#### Climate of India

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## **Introduction:**

India belongs to the tropical monsoon climate zone. Since the Indian subcontinent is separated from the rest of Asia by the lofty Himalayan ranges, they block the cold air masses moving southwards from Central Asia. As a result, during winters, the northern half of India is warmer by 3°C to 8°C than other areas located on same latitudes.

During summer, due to over the head position of the sun, the climate in the southern parts resemble equatorial dry climate.

The north Indian plains are under the influence of hot dry wind called 'loo' blowing from the Thar, Baloch and Iranian Deserts, increasing the temperatures to a level comparable to that of the southern parts of the country.

Thus the whole of India, south of the Himalayas can be climatically treated as a tropical country. The seasonal reversal of winds in Arabian Sea and Bay of Bengal give India a typical tropical monsoon climate.

So, Indian climate is tropical monsoon type (a distinct wet and dry climate) rather than just a tropical or half temperate climate.

## Indian Climate – Seasons

- 1. The cold weather season or winter season(November to March)
- 2. The hot weather season or summer season, (March to June)
- 3. The south-west monsoon season or Rainy season (June to mid-September), and
- 4. The season of the retreating monsoon or cool season (Mid Sept. to October).

# 1. Winter Season in India- November to March.

January is the coldest month. Sun's apparent path is to the south of equator. Clear sky, pleasant weather, low temperature, low humidity, high range of temperature, cool and slow north-east trade winds. The diurnal range of temperature, especially in interior parts of the country, is very high.

## Temperature in Winter Season

- The isotherm of 20°C runs roughly parallel to the Tropic of Cancer.
- To the south of this isotherm the temperatures are above 20°C. Here there is no distinctly defined winter weather.
- . Some parts of Kerala and Tamil Nadu typically experiences temperatures near 30°C.
- . To the north mean temperatures are below 21°C and the winter weather is distinct.

- The mean minimum temperature is about 5°C over north-west India and 10°C over the Gangetic plains.
- . **Dras Valley** in Kashmir is the coldest place in India.
- . The minimum temperature recorded at Dras was  $-45^{\circ}$ C in 1908.

#### Pressure in Winter Season

- . High air pressure prevails over large parts of north-west India due to low temperatures coupled with divergence induced by the ridge of the STJ.
- . Pressure is comparatively lower in south India.
- The winds start blowing from high pressure area of north-west to low pressure area of south-east.

- The wind velocity is low due to low pressure gradient.
- The path of the winds depend on pressure gradient and physiography.

### Western Disturbances in Winter Season

- The spell of fine weather over north-western and northern India is often broken due to inflow of western disturbances.
- . They intensify over Rajasthan, Punjab, and Haryana.

They move eastwards across the sub-Himalayan belt up to Arunachal Pradesh. They cause light rain in the Indus-Ganga plains and snowfall in the Himalayan belt. After the passage of the disturbance, widespread fog and cold waves lowering the minimum temperature by 5° to 10°C below normal are experienced. Fog lowers visibility and causes great inconvenience for transportation.

## Tropical Cyclones in Winter Season

- This is the season of least tropical cyclone activity.
- The frequency of tropical cyclones decreases with the advancement of the season. This is due to low sea surface temperature and exit of ITCZ farthest south.
- . The storms which are born in the Bay of Bengal strike Tamil Nadu and bring heavy rainfall.

- . Some of them cross the southern peninsula over to the Arabian Sea.
- . Some storms originate in the Arabian Sea and move towards either north or west.

## Precipitation in Winter Season

The retreating winter monsoons pick up some moisture while crossing the Bay of Bengal and cause winter rainfall in Tamil Nadu, south Andhra Pradesh, south-east

- Karnataka and south-east Kerala (Usually in the first weeks of November).
- . The highest seasonal rainfall of about 75 cm between October and December.
- . Most of it occurs along the south-eastern coast of Tamil Nadu and adjoining parts of Andhra Pradesh.
- . Thereafter, it gradually decreases.
- . The western disturbances also cause a little rainfall in north-west India.

- The amount of rainfall gradually decreases from the north and north-west to east (it is opposite in rainy season).
- . The northeastern part of India also gets rainfall during the winter months.

## **Summer Season in India**

. March to June. High temperature and low humidity are the chief characteristics. Sometimes referred to as pre-monsoon period.

## Temperature in Summer Season

- High sun's insolation due to apparent movement of sun between the equator and the Tropic of Cancer.
- The southern parts of the country are distinctly warmer in March and April whereas in June, north India has higher temperatures.
- In March, the highest temperatures occur in the southern parts (40-45°C).

- In April the highest temperature of about 45°C is recorded in the northern parts of Madhya Pradesh.
- . In May the highest temperature shifts to Rajasthan where temperatures as high as 48°C may be recorded.
- In June the maximum temperature is in Punjab and Haryana.

- The highest temperatures recorded are 50.5°C at Alwar on 10th May, 1956 and 50.6°C at Ganganagar on 14th June, 1935.
- The highest temperatures are recorded just before the onset of the southwest monsoons (late May).
- . The diurnal range of temperature is also very high.
- . It may be as high as 18°C in some parts.

- The maximum summer temperatures are comparatively lower in the costal and southern peninsular regions due to moderating effect of the sea.
- The temperatures along the west coast are comparatively lower than those prevailing on the east coast due to the prevailing westerly winds.
- . There is large contrast between land and sea temperatures.

Northern and central parts of India experience heat waves in this season.

Note: A heat wave is an abnormally high temperature experienced by a regions. Temperature increase of the order of 6° to 7°C above normal is termed as 'moderate' and 8°C and more as 'severe' heat wave.

- . Most of the heat waves develop over Rajasthan, Punjab and Haryana (location far away from the sea). From here they spread over Uttar Pradesh and Bihar.
- . The strong north westerly winds (caused due to strong divergence in north-west India) with a long land journey over hot regions check the onward march of the sea breeze over eastern coastal belt and create heat wave conditions over Odisha and Andhra Pradesh.

- The heat waves strike by the end of April and their maximum occurrence is in May. They last till the onset of southwest monsoon.
- The normal duration of heat waves is 4 to 5 days. However, heat waves are rare over the peninsula south of 13°N latitude due to maritime conditions prevailing there.

#### Pressure in Summer Season

- . The atmospheric pressure is low all over the country due to high temperature.
- . But strong dynamically induced divergence over north-west India prevents the onset of south-west monsoons.

## Winds in Summer Season

- There is a marked change in the direction and speed of the winds from winter.
- . The winds are by and large light and variable.

### Loo

- Loo winds originate over Iranian, Baloch and Thar deserts.
- . In May and June, high temperature in northwest India builds steep pressure gradient.

- . Hot, dust laden and strong wind known as loo blows.
- Loo normally starts blowing by 9.00 A.M., increases gradually and reaches maximum intensity in the afternoon.
- . It blows with an average speed of 30-40 km per hour and persists for days.

#### **Andhis**

- The strong dust storms resulting from the convective phenomena are locally known as andhis (blinding storms). They move like a solid wall of dust and sand.
- . The wind velocity often reaches 50-60 kmph and the visibility is reduced to a few metres.
- Such dust storms are common in Rajasthan, Haryana, Punjab, Jammu region, Delhi, Uttar Pradesh, Bihar and Madhya Pradesh.

They are short lived. The squall and showers which follow these storms bring down the temperature sharply temporarily.

### Frontal Thunderstorms in Summer Season

The strong convectional movements related to the westerly jet stream lead to thunderstorms in eastern and north-eastern part of the country.

- They normally originate over Chota Nagpur plateau and are carried eastwards by westerly winds.
- . The areas with highest incidence of thunderstorms are Assam, Arunachal Pradesh, Nagaland, Mizoram, Manipur, Tripura, Meghalaya, West Bengal and the adjoining areas of Odisha and Jharkhand.

# Northwesters and Thunderstorms in Summer Season

- In West Bengal and the adjoining areas of Jharkhand, Odisha and Assam, the direction of squalls is mainly from the northwest, and they are called **northwesters**.
- . They are often very violent with squall speeds of 60 to 80 km per hour.
- . Hailstones sometimes accompany showers and occasionally attain the size of a golf ball.

- They cause heavy damage to standing crops, trees, buildings, livestock and even lead to loss of human lives.
- . However, they are, sometimes, useful for tea, jute and rice cultivation. In Assam, these storms are known as 'Barodoli Chheerha'.
- The period of maximum occurrence of these storms is the month of Vaisakh (mid-March to mid-April) and hence, they are locally known

as **Kalabaisakhis**, the black storms or a mass of dark clouds of Vaiasakha.

# **Convectional Thunderstorms in Summer Season**

In the south the thunderstorms occur in **Kerala** (**Mango Showers**) and adjoining parts of **Karnataka** (**Blossom Showers**) and Tamil Nadu, particularly during evenings and nights.

## Western Disturbances in Summer Season

- . Their frequency and intensity gradually decrease with advancement of summer.
- Approximately 4, 3 and 2 western disturbances visit north-west India in March, April and May respectively.
- . They cause snowfall in higher reaches of the Himalayas.

## **Tropical Cyclones in Summer Season**

- . Tropical cyclones originate in the Bay of Bengal and Arabian Sea.
- . A few cyclones are formed in the Bay of Bengal in the month of March but they do not affect the mainland of India.
- Their frequency rises steeply in April and the number of cyclones originating in May is more than double than those originating in April.

- About three-fourths of the tropical cyclones are born in the Bay of Bengal and the rest originate in the Arabian Sea.
- . Most of the depressions in April originate to the south of 10°N while those originating in May are born to the north of this latitude.
- . Most of the storms of this season initially move west or north-west but later they recurve northeast and strike Bangladesh and the Arakan Coast of Myanmar.

- . Very few hit Indian coast while some dissipate over the sea itself.
- The whole of the east coast of India, the coastal areas of Bangladesh and Arakan Coast of Myanmar are liable to be hit by tropical storms in May.
- . Many of them are quite severe and cause heavy damage to life and property.
- . In the Arabian Sea, major storms are formed in May between 7° and 12° N latitudes.

- . Most of them move away from the Indian coast in a north-westerly direction and dissipate in the sea.
- . Few originate close to the Indian coast. They move towards the north-east and hit somewhere along the west coast of India.

### Precipitation in Summer Season

This season is not totally rainless (only one per cent of the annual rainfall).

- In the northeastern parts of the country, dust storms bring little rainfall.
- The precipitation in Kashmir is mainly in the form of snow caused by western disturbances.
- The norwesters bring some rainfall in Assam, West Bengal and Odisha. The intensity of rainfall is high.
- . The rainfall brought by the norwesters is known as the **spring storm showers**.

- This small amount of rainfall is very useful for the cultivation of tea, jute and rice and is known as **tea showers in Assam.**
- . Coastal areas of Kerala and Karnataka receive rainfall from thunderstorms.
- . Such showers are called **mango showers** in Tamil Nadu and Andhra Pradesh because they are very beneficial to mango crop.

In Karnataka they are called **cherry blossoms** due to their effect on the coffee plantations.

# 3. South West Monsoon Season - Rainy Season

- . South West Monsoon Season June to mid-September.
- . South West Monsoon Season is also known as **hot-wet season**.

- Sudden onset is the important feature of South West Monsoons.
- . With the onset of monsoons, temperature falls drastically and humidity levels rise.

# Temperature during South West Monsoon Season

. Sudden onset of South West Monsoons leads to significant fall in temperature [3° to 6°C].

- The temperature remains less uniform throughout the rainy season.
- . The temperature rises in September with the cease of south-west monsoons.
- . There is rise in temperature whenever there is **break in the monsoons**.
- . The diurnal range of temperature is small due to clouds and rains.
- . The highest temperatures are experienced at places west of the Aravali [38° to 40°C].

- . This is due to lack of clouds and hot continental air masses.
- . Other parts of Northwest India also have temperatures above 30°C.
- . The temperatures are quite low over the Western Ghats due to heavy rainfall.
- The coastal areas of Tamil Nadu and adjoining parts of Andhra Pradesh have temperatures above 30°C as they receive little rainfall during this season.

# Pressure and Winds During South West Monsoon Season

- . Low pressure conditions prevail over northwest India due to high temperature.
- . ITCZ (monsoon trough) lies along the Ganga plain. There are frequent changes in its location depending upon the weather conditions.

- The atmospheric pressure increases steadily southwards.
- Over the peninsular region, due to pressure gradient between north and south, winds blow in a southwest to northeast direction from Arabian sea and Bay of Bengal.
- Their direction undergoes a change in Indo-Gangetic plain where they move from east to west.

### Rainfall During South West Monsoon Season

- . Three fourths of the total annual rainfall is received during this season.
- The average rainfall over the plains of India in this season is about 87 per cent.
- . Normal date of the arrival of the monsoon is 20th May in Andaman and Nicobar Islands.
- The advance of the monsoon is much faster in the Bay of Bengal than in the Arabian Sea.

- The normal date of onset of the southwest monsoon over **Kerala i.e. the first place** of entry in the mainland of India is 1st June.
- The monsoons advance quickly accompanied with a lot of thunder, lightning and heavy downpour.
- . This sudden onset of rain is termed as **monsoon burst**.
- . Sometimes monsoons are delayed or they come much earlier than normal.

. Normally the onset occurs between 29th May and 7th June.

. The earliest onset was on 11th May in 1918 and 1955, while the most delayed onset was on 18th June in 1972.

### 4. North East Monsoon-Retreating Monsoon Season

- . Starts with the beginning of the withdrawal of southwest monsoon [middle of September
  - November] and lasts till early January.
- . The monsoons withdraw from the extreme north-west end of the country in September, from the peninsula by October and from the extreme south-eastern tip by December.

- In Punjab the south-west monsoons reach in the first week of July and withdraw from there in the second week of September.
- . The south-west monsoons reach Coromandel coast in the first week of June and withdraw from there only in the middle of December.
- . Unlike the sudden burst of the advancing monsoons, the withdrawal is rather gradual and takes about three months.

### Temperature during Retreating Monsoon Season

- . With retreat of the monsoons, the clouds disappear and the sky becomes clear.
- . The day temperature starts falling steeply.
- . The diurnal range of temperature increases due to lack of cloud cover.

# Pressure and Winds during Retreating Monsoon Season

- As the monsoons retreat, the monsoon trough weakens and gradually shifts southward. Consequently the pressure gradient is low.
- . Unlike south-west monsoon, the onset of the north monsoon is not clearly defined.
- The direction of winds over large parts of the country is influenced by the local pressure conditions.

### Cyclones during Retreating Monsoon Season

- . Most severe and devastating tropical cyclones originate in the Indian seas especially in the Bay of Bengal.
- The highest frequency of the cyclones is in the month of October and the first half of November.

### More cyclones are born in October and then in November and more cyclones originate in the Bay of Bengal than in the Arabian Sea.

- In October, the Cyclones of the Bay of Bengal originate between 8°N and 14°N.
- Initially they move in a west or northwesterly direction, but many of them later recurve and move towards the north-east.

- . Near 55 per cent of the Bay storms cross or affect the Indian coast.
- The area's most vulnerable to these storms include the coastal belts of Tamil Nadu, Andhra Pradesh, Odisha and West Bengal.
- . Many of the cyclones which strike the eastern coast of India, south of 15°N latitude cross the southern Peninsula and enter Arabian Sea.

- During this process, they may weaken, but on re-entry over the Arabian sea they intensify into cyclonic storms.
- The storms of Arabian sea originate between 12°N and 17°N latitudes in October and between 8° N and 13° N latitudes in November.
- . Generally they move away from the coast in a north-westerly direction. But about 25% of

- them later recurve northeast and strike the Maharashtra or Gujarat coast.
- In north-west India the western disturbances produce clouding and light rainfall in the otherwise fine weather.
- The precipitation is in the form of snow in higher reaches of Jammu and Kashmir, Himachal Pradesh and in Kumaon Hills.

# **Precipitation during Retreating Monsoon Season**

- The humidity and cloud cover are much reduced with the retreat of the south-west monsoons and most parts of the country remain without much rainfall.
- . October-November is the main rainy season in Tamil Nadu and adjoining areas of Andhra Pradesh to the south of the Krishna delta as well as a secondary rainy period for Kerala.

The retreating monsoons absorb moisture while passing over the Bay of Bengal and cause this rainfall.

#### **Features of Indian Climate**

India has high Regional Climatic Diversity because of its topographical diversity (location, altitude, distance from sea and relief).

#### Rainfall:

The climate in most of the regions is characterized by distinct wet and dry seasons. Some places like Thar desert, Ladakh have no wet season. Mean annual rainfall varies substantially from region to region. Mawsynram and Cherrapunji in Meghalaya receives around 1,000 cm of annual rainfall while at Jaisalmer the annual rainfall rarely exceeds 12 cm.

The Ganga delta and the coastal plains of Odisha see intense rainfall in July and August while the Coromandel Coast goes dry during these months.

Places like Goa, Hyderabad and Patna receive south-west monsoon rains by the first quarter of June while the rains are awaited till early July at places in Northwest India.

### **Temperature:**

Diurnal and annual temperature ranges are substantial.

Highest diurnal temperature ranges occur in the Thar desert and the highest annual temperature ranges are recorded in the Himalayan regions. Both diurnal and mean annual temperature ranges are least in coastal regions.

In December, the temperature may dip to – 40°C at some places in J&K while in many coastal regions average temperature is 20-25°C. Winters are moderately cold in most of the regions while the summers are extremely hot. Himalayan regions experience brutal winters while the summers are moderate.

### **Factors Influencing Indian Climate:**

Latitudinal location Distance from the Sea The Himalayas Physiography Monsoon Winds **Upper Air Circulation** El Nino and La Nina Tropical Cyclones and Western Disturbances

#### **Latitudinal location:**

Indian climate resembles the climate of a tropical country.

The mainland of India extends between 8°N to 37°N.

Areas south of the Tropic of Cancer are in tropics and hence receive high solar insolation. The summer temperatures are extreme and winters temperatures are moderate in most of the regions.

The northern parts on the other hand lie in the warm temperate zone.

They receive comparatively less solar insolation.

But summer are equally hot in north India because of hot local wind called 'loo'.

Winter are very cold due to cold waves brought by the western disturbances.

Some places in Himalayas record low temperatures particularly in winter.

Coastal regions see moderate climatic conditions irrespective of latitudinal position.

#### Distance from the Sea:

Coastal regions have moderate or equable or maritime climate where as interior locations are deprived of the moderating influence of the sea and experience extreme or continental climate. The monsoon winds first reach the coastal regions and hence bring good amount of rainfall.

#### Himalayas and Indian Climate:

This is the most important factor that influences Indian Climate.

The Himalayas act as a climatic divide between India and Central Asia.

During winter, Himalayas protect India from cold and dry air masses of Central Asia. During monsoon months these mountain ranges act as an effective physical barrier for rain bearing south-west monsoon winds. Himalayas divide the Bay of Bengal branch of monsoon winds into two branches – one branch flowing along the plain regions towards northwest India and the other towards South-East Asia.

If the Himalayas were not present, the monsoon winds would simply move into China and most of the north India would have been a desert.

Why rainfall decreases form east to west in plains region (Indus-Ganga Plains)? In summer, there are many minor low pressure cells that exist all over the plain region.

As the monsoon winds move from east to west the moisture levels decrease due to successive rainfall at each low pressure regions.

By the time winds reach western parts of the plains (Delhi, Haryana etc.) all the moisture in the monsoon winds in exhausted.

Then how come Haryana and Punjab not deserts like Rajasthan?

They receive rainfall due to Western Disturbances in winter. (In summer the rainfall is very low.)

#### Physiography and Indian Climate:

Physiography is the most important factor that determines the mean annual rainfall received by a region.

Why are some parts in peninsular India semiarid?

Places on the windward side of an orographic barrier receive great amount of rainfall where as those on the leeward side remain arid to semiarid due to rain-shadow effect.

### Example:

The south-west monsoon winds from the Arabian sea strike almost perpendicular at the

Western Ghats and cause copious rainfall in the Western Coastal plain and the western slopes of the Western Ghats. On the contrary, vast areas of Maharashtra, Karnataka, Telangana, Andhra Pradesh and Tamil Nadu lie in rainshadow or leeward side of the Western Ghats and receive scanty rainfall.

Why no significant rainfall in Gujarat and Rajasthan?

Monsoons winds flowing in Rajasthan and Gujarat are not obstructed by any orographic barrier and hence these regions receive no rainfall.

## Mawsynram and Cherrapunji

are the wettest places on earth with mean annual rainfall over 1000 cm.

Copious rainfall in these places is due to funneling effect followed by orographic upliftment. [Funneling effect = clouds are channeled into a narrow region between mountains and hence the cloud density is extraordinary].

### **Monsoon Winds and Indian Climate:**

The most dominating factor of the Indian climate is the 'monsoon winds'.

Important features of Indian Monsoons are Sudden onset (sudden burst)

Gradual progress

Gradual retreat

### Seasonal reversal of winds:

The complete reversal of the monsoon winds brings about a sudden change in the seasons. The harsh summer season suddenly giving way to monsoon or rainy season.

The south-west monsoons from the Arabian sea and the Bay of Bengal bring rainfall to the entire country.

The north-eastern winter monsoon do not cause much rainfall except along the Coromandel coast (TN coast) after getting moisture from the Bay of Bengal.

## **Upper Air Circulation:**

The changes in the upper air circulation over Indian landmass is brought about by Jet streams.

## Westerly Jet Stream:

Westerly jet stream blows at a very high speed during winter over the sub-tropical zone. Southern branch of the jet stream exercises a significant influence on the winter weather conditions in India.

This jet stream is responsible for bringing western disturbances from the Mediterranean region in to the Indian sub-continent.

Winter rain and heat storms in north-western plains and occasional heavy snowfall in hilly regions are caused by these disturbances. These are generally followed by cold waves in the whole of northern plains.

## **Easterly Jet Stream:**

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 stream is replaced by the easterly jet stream which owes its origin to the heating of the Tibet plateau.

This helps in the sudden onset of the south-west monsoons.

# Tropical Cyclones and Western Disturbances:

Tropical cyclones originate in the Bay of Bengal and Arabian Sea and the influence large parts of the peninsular India.

Majority of the cyclones originate in the Bay of Bengal and influence the weather conditions during the south-west monsoon season (low intensity cyclones).

Some cyclones are born during the retreating monsoon season, i.e., in October and November (high intensity cyclones) and influence the weather conditions along the eastern coast of India.

The western disturbances originate over the Mediterranean sea and travel eastward under the influence of westerly jet stream.

They influence the winter weather conditions over most of Northern-plains and Western Himalayan region.

# El-Nino, La Nina, ENSO and Indian Climate:

### El Nino

a) Adversely affects monsoon rainfall and cyclogenesis in Bay of Bengal.

- b) Good for cyclogenesis in Arabian Sea.
- c) Droughts are common during El Nino events due to less monsoonal and cyclonic rainfall.

#### La Nina

- a) Good for monsoons and cyclogenesis in Bay of Bengal.
- b) Suppressed cyclogenesis in Arabian Sea.
- c) Floods will be common.

#### **ENSO**

Southern Oscillation is simply the oscillation or alternating positions of low pressure and high pressure cells over eastern and western Pacific. Southern Oscillation coinciding with El Nino is called ENSO or El Nino Southern Oscillation. (SO usually coincides with EL Nino. This why El Nino is usually referred to as ENSO).

## **Terminologies:**

ISOLINE: line of equal rainfall or any other parameter.

ISOBAR: line of equal pressure.

ISOTHERM: line of equal temperature.

ISOHYET: line of equal rainfall.