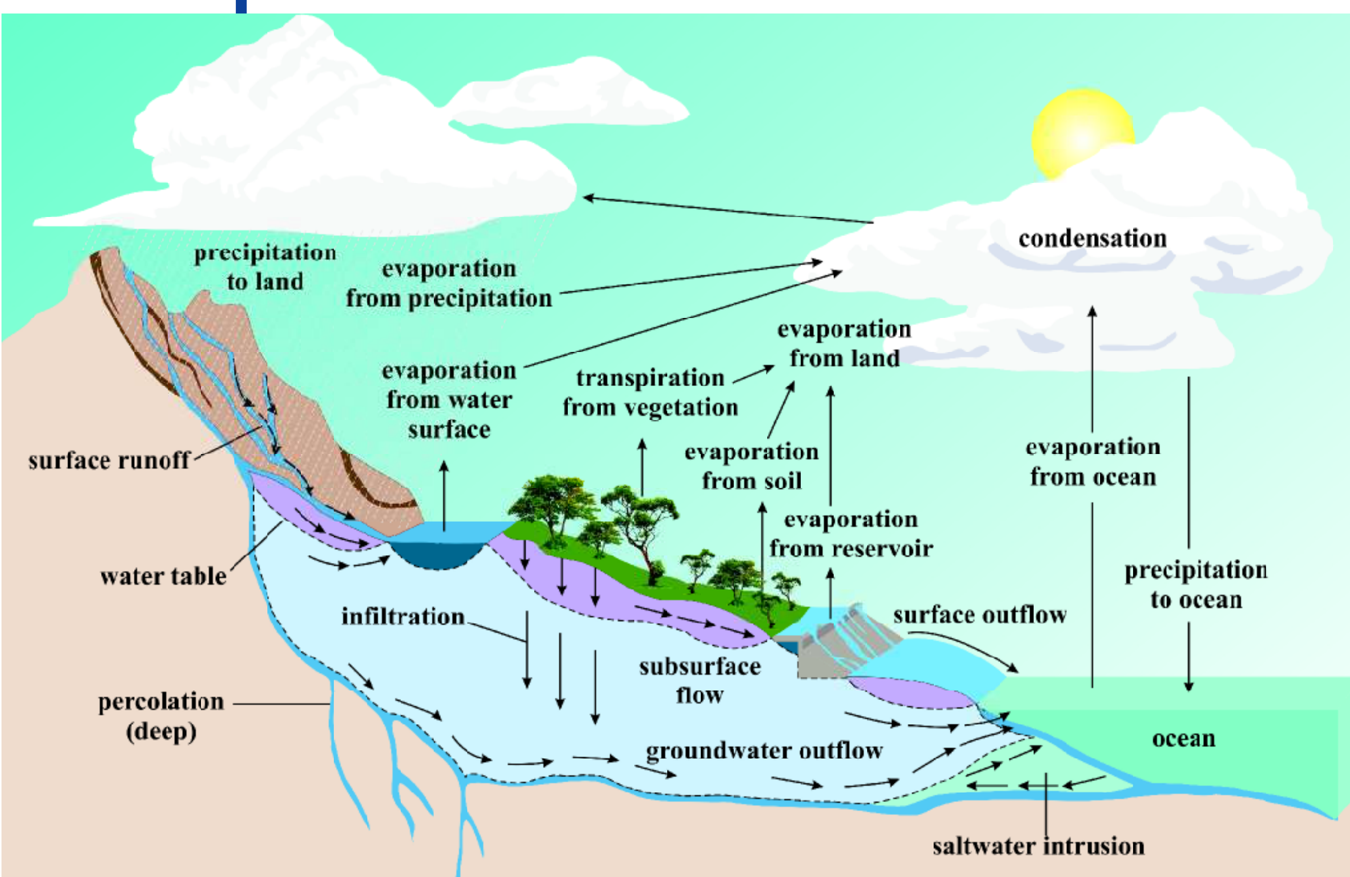



Fig. 5.1: Hydrological Cycle

**Let's know some of the important processes of hydrological cycle:**

a. **Evaporation:** Evaporation is the process through which water changes from liquid state to the gaseous state due to increase in temperature and pressure. It is one of the fundamental processes of water cycle. Water stored in ocean moves to the atmosphere through evaporation or evapotranspiration.

b. **Condensation:** Condensation is the process by which water from gaseous state changes into its liquid state i.e. cloud .It is the opposite of evaporation. This state is also known as cloud formation state. Low temperature is required for condensation to happen.Water in the gaseous state is condensed to form cloud.

c. **Precipitation:** Water that got condensed to form cloud gets accumulated in atmosphere in different forms and that accumulated water comes back to land surface in form of snow, rain, sleet, fog and hail due to the increased velocity and force of gravity.

d. **Evapotranspiration:** Evapotranspiration is the process by which water is transferred from the land to the atmosphere by evaporation from the soil and by transpiration from plants. Evapotranspiration accounts for about 10 percent of vapor in the atmosphere.

e. **Transpiration:** Transpiration is the process by which water from the plant surface gets evaporated and gets changed into gaseous form due to change in temperature, humidity and pressure.

f. **Runoff:** Runoff is the form of precipitation that does not get infiltrated or absorbed by soil and it gets collected to form ponds, seas and oceans. Runoff is one of the major causes of soil erosion and it also carries lot of chemicals thus causing water pollution.

g. **Infiltration:** The process of the absorption of the precipitated water is known as infiltration. Water gets absorbed by soil and also runs through pores and spaces in the land surface. Water can be absorbed by the soil and stay in the soil for a long time and gradually gets evaporated. In the area with a lot of green plants the infiltrated water gets absorbed by plant roots and later gets transpired. Infiltration occurs in the upper layers of the ground but may also continue further downwards into the water table.

h. **Groundwater Hydrology:** Water below the surface of Earth, occupying all or part of the void spaces in soils or geologic strata is Groundwater. Both surface and groundwater are related through the hydrologic cycle a cyclical process in the Earth-atmosphere system. Flow of ground water depends upon porosity of the soil and its permeability.

i. **Porosity and Permeability: Porosity** is the measurement of the open space within the rocks. This space can be between grains or within cracks or cavities of the rock. It depends on size of sediments, shape of sediments and sorting of sediments. **Permeability** is the measurement of the ease through which fluid (water) can move through a **porous** rock.

**j.** **Aquifer:** The underground layer of permeable rock, rock fractures or unconsolidated materials which bear the water is known as an aquifer. We can extract groundwater by using water well. The study of the flow of aquifers is known as hydrogeology.

### Importance of hydrological cycle

- Precipitation is essential for the growth of plants.
- Infiltration is essential for cleaning water and also helps in filtration.
- Glaciers, ice, and snow can act as stores of freshwater for both humans and other organisms.
- Runoff contributes to rivers, other freshwater bodies, and eventually the ocean, sustaining freshwater and marine life.

All of these processes sustain life and create the ecosystems around us.

### Water Budget

A water budget provides a ground for evaluating availability and sustainability of a water supply. A water budget simply states that the rate of change in water stored in an area, such as a watershed, is balanced by the rate at which water flows into and out of the area.

### INTEXT QUESTIONS 5.1

1. What is Porosity?
2. Define water budget?
3. Name any two the processes involved in the hydrological cycle?
4. What are Aquifers?

## 5.3 OCEAN RELIEF: MAJOR OCEAN RELIEF FEATURES

Ocean relief is an outcome of tectonic, volcanic, erosional and depositional processes and their interactions. The ocean basins have features similar to the topography of the land surface.

The two broad categories of ocean relief are **major relief features** and **minor relief features.**

Notes

## a. Major relief features

The major relief features of the oceans are divided into four.

i. The Continental Shelf

ii. The Continental Slope

iii. The Continental Rise

iv. The Deep Sea Plain or the Abyssal Plain

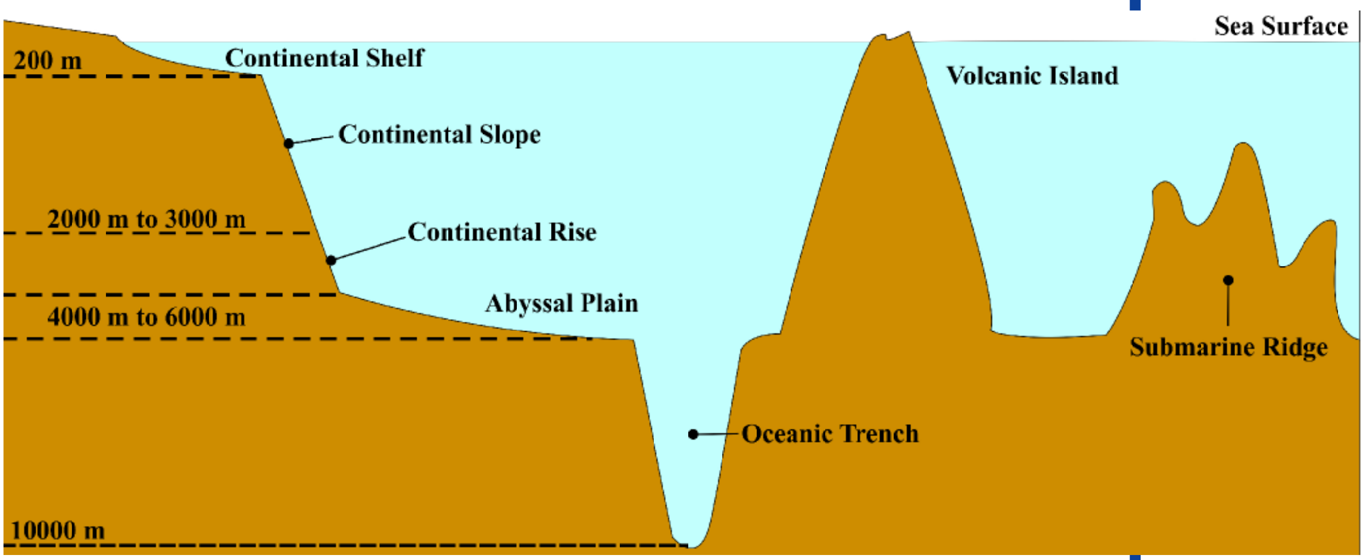



Fig. 5.2 Major Ocean Relief

i. **The Continental Shelf**- The Continental Shelf is the continental margin which starts from the shoreline and extended upto the continental edge. The reasons for the formation of shelves are:

- Submergence of a part of a continent,
- the relative rise in sea level,
- sedimentary deposits, smaller continental shelves could have been caused by wave erosion where the land is eroded by the sea. Continental shelves covers an area of 7.5% of the total area of the oceans and 18% of earth's dry land area. The average width of the shelf is 70 -80 kms.

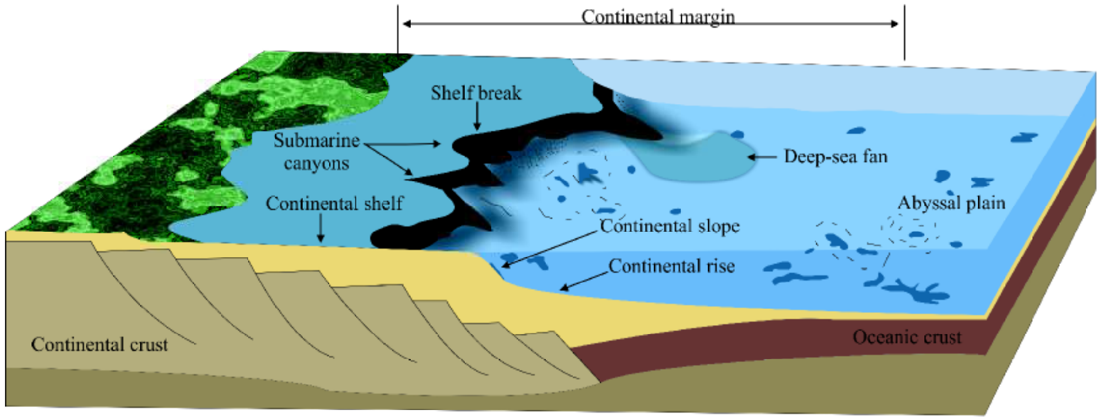



Fig. 5.3 Ocean Relief Features

**The significance of Continental Shelves-** Continental Shelves are economically and ecologically significant. It is one of the most accessible part of the ocean. Shelves provide conditions for the growth of millions of plankton and microorganisms through penetration of sunlight which makes them excellent breeding ground for fish. Hence continental shelves are the richest fishing grounds in the world. Marine food almost comes entirely from continental shelves. It is also the source of Fossil fuels and leads to the formation of metallic and non metallic ores.

ii. **The Continental Slope-** We can see as the continental slope is the connection between continental shelf and continental rise. The end of the Continental shelf is marked by the sharp increase in the slope. From this point, continental slope starts. There is an abrupt change in the gradient to about 1 in 20. The gradient of the slope is highest off coasts with young mountain ranges and narrow continental shelves and lowest off stable coasts without major rivers. Canyons are also found in this region.

iii. **The Continental Rise-** The Continental Rise is the link between Continental slope and the deep sea or abyssal plain. The steepness of continental rise is lower than that of the continental slope and it gradually merges into the deep sea plain. It is a major depositional regime in oceans made up of thick sequences of continental material that accumulate between the continental slope and the abyssal plain.

iv. **The Deep Sea plain or the Abyssal plain-** Abyssal plain are the sloping areas of the ocean basins. It is considered to be flattest and smoothest regions of the world. These plains are covered with sediments like clay and slit.

**b. Minor Relief features:**

i. **Ridges:** The underwater mountain formed by plate tectonics (divergent boundaries) is known as mid-oceanic ridges. These mountains are separated by a large depression

ii. **Seamounts:** It is a mountain with pointed summits, rising from the seafloor that does not reach the surface of the ocean. Seamounts are volcanic in origin. These can be 3,000-4,500 m tall.

iii. **Guyots:** The flat-topped mountains (seamounts) are known as guyots.

iv. **Trenches:** Trenches are relatively long, steep-sided, narrow basins. These areas are the deepest parts of the oceans. They are originated by plate tectonic and are formed during ocean-ocean convergence and ocean-continent convergence. The greatest known ocean deep, the Mariana Trench is nearly 36,000 feet deep and found near Guam Island in the Pacific Ocean.

v. **Coral reefs:** Coral reefs are built by colonies of tiny animals found in marine water that contain few nutrients. They are diverse underwater ecosystems held together by calcium carbonate structures secreted by marine invertebrates called corals.

vi. **Atolls:** The low islands found in the tropical oceans consisting coral reefs surrounding a central depression is known as Atoll. It may be a part of the sea (lagoon), or sometimes part of a body of fresh, brackish, or highly saline water. Example: Lakshadweep is formed on Atolls.

## INTEXT QUESTIONS 5.2

1. What is the continental slope?
2. Name the minor relief features of the ocean?
3. What are the major relief features of the ocean?
4. Define trenches?
5. Which Island in India is form of Atolls?

## 5.4 OCEAN TEMPERATURE AND ITS DISTRIBUTION

Water has the highest capacity of absorbing heat. About 80 percent of heat is absorbed by oceans. The uppermost 10 percent of the oceans contain more heat than the entire atmosphere.

There is a variation in distribution of temperature in oceanic water. It differs from latitude to latitude and from the surface to the bottom.

**The major determinants of ocean temperature are:**

- **Latitude:** The surface temperature of the oceans declines from the equator towards the poles as the Sun's rays are vertical on the equator.
- **Prevailing Winds:** Direction of the prevailing winds such as the Trade Winds, Westerlies etc., determines the surface temperature of ocean waters at a point.
- **Unequal distribution of Land and Water:** The Northern Hemisphere has more land area than that of the Southern Hemisphere. Hence, the oceans of the Northern are warmer than that of the Southern Oceans.
- **Evaporation Rate:** Highest amount of water is gets evaporated from oceans. However, there is no uniformity in the rate of evaporation. The warmer region experience more evaporation than cooler one.
- **The density of water:** The density of ocean water is governed by the temperature and salinity. There is variation of density of water from latitude to latitude. Areas with high salinity witness the relatively higher temperature of ocean waters and vice versa.
- **Ocean Currents:** The temperature of oceans of surface is also controlled by cold and warm currents. The presence of warm water increases the temperature and thus raising the rate of evaporation. Therefore, the region records more rainfall, while the cold current reduces the temperature of the moisture-laden wind.
- **Local Factors:** Submarine ridges, local weather conditions like storms, cyclones, winds, fogs, cloudiness, the rate of evaporation, lapse rate, condensation, and precipitation are some of the major factor that affect ocean temperature.

### a. Horizontal Distribution of Temperature

The usual temperature of the surface water in the lower latitudes is about 26° Celsius which decreases towards poles. The oceans of the Northern Hemisphere record an average temperature of 19.4° Celsius. However, the average temperature recorded at various latitudes also varies with 22° Celsius recorded at 20° latitude, and 14° Celsius recorded at 40° latitude in the Northern Hemisphere. At the poles, the temperature drops to 0° Celsius.

The maximum and minimum annual temperatures of ocean water in the Northern Hemisphere are in the months of August and February respectively. The average annual range of temperature is about 12 degrees Celsius. The highest annual range of temperature is recorded in the North Atlantic Ocean. Moreover, the annual range of temperature is higher for the inland seas as compared to the open oceans.

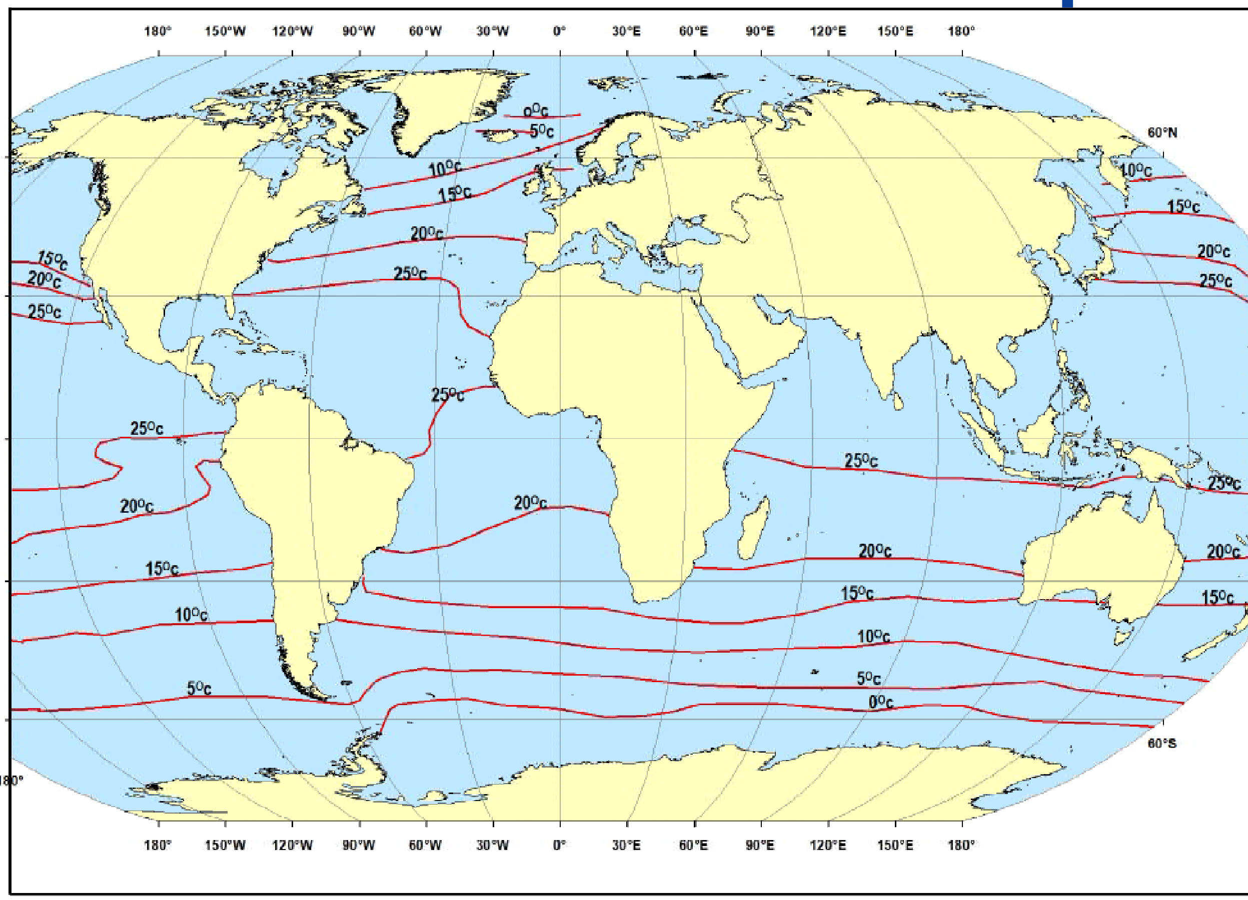



Fig. 5.4: Temperature Distribution in the Oceans

## b. Vertical Distribution of Temperature

With the increased depth in the oceans both energy and sunlight decreases. Only about 45 percent of light energy striking the ocean surface reaches a depth of about one meter, and only 16 percent reaches a depth of 10 meters. On the basis of the temperature, the ocean depths may be divided into the following three zones:

- **Surface Zone or Mixed Zone:** This is also known as the Photic zone or Euphoric zone. It is the upper layer of the ocean. In this layer, the temperature and salinity are relatively constant. It contains about 2 percent of the total volume of water in the ocean. It is limited to a depth of about 100 meters.

- **Thermocline:** It lies between 100 metres and 1000 metres. It contains about 18 percent of the total volume of water in the ocean. There is a steep fall in temperature in this zone. The density of water increases with increasing depth.

- **Deep Zone:** This zone lies below 1000 metres in the mid-latitudes. This zone contains about 80 percent of the total volume of water in the ocean. The temperature in this zone remains constant. The ocean bottom always has a temperature which is one or two degrees Celsius above the freezing point.

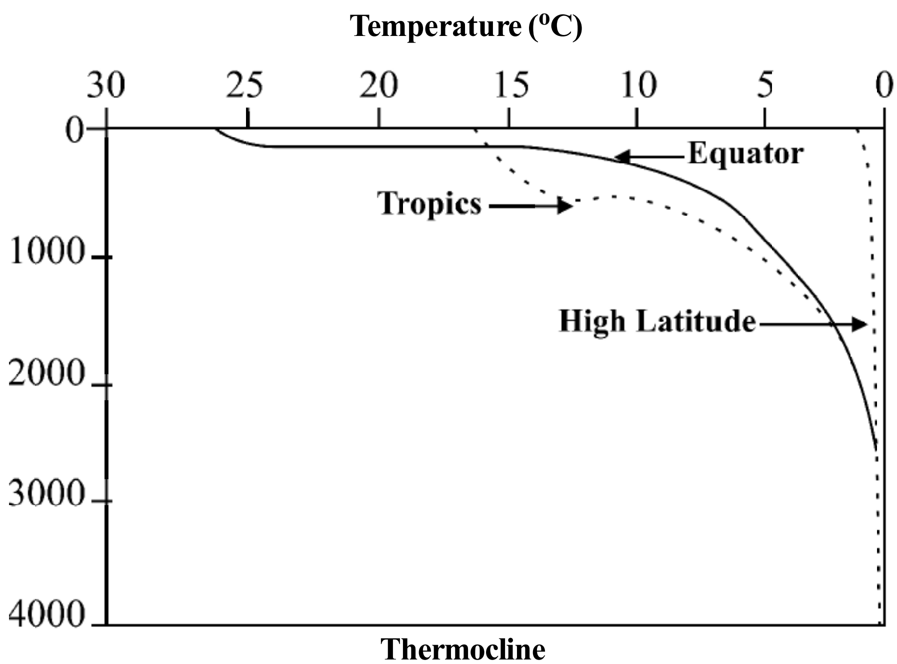



Fig. 5.5 Distribution of Temperature

## INTEXT QUESTIONS 5.3

1. What are the major determinants of Ocean temperature?
2. How prevailing winds determines surface temperature of Ocean waters?
3. What is the average annual range of temperature of ocean?
4. Name the three zones in which ocean is divided on the basis of temperature.
5. Define thermocline zone.

## 5.5 OCEAN'S SALINITY AND SALT BUDGET

The salinity of ocean waters is measured by the amount of dissolved solids present in a unit weight of ocean water, usually expressed in parts per thousand by weight or grams per kilogram.

Notes

## Salinity of Ocean

The salinity of ocean water is usually around 35 parts per thousand on an average at zero degrees Celsius. This implies that in the total weight of ocean water, dissolved salts amount to 3.5 percent. Sodium chloride or the common salt is the most common among all the dissolved salts in the sea.

Table 5.1: The chemical composition of ocean water

| Salt | Percentage |
|---|---|
| Sodium chloride | 2.6 |
| Magnesium chloride | 0.3 |
| Magnesium sulphate | 0.2 |
| Calcium sulphate | 0.1 |
| Potassium chloride | 0.1 |
| Potassium bromide | 0.01 |
| Other elements | 0.01 |

### *Sources of salinity*

The source of salts dissolved in the ocean waters has their origin on the continental landmasses. They are carried into the oceans by rain, rivers, groundwater table, sea-waves, winds, and glaciers. Some of the dissolved salts are originated from the ocean bottom. The layers of the earth beneath the crust contain minerals in a molten state which can reach the crust either due to volcanic activity or due to their continuous emission in the form of gasses.

## Determinants of the salinity of the oceans

Ocean salinity is dependent upon several factors and it keeps varying with the place and time. The major determinants of ocean salinity are-

- **Evaporation:** Salinity is usually higher at places with high rates of evaporation. i.e. the tropical seas such as the Red Sea, Persian Gulf etc.
- **Temperature:** Temperature and ocean salinity are directly proportional to each other. Generally, regions with high temperatures are also the regions with high salinity.
- **Precipitation:** Precipitation and salinity inversely proportional to each other. Hence regions with higher levels of precipitation have lower levels of salinity.

- **Ocean Currents:** Ocean currents plays crucial role in the spatial distribution of dissolved salts in ocean waters. The warm currents near the equatorial region push away the salts from the eastern margins of the oceans and accumulate them near the western margins. Similarly, ocean currents in the temperate regions increase the salinity of ocean waters near the eastern margins.

- **The influx of Fresh Water:** Salinity is relatively lower in areas where major rivers meet the oceans.

## a. Horizontal Distribution of Salinity

The surface salinity of oceans decreases on either side of the tropics. For example, the surface salinity along the Tropic of Cancer is around 36 parts per thousand (ppt) while at the equator it's around 35 parts per thousand. On the basis of their salinity levels, seas are categorized as follows:

- **Seas with salinity levels below the normal:** They have a low salinity due to the influx of fresh water. They include the Arctic Ocean, Southern Ocean, Bering Sea, Sea of Japan, Baltic Sea etc. Their surface salinity can be as low as 21 ppt.

- **Seas with normal salinity levels**: They have salinity in the range of 35 to 36 ppt. For example the Caribbean Sea, Gulf of Mexico, Gulf of California, Yellow Sea etc.

- **Seas with salinity levels above the normal:** They have higher levels of salinity because of their location in regions with higher temperatures leading to greater evaporation. For example the Red Sea (39 - 41 ppt), Persian Gulf (38 ppt), Mediterranean Sea (37 - 39 ppt) etc.

## b. Vertical Distribution of Salinity

There is no definite trend in the variation of salinity with depth. Instances of increase, as well as a decrease in salinity levels, have been found with increasing depth.

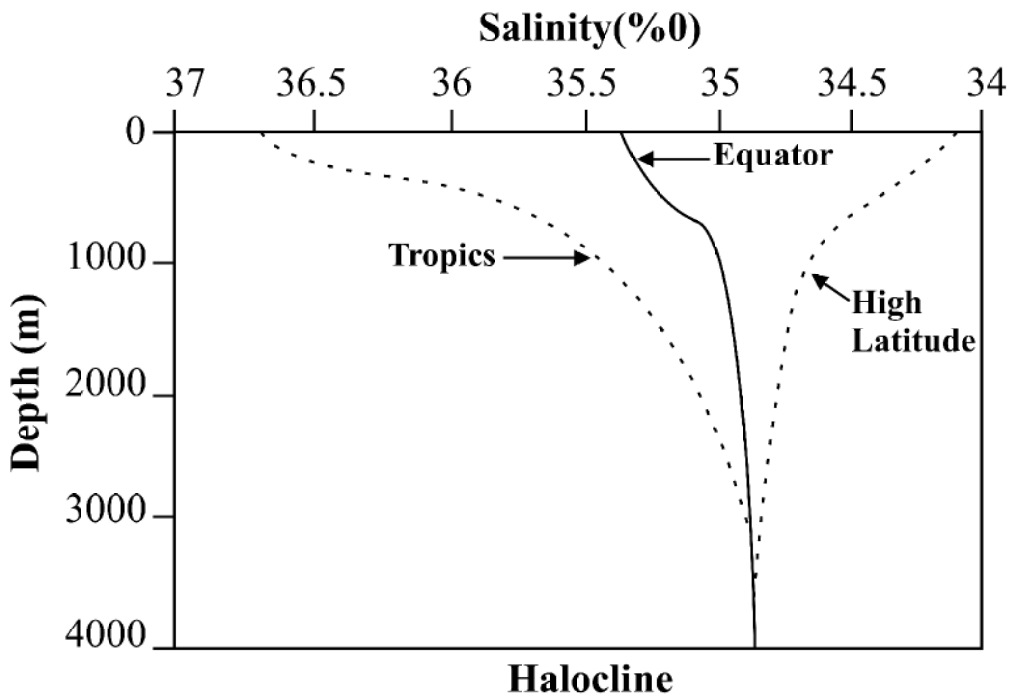



Fig. 5.6 Distribution of Salinity

*Notes*

From the above graph, it can be observed that,

- Salinity decreases with increasing depth at the equator as well as near the tropics.
- At higher latitudes, salinity is found to increase with increasing depth.

## Salt Budget

Salt budget is commonly known as the salt cycle. It involves all the processes through which salt moves from the ocean into the lithosphere, to a certain extent into the atmosphere, and back into the oceans.

- The salinity level of ocean water is increased due to the mineral deposition taken from moving water, including groundwater. Minerals leach from the rocks through the process of surface erosion. The water with minerals joins the rivers and streams which finally reach the oceans. These minerals add to the salinity levels of the ocean waters.
- Some of the salts in the ocean waters accumulate at the ocean bottom through the process of sedimentation turning into mineralized rocks. Over a period of millions of years, some of these rocks get raised above the ocean surface due to plate tectonics, or due to volcanic activity. This brings the salt back to the lithosphere in the form of minerals.
- Salt from the oceans also gets sprayed into the atmosphere due to the action of wind. This salt returns to the lithosphere mixed with precipitation.

*Notes*

- Salt cycle operates over a very long period of time.

Every year, around 3 billion tons of salt gets added to the oceans from the land. A tiny fraction of this salt is extracted by humans for daily consumption.

## INTEXT QUESTIONS 5.4

1. What are the determinants of salinity of the ocean?
2. How ocean currents determine the salinity of ocean?
3. What is the relationship between salinity and depth at higher altitudes?

## 5.6 OCEAN MOVEMENT

The ocean water is very dynamic. There is always some sought of movements happening inside the ocean water due to various physical characteristics such as salinity, temperature etc. and also some of the external factors like sun and moon influence those movements. There are three types of ocean movements-ocean waves tides and ocean currents.

### a. Ocean Wave

Ocean waves are formed as wind blows across the surface of the ocean, creating small ripples, which eventually become waves with increasing time and distance.

The ocean is never still. Whether observing from the beach or a boat, we expect to see waves on the horizon. Waves are created by energy passing through water, causing it to move in a circular motion. Waves transmit energy, across the ocean and if not obstructed by anything, they have the potential to travel across an entire ocean basin.

The most common cause of waves is wind. Surface waves, are created by the friction between wind and surface water. As wind blows across the surface of the ocean or a lake, the continual disturbance creates a wave crest.

Severe weather condition like hurricane can also develop waves. The strong winds and pressure from this type of severe storm causes storm surge due to which a series of long waves are created far from shore in deeper water and intensify as they move closer to land.

Underwater disturbances also cause hazardous waves. It displaces large amounts of water quickly such as earthquakes, landslides, or volcanic eruptions. These very long waves are called tsunamis. Storm surge and tsunamis are not the types of waves. The gravitational pull of the sun and moon on the earth also causes waves. These waves are tides or, in other words, tidal waves.

Notes

## b. Tides

The periodical rise and fall of the water level in oceans and sea, once or twice a day, due to the gravitational pull of the sun and the moon, is called a tide. The study of tides is very complex, spatially and temporally, as it has great variations in frequency, magnitude and height. Three major forces that causes an occurrence of tides are as follows:

1. Moon's gravitational pull
2. Sun's gravitational pull
3. Centrifugal force which acts opposite to gravitational pull of the earth.

Tides occur due to an imbalance between the various forces acting on the ocean water at a point of time. The tide-generating force is the difference between these two forces; i.e. the gravitational attraction due to the mass of the moon and the centrifugal force due to rotation of the earth.

### Mechanism of Tides

- When the two forces are not in balance, it gives rise to the tide-generating force. The side of the Earth which is closest to the moon has the strongest gravitational pull towards the moon while water on the other side of the Earth experiences a weaker gravitational pull.
- The moon's gravitational force has a greater effect than the sun's gravitational force due to the relative distance of moon and sun respectively. The tide-generating force is proportional to the product of the mass of the two bodies but also inversely proportional to the square of the distance between them.

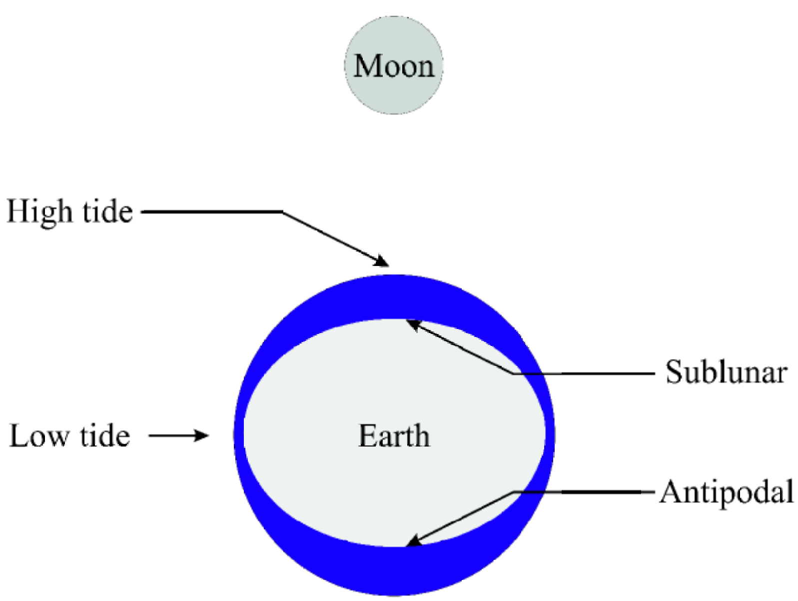



Fig. 5.7 Tide



### Other Factors Controlling Tides

- Uneven distribution of water over the globe.
- Irregularities in the configuration of the oceans.
- When the tide is channeled into bays and estuaries they are called tidal currents.

### Types of Tides

Types of tides is based on-

- Frequency
- The position of the earth, moon, and sun
- The time period between high tide and low tide
- Magnitude

#### i. Based on frequency

- **Semi-diurnal Tide**: This is the most common tidal pattern, featuring two high tides and two low tides each day.
- **Diurnal Tides**: Only one high tide and one low tide each day. The successive high and low tides are approximate of the same height.
- **Mixed Tide**: Tides having variations in heights are known as mixed tides. They generally occur along the west coast of North America and also in the Pacific Ocean.

#### ii. Based on sun, moon and earth's positions

- **Spring Tides**: When the position of the sun, the moon, and the earth are aligned in such a way that it forms a straight line, the height of the tide will be higher than normal. These are called as spring tides. It occurs twice in a month-one on the full moon and the other on the new moon.
- **Neap Tides**: After seven days of spring tides the sun and the moon form a 90 degree angle between each other. The resultant force of gravitation gives rise to a tide of very low magnitude which is termed as the neap tide. It also occurs twice in a month.

Notes

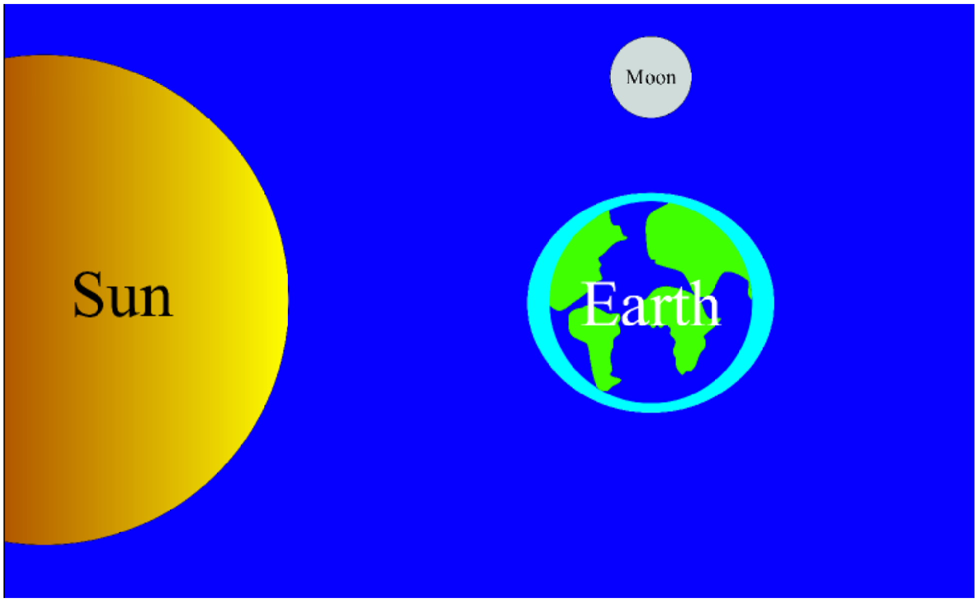



Fig. 5.8 Spring and Neap Tide

### iii. Based on magnitude

- **Perigee**: When the moon's orbit is closest to the earth, it is called as perigee. During this period, unusual heights of high and low tide occur.
- **Apogee**: When the moon's orbit is farthest from the earth, it is called as apogee. Tidal ranges will be much less than average height during this period.
- **Perihelion**: It is the position where the earth is closest to the sun (around January 3$^{rd}$). Unusually high and low tides occur at this time.
- **Aphelion**: It is the position where the earth is farthest from the sun (around July 4$^{th}$). Tidal ranges will be much less than the average height during this period.

### The time period between high tide and low tide

The time between the high tide and low tide, when the water level is falling is called the ebb. The time between the low tide and high tide, when the tide is rising, is called the flow.

### Importance of Tides

- Tides help in navigation. Water level rises during high tide. Large ships can enter or leave harbour safely. Diamond Harbour in West Bengal and Kandla port in Gujarat are examples of such ports.
- Tides help the ships to travel up the mouth of the river in case of river ports. High tide increases the volume of water at the river ports to a high volume so that large ships can sail in safely and use a retreating tide to leave the port. Hooghly (Kolkata), London and New York are examples of some of the important river ports of the world.

- Tides help in removal of silt from river mouth. Rivers carry down a lot of soil and sand. Tides wash away these deposits and help to keep the mouth of the river clear.
- Salt water freezes at a temperature that is low than that of fresh water. In cold regions whereas the rivers are frozen in winter, the warmer seawater rushes into the harbours to keep it free from freezing.
- Tides are largely being harnessed to produce electricity as a renewable source of energy (Tidal energy).
- Tides bring in huge volumes of fish and these areas serve as fishing zones for fishermen without venturing too deep into the sea.

## C. Ocean Currents

The ocean currents are the large masses of surface water that circulate in regular patterns around the oceans. Ocean currents can be classified into warm currents and cold currents depending upon their temperature.

i. **Warm currents -** Warm currents flow from equatorial regions towards the Polar Regions and hence have a higher surface temperature. These currents flow in the clockwise direction in the northern hemisphere and in the anti-clockwise direction in the southern hemisphere.

ii. **Cold currents -** Cold currents flow from Polar Regions towards the equator and have a lower surface temperature. Cold ocean currents flow in the anti-clockwise direction in the northern hemisphere and in the clockwise direction in the southern hemisphere.

### Factors responsible for Ocean Currents

The following factors are responsible for ocean currents:

i. **The Planetary winds-** The Earth's atmosphere is divided into permanent pressure belts - The Equatorial low-pressure belt, The Sub-tropical high-pressure belt, Sub-polar low-pressure belt and Polar high-pressure belts. The planetary winds are permanent winds that blow from one pressure belt to the other.

The Planetary winds influence flow of ocean currents. Evidence of prevailing winds on the flow of ocean currents can be seen in the North Indian Ocean where there is a change in the direction of ocean currents with a change in direction of the monsoon winds. The oceanic circulation pattern corresponds to the earth s atmospheric circulation pattern.

*Notes*

ii. **Temperature-** The energy from Sun reach at the equator more than the poles is the reason behind the difference in the temperature of ocean water. As the temperature gets higher the ocean water gets heated up and expands at the equator. Sun energy makes the warm water lighter and it rises while at the poles, cold water is denser and sinks. Warm water from the equator slowly moves along the surface towards the poles, while the cold water from the poles slowly creeps along the bottom of the sea towards the equator.

iii. **Salinity-**The density of water also depends on its salinity and the salinity of water varies from place to place. Waters of low salinity flow on the surface of waters of high salinity while waters of high salinity flow at the bottom.

iv. **The earth's rotation and Coriolis force-**The earth's rotation deflects moving objects to the right and ocean currents are no exception. Under the action of Coriolis force, the movement of ocean currents in the northern hemisphere is in the clockwise and in the southern hemisphere it is in the anti-clockwise direction. Hence it can be said that ocean currents obey Ferrel's law.

v. **Obstruction due to land-** A land mass obstructs the direction of flow of ocean current and divides the ocean current which in turns flow in a different direction. Example: The south equatorial current in the Atlantic Ocean is obstructed by South American continent and the South equatorial current divides to create the Brazilian current which flows in the south Atlantic Ocean.

## Distribution of Ocean Currents

a. **Currents in the Pacific Ocean;**

- **Warm Currents** are; North Equatorial Current, South Equatorial Current, Counter Equatorial Current, Kuroshio System, East Australia Current, and North Pacific Drift.
- **Cold Currents** are; Oyashio Current, California Current, and Peruvian or Humboldt Current.

## Currents in the Atlantic Ocean

- **Warm currents** are; North Equatorial Current, South Equatorial Current, Equatorial Counter Current, Gulf Stream, Florida Current, and Brazilian Current.
- **Cold Currents** are; Canaries Current, Labrador Current, Falkland Current, South Atlantic Drift, and Benguela Current.

## Currents in the Indian Ocean

- **Drifts** are; The North East Monsoon Drift, and The South West Monsoon Drift.
- **Warm currents** are; North Equatorial Current, South Equatorial Current, Mozambique Current, Madagascar Current, and Agulhas Current.
- **Cold Currents** are; Somali Current, and West Australian Current.

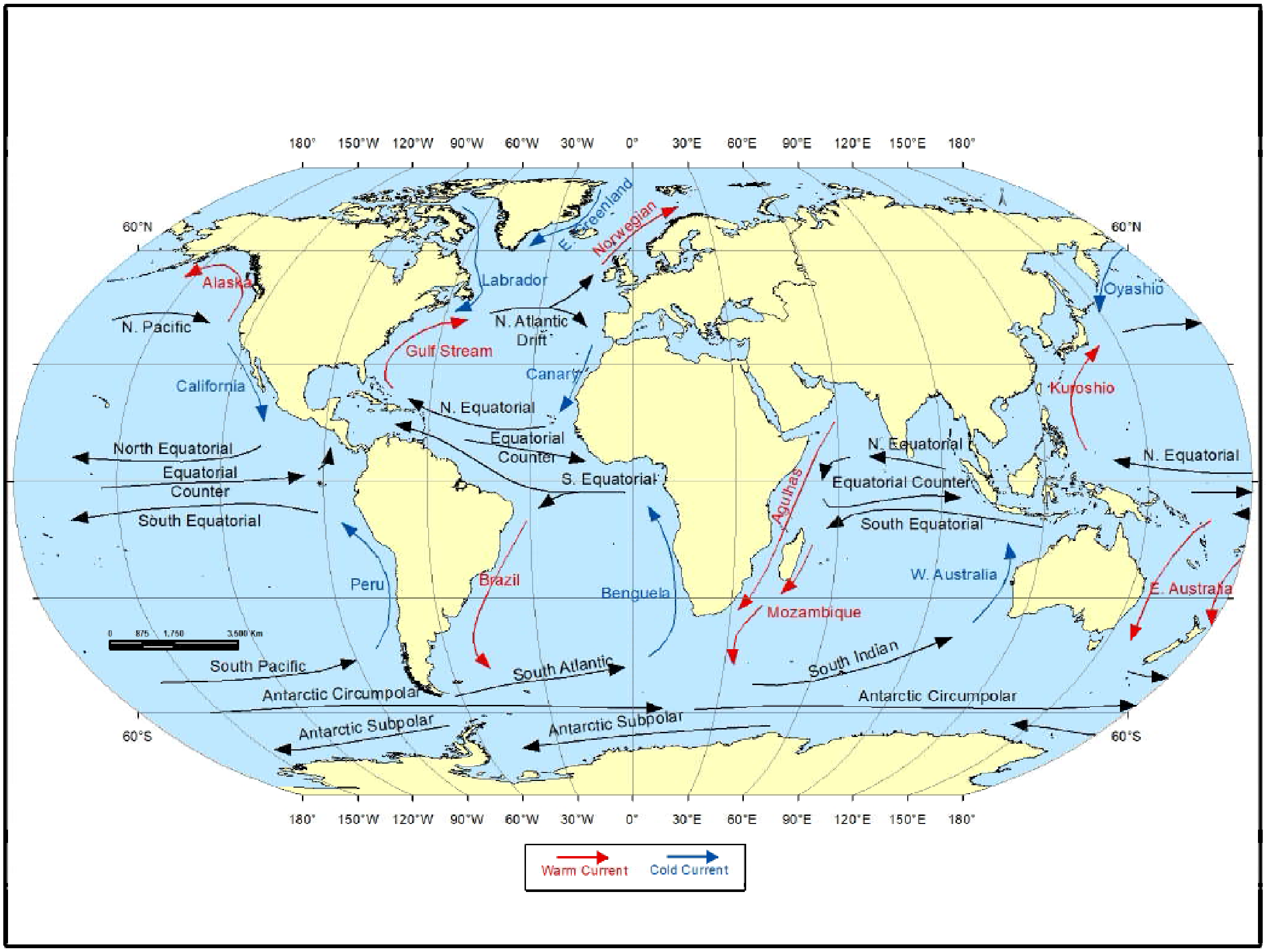



Fig. 5.9: Ocean Currents

## INTEXT QUESTIONS 5.5

1. What is a Diurnal tide?
2. Define Aphelion.
3. Name the position when earth is closest to the sun thus causing unusually high and low tide.

4. Name the drifts of Indian Ocean currents.

5. Name the warm currents of Atlantic Ocean.

6. Name the cold currents of Pacific Ocean.

## WHAT YOU HAVE LEARNT

- ***Hydrological Cycle***: Elements of Hydrological Cycle are; Evaporation, Condensation, Precipitation, Evapotranspiration, Runoff and Infiltration.
- ***Groundwater Hydrology***: Groundwater Hydrology is based on the porosity of Soil, Permeability of Soil, and Aquifers.
- ***Ocean Relief:*** Major Relief features are; Continental Shelf, Continental Slope, Continental Rise and Deep Sea Plain or Abyssal Plain.
- ***Ocean Temperature:*** Major determinants of distribution of temperature are; Latitude, Prevailing winds, Unequal distribution of Land and Water, Evaporation Rate, Density of Water and Ocean Currents.
- ***Ocean Salinity***: Major determinants of distribution of Salinity are; Evaporation, Temperature, Precipitation and Ocean Currents.
- ***Ocean Tides:*** Different types of tides based on position of Earth, Moon, and The Sun are; Spring Tides and Neap Tides
- ***Drifts of Indian Ocean currents:*** The North East Monsoon Drift, and The South West Monsoon Drift.
- ***Warm currents of Atlantic Ocean:*** North Equatorial Current, South Equatorial Current, Equatorial Counter Current, Gulf Stream , Florida Current, and Brazilian Current
- ***Cold currents of Pacific Ocean:*** Oyashio Current, California Current, and Peruvian or Humboldt Current.

## TERMINAL QUESTIONS

1. What is hydrological cycle? Diagrammatically explain the process of hydrological cycle.

2. Describe the major relief features of ocean floor?

3. What are tides? Describe the mechanism of tide formation.

4. Explain the vertical and horizontal distribution of temperatures.

5. What are the determining factors of salinity?

6. Describe the various types of tides.

## ANSWERS TO INTEXT QUESTIONS

**5.1**

1. Porosity is the measurement of the open space within the rocks. This space can be between grains or within cracks or cavities of the rock.
2. A water budget provides a ground for evaluating availability and sustainability of a water supply.
3. Evaporation, condensation, precipitation, interception, infiltration, percolation, transpiration, runoff, and storage (any two).
4. The underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials is known as an aquifer. Groundwater can be extracted using water well. The study which is concerned with the study of the flow of aquifers is known as hydrogeology.

**5.2**

1. The continental slope is the connection between continental shelf and continental rise.
2. Ridges, Seamount, Trenches, Guyots, Coral reefs, Atolls.
3. The Continental Shelf , The Continental Slope , The Continental Rise ,The Deep Sea Plain or the Abyssal Plain
4. Trenches are relatively long, steep-sided, narrow basins. These areas are the deepest parts of the oceans.
5. Lakshadweep Islands.

**5.3**

1. Latitudes, Prevailing winds, Unequal distribution of land and water, Evaporation rule,density of water and ocean currents.
2. Direction of the prevailing winds such as the Trade Winds, Westerly's etc., determines the surface temperature of ocean waters at a point

3. 12 degrees Celsius.

4. Surface zone or mixed zone, Thermocline and Deep zone.

5. It lies between 100 meters and 1000 meters. It contains about 18 percent of the total volume of water in the ocean.

**5.4**

1. Evaporation, Temperature, Precipitation, Ocean Currents, The influx of fresh water.

2. Ocean currents plays crucial role in the spatial distribution of dissolved salts in ocean waters.

3. At higher latitudes, salinity is found to increase with increasing depth.

**5.5**

1. Diurnal tide is tide which takes place 0nly one high tide and one low tide each day. The successive high and low tides are approximate of the same height.

2. It is the position where the earth is farthest from the sun (around July 4th). Tidal ranges will be much less than the average height during this period.

3. Perihelion.

4. The North East Monsoon Drift, and The South West Monsoon Drift.

5. North Equatorial Current, South Equatorial Current, Equatorial Counter Current, Gulf Stream , Florida Current, and Brazilian Current

6. Oyashio Current, California Current, and Peruvian or Humboldt Current.

# MODULE - 4

## Dynamics of Atmosphere

6. Structure and Composition; Insolation
7. Atmospheric Pressure and Winds
8. Humidity and Precipitation
9. Climate and Climate Change

6

# STRUCTURE AND COMPOSITION; INSOLATION

In the earlier lesson, you got familiar with the significance of oceans and its variation in the temperature. As you know, life on earth originated in the oceans. In other words, Earth is the only known planet in the universe where life exists due to the presence of air and water. Both have noteworthy effects on our survival as they have different characteristics. For example, we can see and touch water but we can neither see nor touch air; we can only feel the movement of air. In this lesson, you will learn about the structure and composition of atmosphere, insolation, distribution of temperature and heat budget.

## OUTCOMES

After studying this lesson, learner:

- identifies the layers of atmosphere;
- describes the composition of atmosphere;
- explains the factors influencing insolation and its horizontal distribution and
- describes the heat budget with the help of a diagram.

## 6.1 ATMOSPHERE

Before discussing composition and structure of the atmosphere, let us know more about the atmosphere in general. We know that life is only possible on the Earth's surface. The main reason for this is the presence of air. Without any horizontal movement we can't feel the presence of air. The earth is surrounded by a gaseous envelope which acts like an air blanket on the earth 's surface. It is attached due to the gravitational force of the earth. This is known as the atmosphere. Earth is a green planet only due to its atmosphere, without this existence of water bodies, clouds and sound  are not possible.

Atmosphere protects the earth from harmful solar energy such as ultraviolet radiation. It is a very important part of our fragile earth system which controls our various human activities by different processes. Earth receives solar energy through the atmosphere. The climatic phenomena such as temperature, air pressure, winds, moisture, clouds, precipitation, fog, frost etc. are occurring in lower atmosphere. Atmosphere plays a fundamental role in the distribution or redistribution of energy over the planet earth through energy exchange to each other.

In recent years, the changing environment of the earth's surface has contributed to changes in atmospheric composition in the form of undesirable concentration of carbon dioxide, high pollution levels, ozone depletion and global warming. Among all, global warming is a major cause of concern. However, all these problems are also a matter of atmospheric dynamics.

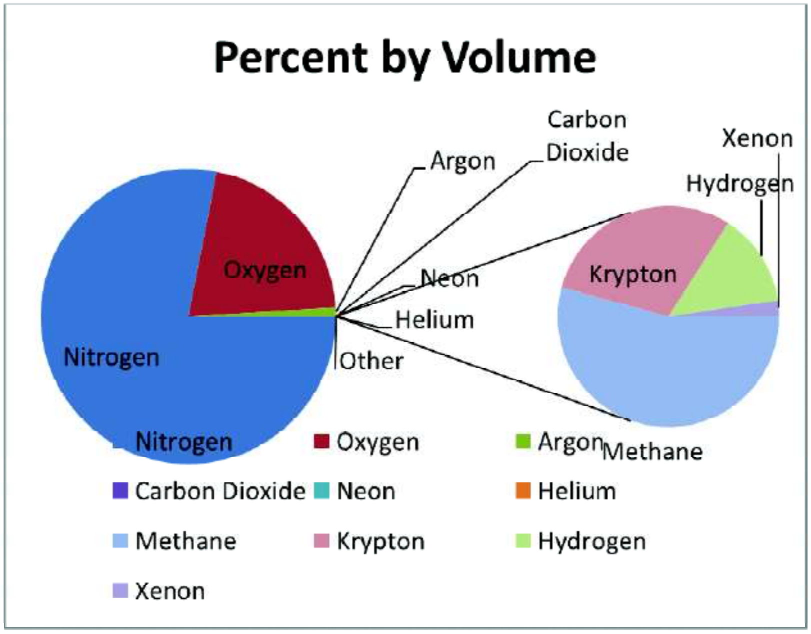
Among all of them global warming is major of concern in present scenario. Global warming is the result of greenhouse effect. It means the gradual increase in world-wide atmospheric warming due to accumulation of heat in lower atmosphere through the greenhouse gases like carbon dioxide ($CO_2$), Methene ($CH_4$), Chlorofluorocarbons (CFCs), Nitrous Oxide ($N_2O$), Ozone ($O_3$), water vapour. These phenomena are changing the composition of the atmosphere. We can better understand atmosphere, by knowing its composition.

## 6.2 COMPOSITION OF ATMOSPHERE

As we know, the atmosphere is made up of various gases, dust particles and water vapour. These are neither static nor spread uniformly in the atmosphere. We can find variation in their distribution according to altitude, latitude and seasons. The characteristics of three basic constituents' namely, gases, water vapour and dust particles are as follows:

### a. Gases of atmosphere

Gases of atmosphere are, broadly, divided into two groups i.e. permanent and variable gases. Nitrogen, Oxygen, Argon, Neon, Helium, Hydrogen, and Xenon are permanent gases and Carbon dioxide, Methane, Nitrous oxide, Ozone and Chlorofluorocarbons (CFCs) are variable gases. We can see their amount of concentration by percentages in the given figure. It shows Nitrogen and Oxygen are found in large amounts.




| Gases | Percent by Volume |
|---|---|
| Nitrogen | 78.08 |
| Oxygen | 20.95 |
| Argon | 0.93 |
| Carbon Dioxide | 0.0314 |
| Neon | 0.0018 |
| Helium | 0.0005 |
| Methane | 0.0002 |
| Krypton | 0.00011 |
| Hydrogen | 0.00006 |
| Xenon | 0.000009 |

Fig. 6.1 Composition of atmosphere

i. **Nitrogen:** Nitrogen is very important for all life forms in the biosphere because it is an essential part of amino acids which makes up proteins. It helps in controlling combustion by diluting oxygen and also indirectly helps in oxidation.

ii. **Oxygen:** Oxygen is a very active gas which combines with the majority of elements in the biosphere. Through the process of photosynthesis and respiration, it is exchanged between atmosphere and living organisms.

iii. **Carbon Dioxide:** The role of this gas is very important in atmospheric processes because of its ability to absorb radiant heat. It is a vital greenhouse gas that taps earth's outgoing radiation and is causing global warming. Its percentage is increasing in the atmosphere due to increasing burning of fossil fuels such as wood, coal, natural gas, gasoline and oil etc.

iv. **Ozone:** It is unevenly distributed and lies in between 20 km to 25 km of altitude. Ozone has a protective role in the atmosphere as it's essential for maintaining habitability of earth. It blocks the harmful ultraviolet radiation from the sun.

v. **Methane:** Methane is a second most abundant greenhouse gas which is emitted from both anthropogenic (landfills, agricultural activities, coal mining, stationary and mobile combustion) and natural sources. Methane absorbs earth radiation quite efficiently. Its presence in the atmosphere affects the temperature and climate system of earth.

### b. Water Vapour

Water vapour is water in gaseous instead of liquid form. It is also the most important gas in the atmosphere. Some important facts about water vapour are as follows:

- Hydrosphere is the source of atmospheric water vapour.
- It changes their state from vapours (gas) into liquid (water) and liquid into solid (ice).
- Amount of water vapour varies in different regions. Maximum amount of water vapour present in the atmosphere is up to 4%.
- All forms of precipitation whether in liquid or solid are possible only by conversion of water vapour into the other forms.
- It also absorbs long-wave terrestrial radiation. Water vapour plays an important role in heat energy balance.

### c. Dust Particles

Dust particles are made of fine particles of solid matter. It is found in the atmosphere. Its main significance is that they help in the formation of clouds, which in turn is important for precipitation and rainfall on earth.

### INTEXT QUESTIONS 6.2

**Write True against the correct statement and False against the incorrect statement:**

i. Carbon dioxide is responsible for global warming.

ii. Nitrogen is very important for making proteins which is an essential part of amino acid.

iii. Atmospheric dust particles are mainly found in the upper part of the atmosphere.

iv. Methane is a permanent gas.

## 6.3 STRUCTURE OF THE ATMOSPHERE

Atmosphere is multi-layer gases and it is a component of the Earth-environment system. The atmosphere can be divided into various vertical layers. These layers are distinguished from one another by temperature, chemical composition and related phenomena.

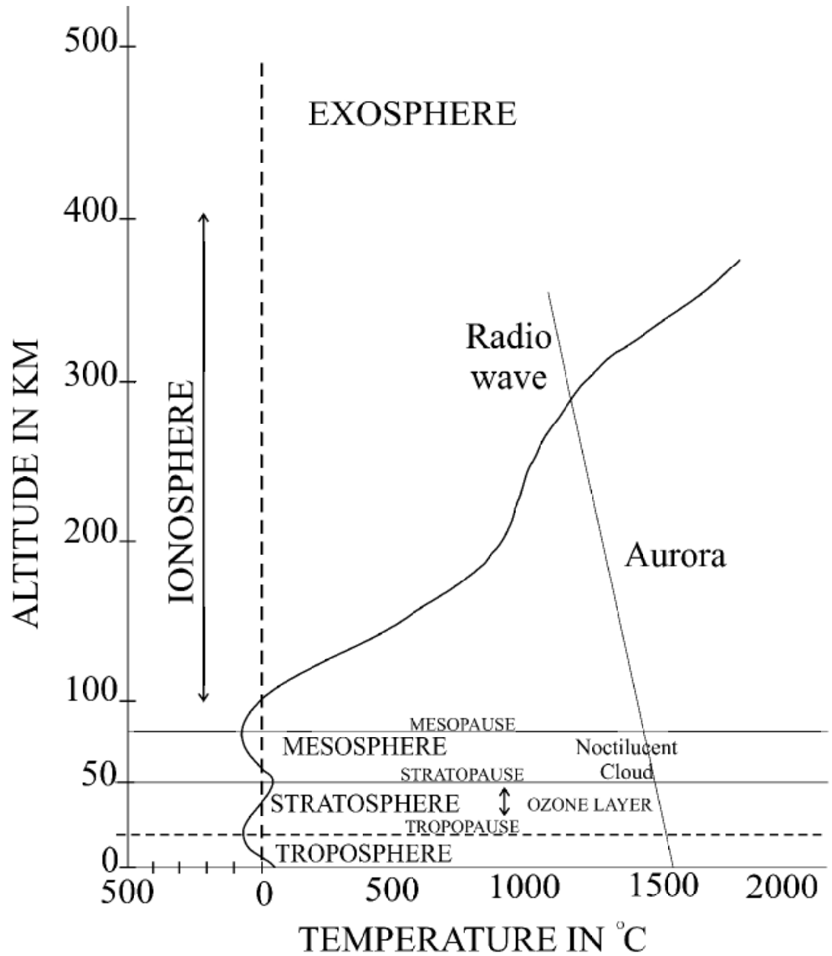



Fig. 6.2 Vertical Layer of Atmosphere

## i. Troposphere

- The Troposphere is the first and lowermost layer of the atmosphere. This layer contains about 75% of gaseous mass along with the concentration of pollutants.
- The average height of this layer is around 12 kms., which varies with latitude. The height of the troposphere is not constant as it is 16 kms. on the equator, whereas 8 kms. on the poles.
- On the equator, height of this layer is determined by the presence of conventional hot currents.
- The lowest temperature is observed in this layer with increasing height. Moreover, all types of climatic and weather phenomena take place within the troposphere.
- A gradual decrease in the temperature with height is 6.5°C per thousand metres. This phenomenon is known as "Normal lapse rate". As the gradual decrease in temperature stops, tropopause starts.

### ii. Stratosphere

- The stratosphere extends from tropopause to a height of 50 kms.
- Thermal conditions of the lower part of the stratosphere are stable due to non-existence of dust particles, water vapours and conventional current. It is known as an isothermal zone.
- This layer is considered ideal for flying aeroplanes because weather events do not take place. The Stratosphere covers about 24 % of the total air mass.
- As height increases, the temperature in the stratosphere increases due to the presence of ozone gas in the upper part of the layer.
- Without the Ozone layers, all living things could not exist on earth's surface. It protects us from the harmful effects of ultraviolet solar radiation.

**DO YOU KNOW?**

Vertical layer of lower stratosphere is known as **Isothermal zone** because the temperature remains constant with increasing altitude.

### iii. Mesosphere

- Mesosphere is the third layer of the atmosphere which extends up to 80 kms.
- The temperature in the mesosphere continuously decreases with increasing height. The layer records the lowest temperature in the atmosphere i.e. -100° Celsius.
- Meteors occur in the mesosphere and "Noctilucent" clouds are formed by the process of condensation in association with meteoric dusts.

### iv. Ionosphere

- The fourth layer, the ionosphere , is located above the mesosphere up to the height of 400 kms.
- Due to the high concentration of ions particles, this layer is known as the ionosphere. Temperature rises with increasing height in this layer.
- The Ionosphere plays a significant role in radio communications. From this layer, radio waves are reflected back on the earth and due to this radio broadcasting has become possible.
- The phenomenon known as "Aurora" has also been observed in this layer.

### v. Exosphere

- This is the last and uppermost layer of the atmosphere.
- Exosphere is located above 400 kms of height after the ionosphere.
- Gases are very sparse in this layer because of the lack of gravitational forces.
- Hydrogen and Helium gases are predominant in this layer. They are very light in nature. Therefore, the density of this layer is very low.

## INTEXT QUESTIONS 6.3

i. Name the layer which is related to "Normal lapse rate"

ii. Which gas protects us from ultraviolet solar radiation and where is it located?

iii. What is the importance of the ionosphere?

iv. Name the Layer where density is very low.

## 6.4 INSOLATION

The Sun is the primary source of energy, which has a surface temperature of more than 6000° Celsius. The radiant energy from the sun comes in the form of short-wave radiation. Incoming solar radiation (IN+SOL+ATION) is known as insolation. Therefore, Insolation has been defined as the energy received from the sun in the form of short-wave radiation.

### A. Factors influencing Insolation

Amount of insolation is not uniform and varies with time and place. The tropical region receives more insolation than the polar region. Similarly, seasonal variation has also been observed, such as the amount of insolation is greater in summer than winter.

#### i. The Angle of Incidence

The amount of insolation on the earth surface depends on the angle of sun's rays which formed at the time of sun striking on earth surface. Every place on earth has a different angle of the sun's rays. As some places receive vertical angle and some receive oblique angle of the sun's rays. It is known as angle of incidence. This controls the amount of insolation in two ways: -

- When the sun rays are vertical, they are concentrated on a smaller area and give maximum insolation. On the contrary, the place where the angle of sun's rays is oblique, heats up a large area and receives less amount of insolation.

On the equator, the sun is always vertically overhead, as we move towards poles, the angle of incidence becomes oblique gradually. Therefore, the amount of insolation is greater on the equator and continues to decrease towards poles.

- Before reaching the earth surface, rays have to pass through the atmosphere. We know, rays with oblique angles have to travel a larger area. Therefore, much of their heat is reflected and absorbed by water vapours, clouds and dust particles. This is the reason why poles receive less amount of insolation. On the other hand, the Equator receives a high amount of insolation, because the distance between earth and atmosphere is less.

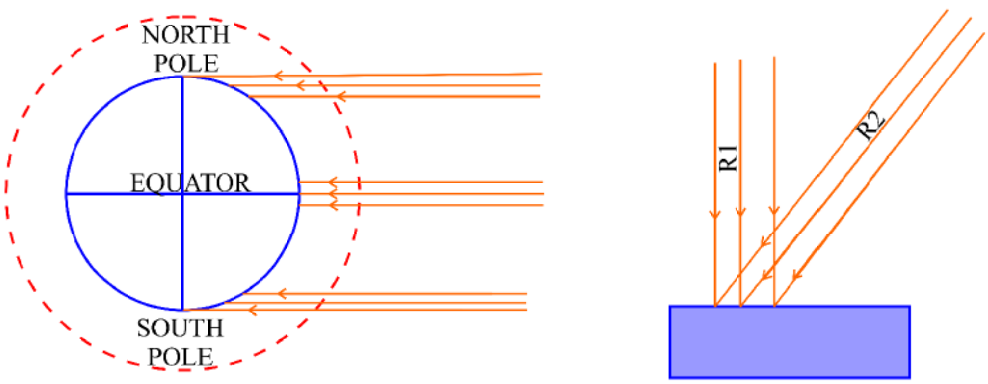



Fig. 6.3 (a) Angle of sunlight and altitude (b) Vertical (R1) and Oblique (R2) Sunrays

### ii Duration / Length of day

The amount of insolation depends on the length of the day because it is received only in the daytime. Therefore, as the length of day is longer, the amount of insolation will be maximum. Length of day or duration of day time also varies from place to place and seasons to season. Only at equator, day and night is 12 hours, throughout the year. As we move towards poles from the equator, we can observe the variance between day and night as per the latitudes.

Table 6.1 Maximum length of day at different latitudes

| **Latitude** | 0° | 17° | 41° | 49° | 63° | 66.5° | 67°21' | 90° |
|---|---|---|---|---|---|---|---|---|
| **Length of the day (hours)** | 12 | 13 | 15 | 16 | 20 | 24 | 1 month | 6 months |

### iii. Transparency of atmosphere

The amount of insolation also depends on the transparency of the atmosphere. The transparency of the atmosphere may also control the amount of insolation. It is

Notes

determined by cloud cover, water vapours and dust particles. As an increase in the quantity, especially clouds and dust particles, they reflect the insolation. Besides this, insolation is also absorbed by water vapour in the atmosphere. For example, thick clouds hinder the insolation to reach while clear sky condition helps in reaching insolation on earth surface.

## B. Way of Energy Transfer

We already know, sun is the only source of energy and we get it directly as insolation. Besides that, there are some ways by which energy can be transferred from one place to another place as follows:

i. **Radiation:** Radiation is a very important process in the atmosphere. In radiation, heat transfers through space by waves, it is called electromagnetic waves. The Process of radiation does not require any medium to transfer the heat. It can pass through the atmosphere without the aid of the air molecules and also move even in a vacuum. In other words, radiation is the way by which solar energy reaches the earth in short waves and heat is radiated from the earth in long waves. Temperature and wavelength are inversely related. Hotter the object shorter is the length of the wave and vice versa.

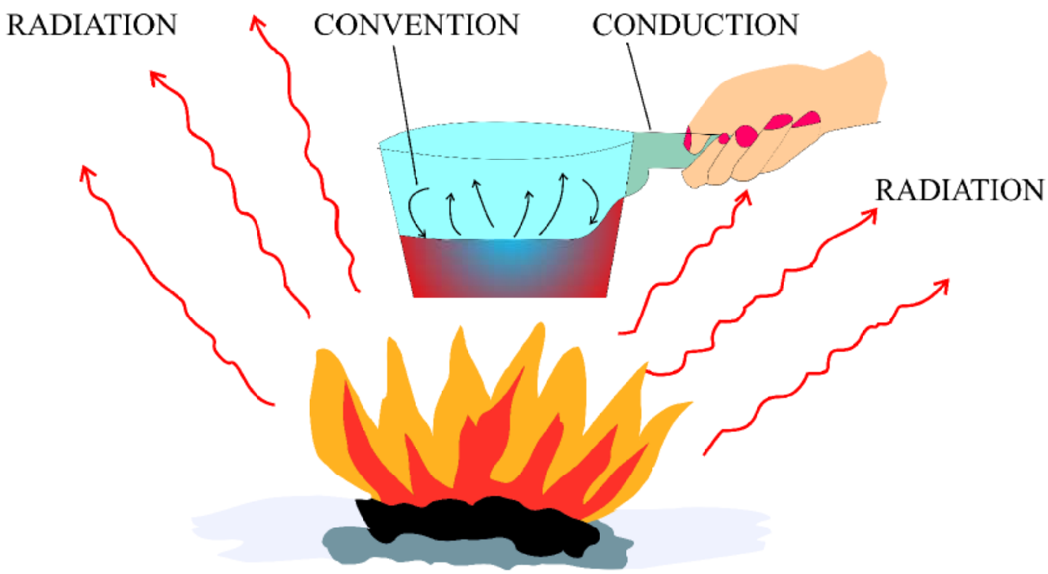



Fig: 6.4 Ways of energy transfer within the Earth atmosphere

ii. **Conduction:** In the process of conduction, heat transfers from one molecule to another molecule within a substance. In this process, heat energy flows from the warmer object to the cooler object. This process continues till the temperature of both objects become equal, or the contact is broken. When material and objects can easily pass energy from one place to another, it may be called the lower good conductor of conduction. Air is a bad conductor of conduction. By this process, the atmosphere is heated in contact with the surface heat.

iii. **Convection:** In this process, heat has been transferred by the mass movement of fluids like water and air. It is a very important process of heating the atmosphere. The conventional process in the atmosphere is associated with the cyclic movement of heat transfer from the lower layer to the upper layer. In cyclic movement, atmosphere heats a higher part of the atmosphere

When incoming solar radiation strikes with atmospheric gases, dust particles and air molecules, some amount of energy is lost through various processes, which are as follows:

- **Scattering:** During the process of incoming solar radiation, sun rays strike at air molecules and dust particles. The sunlight deflected in different directions (up, down, and sides); this is called scattering. It depends on the size of particles and wavelength of light. For example, blue light with shorter wavelength scatters more easily than red light. This is the reason behind the blue colour of our sky.

- **Reflection:** When some sunlight is striking by air molecules and clouds that insolation is reflected to space. For example, clouds are the most important reflector which reflectivity depending upon the thickness of clouds. The amount of reflected sunlight is known as albedo.

- **Absorption:** In this process, radiation is retained by a substance and converted to heat energy. Mainly heat has been absorbed by gases, water vapour and dust particles in the atmosphere. Oxygen, ozone, carbon dioxide and water vapour are known to be good absorbers. For example, ultraviolet radiation is absorbed by oxygen and ozone at the stratosphere.

## INTEXT QUESTIONS 6.4

i. Define insolation.

ii. What are the factors influencing the amount of insolation?

iii. By which process energy transfers from sun to earth?

iv. In which place, hours of the day and night are equal throughout the year.

Notes

## 6.5 HEAT BUDGET

Earth not only received solar energy but also reradiated the energy. Energy released from the earth surface is in the form of longwave radiation.This is known as terrestrial radiation. Earth receives continued energy from the sun but earth maintains average temperature. Incoming energy from sun to earth and outgoing energy from earth to sun is going on simultaneously. This flow of energy is a complex system; this involves radiation, storage and transport of heat.

As we already know, water plays a powerful controller in global heat supply and energy exchange.  Water has the capacity to absorb or release heat between the atmosphere - ocean - continent systems.

At global level, heat received and energy absorbed by our planet is matched by planetary output of terrestrial energy transferred into outer space. The energy exchange between earth and atmosphere absorbs energy from the sun as well as from each other a delicate balance is maintained. These gains and losses of heat through incoming and outgoing radiation are known as **'Heat Budget'**

The 100 units of energy from the sun reaches the top of earth's atmosphere. Out of the total 35% of insolation are reflected through clouds (27%) and scattered (6%) out to space. It has no role in heating the earth. This amount of reflected energy is known as **'Albedo'**. From the remaining 65%, 14% of energy is absorbed by gases and water vapour in the atmosphere. The Rest 51% (65-14=51) of energy is received as through the direct radiation (34%) and by diffuse daylight (17%) on earth's surface.

On the other hand, earth warms the layers of air above by direct contact or conductions and transmission of heat by upward movement of air through convection currents. Out of 51% of total energy received by the earth's surface is sent back to the atmosphere (34%) and in space (17%) through terrestrial radiation.

Total budget of the atmosphere is 48% of which 14% is received through absorption of solar radiation. Others ( 48-14=34) received  by various ways like evaporation (19%) convection (9%) or turbulence and absorption 6% by atmosphere (19+9+6=34) of terrestrial radiation.

Notes

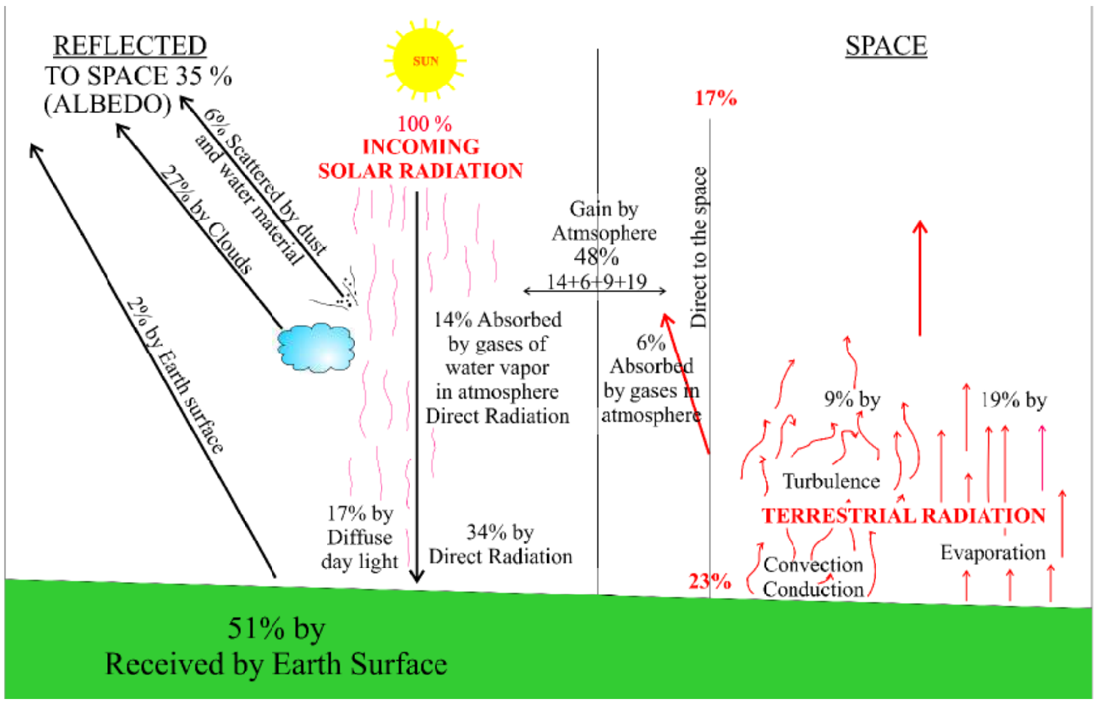



Fig 6.5 The earth's heat budget

### i. Heat Transfer

On the basis of the above discussion, net annual radiation for the globe is zero. In some places energy is coming faster than it is going out. This is known as gain or energy surplus and loss or energy deficit. High intensity of insolation at low latitude, it gradually decreases towards the poles. At the global level, the area between 40 north latitude to 40-degree south latitude is an energy surplus region. Poleward from the 40 north and south latitude is a two deficit set of energy regions. Therefore, the latitudinal balance of energy is not maintained by each latitude. To compensate for the deficit and surplus of energy, wind in the atmosphere and currents in the oceans exchange warm air and water towards poles and cold air and water towards the equator. By this process net latitudinal radiation for the entire globe is zero.

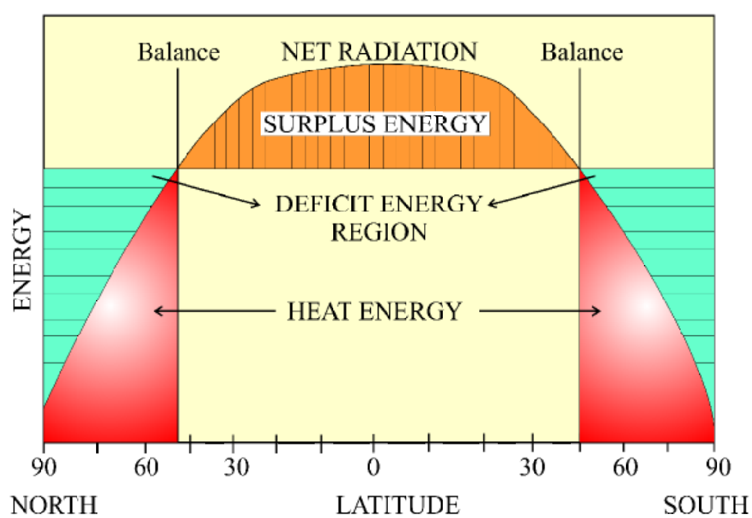



Fig 6.6 Average latitudinal distribution of radiation

Notes

## INTEXT QUESTIONS 6.5

i. What do you mean by the term 'Albedo'?

ii. What is the Heat budget?

iii. Which amount of energy received by earth?

iv. What is the net annual radiation for the globe?

## 6.6 TEMPERATURE

Do you know, intensity of heat is known as temperature? It is measured by the degree of hotness of the heat energy available in the air and soil. Temperature only indicates how "hot" or "cold"an object or particle is. The temperature of air near the surface of the earth is warmer than the air above it. We know that the temperature decreases with height in the troposphere. But sometimes the temperature increase with height under special circumstances is called inversion of temperature. It may occur at close to land surface or it may also at upper atmosphere. Temperature inversion near the surface may occur under such conditions like long and clear winter nights, clear skies, calm air and snow-covered surface etc.

Temperature of any particular place is a result of several complex combinations of elements, which are directly and indirectly controlled by various factors. It, directly depends on the amount of insolation of a given place and distribution of temperature which indirectly determined by the several others elements of earth's surface such as winds, currents, water and land distribution etc.

### a. Factors of temperature distribution

Among various factors regarding the amount of insolation received, Latitude is an important factor that controls spatial variations of temperature distribution on the earth's surface. Some others factors which determine temperature of place are as follows:

i. **Latitude:** The total amount of solar energy received varies as per different latitudes. It is intense in amount at the lower latitudes and gradually decreases towards higher latitudes. In the last section we have already understood that the vertical position of the sun's rays at the equator almost throughout the year, favours the high amount of isolations. Inclination of the sun's rays increases from equator (low latitude) to poles (high latitudes). Therefore, the angle of the sun rays is the prime reason for the variation in the amount of solar energy.

ii. **Altitude:** Height above the sea level (altitude) of any place also controls the temperature of a given place. Temperature decreases with height at the rate of 1 degree for 165 metres. It is known as normal lapse rate.

iii. **Cloudiness:** As we know, the amount of insolation is also determined by the sky conditions, especially cloudiness. Clouds reflect insolation to space and do not express high temperature. High temperature found in clear and cloudless sky.

iv. **Winds:**Winds are the most important changer of the place. Warm winds raise the temperature while cold winds cause a fall in temperature. Winds wherever they are blowing from their original place changes the temperature of that place as per their nature (hot or cold). For example, the hot wind of the Sahara Desert "Sirocco" blows towards Italy and raises the temperature.

v. **Nature of the Land Surface:** Land surface affects inversely towards amount of insolation as per their nature. For example , snow cover areas (bright and smooth) reflect the maximum amount of solar radiation and temperature remains low while dark colour surfaces (black soil region) absorb maximum solar radiation which helps in raising the temperature.

vi. **Distribution of Sea and Land:** Due to variations in the rate of heating and cooling of land and water experiences great variations in temperature of the same place. On the land temperature is higher during summer and day time. On the other hand, oceans have high temperatures in winter and during nights. The seasonal variations in temperature are the results of spatial variations.

vii. **Oceanic Currents:** Like wind, oceanic currents also influence the temperature of adjacent areas. An oceanic current moves from warm temperature areas to colder temperature areas and vice versa. Moving currents influence the temperature of their path by its original nature of current like warm or cold. The warm currents raise the temperature whereas cold currents lower the temperature of areas.

### b. Horizontal Distribution of Temperature:

When we study temperature across latitudes is known as horizontal distribution. It is shown by the "isotherm" lines on the map. Isotherm (ISOS means equal and THERMS means temperature) line is an imaginary line which joins places having equal temperature. After a detailed study of isotherms, we can understand the temperature of a particular place. If we look at the global level, January is considered the coldest month while July is the hottest month of the year. Both the months represent seasonal extremes of temperature. Therefore, we should study these months separately.

**(i) Horizontal Distribution of Temperature in January:** In the month of January, Winter season in the northern hemisphere and summer season in the southern hemisphere. Its main reason is the position of the sun which is vertically overhead near the tropic of Capricorn. High temperature regions are in the southern hemisphere i.e. north-west Argentina, east-central Africa, Borneo and central Australia. We can see Isotherms of 30° Celsius passing through these regions.

In January, the landmass of the northern hemisphere is colder in comparison to ocean areas. In the northern hemisphere, the Northeastern part of Asia experiences low temperatures. Especially, the middle part of the continent shows a lower temperature than the oceans areas of the same latitude.

Due to large expanse of water exist in the southern hemisphere; isotherms lines are regular and widely spaced. On the other hand, in the northern hemisphere isotherms lines are irregular and closely spaced due to large expanse of land masses.

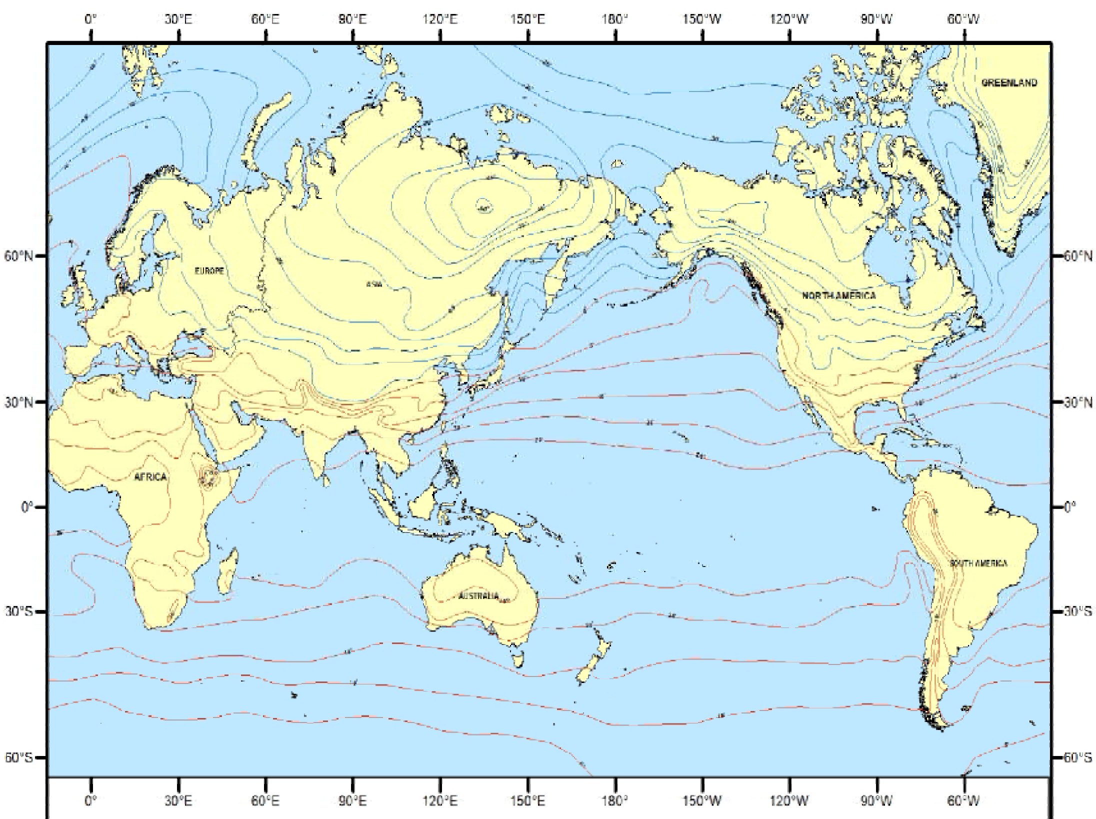



Fig. 6.7 Horizontal distribution of temperature in January

**(ii) Horizontal Distribution of Temperature in July:** As the sun position is vertically overhead near the tropic of cancer in the month of July. Therefore, the northern hemisphere experiences summer seasons. High temperature is experienced in the entire northern hemisphere and isotherms line of 30° Celsius located between 10°

north and 40° north latitudes places like south-eastern U.S.A, the Sahara, and Arabia, Iraq, Iran, Afghanistan, the Gobi Desert, Chani and Thar Desert of India have high temperatures. At the same time, the lowest temperature of 0° Celsius is also located in the northern hemisphere, especially in the central part of Greenland. The temperature of middle areas of the continents in the northern hemisphere is higher than oceans of the same latitude. Oceans areas have shown wider spacing isotherms lines than continents.

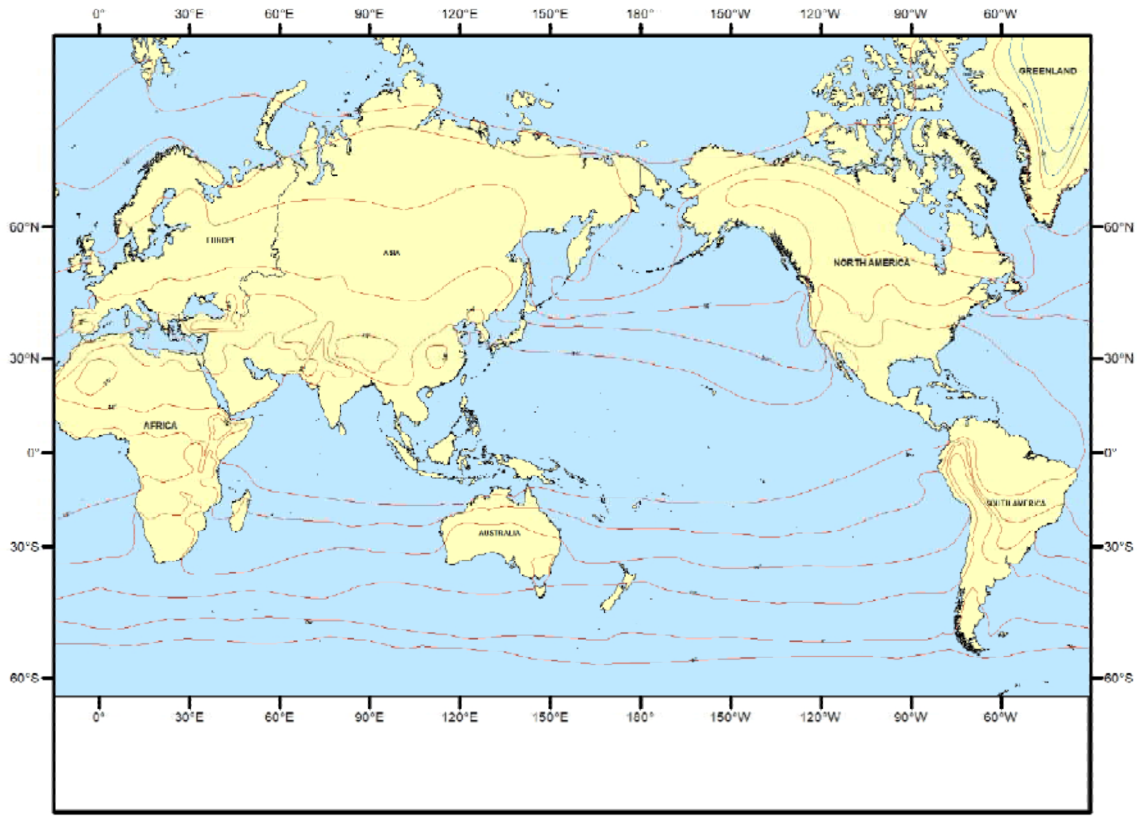



Fig. 6.8 Horizontal distribution of temperature in July

After the study of the isotherms line of January and July, we found lines change very little in position over the equator. This shows the feature of consistency of insolation throughout the year near the equator.

Apart from the horizontal distribution of temperature, vertical distribution of temperature is also important. Generally, temperature decreases with increasing height in the troposphere. It varies with height, latitude and seasons. Sometimes temperature increases with increasing altitude but the phenomenon has been characterised temporarily and locally.

## INTEXT QUESTIONS 6.5

i. Which latitude receives the maximum amount of insolation?

ii. What is the nature of "Sirocco" wind and where is it blown?

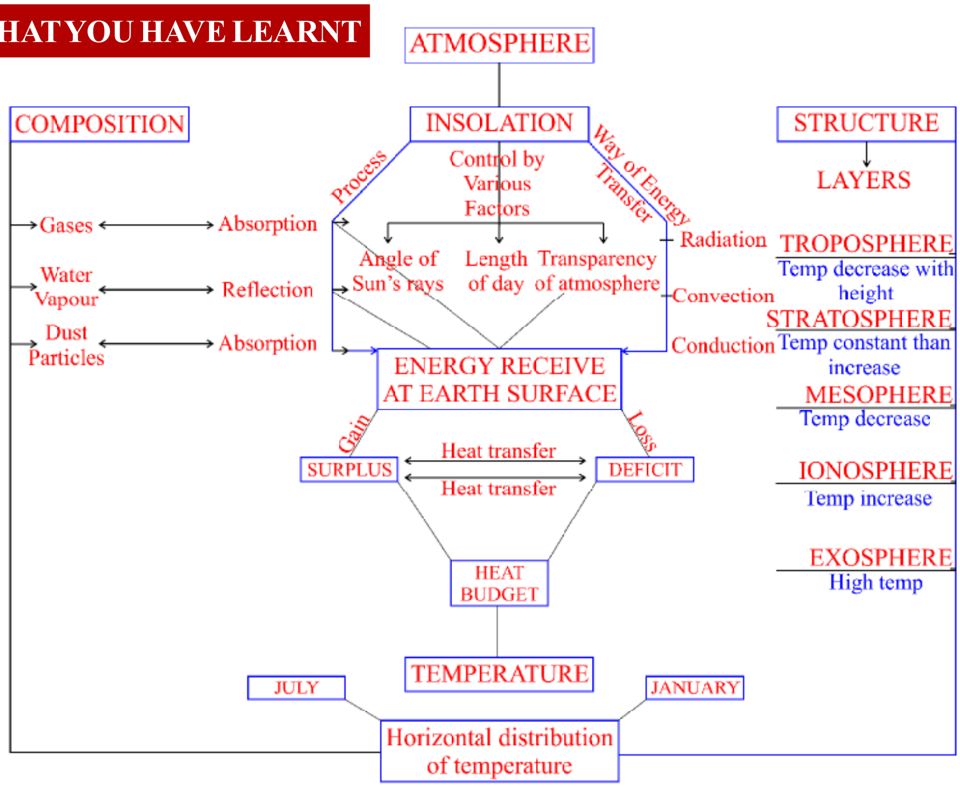
iii. Which months represent seasonal extremes of temperature on the globe?

iv. In the southern hemisphere, which season is found in the month of January?

## ACTIVITY

Make lists of various examples which represent processes of energy transfer.

## WHAT YOU HAVE LEARNT




## TERMINAL QUESTIONS

1. What are the three mechanisms by which heat energy is transferred?

2. Write a note on the important gases of the atmosphere.

3. Explain different layers of the atmosphere with the help of a diagram.

4. Distinguish between convection and radiation ways of heat transfer.

5. Why do Poles receive less amount of insolation?
6. Describe important factors of horizontal distribution of temperature.
7. Identify surplus and deficit zones of energy on earth.
8. Describe heat budget with the help of diagrams.

## ANSWERS TO INTEXT QUESTIONS

**6.2**

(i) T  (ii) T

(iii) F  (iv) F

**6.2**

(i) Troposphere  (ii) Ozone gas and Stratosphere

(iii Ionosphere plays an important role in radio communication.

(iv) Exosphere

**6.3**

(i) Incoming solar radiation is known as insolation.

(ii) Angle of incidence, length of day, transparency of atmosphere.

(iii) Radiation  (iv) Equator

**6.4**

(i) Amount of reflected solar energy is known as 'Albedo'.

(ii) Heat budget is the balance between incoming and outgoing radiation.

(iii) 51%  (iv) Zero

**6.5**

(i) Low latitudes

(ii) Hot wind and blowing towards Italy.

(iii) January and July

(iv) Summer season

# 7

# ATMOSPHERIC PRESSURE AND WINDS

You have learnt in the previous lesson about the atmosphere's composition and its structure, insolation, distribution of temperature and heat budget. We all can feel the sensation of moving air. Have you ever thought about why it moves or what is the reason behind the movement of air? You have also observed its speed and frequency which vary from one place to another. It is all due to variation in the atmospheric pressure which is controlled by temperature.

In this lesson, you will learn about atmosphere pressure, factors affecting atmospheric pressure, pressure belts, planetary and local winds.

## OUTCOMES

After studying this lesson, learner:

- defines atmospheric pressure;
- explains factors affecting atmospheric pressure;
- describes atmospheric pressure belts; and
- distinguishes between planetary and local winds.

## 7.1 ATMOSPHERIC PRESSURE

As we have learnt that, the air is the mixture of gases, water vapour and dust particles. The air with heavy weight means gases, water vapour and dust particles come together or air particles are compressed, while in low weight or pressure, air particles are dispersed or located far to each other. This weight of the air is known as air pressure or atmospheric pressure.

In other words, the mass of the air molecules can define atmospheric pressure. It is measured at a particular surface per unit area. It acts as a force on the earth's surface. It may be measured at any surface. Therefore, the total mass of the air column above that surface is compressed for measuring air pressure. This air pressure on the earth's surface varies from place and over time.

The air pressure is measured by Barometer. The atmospheric pressure measuring unit is Millibar (mb). The atmospheric pressure is maximum at sea level. The standard sea level atmospheric pressure is 1013.2 mb.It is because above sea level the thickness of the atmosphere is greater, so the atmospheric pressure is highest. You might have gone to some hill stations. Those hill stations have more height then plain or sea coast. Hence, the air pressure over hill station is less because air parcel is less, hence the pressure is less.

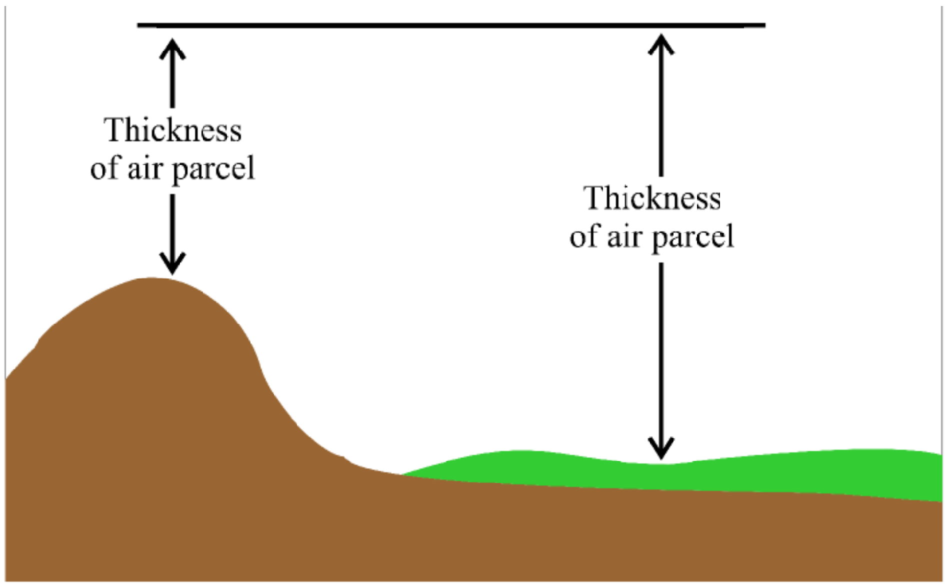



Fig 7.1 Pressure decreases with Height

Air pressure can be shown by Isobars lines on a weather map. It means all the places with same air pressure is joined by a line and the line is known as isobars.

Mainly, there are two types of atmospheric pressure; high pressure and low pressure. The pressure variations can be identified by the shape of isobars. On the earth's surface, an area with more air is known as high pressure areas and an area with less air is known as low pressure areas. In a high pressure system, pressure decreases outward from the centre and in the low pressure system pressure decreases towards the centre. The high and low pressure is the result of temperature differential in the atmosphere.

The difference in atmospheric pressure between the two places on the surface is known as Pressure Gradient. The pressure gradient is a result of differential heating over space. Through the study of spacing between isobars, we can understand pressure gradients. Small difference in pressure over large space indicates weak gradient while close spacing of isobars express strong pressure gradient. As air is a compressible fluid, due to the pull of gravity it is most dense near the ground surface. Moreover, it also decreases rapidly with height.

There are two types of air motion i.e. horizontal and vertical. Convergence and divergence of air is an example of horizontal motion. Whenever winds flow towards each other or converge, besides this when surface winds diverge there must be a subsidence of the air. Ascent and subsidence is an example of vertical motion.

**DO YOU KNOW?**

On a weather map for a designated place, where sea-level atmospheric pressure is comparatively high, pressure is expressed with symbol "H" and low pressure with "L" symbol.

Let us see figure which shows convergence and divergence associated with high and low pressure systems.

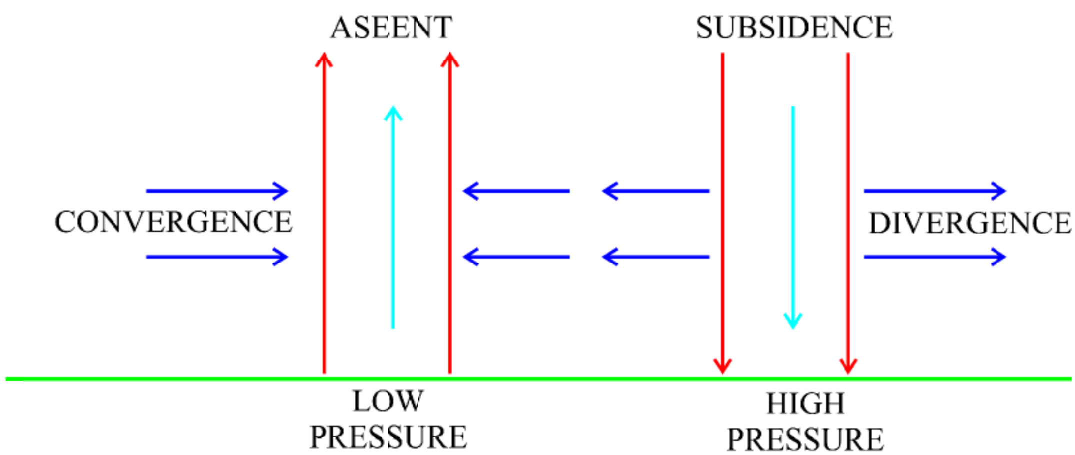



Fig 7.2 Horizontal and vertical movement of Air

The low-pressure regions are associated with clouds and precipitation while the high pressure system is generally associated with dry weather and mostly clear skies with longer diurnal temperature changes; due to greater radiation at night and greater sunshine during the day.

## INTEXT QUESTIONS 7.1

**Give an appropriate term for the following:**

1. A force per unit area exerted by the atmosphere above earth's surface.
2. Name the term by which air pressure is shown on the map?
3. An instrument which is used for measuring air pressure.
4. Name the term showing the difference between two isobars?

## 7.2 FACTORS AFFECTING ATMOSPHERIC PRESSURE

Till now, you have learned that atmospheric pressure varies with time and space. Let's discuss why and how? In this regard, the following factors need to be studied which affect atmospheric pressure.

i. Altitude

ii. Temperature

iii. Earth Rotation

iv. Water Vapour

Let's discuss one by one.

### I. Altitude

Atmospheric pressure decreases with increasing height. It means pressure at ground level is higher than air pressure at the top of High Mountain. Because atmospheric pressure is the weight of all the air above the level at which it is measured.

- Height of the air column is maximum at sea-level and that's why pressure of air is greater at ground level than less pressure at higher elevations.
- As we know, air is highly compressible and a mixture of various gases. Due to the weight of overlying layers, density of lower layers is increased. Its atmospheric pressure increases at lower layers of the atmosphere.
- Heavy gases and particles are found at lower layers and lightweight gases and fewer particles float at higher layers.

**DO YOU KNOW?**

Atmospheric pressure decreases with increased altitude but rapidly at lower atmosphere then slowly at high altitude.

### ii. Temperature

The atmospheric pressure is closely linked with atmospheric temperature. It means the spatial variation in the atmospheric pressure is directly controlled by the temperature. There is an inverse relationship between temperature and pressure because when air is heated due to high temperature, its molecules and particles expand over a large area. Its air pressure decreases. Therefore, we can say, atmospheric pressure decreases when temperature increases. When air is cooled, it contracts and air molecules spread only at smaller areas. Because of this phenomenon, the pressure of the air increases. In other words, atmospheric pressure increases when the temperature falls.

Let's understand the impact of temperature on pressure through flow diagram

**Low air temperature → Shrunk → Density increase → pressure increase**

**High air temperature → Expand → Density decrease → Pressure decrease**

For example, you have already learned in the last lesson that the temperature is very low at the poles and high mountain regions which results in the contraction of the air. Thus, high pressure areas develop at poles. On the other hand, high temperature along the equator and near earth's surface results in expansion of the air and development of low-pressure areas.

### iii. Earth's Rotation

Earth's rotation also makes a great impact on pressure belts of the globe. Due to the earth's rotation on its axis, equatorial air moves far away from the centre while polar air attracts towards the centre. As a result, the air column of mid latitudes changes more. Atmospheric pressure is high at lower layers of the atmosphere due to the gravitational pull of the earth.

### iv. Water Vapour

The existence of water vapour also affects the atmospheric pressure. The greater the concentration of water vapour in the air, the density of air is less. Air with lower water vapour makes it heavy or high in density. Because the molecular weight of water is less than the average molecular weight of dry air. Thus, dry air is heavier than moist air. Similarly, the air is lighter in the rainy season due to the presence of water vapour.

**DO YOU KNOW?**

Water vapour reduces the density of air and thus the light air exists on oceans and heavy air on continents.

## INTEXT QUESTIONS 7.2

Write 'True' for correct and 'False' for incorrect statements-

i. There is an inversely proportional relationship between temperature and pressure.

ii. The maximum atmospheric pressure is at the mountain top.

iii. Earth's rotation on its axis affects the pressure especially in mid latitude.

Notes

iv. Continental airs are lighter in weight than oceanic air.

## 7.3 DISTRIBUTION OF ATMOSPHERIC PRESSURE

It is very important to know about the distribution of the atmosphere. Its distribution varies spatially, diurnally and seasonally. Here, you are going to learn vertical and horizontal distribution of atmospheric pressure.

### A. Vertical Atmospheric Pressure

Generally, Atmospheric pressure decreases with increasing height at the rate of 34 the millibars per 300 metres of height. For example figure shows how altitude affects the pressure distribution. At the height of 5.5 kms air pressure decreases to 550 mb which is half of the sea-level pressure. In other words, we can say that half of the atmospheric mass lies between the earth's surface and the height up to 5.5 kms. In this way, at the altitude of 50 kms, air pressure is about 1 mb. Out of total atmospheric pressure, 99.9 percent lies within 50kms of the earth's surface.

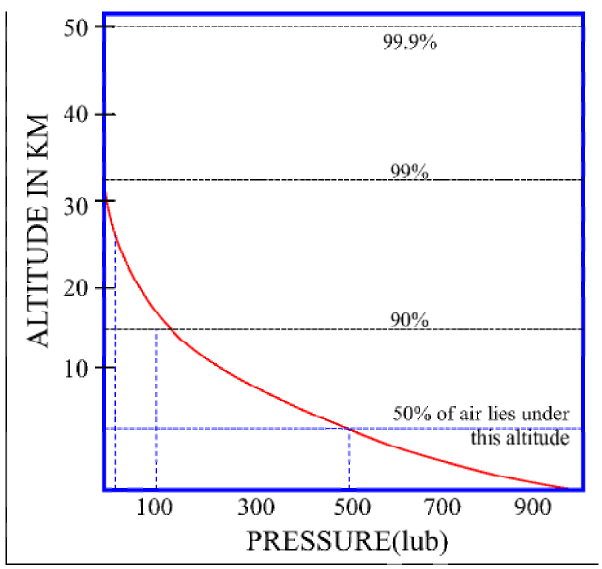



Fig 7.3 Vertical air Pressure and Altitude

### B. Horizontal Distribution of Atmospheric Pressure

As you know, the distribution of air pressure is shown by Isobars. Isobar means the line which connects those places having equal pressure. After studies of pressure distribution, we can say there is a close relationship between pressure and temperature. The horizontal distribution of atmospheric pressure is controlled by some factors. It can be categorised in two groups' i.e. thermal factor and dynamic factor. There are clearly distinguishable homogeneous pressure belts at global level. On that basis, Earth can be divided into seven pressure regimes or belts in which three pressure belts in each hemisphere and one lies near the equator in both hemispheres.

i. **Equatorial low pressures belt:** Equatorial low-pressure belt lies between 5° north and 5° south latitudes. This region receives intense heating throughout the year; air gets warmed up and rises over the equatorial region and creates low pressure. The vertical upward movement of air is the main reason for creating low pressure at the surface of the equatorial zone. The position of this low-pressure belt varies with apparent movement of the sun.

This belt is the zone of convergence of trade winds from subtropical high pressure belts of both the hemisphere. It is known as Inter Tropical Convergence Zone (ITCZ). In this zone winds are very light and variable with frequent calms. It is also called the doldrums. The position of the belt varies with the apparent movement of the sun.

ii. **Sub-tropical high-pressure belt:** Sub tropical high-pressure belt extends from 30° to 35° in north and south latitudes. The following two reasons are responsible for creating high pressure in this region even after intense heating of about 10 months in a year. Here the dynamic factor is responsible for high pressure.

- Due to subsidence of air at 30° north and south latitude, which rises over the equator and moves towards poles and descends after becoming cold and heavy in the upper troposphere.
- Due to the earth's rotation, poleward moving winds are deflected from polar areas to sub-tropical areas and cause high pressure near tropics.

The descending air creates dry, calm conditions with variable and light winds in this high-pressure region. Therefore, they are called 'belt of calm' or 'horse latitudes'. Most of the hot deserts are located in the western side of this belt in both the hemispheres.

iii. **Sub - Polar low-pressure belt:** The sub - polar belt located around 60° north and south latitude. Here, low pressure exists as a result of convergence of westerlies and polar easterlies. Due to great contrast between the temperature of the winds from subtropical warm and polar cold regions produce cyclonic activity in this region.

This sub-polar low-pressure area is best developed over the oceans where temperature differences between summer and winter are negligible.

iv. **Polar high-pressure belt:** The Polar high-pressure belt situated on the north and south poles at 90° in both the hemispheres where temperature is extremely low below freezing point. It causes air compressions and density increases. Thus, create a belt of high-pressure.

On the basis of the above explanation, equatorial low pressure belt and polar high pressure belt are thermally induced while sub tropical high pressure belt and sub polar low pressure belt are dynamically induced. Above pressure belts are just a generalised picture, not permanent. Because they change their position and shift northward in July and southward in January.

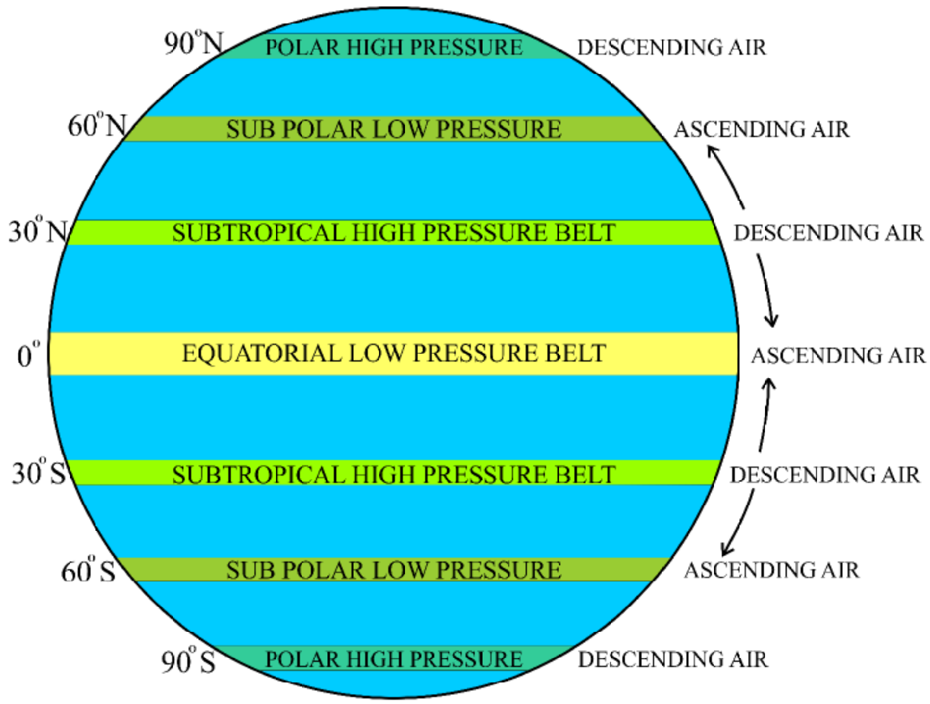



Fig 7.4 Distribution of world pressure belt

## C. Seasonal Distribution of Pressure

The pressure variation from place to place and season are important in respect of weather and climate. The variation can be analysed by the study of isobar maps. Pressure of all places drawn on an isobar map is reduced to sea level to avoid the effect of altitude on air pressure. World isobaric maps are generally constructed to show average pressure for two months - January and July.

### i. Pressure conditions of January

In the month of January, the apparent movement of the sun is towards the Tropic of Capricorn. This is the time of summer in the southern hemisphere. The equatorial low pressure belt shifts little towards the south. The areas of lowest pressure occur over the warm continents of Australia, Africa and South America. We know land tends to get hotter rapidly than water and the subtropical high-pressure cells are centred over the ocean in the southern hemisphere. The high pressure belt is interrupted by the continental land masses where the temperature is much higher. There are well - developed

*Notes*

circumpolar belts of low pressure in the southern hemisphere. This is due to no land masses in the high latitudes. It has also been observed that over the coastal regions of Antarctica and the southern oceans clearly indicate that beyond latitude 65° south, there is a gradual increase in the atmospheric pressure.

In the northern hemisphere, the sub - tropical high pressure belt is located well to the north mainly over the continents. The high pressure exists over North America and Eurasia. This is due to the fact that land cools more rapidly than oceans. Its temperature is lower in winter than the surrounding seas. The north - eastern part of Asia has the highest pressure on the earth's surface. Because of large continental areas in the northern hemisphere the sub-polar low-pressure belt is represented by individual oceanic cells and their continuity is broken. There are two low pressure cells namely Iceland low and Aleutian low develop over the north atlantic and north pacific oceans respectively in the northern hemisphere.

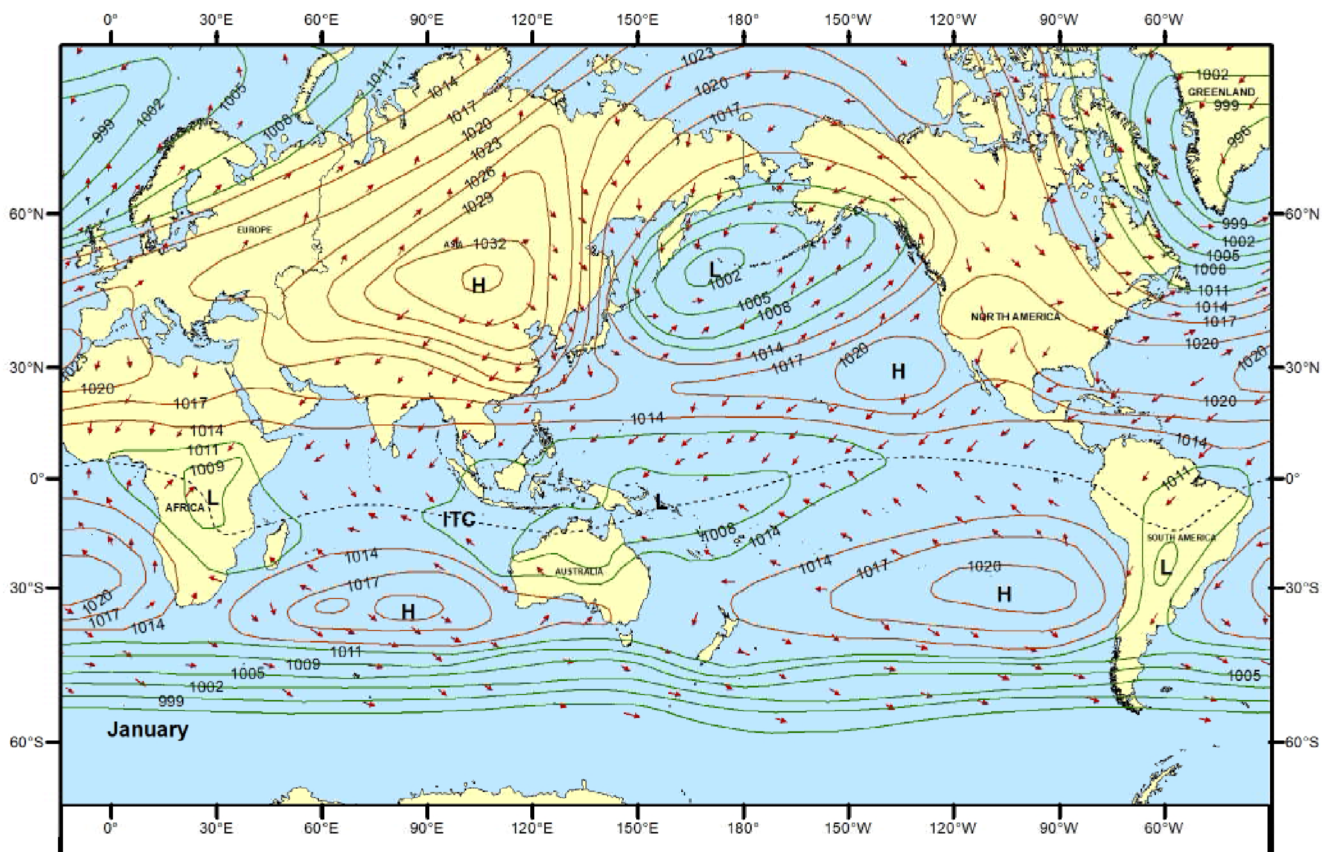



Fig. 7.5 Pressure Condition in January

## ii. Pressure conditions of July

This is the season of summer in the northern hemisphere because of the apparent movement of the sun towards the Tropic of Cancer. Therefore, all pressure belts shift northward. Equatorial trough is located well north of the equator over the warm land mass. The sub - tropical high-pressure cell is more developed and found over the north atlantic and north pacific. They are called the Azores high and the Hawaiian high. There is a winter season in the southern hemisphere. The subtropical high pressure belt is a continuous and high pressure cell established over the continent of Australia. The Sub - polar low forms a continuous belt in the southern hemisphere. In the northern hemisphere, the sub polar low-pressure belt continues to a small degree over oceans.

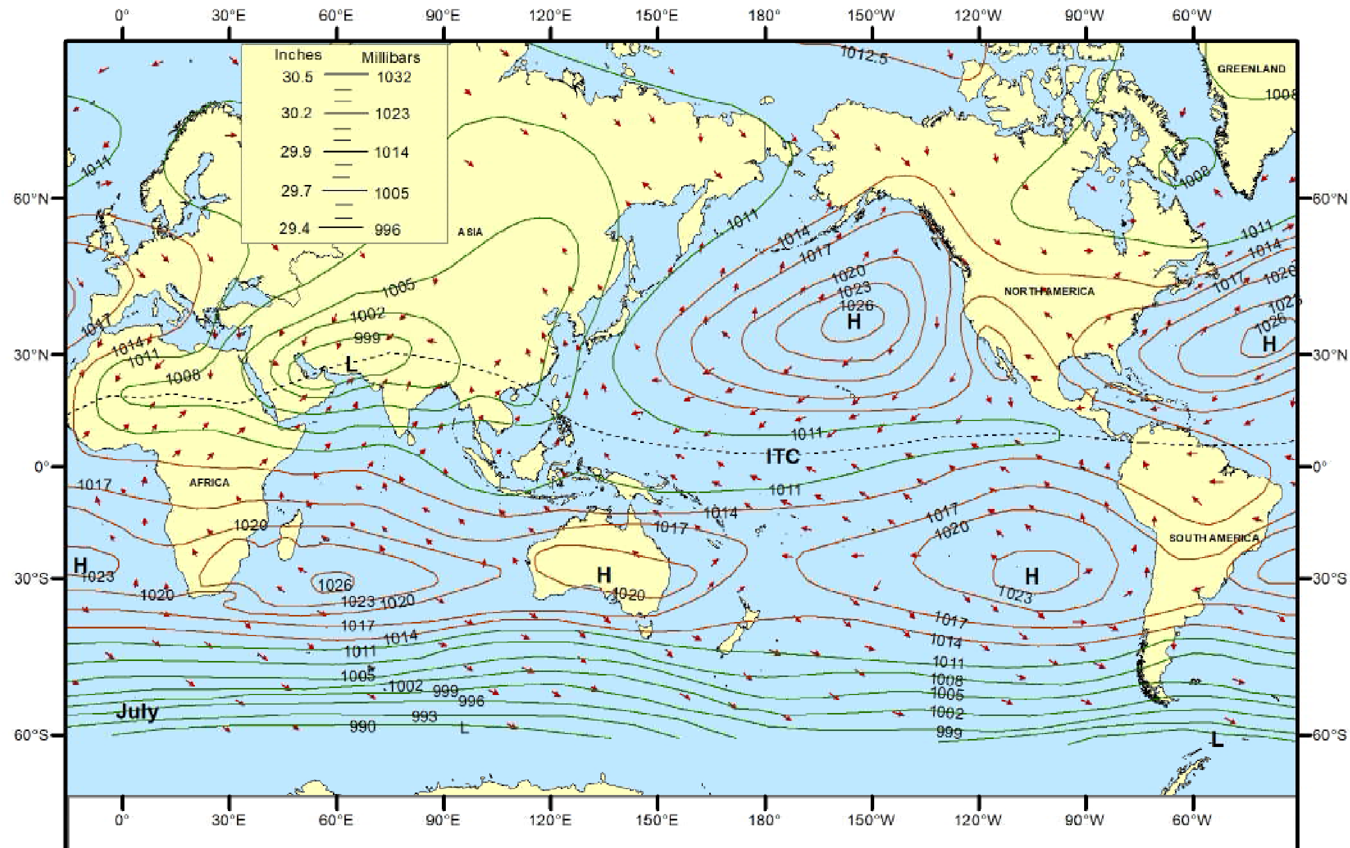



Fig. 7.6 Pressure Condition in July

## INTEXT QUESTIONS 7.3

i. What is the other name of inter tropical convergence zone?

ii. Name the pressure belt which is related to horse latitude.

iii. Which factor is responsible for the sub-polar low pressure belt?

iv. Name the continents where the low pressures exist in the month of January.

## 7.4 WIND

Wind is the common name to use for the movement of air from one place to another place. The nature of wind, its speed and frequency vary from one place to another due to the variation in the atmospheric pressure. Air moves wherever and whenever the pressure difference exists in the atmosphere.

Technically, wind is the horizontal movement of air molecules over the earth's surface. It is the result of spatial difference in the air pressure. Wind is one of the important modes of equalisation of the atmosphere, transporting heat, moisture, pollutants and dust to a great distance around the globe.

We have learnt in previous lessons that water and air are important in maintaining the heat budget of the earth surface. Like water in the oceans through the motion of wind, transfer heat over the earth's surface and carries water vapour from ocean to the continents. Life is possible on earth's surface only because of this heat transfer from equator to poles and poles to equator. Winds also influence various economic activities and human comfort. They not only have a larger impact at global level but they have also influence at local level. Winds tend to blow from the high-pressure belts to the low-pressure belts. Air direction and velocity are two important characteristics of wind.

### A. Factors Affecting Wind Motions

An air movement is a normal phenomena of the atmosphere. It moves as the difference in atmospheric pressure develops. The Pressure gradient plays an important role in air movement and controls the direction and speed of the air. Once air moves along the pressure gradient, several other forces affect its direction and velocity. For example, instead of blowing directly from one pressure belt to another, winds tend to deflect the direction of the winds due to the effect of earth's rotation.

Pressure gradient is defined as difference in pressure over space. The difference in pressure gradient is due to the difference in heating over space. The two key factors affect wind motion are:

i. **The pressure gradient force:** The pressure gradient force has been generated due to horizontal difference in pressure which is a result of uneven heating. With the effect of this force air moves from high pressure areas to low pressure areas, without this difference air cannot move. It means the wind direction follows the direction of change of pressure. Not only wind direction but wind speed is also controlled by the pressure gradient force. For example, closely spaced isobars indicate steep pressure gradient and large space between isobars is an example of weak gradient. The pressure gradient is the force that determines the strength of the wind.

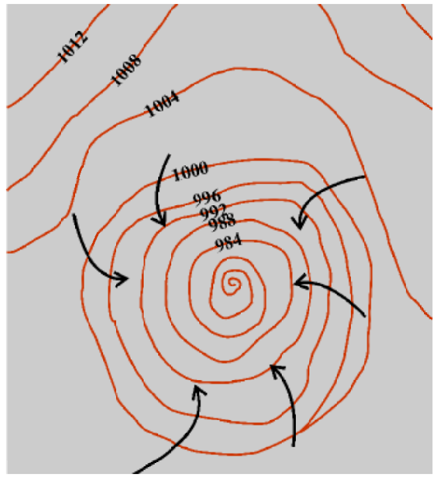



Fig 7.7 ISOBAR showing steep pressure Gradient

ii. **The Coriolis force:** Normally winds will follow the direction of pressure gradient. But it is not like this, winds do not cross the isobars at right angles according to pressure gradient. Therefore, winds are greatly deflected by their original path due to Coriolis force which is a result of rotational movement of earth on its axis. The effect of Coriolis force can be stated as any object and liquid moving horizontally tends to be deflected to the right to its path of motion in the northern hemisphere and deflection towards the left of the path of motion in the southern hemisphere. The Coriolis Effect is absent (0) at equator but increases towards the poles (100%).

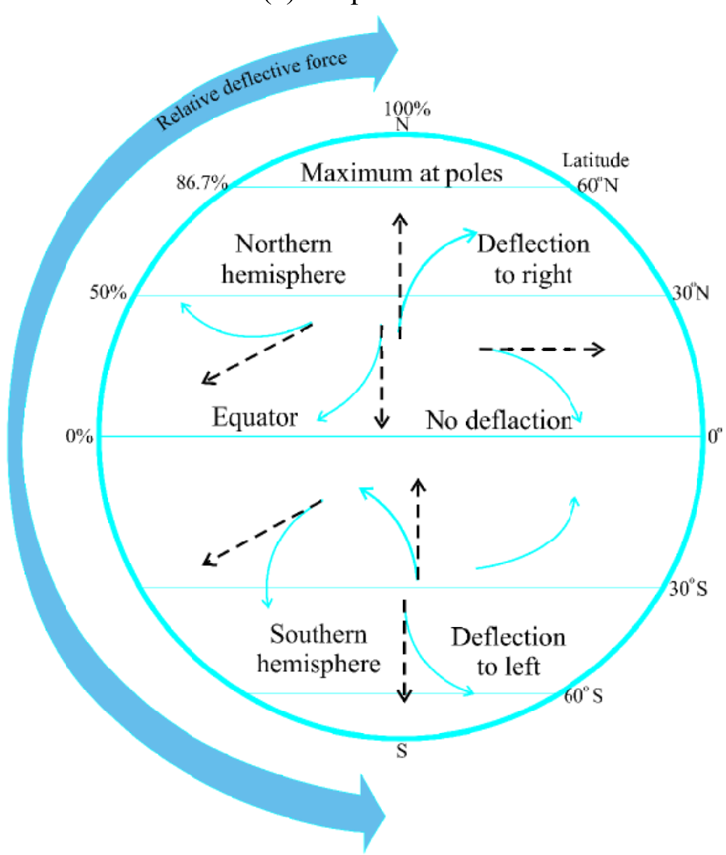



Fig. 7.8 The coriolis force

## B. Types of Winds

Winds play an important role in understanding the climatic characteristics of different parts of the world or our surroundings. There is a closer relationship between winds and the belt of atmospheric pressure. Throughout the world there are many wind systems which influence not only our economic activities but also our comfort. Winds are classified broadly in following categories.

a. Planetary winds or permanent winds

b. Periodic or seasonal winds

c. Local winds

**a. Planetary winds-** The planetary winds blow from high pressure areas to low pressure areas in the same direction throughout the year. These winds blow extensively over the continent and oceans. They are known as the easterlies or trade winds, westerlies and polar easterlies.

**i. The Easterlies or Trade winds -** The Easterlies winds blow from sub- tropical high-pressure areas towards equatorial low-pressure areas. It is also known as trade winds. The direction of these winds in the northern hemisphere is from north-east to south - west and southern hemisphere south - east to north - west. The deflection of winds is a result of Coriolis Effect. Because winds tend to blow out of the east, they are called easterlies.

These winds are stable in their area of origin and when they reach the equator becomes humid after picking moisture on their way. The Trade winds of both the hemisphere meet at equator and due to convergence, they rise and cause heavy rainfall.

**ii. Westerlies -**The westerlies are the winds which blow towards poles from sub - tropical high-pressure belts in the northern hemisphere deflected to the right and blow from south-west to north-west. In contrast wind deflected to the left in the southern hemisphere and blew from north-west. Thus, these winds are called westerlies. In the southern hemisphere, there is a vast expanse of ocean. Therefore, westerlies blow with great force and regularly throughout the year between 40° south latitude to 60° south latitudes. Due to their tremendous speed they are known as Roaring forties, Furious fifties and Shrieking sixties.

**iii. Polar easterlies-** The polar easterlies blow from polar high pressure regions towards sub-polar low pressure regions. It blows from the north east to the south west direction in the northern hemisphere. In the southern hemisphere, the direction of wind is from South-East to North-West. The Polar easterlies have characteristics of being extremely cold, dry and stable.

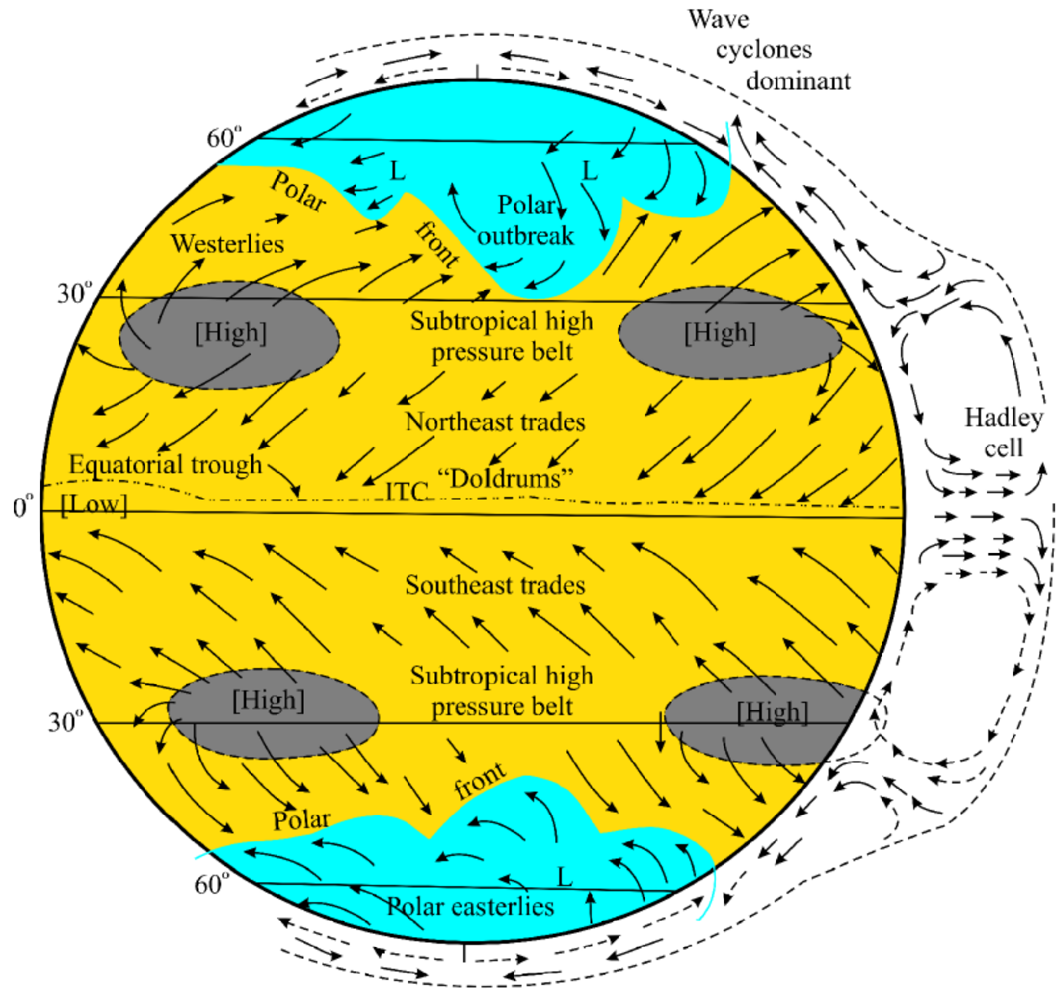



Fig.7.9 Planetary Winds

b. **Periodic winds -** The Periodic winds are those winds which change their direction with the change of seasons. This is also known as seasonal winds. Monsoon winds are the best example of periodic winds.

i. **Monsoon winds -** The word "monsoon" is described as a wind of seasonal reversal. It means monsoon winds are those seasonal winds which completely reverse their direction with the change of seasons. Monsoon winds blow from sea towards land in summer seasons and from land towards sea in winter. They blow on an extensive area of the Asian continent, and other parts of the world. Monsoon of Asian region is the result of interaction of both planetary wind systems and regional factors, both at the surface and in the upper troposphere. The most important areas of monsoon climate are located in India, Burma, Bangladesh, China, and Philippines etc.

India truly represents monsoonal climate. The climate of India is marked by distinct winter and summer seasons. The rain comes in summer in one part of the country and in winter in another part.

c. **Local winds -** Local winds develop due to local differences in temperature and pressure. Such winds affect small areas in extent and are confined to the lowest level of the troposphere. Some examples of local winds are as follows:

i. **Land and Sea Breezes-** Land and sea breezes are a good example of the change in temperature and pressure of the air over land in contrast to that over water. The land and sea absorb and transfer heat differently. In the daytime the land area gets more heated and becomes warmer than the adjacent sea. Thus, over the land the air rises and develops low pressure. Whereas the sea is relatively cool and pressure over sea is comparatively high. Therefore, pressure gradient from sea to land is created. Wind blows from sea to land as 'sea breeze'. At night the reversal of conduction takes place. After sunset land loses heat faster and becomes cooler than the sea. This results in high pressure over the land and low pressure over the sea. The pressure gradient is from the land to the sea. Air starts blowing from land to sea and it is known as 'land breeze'.

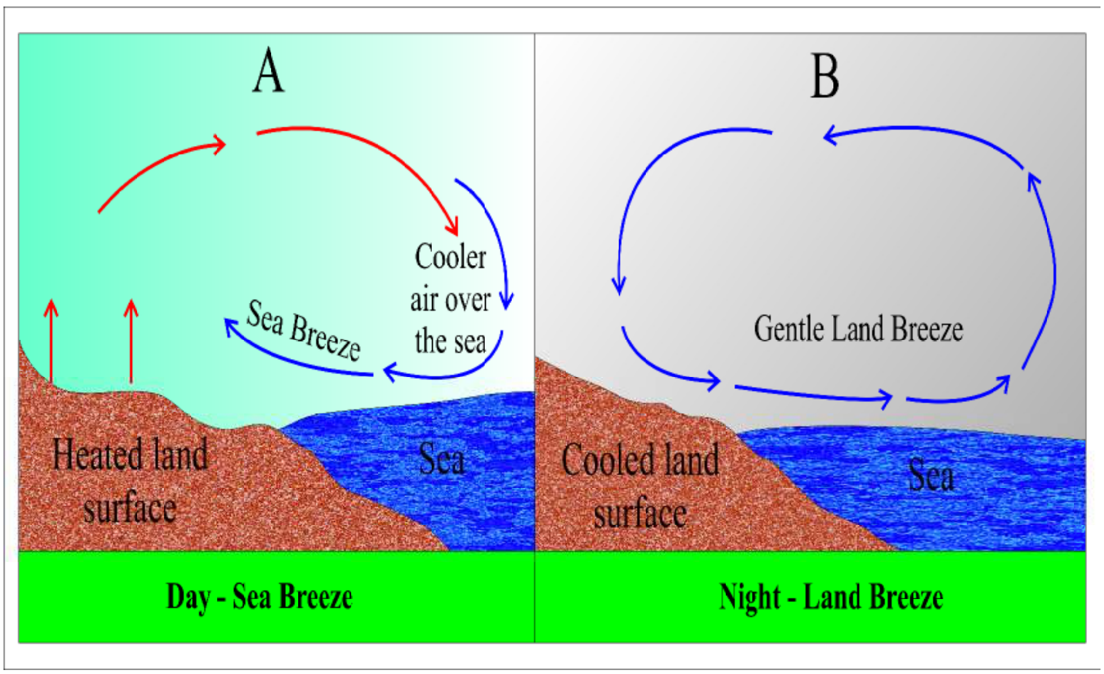



Fig. 7.10 Sea and land Breezes

ii. **Mountain and Valley Breezes-** A mountain and valley breeze is an example of a diurnal wind system. It develops frequently over areas with large differences in relief or some highland areas. During the day , the sun heats up the valley air rapidly. This causes it to raise a warm, upslope wind. The warm air rises creating a valley breeze. In the night mountain air cools rapidly and cold air is dense so it sinks from the mountain tops into the valley below creating a mountain breeze. A mountain breeze and a valley breeze are two related, localised winds that occur one after the other on a daily cycle.

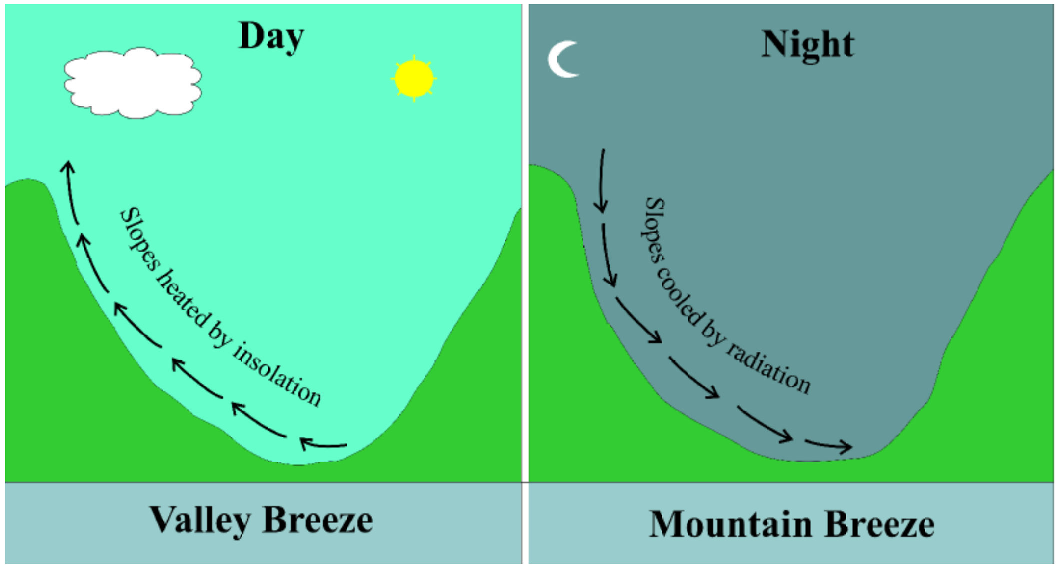



Fig 7.11 Valley and Mountain Breezes

**iii. Hot winds**

Let's know about some of the important hot winds.

| Name of hot winds | Location | Characteristics |
|---|---|---|
| Loo | Plain of north India and Pakistan | Loo is a very hot and dry wind, which blows in the months of May and June, usually in the afternoon. Its temperature varies from 45 degree Celsius to 50 degree Celsius. |
| Fohn | Alps mountain | The fohn is warm, dry, gusty wind which occurs over lower slopes on the lee side of a mountain barrier. The onset of fohn is generally sudden. It may raise the temperature by 15 degrees to 30° F within an hour. |
| Chinook | Eastern slopes of Rockies | A very dry and warm wind with a capacity to evaporate snow. The meaning of chinook is 'the Snow eater'. Chinook have been known to raise temperature by 35° F within 15 minutes. |
| Leveche | Spain | A dry, dust laden wind blowing from Sahara Desert into Spain |
| Sirocco | Sahara desert | A hot, dry wind blowing north across the Mediterranean sea. |



| | | |
|---|---|---|
| Khamsin | North Africa and Arabia | A hot desert, dry, dust- laden, wind occurring mainly in Egypt. It occurs during the period February to June, being most frequent in March and April. |
| Zonda | Argentina | A warm, dry wind on the edge of the Andes. |
| The Santa Ana | Southern California | A hot, dry, strong, blustery, fohn-type wind. It is most frequent in winters but may also occur in spring or autumn. In spring Santa Ana winds can cause considerable damage to fruit trees. |
| Harmattan | West Africa | A hot, dry, dusty north-eastern wind blowing out of the Sahara across the Sahel. It is hot from about March to June and cool from November to February. |

**iv. Cold winds**

Some of the important cold winds are:

| **Name of cold winds** | **Location** | **Characteristics** |
|---|---|---|
| Bora | Adriatic coast | A cold, dry winter, blowing down off the highlands of Yugoslavia and affecting the Adriatic coast. |
| Blizzard | Rocky Mountain | An extremely cold, violent, storm of powdery snow ice carried by a high wind during which visibility is limited. |
| Buran | Central Asia and Russia | A extremely cold, strong northeasterly or easterly winds blowing found in central Asia and Russia chiefly during the winter |
| Mistral | Rhone valley | A strong, cold, dry and violent wind originates on the Alps in france. It blows from north or north-west towards the Mediterranean through the Rhone valley. It may blow any time of year continuously for a day or two with speeds of 100 km/h. |

Notes

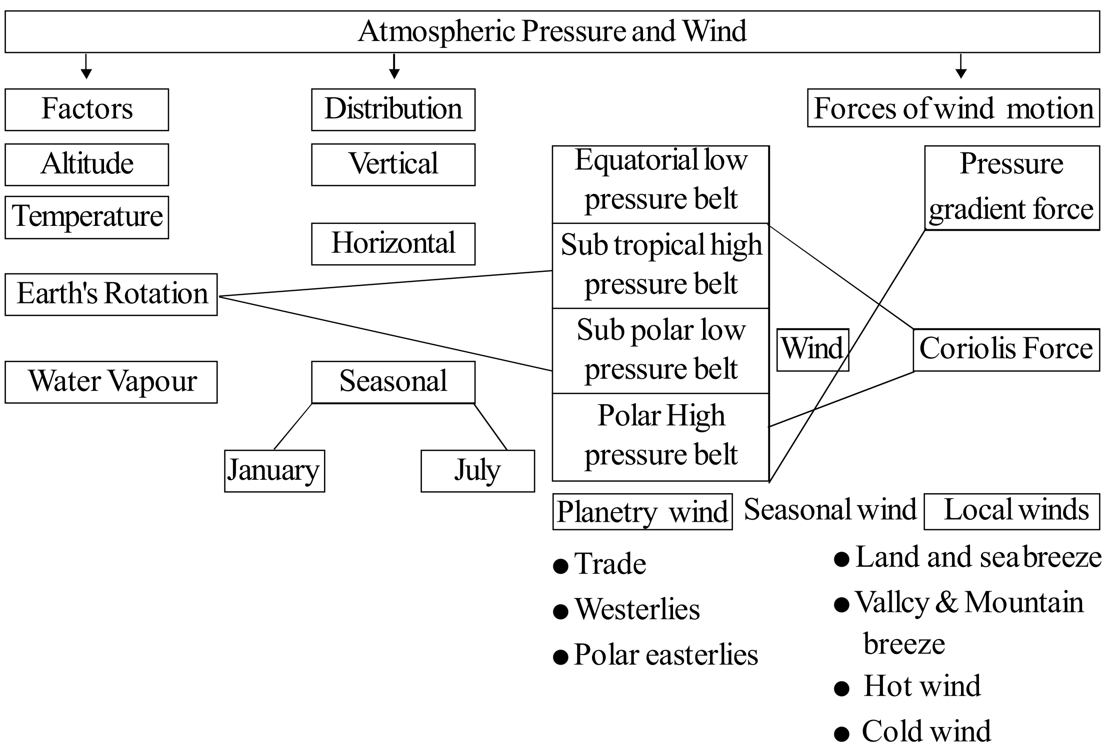
| | | |
|---|---|---|
| Norther | Texas, Gulf of Mexico to W. Caribbean | A cold, strong, northerly wind whose rapid onset may quickly drop the temperature. Severe thunderstorms and hail are common and the wind can reach speeds of between 40 and 60 mph. |

The distinctive wind patterns from planetary to local in various parts of the world are the result of variation in atmospheric pressure.

## INTEXT QUESTIONS 7.4

1. Name the forces of wind motions.
2. Give an example of planetary winds.
3. Loo, Chinook and Sirocco are examples of which type of wind?
4. What is the main characteristic of Monsoon winds?

## WHAT YOU HAVE LEARNT



## ACTIVITY

Let's make a map showing different winds of your area and try to find out their reason for movement.

## TERMINAL QUESTIONS

1. Choose the correct answer for each of the following:

   a. Sirocco is a type of wind.

      (i) Hot local wind

      (ii) Cold local wind

      (iii) Seasonal wind

      (iv) Planetary wind

   b. Where is the maximum deflective force ?

      (i) Equator

      (ii) Tropics

      (iii) Poles

      (iv) Mid latitudes

   c. Which one is a example of periodic wind

      (i) Land and Sea Breezes

      (ii) Westerlies

      (iii) Monsoon

      (iv) Fohn

2. Name the factors on which the atmospheric pressure of any place depends.

3. Define atmospheric pressure and how it can be measured?

4. Write a short notes on following:

   a. Pressure gradient force

   b. Land and sea Breezes

5. Distinguish between the following:

a. Planetary winds and Periodic winds

b. Mountain and Valley Breezes

6. Explain the role of Coriolis force in wind motion.

7. With the help of diagrams show the various pressure belts of the earth surface.

8. Describe any two planetary winds.

9. Explain the seasonal variation in pressure distribution of earth with the help of a map.

## ANSWERS TO INTEXT QUESTIONS

**7.1**

(i) Atmospheric pressure

(ii) Isobar

(iii) Barometer

(iv) Pressure gradient

**7.2**

(i) True

(ii) False

(iii) True

(iv) False

**7.3**

(i) Doldrums

(ii) Subtropical high pressure belt

(iii) Dynamic factor

(iv) Australia, Africa and South America

**7.4**

(i) Pressure gradient force and Coriolis force.

(ii) Trade winds, Westerlies and Polar easterlies.

(iii) Hot winds

(iv) Seasonal reversal of winds is the main characteristic of monsoon winds.

# 8

# HUMIDITY AND PRECIPITATION

The air that surrounds us contains water in the form of vapour. Sometimes we can see it around us in the form of fog or mist or clouds above us. Through water vapour is a minor component of the atmosphere, yet it is a very important element of the atmosphere. In this lesson, we will study the role of water vapour in day-to-day weather conditions. Heat and water are vital ingredients of the biosphere.  Plant and animal life on which our life depends need fresh water. The only primarybasic source of water is from the atmosphere through the condensation of water vapour. In this lesson, we are mainly concerned with water in the vapour state in the atmosphere and the process by which it passes into the liquid or solid state and ultimately arrives at the surface of oceans and lands through the process of precipitation.

## OUTCOMES

After studying this lesson, learner:

- distinguishes between absolute and relative humidity;
- explains evaporation and the factors affecting the rate of evaporation;
- explains condensation and its various forms;
- explains conditions required for precipitation;
- explains types of rainfall with a diagram;
- describes various forms of precipitation and
- identifies factors affecting the distribution of precipitation.

## 8.1 IMPORTANCE OF WATER VAPOUR

Thus the presence of water vapour in the air is an extremely important factor for the existence of human being on the earth. It is the most variable gas inof the atmosphere with a proportion varying from almost zero to as much as four percent by volume.

Importance of water vapour is given below:

1. Precipitation occurs on account of water vapour.
2. Water vapour in the atmosphere absorbs a significant portion of both incoming solar radiation and outgoing earth radiation. It helps in maintaining a suitable temperature on the earth.
3. The amount of water vapour present in the air affects the rate of evaporation.
4. The water vapour provides necessary energy needed for storms (cyclones, hurricanes etc)Necessary energy needed for storms (cyclones, hurricanes etc) is provided by the water vapour in the form of latent heat energy.
5. The amount of water vapour present at a place or region indicates the potentiality of precipitation
6. Air poorly in water content makes our body skin dry and rough.
7. The presence of water vapour present in the air also affects standing crops.

## 8.2 HUMIDITY

Humidity is the concentration of water vapour present in the air. Water vapour, the gaseous state of Water, is generally invisible to the human eye. Humidity indicates the likelihood of precipitation, dew or fog to be present. Humidity depends on the temperature and pressure of the System. It also indicates the degree of dampness or Wetness of the air. Humidity of the air is mainly expressed in the following two ways-

### A. Absolute Humidity

The amount of actual water vapour per unit of air is known as absolute humidity and expressed in grams per cubic metre of air. For example, if the absolute humidity of air is 10 grams, it means that one cubic metre of that air holds 10 grams of moisture in the form of water vapour. Absolute humidity is variable and changes from place to place and with change in time.

The capacity of air to hold water vapour fully depends on temperature. The capacity of holding water vapour in the air increases with the increase in temperature. For example at 10° C, temperature one cubic metremeter of air can hold 9.4 grams of water vapour. If the temperature is increased to 20°C, its Capacity to hold water vapour also increases to 17.12 grams per cubic metre of air. Likewise at 30°C temperature it may rise to 30.04 grams per cubic metremeter of air At Certain temperatur the quantity of water vapour held per cubic metre of air is known as its capacity to hold water vapour. When humidity in air is equal to its capacity, it is known as saturated air. Cold air has less capacity to hold water vapour in their warm air. See below given figure.

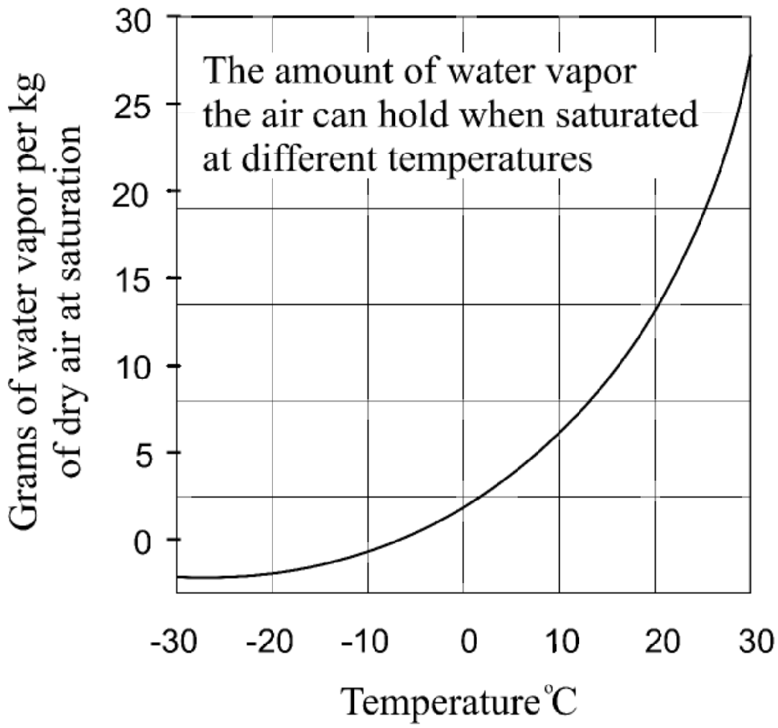



Fig. 8.1 Relation between Temperature and Absolute Humidity

Absolute humidity is a measure of the quantity of water that can be extracted from the atmosphere as precipitation. Cold air can supply only a small quantity of rain or snow whereas warm air is capable of supplying a huge quantity of water.

There is a disadvantage of using absolute humidity, when air rises or sinks in elevation, it undergoes corresponding volume changes like expansion or compression. Thus the absolute humidity cannot remain a constant figure for the same body of air. Modern meteorologists, thus make use of another measure of moisture content specific humidity.

The weight of water vapour per unit weight of air is called specific humidity. The unit of air weight is in kilograms and unit weight of water vapour is in grams. Hot and humid air of Equatorial regions can have 16 to 18 grams water vapour.

## B. Relative Humidity

Relative humidity is the most important and reliable measure of atmospheric moisture. It states the relationship between the absolute humidity and the maximum capacity of the air to hold moisture at the same temperature.

This ratio between the actual humidity of air and its maximum capacity to hold moisture at a given temperature is known as Relative Humidity. It is always expressed in percentage. It can best be understood with the help of a simple formula.

$$\textit{Relative Humidity} \ \frac{\textit{Absolute humidity(Actual amount of water vapour present in the air at a given temp}}{\textit{Humidity relative capacity (Amount of water vapour that can be held by the same air at the same temperature)}}$$

It is quite clear that air can hold a definite maximum quantity of water vapour at a given temperature. When this situation is attained, the air becomes fully saturated. The temperature at which a given sample of air becomes fully saturated is called the dew point or saturation point. The relative humidity of an air of saturation point is hundred percent. To make it clearer, let us take an example. An example considers at a given time, the temperature of the air is 21°C and the total amount of water vapour present is 11.1 grams. Whereas its retentive capacity is 22.2 gms. Relative humidity will be:

$$\text{Relative humidity} \ \frac{\textit{Absolute humidity 11.1 gms}}{\textit{Retentive Capacity 22.2 gms}} \times 100 = 50\%$$

If the same air is holding 22.2 gms. of water vapour at the same temperature, the relative humidity will be 100 percent.

The relative humidity increases when the temperature of the air goes down or when more moist air is added to it. The relative humidity decreases when the temperature of the air increases or when less moist air is added to it.

- Absolute humidity is the actual amount of water vapour present in grams per cubic metres of a given air.
- Relative humidity is the ratio of actual water vapour content to the maximum moisture holding capacity of an air at a given temperature and it is expressed in percentage (RH=AH/Max. capacity × 100).
- The weight of water vapour per unit of air is called specific humidity. The unit of air weight is in kilograms and unit weight of water vapour is in grams.
- The temperature at which a given sample of air becomes fully saturated is called 'dew point' or 'saturation point'.

| | Absolute Humidity | Relative humidity |
|---|---|---|
| 1. | It helps us to know the actual amount of water vapour present in air | It shows the ratio of water vapour actually present in the air at a given temp. to the retentive capacity of humidity of the same parcel of air at the same temp. |
| 2. | It does not take temp. into account | It takes temp. into account |
| 3. | It is expressed in grams per cubic metre | It is expressed in percentage |
| 4. | It is not useful measure of humidity because it does not fell us the amount of water vapour required for the air to become saturated | It is a useful measure of humidity because it can show how humidfor the air isis humid. |

**Changes in the relative humidity of Air**

Change in Relative Humidity can occur in the following three ways:

1. The temperature remains the same and the amount of water vapour in the airin air increases. Its relative humidity will also increase.

2. When the temperature of air rises, its water vapour retentive capacity also rises correspondingly, the relative humidity decreases.

3. If the temperature of air decreases, its water vapour retentive capacity also decreases and relative humidity decreases.

The humidity of air determines the amount and rate of evaporation. It is why humidity is an important element of climate.

**Effects of humidity**

1. High relative humidity causes irritation to human beings because perspiration does not dry easily.

2. In the case of low relative humidity, skin becomes dry. Cracks begin to appear on the skin.

3. On account of rise in relative humidity patients suffering from trouble in joints feel pain.

Notes

## INTEXT QUESTIONS 8.1

1. Fill in the blanks with appropriate word -

   (a) _______________ is very important among elements of weather.

   (b) The temperature at which the air becomes fully saturated is called ___________.

   (c) The relative humidity of saturated air is ____________________ percent.

2. Give a geographical term for each of the following;

   (a) The amount of water vapour actually present in the atmosphere.

   ________________________________________________________________

   (b) The air that contains moisture to its full capacity is called

   ________________________________________________________________

   (c) Amount of invisible water vapour present in atmosphere is generally termed as

   ________________________________________________________________

   (d) The temperature at which a sample of air becomes saturated.

   ________________________________________________________________

   (e) The weight of water vapour per unit of air is termed as _______________________

   ________________________________________________________________

## 8.3 EVAPORATION

The evaporation is the physical process by which a liquid like water is transformed into a gaseous form. This process takes place at all places, at all times and at all temperatures excepts at dew point or when the air is saturated. It is important to note that about 600 calories of heat is used for converting each gram of water into water vapour (calorie is a unit of amount to energy). To raise the temperature of 1 gram of water through 1°C, one calorie of energy is required. At the time of evaporation, heat is absorbed and conserved in water vapour. It is known as latent heat. It is a sort of hidden heat. The latent heat consumed in changing water into gaseous form is released when water vapour changes into water or ice. The release of latent heat in the air is an important source of energy for causing the development of storms, cyclones or typhoons. A loss of water from leaf and stem tissues of growing vegetation is called transpiration. The combined losses of moisture by evaporation and transpiration from given areas are termed as evapo-transpiration.

The rate of evaporation is affected by several factors. Some important factors are given below: -

1. **Accessibility of water bodies-** the rate of evaporation is higher over the oceans than on the continents.

2. **Temperature -** Due to higher temperature in summers, the rate of evaporation is more in summers than in winter. That is why wet clothes dry faster in summers than in winters.

3. **Air moisture -** Aridity or dryness of the air also increases the rate of evaporation. During rainy days, wet clothes take more time to dry owing to the high percentage of moisture content in the air than on dry days.

4. **Cloud cover -** The cloud cover prevents solar radiation and thus influences the air temperatures at a place. This way, it indirectly controls the process of evaporation.

5. **Wind -** Winds induce a higher rate of evaporation. Winds blow away humid air and dry winds take over their place. Dry winds cause rapid evaporation.

   - The evaporation is the process of charging water into water vapour.
   - The rate of evaporations is affected by the accessibility of water, temperature, aridity of air, wind and cloud cover.
   - The heat energy used for changing the state of water or liquid to gaseous state or from solid to liquid state without changing its temperature is called latent heat.

## 8.4 CONDENSATION

The process of condensation is the reverse of evaporation. In this process a gaseous substance changes its state into liquid or solid state. When the temperature of saturated air falls below the dew point, the air becomes incapable of holding its entire moisture content in vapour form. The excess of moisture is then released into liquid state, and if the temperature is sufficiently low, the release can be in solid state. This change of the state of moisture from invisible water vapour to visible liquid (water) or solid (ice or snow) state is known as condensation.

Condensation always takes place around some particles present in air. These may be dust particles, smoke, oceanic salt or carbon dioxide which act as a nuclei to hold water. They are thus called hydroscopic nuclei.

The process of condensation is directly related to the relative humidity and the rate of cooling. The most favourable condition for condensation is on account of fall in temperature of air. When the humid air faces an obstruction like a hill, it rises. On rising its temperature further decreases and the process of condensation begins to operate.

- Condensation is a process of changing water vapour in tiny droplets of water or ice crystals.
- Condensation takes place when temperature of air falls below dew point and is controlled by relative humidity of the air and rate of cooling.

### Forms of condensation

The forms of condensation may be classified into two groups on the basis of place where it is occurring.

| | |
|---|---|
| On the ground or on natural objects such as leaves of plants or trees and grass | In the air at some height in the troposphere. |
| Dew, frost, fog, mist, smog | Clouds |
| Condensation may also take place according to temperature | |
| When the dew point is below freezing point or below 0°c | When it is above freezing point |
| Frost, snow and cirrus clouds | Dew, mist, fog, smog and some clouds are formed |

### A DEW

The tiny drops of Water found early morning on the blades of grass, on the leaves of small plants and trees are called dew. It is formed on account of condensation of moisture in the atmosphere on or near the ground surface. Some favourable conditions for the formation of dew are the following.

1. **Long Nights -** During long nights earth's surface is cooled. When humid air comescome into contact with thethe contact with cold surface, condensation occurs in the form of dew.

2. **Cloudless clear sky -** When there is clear sky, little or no wind, high relative humidity and cold long nights condensation occurs in the form of dew. These conditions lead to greater terrestrial radiation and the solid objects become cold enough to bring the temperature of air down below dew point. In this process extra moisture of the air gets deposited on various objects or surfaces.

3. **Relative humidity -** High relative humidity promotes more condensation and dew formation. Therefore dew can be found more in the months of August - September in India.

Notes

4. **Dew point -** Dew point being higher than freezing point, promotes dew formation and conversely frost is formed.

## B. Frost

When the dew point is below freezing point, the condensation of extra moisture takes place in the form of very minute particles of ice crystals. It is called frost. This form of condensation is disastrous for standing crops, such as potato, peas, pulses, grams. Generally the conditions of formation of dew and frost are the same. Only temperature should fall below freezing point for the formation of frost.

## C. Fog

Fog comprises a dense mass of small water drops or smoke or dust particles in the lower layers of the atmosphere. Fog results from the cooling of air below its dew point; cooling is caused by radiation, conduction and mixing of warm and cold air masses.

Three types of fog have been identified. These are as follows -

(a) Radiation Fog - It is the commonest type of fog. It needs the following for its formations - (i) An should have been under a cloud cover with rain falling a day before (ii) Pools of air, cooled to an excessive degree (iii) cloudless sky on the night before.

(b) Advection fog is formed through the transportation of warm, moist air over cold surfaces. This type of fog occurs along the sea coasts and shores of large inland water bodies.

(c) Frontal fog is formed along the front separating cold and warm air masses. Cooling is caused by the forced ascent of air due to convergence. Frontal fogs are commonin the cool temperate belt where fronts are frequent.

## D. Mist

Mist is a type of fog in which the visibility is more than 1000 metres but less than 2000 metres. It becomes foggy when the visibility is less than 1000 metres.

## E. Smog

Smog is a fog that has been polluted by smoke, dust, carbon monoxide, sulpher dioxide and other poisonous wastes smog frequently occurs in large cities and industrial centres. In 1952 smog caused deaths of over 4000 people in London.

## F. Clouds

As against fog clouds are formed at considerable height above the ground in the atmosphere. Condensation is the common cause of formation of clouds. Moist air gets cooled after reaching considerable height. Water vapour isare changed into tiny droplets of water or snow crystals, when these droplets a crystal rise up or travel across the sky close together, they are called clouds.

The clouds change their shape and appearance almost every second. Sunlight also affects their appearance. Therefore clouds are seen in different sizes. To facilitate classification of clouds, some important types are given below -

**(a) Cirrus cloud -** being at considerable height these clouds are formed of ice crystals. They look like fan -shaped and are rightly called cirrus clouds.

**(b) Cumulus clouds -** with a flat base, they look like domes at the top. In appearance, they look like a cauliflower.

**(c) Stratus Clouds -** They appear like sheets in layers and cover the whole or large parts of the sky.

- Dew, fog, frost, mist, smog and clouds are forms of condensation.
- Frost and some clouds are formed when condensation take place below freezing point
- Clouds are grouped into three types on the basis of their appearance.

## INTEXT QUESTIONS 8.2

1. Write geographical term for each of the following -

(a) Physical process in which liquid like water transformed into vapour or gaseous state ____________

(b) At the time of evaporation, heat is absorbed and conserved in water vapour. It is known as ___________.

(c) The process of change of water vapour into liquid or solid state

___________________

(d) Condensation always takes place around some particles that are known as

__________.

2. Name three types of fog.

   (i) ____________________________

   (ii) ____________________________

   (iii) ____________________________

3. List any three factors which affect the rate of evaporation.

   (i) ____________________________

   (ii) ____________________________

   (iii) ____________________________

## 8.5 PRECIPITATION

The falling of water droplets, ice crystals and other forms on the ground is called precipitation. It includes drizzle, rain, cloud burst, snow fall, sleet and hail.

When water vapour rises up in the atmosphere, condensation takes place and the tiny droplets and ice crystals form the clouds. These tiny droplets in the cloud ascend further and under certain favourable conditions join together and become bigger and heavy. When they are unable to remain suspended in the atmosphere, these fall on the ground in the form of precipitation.

### Forms of Precipitations

**A.** **Drizzle -** The light rain falling in very tiny drops is called drizzle. These droplets are tiny particles of less than 05 mm diameter. They are so tiny and light that even the light wind may blow them away.

**B.** **Rain -** Rainfall is in the form of drops of water. These drips may vary in diameter from 0.5mm to 7 mm. Sudden and violent rainfall is termed as a shower. The shower drops are large and heavy.

**C.** **Snowfall -** When condensation takes place below freezing point, the water vapour changes into tiny ice crystals. These tiny ice crystals grow in size and form the flakes which become big and heavy and start falling on the ground. This form of precipitation is called snowfall. Snowfall is very common in western Himalayas and mid and high altitude regions in winter.

**D.** **SLEET -** Sleet is frozen rain, formed when rain before falling on the ground passes through a cold layer of air and freezes. The result is the creation of solid particles of clear ice. It is usually a combination of small ice balls and rime.

**E. HAIL -** The precipitation in the form of hard solidified pellets of ice is known as hail. These pellets may be rounded and small sized like those of peas. The small ice granules may also grow in size and their structure resembles that of an onion and may grow to the size of a tennis ball. In this case bigger granules have frozen layered structure. The bigger granules cause great harm to standing crops. In India, during the months of March to May hail storms are common.

- Falling down of atmospheric moisture on the Earth's surface is called Precipitation.
- The precipitation in the form of tiny droplets of water and bigger water droplets are known as drizzle and rainfall respectively.
- When the precipitation is in the form of big ice balls, it is called snowfall.

When a mass of moist air ascends to altitude it cools down. In doing so, it attains dew point which leads to condensation and ultimately precipitation. Thus the cooling of air occurs mainly when it rises. There are three important ways in which a mass of air can be forced to rise and each of these ways produces its own characteristic precipitation or rainfall.

Based on the ascend of air, rainfall is classified into three types -

1. **Convectional Rainfall -** Excessive heating of the earth's surface in tropical regions results in the vertical convectional currents. These currents lift the warm moist air to higher strata of the atmosphere. When the temperature of such humid air starts falling below dew point continuously, clouds are formed. These clouds cause heavy rainfall associated with lightning and thunder. This type of rainfall is known as convectional rainfall. It is very common in equatorial regions where it is a daily phenomenon in the afternoon at 4 pm throughout the year. For this reason it is also called 4' o'clock rainfall.

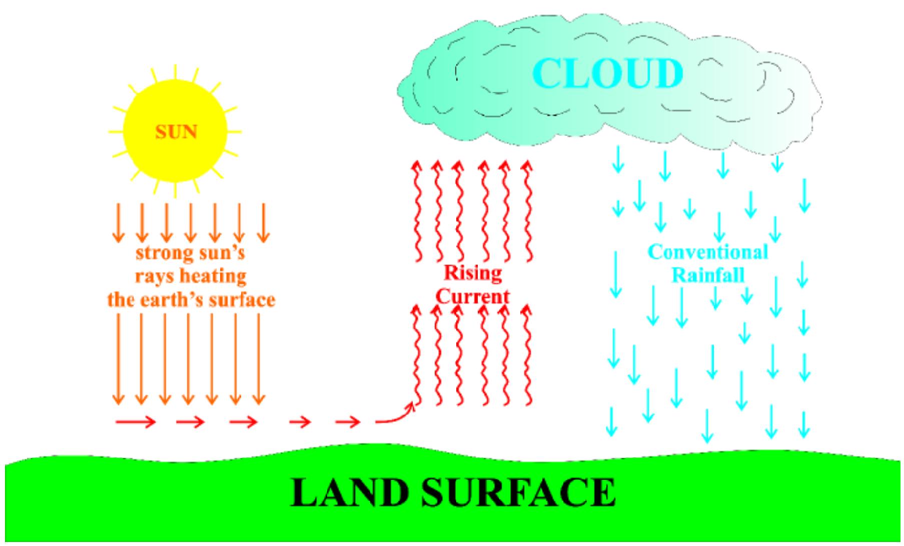



Fig - 8.2 Diagram of convectional rainfall

ii. **Orographic Rainfall -** It may also be called as relief rainfall. It is caused when air is forced to rise up a hill, mountain or hilly plateau. The winds facing the direction of the mountain range ascend and are cooled upon gaining a certain height. On reaching the saturation point condensation starts, and on further cooling rainfall begins. The special feature of the areas of high relief is that the windward side receives more rainfall than the leeward side because the winds shed most of their moisture before crossing the barrier. Not only this while descending on the seaward of the mountain the winds are further warmed and their capacity to hold moisture rises. As a result there is either less or no rainfall. For example Mahabalshwar lying on the windward side of western Ghats receives annual rainfall of about 622 cms against Pune on the leeward side only 70 km. away from Mahabaleshwar receive only 66 cms annual rainfall.

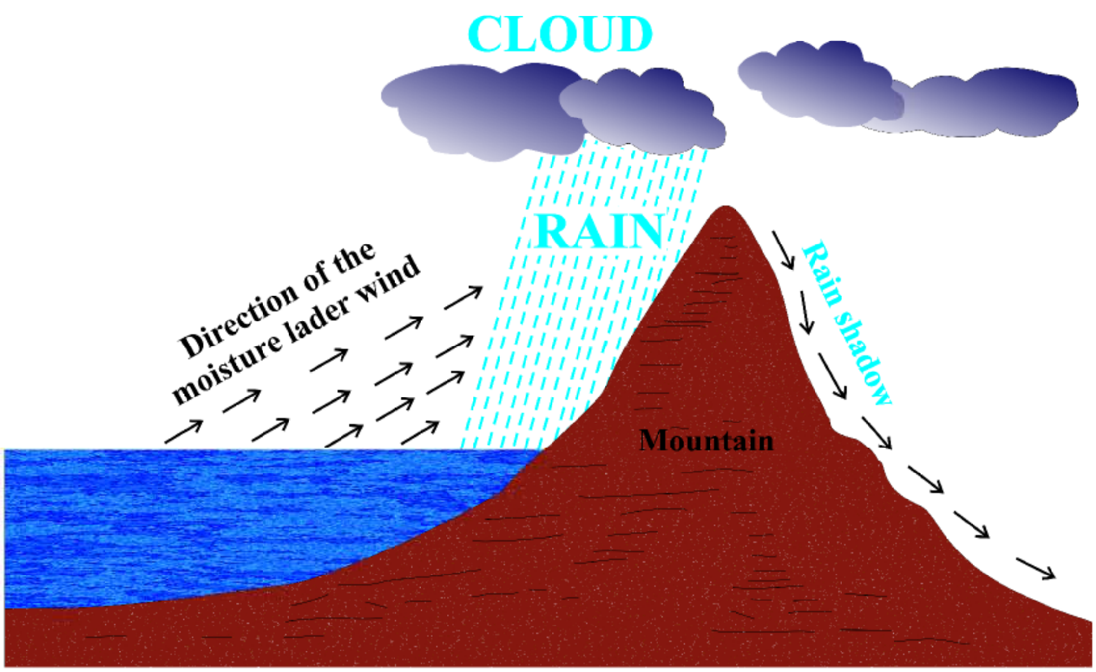



Fig. 8.3 Diagram of Orographic Rainfall

iii. **Cyclonic Rainfall-** When a warm air mass converges with a cold air mass stormy conditions are created. Being lighter, warmlighter warm air mass rises above the cold air mass. The humid and warm air upon ascent is cooled. On becoming cooler below the saturation point condensation takes place and clouds are formed. These clouds are rain bearing cumulus clouds and give heavy rainfall. This type of rainfall is generally received in mid latitudes where comparatively warm westerly humid winds converge with dry polar winds.

It is on account of this convergence, cyclonic or convergence precipitation occurs in these areas. In cyclonic rainfall air from all sides rushes towards the centre and it then forced to rise upward. On ascent, it cools and the process of condensations begins to cause rainfall. The path followed by cyclones gettingget heavy to moderate rainfall on the eastern coasts of India isare its bestit s best example.

## 8.6 DISTRIBUTION OF PRECIPITATION

The spatial distribution of precipitation is not uniform all over the world. The average annual precipitation of the world is 97.5 cms. but the landmass receives areceive lesser amount of rainfall than the oceans. The annual precipitation shows marked difference In the land. Different places of the earth's surface receive different amount of annual precipitators and that too in different seasons. Somewhere it rains torrentially throughout the year, at other places it rains occasionally and those two are very scanty like in deserts. There is a place in the Atacama desert in Chile where no rainfall was received for four years continuously. On the other side Mansynram in Meghalaya is the wettest place on earth. It received 26000 mm (1000 inches) of rainfall in 1985.

The main features of the distribution of precipitation can be explained with the help of global pressure and wind belts, distribution of land and water bodies and the nature of relief features - Now let us first see regional distribution of precipitation

### A. Regional Variations

On the basis of average amount of annual precipitation, the following four precipitation regions can be recognized.

(i) **Region of Heavy Precipitation : -** The regions which received more than 200 cms of rainfall are included in this category. Equatorial coastal areas of tropical zone and west coastal regions at temperate zone are included in this category.

(ii) **Regions of moderate Precipitation :-** The regions receiving 100 to 200 cms. of rainfall are included in this category. Eastern coastal regions of sub-tropical zone and coastal regions of the warm temperate zonegone are included in the category.

(iii) **Regions of less Precipitation :-** These regions tie in the interior parts of the tropical zone and eastern interior parts of temperate zone and receive precipitation between 50 to 100 cms of.

(iv) The areas lying in the leeward side (rain shadow areas) of the mountain range, in interior parts of continents, western margins of continents receive less than 50 cm precipitation.

### B. Seasonal Variations

The regional variations in the distribution of precipitation do not give the correct picture of the nature of precipitation in such regions where seasonal fluctuations in the amount of precipitation are very common. Therefore it is important to study seasonal variations of precipitation in the world.

Seasonal distribution of precipitation provides us an idea to judge its effectiveness. For example the scanty precipitation during short growing season in high latitudes is more effective than that of heavy precipitation in lower latitudes, precipitation in form of dew, fog and mist in some parts like Central India and Kalahari desert has an appreciable effect on standing crops and natural vegetations.

## C. Factors affecting Rainfall Distributions-

(i) Moisture supply- to the atmosphere is the main factor in determining the amount of rainfall in any region.

(ii) Wind direction - winds blowing from sea to land cause rainfall while bearing lands are dry.

(iii) Ocean Currents - Warm currents help in causing rainfall while cold currents cause no rainfall.

(iv) Preserving mountains across the directions of winds causes more rainfall on the windward side and creates rain shadow on the leeward side.

(v) Pressure belts are closely related with wind direction and rainfall.

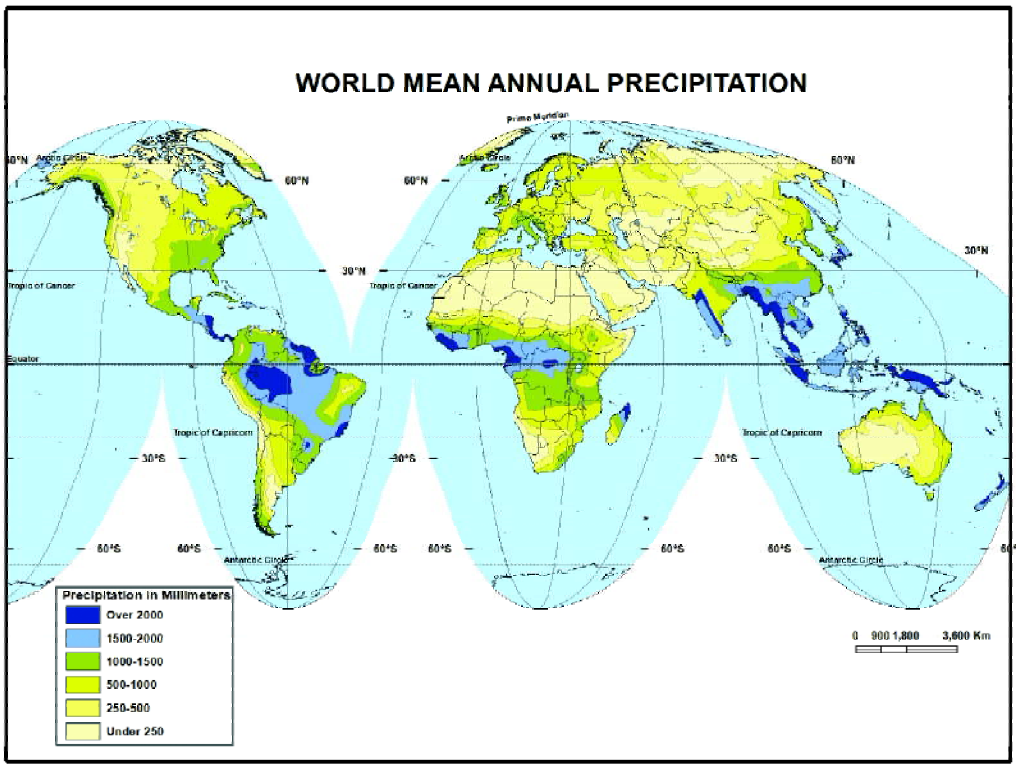



Fig 8.4 Distribution of mean precipitations in the world

## INTEXT QUESTIONS 8.3

1. Give a geographical term for each of the following.

   (a) The process in which water vapour is changed into water ________________.

   (b) Leeward side of the mountains or hill receive less rainfall ____________________.

   (c) The Ascent of humid and warm air and its contact with colder air results in _____________.

   (d) The light rain falling in very tiny drops is called____________________________.

2. List any four forms of Precipitation.

   (a) ________________________ (b) ________________________

   c) ________________________ (d) ________________________

3. Name three types of rainfall.

   (a) ________________________ (b) ________________________

   c) ________________________ (d) ________________________

## WHAT YOU HAVE LEARNT

- Water vapour is an important element of the atmosphere. It is responsible for global heat balance, atmospheric phenomena and sustaining plant, animal and human life and earth.
- The water vapour present in the atmosphere is called humidity which can be expressed in two ways - absolute humidity and relative humidity.
- Relative humidity is the most reliable measure for forecasting weather.
- Water vapour enters into the atmosphere through a process called evaporation.
- Temperature of the air controls the capacity of holding moisture at a given volume.
- The air which holds the moisture to its full capacity is called saturated air and the temperature at which it reaches saturation point is called dew point.
- Condensation is a process of changing of water vapour into liquid or solid state. It happens where the temperature of an air falls below dew point condensation occurs

near the ground as dew, mist of fog and at higher levels of clouds.

- Falling down of atmospheric moisture is called precipitation. Drizzle, rainfall, snowfall, sleet and hail are various forms of precipitation.
- There are three ways in which rainfall occurs - convectional, orographic and cyclonic.
- The spatial distribution of precipitation is not uniform all over the world. The landmass receives less rainfall than oceans.

## TERMINAL QUESTIONS

1. Explain the importance of water vapour in the atmosphere.
2. Define, humidity
3. On which factors does evaporation and its rate depend?
4. When and how does condensation take place?
5. Explain forms of condensation.
6. Condensation begins only after saturation of air elaborate this statement.
7. Distinguish between each of the following -
8. "With changes in temperature relative humidity also changes". Explain the statement.

9 Describe any five factors affecting rainfall distribution.

## ANSWERS TO INTEXT QUESTIONS

**8.1**

1. (a) humidity (b) dew point
   (c) 100 percent
2. (a) Absolute humidity
   (b) Saturated air (c) humidity
   (d) dew point (e) specific humidity

**8.2**

1. (a) Evaporation (b) Latent heat

   (c) Condensation (d) Nuclear

2. (i) Radiation fog

   (ii) Advection fog

   (iii) Frontal fog

3. (i) Accessibility

   (ii) Temperature

   (iii) Air moisture

   (iv) Wind

   (v) Cloud cover (any three)

**8.3**

1. (a) condensation

   (b) less rainfall

   (c) cyclonic rainfall

   (d) drizzle

2. (a) Drizzle

   (b) Rain

   (c) Snowfall

   (d) Sleet

   (e) Hail

3 (a) Convectional

   (b) Orographic or Relief rainfall

   (c) Frontal or cyclonic rainfall

9

# CLIMATE AND CLIMATE CHANGE

In the previous lessons, you have studied the dynamics of the atmosphere with special reference to its structure and composition, insolation, air pressure, winds, humidity and precipitation. These climatic elements have a significant effect on our existence. For instance, the houses we build, the garments we wear, and the food we consume largely depend on the climatic conditions. In this lesson, you will learn about the climate, major climate regions, climate change - causes and consequences and global initiatives to mitigate the effects of climate change. Climate and weather are sometimes used interchangeably but they are conceptually quite different. Therefore, to understand climate, it is very essential to comprehend the meaning of weather.

## OUTCOMES

After studying this lesson, learner:

- differentiates between weather and climate;
- describes various climate regions;
- explains the concept of climatic change;
- identifies the causes and consequences of climate change and
- describes major global initiatives - related to climate change;

## 9.1 WEATHER AND CLIMATE

As you know, the blanket of air which surrounds Earth is called atmosphere. Earth's atmosphere is very dynamic and continually changing on a daily basis in terms of temperature, pressure, wind, humidity and precipitation. You are aware that there is an inverse relationship that exists between temperature and pressure; pressure and wind. For example, the area experiencing high temperature will have low air pressure and consequently strong wind prevails and vice versa. In addition to that, temperature, pressure and wind affect precipitation, humidity, sunshine, cloudiness and other atmospheric conditions. Therefore, all these atmospheric elements are interconnected and influence the atmospheric conditions of a place. These conditions differ from place to place and time to time.

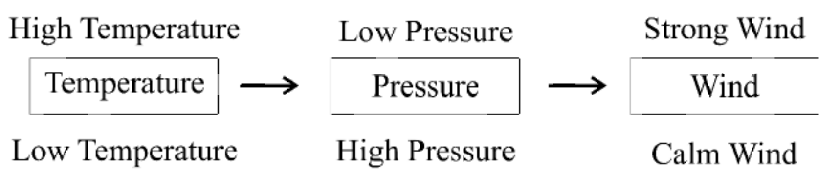



Fig. 9.1. Relationship among the Weather Elements

## a. Difference between Weather and Climate

Climate and weather are sometimes used as synonyms but they are not the same (Table 1). The state of general atmospheric conditions with respect to temperature and pressure is called weather. An important characteristic of weather is it changes every day and can be erratic.That is why we get daily weather updates and alerts. The meteorological agencies like Indian Meteorological Department (IMD) provide weather forecasts. On the other hand, climate refers to the long-term averaged weather conditions of a particular area or region. According to the World Meteorological Organisation (WMO), the average of the weather conditions is calculated from the data collected over the period of 30 years.

Table 9.1.Difference between Weather and Climate

| **Criteria** | **Weather** | **Climate** |
|---|---|---|
| Definition | Daily changes in the atmospheric conditions is called weather | Averaged weather conditions of a particular regions is called climate |
| Period of time | Short period -24 hrs | Long period - more than 30 years |
| Elements | Temperature, air pressure, wind, precipitation, humidity, sunshine, cloudiness | Average temperature, average pressure conditions, average wind velocity etc |
| Areal Extent | Small area/Local | Large area/Global |
| Change | Very frequently | Largely permanent |
| Types | Different types of weather conditions prevail in a day | Broadly one type of climate is experienced in an area |

## b. Factors Affecting Climate

There are various types of climate on the basis of elements for example, hot or cold (with reference to temperature), dry or wet (amount of rainfall), arid or humid (humidity or moisture content). Different regions of the world experience different types of climate and influence human activities. To understand the variation in climates, let us discuss the factors which cause the variation in the climate of a particular region.The climate of an area is determined by various factors. These factors are as follows:

i. **Distance from the equator or Latitude:** The climate of an area is influenced by the distance from the equator. The places located near the equator are warmer than the places located away from it. The reason, you have already learnt in lesson 5, is insolation. Equatorial areas receive more heat as intense vertical sun rays fall on a small area whereas Temperate and Polar Regions receive slant rays which are less intense. Maldives is located near the equator which experiences a hot climate whereas Switzerland is situated far away and has a cold climate.

ii. **Elevation:** Highlands are cooler than the lowlands. As we move upwards from the sea level, temperature decreases. The lapse rate is 1 decreases with every 100 metres. Leh is situated at a higher altitude when compared to Jaisalmer. Therefore, Leh is cooler than Jaisalmer.

iii. **Global Winds and Ocean Currents:** Global winds are also known as prevailing winds. They are the result of atmospheric circulation cells and pressure belts. Upwards and downwards movement of air causes precipitation. Besides that, onshore winds are moisture-laden as they come from sea or ocean therefore bring rain, whereas off-shore winds originate from land and they are dry.

Another characteristic of prevailing winds is that they bring air from one type of climate to another. For example, warm winds that travel over water are moisture-laden, the water vapour in the air will condense as it moves into cooler climates and temperature coastal regions receive heavy rainfall.

Surface ocean currents are driven by a global wind system.Their pattern is determined by the wind direction, Coriolis force and position of landforms. The warm current raises the temperature of the coast and may bring rainfall while the cold current reduces the temperature and creates fog and mist.

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Due to the rotation of the earth, circulation of winds is deflected towards the right in the northern hemisphere and left towards the southern hemisphere. This defection is called CoriolisEffect.

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iv. **Geographic Character:** Geographic character of an area encompasses the locational aspect such as distance from the sea or ocean, direction of mountains etc. As you know, the sea has a moderating effect. The places near large water-bodies have a low range of temperature and very high humidity. The places which are away from the oceans experience extreme temperature as they are away from water-bodies.

Direction of mountains is another factor which affects the climate of a region by influencing the direction of moist winds to rise and cause rainfall on the windward side. And when they descend on the leeward side they become dry and cause less rainfall.For example, the places located on the windward side of Western Ghats like Mumbai receive more rainfall as compared to Nagpur, which is located on the leeward side.

v. **Vegetation:** Climate produces forest, desert and so on. Temperature and rainfall patterns decide the characteristics of the soil formation and eventually affect the type of vegetation. Stony or sandy soils are good conductors of heat while black clay soil absorbs heat quickly. The areas which lack vegetation like deserts are hot during the day time and cold at night. On the other hand, forested areas have a lesser range of temperature throughout the year.

vi. **Other Factors:** There are various other climate controlling factors which have been highlighted in following Table.

Table 9.2: Climate Controlling Factors

| **Factors** | **Effects** |
|---|---|
| Land Surface | Albedo Evaporation Temperature |
| Oceans | Albedo Evaporation Energy transferred from the ocean currents and vertical mixing |
| GreenHouse Gases | $Co_2$, $O_2$ |
| Solar Radiations | Orbital controls, Latitude |
| Clouds | Albedo, Emissivity, Absorption, scattering of solar radiation |
| Aerosols | Absorption, Scattering of solar radiation, Condensation nuclei |

## INTEXT QUESTIONS 9.1

1. Write True against the correct statement and write False against the wrong statement.

   (i) Weather provides average atmospheric conditions of a particular area.

   (ii) Area located near equator experience low temperature

   (iii) Warm ocean currents increases the temperature of the coast

   (iv) The lower the elevation higher is the temperature.

## 9.2 CLIMATIC REGIONS

An area which has homogenous climatic characteristics and has geographic continuity is known as climate regions. To create similar types of climate regions, various attempts have been made by the scholars but there is no single perfect classification available. It is believed that Greek philosopher, Aristotle, probably made the first attempt to classify Earth's climate on the basis of insolation. He divided the world into three thermal zones viz. torrid zone, temperate zone and frigid zone.

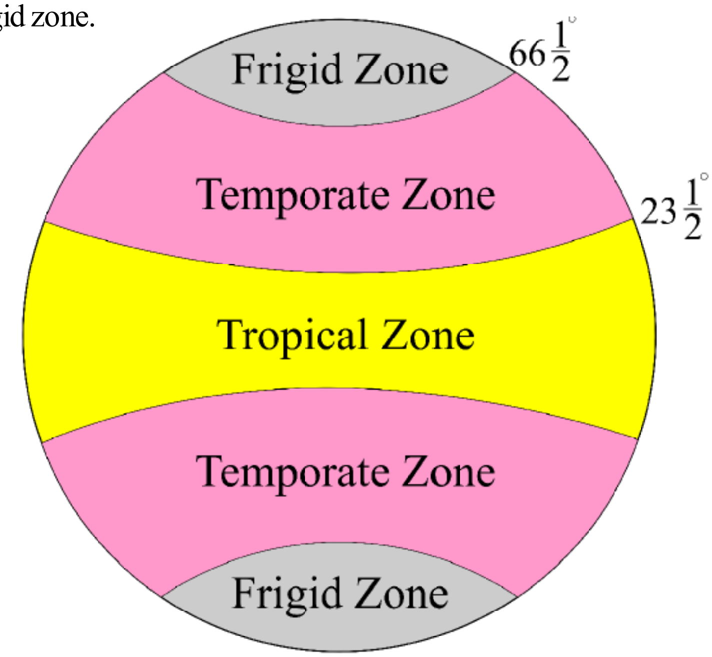


Fig 9.2: Thermal Zones of the World

### a. Koppen's Classification of Climate

The most widely used empirical classification of climate was developed by Waldimir Koppen. He identified a close relationship between climate and vegetation and believed that vegetation is an indicator of climate type. On the basis of annual and mean monthly temperature and precipitation data along with the distribution of vegetation, he divided Earth's climate into five major regions tropical, dry, temperate, cold and polar.

**Design of Koppen Classification**: He recognised five major climatic regions and designed by four capital English letters- A, C, D, E on the basis of temperature and one, B, on precipitation. These major groups were subdivided and designed by small letters, f, m, w, s based on seasonality of precipitation and temperature characteristic.

Table 9.3: Major Climate Regions of the World by Koppen

| Major Group | | Sub-Group | | Characteristics | Climate |
|---|---|---|---|---|---|
| A | Tropical Hot and Humid Climate | Af | Tropical rainforest | Hot and rainy all seasons | Hot and humid climate |
| | | Am | Tropical Monsoon | Hot; seasonally excessive rainfall | Monsoon Climate |
| | | Aw | Tropical Wet and Dry | Hot; seasonally dry esp. winter | Savanna Climate |
| B | Dry Climate | BSh | Subtropical Steppe | Semi arid; hot | Hot Steppe Climate |
| | | BWh | Subtropical Desert | Arid; hot | Hot Desert Climate |
| | | BSk | Mid-Latitude Steppe | Semiarid; cool | Cool Steppe Climate |
| | | BWk | Mid-Latitude Desert | Arid; cool | Cool Desert Climate |
| C | Warm Temperate Climate | Cs | Mediterranean | Mild winter; summer dry | Mediterranean Climate |
| | | Cw | China Type | Mild winter; winter dry | China Type Climate |
| | | Cf | Europe | Mild winter; moist all seasons | Europe Climate |

| | | | | | |
|---|---|---|---|---|---|
| D | Cold Snow Forest Climate | Df | Humid continental | No dry season; severe winter | Taiga Climate |
| | | Dw | Subarctic | Winder dry and very severe | Continental Climate |
| E | Polar Climates | Et | Tundra | Very short summer | Tundra |
| | | Ef | Polar ice cap | Perpetual ice and snow | Polar ice cap |
| H | Highlands | | Highland | Highland with snow cover | Undifferentiated highland climates |

## b. Climatic Regions of the World

As you are aware, Koppen has provided a climate scheme with the first (Major Group) and second letter symbols. For some regions like B, C and D, he has created third letter symbols as well which has been discussed below. The distribution of climate major groups, sub-groups and its characteristics are presented in Table 9.3 and map highlights the locational aspect. If has been devided five major groups.

(i) Major Group A: Tropical Hot and Humid Climate

(ii) Major Group B: Dry Climate

(iii) Major Group C: Warm Temperate Climate

(iv) Major Group D: Cold Snow Forest Climate

(v) Major Group E: Polar Climate

i. **Group A Climate:** The tropical hot and humid climate is characterised with high temperature (>18°C) and high rainfall (6 cms) throughout the year. On the basis of seasonality and periodicity of rainfall, it has been further subdivided into Af, Aw and Am.

ii. **Group B Climate:** Dry climate is signified with low precipitation and high rate of evaporation. The region is further classified into BW and BS. On the basis of annual temperature, it has been further subdivided into-

BWh = Tropical hot desert with mean annual temperature >18°C

BSh = Tropical steppe climate with average annual temperature >18°C



BWk = Moderate latitude cold desert climate with mean annual temperature <18°C

BSk = Moderate latitude cold steppe climate with average annual temperature <18°C

iii. **Group C Climate:** Warm Temperate Rainy climate is characterised with precipitation throughout the year with mean temperature ranging between 3°C to 13°C. On the basis of seasonality of rainfall, the region further categorised into-

Cf = Precipitation > 1.2" throughout the year. This category has three second order sub-classes namely Cfa (Humid subtropical), Cfb (marine west coast type) and Cfc (marine type with short cool summers)

Cw = Winters are mild and dry. Its second order classes are Cwa (Subtropical monsoon) and Cwb (Tropical Upland)

Cs = Winters are wet but summers are dry, precipitation < 1.2". The second order sub-categories are Csa (Interior Mediterranean) and Csb (Coastal Mediterranean).

iv. **Group D Climate:** In the cold snow frost climate, average temperature varies between 0°C to > 10°C. This type of climate has been further classed into Df and Dw. The second order sub-regions are:

Df = Humid cold climate with no dry season

Dfa = Humid continental with long warm summer

Dfb = Humid continental with short warm summer

Dfc = Sub-arctic with humid short cool summer

Dfd = Sub-arctic with humid extremely cold winters

Dw = Humid cold with dry winters

Dwa = Humid Continental climate with long hot summers

Dwb = Humid Continental warm summer

Dwc = Sub-arctic short cool summers

Dwd = Sub-arctic extremely cold winters and short cool summers

v. **Group E Climate:** The region is featured with very cold conditions in which average temperature is <10°C. The second order classes are as follow

ET = Tundra climate ranging between 0°C to 10°C

EF = Permanent snow field temperature <0°C.

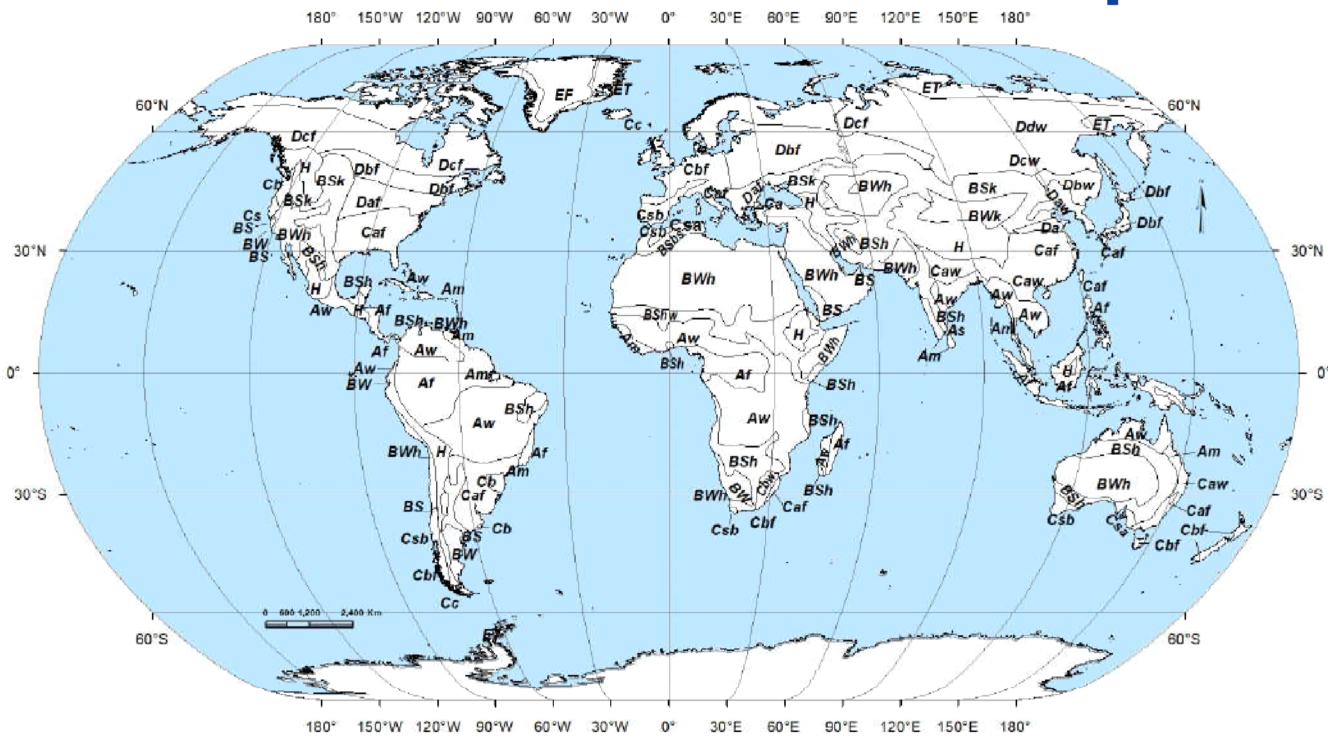


Fig. 9.3 Koppen's Climatic Classification

## INTEXT QUESTIONS 9.2

1. Multiple Choice Questions

   i. Koppen identified how many major climatic regions of the world:

   (a) 6     b) 4

   (c) 5     (d) 7

   ii. Climate classification of Koppen is considered as

   (a) Applied

   (b) Empirical

   (c) systematic

   d) Generic

   iii. Greeks divided the world climate into how many thermal zones

   (a) 3     (b) 4

   ( c) 5     ( d) 6

iv. Major climate group "C" refers to:

(a) Tropical hot and humid climate

(b) Dry Climate

(c) Warm Temperate Climate

(d) Polar

## 9.3 CLIMATE CHANGE

In the previous sections, you got some understanding about the present climatic regions. Largely, the type of climate we experience might have prevailed thousands of years ago with mild changes. The earth has observed various changes in the climate since its evolution. Geological and historical records prove that climate change is not a new phenomenon; instead, it's natural and continuous. Geological records with reference to glacial and interglacial periods provide traces of advance and retreat of glaciers in the highlands. On the other hand, historical records especially documents signify that earth experiences dry and wet periods.

Currently, the climate of all the regions of the world is changing drastically.Therefore, climate change is a global phenomenon which refers to significant variations in the statistics of averaged weather conditions over a period of time. It has become a serious problem for mankind.

### a. Climate Change and Climate Variability

If a person truly wants to understand the concept of climate change then its important to understand climate variability. As you are aware that Earth's climate is dynamic and another significant feature is its variability. Therefore, climate variability refers to anomalies in the existing state of climate which can be observed spatially and temporally. On the other hand, climate change denotes changes in either the average state of climate or in terms of its variability, continuing for several decades or more. The difference between climate variability and climate change is given in Table 9.4.

Table 9.4: Difference between Climate Variability and Climate Change

| Climate Variability | Climate Change |
|---|---|
| The fluctuations in the distinct weather events results in climate variability | A mean or average trend of climate variability is known as Climate change |
| It includes short period of combined form of weather trends | It includes long period of accumulated form of climate variability |
| It is a micro level or regional phenomenon | It is a macro level or global phenomenon. |

Notes

## b. Global Warming

Global warming refers to the heating of the whole Earth's air temperature over the past few centuries. This phenomenon occurred due to the presence of greenhouse gases.Greenhouse is a structure in which sun's heat is trapped and used for providing warmth. For example, if you park your car in an open area on a hot sunny day, after sometime you will find that solar energy entered into the car through the door's glass or windscreen and trapped in the car resulting in excessive heating. Similarly, our atmosphere behaves like a greenhouse in the presence of greenhouse gases. The gases that absorb long wave radiation are called greenhouse gases. The whole process that heats the atmosphere is referred to as the greenhouse effect. It increases the temperature of the troposphere.

The major greenhouse gases (GHGs) which help in increasing global warming are carbon dioxide, chlorofluorocarbons, methane, carbon monoxide, ozone and nitrous oxide. The effectiveness of any greenhouse gas depends upon the magnitude of the increase in its concentration, its lifetime in the atmosphere and the wavelength of radiation that it absorbs. Chlorofluorocarbons and ozone are highly effective gases whereas carbon dioxide is largely concentrated in the atmosphere.The level of Co2 is constantly increasing due to burning of fossil fuel and changes in the land use. It is growing at about 0.5 per cent yearly.

**Trends of Global Warming:** One of the prime problems of the world in the present century is earth's rising temperature or global warming. Now, let us explore to what extent our earth has warmed up. Earth's rapid heating started with the industrial revolution. Since the advent of industrialization, the global annual temperature has risen to more than 1%. From 16880 to 1980, it has increased on an average by 0.07% every decade. Since 1981, the rate of growth in the global temperature has doubled. For the last four decades, it has risen by 0.18% every 10 years. If the trend continues then the global temperature would reach around 1.5% in 2040.

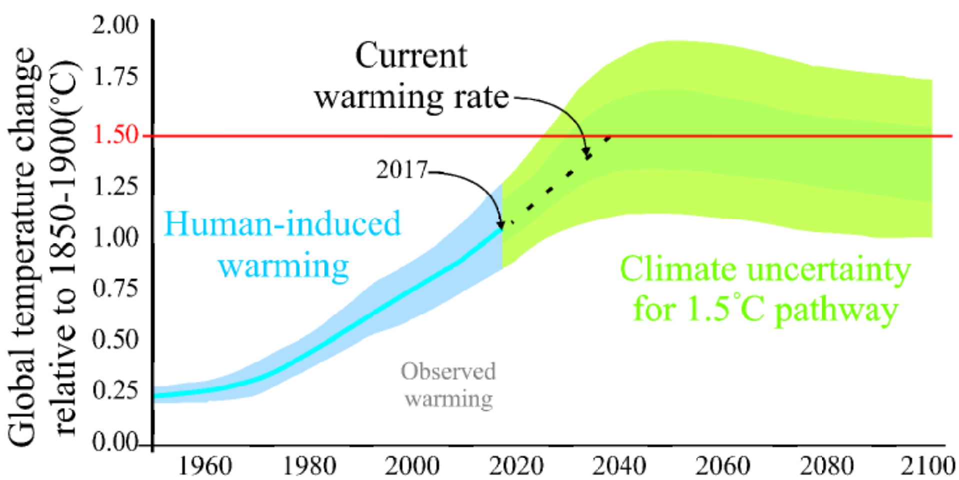


Fig. 9.3: Global Warming (Source: IPCC)

**DO YOU KNOW?**

Till now, our planet has experienced 9 out of 10 warmest years since 1880.

It is believed that the year 1998 was the warmest in the history of earth's climate.

## INTEXT QUESTIONS 9.3

1. Fill in the blanks

   (i) ………..and ……… records prove that climate change is not a new phenomenon, instead it's natural and continuous.

   (ii) …………..is the heating of the whole Earth's air temperature over the past few centuries.

   (iii) Climate change is a ……… phenomenon.

   (iv) The whole process of heating the atmosphere is called the …………..

## 9.4 CAUSES AND CONSEQUENCES OF CLIMATE CHANGE

As you know, Earth's climate is dynamic and keeps on changing through natural processes. The matter of concern is that the changes that are occurring presently have been exaggerated due to human activities. The causes of climate change can be divided into two categories i.e. natural and man-made.

### a. Natural Causes:

i. **Continental Drift:** Around 200 million years ago, the face of the earth was not the same. There was a large landmass which had drifted apart due to tectonic forces. The drift had an impact on climate as it changed the position of landmass and waterbodies. It resulted in the changes in the flow of ocean currents and winds. Besides that, Himalaya was born out of this phenomenon which shapes the climate of the Indian subcontinent.

ii. **Ocean Currents:** As you know, ocean absorbs large amount of heat and ocean currents move vast amount of heat across the planet. It has been discussed earlier that how ocean currents influence the climate. The interaction between ocean and atmosphere shapes the climate system and produce El nino Southern Oscillation (ENSO) which occur every 2 to 6 years. The ENSO describes the fluctuations in temperature between ocean and atmosphere, which has two phases El Nino (warm phase) and La Nina (cold phases). The deviation from normal surface temperature



can have a large impact on ocean processes and global weather processes. Oceans play a significant role in determining the atmospheric concentration of $co_2$. Changes in the ocean pattern may affect the climate through the movement of $co_2$ into or out of the atmosphere. Now-a-days, the terms El Nino and ENSO are used interchangeably. El Nino produces severe and extensive changes in climate. Ecuador and northern Peru have arid climates but due to the El Nino affect rainfall has increased drastically. As it brings rain to the region, Indonesia and Australia experience drought.

iii. **Volcanoes:** Massive volcanic eruption changes the climate of the earth, temporarily. The material erupted such as sulphur dioxide, water vapours, ashes and dust reached lower stratosphere,blocked the sun rays and reduced the temperature about 0.5°C.The eruption of Novarupta in 1912 and Mount Pinatubo in 1991 are the example which has affected the climate of earth to some extent.

iv. **Solar Output:** The Sun is the prime source of energy. Global climate is affected by the long and short variation in the intensity of the sun. A smallest change in the intensity can lead to changes in our climate. Scientists demonstrate that solar variations have played a key role in past climate changes. It is believed that a slight decrease in solar movement has caused the little Ice age between 1650 and 1850. But present global warming cannot be described with this phenomenon.

v. **Earth's Orbital Changes:** Earth is tilted at an angle of 23.5 degree to the perpendicular plane of its orbital path. Any change, whether big or small, in the tilt can affect seasons. In other words, we will experience warmer summers and cold winters if the tilt is more and cool summers and mild winters if the tilt is less. The orbital changes lead to Milankovitch cycles. According to IPCC, Milankovitch cycles have a great impact on climate. It is belived that they drove the ice age cycles.

### b. Human Induced Causes

The increase in temperature affects other variables of the climate system. Combined effects of human activities on the climate are known as human induced climate change.

There are:

i. **Fossil Fuels:** Climate is a physical phenomenon but anthropogenic factors have altered it immensely. After the advent of the Industrial Revolution, the amount of greenhouse gases in the atmosphere has increased. More greenhouse gases mean more absorption of heat and increase in earth's temperature which will lead to global warming, largely due to burning of fossil fuel like coal and petroleum. Besides that, Industries are exhausting our resources and polluting land, water and air in the



wake of developmental activities. It is estimated that about 20 percent contribution is due to changes in the emission of greenhouse gases.

ii. **Land use Change:** The change in the land use is largely governed by industrialization, urbanisation and cutting of trees for agricultural activities. Deforestation changes the amount of sunlight reflected from the ground back to space, Albedo. In Eurasia and North America, around 50 percent of the land use changes occurred during the industrial period due to replacement of forest with either agricultural or industrial activity.

iii. **Deforestation:** The rainforest plays a vital role in regulating the temperature of the world. These forests absorb one-fifth of human induced carbon emission. Hence, deforestation has been considered as a major contributor to the cause of climate change.The carbon is stored in the form of wood and vegetation through carbon sequestration.

iv. **Agricultural Activities:** According to IPCC, agricultural activities are one of the major drivers of climate change. In order to fulfil human's food demands, more land has been brought under cultivation and animal husbandry. Agricultural activities like animal keeping and rice cultivation have increased the carbon and methane emission. It is believed a quarter of methane emission comes from domesticated animals such as cows, pigs, etc. Moreover, paddy fields also release methane when the field is flooded during the sowing and maturing stage of the crops. Around 90 percent of the rice grows in Asia as a staple crop. Therefore, Asians are considered as a major contributor of climate change.

## c. Consequences of Climate Change

Climate change is creating serious threats to the survival of humankind. Every aspect of ecology has been disturbed by human interference. The impacts of climate change are easily visible on water systems (glaciers and sea), agriculture, flora and fauna and human health.

i. **Melting of Glaciers and Ice-caps:** Glaciers and ice-caps are either vanishing or receding especially in the highlands of our planet due to rising atmospheric temperature. Man-made influences have significantly contributed to the retreat of glaciers since 1960's. Earth has lost more than 600 glaciers over the past few decades. They are largely melted in the Greenland, Canadian Arctic, Rocky Mountains, Andes, Patagonia, Himalayas and on various other continents.

ii. **Rising sea level:** The level of sea is rising at an alarming rate due to thermal expansion and the loss of glaciers. The increased concentration of $co_2$ in the ocean triggered the change and made the water more acidic. Presently, our oceans are

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more than 40 percent acidic than it used to be affecting marine life ecally. corals and shellfish. the coral reefs of great Barrier Reef of Australia and Lakshadweep island of India, are facing problems like bleaching and loss of habitat.

**iii. Extreme weather:** Extreme weather events are common phenomena occurring on earth like heat waves, heavy rainfall, intense cyclones, droughts, ice storms, avalanches, dust storms and floods. The frequency and magnitude of these events have also increased due to change in the temperature conditions of the earth. Tropical cyclones have been increasing since the 1970s and causing huge destruction. In India, cyclone Tauktae emerged from Arabian Sea in 2021, killed more than 100 people and was classified as a very severe cyclonic storm.

**iv. Impact on Agriculture:** Agriculture is climate-sensitive and most vulnerable to climate change. As mentioned earlier, it is one of the major cause of climate change and prime source of greenhouse gases.It was predicted by IPCC that higher temperature will reduce crop yield while encourage the growth of weeds and pests.The climate change impact on farm productivity has been divided into two group: a) high and mid-latitude nations and b) low latitude nations. In the former region (North America, Europe, Australia), there is a strong probability that productivity will increase due to extended growing season whereas on the latter region (Africa and Asian countries) farm productivity will decrease.But the overall impact is expected to be negative which will threaten the global food security especially in the less developed countries.

**v. Impact on Flora and Fauna:** The distribution and size of flora and fauna largely depends upon the climate. Climate change can affect both plant and animal species in a number of ways-

- Changes in the climate altering the timing in reproduction and life cycle of plants (budding early) and animals,
- Migration pattern of birds and animals. They have to migrate early.
- Length of growing season of plants.
- Increase the frequency of weeds and pests outbreak.
- Increased the occurrence of diseases and invasive species.
- Altering the range boundaries of flora and fauna: In Europe butterflies have shifted their range 200 kms upwards; moreover, tree lines are also shifting.

**vi. Impact on Health:** Climate change is not only affecting human health but also affecting animals as well. Due to increased temperature and more frequency of heat waves, it has a direct effect on health. In the summer season, some regions have been experiencing increased heat-related mortalities such as heat stroke, cardiovascular and kidney diseases. The changes in the rainfall and temperature conditions have transformed the distribution of both waterborne and vector diseases like dengue fever, Lyme disease, West Nile virus. On the other hand, in the winter season, climate change has created conditions in some areas with warm and stagnant air eventually forming ground-level ozone or smog. Smog (air pollution) is one of the major reasons for asthma attacks. According to WHO, "Climate change is expected to cause approximately 250,000 additional deaths per year" between 2030 and 2050.

## INTEXT QUESTIONS 9.4

1. Match the column

| | Climate Change | | Impact |
|---|---|---|---|
| (i) | Glaciers | (a) | severe floods |
| (ii) | Extreme weather event | (b) | affect farm productivity and food security |
| (iii) | Flora and Fauna | (c) | increased heat-related mortality |
| (iv) | Agriculture | (d) | recede or vanish |
| (v) | Health | (e) | alter the timing of reproduction and migration |

## 9.5 GLOBAL INITIATIVES ON CHANGE

International initiatives on climate change are extensive efforts to mitigate the effects of global warming and reduce the emission of greenhouse gases across the globe. The most significant initiatives are the setting up of the Intergovernmental Panel on Climate Change (IPCC) and the Paris Climate Agreement.

### a. Intergovernmental Panel on Climate Change (IPCC)

The Intergovernmental Panel on Climate Change was created by the United Nations Environment Programme and World Meteorological Organization in 1988. It is an organisation of governments that are members of the UN or WMO. Presently, there are 195 members. The main objective of the panel was to provide scientific and rational information to all the governments of the world so that they can develop climate policies.

The main activity of the panel is the preparation of reports which provides an important input into global climate change negotiations. IPCC prepares three types of reports namely assessment reports, synthesis report and methodology report.

The Assessment Reports provides the state of the scientific, technical and socio-economic knowledge and basis of climate change, its effects, predictive risks and ways for adaptation and mitigation.

Thousands of people across the globe voluntarily contribute to work with IPCC in the form of report preparation and review reports. IPCC is divided into three working groups -

Group I - Physical science basis of climate change

Group II - Climate change impact adaptation and vulnerability

Group III - Mitigation of climate change

The first IPCC report played a pivotal role in the formation of UNFCCC, an international treaty to reduce global warming and combat the effects of climate change. Presently, the panel is working on the sixth Assessment Report that constitutes the above mentioned first three working groups contribution and a synthesis report.

### b. Paris Climate Agreement

Global efforts have been initiated to reduce the emission of greenhouse gases into the atmosphere by signing the Paris Climate accord. The agreement was designed to replace the Kyoto Protocol. The United Nations Framework Convention on Climate Change(UNFCCC) adopted the Kyoto Protocol in 1997 but it came into effect in 2005. It was consented by 141 countries. The protocol restricted 35 industrialised nations to reduce their emission by the year 2012 to 5 percent less than the level prevalent in the year 1990.

The Paris agreement was adopted in 2015 but came into effect in 2016. It is a legally binding treaty in which industrialised economies work towards reducing GHGs emission and limit global warming to less than 2% compared to pre industrial level. In addition to that, the Paris Agreement insists that developed nations should provide financial and technological support to underdeveloped nations.

## INTEXT QUESTIONS 9.5

1. Fill in the Blanks with suitable words:

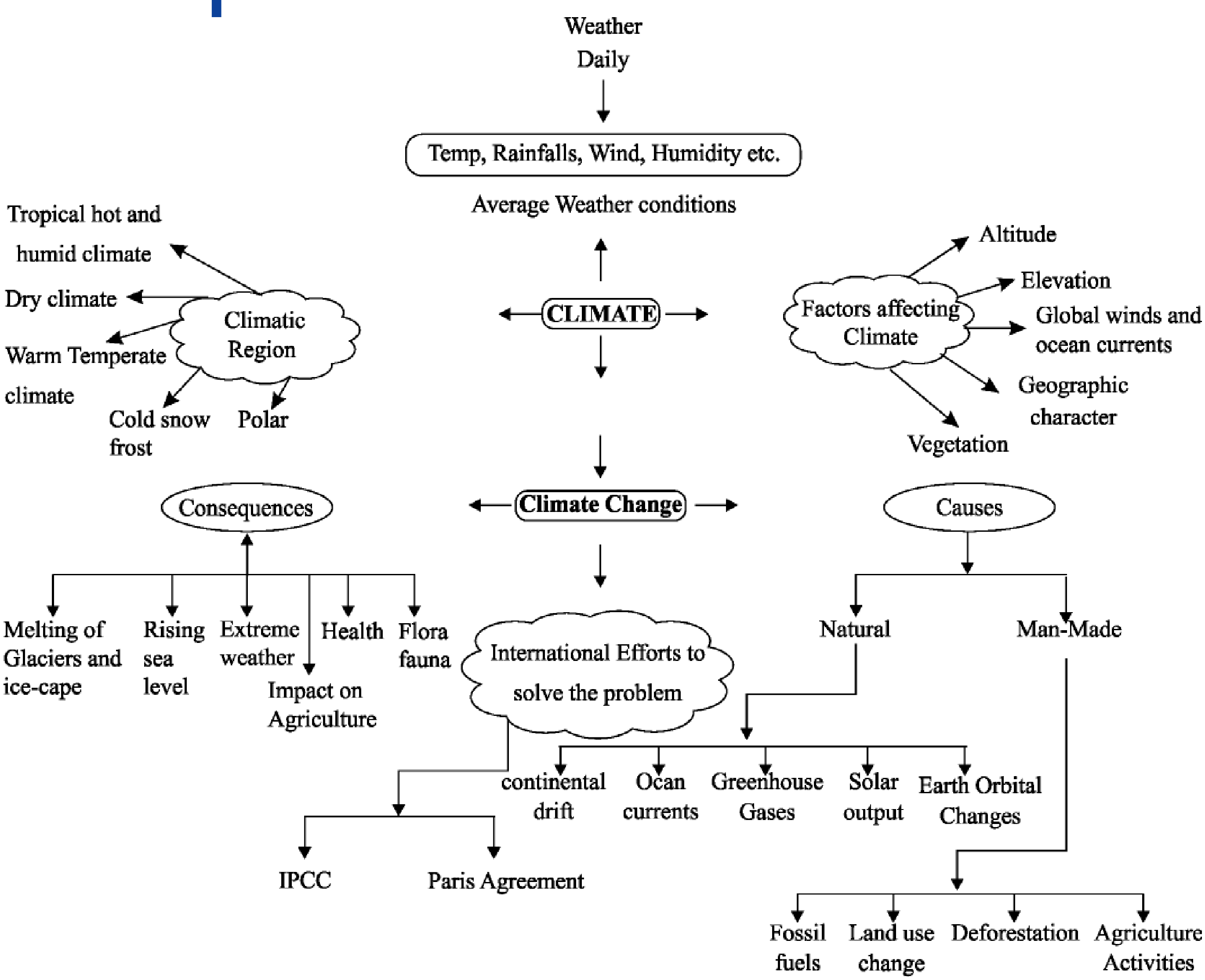
   (i) The main objective of……… to provide scientific and rational information to all the governments of the world so that they can develop climate policies.

(ii) The Intergovernmental Panel on Climate Change was created by the ………………….. and ………………………

(iii) The Paris agreement designed to replace ……………..

(iv) The ……………agreement limits global warming to less than 2% compared to pre industrial level.

## WHAT YOU HAVE LEARNT




## TERMINAL QUESTIONS

1. Differentiate between weather and climate.
2. Discuss the climate regions of the world.
3. What are the factors that affect the climate of a region?

4. Define global warming. Why is the issue important?
5. What is Climate Change?
6. What is the significance of the Paris Agreement?
7. Define the term Greenhouse. Make a list of greenhouse gases.
8. Elaborate the factors that are propelling climate change?
9. Describe the major effects of climate change?
10. Explain the important global initiatives taken to combat climate change?

## ANSWERS TO INTEXT QUESTIONS

**9.1**

| | | | | |
|---|---|---|---|---|
| (i) F | (ii) F | (iii) T | (iv) F | (v) T |

**9.2**

| | | | | |
|---|---|---|---|---|
| (i) c | (ii) b | (iii) c | (iv) c | (v) a |

**9.3**

(i) Geological records, historical records

(ii) Global warming

(iii) global

(iv) greenhouse effect

**9.4**

| | | | | |
|---|---|---|---|---|
| (i) d | (ii) a | (iii) e | (iv) b | (v) c |

**9.5**

(i) IPCC (ii) UNEP and WMO (iii) Kyoto Protocol

(iv) Paris agreement (v) 2016

## PROJECT WORK/ACTIVITY

1. Try to find out how you can protect an endangered species in your area.
2. Prepare a report on the initiatives taken to combat climate change in your area.

# MODULE -5

**Biogeography and Biodiversity**

# 10

# BIOSPHERE, BIOMES AND BIODIVERSITY

You might be aware about different realms of the earth that are the lithosphere, the atmosphere and the hydrosphere. Life in all forms exists in all these three realms. Thus, the zone where life exists is known as the biosphere. You are also aware that our earth is the only planet in the solar system where life exists. This lesson will enable you to comprehend basic concepts of Biosphere and Biomes and their characteristics. There are several Biosphere reserves found in India. You will be able to locate them on the map of India. Moreover, this lesson will help you to sensitise others for protection of the environment and take necessary steps for its conservation.

## OUTCOMES

After studying the lesson, learner:

- describes the term i.e Biosphere, Biodiversity and Biome;
- classifies different types of Biomes of the world;
- explains characteristics of different types of Biomes;
- locates biomes on the world map;
- illustrates various causes and consequences of loss of biodiversity and
- justifies the initiatives taken for conservation of biodiversity from local to global.

## 10.1 BIOSPHERE

You might have observed in your surroundings that different types of organisms or creatures are found on the land, water and air. Some animals or plants may be available everywhere while some may be found in any specific area.

All these enquire about an area where land, water and air are available is called a biosphere. It can be defined as "The narrow zone of contact between land, water and air, where life exists, is called Biosphere."

All the living creatures on the earth including plants, animals and humans are linked to each other as well as interact with other environmental realms i.e. lithosphere (land), hydrosphere (water) and atmosphere (air). Moreover, there are also many organisms that move from one realm to the other to survive.

Can you give any examples of organisms that live on land and water both? You might have read that the environment of the earth is made up of abiotic and biotic components.

**a. Abiotic component**

For the survival of living organisms various elements such as sunlight, water, minerals, and different gases are required. These elements do not have life but are essential for the living beings. They are called Abiotic components.

**b. Biotic component**

The biotic components may broadly be divided into the plants and the animals. All living beings whether plants or animals from micro to macro levels are called Biotic components.

**ACTIVITY**

Make a list of such organisms that live on land, water and air.

## 10.2 ECOSYSTEM

An ecosystem is a system in which plants and animals are linked to their environment through a series of links. For example, the ecosystem of small water bodies i.e. ponds or lakes. A lake or pond may be a water body of stagnant water. Generally such a lake receives water from rainfall or from any streams. The water from the lake evaporates due to solar energy. Due to direct sunlight the upper layers of the water body get warmer and there is a vertical difference in water temperatures. Thus the physical process is responsible for change in temperature in water, water flow, deposition of sediments in the bottom, etc. At the same time biological processes are also going on in the water body. The biological processes are more complex in which biotic organisms provide food to small larvae which are consumed by small fish. These small fish are eaten by larger fish, which provide food for other animals including humans. When the biotic organisms like plants and animals die and decay, they release chemicals back into the water body.

## INTEXT QUESTIONS 10.1

**Fill in the blanks:**

1. The Banyan tree is ……..component of the environment.
2. Temperature of water changes due to ……. Process.
3. Biosphere includes ……. and …….. component.
4. All creatures of the environment including animals and plants are ……… with each other.

## 10.3 FOOD CHAIN IN THE ECOSYSTEM

You know that all living beings whether micro organisms like insects or macro level such as tigers, elephants or humans get their food from plants, either directly or indirectly. Now you are aware about the lake ecosystem where a simple food chain is stretching from the millions of microscopic plants on a lake surface to humans as fishermen. There are different levels in a food chain. It can be understood through a pyramid diagram. In the pyramid each level is termed as a Trophic level. Trophic word originates from the Greek word trophies, which means food. The base level (T1) of the pyramid is composed of natural vegetation. The second level (T2 ) consists of herbivorous animals that feed on the plants; the third level of pyramid (T3) is composed of carnivorous animals that depend on herbivorous animals; carnivorous animals such as humans that consume other carnivorous animals and all others which are found in lower levels are on the fourth level (T4) of the pyramid. Decomposers are found on the fifth level, which break down the dead tissues of organisms at all the other levels of the food chain.

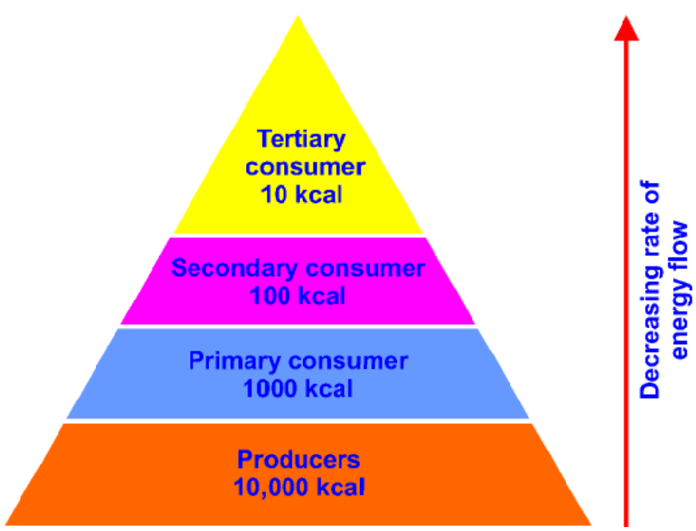



Fig. 10.1 Food Pyramid

**Ecosystems can be of two types:**

I. Terrestrial Ecosystem

II. Aquatic Ecosystem

## I. Terrestrial Ecosystem

Terrestrial ecosystem covers about 29% of the land area on the earth surface. The major source of food and raw materials are found in this ecosystem because a variety of flora and fauna are available here for humans. The terrestrial ecosystems are further subdivided into various sub-types. Major sub types are (i) upland or mountain ecosystem (ii) low land ecosystem and (iii) desert ecosystem. You will be surprised to know that the maximum life forms are found in lowlands on the earth and this diversity decreases with increasing altitude since the level of oxygen and atmospheric pressure decreases with increase in height.

## II. Aquatic Ecosystem

Aquatic ecosystem includes various forms of water available on the earth surface which covers about 71% of the entire earth. Aquatic ecosystems can further be divided as (i) fresh water, (ii) estuarine (iii) marine. In terms of size or extent it may range from open sea, lake, pond, etc. The biodiversity in aquatic ecosystems depends on the depth up to which sunlight can penetrate and the availability of nutrients and the concentration of dissolved oxygen. Keeping all these factors in view, estuarine ecosystems are found the most productive of aquatic eco-systems. On the ocean surface, shallow continental shelves are more productive than other configurations of ocean floor and open oceans. Open oceans are the least productive of all aquatic ecosystems. They are like the deserts in the terrestrial ecosystem. Some of the organisms exclusively live in water whereas some of the organisms can live in water and on land i.e. frogs, crocodiles, hippopotamus, etc. Moreover, some organisms live only in either fresh water or saline water and some others live in fresh and saline water both.

## INTEXT QUESTIONS 10.2

**Marks ( ✓) for True or ( ✗) for False:**

1. Humans are found on the base level of the pyramid depicting the food chain.
2. Herbivore animals feed on plants.
3. Carnivorous animals feed on plants.
4. Decomposers break down dead tissues of organisms.

**ACTIVITY**

Explore which organisms are found only in fresh waters.

## 10.4 BIOMES

A biome is a plant and animal community which comes under a terrestrial ecosystem that covers a large geographical area. The boundaries of different biomes on land are determined mainly by climate and types of vegetation. Therefore a biome can be defined as the total assemblage of plant and animal species interacting within specific geographical conditions. These conditions include specifically rainfall, temperature, humidity and soil conditions. Some of the major biomes of the world are: forest, grassland, desert and tundra biomes

Biome can be subdivided on the following basis:

1. On the basis of climatic conditions, primarily temperature and humidity: there are four major types of biomes:
   (i) Forest biome
   (ii) Savanna biome
   (iii) Grassland biome
   (iv) Desert biome

Table 10.1 - Biomes of the World

| **Biomes** | **Sub types** | **Regions** | **Flora and Fauna** |
|---|---|---|---|
| Forest | A. Tropical<br>1. Equatorial<br>2. Deciduous<br>B. Temperate<br>C. Boreal | A1-10°N-S<br>A2-10°-25°N-S<br>B- Eastern North America, N.E. Asia, Western and Central Europe<br>C- Broad belt of Eurasia and North America, parts of Siberia, Alaska, Canada and Scandinavia | A1-Multi-layered canopy, tall and large trees<br>A2-Less dense, trees of medium height; many varieties co-exist, insects, bats, birds and mammals<br>B. Moderately dense broadleaf trees, less diversity of plant species, Oak, birch, maple etc. are common |

| | | | |
|---|---|---|---|
| | | | trees. Squirrels, rabbits, black bears, mountain lions, etc. are common animals.<br>C. Evergreen conifers like pine, firand spruce etc. Woodpeckers, hawks, bears, wolves, deer, hares and bats are common animals. |
| Desert | A. Hot and Dry<br>B. Semi -Arid<br>C. Coastal<br>D. Cold | A. Sahara, Kalahari, Thar, Rub-al-e-Khali<br>B. Marginal areas of hot deserts<br>C. Atacama<br>D. Tundra climatic regions | A-C- Scanty vegetation; few large mammals, insects, reptiles and birds<br>D-Rabbits, rats, antelopes, and ground squirrels |
| Grassland | A. Tropical Savannah<br>B. Temperate Steppe | A. Large areas of Africa, Australia, South America , and India<br>B. Parts of Eurasia and North America | A. Grasses: trees and large shrubs absent; giraffes, zebras, buffaloes, leopards, hyena, elephants, mice, moles, snakes, worms, etc. are common animals<br>B. Grasses; occasional trees such as cottonwoods, oaks and willows, gazelles, zebras, rhinoceros, wild horses, lions, varieties of birds, worms, snakes etc. are common animals |
| Aquatic | A- Freshwater<br>B- Marine | A- Lake, river, streams and wetlands<br>B- Oceans, coral reefs, lagoons and estuaries | Algal and other aquatic and marine plant communities with varieties of water dwelling animals |

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| | | |
|---|---|---|
| Altitudinal | Slopes of high mountain ranges like the Himalayas, the Alps etc. | Deciduous to tundra vegetation varying according to altitude |

2. On the basis of climate and vegetation-

For detaied study these biomes have been identified:

(i) The Evergreen Rainforest Biome

(ii) The Temperate Grassland Biome

(iii) The Arctic Tundra Biomes

## i. The Evergreen Rainforest Biome

The evergreen rainforest biome is found in the equatorial zone extending 10º North and South latitudes from the equator. These evergreen forests are found in the equatorial belt including areas of Amazon lowland of South America, Congo basin of Africa and islands of South East Asia. As you are aware the sun rays fall directly on the equator throughout the year therefore the area experiences high temperature .This area also gets heavy rainfall throughout the year ranging between 150 cm - 250 cm. Every day in the afternoon heavy rainfall (convectional rainfall) occurs in this region. You might have read about convectional rainfall in the lessons on climate. In equatorial areas high temperature and rainfall are helpful for the growth of a variety of natural vegetation and wildlife.

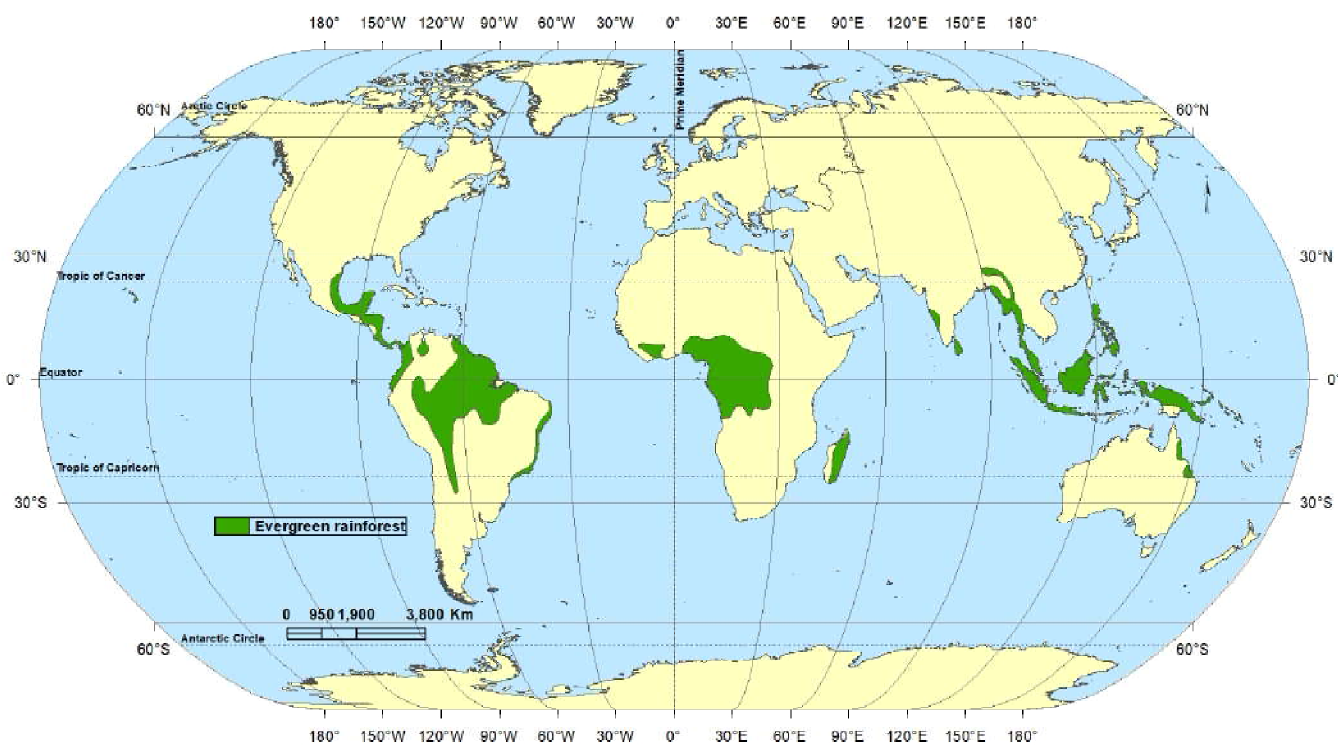


Fig. 10.2 The Evergreen Rain forest Biome

Trees of evergreen forests have generally buttressed trunks and shallow roots. There are three levels of evergreen rainforests,

i. The canopy or upper level where height of trees are about 20 metres to 60 metres. These are hardwood trees for example ebony, rose wood, sandalwood, cinchona, mahogany, etc.

ii. The intermediary level or second level where the height of trees is about 10 metres to 20 metres. Palm is an important species of this level. Besides that other parasitic plants are also found in this layer

iii. The lower level or third level where height of vegetation is about 10 metres from the surface. In this level a variety of plants such as ferns, mosses, orchids, etc. are found. Because of tall and broad leaf dense plants here sunlight does not reach the ground. Therefore the surface layer is always wet and muddy. Evergreen rainforest is inhabited by numerous wildlife species like elephants, lemur, birds, reptiles, insects, etc. The water bodies of the equatorial areas are also rich in animal life with alligators, fishes, frogs, Hippopotamus etc. Because of the impenetrability and high vegetation growth in the lower part, most of the insects, birds and animals reside on the branches of the trees. Generally, they do not come down to the ground. The productivity of the tropical rainforest biome is the highest of all biome types of the world. It may be pointed out that the rainforest biome represents only 13 percent of the total geographical area of the world but this biome accounts for 40 percent of the total productivity of the world.

For the last several decades people from other areas have encroached this area and started exploiting natural resources in the name of various developmental activities. These rainforests contain about 40% of all known species of plants and animals of the world. Deforestation of rainforest is just not ecological but also has very adverse environmental consequences. These evergreen forests are known for carbon sinks which help to reduce the impact of global warming on the earth.

### ii. Temperate Grassland Biome

Temperate grasslands located in temperate zones, by the northern hemisphere i.e. Eurasia and North America have continental types of climate. Whereas grasslands in the southern hemisphere are located along the coastal areas of Australia and South America. Since these areas are located in the rain shadow areas of the high mountains, therefore receive scanty rainfall. These grasslands are called by different names in all these areas. For example in Eurasia, the grasslands are called the Steppes which extend towards east from the coasts of the Black sea to the plains of Manchuria in China. In North America, the grasslands lie between Rockies mountains and Great Lakes are called Prairies. In

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South America these grasslands are known as Pampas in Argentina and Uruguay. In Africa these grasslands are found in South Africa and called Veldt. The same temperate grasslands of Australia are called Downs and are located in the Murrary - Darling river basins.

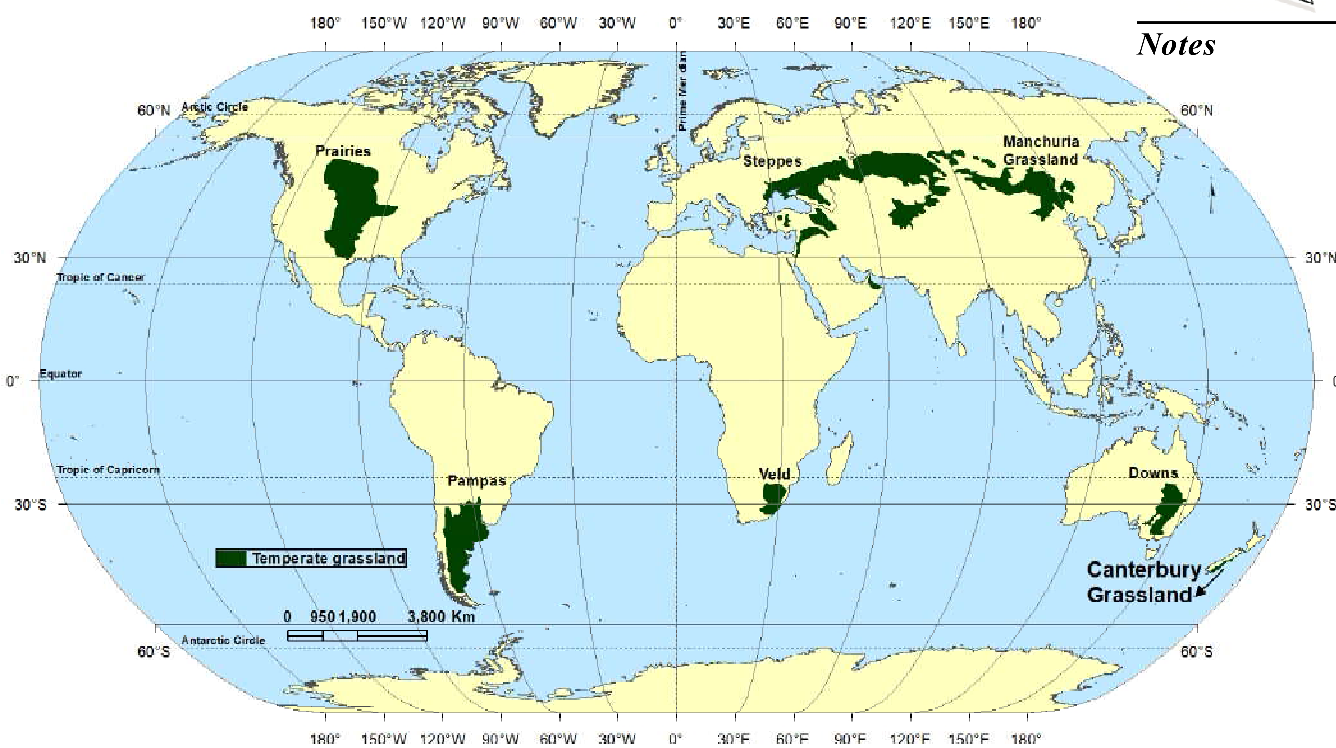


Fig. 10.3 Temperate Grassland Biome

**ACTIVITY**

Locate areas lying in the Temperate Zone on the outline map of the world.

As you are aware that regions that lie in temperate climates receive very less precipitation. The amount of precipitation is not sufficient for the growth of trees but is suitable for grass, therefore in this region extensive grasslands are found. In Eurasia Steppes grasslands are known for short and nutritious grass. These grasslands are known for different types of animals like antelopes, horses, wolves, kangaroos, emu, wild asses, wild dogs, etc.

These Areas are extensively affected by human interventions. Due to human intervention these temperate grasslands have been converted into agricultural fields and are known as 'granaries of the world'. Temperate grasslands are suitable for production of wheat. Another major activity in these grasslands is pastoralism or domestication of animals.

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### iii. Tundra Biome

Tundra biome is located in the northern parts of North America including Alaska, northern most areas of Canada, Greenland and the Arctic regions of Russia. This is a cold desert area where summers are very short and cool.

Natural vegetation includes grasses, mosses, lichens, etc. The animal species include resident and migrant animals. Resident animals are those which can adjust to the changing climatic conditions. Whereas migratory animals are those which start migrating to the warmer places in the very beginning of winter for example several birds such as water fowl, ducks, swans, geese etc. Some other animals of this region are reindeer, wolves, foxes, musk-ox, aortic hare, seal, etc. Productivity in tundra biomes is very low since this region receives very less amount of solar energy and most of the surface in the region is frozen throughout the year. Soils are also not developed and suitable for plants. In such circumstances the crop growing season is also very short.

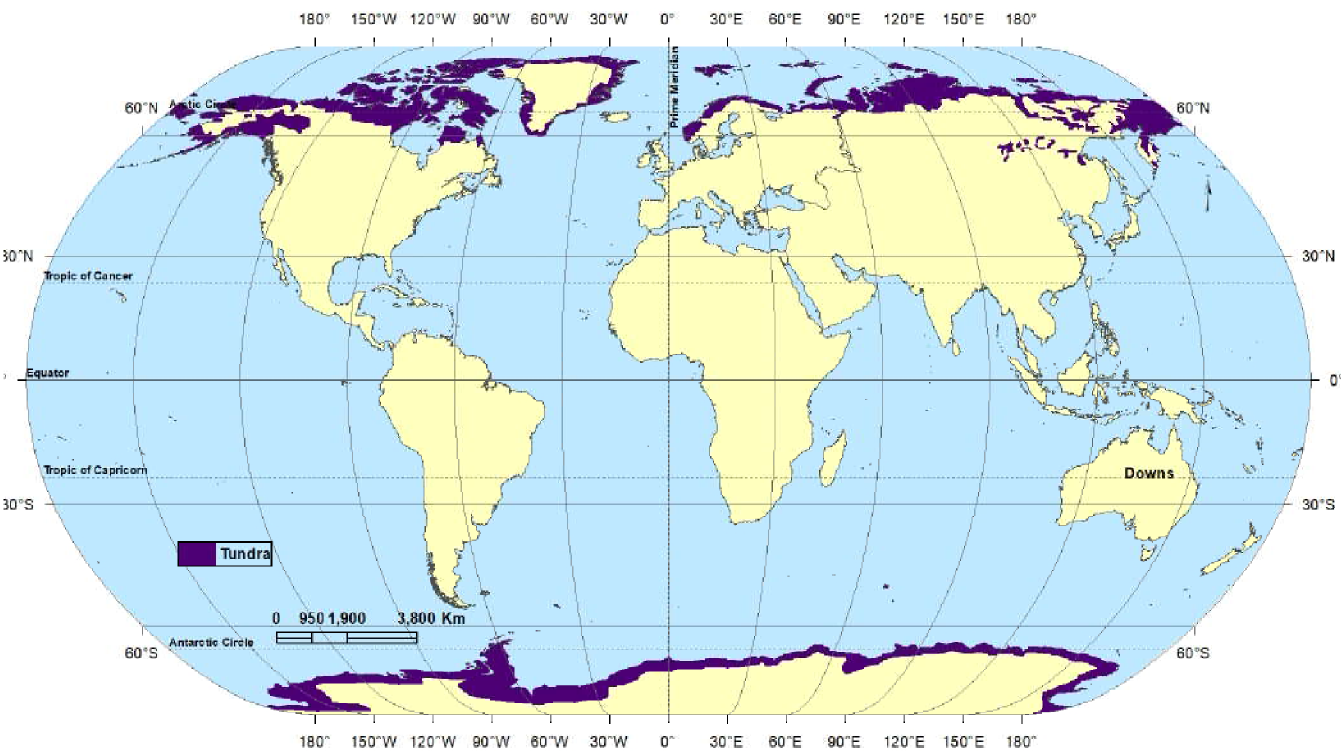



Fig. 10.4 Tundra Biome

Due to very harsh climatic conditions, the population here is very low. Some tribes such as Samoyeds, Lapps, Finns and Yakuts, Eskimos live in tundra regions of Eurasia, Canada and Alaska respectively. By introducing developmental work and modern technologies a lot of efforts are being done to bring these tribes into the mainstream.

## INTEXT QUESTIONS 10.3

1. Explain the meaning of Biomes.

2. Name any two region where desert types of biomes are found.

### ACTIVITY

Collect visuals of animals found in different Biomes and prepare a chart.

## 10.4 BIODIVERSITY AND ITS IMPORTANCE

The term Biodiversity originated from two words, Bio (life) and diversity (variety). Biodiversity may be defined as a specified geographical area where a variety of organisms including flora and fauna are found. It encompasses terrestrial and aquatic ecosystems formed by the varieties of plants, animals, and micro-organisms, including the genes these organisms contain. Biodiversity is related to the variability within the species and between the species and that within and between the ecosystems. As you are aware that biodiversity on the earth is very precious for all including living or non-living things. Actually biodiversity is a result of millions of years of evolutionary history of different species on the earth.

The impact of biodiversity on humans and humans on biodiversity is visible at all places of the earth. Biodiversity has contributed in various ways to the development of human cultures in all geographical regions of the world as well as Human societies in all parts of the globe have also played an important role in shaping the diversity of nature at different levels.

### DO YOU KNOW?

Every year on 22 May is celebrated as International Biodiversity Day.

In an ecosystem each and every organism extracts its needs from others and also contributes something useful to other organisms. If an ecosystem is more diverse then there are more chances for species to survive through adversities and attacks and as a result the whole ecosystem becomes more productive. Therefore the loss of species in any ecosystem will decrease the capability of the ecosystem to maintain itself. Hence, the variety of species in an ecosystem makes it more stable.

Biodiversity is an important resource for all human beings in their daily life. In terrestrial ecosystems an important part of agro-biodiversity is 'crop diversity'. Apart from that other economic commodities such as food crops, livestock, forestry, fish, medical resources, etc. are also provided by the natural biodiversity to humans.

**ACTIVITY**

Enlist the commodities provided by nature to humans.

Biodiversity enables us to understand how life functions and the role of each and every species in sustaining the ecosystems of which humans are also a species. That is why biodiversity is necessary to sustain life on the earth and it is the responsibility of humans to consider that each and every species along with us have a basic right to exist on the earth. If the level of biodiversity is high that means the state of our relationships with other living species in the ecosystem is good.

### Loss of Biodiversity

Fast growth of population and subsequently increasing demands of resources have accelerated the rate of consumption of natural resources tremendously in the world over. It has also increased the loss of different species and their habitations in all parts of the world. The impact of the growing population may be seen in tropical regions which occupy only about one -fourth of the total area of the world and contain about three fourth of the world population. In these areas over exploitation of the natural resources and deforestation to fulfil the needs of a large population have become a great cause of concern. The tropical rain forests contain about fifty per cent of the different species on the earth therefore destruction of natural habitats of wild flora and fauna in these forests have proved disastrous for the biosphere of the entire world.

Natural calamities such as earthquakes, floods, volcanic eruptions, forest fires, droughts, etc. cause damage to the flora and fauna of the earth. Pesticides such as hydrocarbons and toxic heavy metals and other pollutants destroy the weak and sensitive species. Species which are not the natural habitants of the local habitat but are introduced in the systems, are called "exotic species". There are many examples when a natural biotic community of the eco systems suffered extensive damage because of the introduction of exotic species.

**DO YOU KNOW?**

Chir is an exotic species which was planted in the Himalayan areas during colonial time in India.

## Conservation of Biodiversity

Biodiversity is important for human existence. All forms of life are so closely interlinked that disturbance in one gives rise to imbalance to the others. If species of plants and animals become endangered they cause degradation in the environment, which may threaten human beings' own existence.

There is an urgent need to educate people to adopt environment-friendly practices and reorient their activities in such a way that our development is harmonious with other life forms and is sustainable. There is an increasing consciousness of the fact that such conservation with sustainable use is possible only with the involvement and cooperation of local communities and individuals.

**DO YOU KNOW?**

Every year World Sparrow Day is celebrated on 20th March. This is the most common bird species in urban areas in India. Sparrows are generally found in groups and feed on grains. Now numbers of these house sparrows are declining due to various reasons.

Can you find out the reasons?

**ACTIVITY**

**The Bishnois** community living in north India is known for conservation of natural vegetation and wildlife in India. There are several other communities in India who depend on forests for their livelihood. Collect information about them.

There is a need to develop local level institutions like Van Panchayat for forest management and to promote practices for conservation of species and their habitats. Such institutions are very active in some states like Uttarakh and. Moreover, school students can also take initiatives by organising local level events for sensitising and motivating local communities in the process of forest and wildlife conservation and management.

The government of India along with other nations have signed the Convention of Biodiversity at the Earth Summit held at Rio -de-Janeiro, Brazil in June 1992.The Convention of biological diversity covers biodiversity at all levels including ecosystems, species and genetic resources.

In India several national parks and sanctuaries have been established to protect, preserve and propagate the variety of wildlife species within natural boundaries.

**ACTIVITY**

Prepare a list of national parks and show them on the map of India.

Countries which are situated in the tropical region possess a large number of the world's species diversity. There are some countries namely, Mexico, Columbia, Ecuador, Peru, Brazil, Zaire, Madagascar, China, India, Malaysia, Indonesia and Australia in which mega biodiversity places are located. In order to concentrate resources on those areas that are most vulnerable, the International Union for Conservation of Nature and Natural Resources(IUCN) has identified certain areas as biodiversity hotspots As you are aware that different types of vegetation are very significant since these determine the primary productivity of any ecosystem. Hence, hotspots are defined according to different vegetation species found in the area.

**ACTIVITY**

Locate countries situated in tropical regions known for rich biodiversity. Identify Biodiversity Hotspot on the map of India.

## INTEXT QUESTIONS 10.4

1. Name any 3 countries which has mega Biodiversity hotspots.
2. In which year India has signed the convention of biodiversity.

## WHAT YOU HAVE LEARNT

- Biosphese
  - Biotic Component
  - Abiotic Component
  - Ecosystem
    - Terrestrial
    - Aquatic
    - Food chain
  - Biomes
    - On the basis of climatic condition
    - On the basis of climate & vegetation
  - Biodiversity & its importance
    - Loss of Biodiversity
    - Conservation of Biodiversity

## TERMINAL QUESTIONS

1. What is a biome? Explain types of biomes.
2. Explain the characteristics of the evergreen rainforest biome.
3. Distinguish between Tundra and Temperate biomes.
4. What is the importance of Biodiversity?
5. What efforts should be done to conserve Biodiversity?

## ANSWERS TO INTEXT QUESTIONS

**10.1**

1. Biotic
2. Physical
3. Biotic, Abiotic
4. linked

**10.2**

1. False
2. True
3. False
4. True

**10.3**

1. A biome is plant and animal community which comes under a terrestrial ecosystem that covers a large geographical area.
2. Sahara, Valahar, Thar, etc. (any 2)

**10.4**

1. Mexico, Peru, India, China, Indonasia etc (any 2)
2. 1992

# MODULE -6

## Physical Geography of India

11

# PHYSICAL SETTINGS

India or Bharat, our nation, is an ancient country. It is surrounded on three sides by the sea, with a high mountain range separating it from the rest of Asia. As a result, the Indian subcontinent has emerged as a separate entity. India is the world's seventh-largest country by area. It is a vast country with a wide range of physical characteristics. As a result, it is essential to have some understanding of its basic physical settings. You may become familiar with its significant features such as the location of India in terms of neighbouring countries, major physiographic divisions and their salient features, the drainage system, and unity in diversity in India.

## OUTCOMES

After studying this lesson, learner:

- locates India in terms of neighbouring countries;
- describes major physiographic divisions of India and their salient features;
- describes the drainage system and
- explains unity in diversity in India.

## 11.1 LOCATION OF INDIA AND ITS NEIGHBOURING COUNTRIES

A vast landmass of South Asia is flanked by new fold towering mountains on the northwest, north, and northeast. The Arabian Sea lies to its south west, the Bay of Bengal to its south east, and the Indian Ocean to its south. This well-defined South Asian landmass is called the Indian subcontinent. This sub-continent consists of the countries of India, Pakistan, Bangladesh, Nepal, and Bhutan, including Sri Lanka, an island narrowly separated by the Palk Strait. India alone covers about three-fourths of the area of this sub-continent and has a common frontier with each one of them. Our country and five neighbours form an identifiable geographical unit with certain common cultural parameters. Since old times, the country has been known by various names such as Jambudvipa, Aryavarta, Hindustan, and Bharat, and presently it is called India. The Indian Ocean, or Hind Mahasagar, has also been named after India - the only country is to be named. According to the Constitution of India, the country is known as Bharat or India.

India lies wholly in the northeastern hemisphere. The Indian mainland extends between 8°4'N to 37°6' N latitudes and from 68°7' E to 97°25' E longitudes. Thus, the latitudinal and longitudinal extent of India is about 29 degrees. It measures about 3,214 km from north to south and 2,933 km from east to west. The southern most point of mainland India is Kanyakumari in Tamilnadu. However, the country's southernmost point lies further south in Andaman and Nicobar Islands. It is now called Indira Point. It is situated at 6°45'N latitude. The western most point of India is Ghuar Moti, which lies in the Kutch district, Gujarat, and the easternmost point is Kibithu, which lies in Arunachal Pradesh.

Let us see the impact of such a large latitudinal extent on the lives of the people of India. The northern parts of the country are quite far off from the equator. Therefore, the rays of the sun strike those parts more obliquely. Consequently, this part of the country receives less insolation and has a cold climate, unlike the southern regions. Secondly, the difference between the length of day and night in the southernmost part of India is much less, only about 45 minutes, as they are situated near the equator. This difference between day and night in the northern parts of India steadily goes on increasing till it becomes as much as 5 hours.

The Tropic of Cancer passes almost halfway through the country from eight states i.e. Gujarat, Rajasthan, Madhya Pradesh, Chattisgarh, Jharkhand, West Bengal, Tripura, and Mizoram. Thus half of the country to the south of the Tropic of Cancer is situated in the Tropical or Torrid zone, and the other half lying north of the Tropic of Cancer falls in the Sub-tropical zone.

The earth takes 24 hours to complete one rotation on its axis. The Sun rises first in the east and then in the west because the earth rotates from west to east. The earth's longitudinal expanse of 360° is thus covered in 24 hours at the pace of 15° per hour. As the longitudinal extent of India is nearly 29°, the real-time difference in India between its eastern and western extremities is roughly two hours. While at the eastern extremity of India, the day may have just broken out, the extremity of the west would take nearly another two full hours to do so.

To iron out this big chunk of the time difference, India, like all other countries of the world, follows the local time of its relatively central meridian as the standard time for the whole country. Each country chooses its standard meridian in a multiple of 7°30' for convenience. Accordingly, the standard meridian of India has been selected to be 82°30' E.

Notes


Fig. 11.1: India: Longitude and Latitude Extents

The north-central part of India is broad, while the southern part tapers down towards the Indian Ocean in the south. Thus, the northern part of the Indian Ocean has been divided into two by the sheer presence of the Indian Peninsula. The western part of the north Indian Ocean is called the Arabian Sea, while the eastern part is called the Bay of Bengal. The total length of the coastline of India, including the island groups, is about 7,516.6 km. The Palk Strait separates the Indian mainland from Sri Lanka.

India accounts for 2.42 percent of the world's total land area, whereas it sustains about 17 percent of the world's population. The land frontiers of India measure 15,200 km. Pakistan, Afghanistan, China, Nepal, Bhutan, Myanmar, and Bangladesh share common boundaries with India. The kingdom of Bhutan is situated in the Eastern Himalayas. Most of our boundary with Pakistan and Bangladesh is almost manufactured. There is no mountain range or river to form a natural boundary. The international border of India passes through various landforms - barren desert lands, lush green agricultural fields, gushing rivers, snow-clad mountains, and densely forested mountain ranges.

## INTEXT QUESTIONS 11.1

1. Fill in the blanks:

   i. The Indian mainland extends between ............ to .......north latitude.

   ii. The southern most point of India is called .............

   iii. 82°30' E longitude is called ......... meridian of India.

   iv. The land frontiers of India measure ..............kms.

2. Answer the following questions in one word or a sentence.

   i. By which parallel of latitude is India divided into tropical and temperate belts?

   ii. How much is the real time difference between its eastern and western extremities?

   iii. Name the southernmost point of India republic.

## 11.2 PHYSIOGRAPHIC DIVISIONS OF INDIA AND THEIR SALIENT FEATURES

India is a land of physical diversities. Almost all types of dramatic and breathtaking landforms are found here. According to one estimate, 29.3 percent of the area of India is occupied by mountains and hills, 27.7 percent by plateaus, and 43 per cent by plains.

From a physiographic point of view, India can be divided into the following six regions:

A. The Northern Mountains

B. The Northern Plains

C. The Peninsular Plateau

D. The Indian Desert

E. The Coastal Plains

F. The Islands

Let us know more about these physiographic divisions.

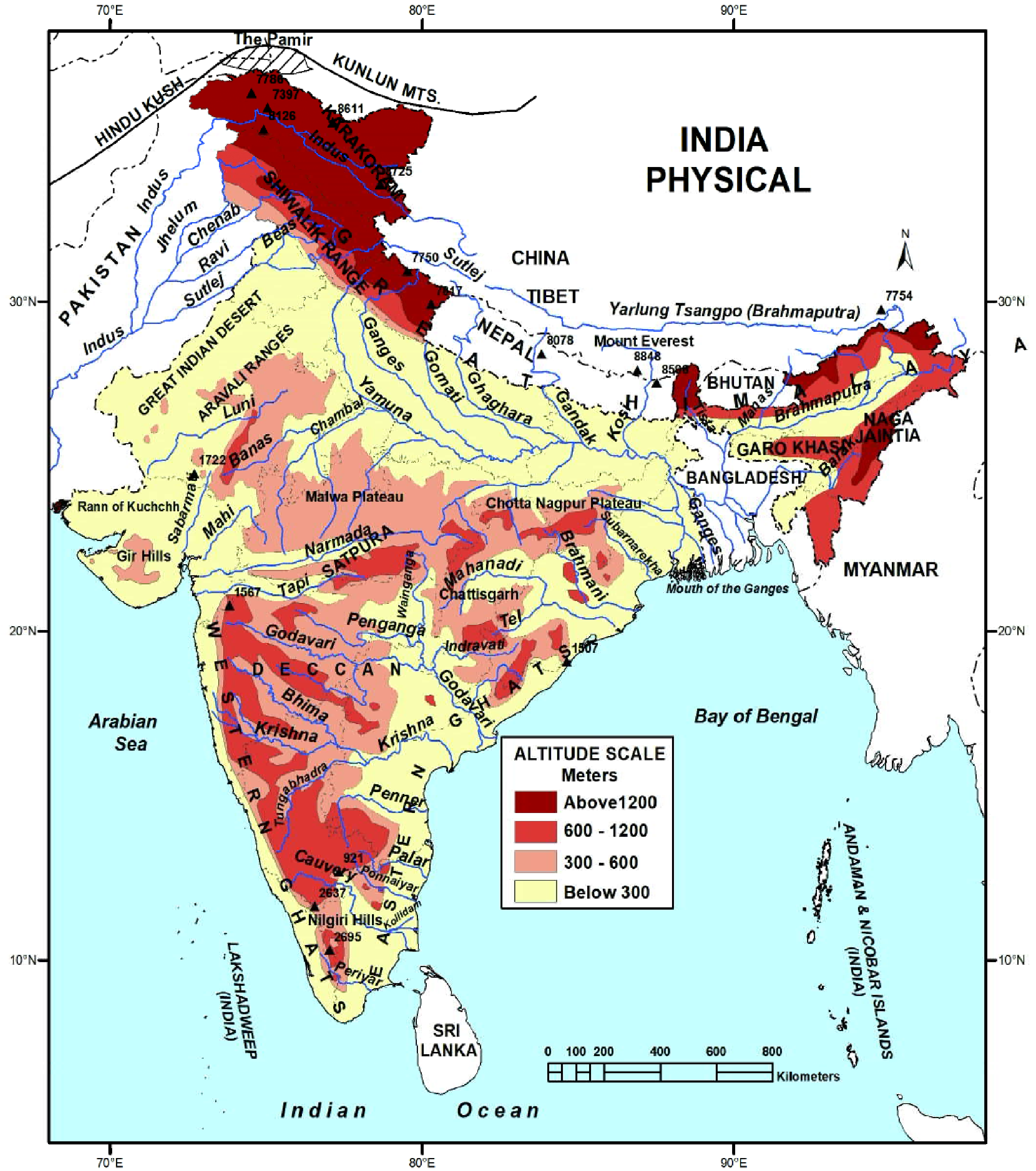



Fig. 11.2: Physiographic Divisions of India

## A. The Northern Mountains

They include the mountains and plateaus of northern Kashmir, the Himalayas and the hills of Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, and Meghalaya. They are divided into three groups. They are:

a. The Himalayas

b. The Trans-Himalayas

c. Purvanchal or the hills of the north-east

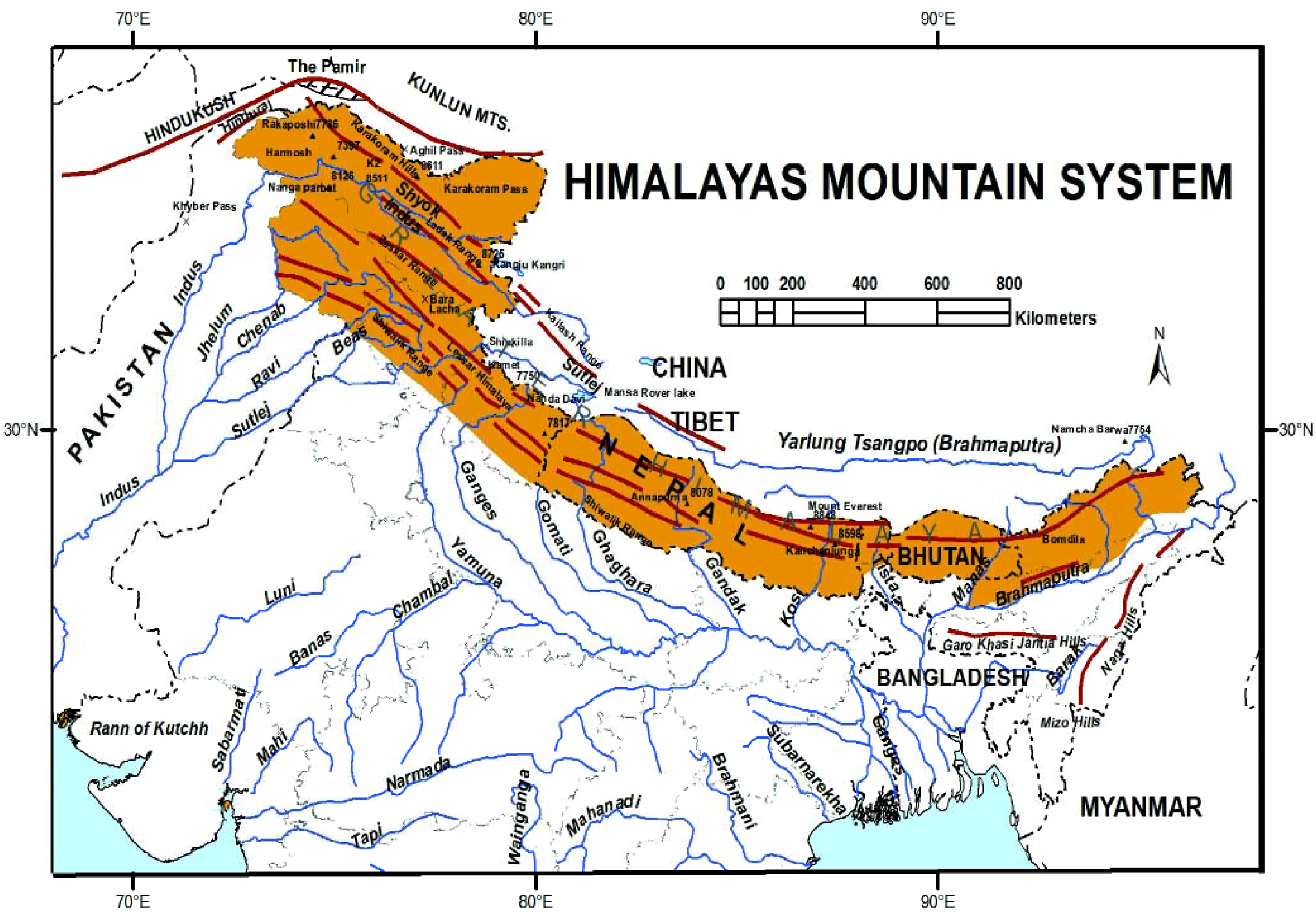



Fig. 11.3 Himalayas Mountain System

### a. The Himalayas

It is the highest mountain range in the world. It extends in the shape of an arc for a distance of about 2500 km from west to east along the northern boundary of India. It is spread between the Indus gorge in Ladakh in the west and Brahmaputra gorge in Arunachal Pradesh in the east. The breadth of the Himalayas ranges between 400 km in the west to 150 km in the east. The area covered by this mountain system is about 5 lakh square km. It has three major ranges. Deep valleys and plateaus separate these ranges. The southern slopes of the Himalayas facing India are steeper, and those facing the Tibetan side are generally gentler. In the east, the Himalayas rise almost abruptly from the plains of West Bengal and Assam. That is why two of the highest peaks of the Himalayas, Mt. Everest (in Nepal) and Kanchenjunga are not very far from the plains.

On the other hand, the western part of the Himalayas rises rather gradually from the plains. Hence, the higher peaks in this part are farther from the plains, and several ranges lie between the plains and the high mountain. The high peaks of this part, such as Nanga Parbat, Nanda Devi, and Badrinath, are very far from the plains.

Three parallel ranges can be identified in the Himalayas. These are:

i. Himadri

ii. Himachal and

iii. Siwalik

**i. Himadri (Greater Himalaya):** Himadri is the northern most and highest range of the Himalayas. It is the only Himalaya range that maintains its continuity from west to east. This range's core comprises granite rocks flanked by metamorphic and sedimentary rocks. The extent of this range is between the Nanga Parbat peak (8126 m.) in the west and the Namcha Barwa peak (7756 m.) in the east. The average height of this range from sea level is about 6100 metres. Over 100 peaks have a height of more than the average height of the range. The highest peak in the world, Mount Everest (8848 m), is situated in this range. Kanchenjunga, Makalu, Dhaulagiri, and Annapurna are some other peaks with a height of more than 8000 metres. Kanchenjunga is the highest peak of the Himalayas in India. The Himadri range is snow-clad throughout the year. There are many large and small glaciers. After the melting of snow and ice, their water falls in the rivers of northern India and make them perennial. Gangotri and Yamunotri are good examples of such glaciers. The Himadri range can be crossed through some passes like Zojila, Shipki La, Niti, Nathula, etc.

**ii. Himachal (Lesser or Middle Himalaya):** It is located southwards of Himadri. The breadth of the Himachal range is 60 to 80 km, and the height varies from 1000 metres to 4500 metres. Some of the peaks of this range have a height of more than 5000 metres. This range is highly dissected and uneven. Rocks in this zone have been metamorphosed due to violent thrusts and compression. Therefore, this range mainly consists of metamorphosed rocks. The gentle slopes of the eastern part of this range are covered with dense forests. The south-facing slopes of other parts of this range are steep and generally devoid of vegetation. The north-facing gentle slopes of this range are covered by dense vegetation. Pir Panjal in Jammu and Kashmir and Dhauladhar in Himachal Pradesh are the local names of this range. The beautiful valley of Kashmir extends between the Pir Panjal and Himadri ranges. The famous valleys of Kullu and Kangra are also a part of the Himachal ranges. Most hill towns or resort towns are located in the Himachal range. Shimla, Nainital, Mussouri, Almora, and Darjeeling are some famous hill towns. There are many beautiful lakes around Nainital.

iii. **Siwalik (Outer Himalaya):** The southern most range of the Himalayas is known as Siwalik. The Himadri and Himachal ranges were formed much before the Siwalik range. The rivers rising in the Himadri and Himachal ranges brought gravel, sand, and mud, deposited in the rapidly shrinking Tethys Sea. With time, the earth's movements caused the folding of these relatively fresh deposits of sediments, giving rise to the least close Siwalik range. The average height of the Siwalik range is very low, about 600 metres only. There are some broad valleys between the Himachal and the Siwalik ranges. These valleys are known as 'duns.' Dehradun valley is one of the best examples.

### b. The Trans-Himalayan Ranges

There are some mountain ranges north of Himadri in Jammu and Kashmir. The range extending to the north of the Himadri and running parallel to it is called the Zaskar range. North of the Zanskar range is the Ladakh range. The river Indus flows north west between Zaskar and Ladakh ranges. Many scholars treat Zaskar and Ladakh ranges as parts of the Great Himalayas and include them in Kashmir Himalayas. North of the Ladakh range lies the Karakoram. The name of the Karakoram in Sanskrit literature is Krishnagiri; K2 (8611m) is the highest peak of the Karakoram Mountains. It is the second-highest peak in the world, next only to Mt. Everest.

Ladakh plateau is situated in the UT of Ladakh. This plateau is very high and arid. It forms one of the remote areas of our country.

### c. Purvanchal

Purvanchal is the name given to all the hills of north east India beyond Brahmaputra gorge. The average height of these hills from sea level is 500 to 3000 metres. These hills are located in Southern Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, and Meghalaya. Mishmi, Patkai Bum, Naga, Manipur, Mizo (Lushai), and Tirupur are the major hilly ranges of this region. Meghalaya Plateau is also part of these hills of the north eastern region. This plateau includes the hills of Garo, Khasi, and Jaintia. However structurally, it is a part of Peninsular India.

Notes

## INTEXT QUESTIONS 11.2

1. Name the three parallel ranges of Himalayas.
2. Name the highest mountain peak of the world.
3. Fill in the blanks:
   i. The beautiful valley of Kashmir extends between …….. and ……..
   ii. Famous hill stations such as Shimla, Nainital, Mussouri etc. are located in ……. Range.
   iii. The river Indus flows between ……….. and …….. range.

## B. The Northern Plains

This plain extends from west to east, between the Himalayas in the north and Great Indian Plateau in the south. The plain extends from the arid and semi-arid areas of Rajasthan in the west to the Brahmaputra valley in the east. The area of this plain is more than 7 lakh square km. This plain is very fertile, and a very sizable part of the Indian population lives in numerous villages and big cities.

The northern plain comprises the soils brought down and deposited by the rivers flowing from the Himalayas in the North and the Great Indian plateau in the South. The rivers have deposited sediments in this plain for millions of years. Therefore, the alluvium in this plain is quite a few hundred metres deep. In some parts, the sediments' depth is as much as 2000 to 3000 metres.

This plain is almost dead flat. Its average height is 200 metres above the mean sea level; due to a very gentle slope towards the sea, the rivers in this plain flow leisurely and, sometimes, sluggishly. The slope from Varanasi upto the mouth of Ganga is only 10 cm. per km. The land around Ambala is a bit more elevated. However, it acts as a water divide between the two major river basins - the Satluj in the west and the Ganga in the east. Rivers lying eastwards of this water divide flow into the Bay of Bengal, while that west of it flows into the Arabian Sea.

The relatively higher part of the plain is called Bangar. This area is never covered with flood water from the rivers. Contrary to this, the comparatively lower area is called the khaddar. This area is flooded by streams almost every year. Khadar area is known as bet in Punjab.

Notes

There is a strip of plain about 10-15 km broad along the outer slopes of the Siwaliks in Punjab, Haryana, and Uttar Pradesh. This region is known as 'bhabar.' This strip of bhabar is made of gravel and coarse sand. The smaller streams disappear underground in the 'bhabar' region during summer, and their water surfaces again after crossing the bhabar. This water accumulates in the strip of plain about 15 to 30 km wide and extends to the south of bhabar. Accumulation of this water makes the land marshy. This marshy land is called the terai. Many parts of the terai have been reclaimed for agricultural purposes.

The great Northern Plain can be divided into four parts:

(i) Western plain,

(ii) North Central plain,

(iii) Eastern plain, and

(iv) Brahmaputra plain.

i. **Western Plain:** This region includes the Rajasthan desert and Bangar region lying to the west of the Aravalli ranges. The desert is partly rocky and partly sandy. Some geographers believed that in the ancient period, the perennial streams - Saraswati and Drishadvati - flowed through this region. This region includes the fertile area of Bikaner. River Luni flows through this Bangar region and falls into the Rann of Kutch. The famous saltwater lake of Sambhar is situated in this part of the plain.

ii. **North Central Plain:** This plain extends over Punjab, Haryana, and Uttar Pradesh. The part of this plain extending into Punjab and Haryana has been formed by the alluvium brought by rivers Satluj, Beas, and Ravi. It is a very fertile area. The part of this plain lying in Uttar Pradesh is made up of the deposits laid down by the rivers like Ganga, Yamuna, Ramganga, Gomati, Ghagra, and Gandak. This plain part is highly fertile and has been the cradle of Indian civilization and culture.

iii. **Eastern Plain:** This part of the great plains covers the middle and the lower Ganga valley lying in the states of Bihar and West Bengal. Ganga flows through the middle of this plain in Bihar. Ghagra, Kosi, and Gandak join Ganga from the north, while Son joins from the south. On entering West Bengal, the plain widens further, extending from the foothills of the Himalayas upto the Bay of Bengal. The southern part of the plain is the delta region. Ganga is divided into several distributaries in the delta region. Hooghly is the best example of a distributary of Ganga. This part of the plain is indeed very fertile and rainier.

iv. **Brahmaputra Plain:** The northeastern part of the Great Indian Plain extends into Assam. This plain was formed by the alluvium deposition brought down by river Brahmaputra and its tributaries. Brahmaputra is highly prone to devastating floods at regular intervals. After the floods, the river generally changes its course. This process has led to the formation of various islands in the river. Majuli (1250 square kilometres) in the Brahmaputra river is the world's largest river island. This part is also very fertile. It is surrounded by hills from three sides. Bangladesh is situated on this plain, and the delta is jointly formed by Ganga and Brahmaputra and their distributaries.

## INTEXT QUESTIONS 11.3

1. Distinguish between Khadar and Bangar.

2. Name the four parts of the great Indian plain.

3. Fill in the blanks:

    i. Marshy land is called ……..

    ii. Saltwater lake …………… is situated in the western plain.

    iii. Hoogly is the best example of distributaries of ………………..

    iv. World's longest river islands …………….. situated in Brahmaputra river.

## C. The Peninsular Plateau

The Peninsular plateau is a triangular-shaped landmass. It is part of an ancient land mass called the Gondwana land. It covers an area of nearly 5 lakh sq.km. It is spread over the states of Gujarat, Maharashtra, Bihar, Karnataka, Telangana and Andhra Pradesh. River Narmada divides the peninsular plateau into two parts: The central highlands and Deccan Plateau

a. **The Central Highlands:** It extends between the Narmada river and the northern plains. Aravallis is a mountain that rises from Gujrat through Rajasthan to Delhi. The highest peak of the Aravalli hills is Gurushikhar (1722m) near Mt. Abu. The Malwa Plateau and Chhota Nagpur plateau are parts of the central highlands. The paer of the central highlands which extends to the east of Malwa plateau is known as Bundelkhand and is further followed by Baghelkhand and ultimately to Chhota Nagpur plateau. Vindhyachal ranges form the southern range of Malwa plates. River Betwa, Chambal, and Ken are the important rivers of the Malwa plateau, while Mahadeo, Kaimur, and Maikal are the important hills of the Chhota Nagpur plateau. The valley of Narmada lies between the Vindhyas and the Satpura, which flows east in a rift valley to west and joins the Arabian sea.

**b. The Deccan Plateau:** The Deccan plateau is separated by a fault (A fracture in the rock along which rocks have been relatively replaced) from the Chhota Nagpur plateau. The black soil area in the Deccan plateau is known as the Deccan trap. It is formed due to volcanic eruptions. This soil is suitable for cotton & sugarcane cultivation. The Deccan plateau is broadly divided into (i) The Western Ghats and (ii) The Eastern Ghats.

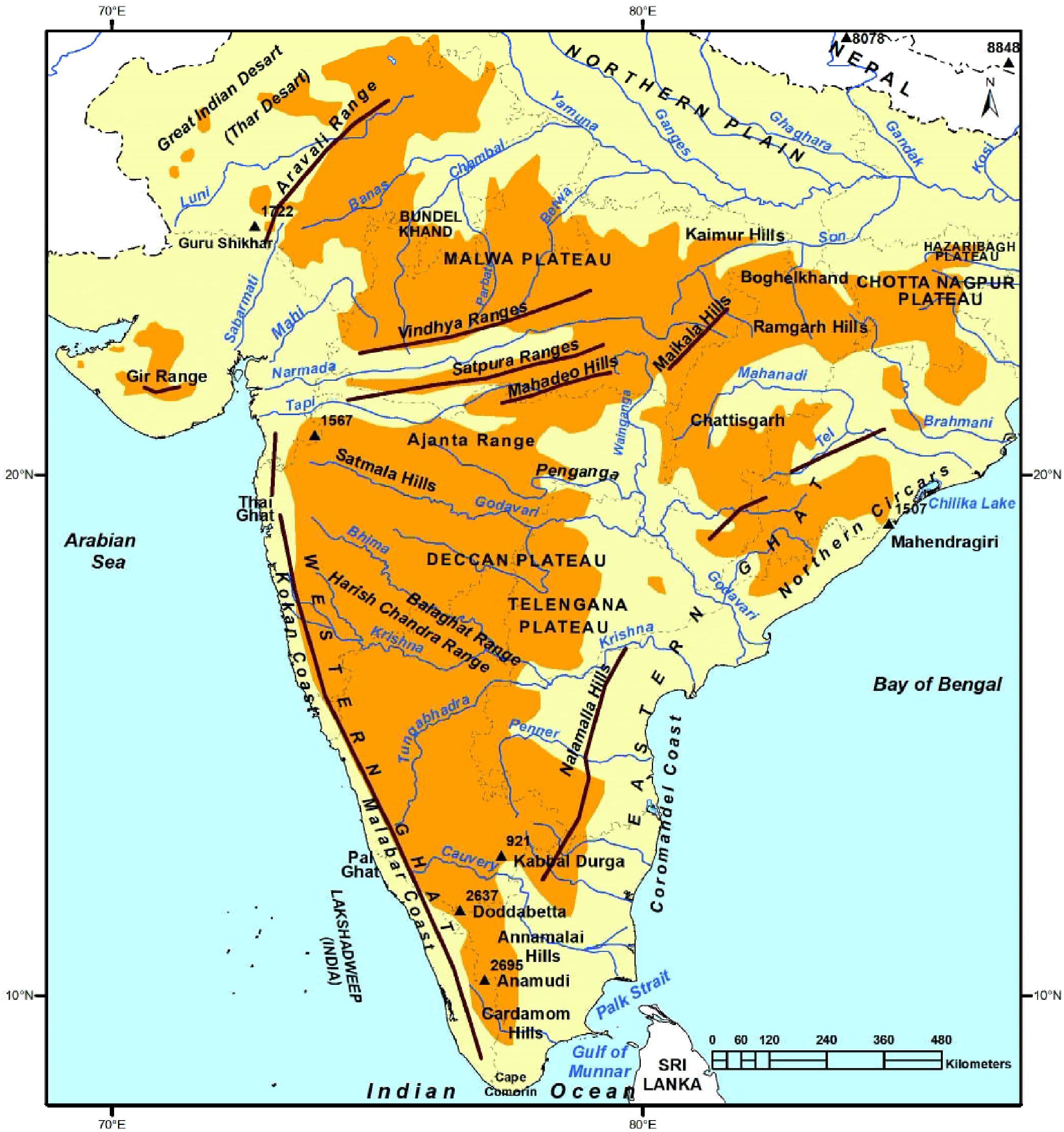
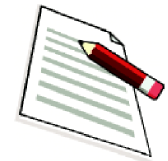



Fig. 11.4: The Peninsular Plateau



Notes

**(i) The Western Ghats:** If we look at the map, we will see the Western Ghats or Sahyadris lie on the Western edge of the Deccan plateau. It runs parallel to the western coast for about 1600 km. The average elevation of the Western Ghats is 1000 metres. The famous peaks in this area are Doda Betta, Anamudi, and Makurti. The highest peak in this region is Anaimudi (2695m.). Western ghats are continuous and can be crossed through passes like Pal Ghat, Thal Ghat, and Bhor Ghat. The rivers like the Godavari, Bhima, and Krishna flow eastward, while the river Tapti flows westward. The streams form many rapids and water falls in Western Ghats. The famous waterfalls are Jog Falls on Sharavathi, Shiva Samudram falls on Kaveri, etc.

**(ii) The Eastern Ghats:** The Eastern Ghats are discontinuous low belts. Their average elevation is 600 m. They run parallel to the east coast from the south of Mahanadi valley to the Nilgiri hills. The highest peak in this region is Mahendragiri (1501 m). The famous hills are Mahendragiri hills, Niyamgiri hills in Orissa, Nallamala hills in Southern Andhra Pradesh, Kollimalai, and Pachaimalai in Tamilnadu. The Mahanadi, Godawari, Krishna, and Kaveri river systems drain the area and fall into the Bay of Bengal. The Nilgiri hills join the Western and Eastern Ghats in the south.

## INTEXT QUESTIONS 11.4

1. Select the correct alternatives:

   i. Which river flows through a rift valley?

      a. Chambal

      b. Yamuna

      c. Godavari

      d. Narmada

   ii. Which is the highest peak of Aravallis?

      a. Gurushikhar

      b. Anamiudi

      c. Mahendragiri

      d. Doda Betta

2. Name any three important rivers of Malwa plateau.

3. Which is the highest peak of Southern India?

## D. The Indian Desert

To the northwest of the Aravali hills lies the Great Indian desert. It is a land of undulating topography dotted with longitudinal dunes and barchans. This region receives low rainfall below 150 mm per year; hence, it has an arid climate with low vegetation cover. It is because of these characteristic features this is also known as Marusthali. It is believed that this region was under the sea during the Mesozoic era. It can be corroborated by the evidence available at the wood fossils park at Aakal and marine deposits around Brahmsar, near Jaisalmer (The approximate age of the wood fossils is estimated to be 180 million years). Though the underlying rock structure of the desert is an extension of the Peninsular plateau, due to extremely arid conditions, its surface features have been carved by physical weathering and wind actions. Some well-pronounced desert land features are mushroom rocks, shifting dunes, and an oasis (mostly in its southern part). Based on the orientation, the desert can be divided into two parts: the northern slopes towards Sindh and the south towards the Rann of Kutch.

Most of the rivers in this region are ephemeral. The Luni river flowing in the southern part of the desert is of some significance. Low precipitation and high evaporation make it a water-deficit area. Some streams disappear after flowing for some distance and present a typical case of inland drainage by joining a lake or playa. The lakes and the playas have salty water, the primary source of salt.

## E. The Coastal Plains

The Great Plateau of India is surrounded by plains on all sides. In the north lies the Great Northern Plain, and in the south, along the east and west, lie the Coastal Plains.

a. **The East Coastal Plain:** It extends along the coast of the Bay of Bengal from Ganga Delta in the north to Kanyakumari in the south. This plain is broader than the western coastal Plains. This plain includes the deltas of the rivers Mahanadi, Godavari, Krishna and Kaveri. Chilka, Pulicat, and Kollur lakes are the famous lagoons of this plain. These lakes have been formed by enclosing small parts of the Bay of Bengal behind sand bars. Lake Chilka is situated south of the delta of Mahanadi. The lake measures 75 km in length. Lake Pulicat is situated north of Chennai city. Koluru lake is situated between the deltas of the Godavari and Krishna rivers. The east coastal plain is fertile, where rice grows in abundance.

b. **The West Coastal Plain:** It extends along the Arabian Sea from the Rann of Kutch in the north and to Kanyakumari in the south. Except for the Gujarat plain, the western coastal plains are narrower than the eastern coastal plain. From southern Gujarat upto Mumbai, this plain is comparatively broader, but it narrows southwards of Mumbai. Occasionally rocky domes and hills are visible in the plains of Gujarat,

Notes

the Rann of Kutch, and the plains of Kathiawar. The plains of Gujarat are made up of black soil. The coastal strip extending for about 500 km between Daman in the north and Goa in the south is called Konkan. This region is highly dissected, and the coastline is indented or irregular with several natural harbours. Several small and seasonal rivers flow through this region. The coast from Goa to Mangalore is called the Karnataka coast. The coast from Mangalore upto Kanyakumari is called the Malabar coast. Here the coastal plain is wider. There are a number of long and narrow lagoons. Eighty kilometres long,Vembanad is an example of its kind. Kochi port is situated on one of the lagoons.

## F. Indian Islands

There are two small groups of islands. One of these, situated in the Bay of Bengal off the coast of Myanmar, is known as the Andaman and Nicobar Islands. The other is known as Lakshadweep and is situated in the Arabian Sea, off the coast of Kerala. The Andaman Islands consist of (i) North, (ii) Middle, (iii) South, and (iv) Little Andaman Islands. Port Blair is the capital city of the entire Union Territory and is located on South Andaman Island. The Ten Degree Channel separates this island group. To its south are situated the Nicobar Islands. They include Car Nicobar, Little Nicobar, and Great Nicobar Islands from north to south. The southernmost point of the Indian Union lies on Great Nicobar Island and has been named after Indira Gandhi. These islands represent a submerged chain of mountains. The Barren Island in the Andamans is India's only active volcano. These islands act as naval and air outposts of our country because of their strategic location. This island group faces seven countries - Bangladesh, Myanmar, Thailand, Malaysia, Singapore, Indonesia, and Sri Lanka.

Lakshadweep Islands are situated in the Arabian Sea, off the coast of Kerala. All these islands are of coral origin. They have been built up by corals, the microscopic polyps. All these islands are very small in size. The largest island among these, the Minicoy, only has an area of 4.5 square km. Kavaratti is the capital city of this island group.

## INTEXT QUESTIONS 11.5

1. Fill in the blanks:

   i. Koluru lake is situated between the deltas of the …….. and …………. rivers.

   ii. The plains of Gujarat are made up of ………… soil.

   iii. The significant river of the Indian desert is …………..

2. Name any three famous lagoons of east coastal plain.

3. Which is the largest island of Lakshadweep Islands?

## 11.3 DRAINAGE SYSTEM OF INDIA

The drainage pattern or system of an area refers to the system of flow of surface water, mainly through the rivers and basin forms. The drainage system studies streams and the directions in which they carry the surface water of an area. The drainage system is related to a number of factors, for example, the slope of the land, geological structure, amount of water volume, and water velocity. Several small and large rivers carry India's surface runoff. The country's drainage system can be studied with reference to two parts: Northern India and Southern India.

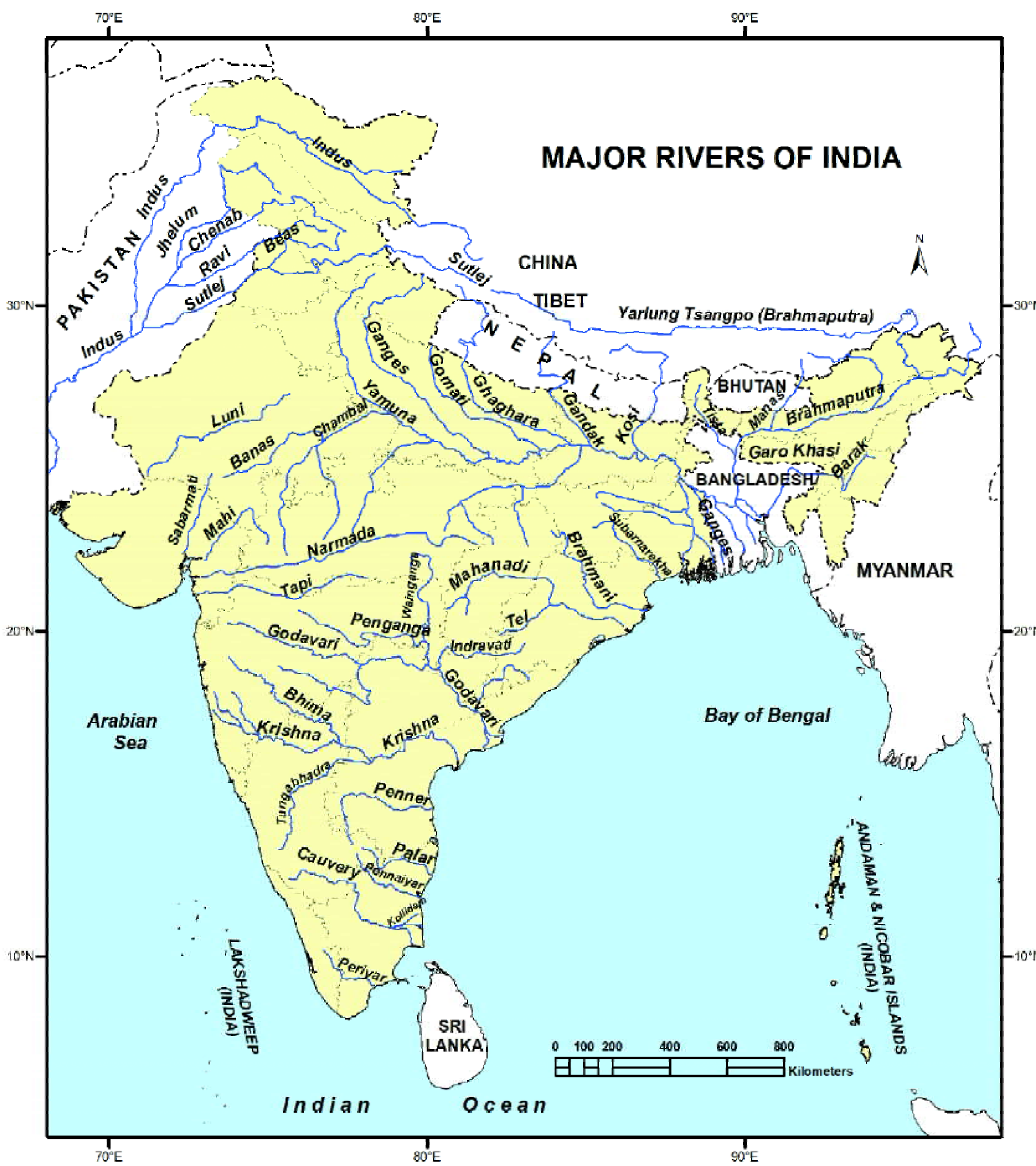



Fig. 11.5: Major Rivers of India

Notes

## A. Drainage System of North India

The Himalayas play an essential role in the drainage system of North India. It is because the rivers of North India have their sources in these mountains and beyond. These rivers differ from South India's as they still rapidly deepen their valleys. The debris eroded by these rivers is carried to the plains and seas and deposited there. This deposition is caused by the reduced velocity of river waters in the plains and deltas for want of necessary slope.

The Great North Indian plain has been formed by the silt brought down by these rivers. Some of the Himalayan rivers are older than the Himalayas themselves. As the ranges of the Himalayas had been rising upwards, these rivers were equally busy in downward cutting, forming deep gorges and valleys. Consequently, parts of the valleys of these rivers are very deep, and gorges have been formed. The depth of the Indus gorge near Bunji (Ladakh) is 5200 metres. Sutlej and Brahmaputra have also formed such gorges.

The drainage system of Northern India can be further subdivided into three subsystems: Indus System, Ganga System, and Brahmaputra System.

The major rivers of the Indus basin are the Indus, Jhelum, Chenab, Ravi, Beas, and Sutlej. The Ganga basin includes Ramganga, Ghagra, Gomti, Gandak, Kosi, and Yamuna and its southern tributaries, Son and Damodar rivers. The major rivers of the Brahmaputra basin are Dibang and Lohit in Arunachal Pradesh and Assam, Tista in Sikkim, West Bengal and Bangladesh, and Meghna, draining the north-eastern part of Bangladesh.

## B. Drainage System of Southern India

Peninsular India is an ancient landmass. Therefore, the streams flowing through this region are in their old stage. They have almost attained their base level of erosion. Their capacity to erode valleys vertically has nearly come to a negligible stage. Now, these streams are eroding their sides at a slow pace. This results in the broadening of their valleys.

Consequently, during floods, their waters spread over a large area. It is believed that the Peninsular block had a slight tilt towards the east due to the time of Himalayan orogeny due to the movements associated with the mountain-building processes. This is why, barring Narmada and Tapi, all the major rivers of south India flow towards the east. Narmada and Tapi both flow through fault or rift valleys. The major rivers of the drainage system of southern India are Mahanadi, Godavari, Krishna, Pennar, Kaveri, and Vaigai.

The slope of the northern part of the southern peninsula is towards the north. Consequently, some of the streams originating in the Vindhyas flow north and join Yamuna and Ganga. Chambal, Ken, Betwa, Sind, and Son are more important among these.

Notes



The difference between the Himalayan rivers and Peninsular rivers:

The rivers which have their origin in the Himalayas are perennial. These rivers are fed by the melting of ice and snow lying near the tongue of glaciers of the Great Himalayan Range (Himadri).

In the rivers of South India, the flow of water is highly fluctuating. While the rivers are in spate during the monsoons, they are almost dry during the long rainless months. Some of these rivers, in many places, become dry.

## 11.4 UNITY IN DIVERSITY IN INDIA

India possesses a wide variety of landforms and relief features. Its young fold mountains of the north have very bold and sharp features. They include long and tall mountain ranges, towering mountain peaks, high mountain passes, and precipitous river valleys. If in one direction lie very steep slopes, in the other, there are gentle slopes. If some parts are without thick forests, the others are clad with varied natural vegetation - from tropical rainforests to Alpine grasslands. They rightly boast of large snowfields, glaciers, picturesque waterfalls along the hanging valleys, and glacial lakes like the Dal in Srinagar. The youthful Himalayan rivers prefer to jump, leap and hop, forming waterfalls, rapids, and cascades on their way. Equally awe-inspiring are its deep gorges establishing a balance between steadily rising mountain ranges on the one hand and the silent down-cutting action of weighty trans-Himalayan rivers like the Indus, Sutlej, and Brahmaputra on the other. Not even a handful of countries can boast of such a majestic and maddening beauty of youthful fold mountains. These world's highest and largest mountain chains have enabled the Indian subcontinent to develop its unique culture by acting as a physical barrier between the subcontinent and the rest of Asia. Perhaps even more compelling is its role as a climatic divide. This physiographic division acts as a storehouse of snow and water, giving rise to hundreds of perennial rivers to drain and irrigate one of the world's largest and most fertile plains. In fact, the plains themselves are a gift of these mountains and rivers flowing from them. It is also a storehouse of hydel power, fuel wood, timber, various forest products, and medicinal herbs, not excluding some strange wildlife species. No wonder this region can attract tourists from far and near, both in summer and winter.

The Northern Plains are matchless in the expanse. These flat or dead-level plains are mostly well-drained and fairly well-irrigated through surface and groundwater. The meandering rivers, oxbow lakes, braided river channels, and a maze of distributaries help to break the monotony of these extremely level plains. Once a forest land, it has been brought almost entirely under the plough. The lower parts of the deltas are ribboned with mangrove or tidal forests. These well-watered plains, supported by highly fertile soils, produce varied crops yearly, sustaining a large chunk of the world's population. They have also been keeping an equally large bovine population. They are one of the world's largest food baskets producing cereals, pulses, oil

Notes

seeds, vegetables, and fruits, besides industrial or cash crops like cotton, jute, sugarcane, and the like.

In sharp contrast with the Northern Mountains and Plains stand the hills of moderate altitude and a highly denuded rocky landscape, representing one of the oldest landmasses of the world - the peninsular block of India. Its rounded hills and flat-topped ridges have a beauty of their own. The varied metamorphic and old granite rocks have given rise to hills, plateaus, and foliated rocks. Furthermore, the basalt or Deccan Trap of Western India has its typical flat-topped hills and that or hairlike structures. Its steep wall-like escarpments run miles without interruption overlooking the Arabian Sea. Their beauty needs to be seen and to be believed. This physiographic division is known for millets and various industrial crops such as cotton, sugarcane, coffee, and groundnut. More importantly, it is a storehouse of minerals - mainly the ferrous ones and mineral fuels like coal and atomic or radio-active minerals. They also have sizable hydel power resources. They, thus, provide a sound base to develop both agro-based and mineral-based industries.

The coastal strips are ribboned with a partly regular and indented coastline. The latter has provided spacious natural harbours like Mumbai and Marmagao. The coastal strips and island groups have ideal conditions to tap deep and shallow water fisheries. The coastal plains in the east have very fertile deltas providing rice bowls. If it is a coast of emergence on the eastern coast, then the major part of the western coast is that of submergence. The plains are rocky and highly eroded. Rice, coconuts, rubber, tobacco, and spices are some of the agricultural produce. Off-shore oil and natural gas fields have also been located. If the Lakshadweep are of coral origin, the Andaman and Nicobar Islands are the peaks of the emerging mountain chain. These islands are of great strategic significance to the defence of the mainland. They face seven countries across the seas washing their shores - Bangladesh, Myanmar, Thailand, Malaysia, Singapore, Indonesia, and Sri Lanka. The islands are known for fishing, forestry, and tourism.

In this way, the enormous variety of macro- and micro-relief features and landforms has enriched our culture, improved agricultural potential to grow almost every crop, laid strong foundations for the modern industry, making all of its physiographic divisions interdependent on one another, and contributed to the unity in diversity in our Bharat.

## INTEXT QUESTIONS 11.6

1. Fill in the blanks:

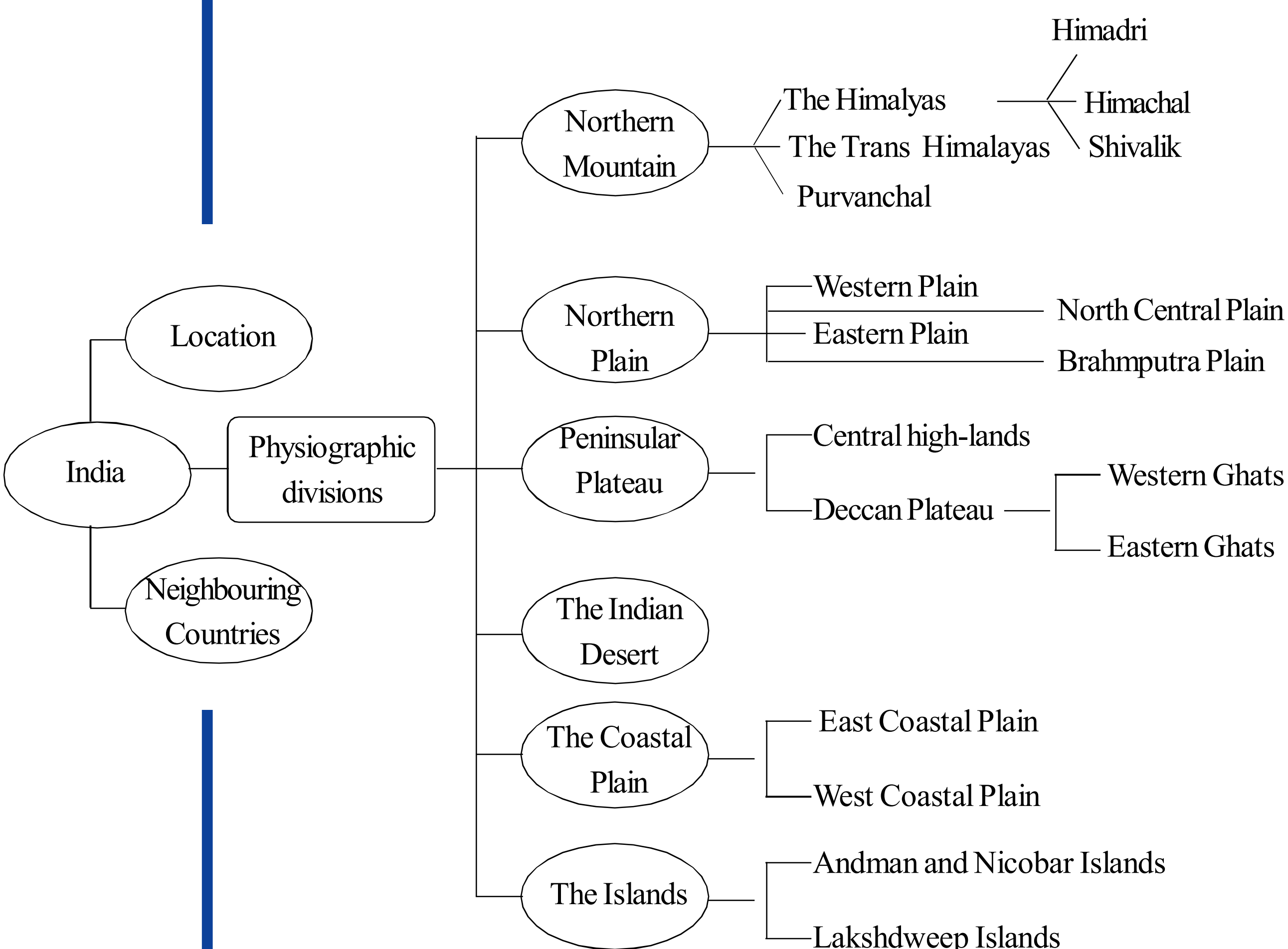
   i. The depth of the Indus gorge near Bunji (Ladakh) is ........... metres.

   ii. Son is the southern tributary of .............

2. Name the drainage system of Northern India.

3. Name any three rivers of the southern drainage system.

## WHAT YOU HAVE LEARNT



## TERMINAL QUESTIONS

1. Give a brief account of the Himachal Range under the following headings.

    a. Location

    b. Their average height and length

    c. A few major peaks

    d. Few prominent glaciers and

    e. Major hill towns

2. Differentiate between:

    a. Western ghat and Eastern ghat.

    b. The Himalayan rivers and peninsular rivers.

3. Divide the Northern Plain into four physiographic divisions and describe briefly the eastern plain.

4. Describe briefly the key features of the eastern coastal plain.

5. Write a brief description of the Indian Islands.

6. Define the following -

    a. Standard Meridian of India

    b. Drainage System

7. Locate the following in the outline maps of India.

    a. Himadri

    b. Karakoram

    c. Pir Panjal Range

    d. Ladakh Range

    e. Satpura and Vindhyachal Range

    f. Satluj river

g. Ganga river

h. Mahanadi river

i. Godavari river

j. Kaveri river and

k. Narmada river

## ANSWERS TO INTEXT QUESTIONS

**11.1**

1. i. 8°4'N, 37°6'.

   ii. Indira Point

   iii. Standard

   iv. 15,200

2. Answer the following questions in one word or a sentence.

   i. Tropic of Cancer

   ii. Approx 2 hours

   iii. Indira Point.

**11.2**

1. Himadri, Himachal and Shivalik

2. Mt. Everest

3. Fill in the blanks:

   i. Pir Panjal, Himadri ranges

   ii. Himachal

   iii. Zaskar, Ladakh

**11.3**

1. The relatively higher part of the plain is called Bangar while the comparatively lower area is called the khaddar.
2. (i) Western plain,

   (ii) North Central plain,

   (iii) Eastern plain, and

   (iv) Brahmaputra plain.
3. Fill in the blanks:

   i. Terai

   ii. Sambhar

   iii. River Ganga

   iv. Majuli

**11.4**

1. Select the correct alternatives:

   i. d. Narmada

   ii. a. Gurushikhar
2. Betwa, Chambal, and Ken
3. Anamudi

**11.5**

1. Fill in the blanks:

   i. Godavari and Krishna

   ii. Black

   iii. Luni
2. Chilka, Pulicat, and Koluru
3. Minicoy

**11.6**

1. Fill in the blanks:

    i. 5200

    ii. Ganga

2. Perennial

3. Narmada, Tapi, Godavari, Krishna, Kaveri etc (Any three)

## 12

# CLIMATE

You have studied India's shape, size, location, and latitudinal extent in previous lesson . You have also learnt that how India's relief characteristics contrast strikingly. These variations have led to climatic variations between regions. The climatic conditions in southern India differ slightly from those in the northern regions.

Now, let us have a closer look at these climatic variations. During Summer, the north-western plains experience high temperatures around 45°C while areas of the Rajasthan desert may record day temperatures around 55°C. At the same time the temperatures around Gulmarg or Pahalgam in Kashmir are hardly around 20°C. Similarly, in December, the people of Kargil or Dras (in Ladakh, UT) experience biting cold because the night temperatures drop to -40°C, while the inhabitants of Thiruvananthapuram experience temperatures around 27° C.

In this lesson, we will look for several variables that contribute to these climatic fluctuations through time and space.

### OUTCOMES

After studying this lesson, learner:

- describes the factors that influence the climate;
- explains the mechanism of monsoon and its significance in the Indian economy;
- becomes familiar with the seasons; and
- describes the distributional patterns of temperature and rainfall.

## 12.1 FACTORS INFLUENCING THE CLIMATE OF INDIA

You may have observed the diversity in Indian climatic conditions while visiting to different places. Such diversity is possible due to various factors influencing the climate of India. These factors are:

### A. Location and Latitudinal Extent

India is located roughly between latitudes 6°N and 37°N. The Tropic of Cancer passes through the middle of the country. Due to their proximity to the equator, the southern regions have hot temperatures all year round. On the other hand, the northern regions are located in warm temperate regions. They consequently endure cold conditions, especially throughout the winter. The climate is milder near the coast of peninsular India because of the water bodies surrounding it.

### B. Distance from the Sea

Southern or peninsular India is surrounded by the Arabian Sea, the Indian Ocean, and the Bay of Bengal. Hence the climate of coastal regions of India is equable or maritime. The climate of the regions in the country's interior is cut off from the oceanic influence. As a result, they have an extreme or continental type of climate.

### C. The Northern Mountain Ranges

India and the rest of Asia are divided by the Himalayan and nearby mountain ranges, which stretch from Kashmir in the north west to Arunachal Pradesh in the north east. During winter, these hills shield India from the savagely chilly and dry winds of Central Asia. Additionally, they serve as a strong physical barrier that prevents rain-bearing southwest monsoon winds from entering India's northern borders. These ranges act as a climate barrier between Central Asia and the Indian Subcontinent.

### D. Physiography

In various regions of the nation, physical characteristics affect the air temperature, atmospheric pressure, wind speed, and rainfall. Look at the physical feature map of India from the previous lesson, and using the climatic maps from this lesson, determine for yourself the link between the relief, temperatures, wind direction, and rainfall amounts. It will clarify why the interior regions of Karnataka and Tamil Nadu, located east of the Western Ghats, have less rainfall than the western coastal plains. Additionally, you will comprehend why the Bay of Bengal branch of the South west monsoon splits into two portions, one travelling down the Ganga Valley to the west and the other along the Brahmaputra Valley to the east.

### E. Monsoon Winds

The complete reversal in the direction of winds over India brings about a sudden change in seasons - the harsh summer season suddenly giving way to the eagerly awaited monsoon or rainy season. These winds, which change their direction completely, are called monsoon winds. The word 'monsoon' is derived from the Arabic word 'Mousim,' which means 'season.' These winds have such a far-reaching influence on India's climate that it is termed a 'monsoon type of climate.' The nature of these winds can be described concerning the surface distribution of pressure in different regions of India during the winter and summer seasons.

(a) **The North east Monsoon and its Effect:** During winter, the weather conditions are influenced by high pressure developed over the Northw estern subcontinent. It results in blowing cold, dry winds from this region towards southern low-pressure areas lying over water bodies surrounding peninsular India. Since these winds are cold and dry, they do not cause rainfall, and weather conditions under their influence remain cold and dry. However, wherever these North east monsoon winds collect moisture while passing over the Bay of Bengal, they bring rain along the Coromandel Coast. Strictly speaking, these winds are planetary winds known as Northeast Trades. In India, they are essentially land-bearing winds.

(b) **The South west Monsoon and its Effect:** During summer, the northwestern parts of India become very hot due to high temperatures. It is ascribed to the apparent shift of the sun in the northern hemisphere. It results in the reversal of air pressure conditions in north western India and water bodies surrounding the peninsular plateau. As a result, North east Trade winds are replaced by South west monsoon winds. Since these winds are sea-bearing and blow over warm water bodies before reaching land, they are moisture-laden, causing widespread rain over most parts of India. This period of the south west monsoon, from June to September, is known as the rainy season for most parts of the country.

## F. Upper-Air Circulation

The changes in the upper air circulation over the Indian landmass are yet another cause for the sudden outbreak of monsoons in India. Jet streams in the upper air system influence the climate of India in the following ways:

(a) **The Westerly Jet Stream and its Impact:** During winter, at about 8 km. above sea level, a westerly jet stream blows at a very high speed over the subtropical zone. The Himalayan ranges bifurcate this jet stream. This jet stream's northern branch blows along the northern edge of this barrier. The southern branch blows eastwards south of the Himalayan ranges along 25° N latitude. Meteorologists believe that this branch of the jet stream significantly influences India's winter weather conditions. This jet stream is responsible for bringing western disturbances from the Mediterranean region into the Indian subcontinent. Winter rain and hail storms in north western plains and occasional heavy snowfall in hilly regions are caused by these disturbances. Cold waves generally follow these in the whole of the northern plains.

**(b) Easterly Jet and its Influence:** Due to the apparent shift of the sun in the northern hemisphere during the summer, the upper air circulation is reversed. The easterly jet stream, created due to the Tibetan plateau's heating, takes the place of the westerly stream. It caused the formation of an easterly, chilly jet stream that was blowing over peninsular India and was focused at 15°N latitude. It aids in the monsoons' quick arrival.

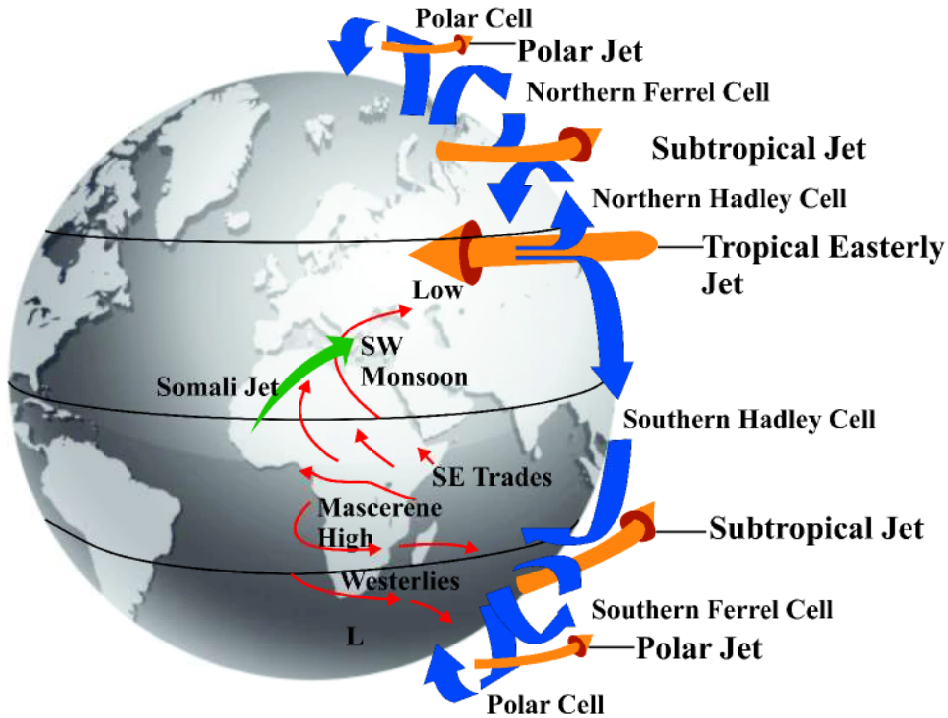



Fig. 12.1 Upper-Air Circulation

## G. Western Disturbances and Tropical Cyclones

Westerly jet streams from the Mediterranean Sea impact the entrance of western disturbances. It affects most of the Northern Plains and Western Himalayan region's winter weather conditions. In the winter, it doesn't rain much. The northern plains' wheat harvests are thought to benefit significantly from this rain.

Additionally, the Bay of Bengal is where tropical cyclones form. In October, November, and December, these cyclones' frequency and trajectory have an impact on the weather along the eastern coast.

Notes


Fig. 12.2 Emergence of Western Disturbances

## H. El - Nino Effect

Weather conditions in India are also influenced by EI-Nino, which causes widespread floods and droughts in tropical regions of the world. El-Nino is a narrow warm current that sometimes appears off the coast of Peru in South America. It is a temporary replacement for the cold Peru current, which generally flows along this coast. Sometimes, becoming more intense, it increases the surface water temperatures of the sea by 10° C. This warming of tropical Pacific waters affects the global pattern of pressure and wind systems, including the monsoon winds in the Indian Ocean. It is believed that EI-Nino caused the severest drought of 1987 over India.

## I. Southern Oscillation and its Effect

The southern oscillation is a pattern of meteorological changes often observed between the Indian and Pacific oceans. It has been noticed that whenever the surface level pressure is high over the Indian Ocean, it is low over the Pacific Ocean and vice-versa. When the pressure is increased over the Pacific Ocean and low over the Indian Ocean, the South west monsoons' in India tend to be weaker. In the reverse case, the monsoons are most likely to be stronger.

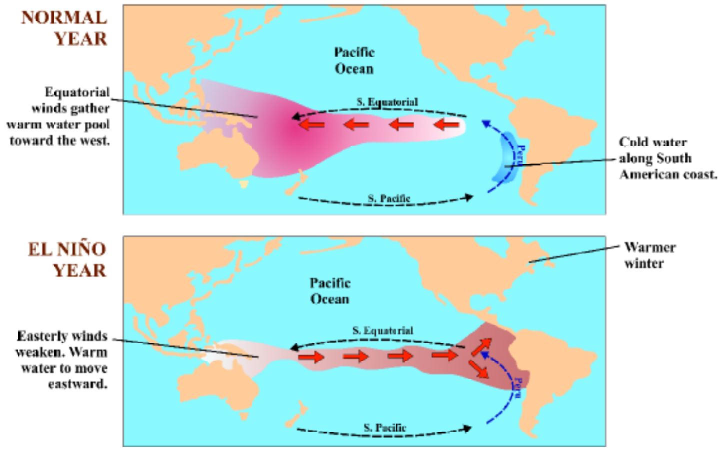


Fig. 12.3 The El Nino Phenomenon

## INTEXT QUESTIONS 12.1

1. Name any three factors influencing the climate of India.
2. Name the current appearing off the coast of Peru.
3. Fill in the blanks:
   i. The word 'monsoon' is derived from the Arabic word …………
   ii. The tropical cyclones form in ……………..
   iii. The jet stream is bifurcated by…………..

## 12.2 MECHANISM OF MONSOON

The term "monsoon" describes a tropical wind pattern in which the direction of the wind entirely changes from summer to winter. In this system, the winds alternate between winter and summer directions, blowing from land to sea. As a result, the monsoon-influenced regions receive most of their rainfall throughout the summer, while the winter is often dry.

According to traditional belief, the monsoon is caused by the differential heating of land and sea. Due to a higher temperature over the land in summer, a low-pressure area develops over the continents, and the winds blow from neighbouring oceans toward the land. These winds are of maritime origin and hence cause ample rainfall in summer. On the other hand, the continents become colder than the neighbouring oceans in winter. As a result, a high-pressure area is developed over the continents. Therefore, winds blow from land to sea in winter. These winds, being of continental origin, are dry and do not cause rain. This traditional theory of the monsoon has been criticised by the German meteorologist Flohn. He argues that the differential heating of land and sea is not enough to cause a seasonal reversal of winds at a global scale. He has explained the origin of the monsoon on the basis of the seasonal shift of the pressure and wind belts under the influence of the shift of the sun's vertical rays.

Notes

According to this theory, as the sun's vertical rays shift northwards over the Tropic of Cancer in the summer season, the Inter-Tropical Convergence Zone (ITCZ) also moves to the north. It forms a low-pressure area over the northwestern parts of India. The high temperatures in this region further intensify this low pressure. This low-pressure area sucks the air from the Indian Ocean towards the Indian landmass in the form of South west monsoons. In the winter, the ITCZ shifts southwards, and a mild high pressure is produced over northern parts of India. This high pressure is further intensified by the equatorward shift of the sub-tropical high-pressure belt. Due to high pressure over north India, the winds start blowing from the northeast as retreating monsoons. According to recent observations, the origin of the Indian monsoon is influenced by several other factors besides the differential heating of land and sea and the seasonal shifts of pressure and wind belts.

One of the most important factors is the sub-tropical westerly and tropical easterly jet streams. The sub-tropical westerly jet streams blowing over India in winter cause high pressure over northern India. It thus intensifies the northeast monsoons. This jet stream shifts northwards beyond India in the summer season, and tropical easterly jets develop over India in this season. The behaviour of these jet streams is partly responsible for the variations in the time of onset of south west monsoons over India.

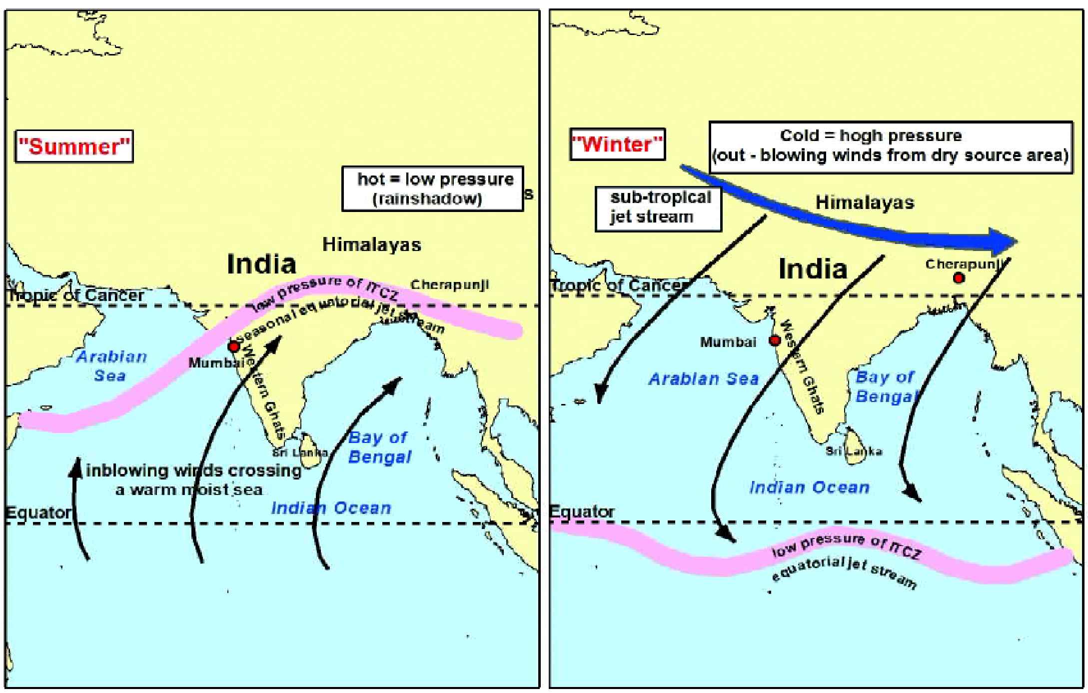



Fig. 12.4 Mechanism of Monsoon

## Significance of monsoon in the Indian economy

The Indian climate is called the 'monsoon climate.' It explains how much influence the monsoon winds have in bringing climatic unity. This unity in climatic conditions results from the combined influence of regular movements of monsoons (seasonal winds) and the bounding role of the Himalayan mountain system.

The monsoonal unity of India caused by these twin factors is discernible. It reflects upon the lifestyles and activities of the common masses in India. The sequence of hot, wet, and cold seasons affects the lifestyles and economic activities of the people throughout India in the following ways:

Farmers all over India start their agricultural activities like ploughing fields, sowing seeds, transplantation, etc., with or just before the onset of monsoons. Kharif crops - rice and millet, cotton and sugarcane in different areas- express the amount of rainfall they receive. During winter, wheat is the major rabi crop in cool and irrigated areas, whereas barley, gram, and oil seeds are common crops in unirrigated regions of northern and central India.

Clothes are also affected by the seasons. During summer, people wear cotton clothes, whereas woollen clothes are used in the winter, especially in the north and central India.

- Most parts of India have to bear a long dry season; on the contrary, the season of life-giving rains is limited to only a few months. It has a far-reaching effect on the lifestyle of the Indian people. The monsoon clouds fall on the thirsty parched land. Their music and fragrance come out of the land to generate similar emotional responses all over India. It is reflected in the Kajari of Bhojpuri and Malhar of Brij and their counterparts in other regions of India. Most Indian festivals are closely linked with seasons. In north India, Baisakhi is celebrated when the rabi crop is ready for harvesting. During winter, when the sun shines vertically over the Tropic of Capricorn, and extremely cold weather conditions prevail over the northern plains, Lohri and Makar Sankranti are celebrated in the north and west. At the same time, Pongal distinctly is its southern counterpart. Holi is celebrated in spring after bidding goodbye to the prolonged cold winter, especially in the north.
- Rainfed subsistence farming has been the oldest response of the village community. Its entire economy is based on it, however meagre rain it may be.
- The seasonal and regional variations in weather conditions have made different regions capable of producing different crops in varying quantities making all regions completely interdependent. This is not a contribution of the monsoons in promoting underlying unity despite all pervasive diversity.

## INTEXT QUESTIONS 12.2

Fill in the blanks:

1. The traditional theory of the monsoon was criticised by the German meteorologist ……...
2. ………… is the major rabi crop during winter.
3. During summer, people wear … clothes, whereas …… clothes are used in the winter.

## 12.3 CYCLE OF SEASONS IN INDIA

By now, you have understood that the complete reversal of the direction of winds is the most striking feature of monsoons. These changing monsoon winds result in the change of seasons over the year. It is, therefore, essential to understand, in detail, the prevailing weather conditions throughout India during different seasons.

Climatically, the year is divided into the following four seasons in India:

i. The cold weather season - December to February;

ii. The hot weather season - March to May in the south and up to June in the north;

iii. The advancing south west monsoon season - June to September;

iv. The retreating southwest monsoon season - October and November.

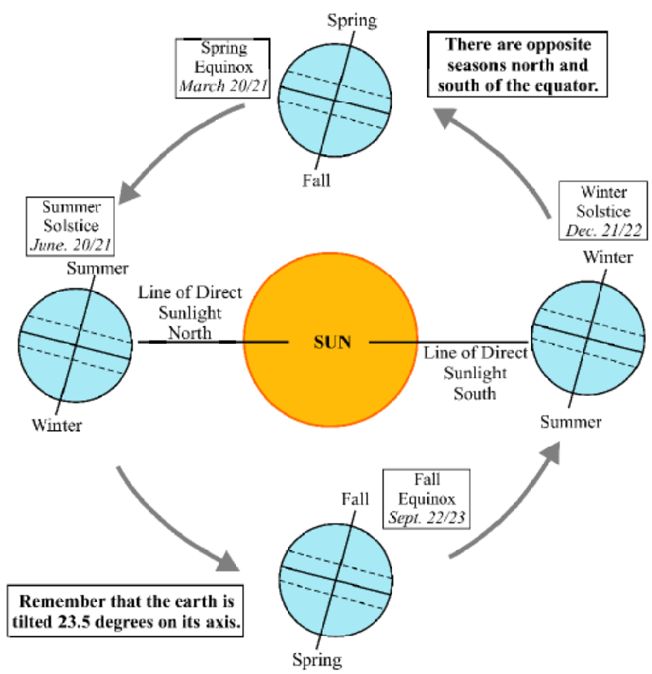



Fig. 12.5 Cycle of Seasons

### i. The Cold Weather Season

In northern India, this season often starts in late November. As the sun shines vertically over the Tropic of Capricorn in the southern hemisphere, January is the coldest month for most of the nation. Over northern plains and mountain regions, the typical daily temperatures during these months stay below 21°C. Sometimes the night time lows are below freezing, which causes widespread frost damage to the standing crops. As one travels from the north to the south, the temperature rises. Low temperatures cause a weak high-pressure region to form over areas of northern India. This modest high pressure brings on the off-shore North east monsoon winds. Due to the relief, they are moving westward on the Northern Plains. These chilly breezes carry dry cold winds.

The succession of depressions is another feature of this season. These low-pressure systems are called "Western disturbances" as they originate in the Mediterranean region. These depressions move with the westerly jet streams. Covering a long distance over Iraq, Iran, and Pakistan, they reach India around mid-December. Their arrival results in the increase of temperature and light rains over northern plains. They cause widespread snowfall over the western Himalayas and the adjoining ranges. At times hailstorms cause widespread damage to the standing rabi crops in north western plains. The meagre rainfall caused by these disturbances is essential to the standing crops, particularly wheat, in irrigated areas. These depressions are followed by cold waves, which bring down temperatures considerably.

Peninsular India has no well-defined winter season. The mean monthly temperatures in January are above 20°C in this part. Moreover, the coastal plains hardly experience any seasonal change, as is clear from the mean monthly temperature above 27°C at Thiruvananthapuram. But Chennai records a temperature of 25°C during December and early January owing to the rains caused by North east monsoon winds.

The essential characteristics of cold weather season are:

- Low temperatures in the north and their gradual increase towards southern parts of India.
- The blowing of cold and dry northeast monsoon resulted in dry weather conditions in most parts. Coromandel coast receives rainfall during winter.
- Western disturbances cause light rain in the northern plains and snowfall over the Himalayan ranges.

### ii. The Hot Weather Season

The sun's apparent movement towards the north increases the temperatures in the northern plains. As a result, spring sets in soon, giving way to the hot weather season, which lasts till the end of June in this region. The temperatures increase northwards and reach around 45°C in mid-May in most parts of the northern plains. The characteristic features of this season are afternoon dust storms and 'Loo,' a hot, dry wind that blows during May and June, mainly over the northern plains. These winds cause heat stroke resulting in the deaths of hundreds of people every year. The day temperatures rise above 45°C in some northwestern parts of the country.

During this season of the year, the wind direction changes. Generally speaking, the nation has hot and dry weather. However, on the Northern Plains, dust storms result in rain. Also seeing light rains are West Bengal, Assam, and Kerala. These pre-monsoon showers are referred to as "Mango Showers" in Kerala. They are referred to as

Notes

Northwesters or 'Kal Baisakhi' in West Bengal and Assam. Sometimes these Northwesters inflict significant loss of life and property because of the tremendous wind speeds.

### iii. The Advancing South west Monsoon Season

It is the rainy season for most parts of India. It starts with the inflow of Southwest monsoons which generally strike the coast of Kerala in the first week of June and cover most of India by mid-July. This weather continues till September. The arrival of these warm, moisture-laden winds brings a total change in weather conditions. Their arrival causes sudden rains, which bring down the temperatures considerably. The decline in temperature is between 5°C to 10°C. The sudden onset of rain is called a break of monsoons or a burst of monsoons. The arrival of these winds may be delayed by a week or two depending upon the pressure conditions over the northern plains and the Indian ocean. The peninsular shape of India divides these Southwest monsoons into two branches - the Arabian Sea branch and the Bay of Bengal branch.

(a) Arabian Sea branch of South west monsoons strikes the western coast of India and causes heavy rains on the western slopes of the Western Ghats. After crossing the Western Ghats, these winds cause less rainfall on the eastern slopes as they gain temperature while descending. This area is, therefore, known as the rain shadow zone. It explains why interior parts of Maharashtra, Karnataka, and Telangana get light rains from these winds. South west monsoons strike along the coast of Saurashtra and Kuchchh and pass over Rajasthan and beyond to meet the Bay of Bengal branch. These winds cause widespread rain in these states and the western Himalayan region.

(b) After encountering the eastern Himalayas, the Bay of Bengal branch splits into two sub-branches. One branch goes in an east-northeasterly direction, causing heavy rainfall across India's north eastern highlands and Brahmaputra valley. The other branch spreads heavy and extensive rain across huge regions as it goes toward the northwest through the Ganga River and the Himalayan peaks. Due to the progressively declining humidity of these winds, rainfall in this area diminishes from east to west.

The characteristics of Southwest Monsoons:

(i) These winds generally strike the Indian coast in the first week of June. But their arrival and departure may be before time or even delayed.

(ii) There may be dry spells in between rainy periods. Such long dry spells may even lead to the failure of crops.

(iii) At times, these winds skip over certain regions without any cause.

(iv) The amount and timing of rainfall and the intervening duration of wet and dry spells vary yearly. It is known as the vagaries of the monsoons.

(v) The spatial distribution of rainfall is uneven - some regions may receive heavy rains while others will have to be content with meagre or scanty rains.

(vi) Generally, these winds start retreating by the end of September. But, sometimes, their departure may be delayed till October, or they may retreat much earlier.

The main features of the advancing South west monsoon season are:

- Low-pressure conditions over north western parts of India and high-pressure conditions overseas.
- The general wind direction, particularly on the Arabian Sea and the Bay of Bengal, is southwest to northeast. They cause widespread rain interspersed with dry spells.
- The onset of monsoons is in the first week of June, and withdrawal is by the end of September.
- The weather is generally hot and humid during this season.

### iv The Retreating Monsoon Season

The Southwest monsoons start retreating from the Pakistan border in Northwest India in the first week of September. Thus, these winds withdraw earlier from the regions where they reach the last. The retreat of these winds occurs due to the weakening of low-pressure areas over the north western parts. It happens due to low temperatures caused by the apparent shift of the sun towards the equator and also owing to the widespread rains bringing down temperatures perceptibly. Consequently, the air pressure starts decreasing. Such changes in the patterns of atmospheric pressure cause monsoons to withdraw. Hence, this period is known as the season of retreating South West monsoons. By the end of October, these winds retreat from most of northern India. As a result, fair weather conditions prevail over this region.

The low-pressure area lying over Northwest India will be transferred to the middle of the Bay of Bengal by the end of October. As a result of these unstable conditions, severe cyclonic storms originate in the Bay of Bengal. These cyclonic storms strike along the eastern coast of India, causing widespread rain in the coastal regions. Sometimes very severe storms cause damage to standing crops, cattle, property, lines of transport, communication, and even electricity. Tamil Nadu coast receives the maximum rainfall during October and November - the period of retreating monsoons.

The main characteristic features of the retreating monsoon season are:

- Weakening of low-pressure area over Northwest India;
- Fall in temperatures throughout India;
- Shifting of the low-pressure area to the south; and
- Origin of cyclonic storms in the Bay of Bengal, causing heavy rains and damage to crops and property along the eastern coast of India.

Notes

## INTEXT QUESTIONS 12.3

1. Name the four seasons of India.
2. What is the name of pre-monsoon showers in West Bengal and Assam?
3. Fill in the blanks:
   i. The duration of the cold weather season is from ………………. to …………..
   ii. The low-pressure systems are called "…………………….
   iii. …………….. coast receives the maximum rainfall during October and November.

## 12.4 DISTRIBUTION OF TEMPERATURE AND ANNUAL RAINFALL

Now, let us have a closer look on the distribution of temperature in India. During June, the north western plains experience high temperature around 45°C when areas of Rajasthan desert record day temperatures around 55°C, while the temperatures around Gulmarg or Pahalgam in Kashmir are hardly around 20°C. Similarly, in the month of December, the people of Kargil (in Laddakh) experience biting cold because the night temperatures drop to -40°C, while the inhabitants of Thiruvananthapuram experience temperatures around 27° C.

The range of temperature increases as one moves away from coastal areas to interior parts of the country. As a result, the people living along Konkan and Malabar coasts do not experience extremes of temperatures or marked change in seasons. On the other hand, people living in north western parts of India, experience sharp seasonal contrasts.

Study the map of rainfall distribution carefully. You may find that the regional variations in average annual rainfall are well-pronounced. The rainfall distribution map shows that northeastern parts of Jammu Kashmir and extreme western Rajasthan receive less than 20 cm. On the other hand, the western coastal plains, and Sub-Himalayan areas of northeast India, including the Shillong plateau, receive more than 200 cm. of annual rainfall. Mawsynram gets the most rainfall in India. Mawsynram has a world record of receiving 26,000 millimetres

(1,000 in) of rain in 1985, making it the wettest place on the Earth. It receives 11,872 millimetres (467.4 in) of rain annually on average. Starting from the southern coast of Gujarat, the isohyet of 200 cm. runs somewhat parallel to the coast of Western Ghats up to Kanyakumari. The rainfall drops abruptly below 60 cm to the east of the Western Ghats over interior Maharashtra and Karnataka. Most parts of Punjab, Haryana, central and eastern Rajasthan, and western Gujarat also receive rainfall below 60 cm. Starting from the southwestern parts of Jammu and Kashmir, the isohyet of 100 cm. moves eastwards up to the east of Allahabad, from where it bends to the west and south west, running over western Madhya Pradesh, eastern Maharashtra, and northern Andhra Pradesh, it joins eastern coast near Visakhapatnam. To the west and south west of this isohyet, the areas receive less rainfall. Some parts of the Coromandel coast receive rainfall of more than 100 cm. The areas receiving less than 100 cm. of rainfall depend on means of irrigation for agricultural activities.

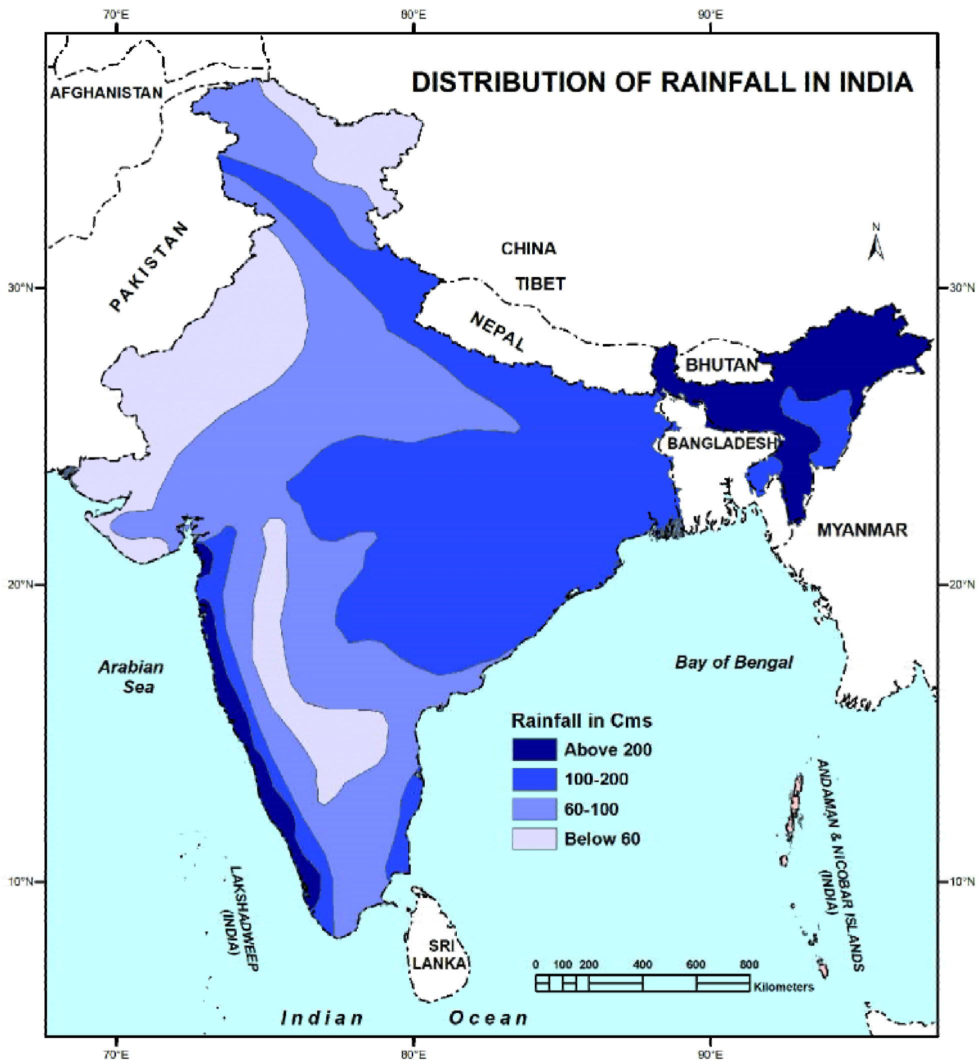



Fig. 12.6 Distribution of Rainfall in India

In India, rainfall distribution, particularly of the south west monsoon, is closely related to the relief. Hence it is even described as "relief" or "orographic" rainfall. By and large, places with higher altitudes have a greater chance of catching more rain than places with less altitude. The direction of moist winds also matters.

The distribution of annual rainfall in different parts of India shows the following trends:

- The rain decreases as one moves from Kolkata to Amritsar.
- It shows the declining trend towards the interior from the coastal areas on the Deccan Plateau.
- North eastern parts receive more rainfall than north western parts of India.
- Areas lying on the windward side receive more rain than those on the leeward side.

## INTEXT QUESTIONS 12.4

1. Fill in the blanks:

   i. …………….. gets most rainfall in India.

   ii. ………………. and extreme western ………… receive less than 20 cm rainfall.

   iii. In India, rainfall distribution, particularly of the south west monsoon, is closely related to the ……………..

## WHAT YOU HAVE LEARNT

- India is a country of climatic diversities expressed in the variations in the distribution of temperature, pressure, winds, and amount of precipitation.
- The factors responsible for determining the climate of different regions of India include her location and latitudinal extent, physiography, the role of Himalayan ranges as a climatic divide, the monsoon winds, upper air circulation, western disturbances, and cyclonic storms.
- Derived from the Arabic word 'mousim,' monsoon implies the rhythm of the season and seasonal reversal of winds.
- Meteorologically, the year in India is divided into four seasons, namely the cold weather season, the hot weather season, the advancing southwest monsoon season, and the retreating southwest monsoon season.
- These seasons have different characteristics of weather conditions.

## TERMINAL QUESTIONS

1. How do western disturbances influence the weather conditions of north west India?

2. Distinguish between:
   (i) The cold weather season and hot weather season;
   (ii) The southwest and northeast monsoons.
3. Describe five major factors which influence the climate of India. Illustrate your answer with examples.
4. Explain with suitable examples the uneven distribution of rainfall in India.
5. Identify the characteristics of monsoons in India.

## ANSWERS TO INTEXT QUESTIONS

**12.1**

1. Location and Latitudinal Extent, Distance from the Sea, The Northern Mountain Ranges, Physiography, Monsoon Winds etc (Any three)
2. El Nino
3. Fill in the blanks:
4. Mousim
5. Bay of Bengal
6. Himalayas

**12.2**

Fill in the blanks:

1. Flohn
2. Wheat.
3. Cotton, Woolen

**12.3**

4. Four seasons in India:
   i. The cold weather season - December to February;
   ii. The hot weather season - March to May in the south and up to June in the north;
   iii. The advancing southwest monsoon season - June to September;
   iv. The retreating southwest monsoon season - October and November.
5. Kal Baisakhi
6. Fill in the blanks:
   iv. December, February
   v. Western disturbances
   vi. Tamil Nadu

**12.4**

2. Fill in the blanks:
   iv. Mawsynram
   v. Jammu Kashmir, western Rajasthan
   vi. Relief

# 13

# NATURAL HAZARDS AND DISASTER

In the previous lesson you have learnt the role of climate. Many natural disasters are of climatic origin. In this lesson we would try to learn how natural extreme events of different origins like climate, hydrology, geology etc impacts humans and their structures resulting in disasters. The disasters have negative impacts on human beings and the environment. The negative impacts can be short or long lasting. The natural disasters cause death, injury, destruction of infrastructures, transport systems etc. It leads to financial losses of development and overall backwardness of the area.

Therefore, adaptation of suitable disaster mitigation and management strategies need to be taken up seriously. Among the top ten natural disaster-prone countries, India stands second after China. In this lesson, we will focus on some important disasters.

## OUTCOMES

After studying this lesson, learner:

- differentiates between 'Hazard' and 'Disaster';
- explains various types of disasters;
- identifies disaster prone areas in India;
- suggests disaster management measures to reduce impacts of disasters and
- explains national and international measures adopted for Disaster Risk Reduction

## 13.1 HAZARD AND DISASTERS

Hazard is a danger defined as a phenomenon or natural condition having the potential of causing loss of lives, injury and destruction of properties. Overall it has the possibility of economic disruptions and environmental damage.

Hazard is called a disaster only when it really affects a certain population. The occurrence of natural disasters cannot be controlled by human beings but with better mitigation and management measures their impacts may be minimised.

Due to human intervention in the natural processes, the destructive magnitude and frequency of natural disasters have increased considerably in recent times. The severity of disasters depends on our preparedness. The scale of the impact in turn depends on the choices we do have. The choices are concerned with our capabilities to cope with the disaster. For example a well built house has a higher possibility of coping with the wrath of nature than ill-built houses. It is called vulnerability. Well built houses are less vulnerable while the ill-built houses are highly vulnerable to disasters.

Hence, disaster is defined as: "… a serious disruption of the functioning of a society, causing widespread human, material, or environmental losses which exceed the ability of the affected society to cope using its own resources." The United Nations defines disaster as "…the occurrence of a sudden or major misfortune which disrupts the basic fabric and normal functioning of a society or community."

It is an event or a series of events which gives rise to casualties and/or loss of property, infrastructure, essential services or means of livelihood on a scale that is beyond the normal capacity of the affected communities to cope with. Disaster is sometimes also used to describe a "catastrophic situation in which the normal patterns of life or ecosystems have been disrupted and extraordinary emergency interventions are required to save and preserve human lives and / or the environment".

a) According to an estimate, about 60,000 people per year are killed by natural disasters and are responsible for 0.1% of global deaths in last 100 years.

b) According to UN statistics, natural disasters cause property damage of around Rs 20,000 crores worldwide every year.

A disaster occurs when hazard impacts vulnerable people or communities of a certain area. It happens when their inability to reduce the potential negative consequences surpasses their capacity to cope.

**(Natural Hazard + Vulnerability Risk)/ Capacity = DISASTER**

The Characteristic of hazard and disaster are summarised in Table 13.1.

Table 13.3 Differences between Natural Hazard and Disaster

| | Natural Hazard | | Disaster |
|---|---|---|---|
| 1. | Hazards are dangerous physical conditions or events. | 1. | Most of the disasters occur rapidly, instantaneously and indiscriminately. |
| 2. | Hazards have potential of damaging different forms of lives | 2. | Disasters are largely viewed from a human perspective causing severe damage to human life and property. |
| 3. | Hazard represents a latent threat to damage biotic and abiotic components of the environment. | 3. | Disaster disrupts the normal functioning of society and the physical environment. |
| 4. | Hazards may or may not turn into disasters. | 4. | All disasters cause damage to property and loss of lives. A large number of people are affected. |
| 5. | External aid is not required to damage biotic and abiotic components of the environment. | 5. | It affects the society and socio, economic and physical environment to such an extent that external aid becomes necessary. |
| 6. | Earthquakes, floods, cyclones, volcanic eruptions, landslides, droughts etc are called natural hazards before they cause loss of life and damage to property. | 6. | Earthquakes, floods, cyclones, volcanic eruptions, landslides, droughts etc are called natural disasters after they cause loss of life and damage to property. |
| 7. | People are not affected. | 7. | People are affected |
| 8. | Hazards also occur in areas not occupied by human beings. | 8. | Hazards turn into disasters when they occur in the inhabited areas with infrastructures, buildings, telecommunications etc. |
| 9. | Hazards are processes of the genesis of extreme events | 9. | Disasters are the responses to the aftermath of natural hazards. |

## 13.2 TYPES OF NATURAL DISASTERS

Natural disasters are those which are caused by nature and are beyond human control. But it is also true that rampant human activities accelerate the impact of natural disasters. For example a judicious use of mountain slope, over irrigation. Deforestation, road construction on slopes intensifies the impact of natural disaster landslides. There are several types of natural disasters like floods, cyclones, earthquakes and volcanic eruptions etc. the types of natural disaster are very clearly shown in figure.

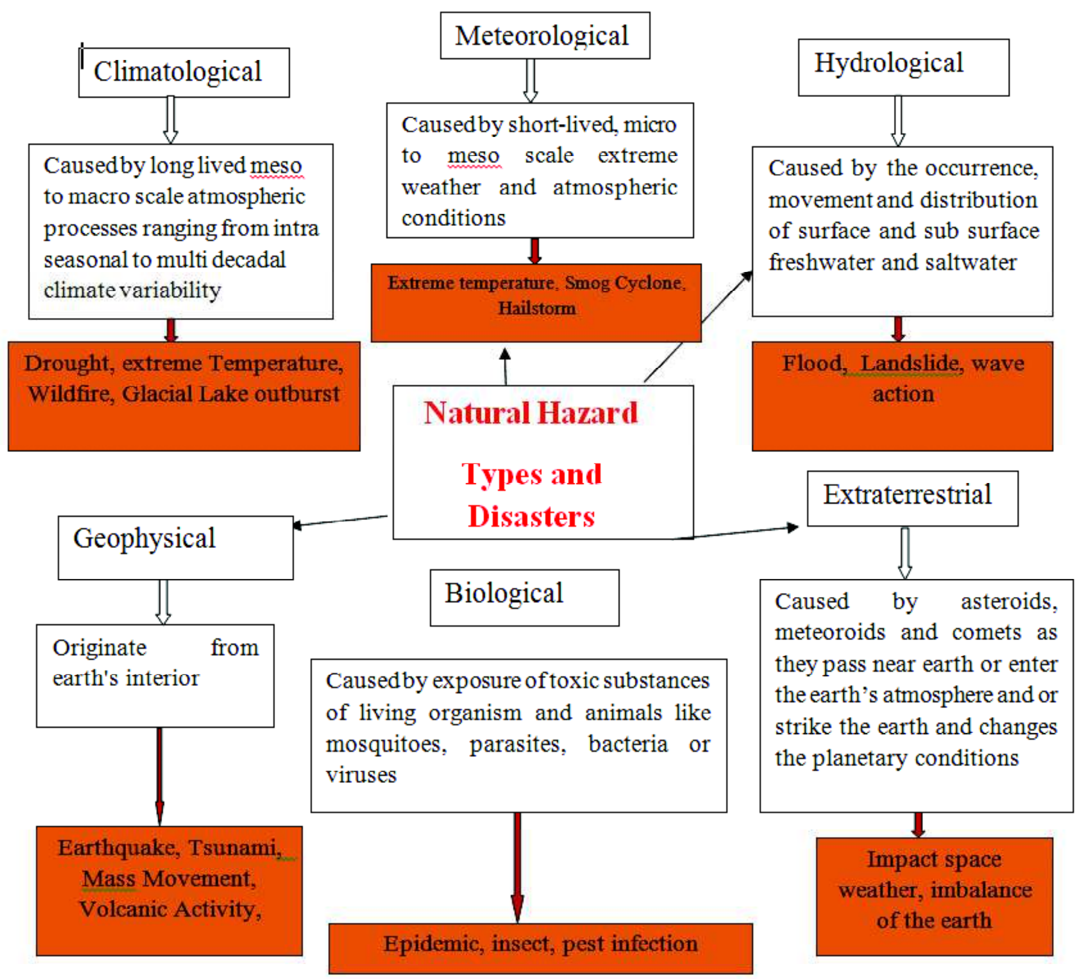
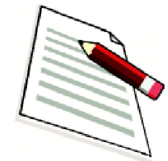



Fig. 13.1 Types of Natural Disaster

## INTEXT QUESTIONS 13.1

1. Deaths and destruction for infrastructures happen in -

   (i)………………………….. (ii)……………………





2. Disaster equation

   (…………………+…………………+……………..…)……………= Disaster

3. Match the following

| Type of natural disaster | Source of natural disaster |
|---|---|
| a) Meteorological | i. Surface and subsurface water - fresh and saltwater |
| b) Hydrological | ii. Outer space material fall of meteoroids and asteroids on earth |
| c) Extra-terrestrial | iii. Living organisms |
| d) Biological | iv. Short lived micro and meso atmospheric conditions |
| e) Geophysical | v. Long lived meso and macro atmospheric processes |
| f) Climatological | vi. Originate from earth's interior |

4. True or false

   a) All disasters cause damage to property and loss of life

   b) People are affected by hazards

   c) Hazards always become a disaster

   d) People enjoy during disaster

## A. Floods

Flood is the rise of water levels which are abnormally high and inundated neighbouring areas. This could be because of heavy precipitation in the river basin, dam failure, rapid snow melts, cloud bursts, glacial lake outbursts, storm surges etc.

Floods are of three types

a) River Floods

b) Flash Floods

c) Coastal Floods

### Causes of flood

The causes of flood are:

(i) Heavy rainfall: Heavy rain in the catchment area of a river causes water rush downstream resulting in flooding in nearby areas.

(ii) Sediment deposition: Siltation in river course causes reduction in capacity to carry water. As a result, the heavy rain waters over flows the river banks.

(iii) Deforestation: Vegetation hampers the quick flow of water and forces it to percolate in the ground. Barren land surface is subject to soil erosion. Obstruction-free surroundings in the catchment area of a channel cause flooding during the rainy season.

(iv) Cyclones: It generates sea waves of abnormal height (storm surges) and causes spreads of water in the adjoining coastal areas.

(v) Interference in drainage system: Drainage congestion caused by badly planned construction of bridges, roads, railway tracks, canals etc. hampers the flow of water and the result is flooding.

(vi) Natural Change in the course of the river: As river changes, it course in inundated new areas

(vii) Tsunami: Large coastal areas are flooded by rising sea water because of underwater earthquakes.

(viii) Dam Failure: due to earthquake or human induced factors dams are damaged and broken causing flooding downstream.

## B. DROUGHT

Drought has economic, environmental and social impacts. In India, around 68% of the country is prone to drought in varying degrees. Area receiving rainfall between 75 cm to 112.5cm is considered drought prone constituting 35% of total area. With rainfall less than 75 cm is chronically drought prone and it covers 33% of the total area of the country.

According to meteorologists the rainfall deficiency during a long period over a large area is called a drought. IMD defines Drought as a situation occurring in any area when mean annual rainfall is less than 75% of the normal rainfall. Some times in Hindi language famine Akal and Anavrishty are also used for drought. Drought can also occur when ground water level is not within reach of agricultural communities. The government also declares drought, if more than 50 percent crop loss happens in an area due to meteorological conditions.

### Causes of Drought

Major cause of drought is scarcity of rain. But humans have interfered in the natural processes by their activities. People have filled up the natural resources like ponds and lakes. They have removed the vegetation cover. Vegetation cover impedes the flow of rainwater and forces it to percolate. Over utilisation of ground water resources through tube wells is drying ground aquifers. Inadequate rainfall changes in local landscape, meteorological, hydrological, agricultural factors cause drought.

### Impact of Drought

Droughts cause scarcity of food and water. People die of hunger, malnutrition and epidemics. Crops fail due to scarcity of water. Cattle are either small nourished or die due to shortage of fodder and water. Farmers are deprived of their employment. People are forced to migrate out of their villages in search of livelihood.

## C. CYCLONES

Cyclones are the centre of low atmospheric pressure. The air pressure increases from the centre to the outer areas. Consequently winds blow from outside to the centre. In cyclones, winds blow in an anticlockwise direction in the northern hemisphere and clockwise in the southern hemisphere. On the basis of their location and physical properties cyclones are of two types; temperate cyclones and tropical cyclones.

Cyclone is a violent circular storm, winds. It is associated with torrential rain, high speed winds and sea surges (water raises). Cyclones play an important role in the general circulation of the atmosphere.

### Occurrence and movement of Cyclones

Cyclones have seasonal cyclic patterns. It originates over the sea surface and dissipates as they reach land. In India, most of the cyclone occurrence is concentrated in the post monsoon season, i.e. from October to December or in the pre-monsoon season from April to May. The lifespan of a cyclone can range between 7 to 14 days from its development to landfall. The cyclone moves forward from east to west in Bay of Bengal with an initial.

Speed of 15 to 30 km per hour. Later on the speed reaches to over 90 KM/hour and in extra cases it goes beyond 250 KM/hour. High sea waves are generated in the sea by speedy cyclonic winds. They strike the coastal areas like high walls of water and flood the areas upto 10-15 km from the coast. The impact can be felt upto 50 kms inland. The cyclone that struck Odisha originated near Andaman & Nicobar Islands and reached Orissa on 29-10-1999 after many days. The movement of a cyclone in a direction is like the movement of a spinning top.

**Impacts of cyclones and floods**

(i) Damage to build up structures: The violent winds of a cyclone destroy whatever comes in their way from; thatched huts to the palaces, houses, forts, lines of electricity and communication.

(ii) Natural Habitat: High speed winds cause damage to vegetation. Trees are uprooted. Salt water intrudes in coastal areas leaving the soil infertile.

(iii) Floods: Torrential rain causes floods. Floods wreak havoc all around.

## D. Landslides

The youngest and the highest Himalayan fold mountain chain is the crown of our country. The Indian Plate is moving in a northward direction causing stress on the rocks making them weak and prone to landslides. Landslides take place in the form of earth flows, debris flows and rock falls.

The slipping of masses of rocks, earth or debris downwards on the mountain slopes or banks of the rivers is called a landslide. Landslides occur when shear stress along the slope exceeds frictional force. It results in a landslide and gravitational force brightens the rock material down the slope. The occurrence of landslides in mountainous areas is increasing day by day.

Landslides are intensified by rain, earthquakes, volcanic eruption, deforestation and slope failure.

### Causes of Landslides

i. Heavy rain: Heavy rain is the main cause of landslides.

ii. Deforestation: Deforestation is another major cause of landslides. Mountain slopes lose their protective cover by felling of trees. The rain water flows on such slopes with unimpeded speed causing landslides of barren slope fronts.

iii. Earthquakes and Volcanic Eruption: Tremors destabilise the mountains and the rocks tumble downwards. Volcanic eruptions also trigger landslides in the mountainous areas.

iv. Building of roads: During the process of the construction of roads, a large amount of rocks and debris has to be removed by blasting. This process dislodges the rock structure and changes the angle of slopes. Consequently landslides are triggered.

v. Shifting Agriculture and Irrigation Networks: In the North Eastern part of India, the number and frequency of landslides has increased due to the practice of shifting agriculture.

vi. Tourism, infrastructure, construction and increasing settlement sizes in fragile mountain ecosystems increases instances of landslides.

### Impact of landslides

(i) Landslides are degrading the environment and natural beauty of mountains.

(ii) Sources of water are drying up.

(iii) Flooding in rivers is increasing due to debris flow from deposits brought by landslides.

(iv) Roads get blocked; power and communication lines get disrupted.

(v) Life and structural property loss.

## E. EARTHQUAKE

Earthquakes can occur at any time. Its impact is very sudden. There are no warning signs of earthquakes. Earthquake is sudden shaking or trembling of the earth surface caused by passage of seismic waves. Most earthquakes are minor tremors. Larger earthquakes usually begin with slight tremors but suddenly they turn into violent shocks and after that they diminish. Tremors or shocks are felt for a few seconds only.

In spite of extensive research, it is not possible to forecast or predict earthquakes. INSAR (Interferometry Synthetic Aperture Radars) are used in certain earthquake prone areas but they can only predict just a few seconds before an earthquake strikes.

### Impact of Earthquakes

**(i)** **Damage of Property:** When an earthquake occurs, buildings from cottages to palaces and skyscrapers are subject to damage. Underground pipelines and railway lines are damaged or broken. Dams on river collapse, resultant floods cause havoc. The earthquake in 1967 in Koyna damaged the Dam.

**(ii)** **Human Loss -** Normally the duration of earthquake tremors is only a few seconds, but thousands of people may die in this short period. The Bihar earthquake of 1934 killed 10,000 people and the Kangra earthquake of 1905 caused 20,000 people dead. Numerous people lost their shelter and many became orphans. The earthquake that occurred in Gujarat on 26 January 2001 was devastating. More than 25,000 people died due to the impact of this earthquake. The destruction of property was tremendous.

**(iii)** **Changes in River Courses:** Sometimes river channels are blocked or their courses are changed due to the impact of an earthquake.

**(iv)** **Tsunamis:** are caused by underwater earthquakes which trigger very high sea waves over the coastal areas. It wreaks havoc on settlements of coastal areas. It sinks large ships. Tsunami that occurred on 26-12-2004 near the coast of Sumatra (Indonesia) damaged property worth billions of rupees. More than two lakh people lost their lives in Southeast Asia, India and Sri Lanka.

**(v)** **Fountains of Mud:** Due to the intense impact of the earthquake, water and mud appear on the surface and take the form of fountains. It leads to spreading sand on agricultural land and making it infertile.

**(vi)** **Cracks and Fissures:** Sometimes cracks and fissures develop in roads, railway tracks, and fields.

(vii) Landslides and avalanches are triggered by earthquakes

## INTEXT QUESTIONS 13.2

1. Name the types of floods.

   (i) ……………………. (ii) …………………..(iii)……………..

2. Fill in the blanks

   a) Flood caused due to dam failure is because of ..............or ………………

   b) The movement of wind in cyclones is …………….. in Northern Hemisphere and ………………in Southern hemisphere

   c) Droughts are called ………………and ……………..in Hindi.

   d) Droughts cause scarcity of …… and………

3. Define landslide.

4. What is caused by underwater earthquakes?

5 True and False

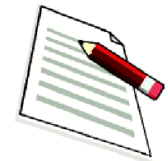
   a) Calm centre of a cyclone is called "eye" of the storm

   b) Heavy rainfall is one of major cause of flooding

   c) It is easy to predict earthquakes

   d) Chronic drought prone areas receive less than 75 cms of rainfall

   e) Shifting agriculture reduces landslides



Notes

## 13.3 DISASTER RISK

Risk is the potential disaster which causes losses of lives, properties and infrastructures. It is dependent upon the situation of danger (hazard). Physical, socioeconomic and environmental coping capacity (vulnerability) and the quality of structures the community has exposure to. Hence a common overlapping of these three is called risk.

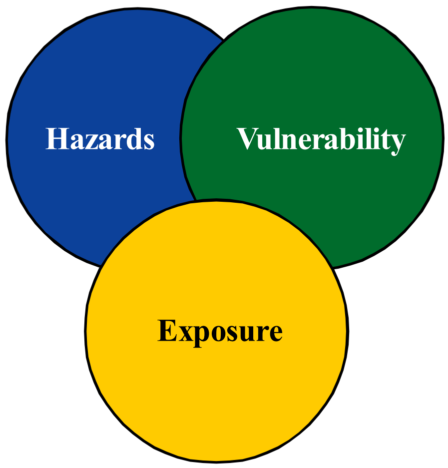



Fig. 13.2 Identification of Risk

A single disaster has a different impact on different people in the society. Poor people have less capacity to cope with the disaster in comparison to rich people. Because poor people have less strong houses constructed in low economic zones, situated in low lying areas with less economic power. All are making them more vulnerable to any disaster. They are more exposed to nature and subject to risk. On the other hand, the reverse is the case with rich people. Therefore risk is determined by hazard, vulnerability and exposure of the people to the disaster.

## 13.4 NATURAL DISASTERS PRONE AREA IN INDIA

India has a unique geo- climate, physiographic and socio- economic conditions. The country is vulnerable to droughts, floods, cyclones, landslides, earthquakes, avalanches, forest fires etc. Out of 28 states and 8 Union territories 27 of them are disaster prone. Almost 68% of cultivable area is prone to droughts; 58.6% of land is prone to earthquakes of moderate to severe intensity; 12% vulnerable to floods 76% of the total coastal length is prone to cyclones and tsunamis; around 8% of greater Himalayas and middle Himalayas is vulnerable to avalanches during winter months around 15% forest areas experience forest fires during dry season.

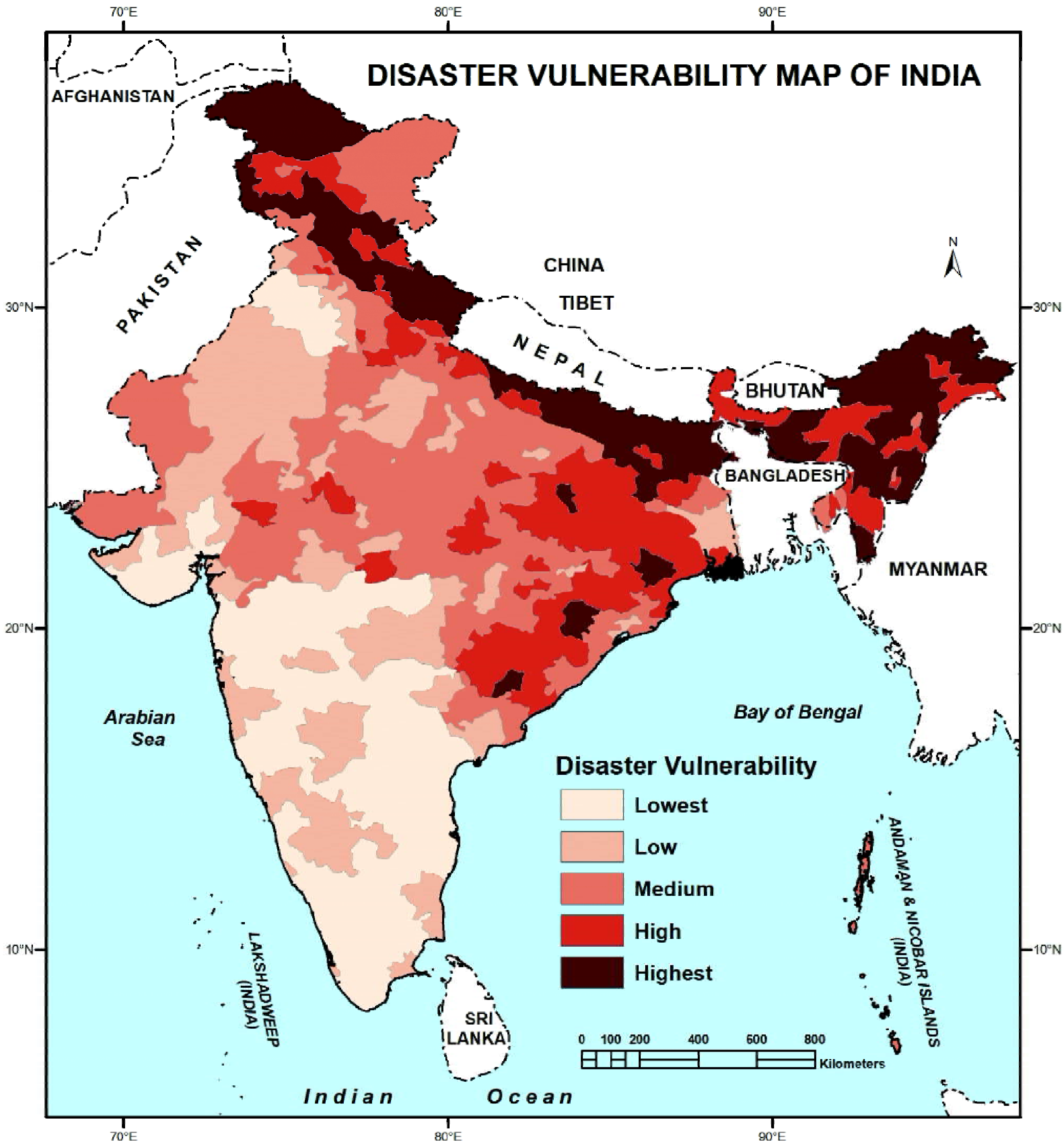



Fig 13.3 Disaster Vulnerability Map of India

India is one of the ten most disaster prone countries of the world. The country is prone to disasters due to a number of factors; both natural and human induced. The Himalayan region is prone to disasters like earthquakes and landslides The geo-tectonic features of the Himalayan region and adjacent alluvial plains make the region susceptible to earthquakes, landslides, water erosion, etc.

The plain is affected by floods almost every year. Major rivers bring a huge quantity of sediment load and choke the river bed. Water carrying capacity is reduced and flooding becomes a regular feature. The desert part of the country is affected by droughts. The western part of Rajasthan, Gujarat and some parts of Maharashtra are hit very frequently by drought. The coastal zone is susceptible to cyclones. The Geo-tectonic movements going on in the ocean floor make the coastal region prone to tsunami disaster too.

Notes

## A. Drought prone areas of India

Study the map carefully given below (Fig 6). There is a Major region between South Rajasthan and Tamil Nadu that is drought prone. It includes west Rajasthan, Gujarat, West Madhya Pradesh, central Maharashtra, Karnataka and Tamil Nadu. Due to deficiency in monsoon rainfall and environmental degradation, Rajasthan and Gujarat are generally affected by drought. Out of 640 districts (2011 census) 283 districts are in the rain-deficient category. They are drought prone districts according to the India Meteorological Department.

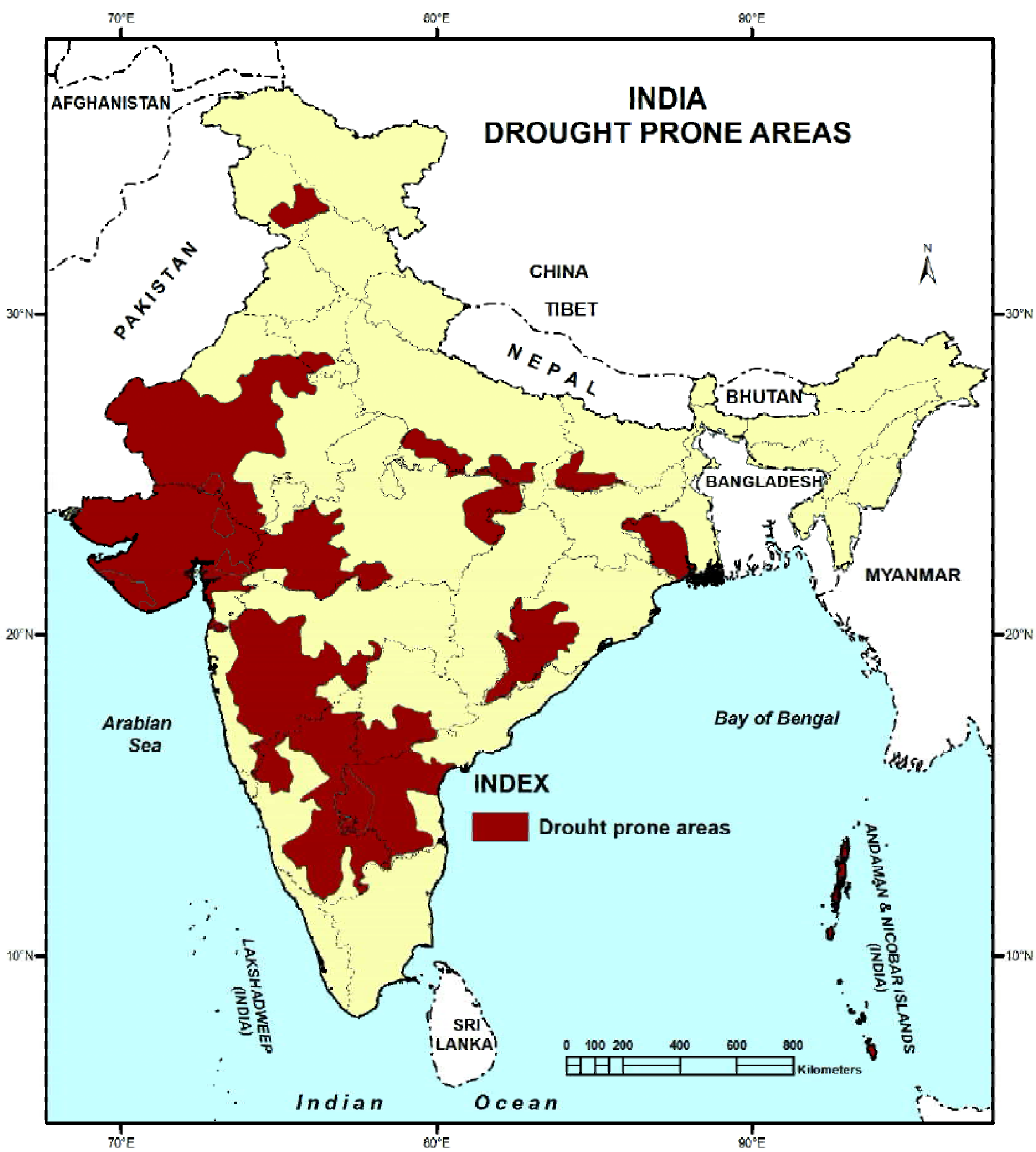



Fig 13.4 Drought Prone Areas

## B. Flood Prone Areas

At present, about 12% of the country is assessed to be flood prone. Out of total damage by floods to crops and property about 75% occurs in northern plains and eastern India drained by Ganga, Brahmaputra and their tributaries. Uttar Pradesh, Bihar and Assam are chronically flood prone followed by Haryana, Punjab and Andhra Pradesh. Recently Rajasthan and Gujarat also feel the fury of floods. Karnataka and Maharashtra are no-longer immune to floods. Most recently added to the list are former Jammu & Kashmir (Kashmir floods of 2014) and Tamil Nadu (Chennai floods of 2015).

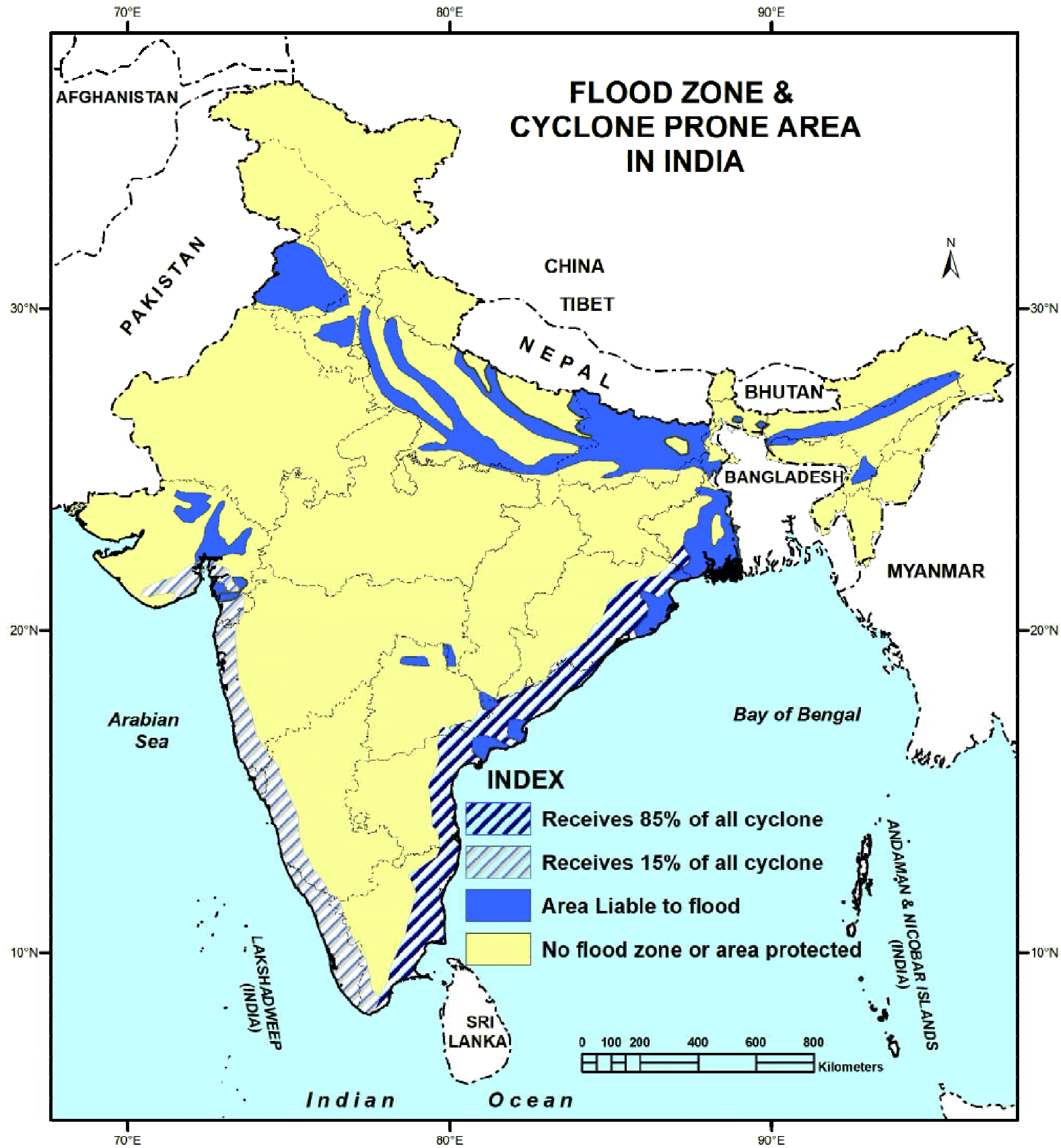



Fig. 13.5 Flood and Cyclone Prone Area

### C. Cyclone Prone Areas

The eastern coast of India is the most cyclone affected region. On an average out of 100 cyclones 85 strike the east coast of India whereas the west coast receives only 15. The cyclone prone states are West Bengal, Odisha, Andhra Pradesh and Tamil Nadu. Western coast is affected by the cyclones which originate in the Arabian Sea. Gujarat is most affected on the west coast.

### D. Landslide Prone Areas

Landslides come under hydro-geological hazards. The Himalayas, Northeastern Hills and Western Ghats, experience landslides especially in monsoon month. The landslides are a common feature in Western Ghats and Konkan hills (Kerala, Tamil Nadu, Karnataka, Goa and Maharashtra). The North West Himalayas (Jammu & Kashmir, Himachal Pradesh, Uttarakhand) and North East Himalayas Sikkim West Bengal Mizoram, Tripura, Meghalaya, Assam, Nagaland and Arunachal Pradesh experience chronic landslide problems. They are most vulnerable and bear the brunt of landslides. They are the cause of recurring economic and human losses.

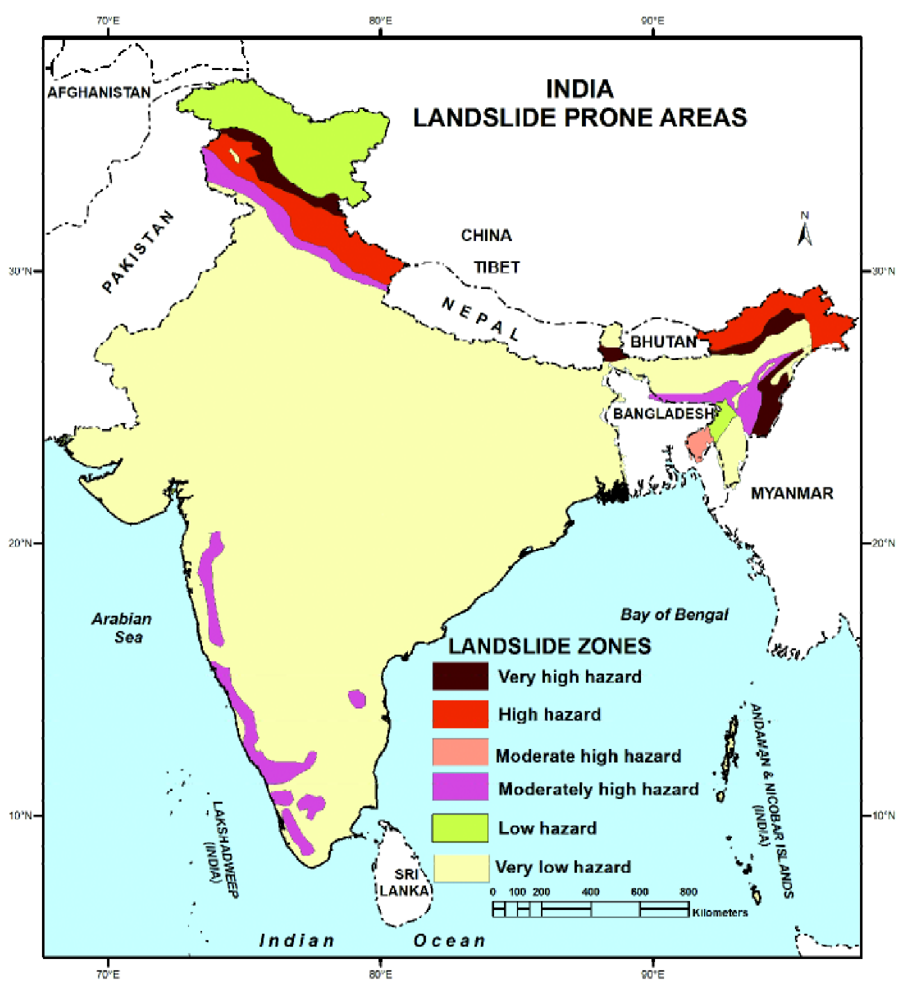



Fig. 13.6 Landslide Prone Area

Notes

### E. Earthquake Prone Areas

Earthquakes are generated due to internal processes of the earth. Primarily, it is caused by earth movements. Depending upon the internal activities, its distribution is clearly marked by spatial patterns. Server earthquakes are associated with plate tectonics and plate boundaries. With increasing distance, its intercity keeps on reducing. Based on the intensity of the earthquakes, India is divided into four seismic Zones. They are;

- Zone - V Highest risk of damage - The area includes northeastern India, parts of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Rann of Kutch in Gujarat, part of North Bihar and Andaman & Nicobar Islands).
- Zone - IV High damage risk - the area includes some parts of Jammu and Kashmir and Himachal Pradesh, National Capital Territory (NCT) of Delhi, Sikkim, northern parts of Uttar Pradesh, Bihar and West Bengal, parts of Gujarat and Maharashtra.
- Zone -III Moderate damage risk - The area includes Kerala, Goa, Lakshadweep islands, southern parts of Uttar Pradesh, Gujarat and West Bengal, parts of Punjab, Rajasthan, Madhya Pradesh, Bihar, Jharkhand, Chhattisgarh, Maharashtra, Orissa, Andhra Pradesh, Tamil Nadu and Karnataka.
- Zone - II Low damage risk - the area includes remaining parts of the country.

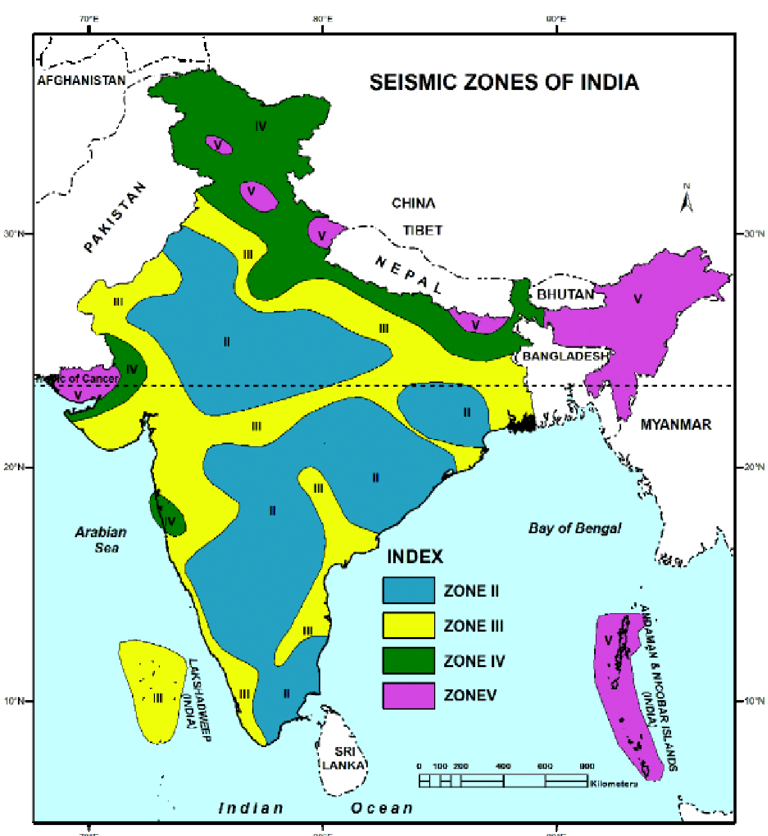



Fig. 13. 7 Earthquake Prone Areas

## INTEXT QUESTIONS 13.3

1. Match the following

| | Disaster | | Area affected in percent |
|---|---|---|---|
| 1 | Drought prone | A | 58.6 % land area |
| 2 | Earthquake prone | B | 8% land area |
| 3 | Floods prone | C | 68 % land area |
| 4 | Avalanche prone | D | 15% land area |
| 5 | Forest fire prone | E | 12% land area |

2. East coast of India witness .................. of total cyclones along Indian coast.

3. At present ...................... of the total land area of the country is assessed to be flood prone.

4. Out of 640 districts (2011 census) .................districts in the country currently fall in the rain-deficient category.

## 13.5 CONCEPTS OF DISASTER MANAGEMENT

Disaster management includes various activities for avoiding or reducing ill effects of disaster. It also helps in providing better recovery, bringing normally after disaster as well as preparing for disaster too. All government, non-governmental and community-based organisations play vital roles in the process. It now includes pre-disaster planning and preparedness activities, organisational planning, training, information management and public relations. Disaster management includes precaution, mitigation, preparedness, response, recovery and reconstruction.

| Pre-disaster | During -disaster | Post-disaster |
|---|---|---|
| Preparedness | Response | Response |
| Prevention | Relief | Recovery |
| Mitigation | | Reconstruction |

1. **Disaster Preparedness :** It is a set of measures adopted well in advance for response and to cope with disaster in a better way. Its prime concern is to reduce the loss of human life and property.

2. **Disaster Prevention :** Avoidance of ill impact of disaster is termed as prevention of disaster. It is quite obvious that complete avoidance of any disaster is not possible but it could be minimised. Its compounding effects could be avoided/prevented by building the capacity of individual/society or community.

3. **Disaster Mitigation :** It is the reduction of harmful effects of disasters. It refers to ongoing efforts at different levels starting from individual, local community, to state and national. It includes hazard and disaster mapping and zonation building specific plans for disasters in certain areas prone to it execution of the plan in needed hours is very important for mitigation.

4. **Disaster Relief :** It is immediate help and support made available to affected people. It is of great importance to minimise suffering and extend basic minimum needs to support life. It includes providing food, water, shelter and medical care.

5. **Disaster Response :** It refers to the action taken up immediately after the disaster happened. This includes many efforts like rescue, establishment of marginal health care, treating injured supplying eatables, shifting people to safe places etc. the first and immediate response is generally provided by local youths, volunteers and later on, the action of district, state or local level help arrives.

6. **Recovery after Disaster:** It refers to providing help to affected people in a shortest possible time. It depends upon the ability of the organisation/efforts taken by the NGOs district state or national level disaster management authority

7. **Disaster Reconstruction :** it refers to the construction of a situation again after its destabilisation/imbalance due to disaster. It involves partial or complete relocation and reestablishment of essential infrastructures and shelter. It helps in reducing the trauma to some extent, especially related to physical facilities needed for infected people.

## INTEXT QUESTIONS 13.4

1. Name any five disaster management activities.
2. What are three stages of Disasters.

## 13.6 MANAGEMENT AND MITIGATION OF MAJOR NATURAL DISASTERS IN INDIA

**Disaster** **Mitigation and Management of Disasters**

**Floods** (i) **Reservoirs:** By constructing reservoirs in the course of rivers could store extra water at the time of flood.

(ii) **Embankments:** By building flood protection embankments, flood water can be controlled from overflowing the banks and spreading in nearby areas.

(iii) **Afforestation:** The fury of flood could be minimised by planting trees in catchment areas of rivers.

Some important precautions:

- Avoid building houses in flood prone areas unless you elevate and reinforce your home.
- Elevate the furnace, water heater, and electric panel if susceptible to flooding.
- Install "Check Valves" in the sewer to prevent backing floodwater.
- Contact community or government officials to find out if they are planning to construct levees or floodwalls.
- Seal the walls in your basement with waterproofing.
- Listen to the radio or television for information.
- Be aware of flash flooding. If there is any possibility of flood, move immediately to higher ground.
- Be aware of streams, drainage channels and other areas known to flood suddenly.
- Secure your home. If you have time, shift outdoor furniture and essential items to the upper floor.
- Disconnect electrical appliances. Do not touch electrical equipment if you are wet or standing in water.
- Do not walk through running water.
- Do not drive into flooded areas. If floodwaters rise around your car, abandon the car and move to higher ground.

**Droughts** (i) **Suitable farming methods for arid areas:** Production of coarse and hardy cereals; conservation of soil moisture by deep ploughing, storing water behind small dams, collecting water in ponds and tanks and use of sprinklers for irrigation.

(ii) **Sowing drought resistant crops:** By sowing drought resistant crops like cotton, moong, pearl millet, wheat etc, the impact of drought could be minimised to a certain extent.

**(iii) Rain water harvesting:** Collection of each and every drop of rain could help in coping with the drought.

(iv) Making high bunds around the fields, planting trees on the bunds of fields, the use of rainwater can be maximised.

(v) Irrigation canal construction with mortar and bricks

(vi) Small quantity of water can irrigate a comparatively larger area by using a drip irrigation method.

**Landslide**

- Database of vulnerable sites and location
- Awareness and development of both indigenous and modern methods
- Detailed landslide hazard zonation mapping
- Afforestation : Trees and brushes help in binding the soil particles.
- Ban on quarrying of stones and mining of minerals in fragile areas
- Permanent crops like orchards of fruits should replace the seasonal or annual crops.
- Retaining walls can be built on mountain slopes.
- Ban construction activities in landslide prone areas/spots.

**Earthquake**

- Analysis of seismic risk and its zonation;
- Design and construction of earthquake resistant structures.
- Retrofitting of existing structures strengthening them.
- Earthquake insurance for houses to reduce the economic impact on individuals.
- Installation of seismological observations for monitoring seismic activity.

**Cyclones**

- Check the house; secure loose tiles and carry out repairs of doors and windows
- Remove dead branches or dying trees close to houses;
- Fixing of removable objects such as lumber piles, loose tin sheets, loose bricks, garbage cans, sign-boards etc.

- Keep some wooden boards ready so that glass windows can be boarded if needed
- Keep a cyclone lantern filled with kerosene, battery operated torches and enough dry cells
- Demolish condemned buildings
- Keep some extra batteries for transistors
- Keep some dry non-perishable food always ready for use in emergency
- Listen to the radio for weather warnings.
- Keep monitoring the warnings. This will help you prepare for a cyclone emergency.
- Pass the information to others.
- Believe in the official information
- When a cyclone alert is on for your area, stay alert to the warnings.

## INTEXT QUESTION 13.5

1. Write major plans and programmes adopted by government of India to control floods
2. Landslide Hazard Zonation -micro zonation on ………………….. scale
3. Give three main measures adopted to control floods.

## 13.7 NATIONAL AND INTERNATIONAL INITIATIVES FOR DISASTER RISK REDUCTION

In 2005 the Indian government took its first major initiatives known as Disaster Management Act-2005. Later on, it is National Disaster Management Policy-2009 and National Disaster Management Plan-2016.

### New Directions for Disaster Management in India

- A National Disaster Mitigation Fund will be administered by the National Disaster Management Authority (NDMA). States and districts will administer mitigation funds.
- A National Disaster Response Fund will be administered by NDMA through the National Executive Committee. States and Districts will administer state Disaster Response Fund and Disaster Response Fund respectively.

Notes

- 8 Battalions of the National Disaster Response Force (NDRF) are being trained and deployed with CSSR and MFR equipment and tools in eight strategic locations. National Institute of Disaster Management (NIDM) is a national level training institute which trains professional, educationalist, government organisations, school and college students.
- A National Disaster Management Policy and National Disaster Response Plan will also be drawn up.
- Strengthening of State Disaster Management Authorities (SDMAs) and District Disaster Management Authorities (DDMAs)

**Future Directions**

- Encourage and consolidate knowledge networks.
- Aapda Mitra Scheme
- Mobilise and train disaster volunteers for more effective preparedness, mitigation and response (NSS, NCC Scouts and Guides, Civil Defense, Home Guards).
- Increased capacity building leads to faster vulnerability reduction.
- Learn from best practices in disaster preparedness, mitigation and disaster response.

The Sendai Framework for disaster risk reduction (2015-30) was adopted at the 3rd United Nations World Conference on Disaster Risk Reduction (WCDRR) on 18th March, 2015 at Sendai, Japan. It was the successor to Hyogo Framework for Action (HFA) 2005-15- Building the Resilience of Nations and Communities to Disasters.

The framework outlines four priorities for action to prevent new and reduce the existing disaster risk.

(i) Priority 1: Understanding disaster risk

(ii) Priority 2: Strengthening disaster risk governance to manage disaster risk

(iii) Priority 3: Investing in disaster risk reduction for resilience

(iv) Priority 4 : Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction

The framework recognizes the primary role to reduce disaster risk is with the state but the responsibility should be shared with other stakeholders including private sector and local government with other stakeholders. It focuses on taking measures addressing three dimensions of disaster risk to prevent. They are (a) creation of new risks and vulnerabilities, (b) reduction of the existing risks and (c) enhancing resilience.

The Sendai Framework monitors 38 indicators towards Seven global targets through online tools that collect self-reports by member countries. Seven global targets for guidance to assess progress are.

- Substantially reduce global disaster mortality by 2030, aiming to lower average per 100,000 global mortality between 2020-2030 compared to 2005-2015.
- Substantially reduce the number of affected people globally by 2030, aiming to lower the average global figure per 100,000 between 2020-2030 compared to 2005-2015.
- Reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030.
- Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030.
- Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020.
- Substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of this framework by 2030.
- Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030.

The purpose is to provide multi-hazard management of disaster risk in development at all levels across all sectors and within. The aim is to achieve substantial reduction of disaster risk.

To prevent new and reduce existing disaster risk by implementation of integrated and inclusive structural, economic, social, health, legal, cultural, educational, environmental, political, technological and institutional measures. They prevent and reduce hazard exposure and vulnerability to disaster, increase recovery and preparedness for response towards disasters. In this way strengthening in resilience is aimed at.

## INTEXT QUESTIONS 13.6

1. Write the full form of the abbreviations-

   a) NDMA-

   b) NDRF-

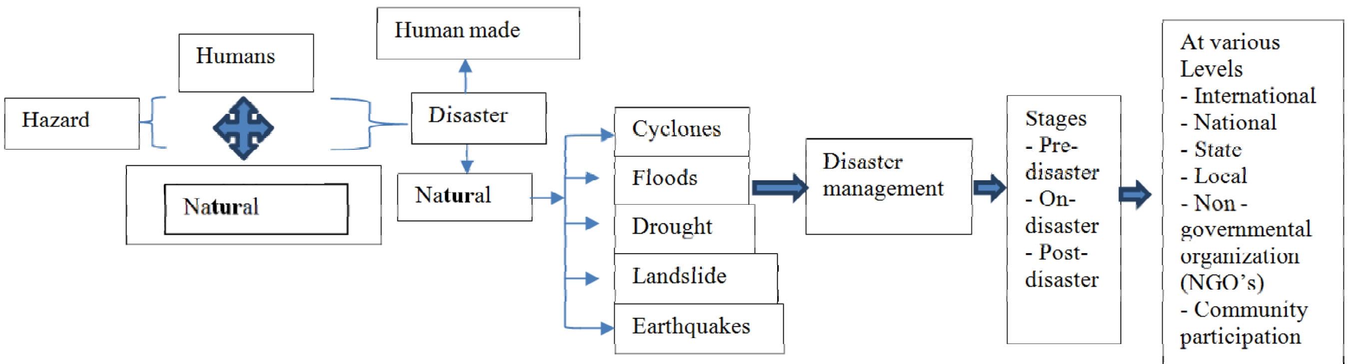
c) SDMA's-

d) DDMA's-

e) WCDRR-

f) NIDM-

## WHAT YOU HAVE LEARNT




## TERMINAL QUESTIONS

1. Differentiate between Hazard and disaster
2. Identify various types of Disaster and their causes with help of flow chart
3. Briefly explain the initiatives taken by the Indian government in the field of Disaster management.
4. What are practices involved in managing following disasters? Explain in detail.
   - Flood
   - Earthquake
   - Cyclone
   - Landslides
   - Droughts
5. Identify Flood Disaster-prone areas in India, also distribution on map of India.
6. Identify Drought Disaster-prone areas in India.
7. Identify Earthquake Disaster-prone areas in India.

8. Identify Cyclone Disaster-prone areas in India.
9. Identify Landslide Disaster-prone areas in India.
10. On the map of India show Levels of Disaster vulnerability.
11. Explain in detail three stages of Disaster Management.
12. Elaborate on Sendai Framework on Disaster Risk Reduction.

## ANSWERS TO INTEXT QUESTIONS

**13.1**

1. (i) natural (ii) human-made
2. Natural Hazard Vulnerability Risk)/ Capacity= DISASTER
3.

| | Type | Source |
|---|---|---|
| a) | Meteorological | Short lived micro and meso atmospheric conditions |
| b) | Hydrological | Surface and subsurface water - fresh and saltwater |
| c) | Extra-terrestrial | Outer space material fall of meteoroids and asteroids on earth |
| d) | Biological | Living organisms |
| e) | Geophysical | Originate from earth's interior |
| f) | Climatological | Long lived meso and macro atmospheric processes |

4. a) True

   b) False

c) False

d) False

**13.2**

1. (i) River (ii) Flash (iii) Coastal
2. Fill in the blanks

Notes

a) Flood caused due to dam failure is because of Earthquake or human induced

b) The movement of wind in cyclones is anti- clockwise in Northern Hemisphere and clockwise in Southern hemisphere

c) Droughts are called Akal and Anavrishty in Hindi

d) Droughts cause scarcity of food and water.

3. The slipping of masses of rocks, earth or debris downwards on the mountain slopes or banks of the rivers is called a landslide.

4. Tsunamis

5 True and False

a) True

b) True

c) False

d) True

e) False

**13.3**

1. Match the following

| S. no | Disaster | Area affected in percent |
|---|---|---|
| 1 | Drought | 68 % land area |
| 2 | Earthquake | 58.6 % land area |
| 3 | Floods | 12% land area |
| 4 | Landslide and avalanche | 15% land area |
| 5 | Cyclone and tsunami | 8% land area |

2. 85%

3. 12%

4. 283 districts

**13.4**

1. Disaster management includes-
   - (i) Prevention,
   - (ii) Mitigation,
   - (iii) Preparedness,
   - (iv) Response
   - (v) Recovery and
   - (vi) Rehabilitation. (any five)
2. Three stages of Disasters
   - (i) Pre- Disaster
   - (ii) On- Disaster
   - (iii) Post- Disaster

**13.5**

1. Major plans and programmes adopted by government of India to control floods
   - a) River Management Activities and Works related to Border Areas (RMBA)
   - b) National Flood Commission
   - c) National Commission for water resources
   - d) National water policy 2012
2. Landslide Hazard Zonation -micro zonation on 1:10,000 scale
3. Three main measures adopted to control floods and also useful in cyclone prone areas
   - a) Reservoirs
   - b) Embankments
   - c) Afforestation

**13.6**

1. Write the full form of the abbreviations

*Notes*

a) NDMA- National Disaster Management Authority

b) NDRF- National Disaster Response Force

c) SDMA's- State Disaster Management Authorities

d) DDMA's- District Disaster Management Authorities

e) WCDRR- World Conference on Disaster Risk Reduction

f) NIDM- National Institute Disaster Management

# GEOGRAPHY
# SENIOR SECONDARY COURSE
# CURRICULUM

## Introduction

Geography is the study of description of the earth's surface. It studies the relationship between human and their environment and their spatial variations in this relationship. One side it's related to natural phenomenon and other side it's related to human activity and their implications on the environment. It also studies the spatial changes. These changes may be seen at the same place over a period of time. It is known as temporal variation. Certain scientific reasons are the driving force for these phenomena. The whole of the earth may be studied with respect to certain component. The distribution of that component may be explained by general principles. The nature and scope of the study of geography is very diverse and evolving. These components may be varied like earth, water, air, climate, soil, vegetation, environment or life for global study.

### Rationale

Geography is introduced as an independent subject at Senior Secondary level. Prior to this, a component of geography is a part of environmental studies till primary level and part of social sciences at secondary level. Being the entry point for higher and professional education, learners choose geography for various purposes. These purposes may broadly be divided as academic interest (i.e. higher studies, research, teaching etc.) and vocational interest (i.e. Cartographer, Regional Planners, GIS & Remote Sensing Specialist, Demographers, Environmentalist, Disaster Management specialist, Sustainable Development planner etc.). Therefore, there is a need for providing a broad understanding about the subject. Apart from this, geography is also very useful for day-to-day life. Its contributions lie in the contents, cognitive processes, skills and values that geography promotes and thus helps the learners explore, understand and evaluate the environmental and social dimensions of the world.

Geography is also known as an integrated science. This is the only discipline which acts as a link between social sciences and physical sciences. The former includes contents from economics, history, political science, sociology, anthropology, commerce etc. whereas the latter includes geology, botany, geo-physics, oceanography, climatology etc.

Keeping in view the fact that NIOS, draws its learners from a widely diversified group-age wise, socio-economically as well as educationally, the course has to be so designed that it is meaningful and relevant to a majority of learners.

## Objectives

After completing this course, the learner will be able to:

- explain the terms, key concepts and basic principles of geography;
- explore the processes and patterns of the spatial arrangements of the natural as well as human phenomena;
- explain the complex relationship that exists between physical and human environment;
- apply geographical knowledge and methods of enquiry to emerging issues and problems at different levels - local, regional, national and global;
- develop an understanding of diverse physical resource base, economic activities and regional inequalities in India;
- summarize the concept of unity in diversity in India and its demographic structure;
- recognize the spirit and purpose of geography as a discipline in the modern world;
- analyse contemporary issues and challenges and their impact on society;
- demonstrates various concepts through Poster, Role play, story, debate, etc; and
- interpret the data in spatial perspective with appropriate maps and diagrams

## Eligibility conditions

**Age:** 15 Years

**Qualification:** 10th pass

**Medium of instruction:** Hindi, English, Urdu, Bengali, Gujarati and Odia mediums.

**Duration of the course:** 1 Year

**Weightage**

**Theory:** 80 Marks

**Practical:** 20 Marks

**Tutor Marked Assignments (TMA):** 20% Marks of theory

## COURSE CONTENT

| No. and Title of the Module/Lesson | | Weigh-tage | Study Hrs | Content description | Learning Outcomes |
|---|---|---|---|---|---|
| **I.** | **The study of Geography as a discipline** | 2 | 4 | | |
| | 1. Nature and as ansubject matter of Geography | | | Definition, nature, scope, relationship with other subjects, approaches in geography, evolution of geography in the world and India, recent trends and job opportunities in geography. | ● explain geography integrating discipline,<br>● identify the development in geography discipline through time and space,<br>● elaborate the prevailing geographical themes, and<br>● explain the development of world geography in general and Indian geography in particular. |
| **II.** | **Dynamic and Geomorphic Processes of the Earth** | 10 | 22 | | |
| | 2. Endogenic Forces | | | Earth's interior, Endogenic and exogenic forces, continental drift theory, plate tectonic, fold and fault, Volcano and earthquake. | ● identify endogenic forces shaping the earth,<br>● distinguish between slow and sudden movements,<br>● differentiate |

| | | | | |
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| | | | | between vertical and horizontal movements and their resultant features, and<br>● explain the causes of occurrence and spatial distribution of volcanoes and earthquakes. |
| 3. Exogenic Forces and their resultant landforms | | | Mountains, plateaus and plains- types and economic significance, Geomorphic processes- aggradational and degradational. | ● identify exogenic forces shaping the earth surface,<br>● describe weathering and gradation and their effects on landforms,<br>● differentiate between aggradational and degradational agents,<br>● classify mountains, plateaus and plains, and<br>● elaborate the economic significance of major landforms. |
| 4. Running water, moving ice, wind and sea waves | | | Weathering, denudation, erosional and depositional landforms formed by Running water, moving ice, wind and sea waves and their significance. | ● describe various erosional and depositional relief features evolved by running waters and moving ice, |

| | | | | |
|---|---|---|---|---|
| | | | | ● describe various erosional and depositional relief features evolved by wind and sea waves and<br>● explain significance of running water, moving ice, wind and sea waves for humans. |
| **III. The domain of the water on the earth** | 6 | 12 | | |
| 5. Hydrological Cycle and Ocean | | | Hydrological cycle, water budget, ocean relief, temperature and salinity, waves, tides and currents | ● explain the importance of oceans, the hydrological cycle and water budget on the earth<br>● differentiate various relief features<br>● analyse the vertical and horizontal distribution of temperature and salinity and its determining factors<br>● describe the three types of ocean movements - waves, tides and ocean currents |
| **IV. Dynamics of Atmosphere** | 10 | 24 | | |
| 6. Structure and | | | Structure and composition, | ● identify the layers |

| | | | | |
|---|---|---|---|---|
| composition; Insolation | | | insolation, distribution of temperature and heat budget | of atmosphere<br>● describe the composition of atmosphere<br>● explain the factors influencing insolation and its horizontal distribution<br>● describe the heat budget with the help of diagram |
| 7. Atmospheric pressure and winds | | | Atmospheric pressure, factors affecting atmospheric pressure, pressure belts, planetary and local winds | ● define atmospheric pressure<br>● explain factors affecting atmospheric pressure<br>● describe atmospheric pressure belts<br>● distinguish between planetary and local winds |
| 8. Humidity and precipitation | | | Humidity- types and measure; precipitation- types and measure; rainfall- types and global distribution | ● distinguish between absolute and relative humidity<br>● explain evaporation, condensation and precipitation<br>● describe various forms of precipitation<br>● explain types of rainfall |

| | | | | |
|---|---|---|---|---|
| 9. Climate and Climate Change | | | Climate, climatic regions, climate change- causes and consequences, Global initiati ves- IPCC and Paris Climate Agreement | ● describe climatic regions of the world<br>● describe factors causing climate change<br>● explain the impact of climate change<br>● describe global initiatives of Paris Climate Agreement |
| **V. Biogeography and Biodiversity** | 4 | 8 | | |
| 10. Biosphere, Biomes and Biodiversity | | | Biosphere and biomes, major biomes of the world and their characteristics, biodiversity and its conservation | ● classify Biomes of the world.<br>● locate Biomes on the world map and compare their characteristics.<br>● identifies causes and loss of biodiversity<br>● explain various conservation measures and global initiatives. |
| **VI. Physical Geography of India** | 10 | 20 | | |
| 11. Physical Settings | | | Location and extent, major physiographic divisions and their characteristics, drainage system, unity in diversity | ● locate India in terms of neighbouring countries;<br>● describe major physiographic divisions and their salient features; |

| | | | | |
|---|---|---|---|---|
| | | | | ● describe the drainage system and<br>● explain unity in diversity in India. |
| 12.. Climate | | | Climates of India, monsoon: mechanism and its significance, El-Nino and La-Nina, Major seasons, distributional patterns of temperature and rainfall, major climatic regions | ● describe the factors that influence the climate;<br>● explain the mechanism of monsoon and its significance in Indian economy;<br>● becomes familiar with the seasons; and<br>● describe the distributional patterns of temperature and rainfall. |
| 13. Natural Hazards and Disasters | | | Hazards and disaster, types of disaster, major disaster prone areas, impact of disaster, mitigation measures, Sendai framework for disaster risk reduction | ● differentiate between hazards and disasters;<br>● describe types of disasters and disaster prone areas;<br>● explain the impact of disasters and<br>● suggest mitigation measures and disaster risk reduction techniques. |

| | | | | |
|---|---|---|---|---|
| **VII. Natural resources, Utilisation and Management** | 10 | 20 | | |
| 14. Land and Soil Resources | | | Land and soil: significance and distribution, land use pattern, land degradation and its consequences, land resource management, soil conservation, soil health card | ● explain the significance and distribution of land and soil resources<br>● describe the land use and soil utilisation<br>● identify responsible factors for land degradation and its consequences<br>● elucidate soil health card for land resource management |
| 15. Forests and Biodiversity | | | Forest resources: significance, types, distribution and uses, major flora and fauna, biodiversity hotspots, conservation methods, community initiatives | ● describe the importance and uses of forest resources and their distribution;<br>● explain the flora and fauna and biodiversity hotspots;<br>● analyse the methods of forest conservation and<br>● appreciate community development initiatives with special reference |

| | | | | |
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| | | | | to joint forest management strategies. |
| 16. Water Resources | | | Water resources: significance, sources, utilization and distribution; water induced problems; conservation: traditional and modern methods, national water policy | ● state different sources of water and its utility;<br>● explain uneven distribution and water induced problems<br>● identify the traditional methods of conservation and management of water resource<br>● elaborate National Water Policy in India |
| **VIII. Economic Geography of India** | 10 | 20 | | |
| 17. Agriculture and Food Security | | | Agriculture: Significance, major practices, growth, types of crops, production and distribution, agricultural development through green, blue, yellow and white revolution; environmental and socio-economic implications, food security and safety | ● analyse spatial and temporal variations in agricultural production since independence;<br>● describe production of cereal and non-cereal crops;<br>● identify environmental and socio-economic implications of agriculture |

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| | | | | development and<br>● explain the concepts of food security and safety. |
| 18. Mineral and Energy Resources | | | Minerals and energy resources: significance and role in national economy, major minerals: occurrence and distribution, conventional and non conventional energy resources and their distribution, energy conservation, National energy policy | ● state the significance of mineral and energy resources in the national economy;<br>● differentiate between conventional and non-conventional energy resources<br>● describe the spatial distribution of different types of minerals and energy resources<br>● assess the development of non-conventional energy resources |
| 19. Major Industries and Industrial Complexes | | | Industries: Significance and role in national development; types of industries, agro based industries- Sugar and Cotton, Mineral based Industries- Iron and Steel, Footloose industries, Industrial regions and complexes, Government initiatives- Startup India and Skill India | ● highlight the role of industries in national development;<br>● differentiate between agro based and mineral based industries;<br>● describe spatial distribution of major industries and their production and<br>● identify the major |

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| | | | | industrial complexes and regions. |
| 20. Foreign Direct Investment (FDI), Transport, Communication and Trade, | | | FDI: Significance, regional pattern and sectors; Transport: road, rail, airways and water ways; Communication, role of ICT, Trade: Import and export, trade imbalance | ● explain the role of FDI in the development over the years;<br>● identify the different modes of transport and their development<br>● trace out the role of ICT in development of India<br>● describe the changing patterns of import and export |
| **IX. Human resource development in India** | 8 | 20 | | |
| 21. Population Growth and Distribution | | | Population: Size, growth and trends, distribution pattern, challenges of growing population, International Conference on Population and Development (ICPD) | ● explain the size of Indian population in the world perspective;<br>● explain the trends in population growth since 1901;<br>● analyse factors responsible for uneven distribution of population and<br>● state the issues and challenges of growing population. |

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| 22. Population Composition | | | Population composition: Rural-Urban, sex ratio, age, demographic dividend, literacy, religious and linguistic population, SC and ST, Gender equality: adolescents and reproductive health | ● explain the rural-urban, Sex ratio, age composition and demographic dividend of Indian population;<br>● describe the spatial and temporal change in levels of literacy;<br>● analyse the concentration of scheduled castes, scheduled tribes, religious and linguistic composition of population.<br>● describe recent population issues related to gender equality and reproductive health |
| 23. Human Development | | | Human development: Concept and human development index, regional pattern of Human development, need for improvement in Human development, UNDP initiatives | ● define the term human development and human development index;<br>● elaborate thegender equality and its role in human development;<br>● describe the regional patterns of human development and<br>● highlight the need |

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| | | | | for improvement in inclusive human development. |
| **X. Contemporary Issues and Challenges** | 10 | 20 | | |
| 24. Sustainable Development Goals (SDGs) | | | MDGs and SDGs: concept, significance, SDG Targets, status of SDGs in India | ● differentiate between MDGs and SDGs;<br>● describe the key concepts and significance of SDGs;<br>● explain sustainable development goals and their specific targets and<br>● explain impact of SDGs on spatial development in Indian context. |
| 25. Environment, Health and Sanitation | | | Environment, health and sanitation: linkages, issues and challenges, health risk, traditional medicines and health practices; Government initiatives: Namami Gange, Ujjwala Scheme and Swachh Bharat Abhiyan | ● identify the linkages between the environment, health and sanitation;<br>● describe environmental management to minimize the health risk;<br>● explain the overview of Namami Gange, Ujjwala Scheme and Swachh Bharat |

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| | | | | Abhiyan, and<br>● elaborate the traditional medicines and health practices. |
| **Practical Geography** | 20 | 70 | | |
| 1. Maps: Types and Elements; Toposheets | 5 | 20 | Maps: definition, types, elements; construction of scales, Toposheets: marginal information, symbols and interpretation | ● differentiate between general and thematic maps<br>● construct linear scales<br>● construct linear recognise map symbols used in topographical sheets and<br>● interpret the physical and cultural features on toposheets. |
| 2. Geospatial Technologies | 4 | 20 | Geospatial techniques: Concepts of remote sensing, GIS and GPS; image interpretation keys, raster and vector GIS, application of remote sensing, GIS and GPS | ● describe the concept of remote sensing, geographical information system and Global positioning system<br>● comprehend elements of image interpretation in areal photo and remotely sensed images |

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| | | | | ● describe the raster and vector GIS<br>● explain the utility of Remote sensing, GIS and GPS |
| 3. Data and Statistical Diagrams | 6 | 30 | Data types, central tendency: mean, median and mode; diagrams: line, bar and pie; Cartographic technique: dot and choropleth; | ● explain the types of data and calculate mean, median, mode and percentile<br>● construct simple line, bar, pie diagrams with suitable data<br>● represent the statistical data with cartographic techniques- dot and choropleth<br>● explain the suitability, merits and demerits of diagrams and cartographic techniques. |
| 4. Practical Record and Viva voice | 5 | - | | |
| **Total** | **100** | **240** | | |

## Scheme of studies

This course is essentially for self-study. The course material has been prepared keeping in mind the social, psychological & intellectual conditions of the intended learners. As the course is designed for self-study therefore at the end of each lesson, questions related to the lesson are given, so that learners are able to develop concepts as well as learn to express them well through writing. Other media of learning i.e. Muktvidya Vani, Swayam (MOOCs platform), Swayamprabha (Free DTH Channels) will provide more learning assistance to learners.

Learners also have the option of attending contact classes at their AIs, where learners will be able to clarify any subject related doubts in these classes as well as discuss them with their peer group. Learners can also clarify their subject related problems at literacy centre and adult education centre.

## Scheme of Evaluation

### 1. Self-Assessment

Learner can keep doing their evaluation throughout the course. For this purpose a scrutiny/ question paper is provided after every four lessons, which contains questions related to those four lessons. Learners can answer these questions and then evaluate their answers by looking at the correct answers provided at the end. This is the self- evaluation method adopted for this course.

### 2. External Assessment

After completing the course the learner will appear in the external evaluation. The method for this evaluation is written examination, which will consist of 100 marks. The duration of this exam will be three hours and question paper will comprise questions based on lessons and concepts in them.

**Feed back on Lesson 1-25**

| Lesson No. | Lesson Name | Was the content | | | | Was the language | | Were the Illustrations | | What you have learnt is | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Easy | Difficult | Interesting | Confusing | Simple | Complex | Useful | Not Useful | Very helpful | Somewhat helpful | Not helpful |
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**NATIONAL INSTITUTE OF OPEN SCHOOLING**

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