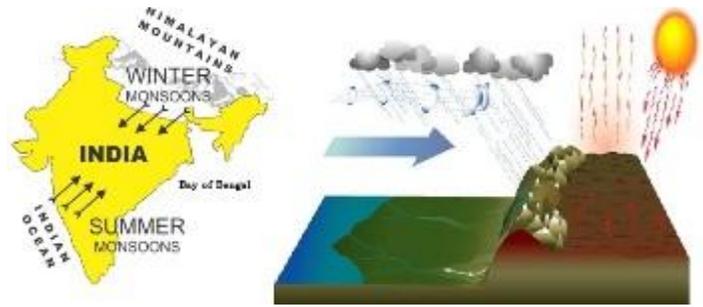


CHAPTER :- 2

CLIMATE OF INDIA



Under the extreme low pressure condition on land, the wind from the southern part of the Indian Ocean (south of Equator) is attracted towards the subcontinent of India.

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

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

- The low pressure areas that develop over the continents during the summer season in the Northern Hemisphere are not stationary.
- These low pressure areas change their position suddenly.
- The low pressure areas stabilizes in June in the northeastern parts of the subcontinent
- represent the cyclonic lows associated with the dynamic factors, and therefore, these low pressure areas cannot be termed as only thermally induced.
- the Tibetan Plateau acts as a physical barrier.
- At the beginning of June, the subtropical jet stream disappears completely over northern India.
- the plateau of Tibet becomes very cold in winter, and proves to be the most important factor in causing the advance of the jet far to the south in the middle of October.
- the abrupt onset of summer monsoon at the beginning of June is prompted by the hydro-dynamic effect of the Himalayas and not by the thermally induced low pressure centre over northwest India. In the middle of October, the plateau proves to be the most important factor in causing the advance of the jet south of the Himalayas or bifurcate it into two parts.

- The summer-time heating of the Tibetan Plateau makes it a high-level heat source.
- This 'Heat Engine' produces a thermal anticyclone over this region.
- A warm core anticyclone (high pressure) is formed over this plateau during the summer monsoon period.
- The formation of this anticyclone takes place in the middle part of the troposphere at 500mb level. It is the result of a process called anti-cyclogenesis.
- on the southern side of this upper air anticyclone, the direction of air flow is from east to west.
- In fact, these easterly winds blowing in the mid-troposphere are known as tropical easterly jets.
- The onset of monsoon puts an end to the scorching weather and the local hot winds (loo) in the northern plains of India.
- The relative humidity increases in the atmosphere tremendously.
- The high temperature and high relative humidity are, however, oppressive and injurious to health.
- It is in the season of general rains (July to September) that people suffer from many diseases and epidemics.

BREAKS IN THE MONSOONS

- The migration of the monsoon rainfall zone is one of the major sub-seasonal variations of the summer (or south-westerly) monsoon.
- the monsoon is not a continual deluge of a number of months, duration, but has inter-seasonal variability; being made of a series of discrete events, both pluvial and dry.
- Periods during which there is a rapid succession of weather disturbances or storms lasting a few days are referred to as active periods of the monsoon.
- Periods during which there is no rainfall for few days are the break periods of the monsoon.
- During an active phase, the Tropical Easterly Jet Stream (TEJ) remains very strong in the upper troposphere indicating strong convection and latent heating.
- But, when the maximum cloudiness remains locked up in the foothills of the Himalayas and the monsoon rainfall zone moves in this direction, subsidence occurs to produce a weak easterly flow in the upper troposphere. This creates the condition of break in monsoons.
- In break monsoon condition, there is a general rise of pressure (as well as temperature) over the country and the isobars show marked refraction along the west coast
- Cloudiness decreases and the south-easterlies at the surface levels over northern India are replaced by hot westerly air which blows over the plains, since the broad-scale surface pressure

(the monsoon trough) shifts to the Himalayas and the rainfall practically ceases over the country outside the Himalayan regions and the southern slopes of the Himalayas, leading to high floods in the plains of these Himalayan rivers.

- Under weak monsoon conditions and in the years when the eastern end of the axis of the monsoon trough is oriented southward in Orissa, Jharkhand, Chhattisgarh and Madhya Pradesh, a low valley trough develops over the Assam Plain aligned along river Brahmaputra between the eastern Himalayas and the Shillong Plateau.

- The vertical extent of this low valley trough is 2 to 3 kilometers with the south west Monsoon lying to the south of the trough, remaining independent of the main monsoon trough.

- But, when the latter moves northwards and extends to the Himalayas, it joins the trough over the Assam Plain to cause heavy rainfall there.

- The break in monsoon conditions generally occurs in the peak months of July and August, and lasts for at least 3 to 5 days over 500 to 1000 kilometres length in these months.

- The temperature in the eastern states of India and in the hilly regions in the month of May is generally cool and invigorating.

- In the month of April the 30°C isotherm of average temperature encloses a vast area of the country between 10degree N and 26°N latitudes (except the west coast and the hilly states of north-east India).

- The diurnal range of temperature ranges between 5°C and 6°C in coastal areas, but reaches 20°C in the interior parts of the country and in the north-west Satluj Ganga Plains.

- the western coast, Sahyadris, Meghalaya, Anmachal Pradesh, Mizoram, Nagaland, Sikkim, and Darjeeling hills get more than 200 cm of rainfall.

- The remaining parts of north, eastern India, West Bengal, Orissa, Jharkhand, Bihar, Chhattisgarh, the Tarai region and hills of Uttarakhand receive rainfall between 100 to 200 cm.

- the southern and western Uttar Pradesh, northern and western Madhya Pradesh, eastern Maharashtra and Gujarat, and northern Andhra Pradesh experience rainfall between 50 and 100 cm.

- Rajasthan, western Gujarat, southern Andhra Pradesh, Karnataka plateau, Tamil Nadu, plains of Haryana., Punjab, and Jammu and Kashmir receive less than 60 cm of rainfall.

- The lowest rainfall is recorded in the Thar desert along the border of Pakistan, and the Ladakh region of Jammu and Kashmir "state

- the highest variability is found in the areas where the average annual rainfall is the lowest. For example, the desert areas of Banner, Ganganagar, Jaisalmer, Jodhpur, etc. have less than 20 cm of average annual rainfall. In these areas the variability of rainfall is around 60 per cent.

- the areas where the average annual rainfall is over 200 cm (Mawsynram and Cherrapunji, Meghalaya Plateau), the annual variability of rainfall is less than 10 per cent.

- The Western slopes of Western Ghats, the Lesser Himalayas, the Shiwaliks and the Tarai belt also record between 100-200 cm of average annual rainfall. The variability of rainfall in these regions is around 10 to 20 per cent.

- an inverse relationship between the average annual rainfall and variability in rainfall.

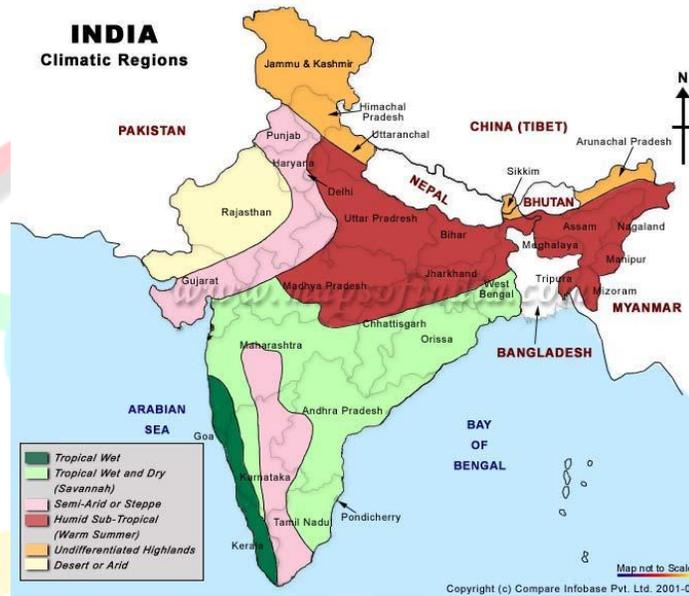
- The variability of rainfall has a significant role in the agricultural operations and other economic activities of the country.

- The areas showing high variability of rainfall have chronic deficiency of water.

- Such regions are highly prone to droughts, floods and famines, while the areas with high average annual rainfall are less affected by droughts; though flood is a regular feature in flood prone areas.

CLIMATIC REGIONS OF INDIA

- India is often referred to as a country with tropical



monsoon type of climate.

- The large size of India, its latitudinal extent, the presence of the Himalayas in the north, and the Indian Ocean, Arabian Sea and Bay of Bengal in the south have resulted in great variations in the distribution of temperature and precipitation in the subcontinent of India.

- A number of attempts have been made by climatologists, geographers and experts of agriculture to divide India into climatic regions.

- While some of these classifications have been suggested for world climates, others are exclusively applied to Indian conditions.

Tropical India

1. Region of Very heavy Rainfall

- stretches over Assam, Meghalaya, Nagaland, Manipur, Tripura and Mizoram.

- The average annual rainfall in these areas is over 200 cm.

- The heaviest rainfall in the world is recorded in this region at the stations of Mawsynram and Cherrapunji.

- Over 90 per cent of the average annual rainfall is recorded during the season of the South-West Monsoon.

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

2. Regions of Heavy Rainfall

- covers West-Bengal, Orissa, Jharkhand and eastern parts of Andhra Pradesh.

- The average annual rainfall in this region varies between 100-200 cm.

- a general decrease in the amount of rainfall from east to west



• The mean January temperature is over 18°C, while about 30°C is recorded during the months of June and July.

3. Region of Moderate Rainfall

• lies to the east of the Western Ghats and includes Gujarat, south-western Madhya Pradesh, Maharashtra, Karnataka and greater parts of Andhra Pradesh.

• Being in the rain-shadow area of the Western Ghats, this region receives relatively less rainfall of about 75 cm.

• The average temperature in the months of January and July is about 18°C and 32°C respectively.

4. The Konkan Coast

• It stretches from the mouth of Tapi river to Goa.

• The average annual rainfall is more than 200 cm, of which over 90 per cent is recorded from the Arabian stream of the South-West Monsoon.

• The mean January temperature remains around 24°C while the mean July temperature reads about 27°C.

• The average annual range of temperature varies between 3°C to 6°C depending on the distance from the coast and the equator.

• the annual range of temperature increases from south to north.

5. The Malabar Coast

• lies between Goa and Cape Camorin (Kanniyakumari).

• records over 250 cm of rainfall.

• The average annual temperature reads around 27°C with 3°C being the annual range of temperature.

• Kochi is a typical example of this region.

6. The Tamilnadu Coast

• includes the greater parts of the state of Tamil Nadu and the Coromandal Coast

• The average annual rainfall varies between 100-150 cm.

• Most of the rainfall is recorded during the season of retreating monsoon (October to December).

• The average temperature for the month of January is 24°C, while the July temperature reads around 30°C.

Different Types of Climatic Regions (Climate Group)

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

Tropical Wet (Humid):

• divided into two sub parts- tropical monsoon climate or the tropical wet climate, and tropical wet and dry climate or savannah climate.

• The Western Ghats, the Malabar Coast, southern Assam, Lakshadweep and Andaman and Nicobar Islands have the tropical monsoon climate.

• It experiences moderate to high temperature with seasonal but heavy rainfall. The months from May to November experience the most rainfall and the rain received during this period is sufficient for vegetation throughout the year.

• Tropical wet and dry climate or the savannah climate is most common in the country and prevails mainly in the inland peninsular region of the country except for some portion of the Western Ghats.

• The summers are extremely hot and the rainy season extends from the month of June to September.

Tropical Dry:

• divided into three subdivisions-(a) tropical semi-arid (steppe) climate, (b) sub-tropical arid (desert) climate and (c) sub-tropical semi-arid (steppe) climate.

• Karnataka, central Maharashtra, some parts of Tamil Nadu and Andhra Pradesh experience the tropical semi-arid (steppe) climate. Rainfall is very unreliable in this type of climate and the hot and dry summers are experienced from March to May.

• With scanty and erratic rainfall and extreme summers, western Rajasthan witnesses the subtropical arid (desert) climate.

• The areas of the tropical desert that runs from the regions of Punjab and Haryana to Kathiawar witness the sub-tropical semi-arid (steppe) climate. The maximum temperature in summers goes up to 40°C and the rains are unreliable and generally take place during summer monsoon season in this climate.

Sub-tropical Humid Climate:

• witnessed by most of the North and Northeast India.

• Summers are very hot, while in winters, temperature can plunge to as low as 0°C.

• Rainfall mainly occurs in summers but snowfall or occasional rainfall in winters is also witnessed in some areas.

• The hottest months are May and June and frost also occurs for few months in winters.

Mountain Climate:

• The temperature falls by 0.6°C for every 100 m rise in altitude in the Himalayas and results in a number of climates from tropical to tundra.

• The trans-Himalayan belt, which is the northern side of the western Himalayas, is cold, arid and windswept.

• There is less rain in the leeward side of the mountains whereas heavy rainfall is received by the well exposed slopes.

• Heaviest snowfall occurs between the months of December to February.

Factors Affecting India's Climate

There are certain factors which affect the climate of India:

Latitude:

• The Tropic of Cancer passes through the middle of India and extends from Mizoram in the east and Rann of Kutch in the west; and considerably affects the climate of the country.

• To the south of the Tropic of Cancer lies the southern part of the country which belongs to the tropical area and to its north lies the northern half of India which belongs to the sub-tropical area.

• Therefore, India experiences both sub-tropical and tropical climates.

Altitude:

• In the north, India is bounded by mountains with an average height of 6,000 metres and in the south, has a vast coastline with maximum elevation of about 30 metres.

• The Himalayas act as a barrier against the cold winds from Central Asia.

• Therefore due to the altitude of these mountains, the Indian subcontinent experiences milder winters than Central Asia.

Monsoon Winds:

• The 'monsoon winds' is the most dominating factor influencing the climate of India. It is often called the monsoon climate.



- A reversal in the monsoon winds can bring a change in the season of the country, for instance the extreme summer season suddenly changing to the rainy or monsoon season.
- The entire country receives rainfall due to the south-west summer monsoons from the Bay of Bengal and Arabian Sea.

Western Disturbances and Tropical Cyclones:

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

Characteristics of rainfall in India

Name of climatic region States or territories

Tropical Rainforest Assam and parts of the Sahyadri Mountain Range
Tropical Savannah Sahyadri Mountain Range and parts of Maharashtra
Tropical and subtropical steppe Parts of Punjab and Gujarat
Tropical Desert Most parts of Rajasthan
Moist subtropical with winter Parts of Punjab, Assam, and Rajasthan
Mountain climate Parts of Jammu and Kashmir, Himachal Pradesh, and Uttaranchal

Drought Rajasthan, Gujarat, and Haryana
Tropical semi-arid steppe Tamil Nadu, Maharashtra, and other parts of South India
Five major climate groups are designated by capital letters as follows:

A–Tropical Rainy Climate:

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

B–Dry Climate:

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

C–Mild, Humid (Mesothermal) Climates:

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

D– Snowy Forests (Microthermal) Climates:

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

E–Polar Climates:

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

Sub-Groups:

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

S – Steppe Climate:

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

W – Desert Climate:

- Arid climate.
- Most regions included have less than 10 inches (25 cm) of rainfall annually.

The letters S and W are applied only to the dry B climates, yielding two combinations – BS and BW.

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

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

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

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

Types of Climates

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

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

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

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

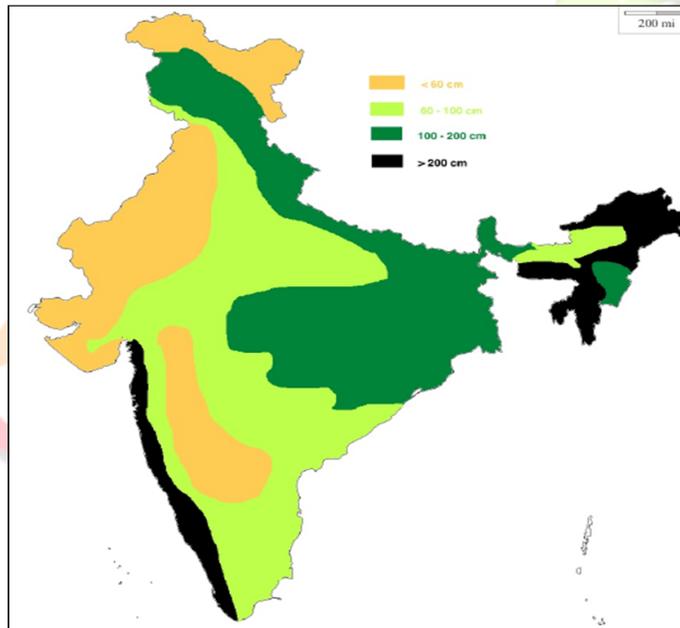
Desert Climate (BW): An arid climate with annual precipitation usually less than 40 cm.

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

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

warmer six months.

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



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

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

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

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

Further Variations

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

a: With hot summer; warmest month over 71.6°F. Used for C and D climates.

b: With warm summer; warmest month below 71.6°F. Used for C and D climates.

c: With cold, short summer; less than 4 months over 50°F. Used for C and D climates.

d: With very cold winter; coldest month below -36.4°F. Used for D climates only.

h: Dry, hot; mean annual temperature over 64.4°F. Used for B climates only.

k: Dry, cold; mean annual temperature under 64.4°F. Used for B climates only.

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

KOPPEN'S CLASSIFICATION OF INDIAN CLIMATE

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

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

1. Aw (Tropical Savanna Type) :

• associated with the tropical savanna grassland and monsoon deciduous vegetation.

• May is the hottest month (the mean maximum reading around 40°C and the mean minimum 27°C) and the temperature of the coldest month is always more than 18°C.

• The annual and diurnal ranges of temperature are high.

• Rainfall occurs mainly during the season of South-West Monsoon (July to September).

• Winters are generally dry.

• Such type of climate is found over major parts of Peninsular India including Jharkhand, Chhattisgarh, Orissa, Andhra Pradesh, Maharashtra, and the Purulia district of West Bengal.

2. Amw (Tropical Monsoon Type):

• This climate has a short dry winter season.

• The rainfall is heavy during the season of South-West monsoon, leading to luxurious growth of evergreen rain forests.

• It occupies parts of Konkan, Malabar Coast and the adjoining areas of the Western Ghats, Plateau of Tamil Nadu, and southern areas of Tripura and Mizoram.

3. As (Tropical Moist Climate):

• It is characterized by dry summer season.

• The mean monthly temperature is more than 18°C in all the months.

• The average annual rainfall varies between 75-100 cm, and about 75 per cent of the total annual rainfall occurs between September and December.

• It occupies a narrow zone along the Coromandal coast.

4. BShw (Semi-Arid Steppe Climate):

• In this climate the mean annual temperature is above 18°C and the rainfall is seasonal (in summer).

• It stretches over the rain-shadow zone of Karnataka and Tamil Nadu, eastern Rajasthan, Gujarat and some parts of south-western Haryana.

5. BWhw (Hot Desert Type):

• The greater part of Rajasthan lying to the west of the Aravalli has the hot desert type of climate. In fact, it covers the Thar desert of India.

• The mean annual rainfall is below 25 cm.

• The mean maximum summer temperature (May-June) often crosses 45°C at Jodhpur and Ganganagar, while the mean minimum temperature in winter seasons may fall to 0°C in the Bikaner, Ganganagar and Jodhpur districts.

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

• This climate is characterised by dry winter.

• The average temperature of the cold months is less than 18°C and the average temperature of the coldest month is over 15°C.

• The maximum temperature is recorded in the month of May or first half of June.

7. Dfc (Cold Humid Winter Type):

• This climate is characterised by short summer and cold humid winter.

• The winter temperatures are about 10°C and the summer temperature is below 18°C.

• Summers are short and humid. It is found in Sikkim and Arunachal Pradesh.

8. E (Polar Type):

• This type of climate is found in the higher mountainous areas of the Jammu and Kashmir, Himachal Pradesh, and

Uttarakhand. In this climate, the temperature of the warmest month is less than 10°C.

• These areas remain under ice during the greater part of the year.

9. ET (Tundra Type):

• In this climate the average temperature of the warmest month is between 0° and 10°C.

• It occupies the higher altitudes of Ladakh, Kashmir, Himachal Pradesh and Uttarakhand.





Flood Control Programme and Strategies

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

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

1. **The Immediate Phase:** This phase extends over two years and includes the collection of basic hydrological data and execution of immediate flood protection measures like construction of embankments, improvement of river channels and raising the vulnerable villages above the flood level.

2. **The Short-Term Phase:** This phase lasts for the next five years. In this phase there is emphasis on improvement of surface drainage, establishment of effective flood warning system, shifting or raising of villages above flood level, construction of diversion channels, construction of embankments and raised platforms to be used during the period of floods.

3. **The Long-Term Phase:** The long-term phase includes construction of dams and storage reservoirs, digging large diversion channels, taking suitable steps for land-use improvement, and soil conservation in the catchment area of the main river and its tributaries. In order to overcome the problem of floods in the country, the Government of India has set up a National Flood Commission (Rastriya Barh Ayog). This Commission has taken a holistic view of the flood problem. Many multi-purpose projects and large dams have been constructed to overcome this problem. Recently, the Brahmaputra River Board has been constituted to control floods in the Brahmaputra Valley.

Multiple Choice Questions

1. The main cause of global climatic change is

- a. Increase in the content of carbon dioxide in the atmosphere
- b. Emissions of industrial gases
- c. Adding of dust
- d. Changes in plant cover

Answer (a)

2. If there is no carbon dioxide in the earth's atmosphere, the temperature of earth's surface would be

- a. Dependent on the amount of oxygen in the atmosphere
- b. Higher than the present
- c. Less than the present
- d. The same

Answer (c)

3. High pressure sub-tropical calm belts known as 'Horse Latitudes' lie between

- a. 0° and 10°
- b. 15° and 25°
- c. 20° and 25°
- d. 30° and 35°

Answer (d)

4. Which from the following can cause a tsunami?

- a. Volcano
- b. Avalanche
- c. Tornado
- d. Earthquake

Answer (d)

5. The direction to which wind blows is known as

- a. Windward
- b. Leeward
- c. Eleeving side
- d. None of these

Answer (b)

6. Consider the following statements :

- 1. All cyclones develop an eye at the centre.
- 2. The temperature inside the eye is nearly 10° C lesser than that of the surroundings.

Which of the statements given above is/are correct?

- a. 1 only
- b. 2 only
- c. Both 1 and 2
- d. Neither 1 nor 2

Answer (a)

7. Which one of the following is a low cloud?

- a. Cirrocumulus
- b. Cirrostratus
- c. Altocumulus
- d. Nimbostratus

Answer (d)

8. Which region of the Earth's surface is called doldrums?

- a. Equatorial low pressure belt
- b. Sub-tropical high pressure belt
- c. Between 10° to 23½° North and South Latitudes

d. Sub-polar low pressure belt

Answer (a)

9. Which one of the following pairs of oceans and currents is not correctly matched?

- a. North Atlantic Ocean : Canaries current
- b. Eastern Pacific Ocean : Kuroshio current
- c. South Atlantic Ocean : Falkland current
- d. Indian Ocean : Agulhas current

Answer (b)

10. Savanna natural region is characterized by which one of the following?

- a. A distinct wet and dry season with annual range of temperature between 3° C – 8° C.
- b. Broad-leaf evergreen forests and grasses
- c. Uniformly high temperature throughout the year
- d. No spatial variation in mean annual rainfall

Answer (c)

11. Name the continent where 'Tundra' type of climate is not found

- a. Europe
- b. Asia
- c. Africa
- d. North America

Answer (c)

12. If the temperature of a place increases suddenly the relative humidity

- a. Increases
- b. Decreases
- c. Remains constant
- d. Fluctuates

Answer (b)

13. Which one of the following is the example of planetary winds?

- a. Monsoon
- b. Trade wind
- c. Land and sea breezes
- d. Chinook

Answer (b)

14. The dew point is the temperature at which -

- a. water in the liquid state changes to vapour
- b. the dew begins to evaporate
- c. water vapour condenses to a liquid
- d. hailstones are formed

Answer (c)

15. Threat of global warming is increasing due to increasing concentration of

- a. Nitrous oxide
- b. Ozone
- c. Sulphur dioxide
- d. Carbon dioxide

Answer (d)

16. El Nino is

- a. A sea storm
- b. A warm ocean current
- c. A tropical disturbance
- d. Another name of typhoon

Answer (b)

17. The earth revolves round the sun. This causes :

- a. Formation of day and night
- b. Deflection of winds and currents
- c. Change of seasons
- d. Differences in longitude and time

Answer (c)

18. Match List-I with List-II and select the correct answer using the code given below the Lists:

List-I (Instrument)	List - II (Used to measure)
A. Udometer	1. Atmospheric pressure
B. Barometer	2. Rainfall
C. Anemometer	3. Humidity
D. Hygrometer	4. Wind speed

Code:

- a. A - 2; B - 3; C - 1; D - 4
- b. A - 2; B - 1; C - 4; D - 3
- c. A - 4; B - 1; C - 3; D - 2
- d. A - 4; B - 3; C - 1; D - 2

Answer (b)

19. Monsoon is caused by

- a. Impact of summer temperatures on the seas.
- b. Movement of clouds
- c. Seasonal reversal of winds





d. Rise in temperature

Answer (c)

20. Consider the following statements :

1. Either of the two belts over the oceans at about 30° to 35° N and S Latitudes is known as Horse Latitude.
2. Horse latitudes are low pressure belts.

Which of the statements given above is/are correct?

- a. 1 only
- b. 2 only
- c. Both 1 and 2
- d. Neither 1 nor 2

Answer (a)

21. The snow on the mountains does NOT melt all at once when it is heated by the sun because

- a. It becomes very hard
- b. It reflects most of the heat from the sun
- c. It has a low specific heat capacity
- d. It has a high latent heat of fusion

Answer (d)

22. Extensive deserts occur in the western tropical regions of continents because -

- a. of easterly trade winds
- b. cold ocean currents flow along the western coasts
- c. of the effect of both the off shore easterly trade winds and cold ocean currents
- d. the rate of evaporation is greater along the western margin areas

Answer (b)

23. Seasons occur because :

- a. The rotation of earth
- b. The earth's revolution around the sun
- c. The earth's axis is inclined by 66½°
- d. Combined effect of (b) and (c) above

Answer (d)

24. The standard sea level in millibars is

- a. 1013 mb
- b. 1060 mb
- c. 960 mb
- d. 990 mb

Answer (a)

25. A huge mass of snow moving slowly down the valley and slopes of mountains till it melts after passing the snow line is called :

- a. Iceberg
- b. Glacier
- c. Avalanche
- d. Typhoon

Answer (c)

26. Isotherms are :

- a. contour lines showing equal amount of sunshine
- b. lines on a map joining places which have the same mean temperature
- c. contour lines of equal rainfall
- d. contour lines of equal air pressure

Answer (b)

27. What is a 'tornado'?

- a. A very high pressure centre
- b. A very low pressure centre
- c. A very high ocean wave
- d. A planetary wind

Answer (b)

28. Consider the following statements:

1. The approach of a cyclone is characterized by a rise in barometric reading.
2. In the cyclones of the northern hemisphere, the winds circulate in anti-clockwise direction.

Which of the statements given above is/are correct?

- a. 1 only
- b. 2 only
- c. Both 1 and 2
- d. Neither 1 nor 2

Answer (c)

29. The fraction of solar energy reflected from Earth into space is known as

- a. insolation
- b. albedo
- c. irradiation
- d. heat loss

Answer (b)

30. What kind of deserts are the Atacama desert and Gobi desert?

- a. trade wind deserts
- b. subtropical deserts
- c. rainshadow deserts
- d. monsoon deserts

Answer (c)

31. Which of the following terms refers to the sum total of weather conditions and variations over a large area for a long period of time (more than thirty years)?

- (a) Atmosphere
- (b) Annual range of temperature
- (c) Climate
- (d) Monsoons

Ans. (c)

32. Which of the following is not an elements of weather and climate?

- (a) Atmospheric pressure
- (b) Temperature
- (c) Humidity
- (d) Altitude

Ans. (d)

33. Which of the following statements defines weather?

- (a) Envelope of air surrounding earth
- (b) State of the atmosphere over an area at any point of time
- (c) Atmospheric conditions over a large area for a long period of time
- (d) Generalised monthly atmospheric conditions.

Ans. (b)

34. Which one of the following terms is used for the state of atmosphere over an area at any point of time?

- (a) Weather
- (b) Winds
- (c) Climate
- (d) Pressure

Ans. (a)

35. In which of the following places of India precipitation is in form of snowfall?

- (a) Shillong
- (b) Drass
- (c) Chandigarh
- (d) Haridwar

Ans. (b)

36. Which of the following places of India experiences the highest summer temperature?

- (a) Pahalgam
- (b) Leh

(c) Thiruvananthapuram (d) Jaisalmer Ans. (d)

37. Which of the following is the rainiest station?

- (a) Shillong
- (b) Mumbai
- (c) Chennai
- (d) Kolkata

Ans. (a)

38. Which one of the following is the driest station?

- (a) Mumbai
- (b) Leh
- (c) Bengaluru
- (d) Delhi

Ans. (b)

39. Most parts of India receive rainfall during which of the following months?

- (a) December to February
- (b) March to May
- (c) June to September
- (d) October to November

Ans. (c)

40. In which of the following months does the Tamil Nadu coast get most of its rainfall?

- (a) December to February
- (b) March to May
- (c) June to September
- (d) October to November

Ans. (d)

41. Which of the following places in India experiences a very high diurnal range of temperature?

- (a) Kolkata
- (b) Jodhpur
- (c) Chennai
- (d) Delhi

Ans. (b)

42. In which of the following places of India there is very little difference between day and night temperatures?

- (a) Guwahati
- (b) Nagpur
- (c) Thiruvananthapuram
- (d) Delhi

Ans. (c)

43. In which of the following places are houses built on stilts?

- (a) Assam
- (b) Rajasthan
- (c) Goa
- (d) Kerala

Ans. (a)

44. Which one of the following is not one of the six major controls of the climate of any place?

- (a) Latitude
- (b) Temperature
- (c) Pressure and wind system
- (d) Distance from the sea

Ans. (b)

45. Latitude and altitude of a place determine which of the following climatic elements of a place?

- (a) Pressure and wind system
- (b) Temperature
- (c) Rainfall pattern
- (d) All the above

Ans. (d)

46. Which of the following places have cooler climate even during summers?





- (a) Allahabad (b) Mumbai
(c) Mussoorie (d) Amritsar Ans. (c)

47. Which of the following places of India experiences extreme type of climate?

- (a) Shillong (b) Bengaluru
(c) Chennai (d) Delhi Ans. (d)

48. Due to which of the following factors does Pune receive much lesser rainfall as compared to Mumbai?

- (a) It is located on the leeward side of Western Ghats
(b) It is located on windward side of Western Ghats
(c) Continentality
(d) Distance from the sea Ans. (a)

49. Which of the following latitudes passes through the middle of our country, giving it the characteristics of tropical as well as subtropical climate?

- (a) Tropic of Capricorn (b) Tropic of Cancer
(c) Equator (d) 82°30'N Ans. (b)

50. The Indian subcontinent experiences comparatively milder winters as compared to Central Asia due to which of the following factors?

- (a) The Tropic of Cancer (b) The surrounding seas
(c) The Himalayas (d) Ocean currents Ans. (c)

Summery

India is a land of contrast of relief and climate. Geographically India is a peninsular extension of the great Eurasian landmass. Climatologically India comes in tropical, sub-tropical and temperate regimes. India is basically a tropical country although its northern part is situated in the temperate belt. In the south, the Indian coasts are washed by the Arabian Sea and the Bay of Bengal branches of the Indian Ocean which give it a typical tropical monsoon climate.

FACTORS DETERMINING THE CLIMATE OF INDIA

1. Location and Latitudinal Extent: The Tropic of Cancer passes through the central part of India in east-west direction. Thus, northern part of India lies in sub-tropical and temperate zone and the southern part falls in the tropical zone. The tropical zone being nearer to the equator, experiences high temperatures throughout the year with small daily and annual range. Area north to the Tropic of Cancer being away from the equator, experiences extreme climate with high daily and annual range of temperature.

2. Distance from the Sea: Arabian Sea and Bay of Bengal surround the Indian peninsula and make climatic conditions mild along the coastal areas. Areas in the interior of India are far away from the moderating influence of the sea thus having extremes of climate. That is why the annual range of temperature at Kochi does not exceed 3°C whereas it is as high as 20°C at Delhi.

3. The Himalayas: The Himalayan Ranges protect India from the bitterly cold and dry winds of Central Asia during winter. Further, these ranges act as an effective physical barrier for rain-bearing south-west monsoon winds to cross the northern frontiers of India. Thus, the Himalayas act as a climatic divide between the Indian Subcontinent and Central Asia.

4. Physiography: Physical map of India is very closely related to the climatic conditions of the country. Places located at higher altitude have cool climate even though they are located in the southern India, i.e., Ooty. Similarly, though Agra and Darjeeling are located on the same latitude, the temperature of Agra in January is 16°C whereas it is only 4°C in Darjeeling. The physiography of India also affects the direction and speed of

wind and the amount and distribution of rainfall. The windward sides of the Western Ghats and Assam receive high rainfall during June-September whereas the southern plateau remains dry due to its leeward situation along the Western Ghats. It is due to physiography that the funnel shaped Cherrapunji valley is the wettest place on Earth.

5. Monsoon Winds: The most dominating factor of the Indian climate is the 'Monsoon winds' as a result of which it is often called the Monsoon Climate. The south-west summer monsoons from the Arabian sea and the Bay of Bengal bring rainfall to the entire country. The north-eastern winter monsoons travel from land to sea and do not cause much rainfall except along the Coromandel coast after getting moisture from the Bay of Bengal.

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

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

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

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

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

9. El-Nino Effect: El-Nino is a narrow warm current which occasionally replaces the cold Peru current. This is responsible for wide spread floods and droughts in the tropical regions of the world. It is believed that the severe drought of 1987 in India was caused by El-Nino.

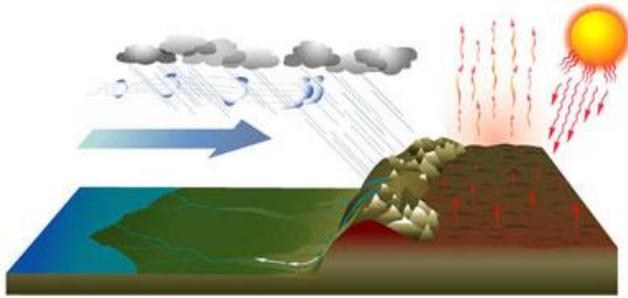
10. La Nina: The returning of the weather conditions to normal after an El-Nino is called La Nina. The presence of La Nina is the harbinger of heavy monsoon showers in India.

INDIAN MONSOON

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



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



Monsoon Diagram

1. Classical theory: Halley explained the monsoon as resulting from thermal contrasts between continents and oceans due to their differential heating. In summer the sun shines vertically over the tropic of cancer resulting in high temperature and low pressure in central Asia while the pressure is still sufficiently high over Arabian Sea and Bay of Bengal. This induces air flow from sea to land and brings heavy rainfall to India and her neighbouring countries.

In winter the sun shines vertically over the tropic of Capricorn. The north western part of India grows colder than Arabian Sea and Bay of Bengal and the flow of the monsoon is reversed. It was lacking in the physical ingredient of the effect of rotation of the earth.

2. Modern theory:

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

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

- The sub tropical westerly jet stream, this jet stream dominates in winter time in upper troposphere circulation of the northern latitudes. It has a global extent between latitudes 25-32 ° N and can be located over south Asia at an elevation of about 12 km. the jet stream is split owing to the presence of Himalayan mountain system in its path. The winds tend to descend over northwestern part of India resulting in atmospheric stability.

- Equatorial easterly jet stream, this jet is a prominent feature of the upper air circulation during the Indian monsoon season appearing as a band of strong easterlies extending from south East Asia across the Indian Ocean and Africa to the Atlantic. The western and eastern jet streams flow in the north and south of the Himalayas respectively. The eastern jet becomes powerful and stationed and this results in more active south west monsoon.

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

This plateau is considered to be one of the key factors in the development of monsoon. The Tibetan plateau exerts its

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

Characteristics of Monsoonal Rainfall

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

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

(iii) The monsoon rainfall has a declining trend with increasing distance from the sea. Kolkata receives 119 cm during the southwest monsoon period, Patna 105 cm, Allahabad 76 cm, Delhi 56 cm and Bikaner 24 cm.

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

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

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

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

(viii) The beginning of the rains sometimes is considerably delayed over the whole or a part of the country. The rains sometimes end considerably earlier than usual, causing great damage to standing

crops and making the sowing of winter crops difficult. This is why monsoons are extremely unpredictable and uncertain.

Rainfall Distribution

1. Areas of very high rainfall (annual rainfall of 200cm and above)

These include the west coast from Thiruvananthapuram in the South to Mumbai in the North (Avg. annual rainfall 200 - 400 cm). Almost the whole of Assam, Nagaland, Meghalaya, Mizoram, Arunachal Pradesh, Sikkim, parts of Manipur, Tripura and northeastern tip of West Bengal also receive 200cm or more, with isolated pockets receiving over 400 cm. Meghalaya (The abode of clouds) is the wettest part of the country with Mawsynram and Cherrapunji getting 1221cm and 1102 cm of annual rainfall respectively.

2. Areas of High rainfall (100-200cm annual rainfall) These include eastern slopes of the Western Ghats, major part of the northern plain, Orissa, M.P. Andhra Pradesh, and Tamil Nadu.

3. Areas of Low rainfall (50 - 100 cm annual rainfall)

Include large parts of Gujarat, Maharashtra, Western M.P., Andhra Pradesh, Karnataka, eastern Rajasthan, Punjab, Haryana and parts of Uttar Pradesh.

4. Areas of very Low rainfall (Less than 50 cm of annual rainfall)



These are desert and semi-deserts areas. They include large parts of Western Rajasthan, Kuchchh, and most of Ladakh region of Jammu and Kashmir.

WESTERN DISTURBANCES

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

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

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

LOCAL WINDS

During summers the atmospheric pressure is low all over the country. In the months of May and June high temperature in North West India builds up steep pressure gradient and under such conditions dust laden and strong winds blows.

- a) **LOO:** it is hot dust laden winds that usually starts in the morning and reaches its peak at afternoon. This increases the temperature of the area and causes high humidity.
- b) **AANDHIS:** these are basically thunderstorms which move like a solid wall of dust and sand. The winds velocity is high and visibility reduces to few meters only. Such dust storms are common in Rajasthan, Haryana, Delhi, Uttar Pradesh etc.

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

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

