- FACULTY NAME:
  - KANHAIYA JHA
- SUBJECT:
  - GEOGRAPHY
- TOPIC NAME:
  - CLIMATE
  - NATURAL VEGETATION
  - AGRICULTURE
  - INDUSTRY

Climate of India

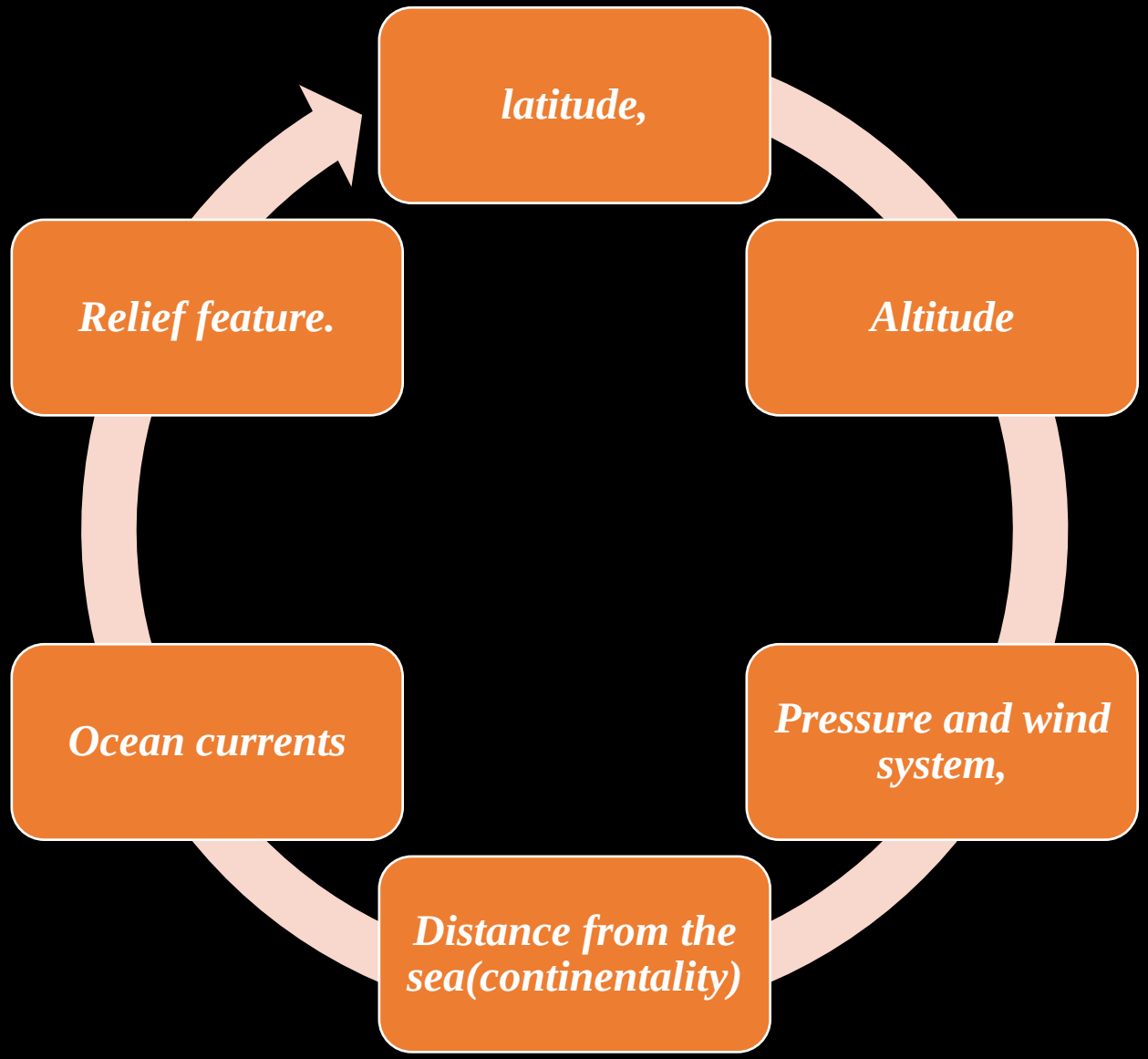
- ***Climate*** refers to the **sum total of weather conditions** and variations over a large area for a long period of time (more than thirty years). While, **Weather** refers to the state of the atmosphere over an area at any point of time.
- The elements of weather and climate are the same, i.e. **temperature, atmospheric pressure, wind, humidity and precipitation**.
- On the basis of the generalized monthly atmospheric conditions, the year is divided into seasons such as winter, summer or rainy seasons.
- The climate of India is described as ***the 'monsoon' type***. In Asia, this type of climate is found **mainly in the south and the southeast**.
- The word monsoon is derived from the Arabic word **'MAUSIM'** which literally means season. 'Monsoon' refers to the seasonal reversal in the wind direction during a year.

Salient Features of Indian Climate

Reversal of Winds	• **Winter:** Winds blow from northeast to southwest (dry, low temperature, high pressure). • **Summer:** Winds reverse direction, blowing from southwest to northeast.
Seasonal and Variable Rainfall	• Over 80% of annual rainfall occurs during summer (1–5 months duration). • Rainfall varies spatially; e.g., **Mawsynram** records extremely high rainfall compared to arid Jaisalmer.
Plurality of Seasons	• India experiences six seasons: winter, late winter, spring, summer, rainy, and autumn.
Unity of Indian Climate	• The Himalayas block cold Central Asian winds, maintaining a tropical climate. • Monsoon winds bring uniform rainfall across the country, unifying the climate.
Diversity of Indian Climate	• **Temperature extremes:** 55°C in Rajasthan (summer) to -45°C in Leh (winter). • Variations in wind, temperature, rainfall, and humidity due to geography and relief.
Characterized by Natural Calamities	• Climate conditions often lead to floods, droughts, famines, and epidemics.

CLIMATIC CONTROLS : FACTORS AFFECTING INDIA'S CLIMATE

- India's climate is controlled by a number of factors which can be broadly divided into two groups —
  - factors related to location and relief, and
  - factors related to air pressure and winds.



Factors Related To Location And Relief

- **Latitude**
  - Due to the curvature of the earth, the amount of solar energy received varies according to latitude.
  - The Tropic of Cancer passes through the middle of the country from the Rann of Kuchch in the west to Mizoram in the east.
  - Almost half of the country, lying south of the Tropic of Cancer, belongs to the tropical area.
  - All the remaining area, north of the Tropic, lies in the sub-tropics.
  - **Therefore, India's climate has characteristics of tropical as well as subtropical climates**
- **Altitude**
  - India has mountains to the north, which have an average height of about 6,000 metres. India also has a vast coastal area where the maximum elevation is about 30 metres.
  - The Himalayas prevent the cold winds from Central Asia from entering the subcontinent.
  - It is because of these mountains that this subcontinent experiences **comparatively milder winters as compared to central Asia.**

Source NCERT Book (India: Physical Environment Class XI)

FACTORS RELATED TO AIR PRESSURE AND WINDS.

Surface Pressure and Winds

- **Winter Season:**
  - During winter, a **high-pressure system** develops north of the Himalayas. This pushes dry, cold winds southward into India.
  - These winds mix with trade winds and can sometimes shift east, affecting areas as far as the middle Ganga valley.
- **Summer Season:**
  - In summer, **low-pressure zones** form over interior Asia and northwestern India.
  - The **Inter Tropical Convergence Zone (ITCZ)** moves north, pulling winds from the southern hemisphere.
  - As these winds cross the equator, they turn right, becoming the **Southwest Monsoon winds**. These winds pick up moisture from warm oceans and bring heavy rainfall across India.

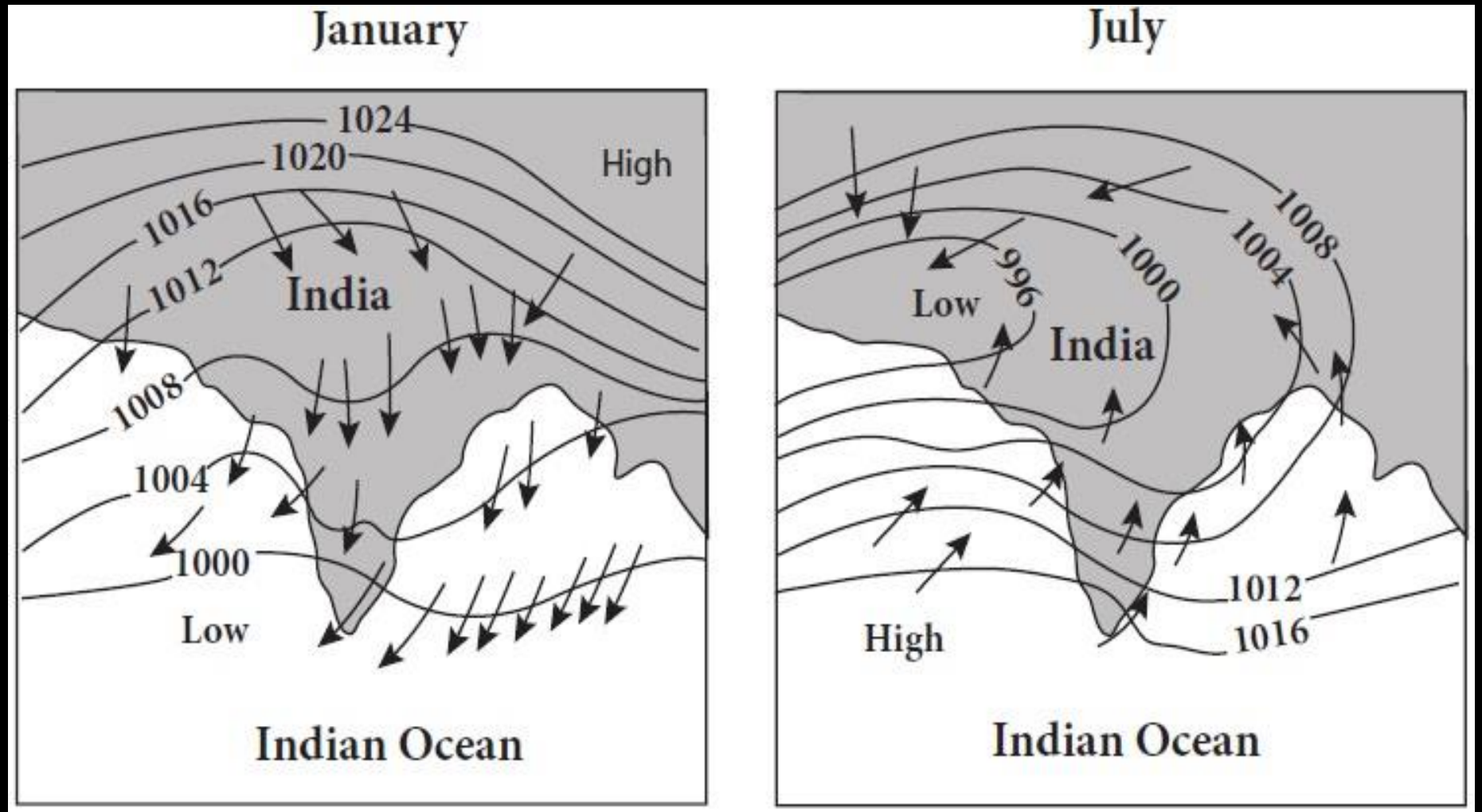
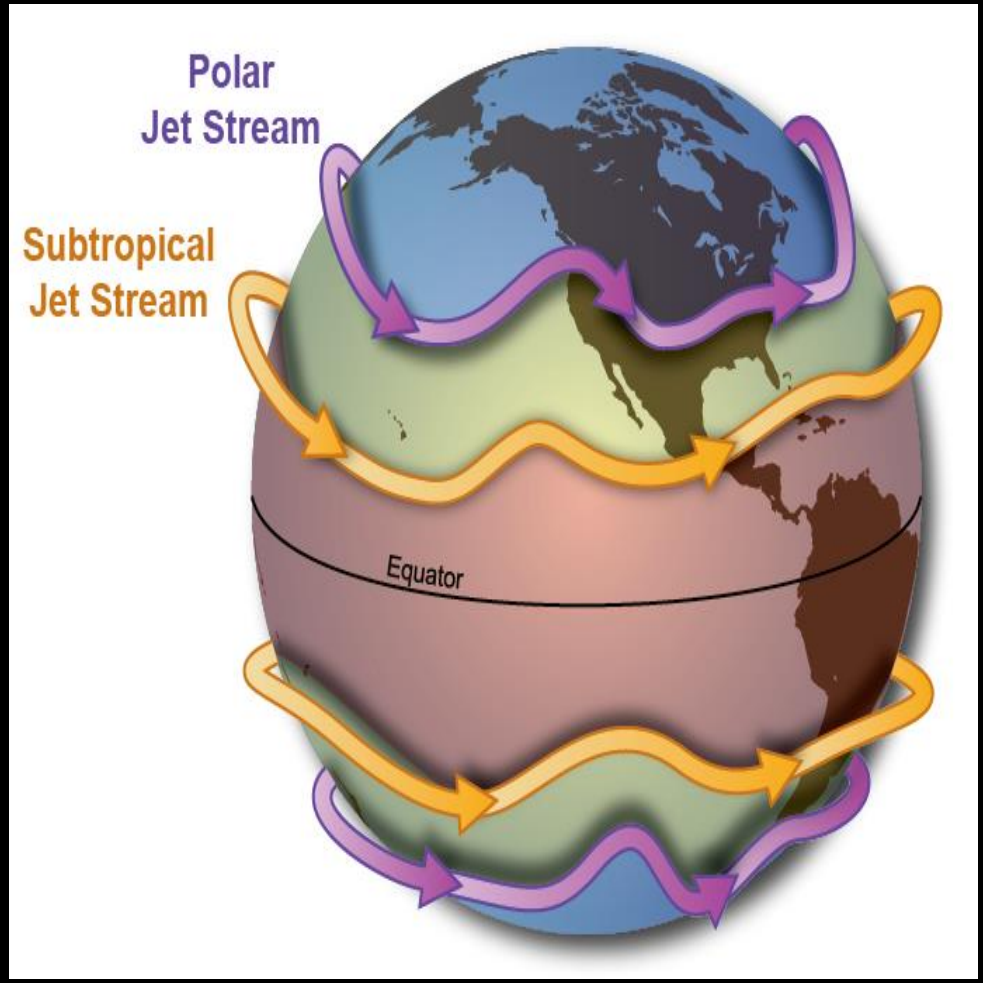


Figure 6.11 Location of High pressure and Low pressure in winter and summer

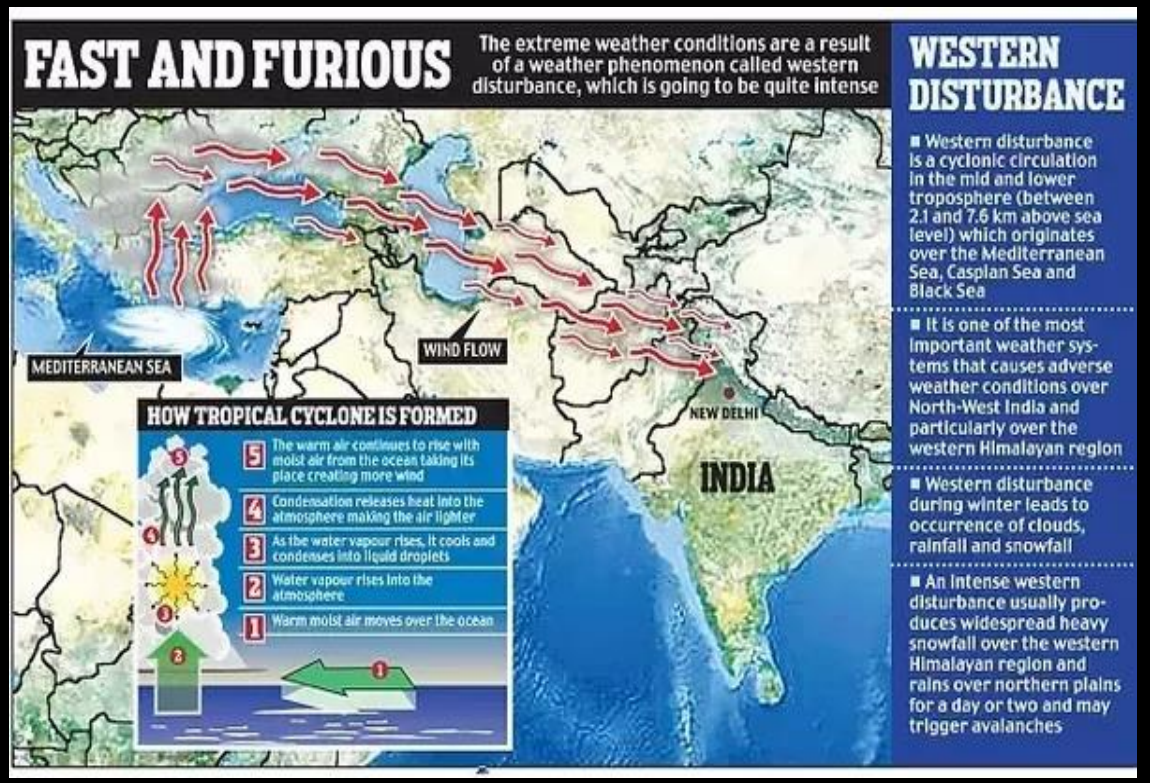
The Jet Stream and Upper Air Circulation

- **Westerly Jet Streams:**
  - The upper air circulation over India is dominated by **subtropical westerly jet streams** found between **27°-30°N latitude**.
  - The **Tibetan highlands** bifurcate these jet streams into two branches:
    - **Northern branch**: Flows north of the Tibetan highlands.
    - **Southern branch**: Flows south of the Himalayas, with its mean position at **25°N** during February at the 200-300 mb level.
  - The southern branch influences **winter weather** in India and brings **western cyclonic disturbances** to northern and northwestern regions.
  - In summer, the **subtropical westerly jet stream** shifts **north of the Himalayas** due to the sun's apparent movement.
- **Easterly Jet Streams:**
  - A **subtropical easterly jet stream** forms during summer, blowing over **peninsular India** around **14°N latitude**.
  - This jet stream plays a key role in shaping monsoon dynamics.



Western Cyclonic Disturbance and Tropical Cyclones

- **Western Cyclonic Disturbances:**
  - These disturbances, originating over the **Mediterranean Sea**, enter India from the **west and northwest** during winter, brought by the **westerly jet stream**.
  - An increase in night temperatures signals their approach.
- **Tropical Cyclones:**
  - Tropical cyclones form over the **Bay of Bengal** and the **Indian Ocean**.
  - These cyclones bring **high winds and heavy rainfall**, typically affecting the coasts of **Tamil Nadu, Andhra Pradesh, and Odisha**.

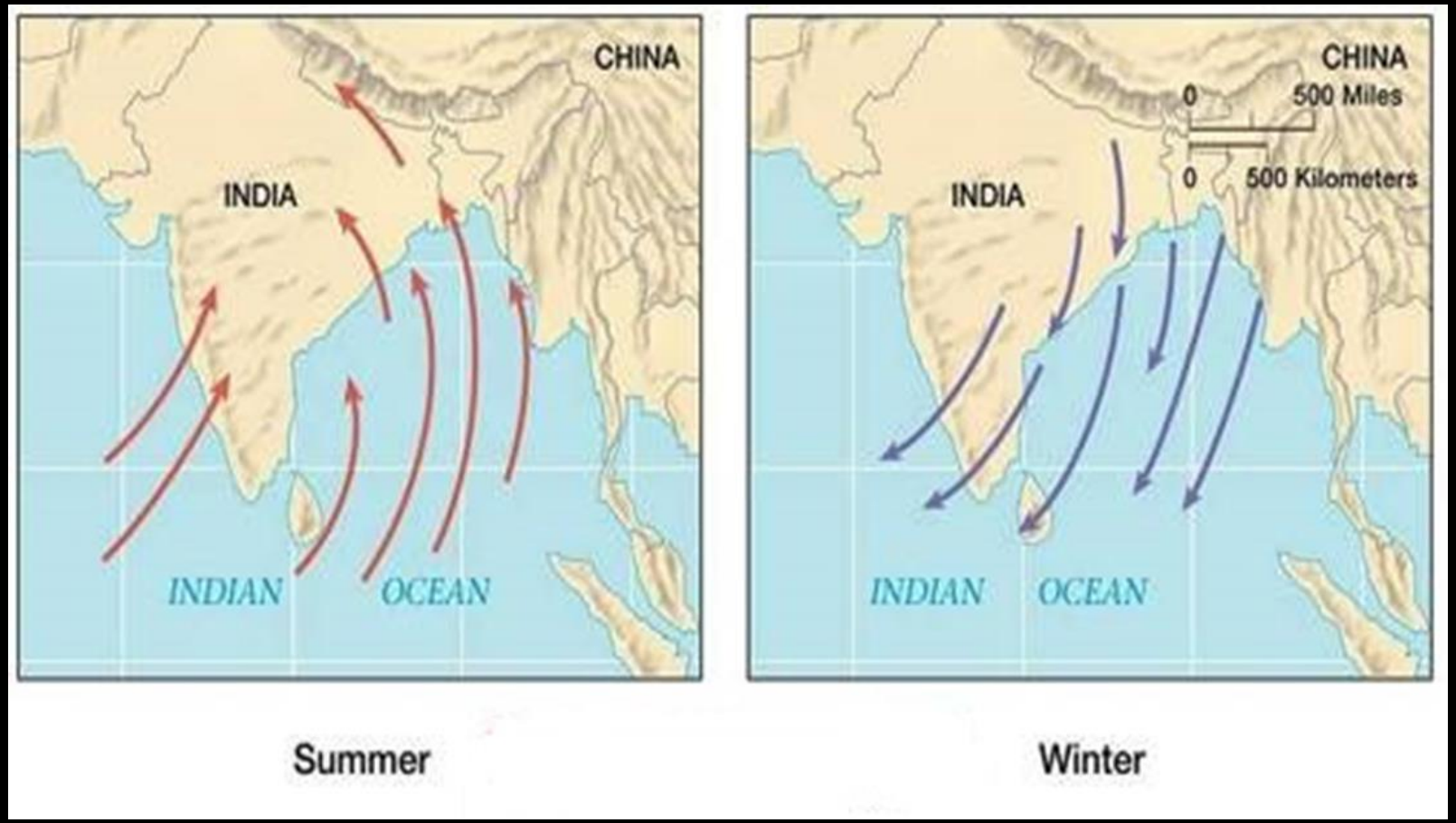


THE SEASONS

- The monsoon type of climate is characterized by a distinct seasonal pattern. The weather conditions greatly change from one season to the other.
- These changes are particularly noticeable in the interior parts of the country. The coastal areas do not experience much variation in temperature though there is variation in rainfall pattern.

Seasons	Months (According to the Indian Calendar)	Months (According to the Gregorian Calendar)
Vasanta	Chaitra-Vaisakha	March-April
Grishma	Jyaistha-Asadha	May-June
Varsha	Sravana-Bhadra	July-August
Sharada	Asvina-Kartika	September-October
Hemanta	Margashirsa-Pausa	November-December
Shishira	Magha-Phalguna	January-February

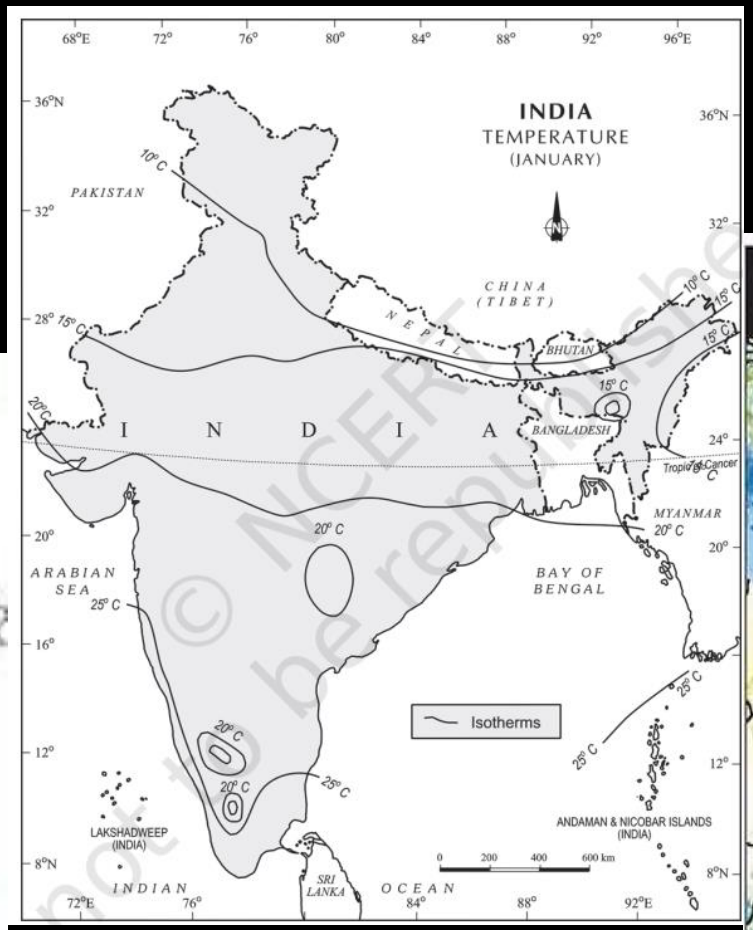
- **Four main seasons** can be identified in India –
  - The **cold weather season (MID NOV. TO FEB),**
  - **The hot weather season (MARCH TO MAY**),
  - The **advancing monsoon (JUNE TO SEP) and**
  - The **retreating monsoon. (OCT. – NOV.)**

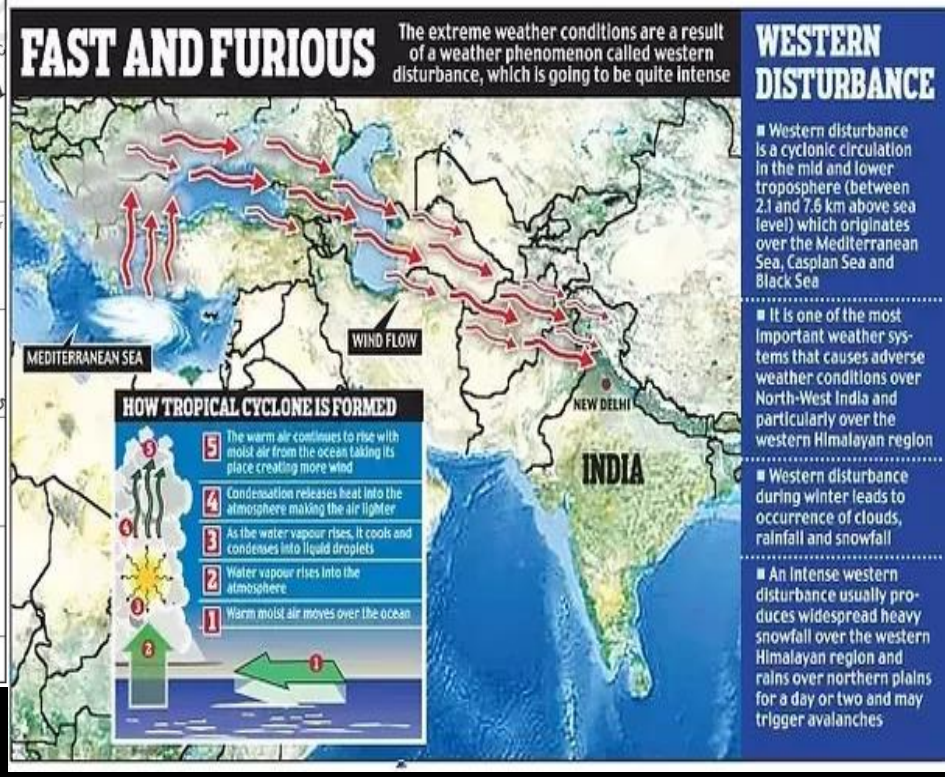


The Cold Weather Season (Winter) – Mid Nov. to Feb

- The **cold weather season** starts in **mid-November** in northern India and lasts until **February**, with **December and January** being the coldest months.
- **Temperature:**
  - **Chennai** (eastern coast): 24°-25°C.
  - **Northern plains:** 10°-15°C.
  - Days are warm, and nights are cold, with frost common in the north. The higher Himalayas experience **snowfall**.
- **Winds:**
  - **Northeast trade winds** prevail, blowing from **land to sea**, making the season generally dry.
  - Some rainfall occurs on the **Tamil Nadu coast**, where winds blow **from sea to land**.
- **Weather:**
  - In the north, a **high-pressure region** forms, leading to light, variable winds.
  - The weather is marked by **clear skies**, **low temperatures**, and **low humidity**.
- **Cyclonic Disturbances:**
  - **Cyclonic disturbances** from the **west and northwest** (originating in the **Mediterranean Sea** and **western Asia**) bring **winter rains** and **snowfall** in the mountains. These rains, known as **‘mahawat’**, are crucial for **rabi crops**.
- **Peninsular India:**
  - The region does not experience a well-defined cold season due to the moderating influence of the sea.


INDIA
BLANK MAP
North East
Trade winds
Arabian Sea
Bay of Bengal


INDIA
TEMPERATURE
(JANUARY)
PAKISTAN
CHINA (TIBET)
NEPAL
BHUTAN
BANGLADESH
MYANMAR
I N D I A
Tropic of Cancer
ARABIAN SEA
BAY OF BENGAL
Isotherms
LAKSHADWEEP (INDIA)
ANDAMAN & NICOBAR ISLANDS (INDIA)
SRI LANKA
INDIAN OCEAN
0 200 400 600 km


FAST AND FURIOUS
The extreme weather conditions are a result of a weather phenomenon called western disturbance, which is going to be quite intense
MEDITERRANEAN SEA
WIND FLOW
NEW DELHI
INDIA
HOW TROPICAL CYCLONE IS FORMED
5 The warm air continues to rise with moist air from the ocean taking its place creating more wind
4 Condensation releases heat into the atmosphere making the air lighter
3 As the water vapour rises, it cools and condenses into liquid droplets
2 Water vapour rises into the atmosphere
1 Warm moist air moves over the ocean
WESTERN DISTURBANCE
■ Western disturbance is a cyclonic circulation in the mid and lower troposphere (between 2.1 and 7.6 km above sea level) which originates over the Mediterranean Sea, Caspian Sea and Black Sea
■ It is one of the most important weather systems that causes adverse weather conditions over North-West India and particularly over the western Himalayan region
■ Western disturbance during winter leads to occurrence of clouds, rainfall and snowfall
■ An intense western disturbance usually produces widespread heavy snowfall over the western Himalayan region and rains over northern plains for a day or two and may trigger avalanches

The Hot Weather Season (Summer) -March to May

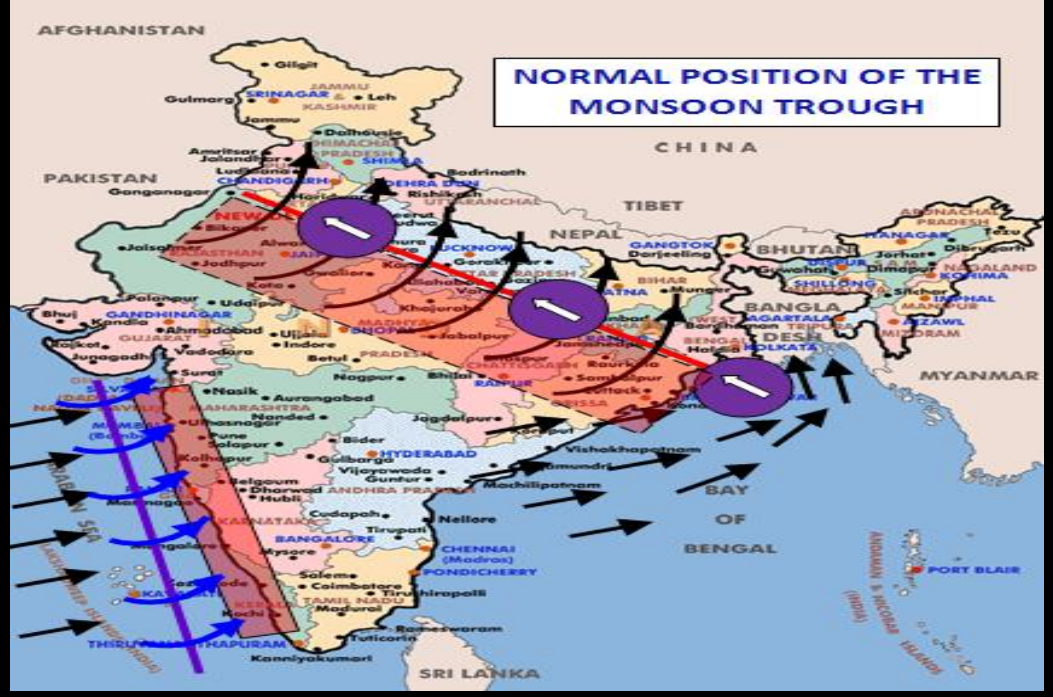
- The global heat belt shifts northward due to the sun's apparent movement.
- **Temperature Trends:**
  - March: Deccan Plateau records an elongated **38°C** zone.
  - April: An elongated region in Gujarat and Madhya Pradesh records temperatures around **42°C**.
  - May: Northwestern parts experience elongated zones of **45°C**.
  - Peninsular India has lower temperatures due to the elongated moderating influence of the oceans.
- **Air Pressure:** Rising temperatures cause an elongated low-pressure area by late May, stretching from the Thar Desert in the northwest to Patna and the Chotanagpur Plateau in the east and southeast, influencing air circulation.

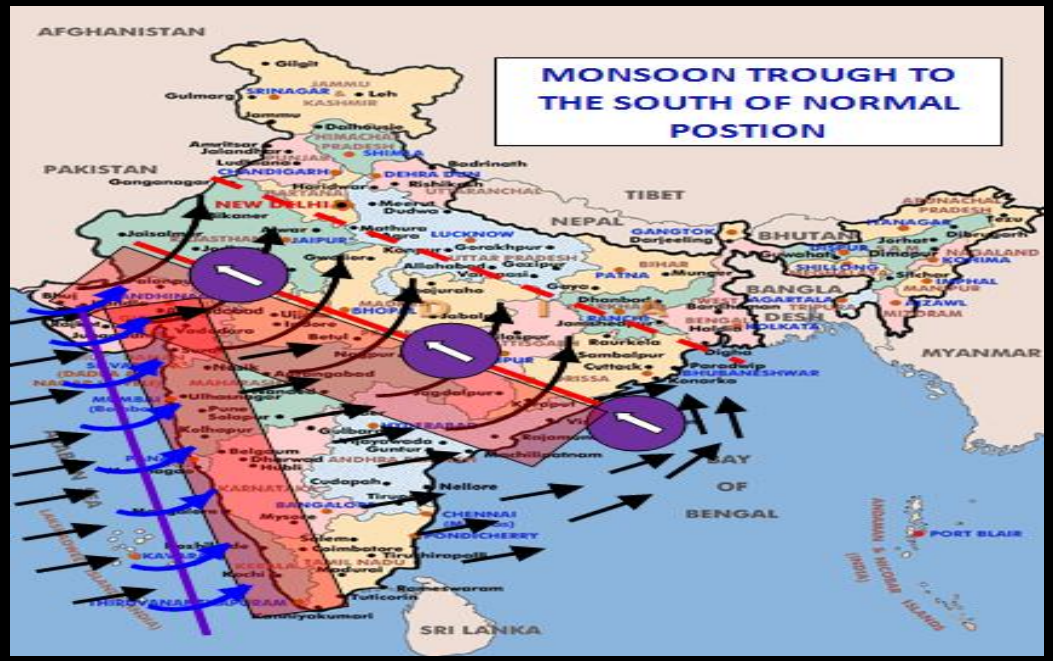
Some Famous Local Storms of Hot Weather Season

- **Mango Showers:**
  - Pre-monsoon showers common in **Kerala** and coastal **Karnataka**.
  - Locally called "Mango Showers" as they aid the early ripening of mangoes.
- **Blossom Showers:**
  - Occur in **Kerala** and nearby areas.
  - Help coffee flowers to blossom.
- **Nor'westers:**
  - Dreaded evening thunderstorms in **Bengal** and **Assam**.
  - Locally called "Kalbaisakhi" in Bengal and "Bardoli Chheerha" or "Bardoisila" in Assam.
  - Beneficial for **tea**, **jute**, and **rice cultivation**.
- **Loo:**
  - Hot, dry, and gusty winds in the **Northern plains**, from Punjab to Bihar.
  - Most intense between **Delhi** and **Patna**.
  - Direct exposure can be fatal.

Advancing Monsoon (The Rainy Season) - June to September

- **Onset and Direction:**
  - By early June, intensified low-pressure conditions over the northern plains attract **south-east trade winds** from the southern hemisphere.
  - These winds cross the equator, shift to a **south-westerly direction**, and enter India as the **south-west monsoon**, carrying abundant moisture from warm oceans.
- **Rainfall Patterns:**
  - **Western Ghats:** Windward side receives over **250 cm** of rainfall.
  - **Deccan Plateau and Madhya Pradesh:** Moderate rainfall despite being in the rain shadow area.
  - **North-East India:** Receives the **maximum rainfall**, with **Mawsynram** in the Khasi Hills recording the highest average rainfall in the world.
  - **Ganga Valley:** Rainfall decreases from **east to west**.
  - **Rajasthan and Gujarat:** Scanty rainfall.





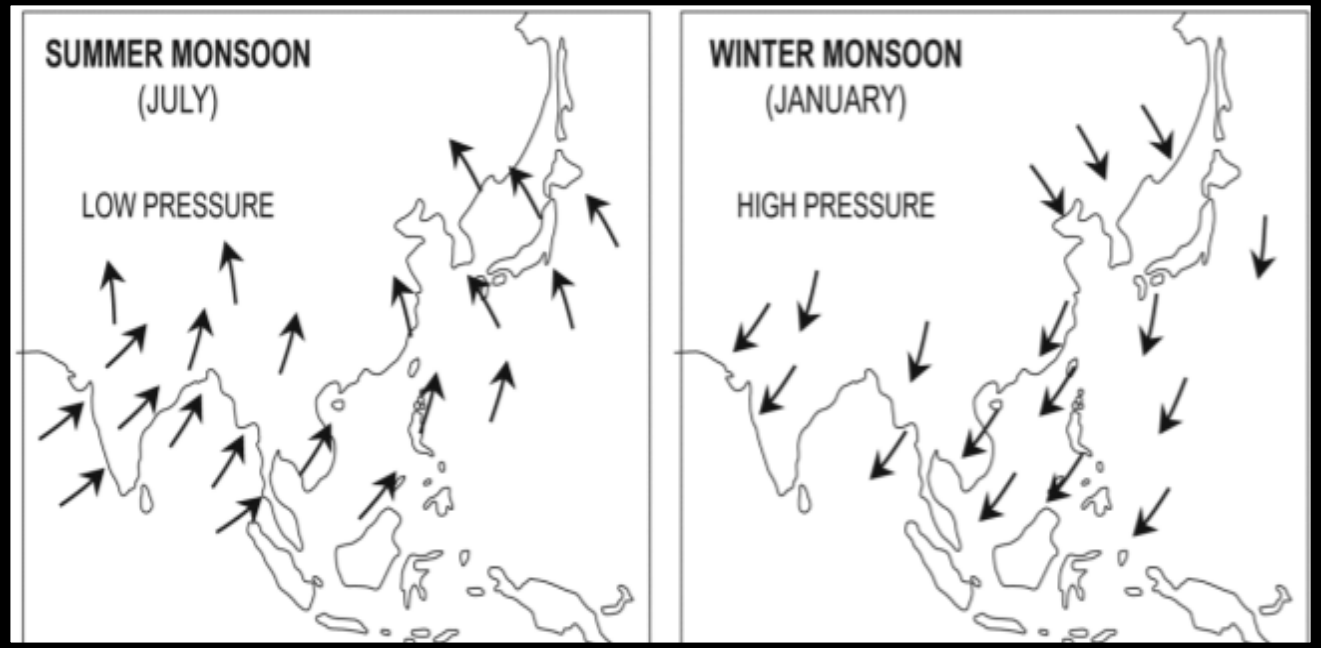
- **Monsoon Breaks:**
  - The monsoon has **wet and dry spells**, caused by the movement of the **monsoon trough**.
  - **Monsoon Trough Axis Movement:**
    - Over the plains: Good rainfall.
    - Closer to the Himalayas: Longer dry spells in the plains and heavy rains in the Himalayan river catchments, often leading to **floods**.
- **Tropical Depressions:**
  - Form in the Bay of Bengal and move along the monsoon trough, impacting rainfall patterns.
- **Uncertainties and Challenges:**
  - Irregular arrival and retreat, alternating **floods** and **droughts**.
  - Disrupts farming schedules, affecting millions of farmers.

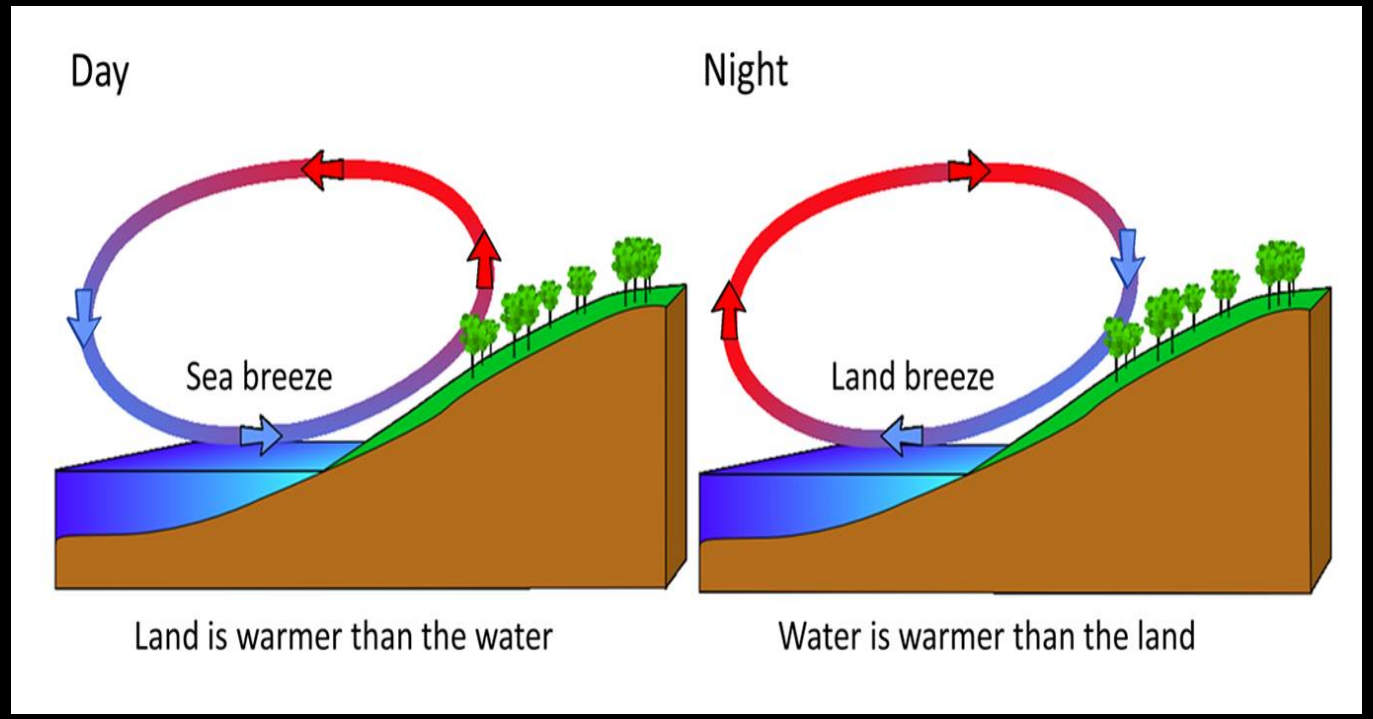
Retreating/Post-Monsoon Season (October-November)

- **Transition Period:** Marks the shift from the rainy season to dry winter conditions as the sun moves southward.
- **Monsoon Withdrawal:**
  - South-west monsoon weakens and withdraws by early October from the **Northern Plains**.
  - High-pressure systems replace the monsoon trough over northern India.
- **Weather Characteristics:**
  - Clear skies with rising day temperatures but cool, pleasant nights.
  - High temperature and humidity cause **'October heat'** during the day.
  - By late October, temperatures drop rapidly in northern India.
- **Cyclonic Activity:**
  - Low-pressure conditions shift to the **Bay of Bengal**, leading to **cyclonic depressions** originating over the **Andaman Sea**.
  - These cyclones bring **heavy rains** to eastern coasts, including the deltas of the **Godavari**, **Krishna**, and **Kaveri**, often causing severe damage.
  - The **Coromandel Coast** receives most of its rainfall from these depressions and cyclones.
  - Cyclones occasionally strike **Odisha**, **West Bengal**, and **Bangladesh**, causing widespread destruction.

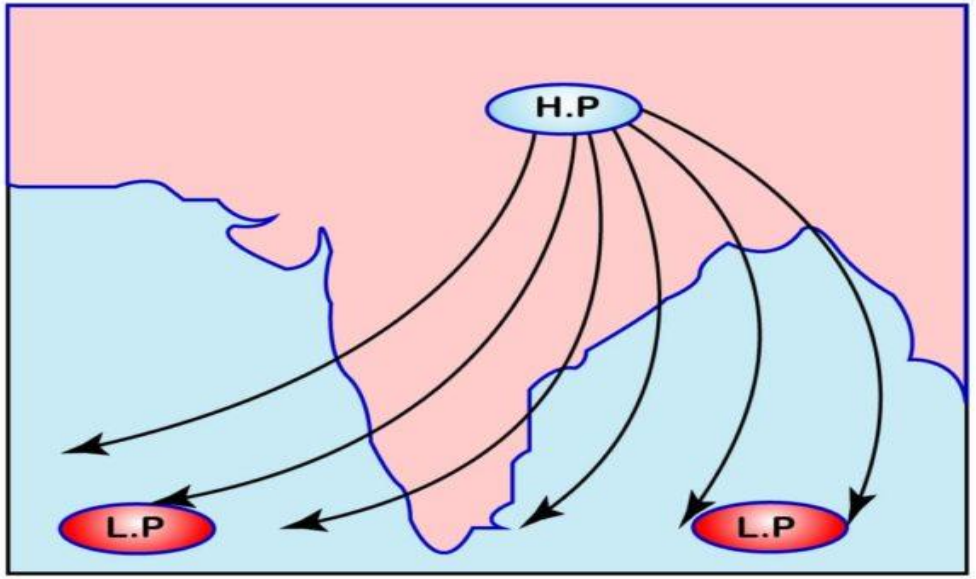
Origin of Monsoon

- The monsoon is a **complex weather phenomenon** that significantly influences the socio-economic and ecological landscape of South Asia. It results from the interaction of **atmospheric, oceanic, and terrestrial factors**, making it one of the most intricate climatic systems. Over time, various theories have emerged to explain its origin, reflecting both traditional and modern approaches.
- **Traditional Theories**
  - **Al Masudi (10th Century):** Described the **seasonal reversal** of monsoon winds.
  - **Sir Edmund Halley (1686):** Introduced the **thermal concept**, explaining monsoons as large-scale land-sea breezes driven by differential heating between land and oceans.
  - **H. Flohn (1951):** Proposed the **dynamic concept**, linking monsoon patterns to global atmospheric circulation and pressure systems.

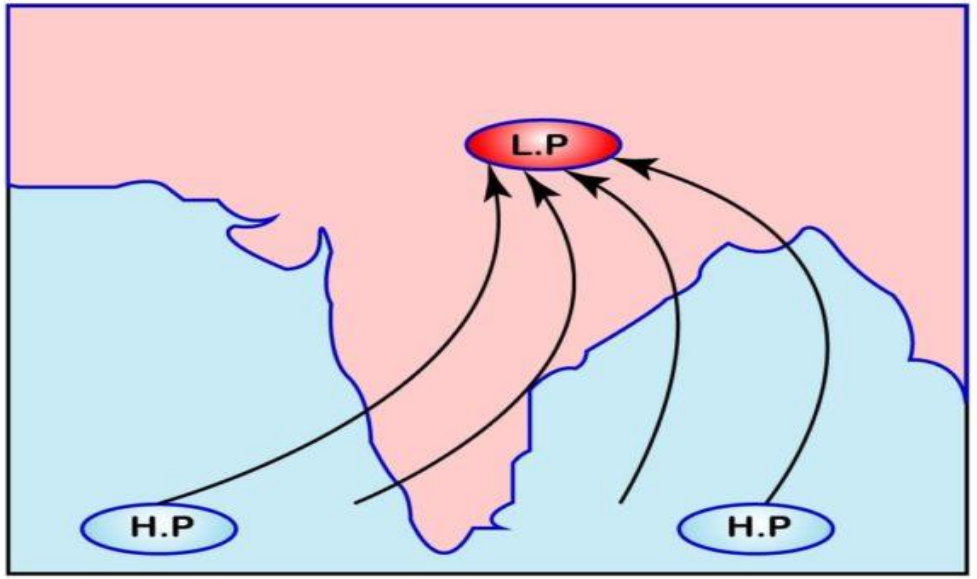




Thermal Concept of Monsoon Origin



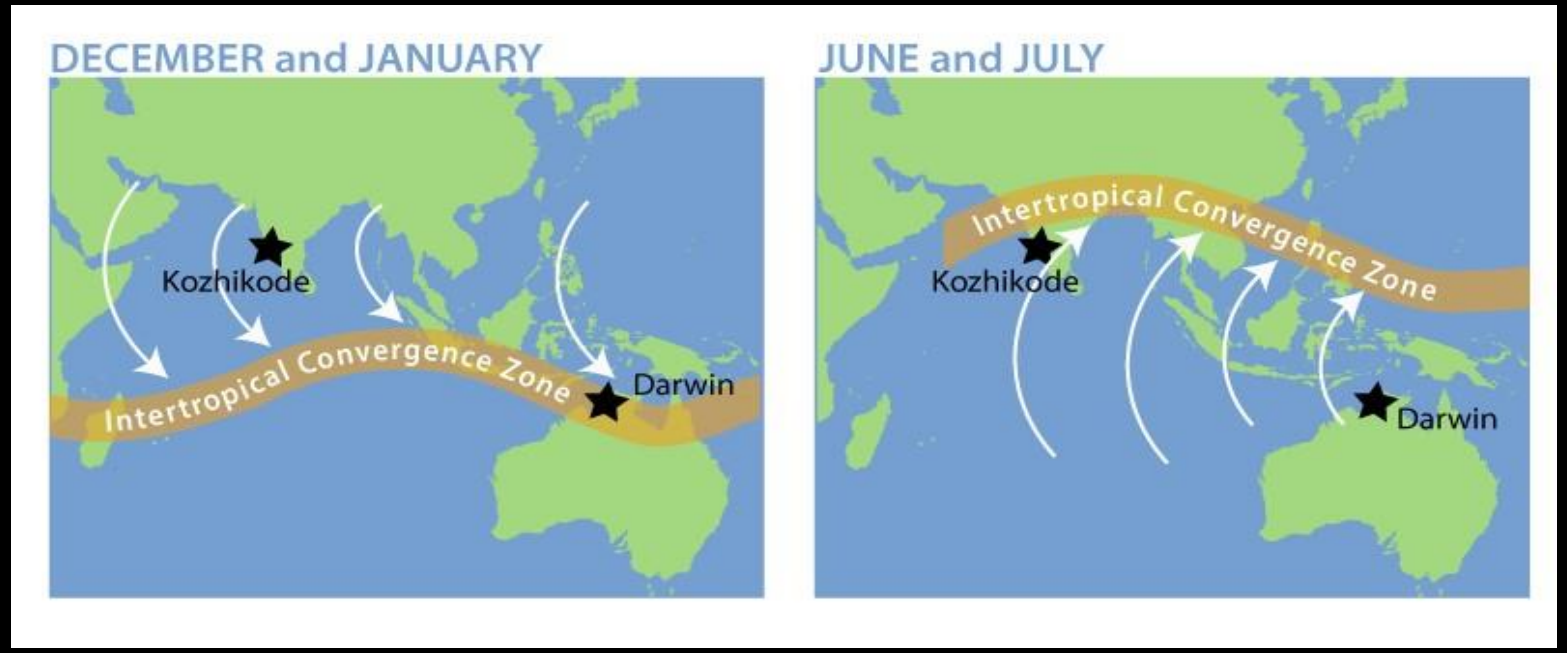
Atmospheric conditions during Winter Monsoon

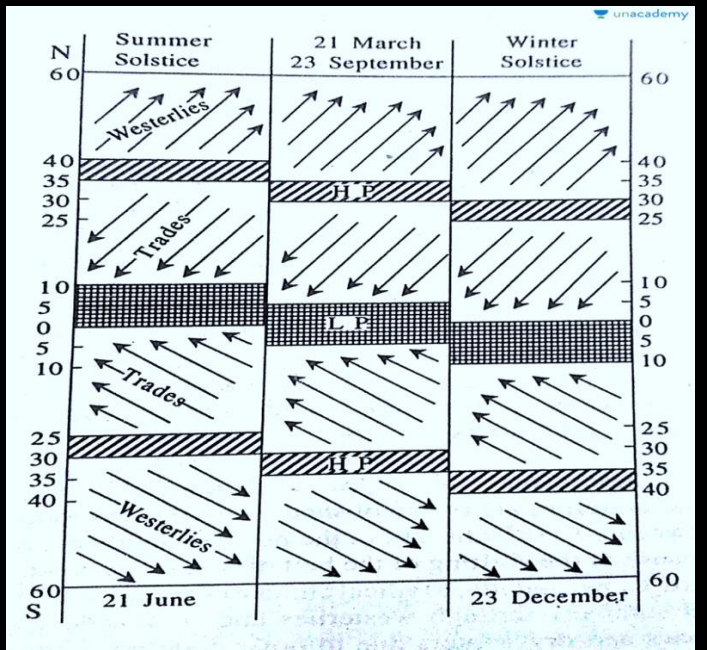


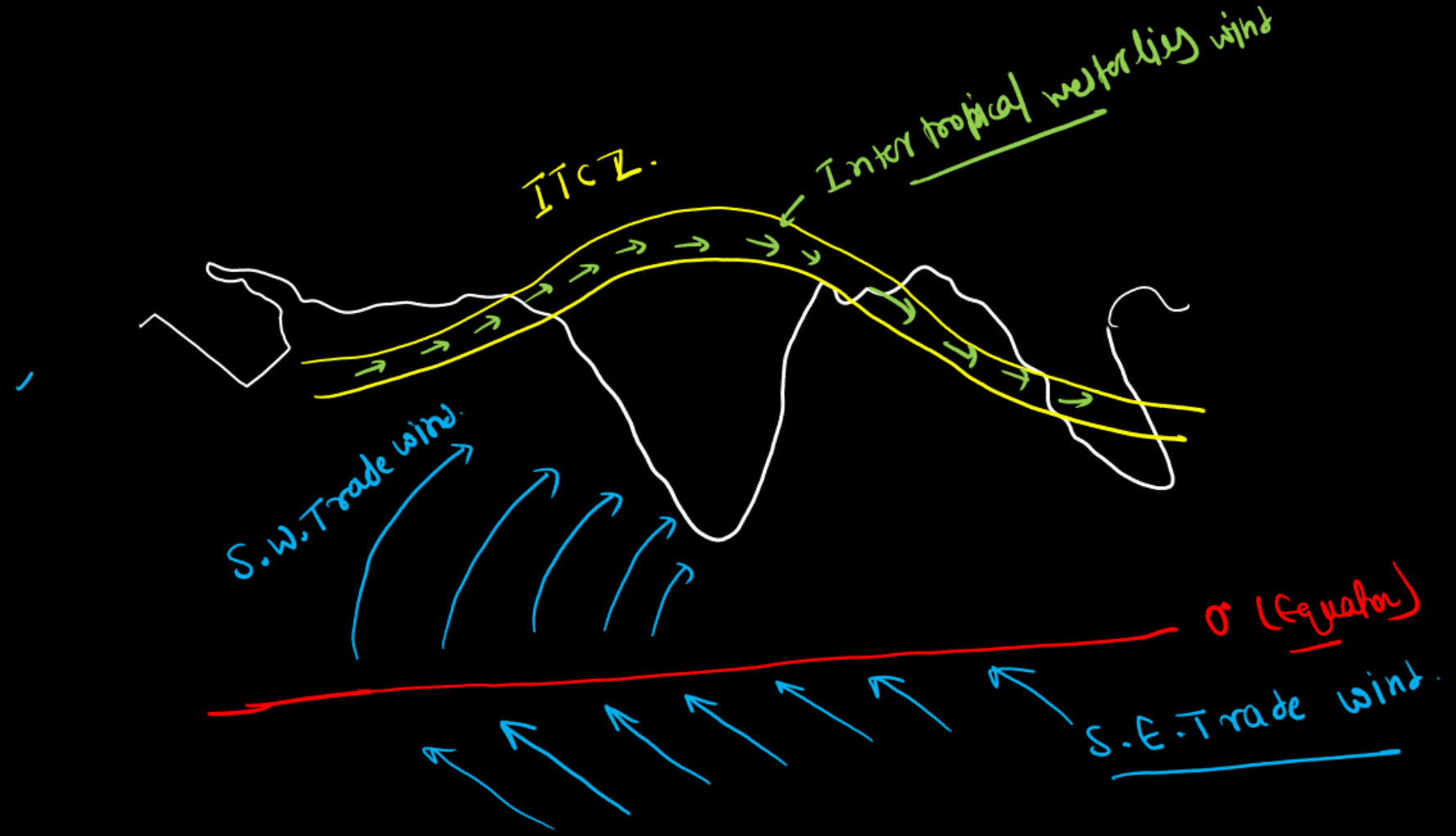
Atmospheric conditions during Summer Monsoon

The dynamic concept of Flohn(1951)

- This concept was propounded by H. Flohn of German Weather Bureau in 1951.
- H. Phone propounded that monsoon wind is the result of **annual Migration of planetary wind and pressure belt.**
- According to this theory intertropical convergence zone(ITCZ) , also known as the 'doldrums' or calm area, extending up to **30 degree north latitude** during summer.
- Therefore **inter tropic westerlies wind** which flows between ITCZ appears over Indian Peninsular blowing from Indian Ocean.
- Besides south east trade wind, after changing its direction joins this westerlies wind.
- Both the strong wind appears as **monsoon wind**.





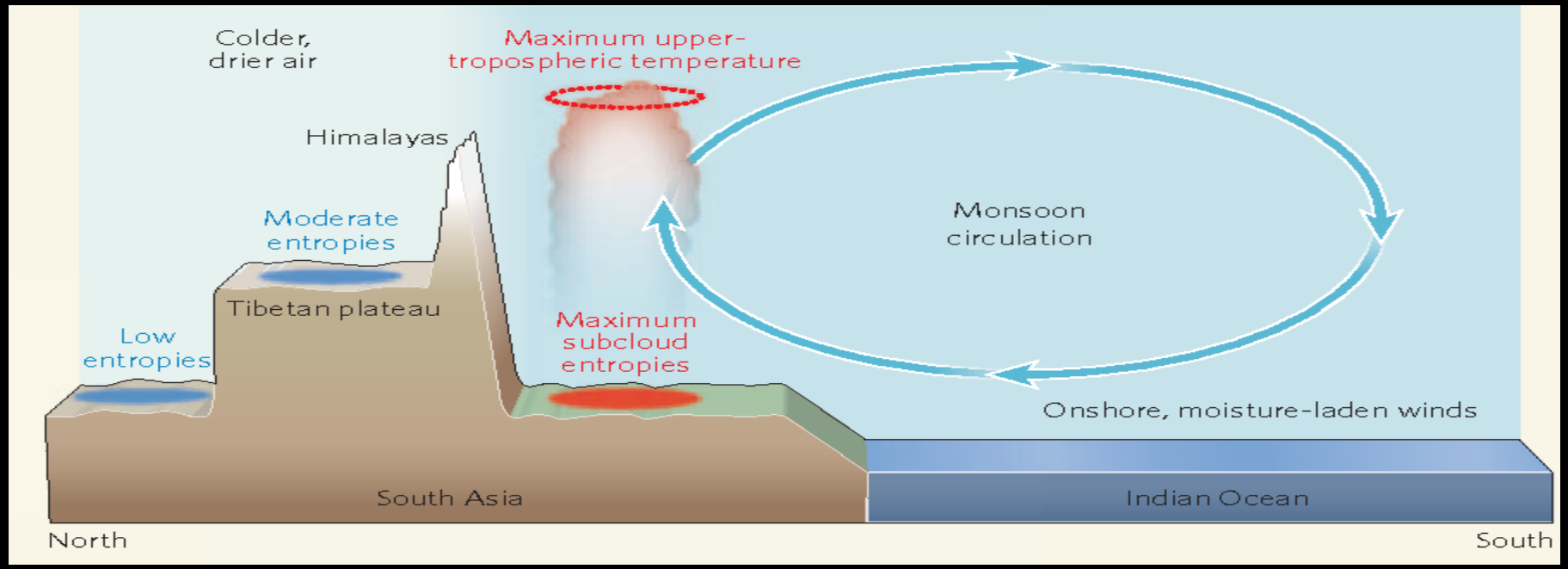

ITCZ.
Intertropical westerlies wind
S.W. Trade wind.
0 (Equator)
S.E. Trade wind.

Modern Approaches to the Origin of the Indian Monsoon

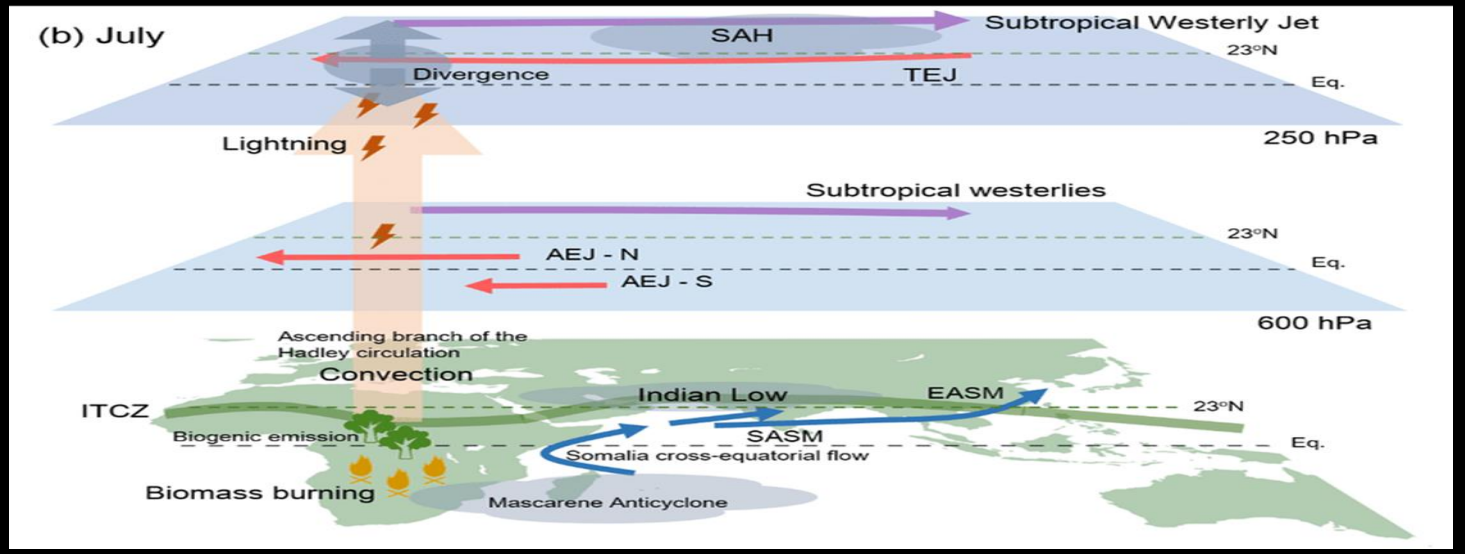
- Recent advancements in meteorological studies, especially after World War II, have significantly reshaped our understanding of the Indian monsoon. It is now recognized that the differential heating of land and sea alone cannot explain the complex monsoon circulation. New research has identified several **teleconnections**, or long-distance linkages between atmospheric and oceanic variables, which play a vital role in shaping the monsoon.
- Modern theories emphasize the following factors:
  - **Himalayas and Tibetan Plateau**
  - **Upper Air Jet Streams**
  - **Circum-Polar Whirl (whirlwinds** in the upper atmosphere over the **North and South Poles)**
  - **ENSO (El Niño-Southern Oscillation)**
  - **Indian Ocean Dipole (IOD)**

Role of Himalayas and Tibetan Plateau

- M.T.Yin (1949) and P.Koteswaram (1952) have expressed the opinion that mechanism of monsoon depends on the upper air circulation.
- The plateau of Tibet extends over an area of about 4.5 million sq. km. The average height of these highlands is 4000 m.
- Due to its enormous height it receives 2-3 C more insolation than the neighbouring areas.
- Heating of these areas leads to a clockwise air circulation in the middle troposphere and strong wind streams originate from this area.
- One of these wind streams blow southward and develops into the tropical easterly jet stream (TEJ).



- **Role of Jet Stream**
- **Sub-tropical westerly jet stream** is bifurcated by the high-land Tibet in winters. Northward branch extends up to 20 N-35 N.
- **Tropical easterly jet stream (TEJ)**, develops over Tibet in summer. This jet descends over the Indian Ocean and intensifies its high pressure cell known as **Mascarene High**.
- The Somali jet, a low level jet, occurs **during the summer over northern Madagascar and off the coast of Somalia**. It strengthen the movement of wind toward India.
- The entire wind system after crossing the equator become south-westerly and are known as the south-westerly summer monsoon.



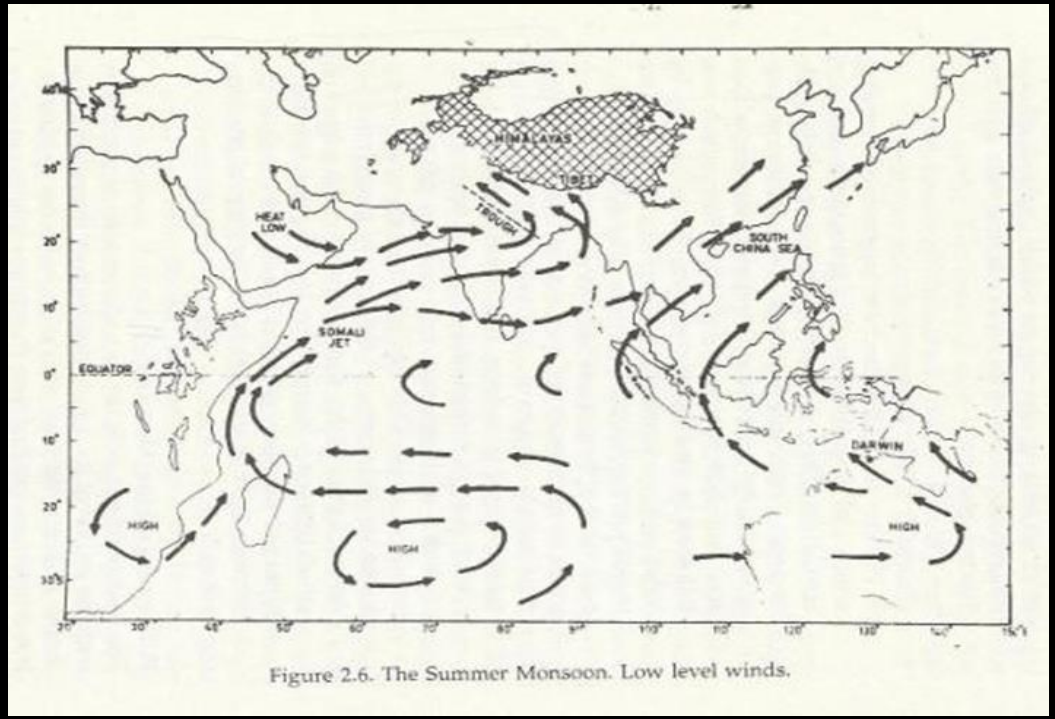
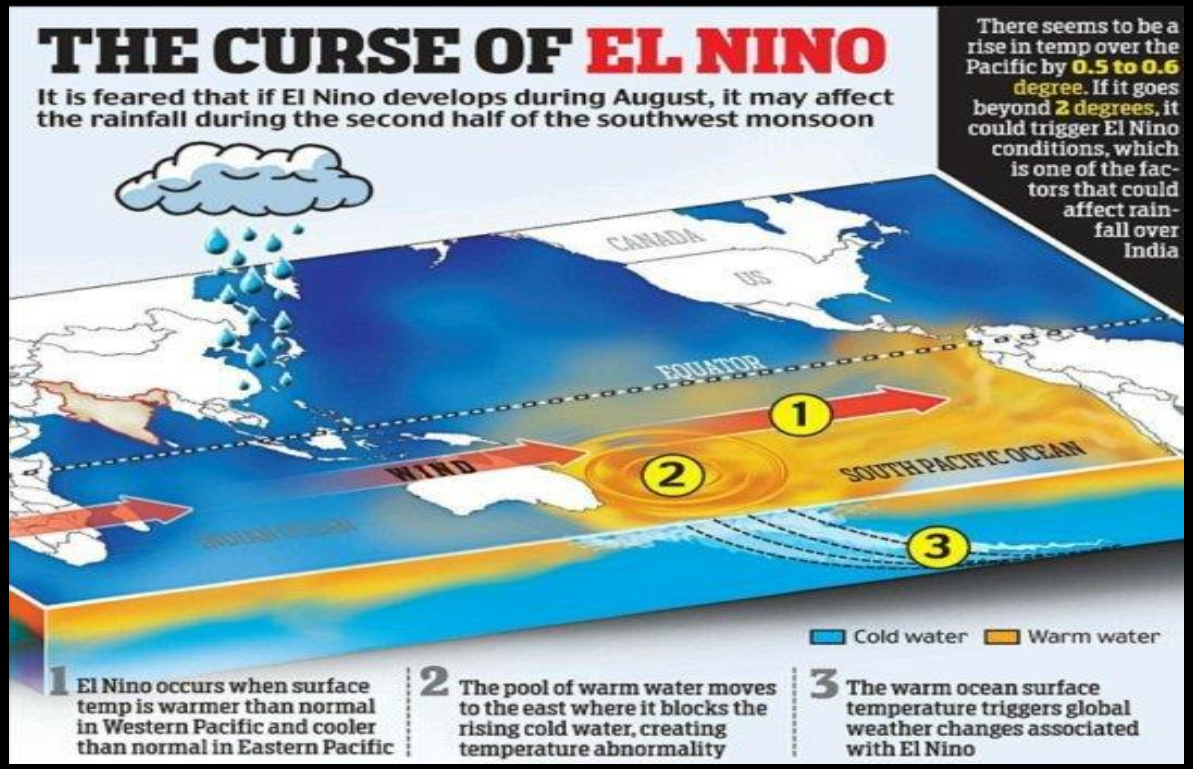
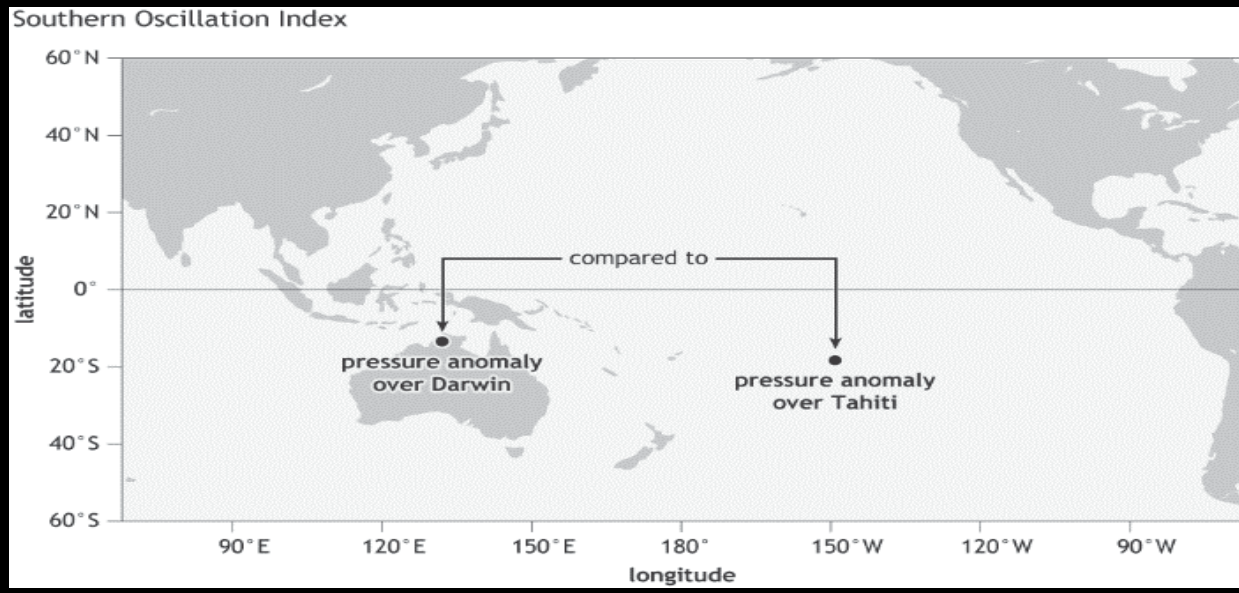
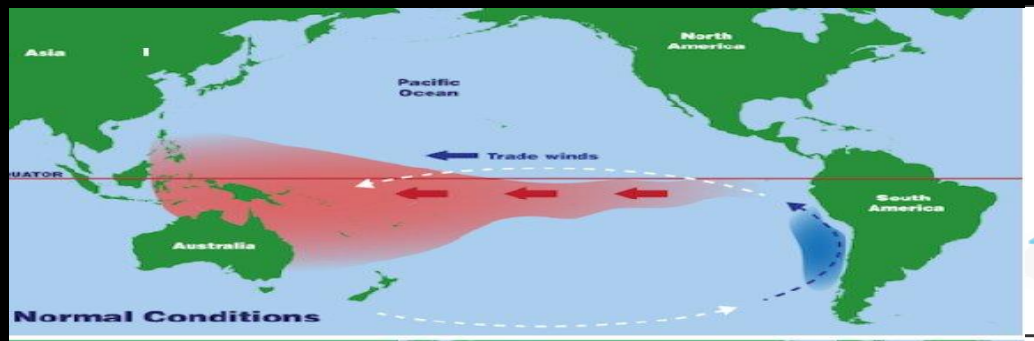


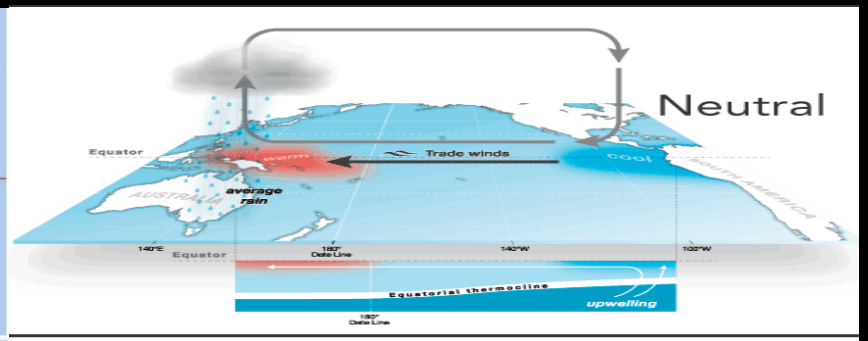
Figure 2.6. The Summer Monsoon. Low level winds.

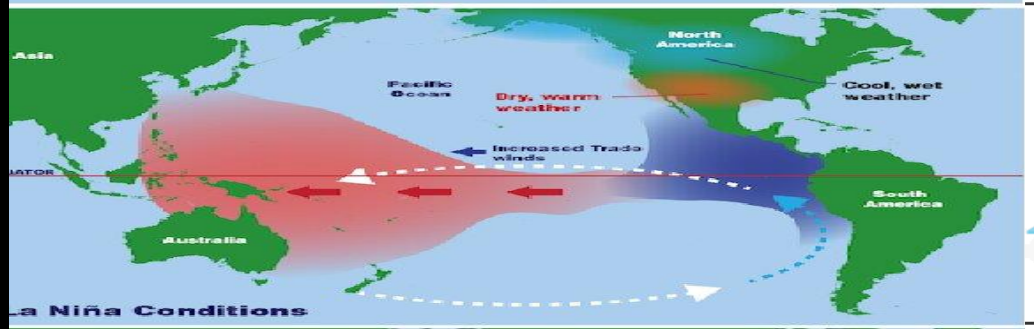
- **Role of ENSO**
- The Indian monsoon is significantly influenced by **El Niño** and the **Southern Oscillation (ENSO)**.
- **El Niño** refers to the reversal of normal sea surface temperatures in the Pacific Ocean, which can cause fluctuations in rainfall patterns.
- **Southern Oscillation** is the periodic see-saw pattern of atmospheric pressure between the eastern and western Pacific Ocean, with a cycle of 2-7 years. It is measured using the **Southern Oscillation Index (SOI)**, based on pressure differences between **Tahiti and Darwin**.
- In a **positive SOI**, low pressure over Australia and Indonesia allows the Southwest monsoon to strengthen. Conversely, during **El Niño** (negative SOI), the **Walker Cell** shifts eastward, weakening the monsoon and leading to drought conditions.
- **La Niña**, the opposite phase, strengthens the Indian Ocean branch of the Walker Cell, intensifying surface winds and leading to a stronger monsoon.

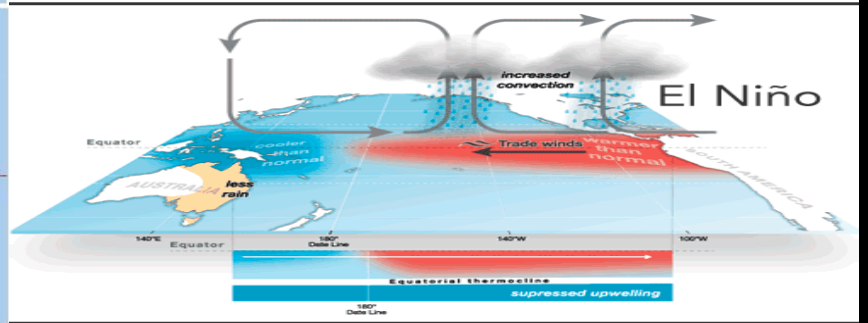


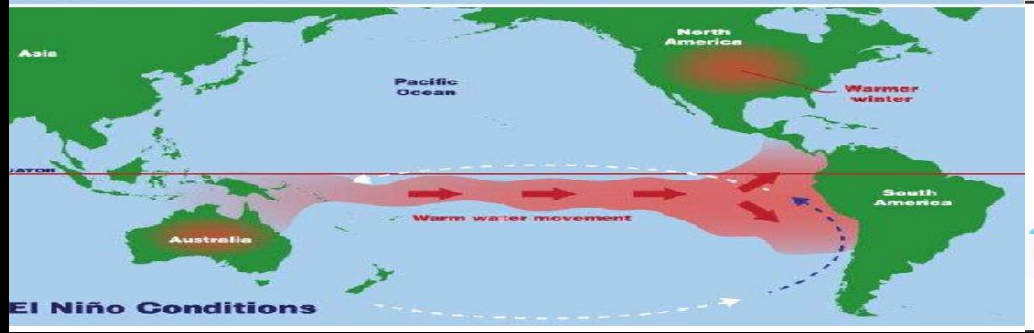


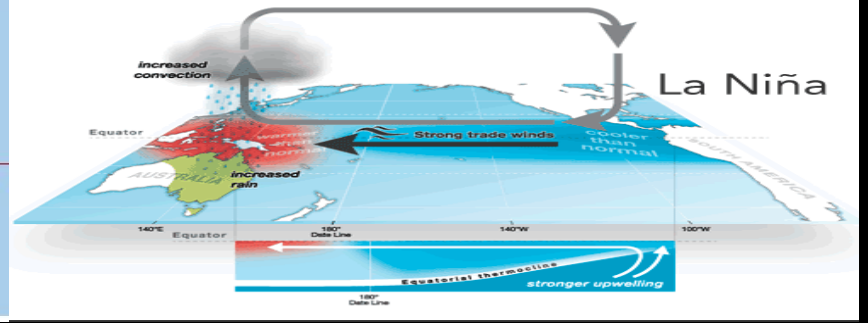

Asia
North America
Pacific Ocean
Trade winds
South America
Australia
Normal Conditions


Neutral
Equator
Trade winds
warm
cool
average rain
AUSTRALIA
140°E
Equator
180° Date Line
140°W
100°W
Equatorial thermocline
upwelling


Asia
North America
Pacific Ocean
Dry, warm weather
Cool, wet weather
Increased Trade winds
South America
Australia
La Niña Conditions

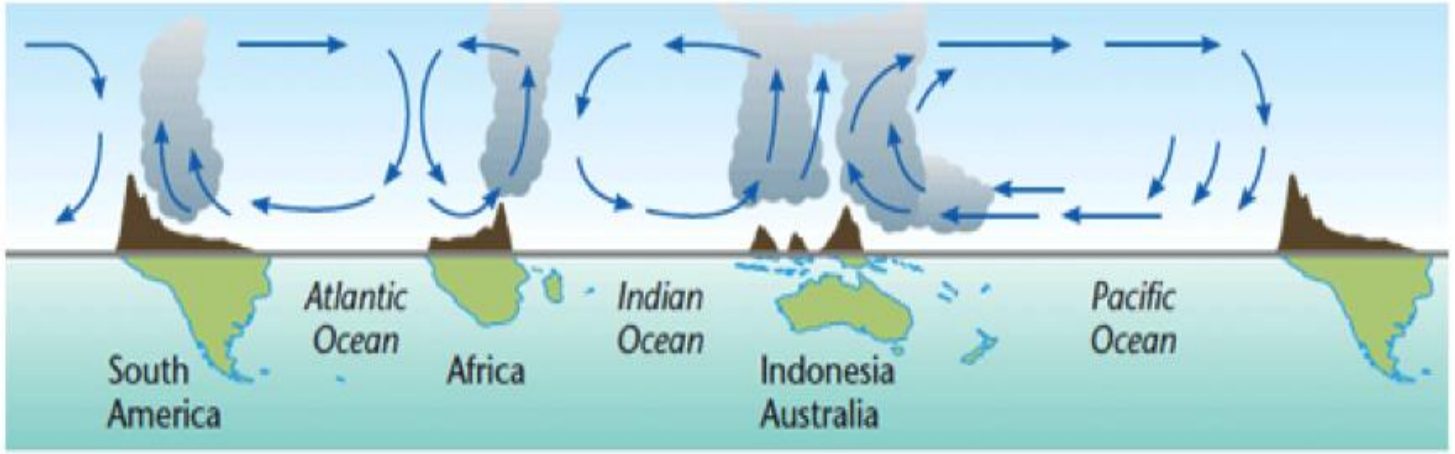

El Niño
increased convection
Equator
Trade winds
cooler than normal
warmer than normal
less rain
AUSTRALIA
140°E
Equator
180° Date Line
140°W
100°W
Equatorial thermocline
supressed upwelling


Asia
North America
Pacific Ocean
Warmer winter
South America
Warm water movement
Australia
El Niño Conditions

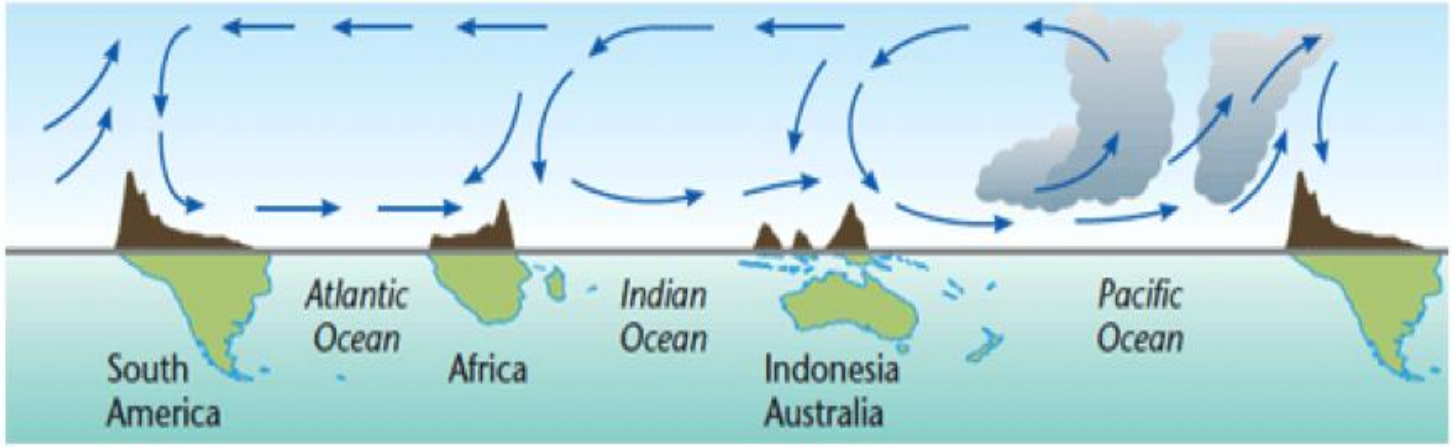

La Niña
increased convection
Equator
Strong trade winds
warmer than normal
cooler than normal
increased rain
AUSTRALIA
140°E
Equator
180° Date Line
140°W
100°W
Equatorial thermocline
stronger upwelling

Walker Cell

- **The longitudinal (east-west) circulation across the equatorial Pacific is known as the Walker cell or Walker circulation.**
- However, many scientists use the term *'walker cell' for all east-west circulations in different oceans.*
- Walker cell is associated with southern oscillation and its strength fluctuates with that of Southern Oscillation Index (SOI).
- The warm water of the central Pacific Ocean slowly drifts towards South American coast and replaces the cool Peruvian current. Such appearance of warm water off the coast of Peru is known as the El Nino.

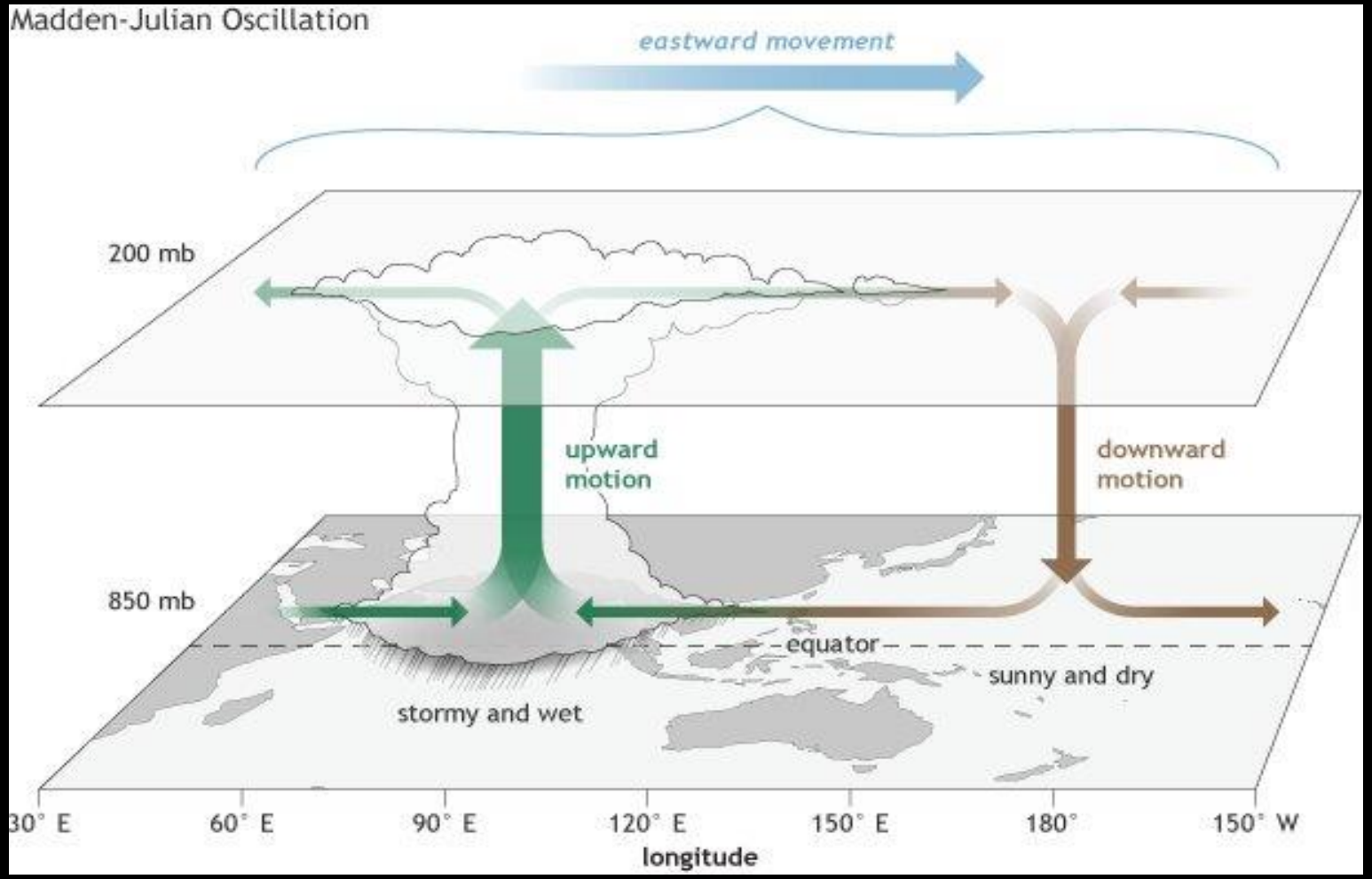


Normal circulation: **with** southern oscillation



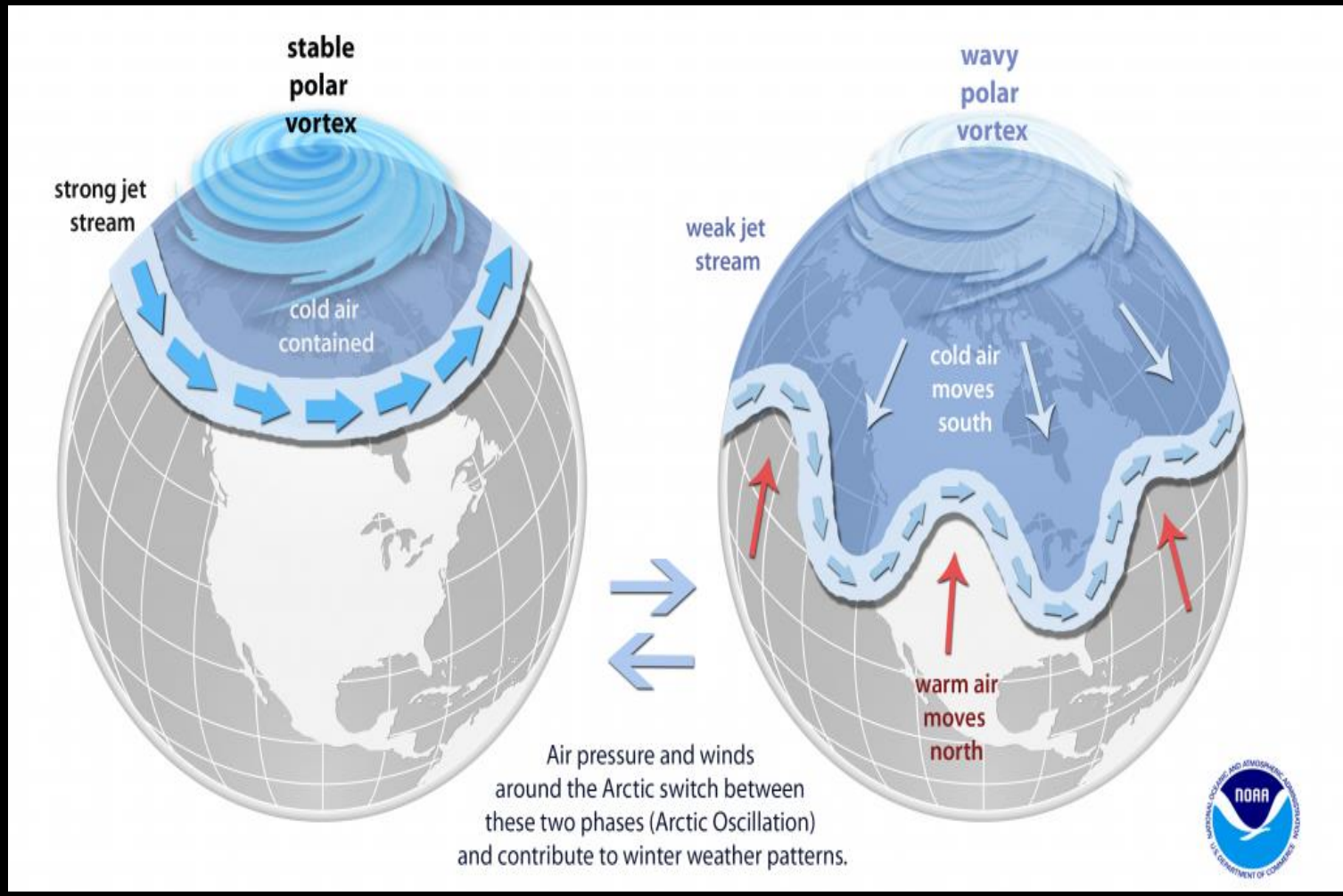
ENSO event: **no** southern oscillation

- **MJO and Indian Monsoon**
- The **Madden-Julian Oscillation (MJO)** is a major tropical atmospheric phenomenon that involves the eastward movement of **tropical rainstorms** and convection across the Indian and Pacific Oceans.
- It was discovered in 1971 by Roland Madden and Paul Julian of the American National Center for Atmospheric Research (NCAR)
- It has a typical cycle of 30 to 60 days and affects monsoon rainfall, including the Indian monsoon.
- The **Madden-Julian Oscillation (MJO)** influences the Indian monsoon by affecting the **timing, intensity, and distribution** of rainfall. The MJO has a cycle of 30 to 60 days, with two main phases:
- **Active Phase**: When the MJO is in its active phase, **tropical convection** increases, leading to more **rainfall**. This phase promotes **uplift** of air in the Indian Ocean, which enhances the Southwest monsoon, causing **heavy rainfall** in India. This phase is associated with **high sea surface temperatures** and favorable conditions for monsoon winds.
- **Suppressed Phase**: During the suppressed phase, convection decreases, causing **reduced rainfall**. This phase is marked by **lower sea surface temperatures** and **stronger subsidence**, which inhibits the upward movement of air and weakens monsoon activity. It can lead to **dry spells** or weaker monsoon conditions.
- In summary, the **active phase of MJO** enhances monsoon rainfall, while the **suppressed phase** causes breaks or drought-like conditions in the Indian monsoon.


Madden-Julian Oscillation
eastward movement
200 mb
upward
motion
downward
motion
850 mb
equator
sunny and dry
stormy and wet
30° E
60° E
90° E
120° E
150° E
180°
150° W
longitude

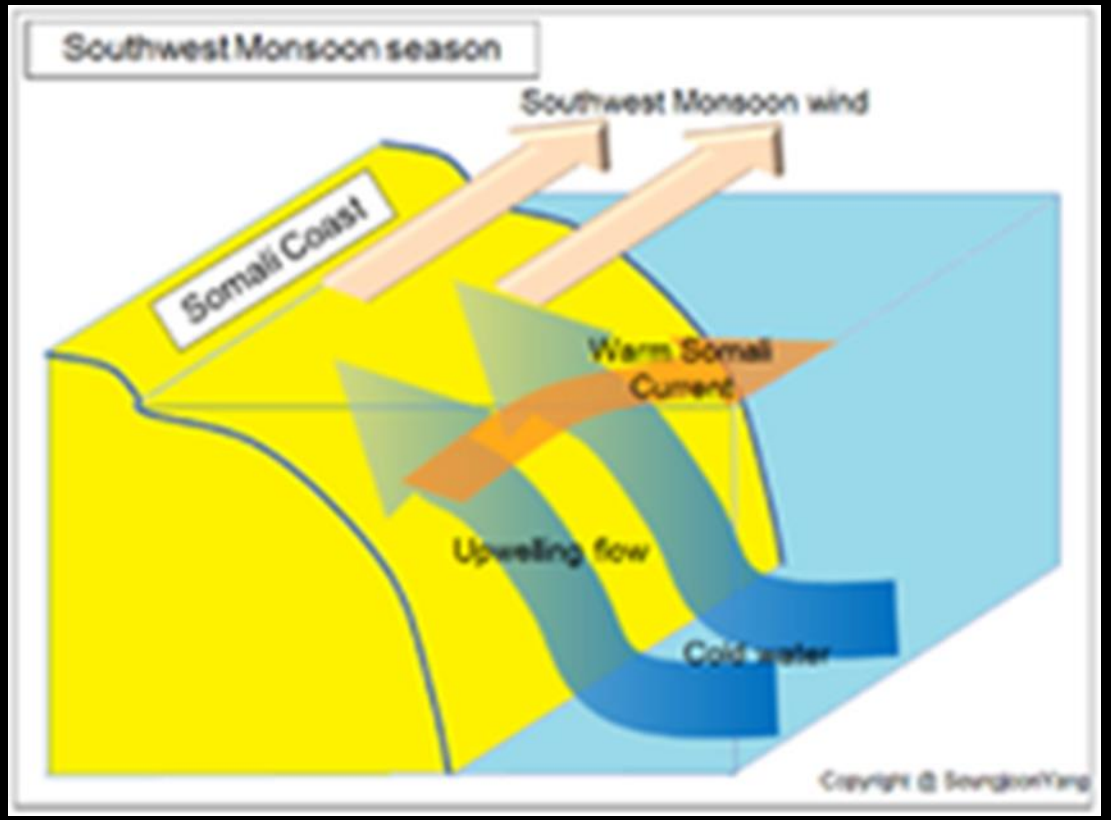
POLAR VORTEX

- A polar vortex, is a large region of cold, rotating air that encircles both of Earth's polar regions.
- Polar vortices are weakest during summer and strongest during winter.
- When it becomes stronger, it pushes latitudinal wind cell along with jet steam.



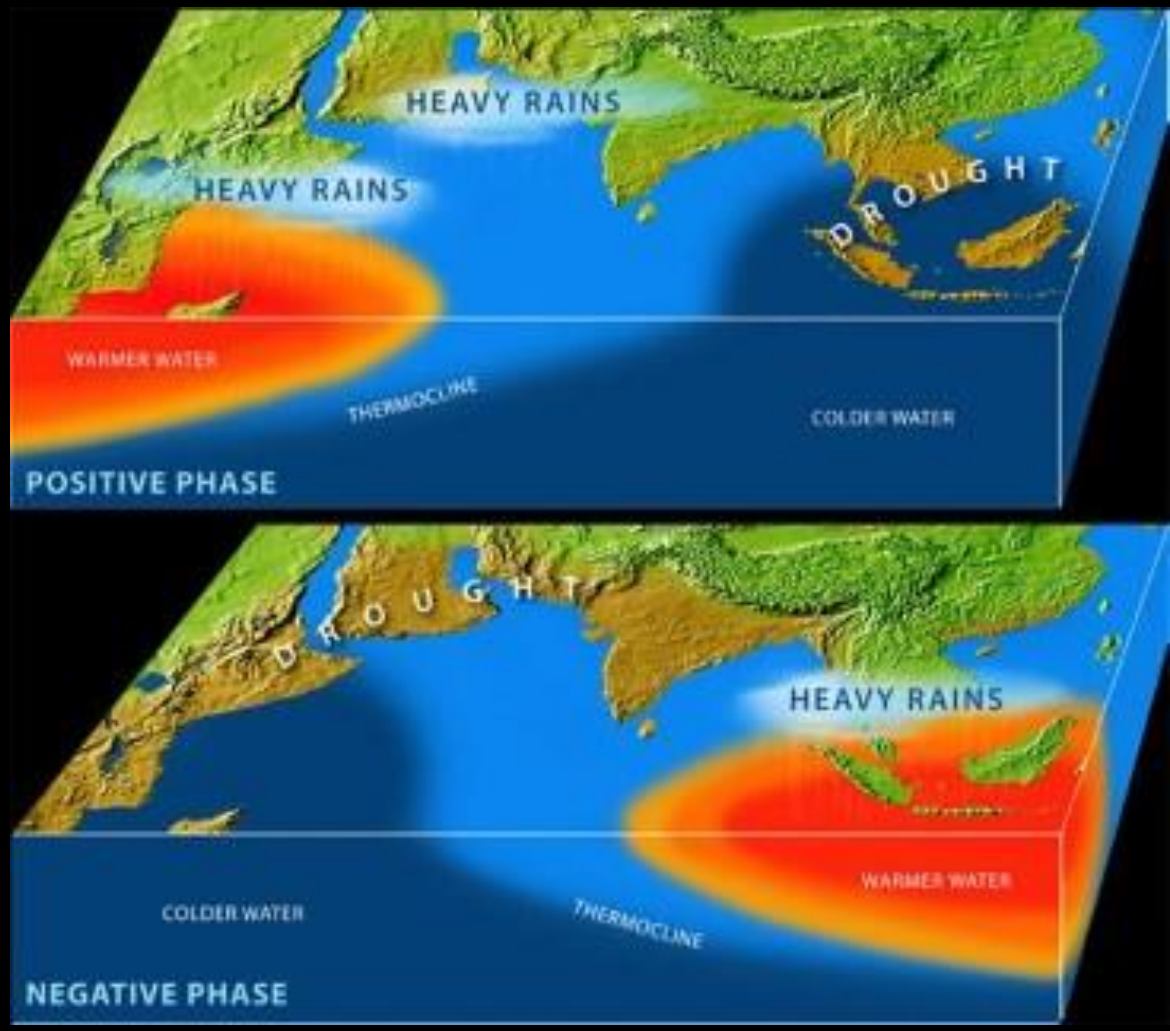
Somalian current

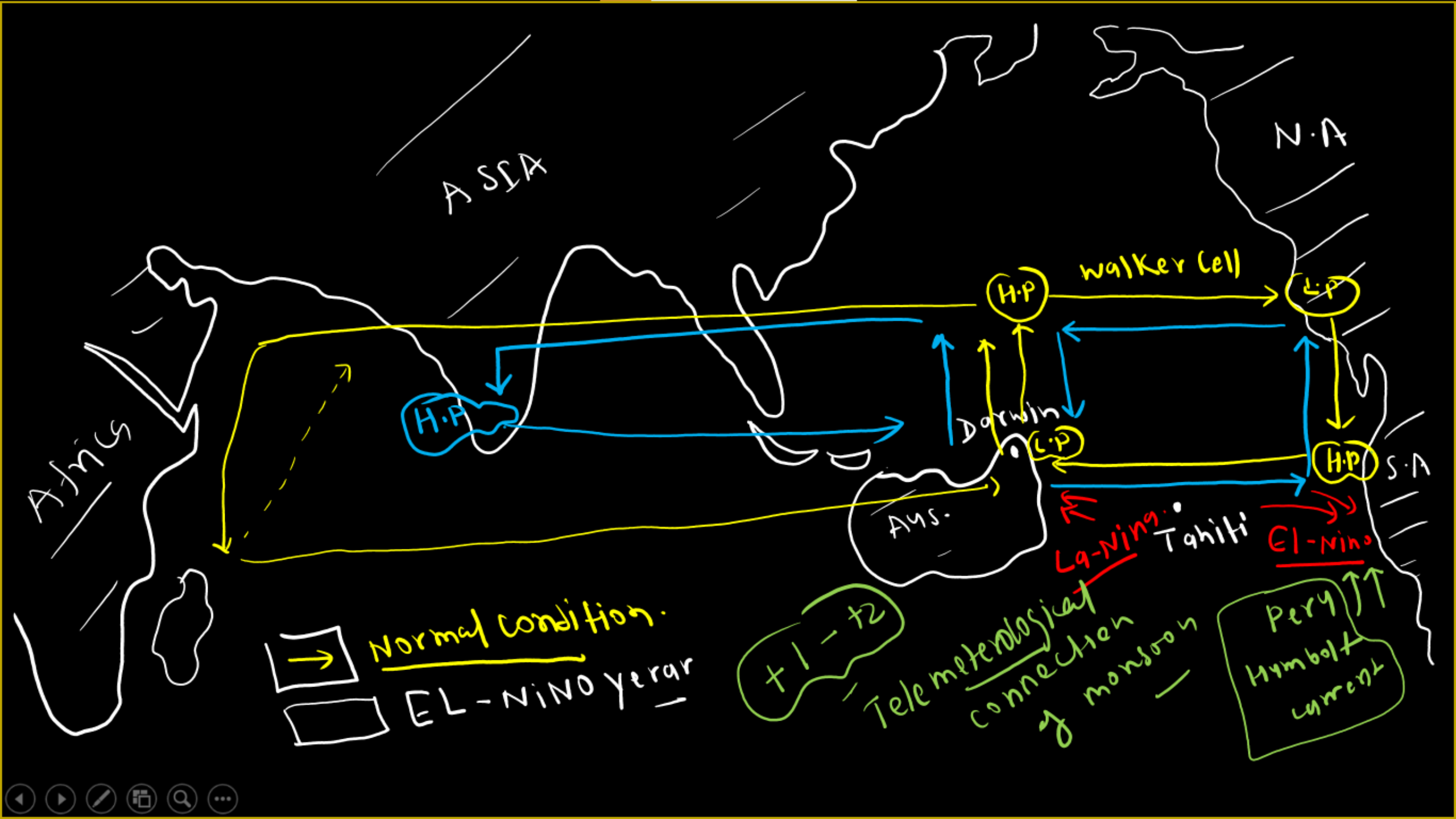
- The **Somalian current is a cold current that** changes the pressure condition of western Indian ocean.
- Normally, there remains a low pressure area along the eastern coast of Somalia.
- In exceptional years, after every six or seven years, the low pressure area in western Arabian Sea becomes a high pressure area.
- It is attributed to the upwelling of Somali current.
- Such a pressure reversal results into a weaker monsoon in India.



Indian Ocean Dipole (IOD)

- The IOD is the difference in sea surface temperature between Arabian Sea (western Indian Ocean) and the eastern Indian Ocean south of Indonesia.
- The IOD involves a periodic oscillation of sea-surface temperatures (SST), between "**positive**", "**neutral**" **and** "**negative**" phases.
- In **positive phase** sea-surface temperatures and precipitation in the western Indian Ocean region founds greater.
- The **negative phase** of the IOD brings about the opposite conditions, with warmer water and greater precipitation in the eastern Indian Ocean, and cooler and drier conditions in the west
- There is no direct correlation between IOD and ENSO.
- The IOD affects the strength of monsoons over the Indian subcontinent. **Positive IOD** which is associated with warm sea-surface temperatures of western Indian Ocean is favorable for monsoon in Indian subcontinent.




ASIA
N.A
H.P
Walker Cell
L.P
Darwin
L.P
H.P
S.A
Aus.
La-Nina.
Tahiti
El-Nino
Normal condition.
EL-NINO Yerar
t1 - t2
Telemeteorological connection of monsoon
Peru
Humbolt current

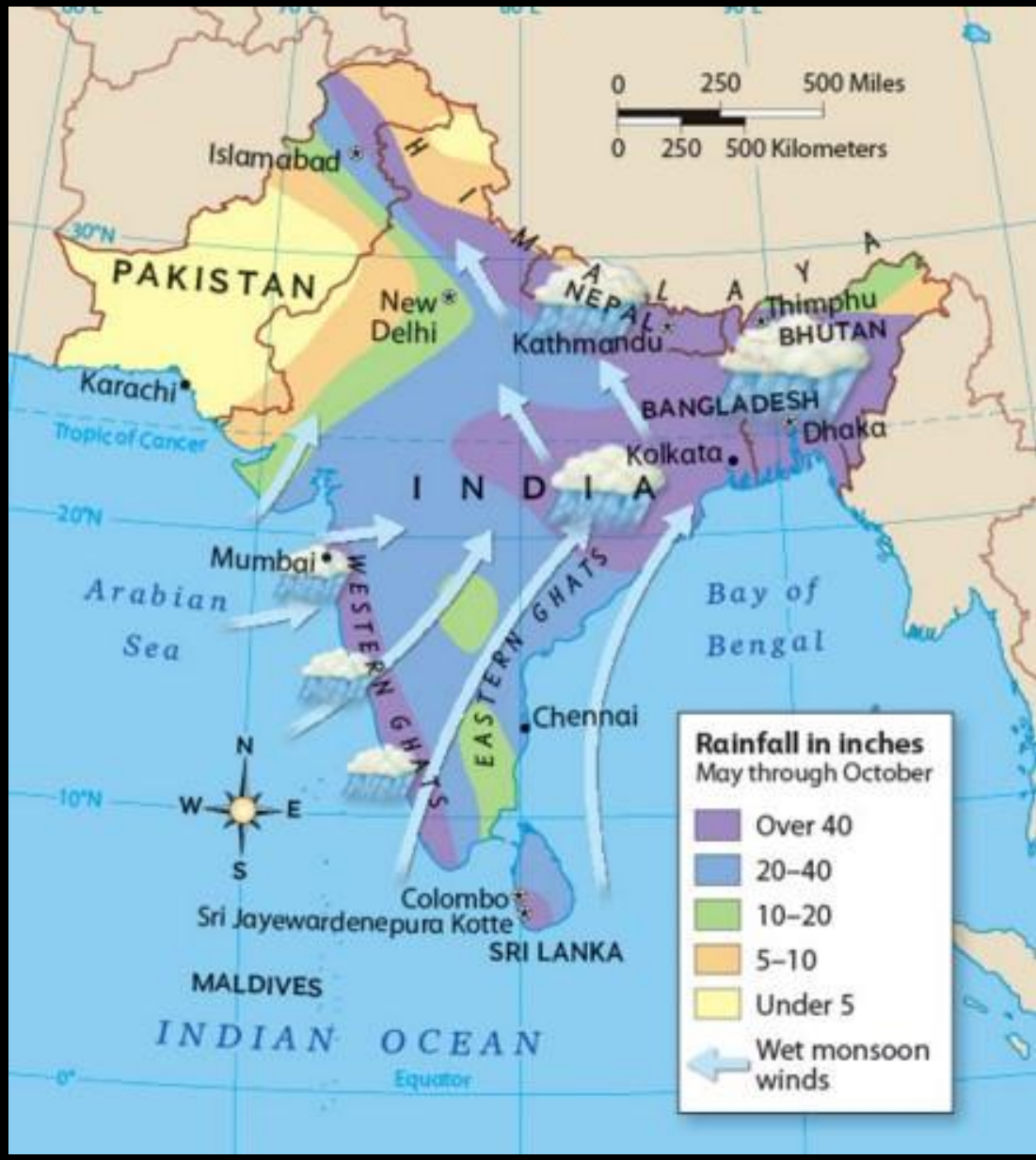
Nature of Indian Monsoon

- The Indian Monsoon is a complex and dynamic weather phenomenon that plays a pivotal role in shaping the climate, agriculture, and water resources of India. It is characterized by the seasonal reversal of winds, bringing heavy rainfall to the subcontinent.
- It include followings:-
  1. Onset and advance of monsoon
  2. Rain-bearing systems and the relationship between their frequency and distribution of monsoon rainfall.
  3. Break in the monsoon
  4. Retreat of the monsoon

Onset and Advance of Monsoon

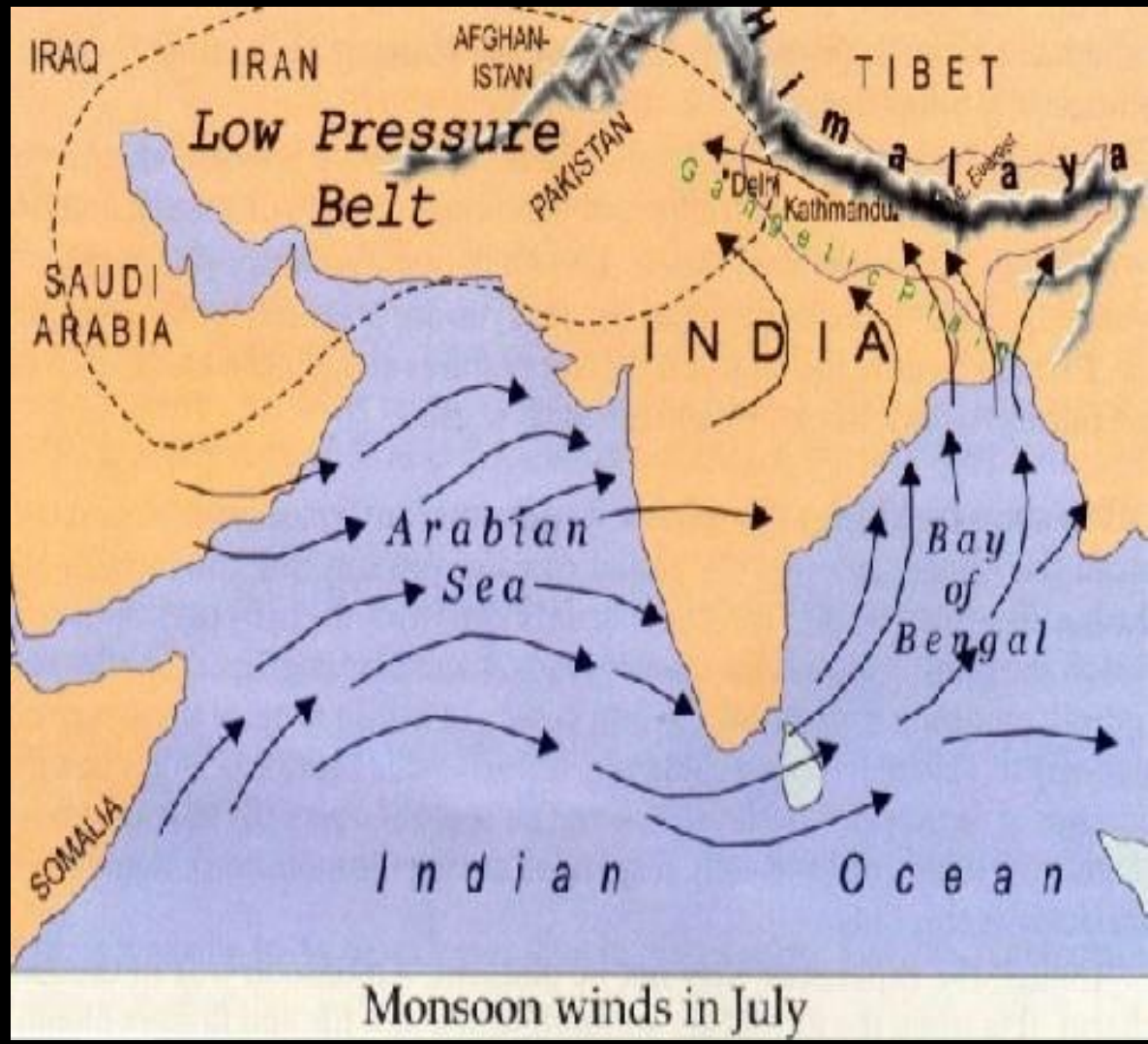
- The differential heating of land and sea is still believed to be the primary cause of the monsoon by many meteorologists. Low pressure at ITCZ which is located over north India in month of May becomes so intense that it pulls the trade winds of the southern hemisphere northwards.
- These southeast trade winds cross the equator and enter the Bay of Bengal and the Arabian Sea, only to be caught up in the air circulation over India.
- Passing over the equatorial warm currents, they bring with them moisture in abundance. With the northwards shift of ITCZ, an easterly jet stream develops over 15 N.
- The rain in the south-west monsoon season begins rather abruptly.
- One result of the first rain is that it brings down the temperature substantially.
- This sudden onset of the moisture-laden winds associated with violent thunder and lightning, is often termed as “burst” of the monsoons.
- **Southwest monsoon first of all reaches in Andaman-Nicobar Islands on 15th May. Kerala coast receives it on 1st June. It reaches Mumbai and Kolkata between 10th and 13th June. By 15th of July, Southwest monsoon covers whole of India**

- **Rain Bearing Systems and Distribution of Rainfall**
- The southwest monsoon splits into two branches, the Arabian Sea Branch and the Bay of Bengal Branch near the southernmost end of the Indian Peninsula.
- The monsoon winds originating over the **Arabian Sea** further split into **three branches**:-
- One branch is **obstructed by the Western Ghats**. These winds climb the slopes of the Western Ghats and as a result of orographic rainfall phenomenon, the windward side of Ghats receives very heavy rainfall ranging between 250 cm and 400 cm. After crossing the Western Ghats, these winds descend and get heated up. This reduces humidity in the winds. As a result, these winds cause little rainfall east of the Western Ghats. This region of low rainfall is known as the **rain-shadow area.**



- **Another branch of the Arabian Sea monsoon strikes the coast north of Mumbai**. Moving along the Narmada and Tapi river valleys, these winds cause rainfall in extensive areas of central India. The Chotanagpur plateau gets 15 cm rainfall from this part of the branch. Thereafter, they enter the Ganga plains and mingle with the Bay of Bengal branch.
- A third branch of this monsoon wind **strikes the Saurashtra Peninsula and the Kutch**. It then passes over west Rajasthan and along the Aravallis, causing only a scanty rainfall.
  In Punjab and Haryana, it too joins the Bay of Bengal branch. These two branches, reinforced by each other, cause rains in the western Himalayas.
- The intensity of rainfall over the west coast of India is, however, related to two factors:
  - The offshore meteorological conditions.
  - The position of the equatorial jet stream along the eastern coast of Africa.

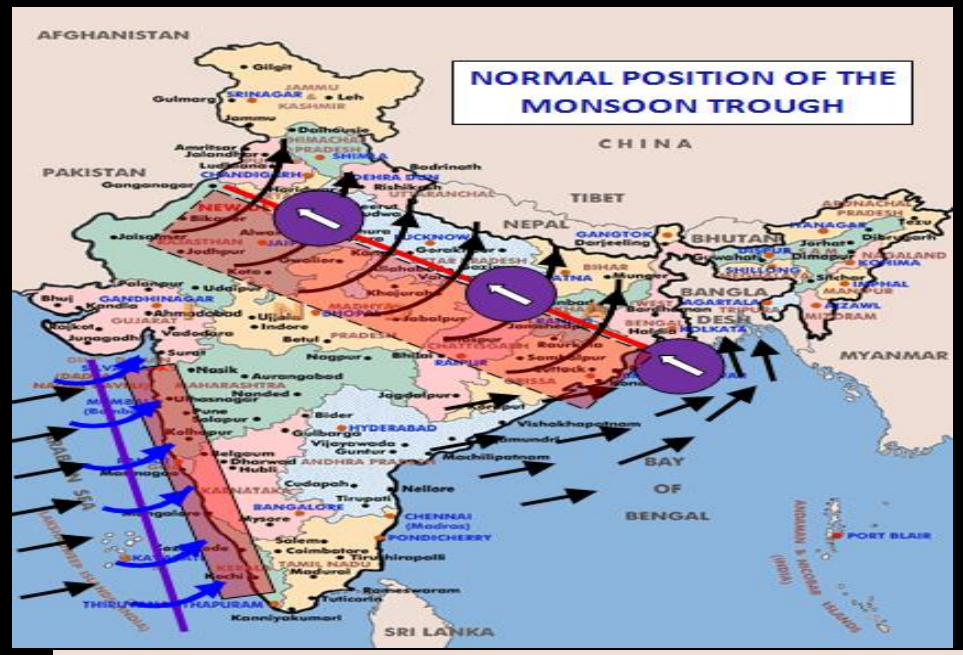
- The **Bay of Bengal branch** strikes the coast of Myanmar and part of southeast Bangladesh. But the Arakan Hills along the coast of Myanmar deflect a big portion of this branch towards the Indian subcontinent. The monsoon, therefore, enters West Bengal and Bangladesh from south and southeast instead of from the south-westerly direction.
- From here, this branch splits into two under the influence of the Himalayas and the thermal low is northwest India.
  - One branch moves westward along the **Ganga plains** reaching as far as the Punjab plains.
  - The other branch **moves up the Brahmaputra valley** in the north and the northeast, causing widespread rains.
  - Its sub-branch strikes the Garo and Khasi hills of Meghalaya.**Mawsynram**, located on the crest of Khasi hills, receives the **highest average annual rainfall** in the world.
- The Tamil Nadu coast remains dry during this season because it is situated in rainshadow area of Arabian Sea branch of the south-west monsoon and lies parallel to the Bay of Bengal branch of south-west monsoon.

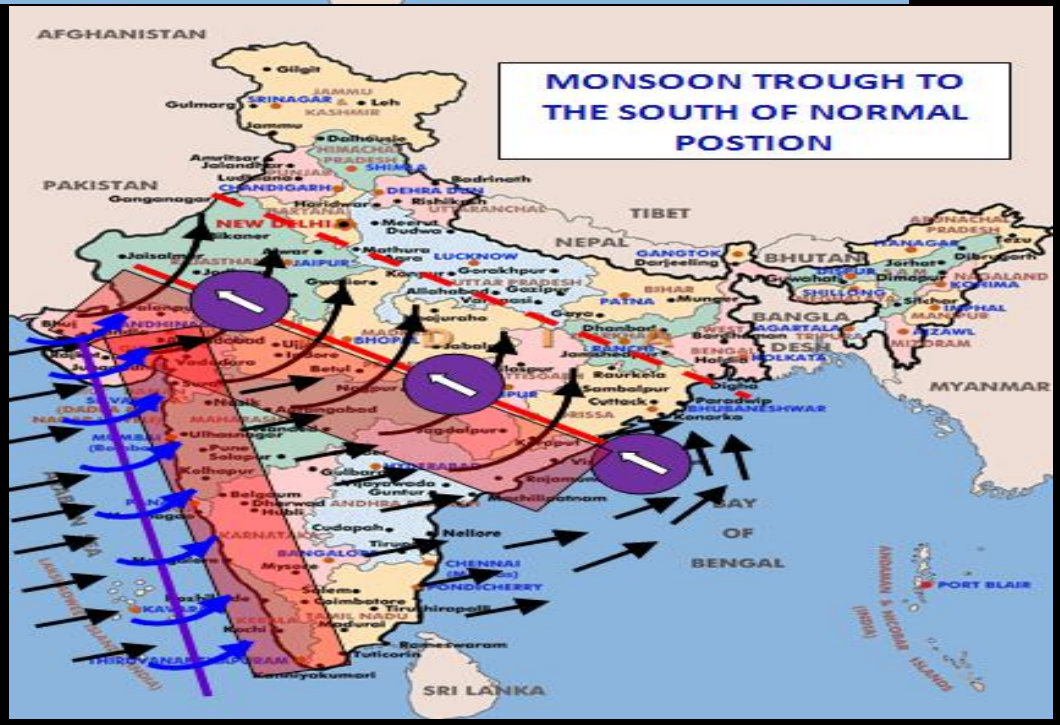


Monsoon winds in July

Break in the Monsoon

- During the south-west monsoon period after having rains for a few days, if rain fails to occur for one or more weeks, it is known as break in the monsoon.
- These dry spells are quite common during the rainy season.
- These breaks in the different regions are due to different reasons:
- i. In northern India rains are likely to fail if the rain-bearing storms are not very frequent along the monsoon trough or the ITCZ over this region.
- ii. Over the west coast the dry spells are associated with days when winds blow parallel to the coast.



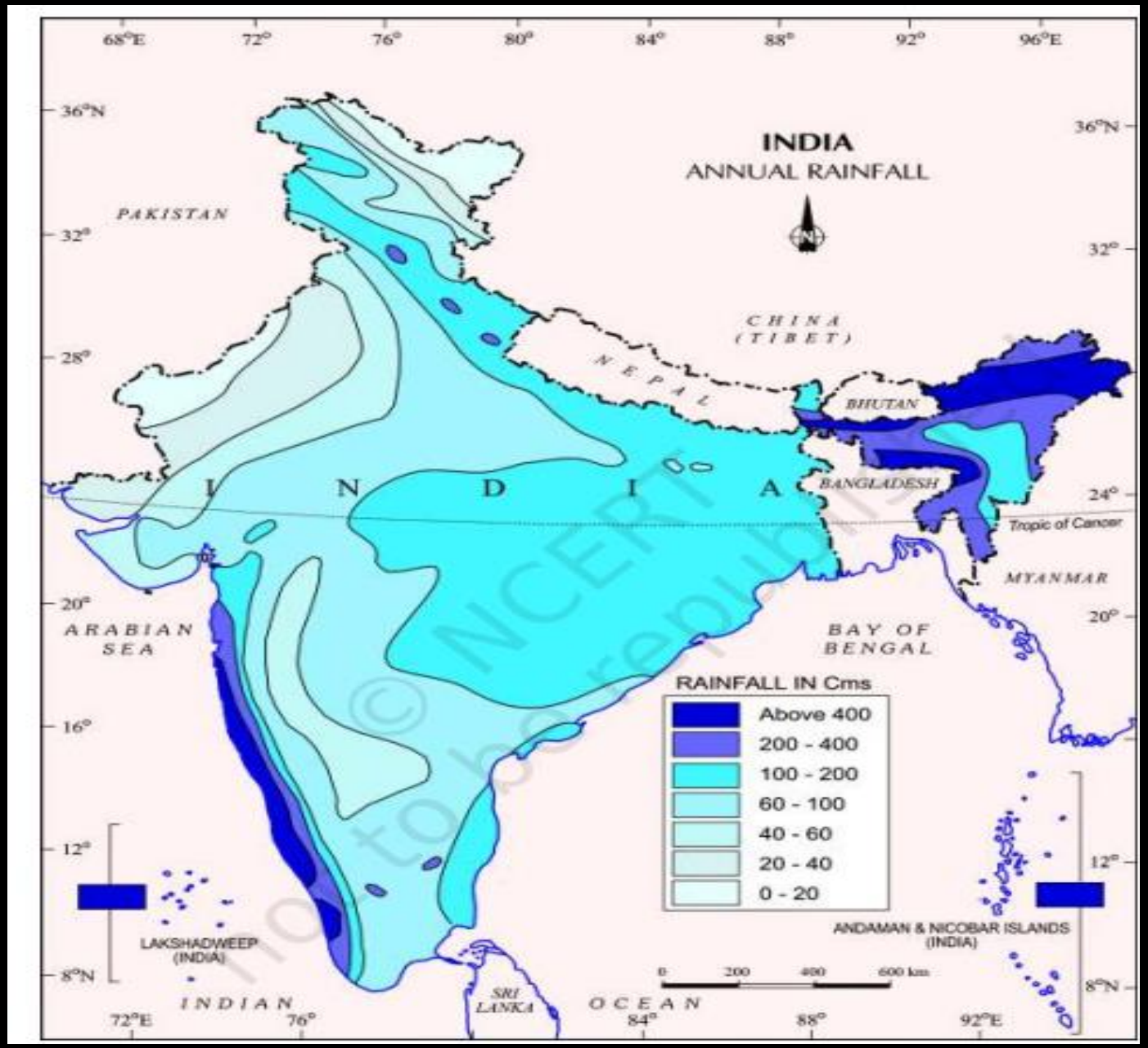


Retreat of Monsoon

- Monsoon starts retreating in September. On the first of September it starts retreating from north-western part of India.
- This day is the last day of rainy season in Jaisalmer and Barmer in Rajasthan.
- By 15th September, monsoon leaves Punjab, Haryana, Rajasthan and Gujarat.
- The area under the monsoon influence shrinks slowly and the monsoon retreats from all parts of India except the southern peninsular region.
- Monsoon winds in most parts of the country are replaced by the north-easterly trade winds.
- These winds blowing over the Bay of Bengal pick up moisture from there and cause rainfall in Tamil Nadu.

Distribution of Annual Rainfall

- The distribution of rainfall in India is uneven.
- The monsoon rainfall has a declining trend with increasing distance from the sea.
- Rainfall decreases from east to west in plains as one branch of monsoon enters from eastern side. Kolkata receives 119 cm, Allahabad 76 cm and Delhi 56 cm only.



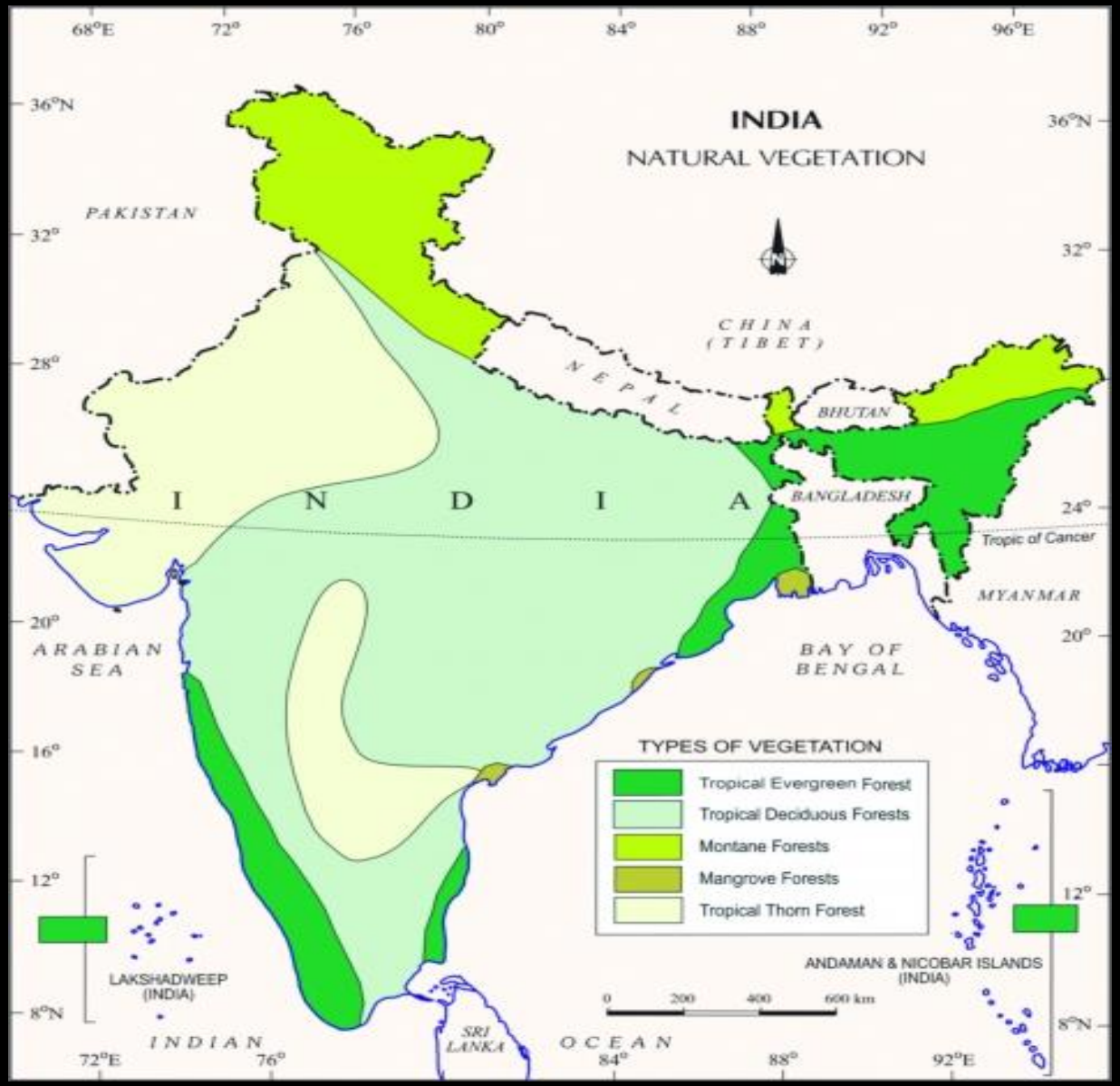
Category	Rainfall in cms	regions
Heavy Rainfall	More than 200	Western coast, western ghats, sub-Himalayan region of north-east, Garo, Khasi and Jaintia hills of Meghalaya. In some parts, rain exceeds 1000 cm.
Moderate rainfall	Between 100 to 200	100 cm isohyet extends from Gujarat to south up to Kanyakumari parallel to western ghats. Northern Andhra Pradesh, eastern part of Maharashtra, Madhya Pradesh, Odisha, some parts of Jammu and Kashmir
Low rainfall	Between 60 to 100	Most parts of Tamil Nadu, Karnataka, Andhra Pradesh, eastern Rajasthan, south western Uttar Pradesh
Inadequate rainfall	Less than 60	Punjab, Haryana, north western Rajasthan, Kachchh, Kathiawar

CLIMATIC REGIONS OF INDIA

Type of Climate	Areas
Amw - Monsoon with short dry season	West coast of India south of Goa
As – Monsoon with dry summer	Coromandel coast of Tamil Nadu
Aw – Tripical savannah	Most of the Peninsular plateaus, south of the Tropic of Cancer
BShw – Semi-arid steppe climate	North-western Gujarat, parts of western Rajasthan and Punjab
Bwhw – Hot desert	Extreme western Rajasthan
Cwg – Monsoon with dry winter	Ganga plain, eastern Rajasthan, northern Madhya Pradesh, NE India
Dfc – Cold humid winter with short summer	Arunachal Pradesh
E – Polar type	Jammu and Kashmir , Ladakh, Himachal Pradesh and Uttarakhand

Natural vegetation in India

Natural vegetation in India



Introduction

- Natural vegetation is a plant community that has grown naturally without human intervention and has been left undisturbed for a long time. It is also known as virgin vegetation.
- On the basis of certain common features such as predominant vegetation type and climatic regions, Indian forests can be divided into the following groups:
- ***Types of Forests***

  (i) Tropical Evergreen and Semi Evergreen forests
  (ii) Tropical Deciduous forests
  (iii) Tropical Thorn forests
  (iv) Montane forests
  (v) Littoral and Swamp forests (Mangrove)

Tropical Evergreen

- These forests are found in the western slope of the Western Ghats, hills of the northeastern region, Lakshadweep and the Andaman and Nicobar Islands.
- They are found in warm and humid areas with an annual precipitation of over 200 cm and mean annual temperature above 22^{o}C.
- Tropical evergreen forests are well stratified, with layers closer to the ground and are covered with shrubs and creepers, with short structured trees followed by tall variety of trees.
- In these forests, trees reach great heights up to 60 m or above. There is no definite time for trees to shed their leaves, flowering and fruition.
- As such these forests appear green all the year round. Species found in these forests include rosewood, mahogony, aini, ebony, etc

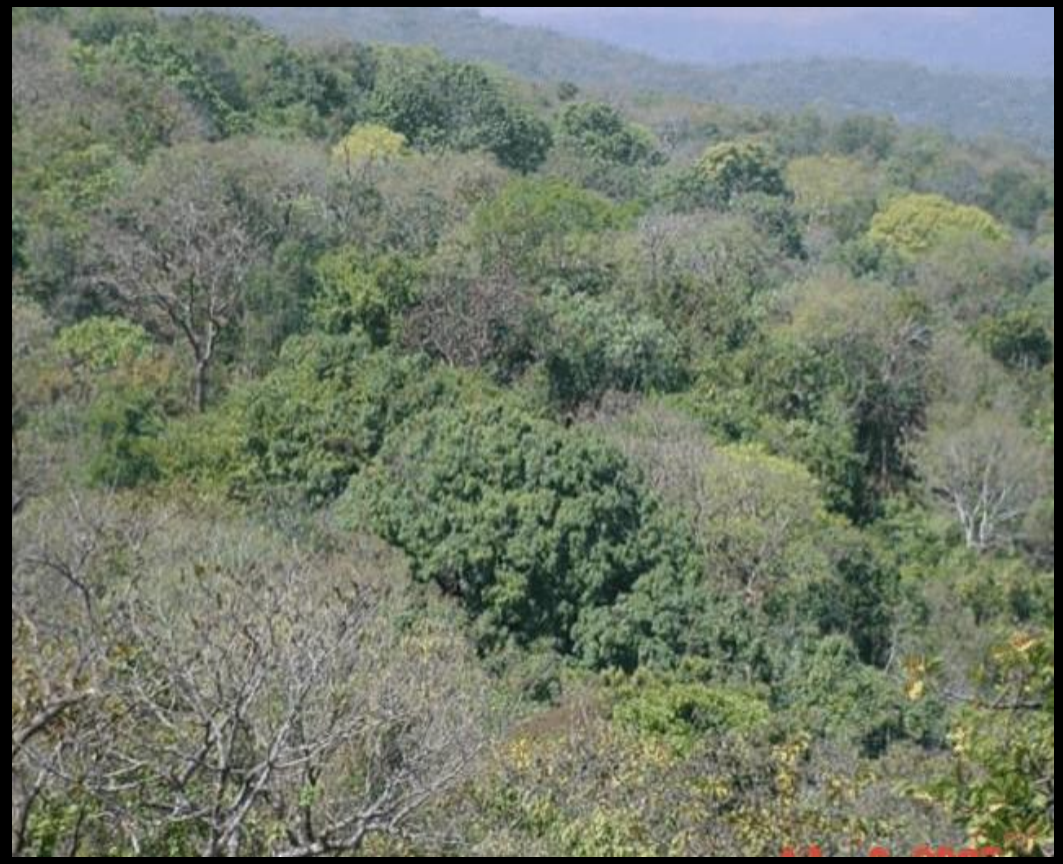

EPIPHYTE
COMMENSALISM

SEMI EVERGREEN FORESTS

- The semi evergreen forests are found in the less rainy parts of these regions.
- Such forests have a mixture of evergreen and moist deciduous trees.
- The undergrowing climbers provide an evergreen character to these forests.
- Main species are white cedar (tamil nadu) , hollock (plywood and containers) and kail.

Tropical Deciduous Forests

- These are the most widespread forests in India.
- They are also called the **monsoon forests**.
- They spreads over regions which receive rainfall between 70-200 cm.
- It is also called Savanah forest in Africa, llanos in Venezuela and campos in brazil.
- On the basis of the availability of water, these forests are further divided into **moist and dry deciduous.**



The Moist deciduous forests

- Are more pronounced in the regions which record rainfall between 100-200 cm.
- These forests are found in the northeastern states along the foothills of Himalayas, eastern slopes of the Western Ghats and Odisha.
- Teak, sal, shisham, hurra, mahua, amla, semul, kusum, and sandalwood etc. are the main species of these forests.

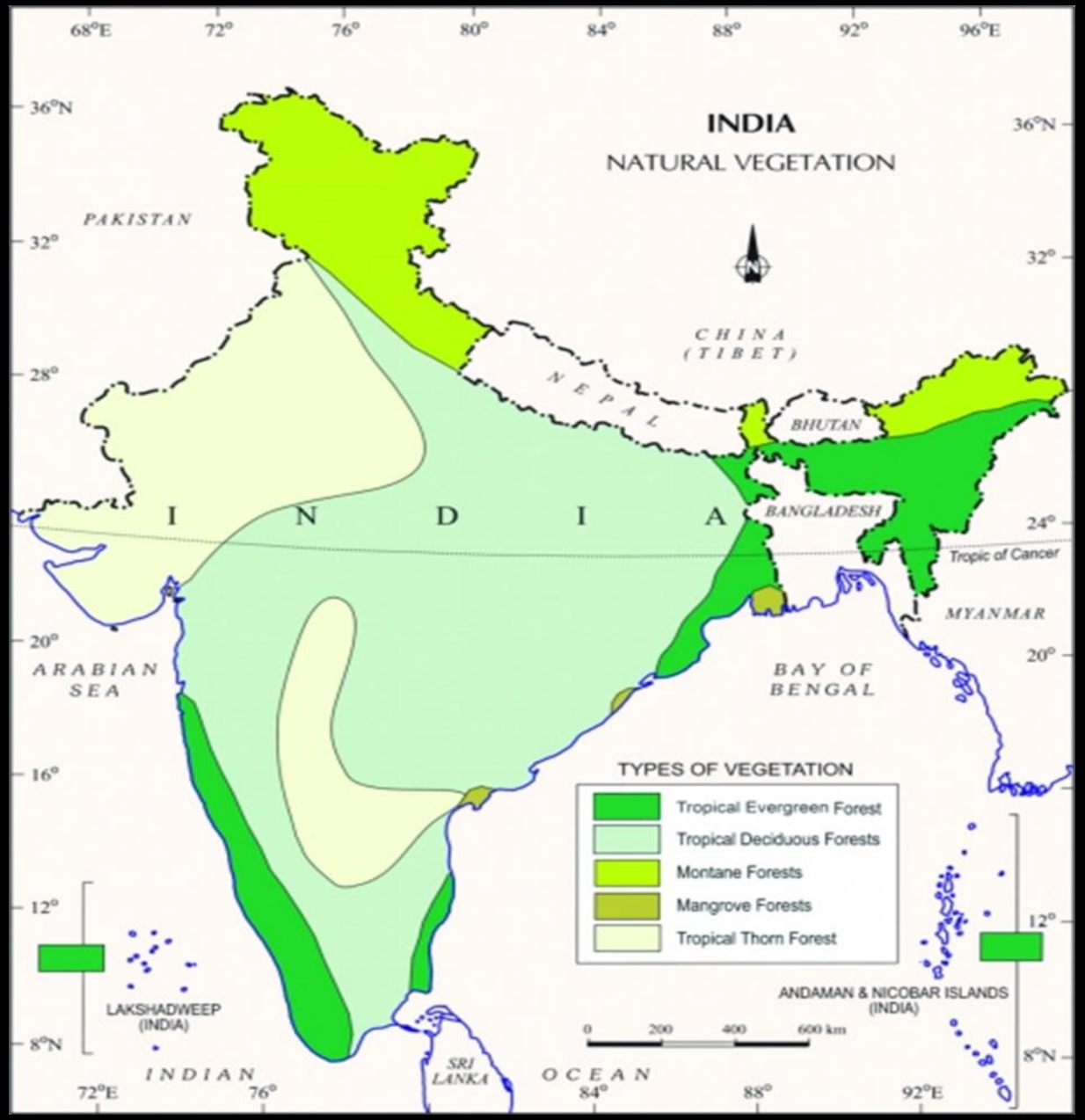
Dry deciduous forest

- Covers vast areas of the country, where rainfall ranges between 70 -100 cm.
- These forests are found in rainier areas of the Peninsula and the plains of Uttar Pradesh and Bihar.
- In the higher rainfall regions of the Peninsular plateau and the northern Indian plain, these forests have a parkland landscape with open stretches in which teak and other trees interspersed with patches of grass are common.
- As the dry season begins, the trees shed their leaves completely and the forest appears like a vast grassland with naked trees all around.
- *Tendu, palas, amaltas, bel, khair,* axlewood, etc. are the common trees of these forests.
- In the western and southern part of Rajasthan, vegetation cover is very scanty due to low rainfall and overgrazing.

Parkland landscape

Tropical Thorn Forests

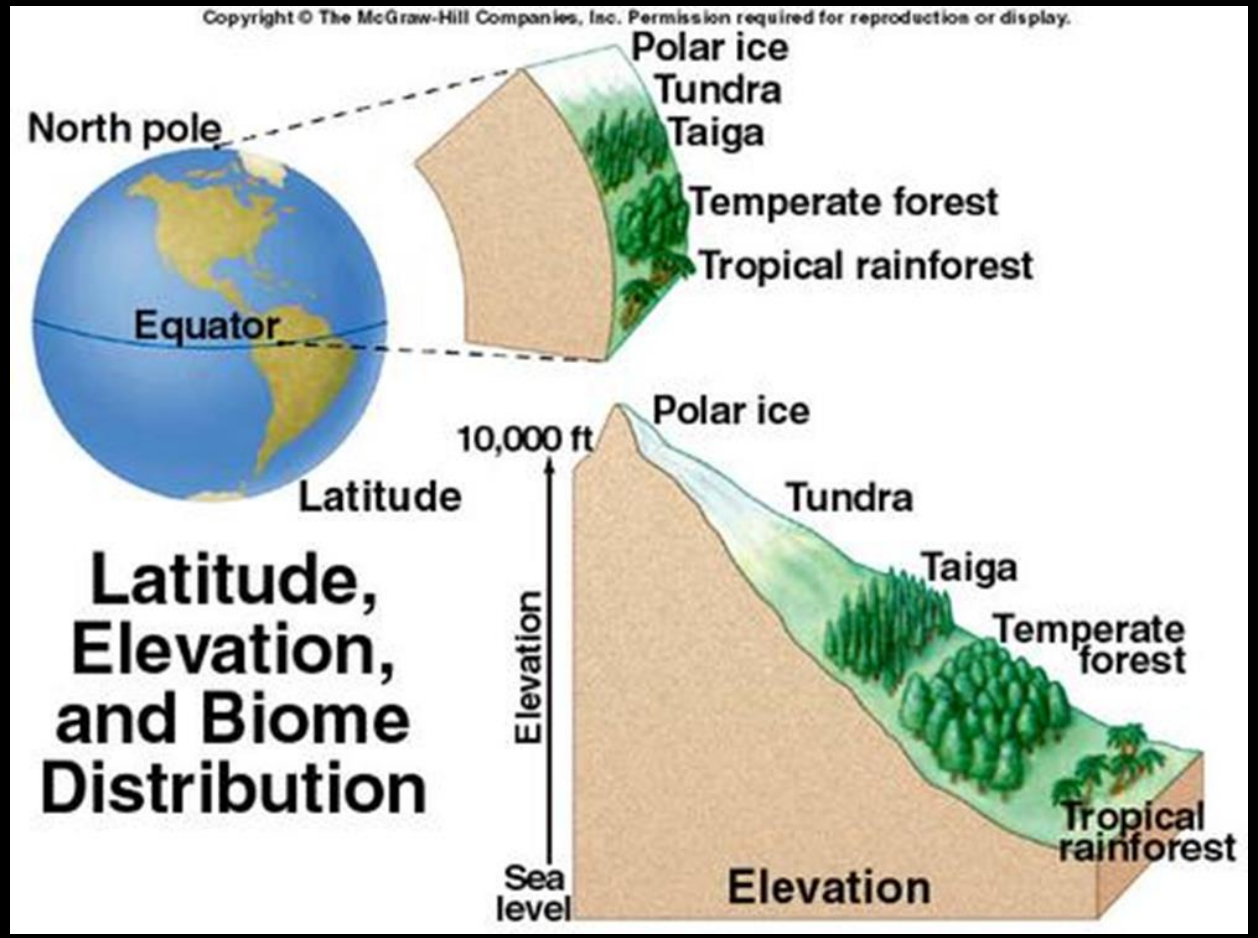
- Tropical thorn forests occur in the areas which receive rainfall less than 50 cm. These consist of a variety of grasses and shrubs.
- It includes semi-arid areas of south west Punjab, Haryana, Rajasthan, Gujarat, Madhya Pradesh nd Uttar Pradesh.
- In these forests, plants remain leafless for most part of the year and give an expression of scrub vegetation.
- Important species found are *babool*, *ber*, and wild date palm, *khair, neem*, *khejri*, *palas*, etc.
- **Tussocky grass** grows upto a height of 2 m as the under growth.


INDIA
NATURAL VEGETATION
PAKISTAN
CHINA (TIBET)
NEPAL
BHUTAN
BANGLADESH
MYANMAR
Tropic of Cancer
ARABIAN SEA
BAY OF BENGAL
INDIAN OCEAN
SRI LANKA
LAKSHADWEEP (INDIA)
ANDAMAN & NICOBAR ISLANDS (INDIA)
TYPES OF VEGETATION
Tropical Evergreen Forest
Tropical Deciduous Forests
Montane Forests
Mangrove Forests
Tropical Thorn Forest
0 200 400 600 km
68°E
72°
76°
80°
84°
88°
92°
96°E
36°N
32°
28°
24°
20°
16°
12°
8°N

XEROPHYTE

Montane Forests

- In mountainous areas, the decrease in temperature with increasing altitude leads to corresponding change in natural vegetation.
- Mountain forests can be classified into two types,
  - The northern mountain forests and
  - The southern mountain forests.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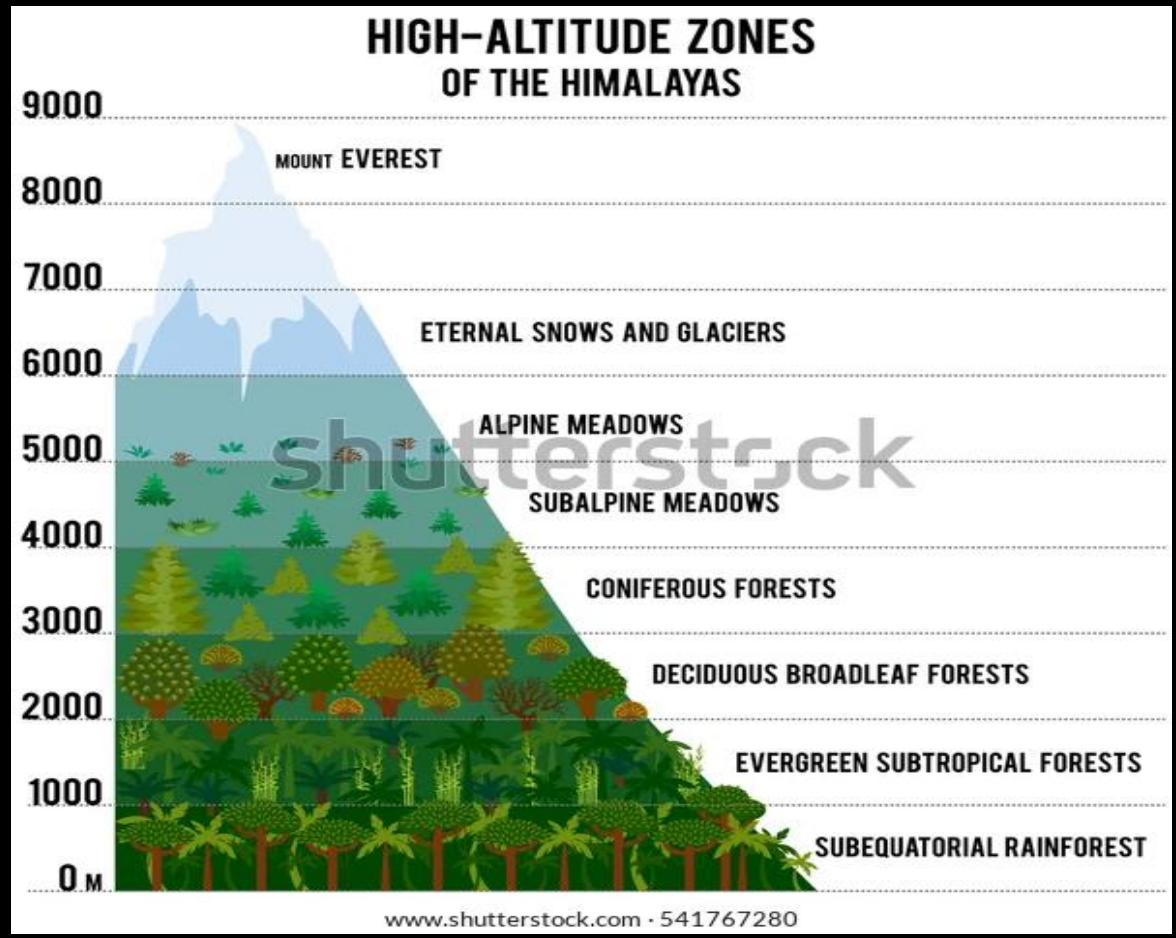
North pole
Equator
Latitude
Polar ice
Tundra
Taiga
Temperate forest
Tropical rainforest
Latitude, Elevation, and Biome Distribution
10,000 ft
Elevation
Sea level
Polar ice
Tundra
Taiga
Temperate forest
Tropical rainforest
Elevation


HIGH-ALTITUDE ZONES
OF THE HIMALAYAS
9000
8000
7000
6000
5000
4000
3000
2000
1000
0 M
MOUNT EVEREST
ETERNAL SNOWS AND GLACIERS
ALPINE MEADOWS
SUBALPINE MEADOWS
CONIFEROUS FORESTS
DECIDUOUS BROADLEAF FORESTS
EVERGREEN SUBTROPICAL FORESTS
SUBEQUATORIAL RAINFOREST
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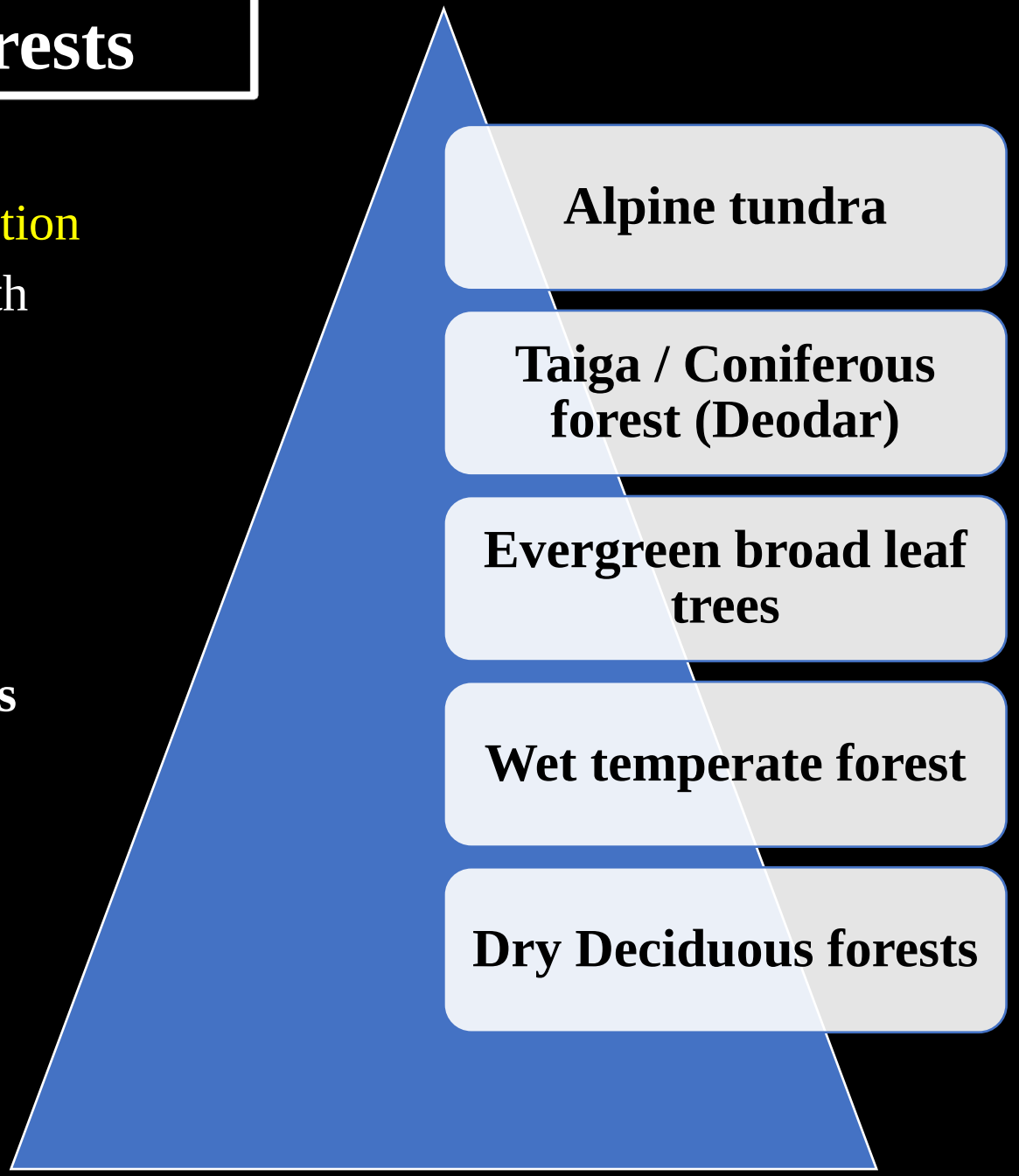
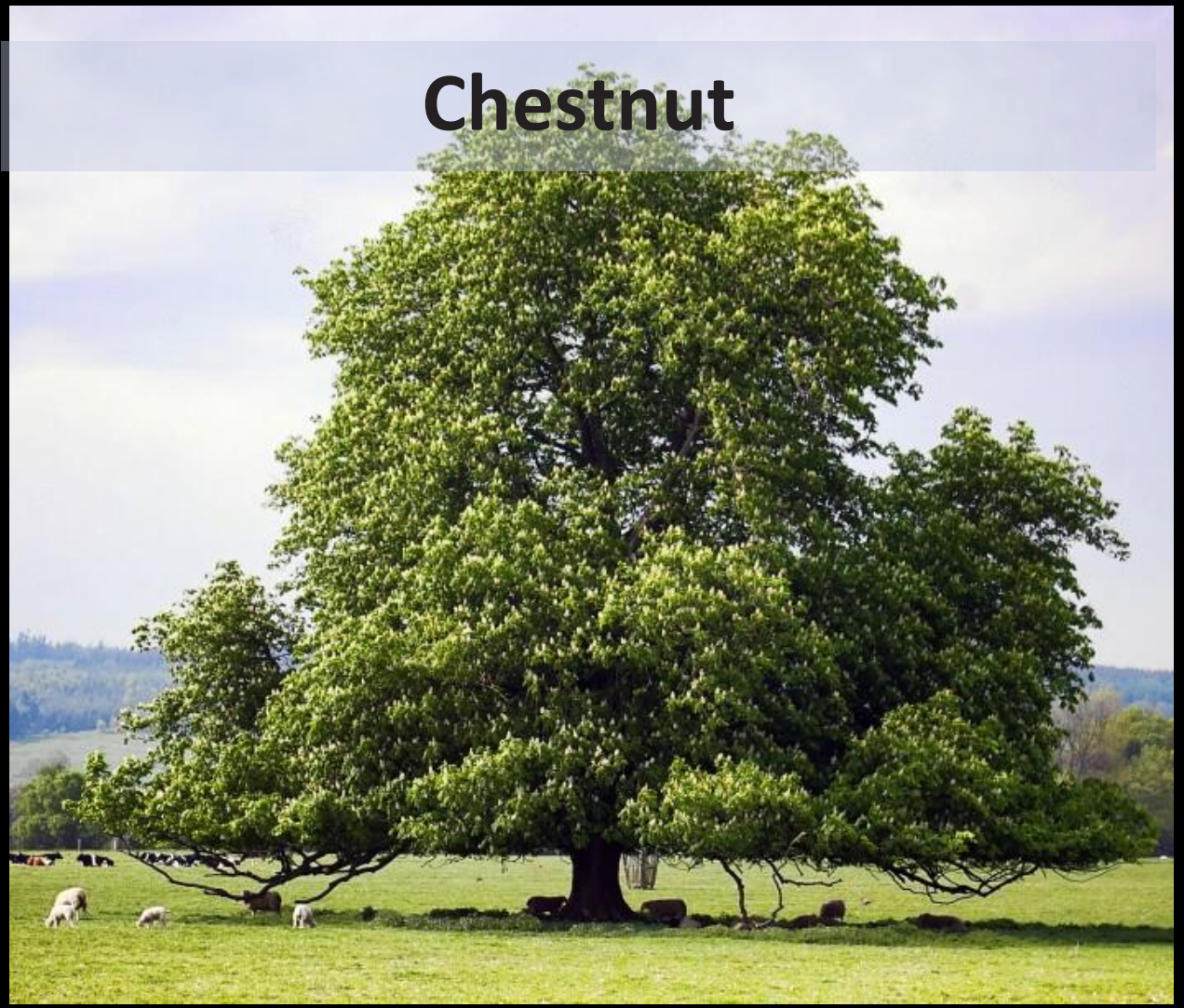
The northern mountain forests

- The Himalayan ranges show a succession of vegetation from the tropical to the tundra, which change in with the altitude.
- **Deciduous forests** are found in the foothills of the Himalayas. It is succeeded by **the wet temperate type(1,000-2,000 m.)**
- In the higher hill ranges **evergreen broad leaf trees** such as **oak and chestnut are predominant.**



Chestnut



- **Between 1,500-1,750 m**, **pine forests** are also well-developed in this zone.
- **Deodar/ Himalayan cedar, Coniferous tress** which generally grows at an altitude of 1500 to 3000 metres., is a highly valued endemic species grows mainly in **the western part of the Himalayan range**. Deodar is a durable wood mainly used in **construction activity**.
- Similarly, the ***chinar* and the walnut**, which sustain the famous Kashmir handicrafts, belong to this zone.
- **Blue pine and spruce** appear at altitudes of **2,225-3,048 m**. At many places in this zone, temperate grasslands are also found.
- At the higher altitude **Alpine forests** and **pastures found**. These pastures are used extensively for **transhumance** by tribes like **the Gujjars, the Bakarwals, the Bhotiyas and the Gaddis**.
- **Silver firs, junipers, pines, birch and rhododendrons, etc. occur between 3,000-4,000 m.**
- At higher altitudes, mosses and lichens form part of the **tundra vegetation.**

Willow tree


Black Spruce
Picea mariana
White Spruce
Picea glauca
Red Spruce
Picea rubens
Norway Spruce
Picea abies
Blue Spruce
Picea pungens

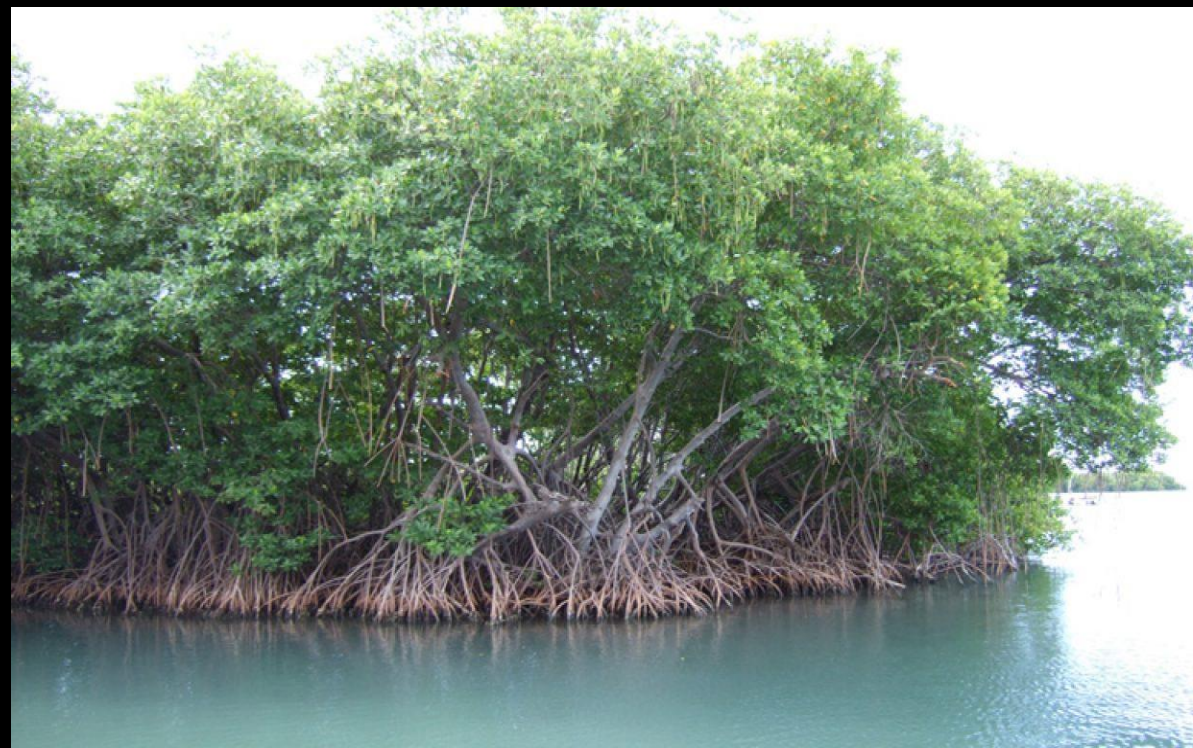
The southern mountain forests

- *The southern mountain forests* include the forests found in three distinct areas of Peninsular India viz;
  - the Western Ghats,
  - the Vindhyas and
  - the Nilgiris.

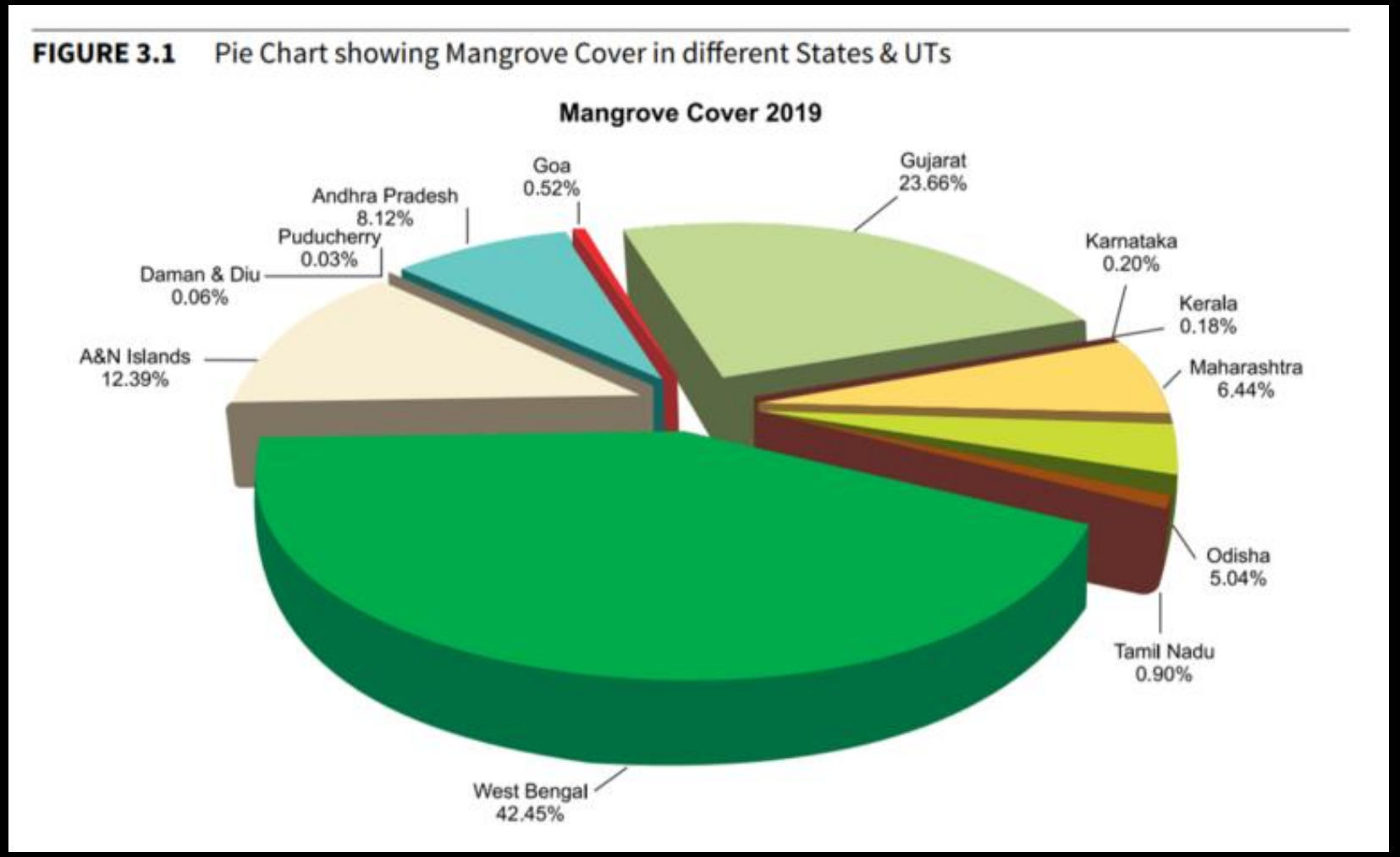
- As they are closer to the tropics, and only 1,500 m above the sea level, vegetation is temperate in the higher regions, and subtropical on the lower regions of the Western Ghats, especially in Kerala,Tamil Nadu and Karnataka.
- The temperate forests are called *Sholas* in the Nilgiris, Anaimalai and Palani hills.
- Some of the other trees of this forest of economic significance include, magnolia, laurel, cinchona and wattle.
- Such forests are also found in the Satpura and the Maikal ranges.

Littoral and Swamp Forests

- In this group the forest under wet-land and coastal region comes.
- According to Champion & Seth Classification (1968), Mangroves are included in Type Group- 4 Littoral & Swamp Forests.
- Mangrove are the most vital group of forest under this. Total **mangrove cover** in the country is **4,992 sq km**.
- Sunderban, located in the northern Bay of Bengal is the world's largest single patch of Mangrove Forests. Spread over approximately 10,000 sq km, in Bangladesh and India.
- Sundarban is the first Mangrove forest in the world, which was brought under scientific management, as early as in 1892.

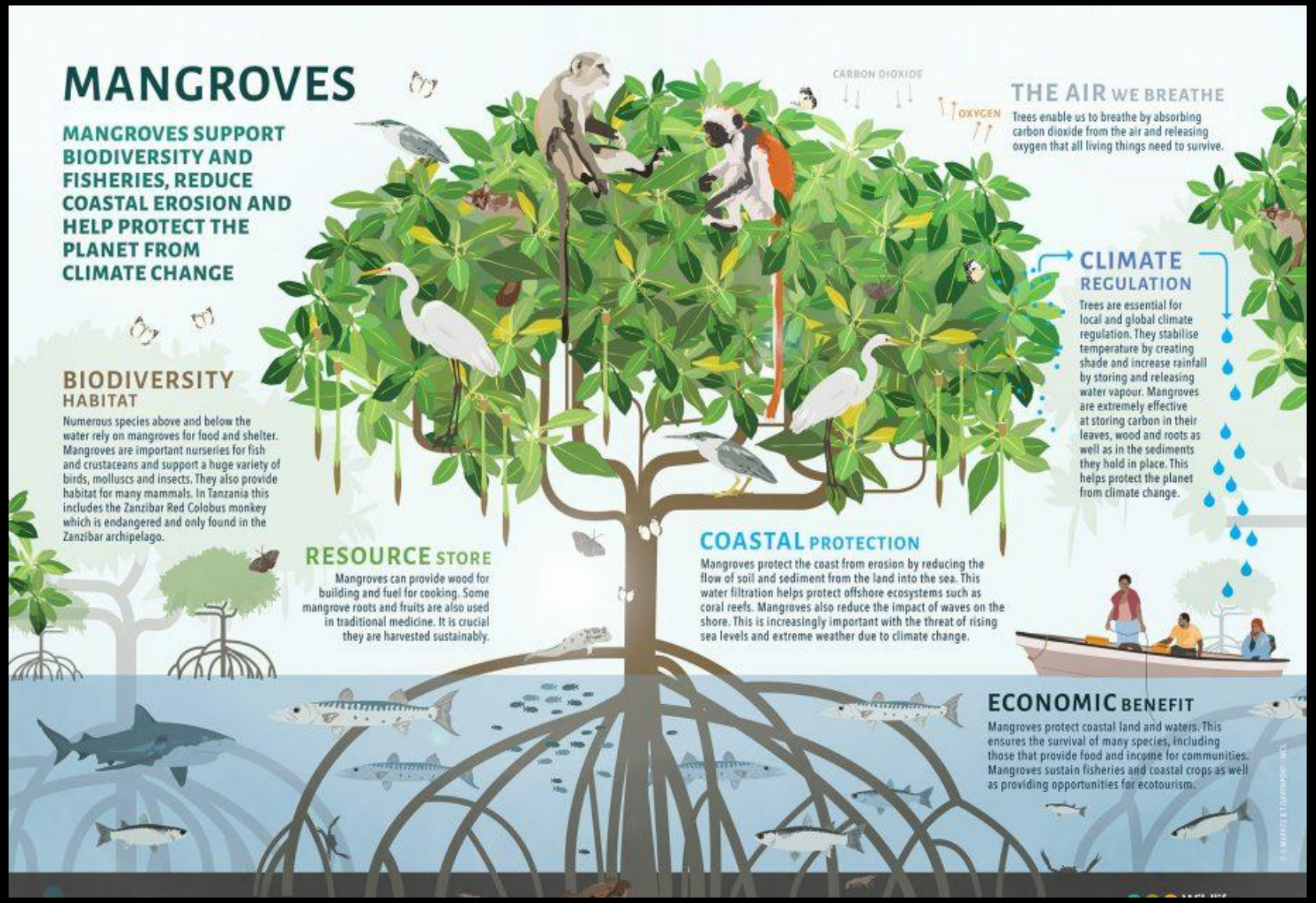


- In the GangaBrahmaputra delta, sundari trees are found, which provide durable hard timber.
- Palm, coconut, keora, agar, etc., also grow in some parts of the delta.



TOP STATES/UTS BY MANGROVE COVER:

Rank	State/UT	Mangrove Cover (%)
1	**West Bengal**	42.45%
2	**Gujarat**	23.66%
3	**A&N Islands**	12.39%
4	**Andhra Pradesh**	8.12%
5	**Maharashtra**	6.44%


MANGROVES
MANGROVES SUPPORT BIODIVERSITY AND FISHERIES, REDUCE COASTAL EROSION AND HELP PROTECT THE PLANET FROM CLIMATE CHANGE
CARBON DIOXIDE
OXYGEN
THE AIR WE BREATHE
Trees enable us to breathe by absorbing carbon dioxide from the air and releasing oxygen that all living things need to survive.
CLIMATE REGULATION
Trees are essential for local and global climate regulation. They stabilise temperature by creating shade and increase rainfall by storing and releasing water vapour. Mangroves are extremely effective at storing carbon in their leaves, wood and roots as well as in the sediments they hold in place. This helps protect the planet from climate change.
BIODIVERSITY HABITAT
Numerous species above and below the water rely on mangroves for food and shelter. Mangroves are important nurseries for fish and crustaceans and support a huge variety of birds, molluscs and insects. They also provide habitat for many mammals. In Tanzania this includes the Zanzibar Red Colobus monkey which is endangered and only found in the Zanzibar archipelago.
RESOURCE STORE
Mangroves can provide wood for building and fuel for cooking. Some mangrove roots and fruits are also used in traditional medicine. It is crucial they are harvested sustainably.
COASTAL PROTECTION
Mangroves protect the coast from erosion by reducing the flow of soil and sediment from the land into the sea. This water filtration helps protect offshore ecosystems such as coral reefs. Mangroves also reduce the impact of waves on the shore. This is increasingly important with the threat of rising sea levels and extreme weather due to climate change.
ECONOMIC BENEFIT
Mangroves protect coastal land and waters. This ensures the survival of many species, including those that provide food and income for communities. Mangroves sustain fisheries and coastal crops as well as providing opportunities for ecotourism.

Mangroves

- These are a **diverse group of salt-tolerant plant communities** of tropical and subtropical **intertidal regions** of the world.
- Mangrove species exhibit a **variety of adaptations** to survive in waterlogged soils with high saline water under the influence of frequent cyclonic storms and tidal surges.
- Mangroves are important refuges of coastal biodiversity and also act **as bio-shields** against extreme climatic events.
- The mangrove cover in India **is 4,992 sq. km,** which is 0.15% of the country's total geographical area. / **India, the mangrove forests spread over 6,740 sq. km which is 7 per cent of the world's mangrove forests**
- Important species of Mangrove ecosystems in India include:
  - **Avicennia officinalis**, Rhizophora mucronata, **Sonneratia alba**, Avicennia alba, Bruguiera cylindrica, Heritiera littoralis, Phoenix paludosa, **Morinda citrifolia** & Ceriops tagal.

Importance of Mangroves

- Mangroves have a **complex root system** that is very efficient in dissipating the sea wave energy thus protecting the coastal areas from tsunamis, storm surges, and soil erosion. Their protective role has been widely recognized especially after the devastating Tsunami of 2004.
- Mangrove roots slow down water flows and **enhance sediment deposition**. Therefore, they act as a zone of land accretion due to the trapping of fine sediments including heavy metal contaminants.
- They also arrest coastal erosion and sea water pollution.
- They act as a **fertile breeding ground** for many fish species and other marine fauna.
- They act as an important source of **livelihood** for the coastal communities dependent on the collection of honey, tannins, wax, and fishing.
- Mangroves are important **carbon sinks.**

Reasons behind the damaging of Mangroves:

- **Natural calamities** (cyclone, tidal surge)
- High rate of Erosion (water)
- **Land reclamation**
- **Agriculture expansion**
- **Industrialization** along the coastlines
- Discharge of **untreated domestic sewage** and industrial effluents (अपशिष्ट)
- Ilegal uprooting and cutting
- Climate change and global warming
- Oil spill from sea vessel
- Un- regulated tourism
- Over fishing

Status of Mangrove Cover Worldwide:

- The largest Mangrove area is reported in:
  - Asia > Africa > North and Central America > South America.
- Oceania has reported the smallest area of Mangroves.
- More than 40% of the total area of Mangroves was reported to be in just four countries: Indonesia (19%), Brazil (9%), Nigeria (7%), and Mexico (6%).

Medicinal Plant	Uses and Benefits	Additional Information
Sarpagandha	Used to treat blood pressure	Found only in India
Jamun	Juice from ripe fruit is used to make vinegar, which is carminative and diuretic, and has digestive properties; seed powder helps control diabetes	Commonly grown in India
Arjun	Fresh juice of leaves cures earache; also used to regulate blood pressure	Native to India
Babool	Leaves are used to treat eye sores; gum acts as a tonic	Known for its medicinal gum
Neem	Has strong antibiotic and antibacterial properties	Widely used in Ayurvedic treatments
Tulsi	Used to treat cough and cold	Considered sacred in India
Kachnar	Used to treat asthma and ulcers; buds and roots aid in digestion	Often found in the Himalayan region

India State of Forest Report 2023 (ISFR 2023)

- The ISFR 2023 was released at the Forest Research Institute, Dehradun.
- The Forest Survey of India (FSI) has been publishing the India State of Forest Report (ISFR) biennially since 1987. The 2023 edition is the 18th in the series.
- **Objective**:
  The report provides detailed data on the state of forests and tree resources across India. FSI, based in Dehradun, conducts forest cover assessments every two years.
- **Current Assessment**:
  - **Total Forest and Tree Cover**: 8,27,357 sq km (25.17% of India's geographical area).
  - **Forest Cover**: 7,15,343 sq km (21.76% of the geographical area).
  - **Tree Cover**: 1,12,014 sq km (3.41% of the geographical area).
- **Comparison with ISFR 2021**:
  The total forest and tree cover has increased by 1,445 sq km since the previous assessment.

States with Largest Forest Cover (Area-wise):

- **Madhya Pradesh: 77,073 sq km.**
- **Arunachal Pradesh: 65,882 sq km.**
- **Chhattisgarh: 55,812 sq km.**

States/UTs with Highest Percentage of Forest Cover (Geographical Area):

- **Lakshadweep: 91.33%.**
- **Mizoram: 85.34%.**
- **Andaman & Nicobar Islands: 81.62%**

- **19 states/UTs** have more than **33%** of their geographical area under forest cover.
- Among these, **8 states/UTs** have forest cover exceeding **75%**:
  - **Mizoram, Lakshadweep, Andaman & Nicobar Islands, Arunachal Pradesh, Nagaland, Meghalaya, Tripura, and Manipur.**

Forest Cover (Area-wise)	Forest cover (percentage of total geographical area)
Madhya Pradesh	Mizoram
Arunachal Pradesh	Arunachal Pradesh
Chhattisgarh	Meghalaya
Odisha	Manipur
Maharashtra	Nagaland

Classification of Forests

ON ADMINISTRATION BASIS

Reserved Forests	Protected Forests	Unprotected Forests
•Under direct supervision of the Government.	•Looked after by the government.	•Unclassified Forests.
•No public entry allowed for the commercial purpose of cattle grazing.	•Local people are allowed to collect forest produce and cattle grazing without causing any serious damage.	•No restriction on cutting trees or grazing cattle.
•53% of the **Total Forest Area (TFA)** of the country under this category.	•Occupy about 29% of the TFA.	•Occupy 18% of the TFA.

CLASSIFICATION AS PER OWNERSHIP

State Forests	Commercial Forests	Private Forests
•Include almost all important forest areas of the country and are under full control of the government (state/central).	•Owned and administered by local bodies (municipal corporations, village panchayats, district boards etc.)	•Under private ownership.
•Cover almost 94% of the TFA.	•Cover 5% of the TFA.	•Cover slightly more than 1% of the TFA.

AGRICULTURE

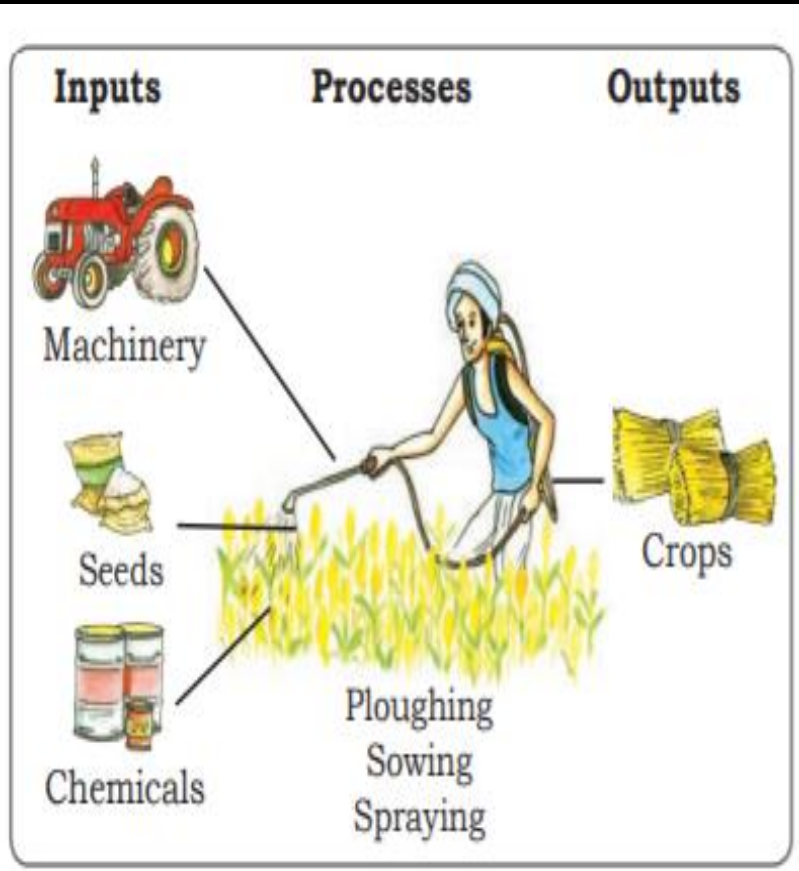


Fig 4.2: The farm system of an arable farm

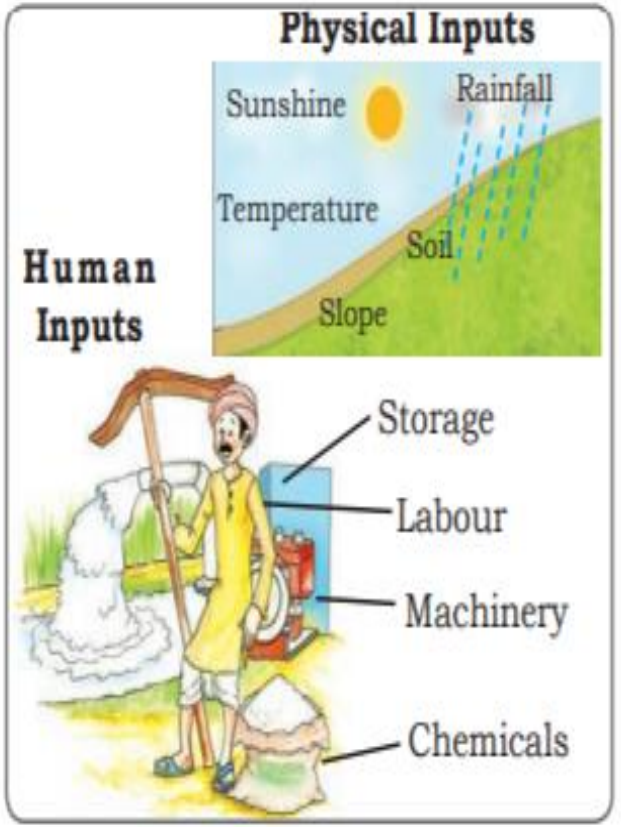
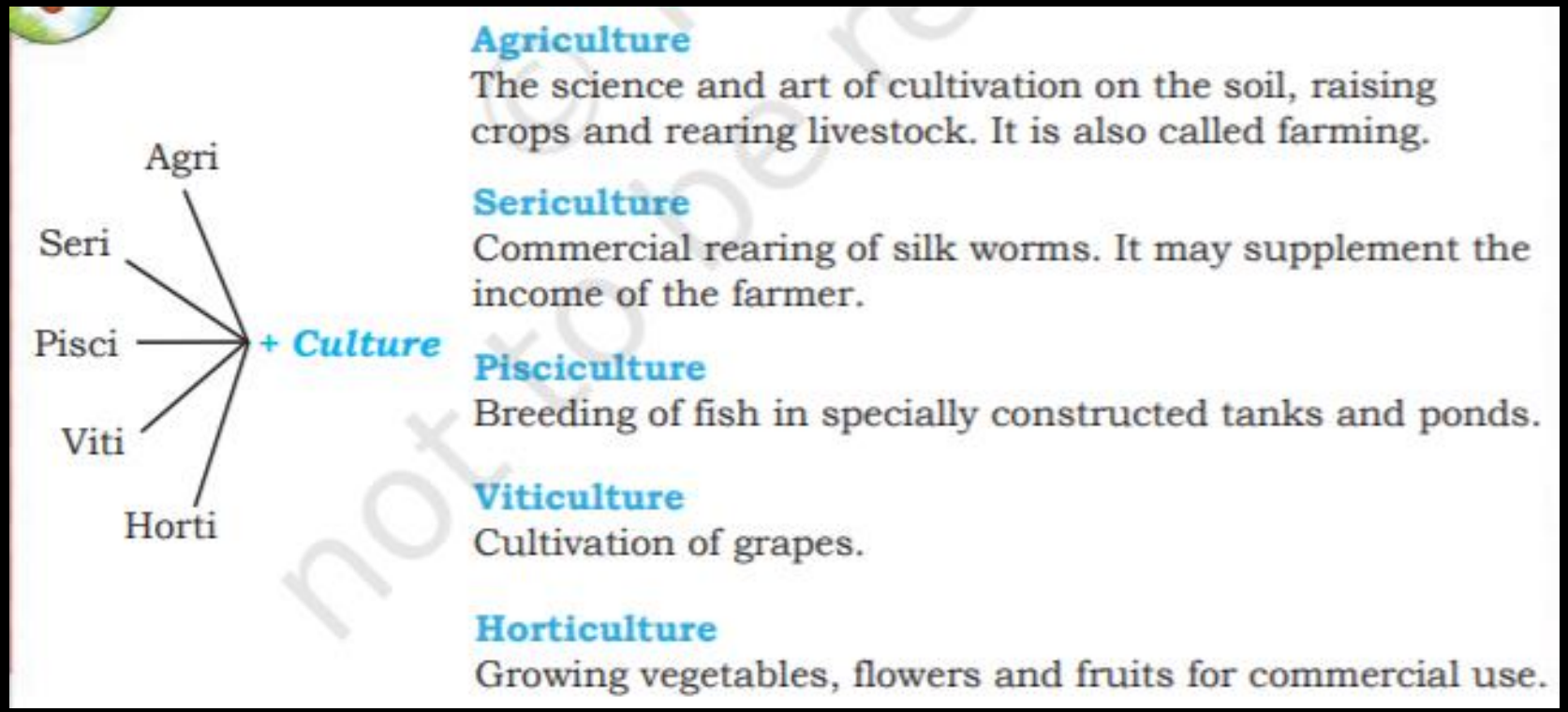


Fig 4.3: Physical and human farm inputs

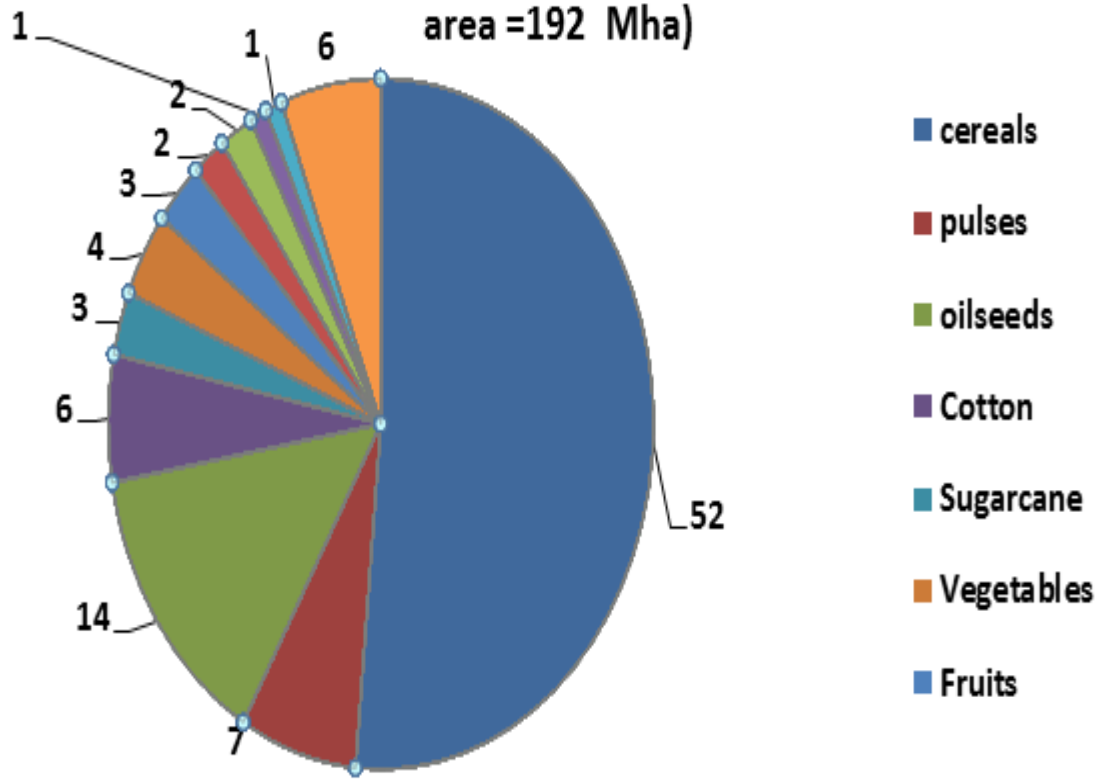
- Agriculture is a ***primary activity***. It includes ***growing crops, fruits, vegetables, flowers and rearing of livestock***.
- In the world, 50 per cent of persons are engaged in agricultural activity, while Two-thirds of India's population is still dependent on agriculture.
- Favourable topography of soil and climate are vital for agricultural activity. The land on which the crops are grown is known as ***arable land.***
- Agriculture is a purely land based activity unlike secondary and tertiary activities.



Characteristics of Agriculture in India

Dependence on Monsoons	• Indian agriculture is largely rain-fed, with approximately 50-60% of cultivated land dependent on monsoons. Erratic rainfall often leads to droughts or floods.
Subsistence Farming	• Most farmers practice subsistence farming, producing primarily for their family's consumption.
Predominance of Food Crops	• A significant portion of the land is devoted to growing food crops like rice, wheat, and pulses.
Small and Fragmented Landholdings	• The average size of landholdings is very small due to inheritance laws and population pressure. Fragmentation reduces productivity and efficiency.
Traditional Methods of Cultivation	• Despite modernization efforts, many farmers still use traditional methods due to a lack of resources.
Low Productivity	• Agricultural productivity in India is low compared to global standards. Factors include outdated technology, soil degradation, and inadequate irrigation facilities.
Diverse Cropping	• PatternsIndia exhibits diverse cropping patterns due to its varied climatic zones. Crops range from tropical (e.g., rice, sugarcane) to temperate (e.g., wheat, barley).

Fig. 1: Cropping pattern of India (%) (2010-11) (Total cropped area =192 Mha)



Rabi Crops


Wheat


Grams


Peas


Mustard


Linseed

Kharif Crops


Paddy


Soybean


Pigeon pea


Cotton


Peas


Green gram

Cropping Season	*Major Crops Cultivated*	
	Northern States	*Southern States*
Kharif June-September	Rice, Cotton, Bajra, Maize, Jowar, Tur	Rice, Maize, Ragi, Jowar, Groundnut
Rabi October – March	Wheat, Gram, Rapeseeds and Mustard, Barley	Rice, Maize, Ragi, Groundnut, Jowar
Zaid April–June	Vegetables, Fruits, Fodder	Rice, Vegetables, Fodder

Summer Crops (Zaid Crops)


Cucumber


Watermelon


Bitter gourd

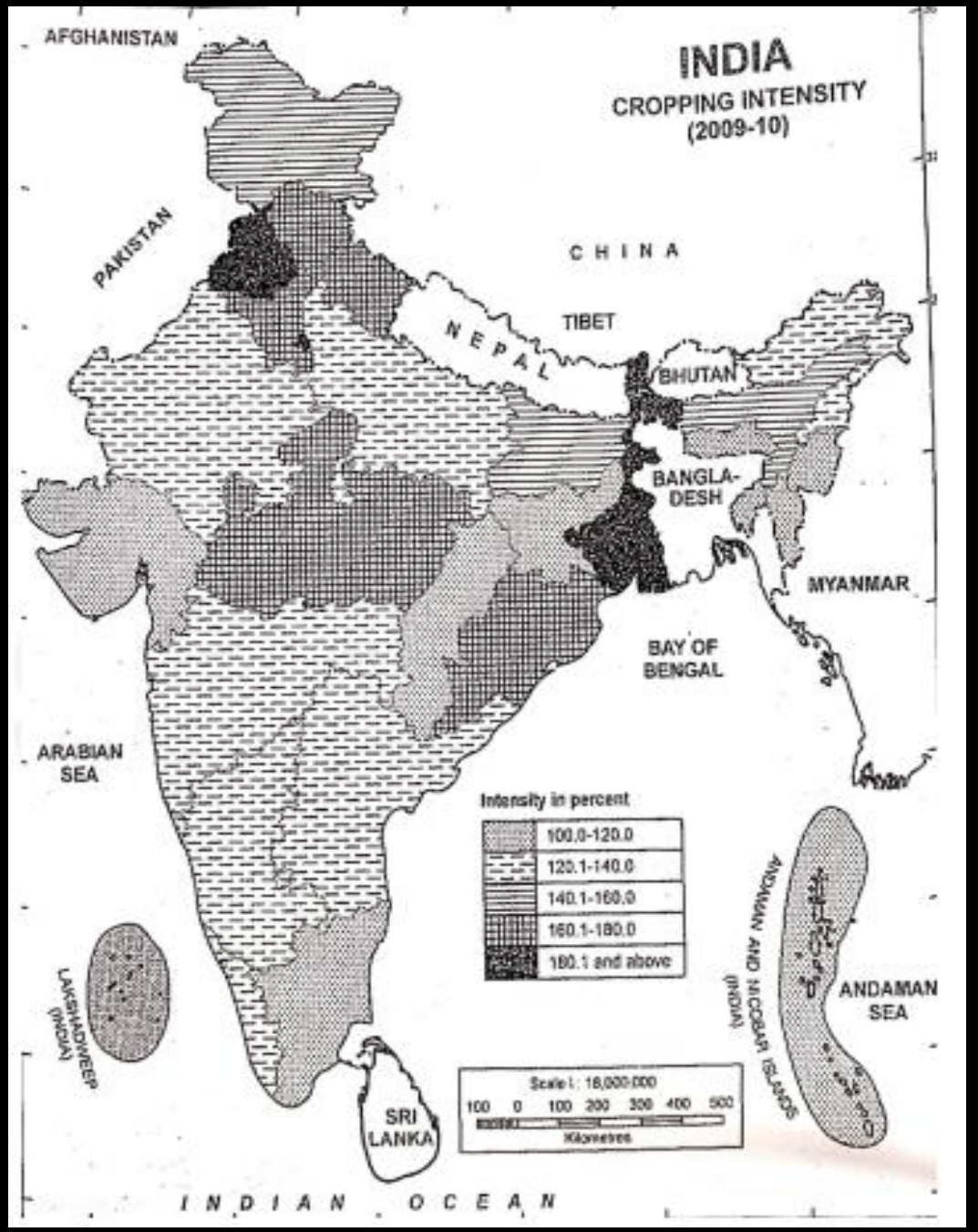
Crop Intensity

- Crop intensity refers to the number of crops grown on a given piece of land during a single agricultural year.
- It indicates the extent of land utilization and agricultural productivity.

Formula:

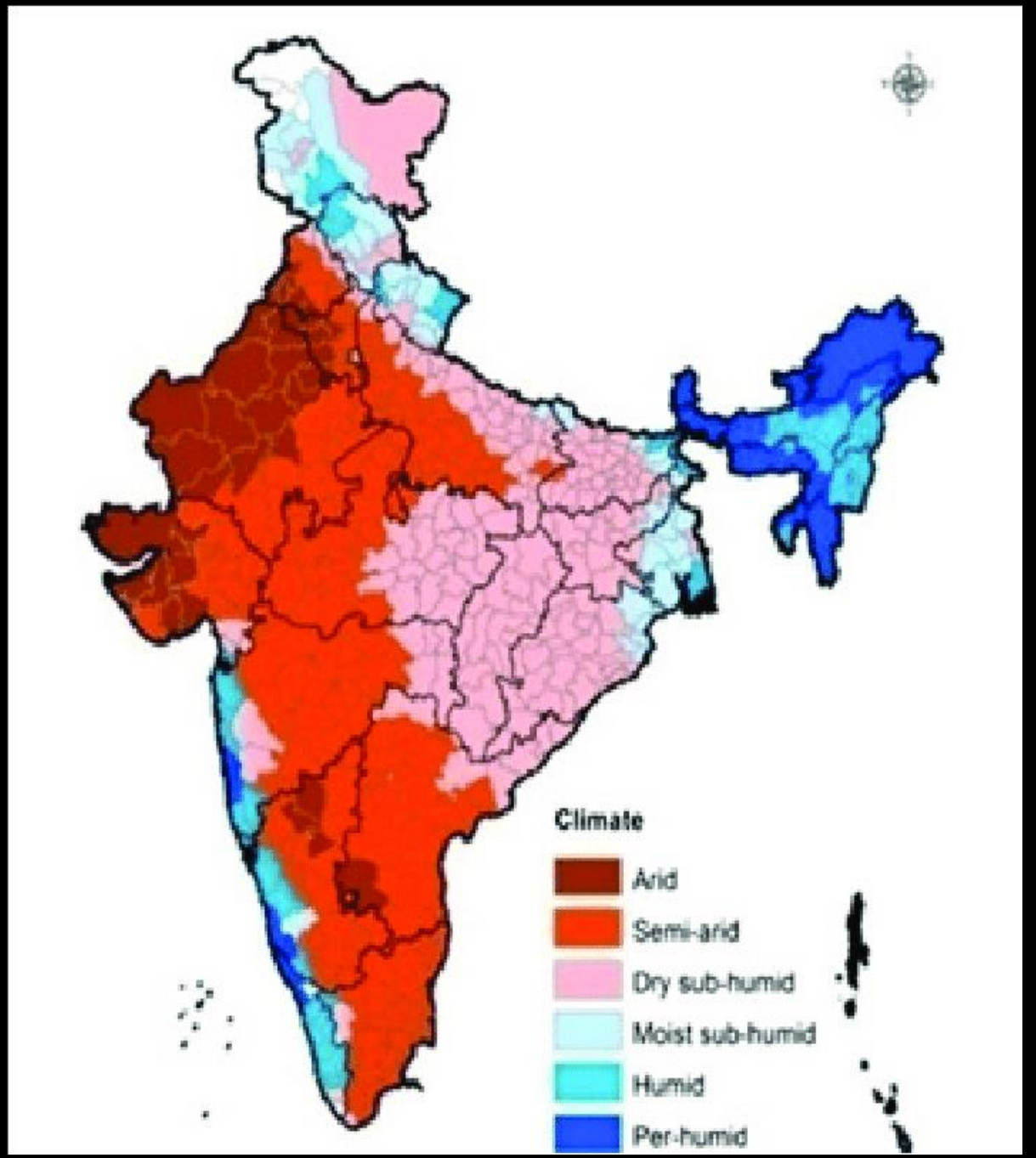
$$\text{Crop Intensity} = \left(\frac{\text{Gross Cropped Area}}{\text{Net Sown Area}} \right) \times 100$$

- India's crop intensity is around 140-150%, meaning, on average, 1.4-1.5 crops are grown per year on the same land.
- **Regional Variations in India:**
  - Higher crop intensity in states like Punjab, Haryana, and Uttar Pradesh due to better irrigation and technology.
  - Lower crop intensity in rain-fed areas like Rajasthan and parts of central India.
- **Factors Affecting Crop Intensity:**
  - **Irrigation Facilities:** Better irrigation allows for multiple cropping seasons.
  - **Fertility of Land:** High fertility supports multiple cropping cycles.
  - **Climate:** Regions with longer growing seasons can support higher intensity.



Types of Farming in India_ Rainfed farming

- On the basis of main source of moisture for crops, the farming can be classified as irrigated and rainfed (barani).
- Rainfed farming is further classified on the basis of adequacy of soil moisture during cropping season into ***dryland and wetland farming***.
- In India, the ***dryland farming*** is largely confined to the regions having annual rainfall less than 75 cm. These regions grow hardy and drought resistant crops such as ragi, bajra, moong, gram and guar (fodder crops) and practise various measures of soil moisture conservation and rain water harvesting.
- In wetland farming, the rainfall is in excess of soil moisture requirement of plants during rainy season. Such regions may face flood and soil erosion hazards


Climate
Arid
Semi-arid
Dry sub-humid
Moist sub-humid
Humid
Per-humid

Foodgrains

- Foodgrains are dominant crops in all parts of the country whether they have subsistence or commercial agricultural economy.
- On the basis of the structure of grain the foodgrains are classified as ***cereals and pulses.***

- ***Cereals***
- The cereals ***occupy about 54 per cent of total cropped*** area in India.
- The country produces ***about 11 per cent cereals*** of the world and ranks third in production after China and U.S.A.
- India produces a variety of cereals, which are **classified as fine grains (rice, wheat) and coarse grains (jowar, bajra, maize, ragi)**, etc.

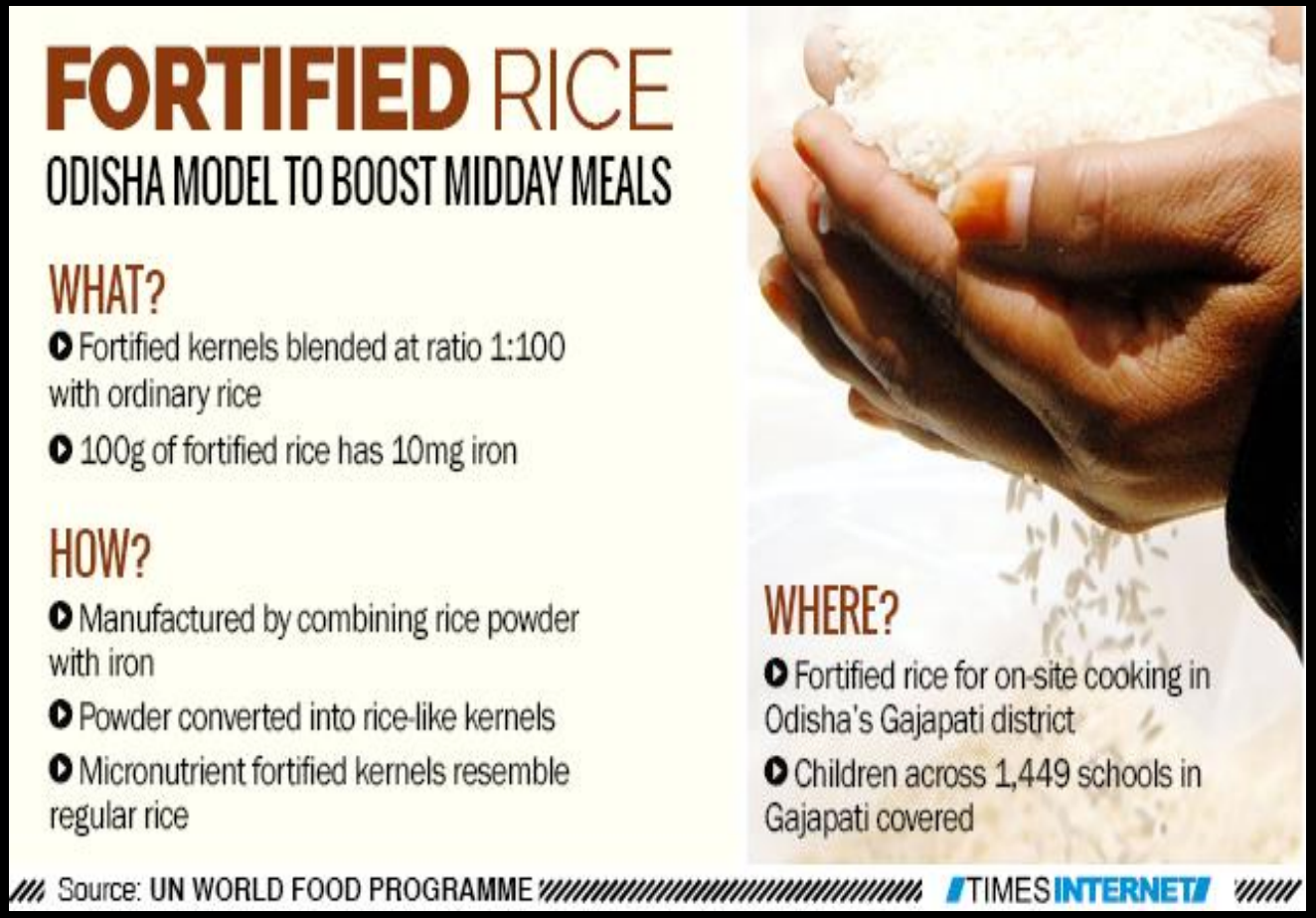
Country	Cereal production (in million tons)
China	658
United States	478
India	382

Rice

- Rice is a staple food for the overwhelming majority of population in India.
- India contributes 21.6 per cent of rice production in the world and ranked second after China in 2016.
- About one-fourth of the total cropped area in the country is under rice cultivation.
- In West Bengal farmers grow three crops of rice called ‘aus’, ‘aman’ and ‘boro’.
- But in Himalayas and northwestern parts of the country, it is grown as a kharif crop during southwest Monsoon season

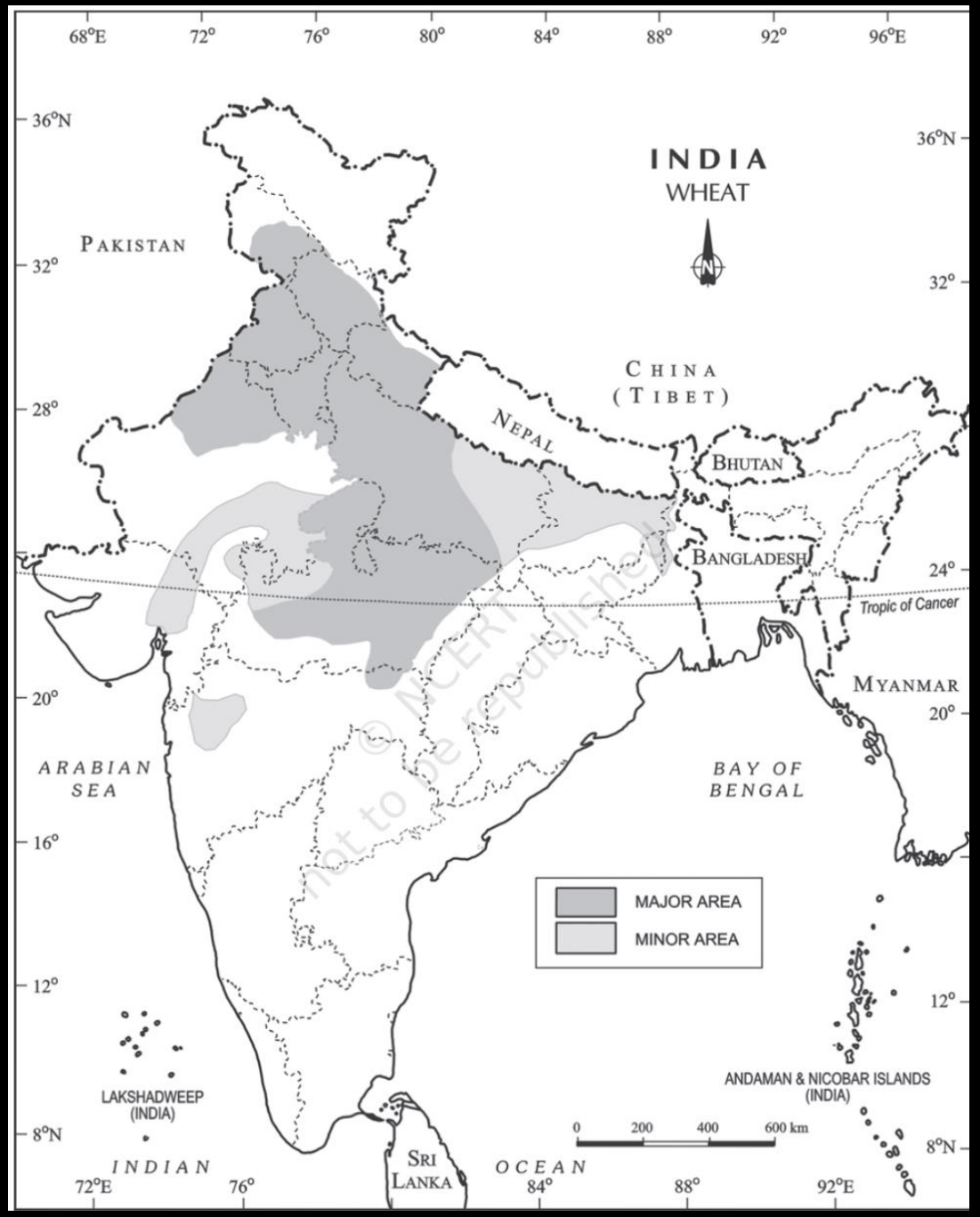
Top Rice-Producing States in India

Rank	State	Rice Production (in Million Tonnes)
1	West Bengal	15.75
2	Uttar Pradesh	12.50
3	Punjab	11.82



Wheat

- Wheat is the ***second most important*** cereal crop in India after rice.
- India produces about 12.3 per cent of total wheat production of world (2016).
- It is primarily a crop of temperate zone. Hence, its cultivation in India is done during winter i.e. **rabi season**
- About 14 per cent of the total cropped area in the country is under wheat cultivation.
- Uttar Pradesh, Madhya Pradesh, Punjab, Haryana and Rajasthan are leading wheat producing states.
- The yield level of wheat is very high (above 4,000 k.g. per ha) in Punjab and Haryana whereas, Uttar Pradesh, Rajasthan and Bihar have moderate yields.

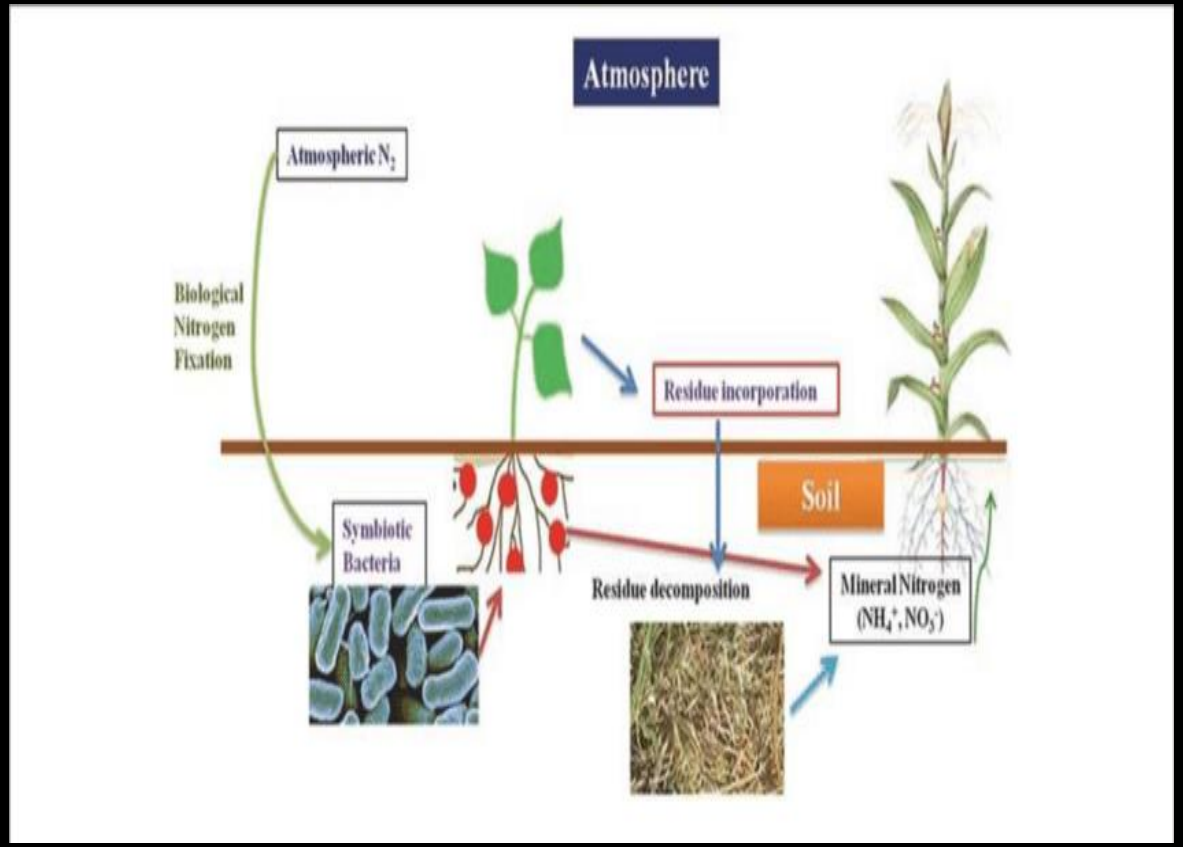


Top Wheat-Producing States in India

Rank	State	Wheat Production (Percentage of National Total)
1	Uttar Pradesh	32.42%
2	Madhya Pradesh	16.08%
3	Punjab	15.65%

Pulses

- Pulses are a very important ingredient of vegetarian food as these are rich sources of proteins.
- These are legume crops which increase the natural fertility of soils through nitrogen fixation.
- India is a leading producer of pulses in the world.
- The cultivation of pulses in the country is largely concentrated in the drylands of Deccan and central plateaus and northwestern parts of the country.
- Pulses occupy about 11 per cent of the total cropped area in the country.
- Being the rainfed crops of drylands, the yields of pulses are low and fluctuate from year to year.
- Gram and tur are the main pulses cultivated in India.



- **Azotobacter ; Clostridium ; Rhizobium; Frankia ; Anabaena** (Cyanobacteria (Blue-Green Algae) ; **Nostoc** (Cyanobacteria (Blue-Green Algae)

Shree Anna (Millets)

- **Shree Anna** refers to **millets**, a group of small-seeded, drought-resistant grains grown in arid and semi-arid regions.
- These are highly nutritious and have been a staple food in India for centuries.
- The term "Shree Anna" highlights their cultural and nutritional significance.
- Ex- Jowar (Sorghum) ,Bajra (Pearl Millet) ,Ragi (Finger Millet), Foxtail Millet ,Kodo Millet, Proso Millet, Barnyard Millet, Little Millet.
- 2023 was celebrated as the **International Year of Millets** by the UN, with India leading the initiative.

Fibre Crops

- These crops provide us fibre for preparing cloth, bags, sacks and a number of other items.
- Cotton and jute are two main fibre crops grown in India

- **Cotton**
  Cotton is a tropical crop grown in kharif season in semi-arid areas of the country.
- India lost a large proportion of cotton growing area to Pakistan during partition. However, its acreage has increased considerably during the last 50 years
- India grows both short staple (Indian) cotton as well as long staple (American) cotton called **'narma'** in north-western parts of the country.
- Cotton requires clear sky during flowering stage.

Other crops

- **Coffee**
- Coffee is a tropical plantation crop. Its seeds are roasted, ground and are used for preparing a beverage.
- There are three varieties of coffee i.e. **arabica, robusta and liberica**.
- India mostly grows superior quality coffee, arabica, which is in great demand in International market.
- But India produces only about 3.7 per cent coffee of the world and ranks seventh after Brazil, Vietnam, Colombia, Indonesia, Ethopia and Honduras in 2016.
- Coffee is cultivated in the highlands of Western Ghats in Karnataka, Kerala and Tamil Nadu.
- Karnataka alone accounts for more than two-third of total production of coffee in the country

- **Tea**
- Tea is a plantation crop used as beverage.
- Black tea leaves are fermented whereas green tea leaves are unfermented.
- Tea leaves have rich content of caffeine and tannin. It is an indigenous crop of hills in northern China.
- It is grown over undulating topography of hilly areas and well drained soils in humid and sub-humid tropicsand sub-tropics.
- In India, tea plantation started in 1840s in Brahmaputra valley of Assam which still is a major tea growing area in the country. Later on, its plantation was introduced in the sub-Himalayan region of West Bengal (Darjeeling,Jalpaiguri and Cooch Behar districts).
- Tea is also cultivated on the lower slopes of Nilgiri and cardamom hills.
- Assam accounts for about 53.2 per cent of the total cropped area and contributes more than half of total production of tea in the country.

INDIA'S AGRICULTURE SECTOR

"Productivity challenges"

Farm holdings

Nearly 50% of the population is engaged in agricultural production. As farms are divided among family members, average farm size today is half what it was 40 years ago.

Irrigation

Water use efficiency is very low . Unsustainable practices such as flooding or canals and pumping ground water resource are depleting the country's aquifers.

Indian monsoon

The country is faced with the prospect of declining rainfall during the monsoon. India's prime growing season for rain fed agriculture.

Subsidy

Government subsidy to farmers for fertiliser, electricity and irrigation increased more than eightfold between 1990-91 and 2006 -07. Areas receiving the highest subsidies regularly underperform those with lower subsidy.

Cold Storage and Food Processing

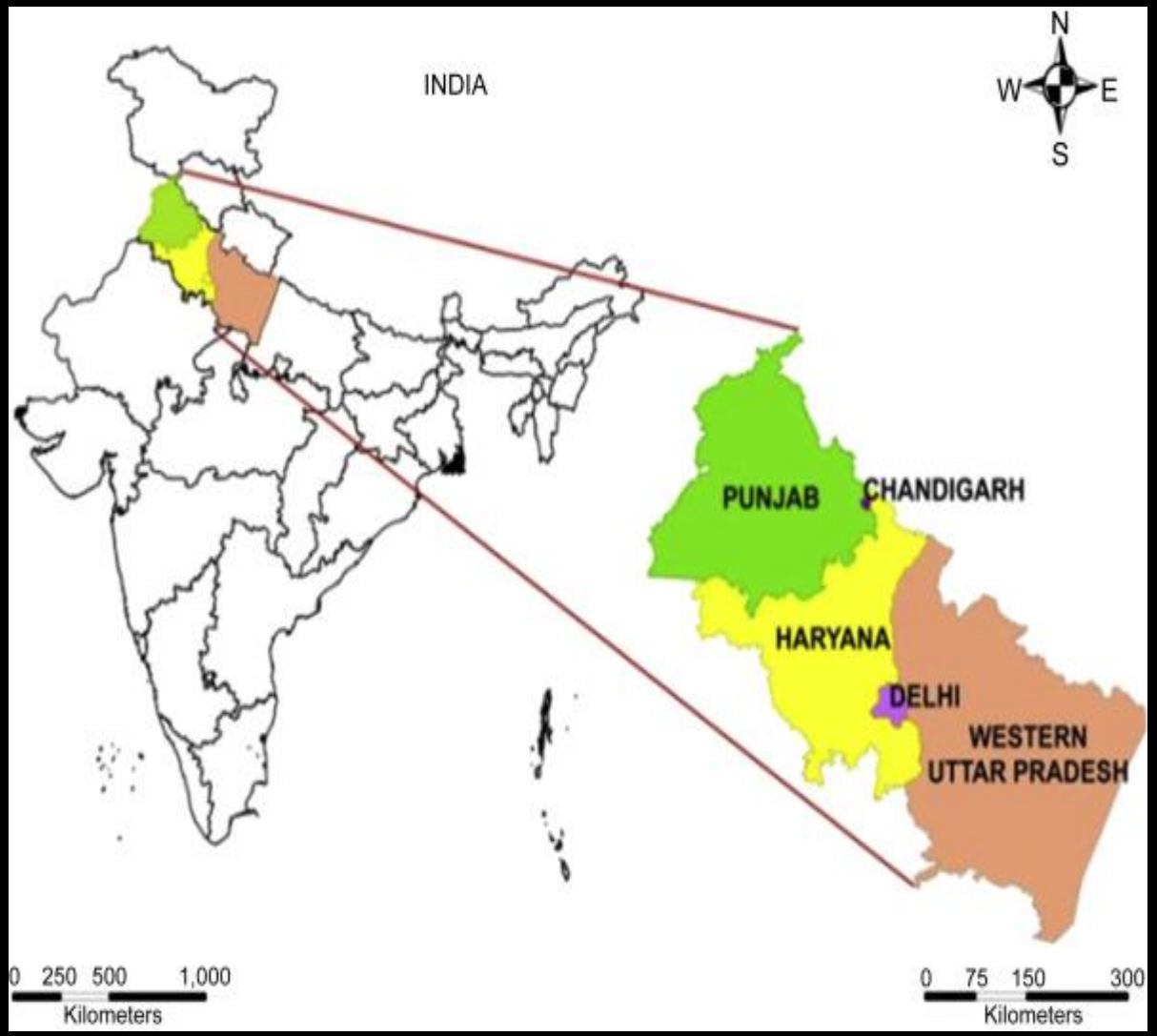
30% of harvest and post-harvest economic losses come from the fruit and vegetable sectors, although that sector comprised only 13.6% of total production.

Crop pattern , Fertiliser and Soil nutrients

The Government of India's top research institute reports that nearly 60% of agricultural land is at risk because of fertiliser misuse, poor cropping pattern and soil nutrient deficiencies.

Green Revolution

- The Green Revolution refers to the significant increase in agricultural production during the 1960s and 1970s, primarily due to the introduction of high-yielding variety (HYV) seeds, modern irrigation techniques, and chemical fertilizers.
- The **Green Revolution**, initiated by **Norman Borlaug** in Mexico during the 1960s, earned him the title of the **'Father of the Green Revolution'** for his development of **High-Yielding Varieties (HYVs)** of wheat, which significantly boosted agricultural productivity. For his work, he was awarded the **Nobel Peace Prize in 1970**.
- The term "Green Revolution" was coined by **William S. Gaud**, the administrator of the **U.S. Agency for International Development (USAID)**, in a speech on **8 March 1968**. Gaud used the term to describe the global increase in agricultural production driven by new technologies like HYVs, modern irrigation, and chemical fertilizers.
- It was spearheaded by M.S. Swaminathan in India, known as the "Father of the Green Revolution in India.“
- The Green Revolution, spreading over the period from 1967-68 to 1977-78, changed India’s status from a food-deficient country to one of the world's leading agricultural nations.


INDIA
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UTTAR PRADESH
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Kilometers
0 75 150 300
Kilometers

Success and Failure of the Green Revolution

Success	Failure
Boosted crop production, especially wheat and rice.	Limited to certain regions; benefits mostly in Punjab, Haryana, and Uttar Pradesh.
Helped India become self-sufficient in food grains.	Focused on a few crops, neglecting other important crops like pulses.
Introduction of high-yielding varieties (HYVs), irrigation, and fertilizers.	Over-reliance on chemical fertilizers and pesticides, leading to environmental degradation.
Increased income for farmers and rural employment.	Larger farmers benefited more, increasing the wealth gap between rich and poor farmers.
Increased agricultural productivity in arid areas.	Soil degradation, water depletion, and pesticide pollution.
Set the foundation for modern agricultural practices.	Long-term sustainability questioned due to overuse of resources.
Transformed agriculture in some areas, improving rural infrastructure.	Left many regions, especially dry and hilly areas, behind.

White Revolution in India:

- The **White Revolution**, also known as **Operation Flood**, was launched on **January 13, 1970**, by the **National Dairy Development Board (NDDB)**.
- It is regarded as the world's largest dairy development program and a landmark initiative that transformed India into the world's largest producer of milk.
- **Dr. Verghese Kurien**, the chairman and founder of **Amul**, is considered the **architect** of the revolution.
- India, once a milk-deficient country, became the largest producer of milk in the world, surpassing the United States in 1998.
- By 2018, India contributed about 22.29% of the global milk production.

Blue Revolution in India

- The **Blue Revolution** refers to the significant growth and development in the **fisheries sector** of India, focusing on **increasing fish production**, **improving fish farming technologies**, and **enhancing sustainable fisheries management**.
- It is often associated with the period between the **1970s and 1990s**, though its impact continues into the present.
- Dr. Hiralal Chaudhuri. is considered the architect of India's Blue Revolution

Agricultural Revolutions in India

Revolution	Key Features
Yellow Revolution	Focused on **oilseeds** production, mainly **groundnut** and **mustard**.
Brown Revolution	Focused on the production of **coffee**, **cocoa**, and other **non-conventional crops**. Initiated by **Hiralal Chaudhuri**, known as the **Father of the Brown Revolution**.
Golden Revolution	Focused on **horticulture**, especially **fruits** (mangoes, bananas, etc.) and **vegetables**.
Silver Revolution	Focused on **egg production** and **poultry farming**.
Pink Revolution	Focused on **meat production**, especially **poultry and goat farming**. Durgesh Patel is known as the Father of the **Pink Revolution**.
Purple Revolution	Also known as the **Lavender Revolution**, focused on promoting the cultivation of **aromatic crops**, especially **lavender**.

INDUSTRIES


Coestruction & building
Energy & Utilities
Transport & logistics
Metals & Mining
Retail
Agriculture food
Oil & gas
Apparel
Electronics High-tec
Chemical
Consumer goods
Manufacuring
Packaging
Finance
Automotive
Tourism
Aerospace
Government

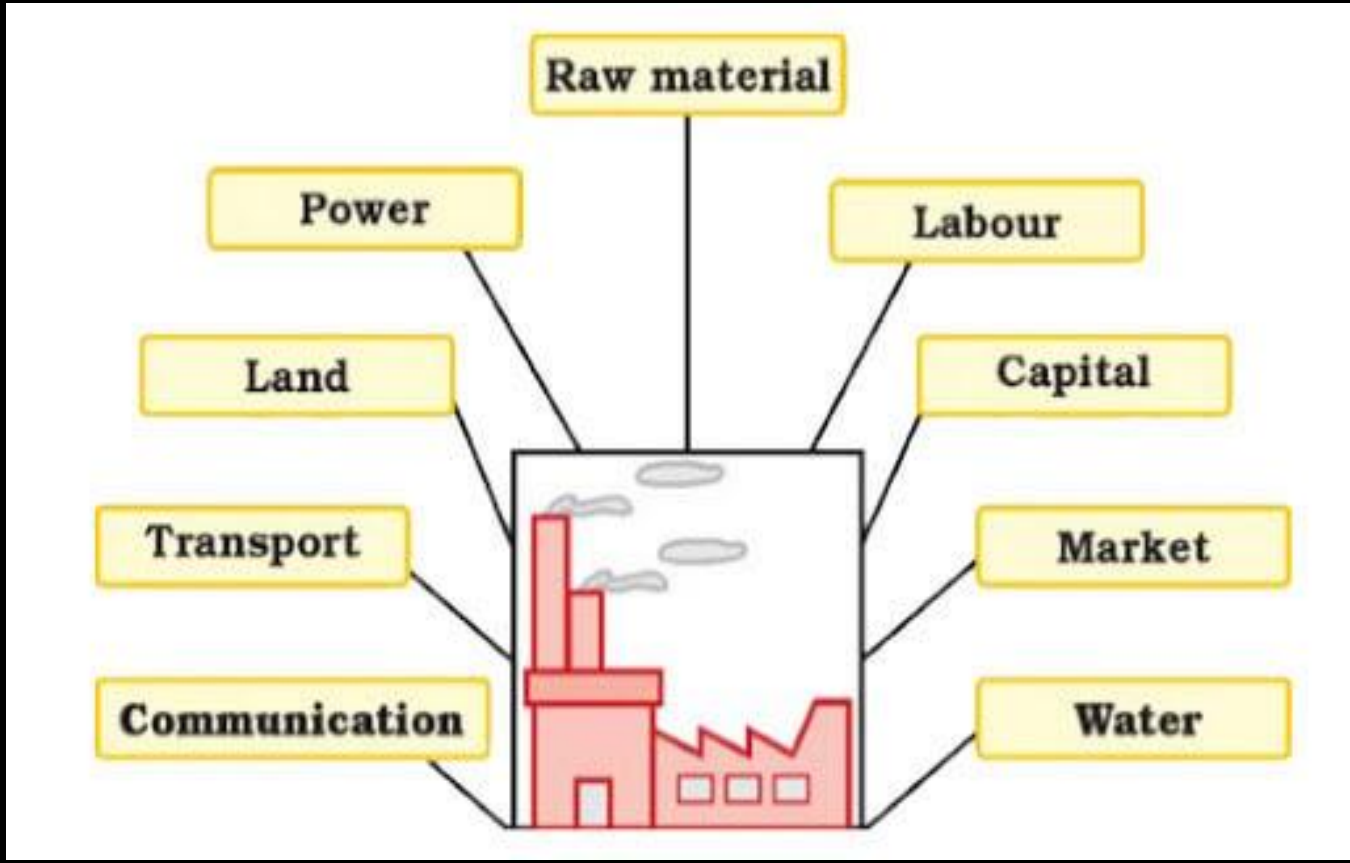
- Industry refers to the economic activity involved in the production of goods, the extraction of minerals, or the provision of services.
- It encompasses the transformation of raw materials into finished products that are more valuable to people.
- **Key feature:**
- **Secondary activities**:
  - Industry is a part of secondary activities that change raw materials into more valuable products. For example, pulp is turned into paper, and paper is further processed into notebooks.
- **Value addition**:
  - During manufacturing, raw materials such as cotton or pulp undergo changes that increase their value and utility. For instance, paper made from pulp and cloth made from cotton have added value at each stage of production.

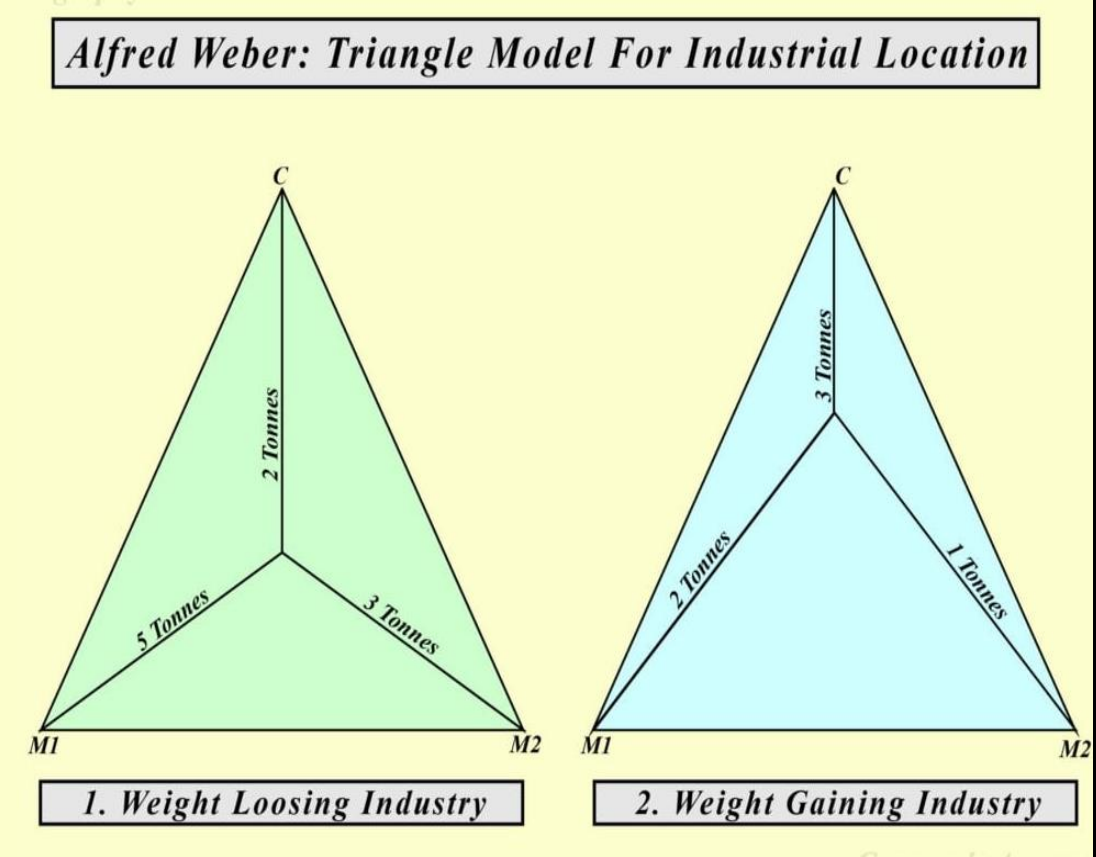
Types of Industries

Basis	Industry Type	Examples
On the Basis of Raw Materials	**Agriculture-based industries**	- Textile industry (using cotton, jute) - Sugar industry (using sugarcane) - Oil extraction industry (using groundnut, sunflower seeds)
	Forest-based industries	- Paper industry (using wood pulp) - Furniture industry (using timber) - Matchstick industry (using wood)
	Mineral-based industries	- Iron and steel industry (using iron ore) - Aluminium industry (using bauxite) - Cement industry (using limestone)
	Raw material-based industries	- Petroleum refining (using crude oil) - Chemical industry (using natural gas) - Glass manufacturing (using silica sand)

Basis	Industry Type	Examples
On the Basis of Ownership	**Public sector**	- Bharat Heavy Electricals Limited (BHEL) - Oil and Natural Gas Corporation (ONGC) - Steel Authority of India Limited (SAIL)
	Private sector	- Tata Steel - Reliance Industries - Hindustan Unilever Limited (HUL)
	Joint and cooperative sector	- The Indian Oil Corporation (IOC) - Amul Dairy - Maruti Suzuki India Ltd.

Location of Industries





Raw materials

- Raw materials can be categorized into two types: pure and impure (weight-losing).
- Industries that use weight-losing raw materials are typically located near their sources.
- Examples of such industries include sugar mills, pulp, copper smelting, and pig iron industries.
- In the iron and steel sector, both iron ore and coal are weight-losing raw materials, making it crucial for these industries to be located near these resources.
- Consequently, iron and steel plants are found near coalfields (e.g., Bokaro, Durgapur) or iron ore sources (e.g., Bhadravati, Bhilai, Rourkela).
- Similarly, industries relying on perishable raw materials are also situated close to their sources.

- **Power**
  Power provides the motive force for machines, and therefore, its supply has to be ensured before the location of any industry.
- However, certain industries, like **aluminium and synthetic nitrogen manufacturing industries tend to be located near sources of power because they are power intensive and require huge quantum of electricity**.

- **Market**
  Markets provide the outlets for manufactured products.
- **Heavy machine, machine tools, heavy chemicals are located near the high demand areas as these are market orientated.**
- Cotton textile industry uses a non-weight-losing raw material and is generally located in large urban centre, e.g. Mumbai, Ahmedabad, Surat, etc.
- Petroleum refineries are also located near the markets as the transport of crude oil is easier and several products derived from them are used as raw material in other industries.
- Koyali, Mathura and Barauni refineries are typical examples.
- Ports also play a crucial role in the location of oil refineries

Transport

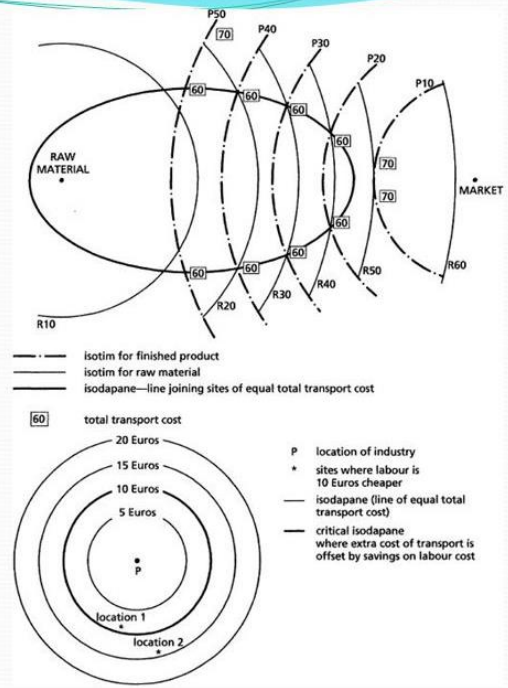
The industries shifted to interior locations, only when railway lines were laid. All major industrial plants are located on the trunk rail routes

Labour

Industries require skilled labour. In India, labour is quite mobile and is available in large numbers due to our large population.

ISOTIM:Lines joining points of equal transport costs of commodity.

ISODAPANE: Lines joining points of equal total transport cost

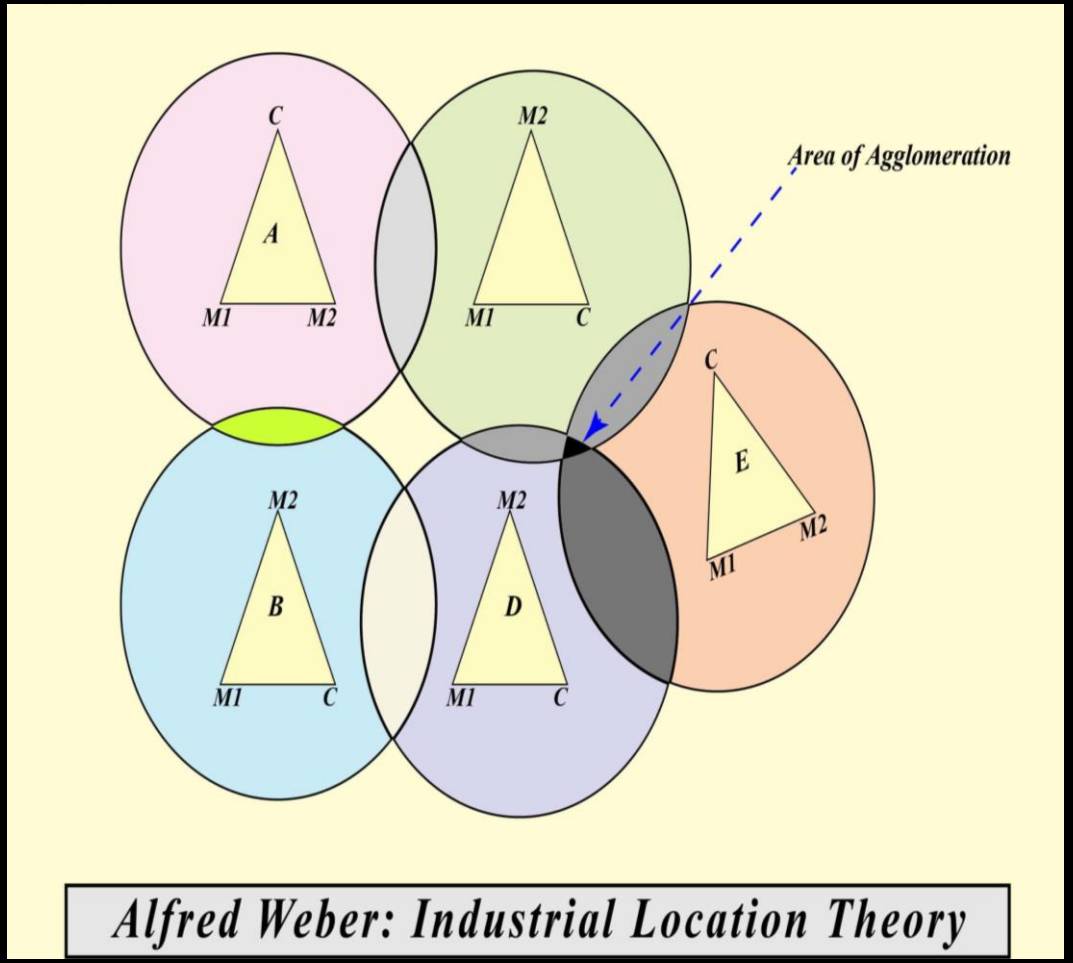


Historical Factors

During the initial phase of colonisation, manufacturing activities received new impetus provided by the European traders.

Places like Murshidabad, Dhaka, Bhadohi, Surat, Vadodara, Kozhikode, Coimbatore, Mysuru etc., emerged as important manufacturing centres.

In the subsequent industrial phase of colonialism, these manufacturing centres experienced rapid growth due to competition from the goods manufactured in Britain and the discriminatory policies of colonial power.



- **Industrial Agglomeration** refers to the concentration of industries in a specific area, creating industrial clusters that reduce transportation costs, improve efficiency, and foster economic growth.
- This concept, developed by **Alfred Weber**, highlights the advantages of locating industries near raw materials, labor, and markets for optimal productivity.

2. Discuss the factors for localization of agro-based food processing industries of North-West India.	2019

The Iron and Steel Industry

The development of the iron and steel industry
opened the doors to rapid industrial development in India. Almost all sectors of the Indian industry depend heavily on the iron and steel industry for their basic infrastructure.

Development of iron and steel industry in India

FIRST ATTEMPT :- PORTO NOVO IN TAMIL NADU, 1830 (UNSUCCESSFUL)

FIRST SUCCESSFUL ATTEMPT:- BENGAL IRON WORKS ,1874(KULTI WEST BENGAL) (RENAMED AS BENGAL IRON WORKS, IISCO 1918)

FIRST LARGE SCALE PRODUCTION UNIT :- TATA IRON AND STEEL COMPANY 1907(SAKCHI)

INDIAN IRON AND STEEL COMPANY (HIRAPUR WEST BENGAL), 1918

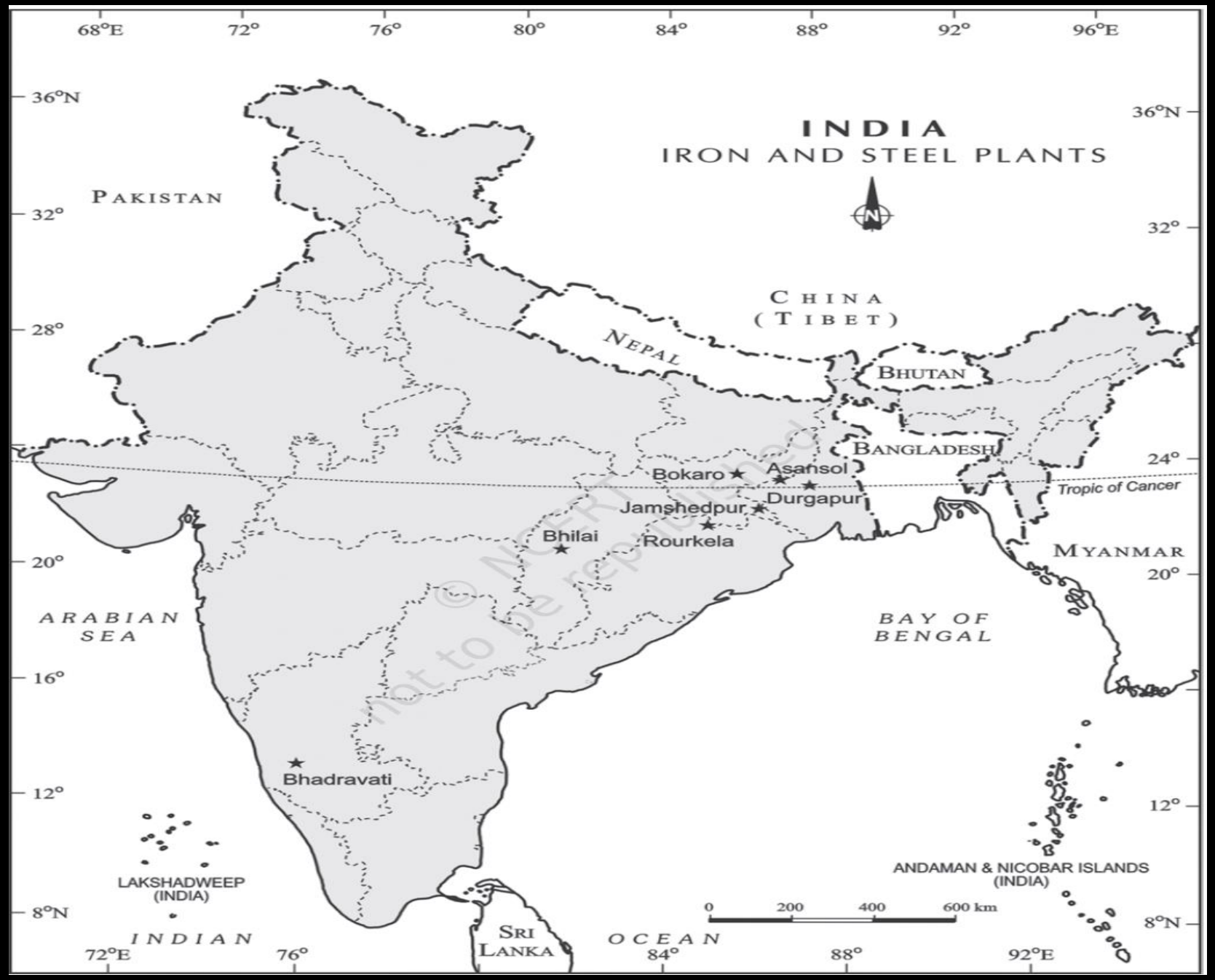
VISVESVARAYA IRON AND STEEL PLANT (BHADRAVATHI KARNATAKA), 1923

POST INDEPENDENCE

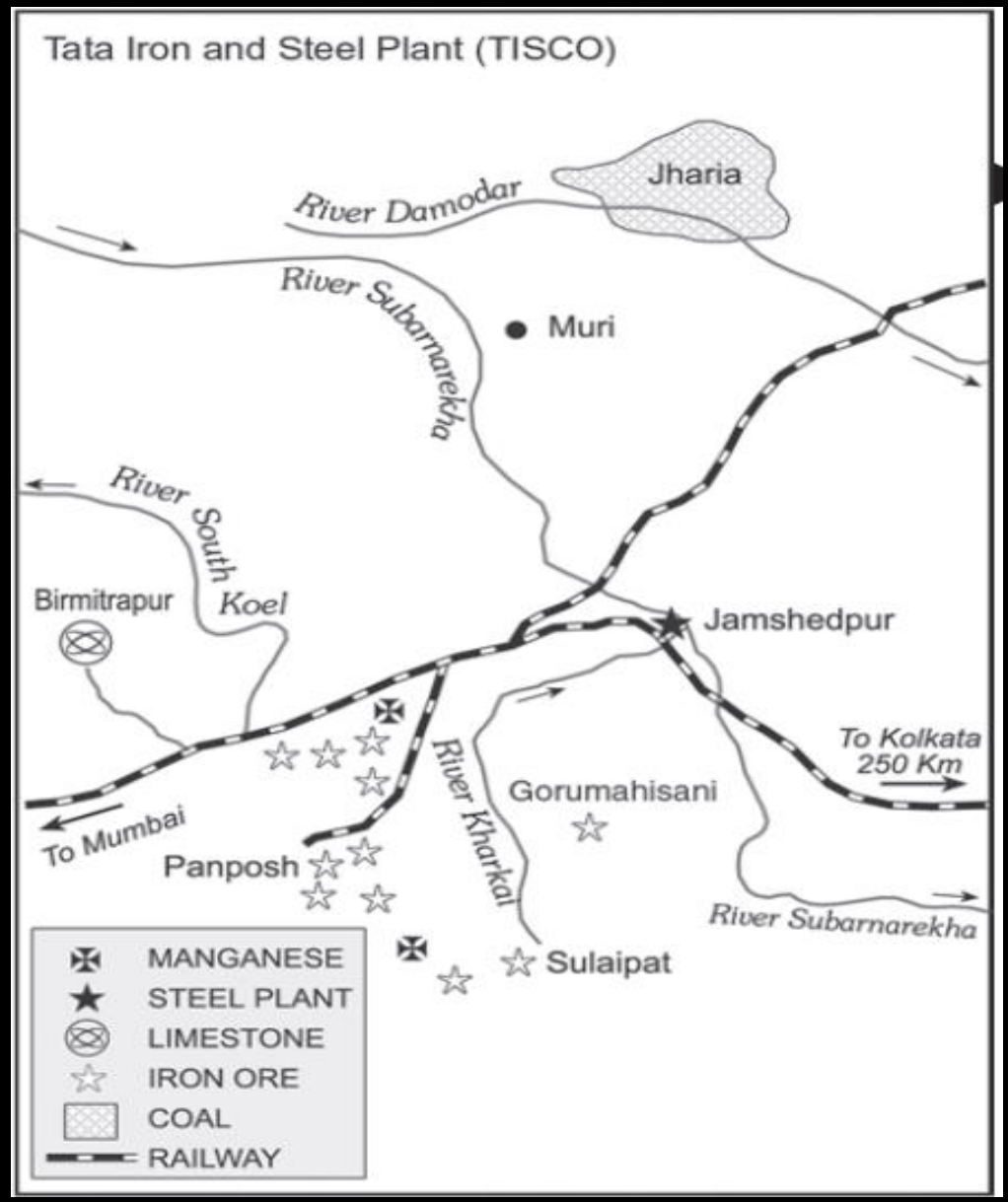
- During SECOND FIVE YEAR PLAN- THREE NEW PLANT INSTALLED UNDER HINDUSTAN STEEL LIMITED
  - 1. Rourkela Odisha with assistance of Germany
  - 2. Bhilai Chhattisgarh with assistance of Russia
  - 3. Durgapur west Bengal with assistance united kingdom

- In 1964 , Bokaro steel plant installed with assistance of Russia
- In 1973 steel authority of India established

- During fourth five year plan :-
- Four new plant installed
  - 1. Salem Tamilnadan
  - 2. Vijayanagar Hospet Karnataka
  - 3. Paradip Odisha
  - 4. Visakhapatnam Andhra Pradesh (first port led plant)

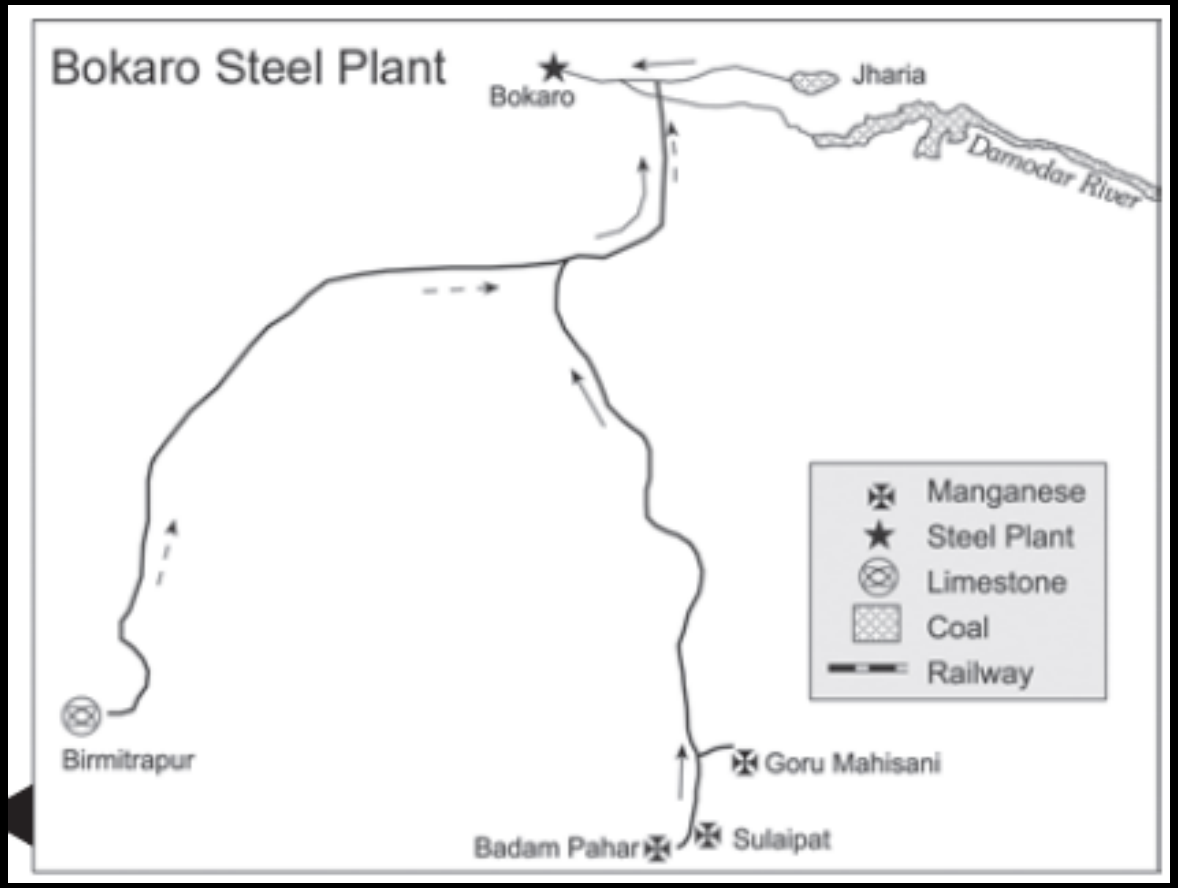

INDIA
IRON AND STEEL PLANTS
68°E
72°
76°
80°
84°
88°
92°
96°E
36°N
32°
28°
24°
20°
16°
12°
8°N
PAKISTAN
CHINA (TIBET)
NEPAL
BHUTAN
BANGLADESH
MYANMAR
Tropic of Cancer
Bokaro
Asansol
Durgapur
Jamshedpur
Bhilai
Rourkela
Bhadravati
ARABIAN SEA
BAY OF BENGAL
INDIAN OCEAN
SRI LANKA
LAKSHADWEEP (INDIA)
ANDAMAN & NICOBAR ISLANDS (INDIA)
0 200 400 600 km

- ***TISCO***
  The Tata Iron and Steel plant lies very close to the Mumbai-Kolkata railway line and about 240 km away from Kolkata, which is the nearest port for the export of steel.
- The rivers Subarnarekha and Kharkai provide water to the plant.
- The iron ore for the plant is obtained from Noamundi and Badam Pahar and coal is brought from Joda mines in Odisha.
- Coking coalcomes from Jharia and west Bokaro coalfields



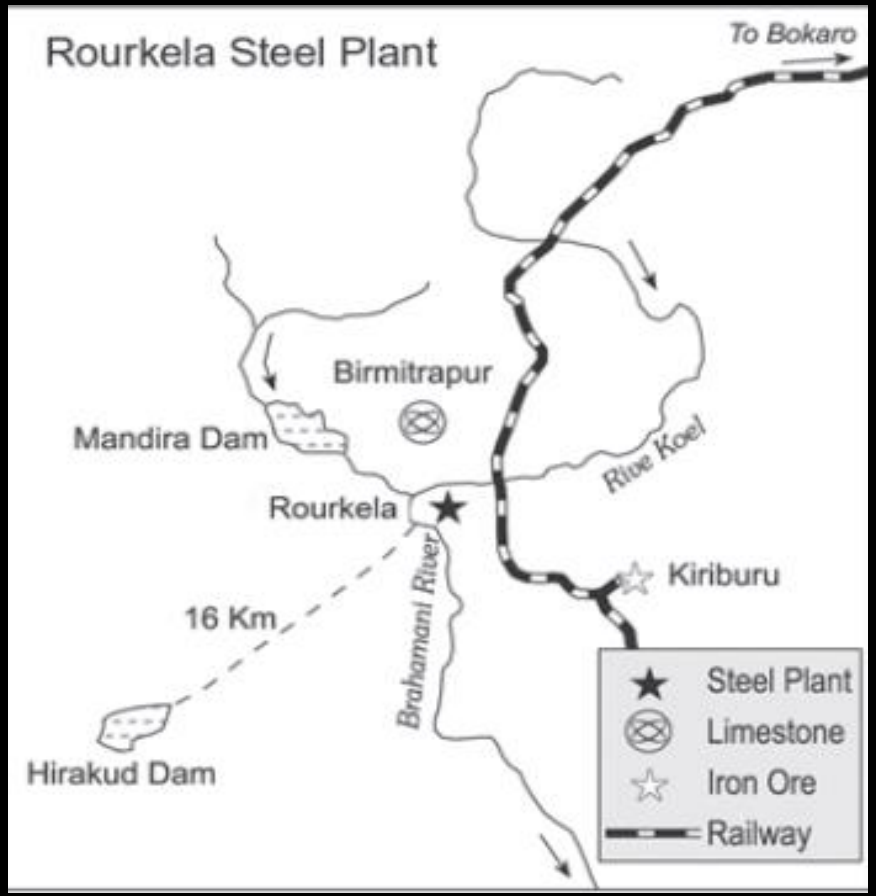
Bokaro Steel Plant

- This steel plant was set up in 1964 at Bokaro with Russian collaboration.
- This plant was set up on the principle of transportation cost minimisation by creating Bokaro-Rourkela combine.
- It receives iron ore from the Rourkela region and the wagons on return take coal to Rourkela.
- Other raw materials come to Bokaro from within a radius of about 350 km.
- Water and hydel power is supplied by the Damodar Valley Corporation.



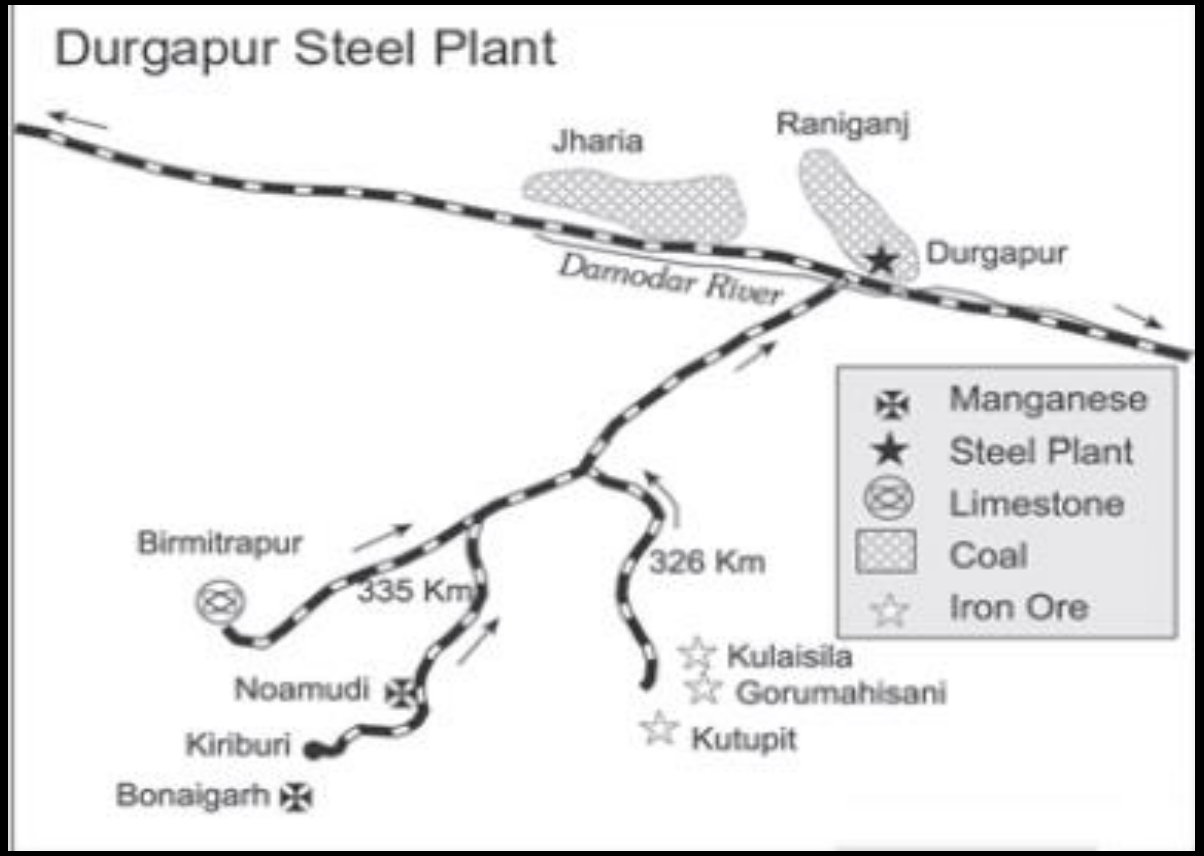
Rourkela Steel Plant

- The Rourkela Steel plant was set up in 1959 in the Sundargarh district of Odisha in collaboration with **Germany**.
- The plant was located on the basis of proximity to raw materials, thus, minimising the cost of transporting weight losing raw material.
- This plant has a unique locational advantage, as it receives coal from Jharia (Jharkhand) and iron ore from Sundargarh and Kendujhar.
- The Hirakud project supplies power for the electric furnaces and water is obtained from the Koel and Sankh rivers.

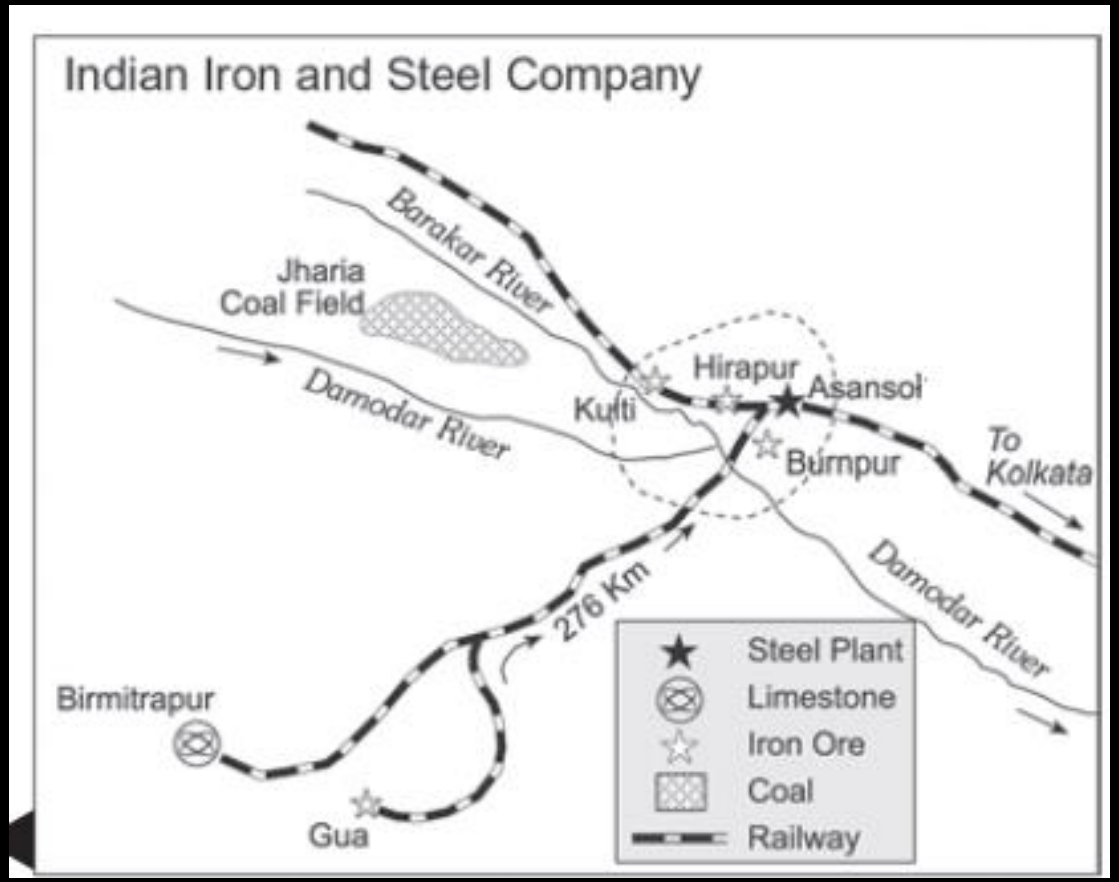


Durgapur Steel Plant

- Durgapur Steel Plant in West Bengal was set up in collaboration with the government of the United Kingdom and started production in 1962.
- This plant lies in Raniganj and Jharia coal belt and gets iron ore from Noamundi.
- Durgapur lies on the main Kolkata-Delhi railway route.
- Hydel power and water is obtained from the Damodar Valley Corporation (DVC).

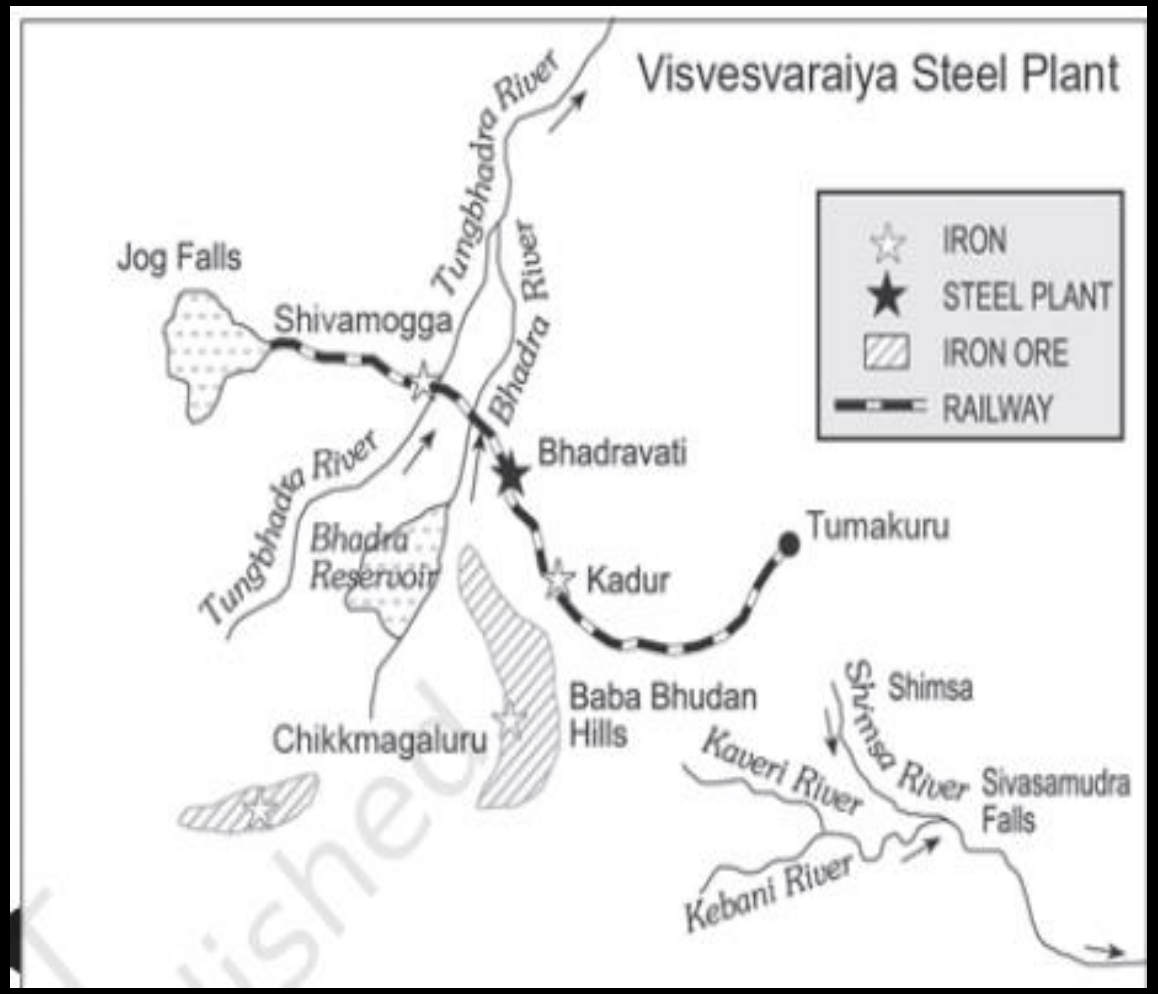


- ***IISCO***
- The Indian Iron and Steel Company (IISCO) set up its first factory at Hirapur and later on another at Kulti.
- In 1937, the Steel corporation of Bengal was constituted in association with IISCO and set up another iron and steel producing unit at Burnpur (West Bengal).
- All the three plants under IISCO are located very close to Damodar valley coal fields (Raniganj, Jharia, and Ramgarh).
- Iron ore comes from Singhbhum in Jharkhand. Water is obtained from the Barakar River, a tributary of the Damodar.
- All the plants are located along the Kolkata-Asansol railway line.
- Unfortunately, steel production from IISCO fell considerably in 1972-73 and the plants were taken over by the government.



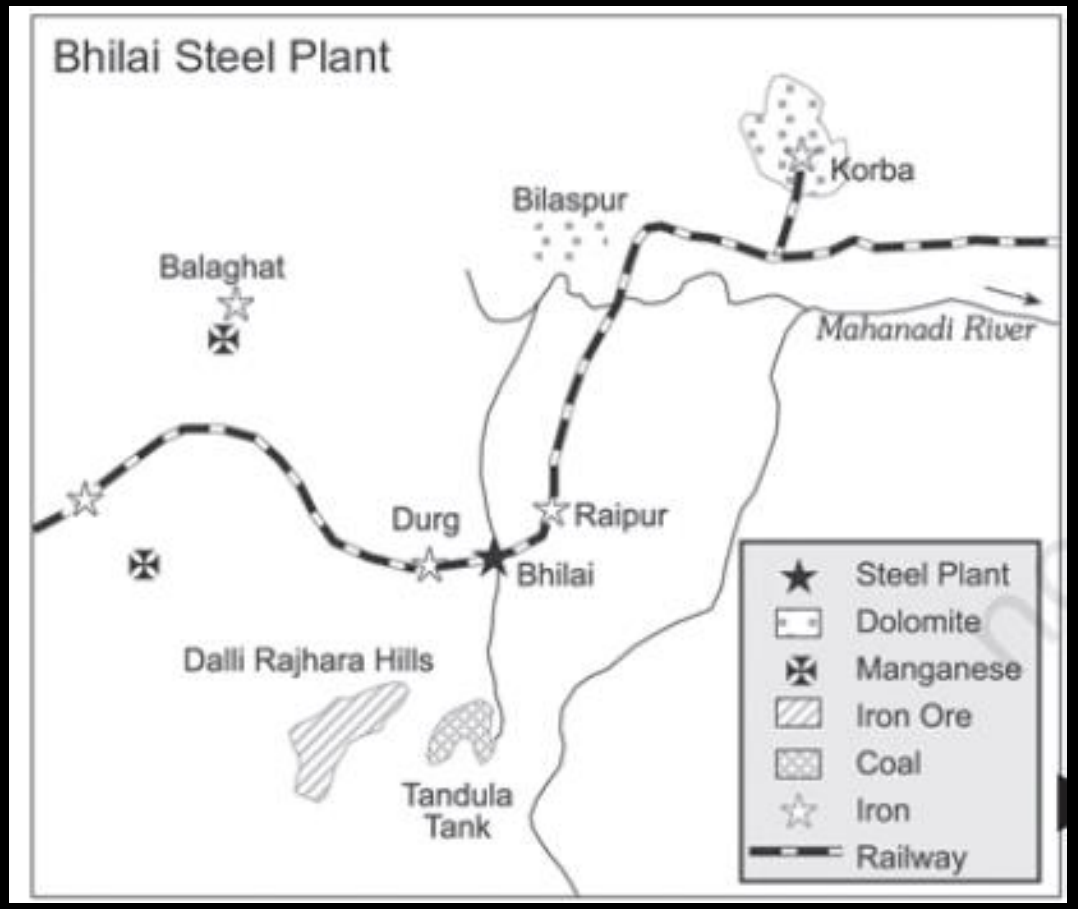
Visvesvaraiya Iron and Steel Works Ltd. (VISL)

- The third integrated steel plant, the Visvesvaraiya Iron and Steel Works, initially called the Mysore Iron and Steel Works.
- It is located close to an iron ore producing area of Kemangundi in the Bababudan hills.
- Limestone and manganese are also locally available. But this region has no coal.
- At the beginning, charcoal obtained by burning wood from nearby forests was used as fuel till 1951.
- Afterwards, electric furnaces were installed which use hydroelectricity from the Jog Falls hydel power project.
- The Bhadravati river supplies water to the plant.
- This plant produces specialised steels and alloys



Bhilai Steel Plant

- The Bhilai Steel Plant was established with Russian collaboration in Durg district of Chhattisgarh and started production in 1959.
- Iron ore comes from Dalli-Rajhara mine and coal from Korba and Kargali coal fields.
- Water comes from the Tanduladam and the power from the Korba Themal Power Station.
- This plant also lies on the Kolkata-Mumbai railway route.
- The bulk of the steel produced goes to the Hindustan Shipyard at Vishakhapatnam.



Other Steel Plants

- New steel plants which were set up in the Fourth Plan period are away from the main raw material sources.
- All three plants arelocated in South India.
- The Vizag Steel Plant
  - The Vizag Steel Plant, in Vishakhapatnam in Andhra Pradesh is the first port-based plant which started operating in 1992.
  - Its port location is of advantage.
- Vijaynagar Steel Plant
- The Vijaynagar Steel Plant at Hosapete in Karnataka was developed using indigenoustechnology. This uses local iron ore and limestone.
- Salem Steel Plant
- The Salem Steel Plant in Tamil Nadu was commissioned in 1982

The Cotton Textile Industry

- The cotton textile industry is one of the traditional industries of India.
- In the ancient and the medieval times, it used to be only a cottage industry.
- India was famous worldwide for the production of ***muslin***, a very fine variety of cotton cloth, calicos, chintz and other different varieties of fine cotton cloth.
- The development of this industry in India was due to several factors.
  - One, it is a tropical country and cotton is the most comfortable fabric for a hot and humid climate.
  - Second, large quantity of cotton was grown in India.
  - Abundant skilled labour required for this industry was available in this country.
  - In fact, in some areas the people were producing cotton textiles for generations and transferred the skill from one generation to the other and in the process perfected their skills.
  - Cotton is a "pure" raw material which does not lose weight in the manufacturing process.
  - so other factors, like, power to drive the looms, labour, capital or market may determine the location of the industry.
  - At present the trend is to locate the industry at or close to markets, as it is the market that decides what kind of cloth is to be produced.
  - Also the market for the finished products is extremely variable, therefore, it becomes important to locate the mills close to the market.

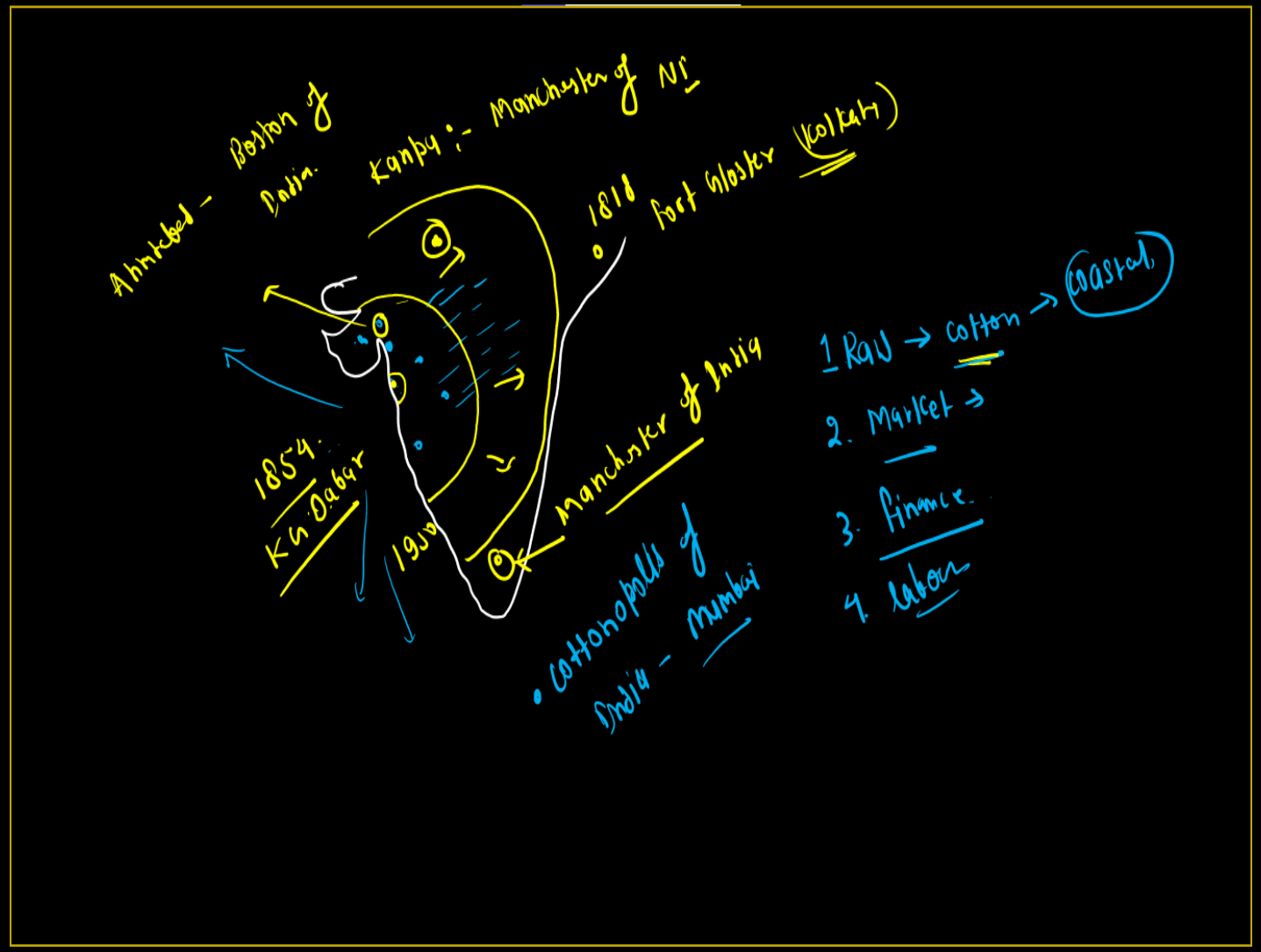


Fig. 8.11 : Cotton Textile Industries

10. Analyze the factors for highly decentralized cotton textile industry in India	2013

Aluminum Industry

- The aluminium industry is the second most important metallurgical industry in the country, with diverse applications across various sectors.
- India is the 2nd largest Aluminum Producer country in the world (in 2024; PIB)
- To obtain one tonne of aluminium, approximately 4 to 5 tonnes of bauxite are processed into 2 tonnes of alumina, which is then used to produce 1 tonne of aluminium.
- **The industry is power intensive as 30 to 35% of cost of production is accounted for by power. Thus availability of power at economic rates is necessary.**.

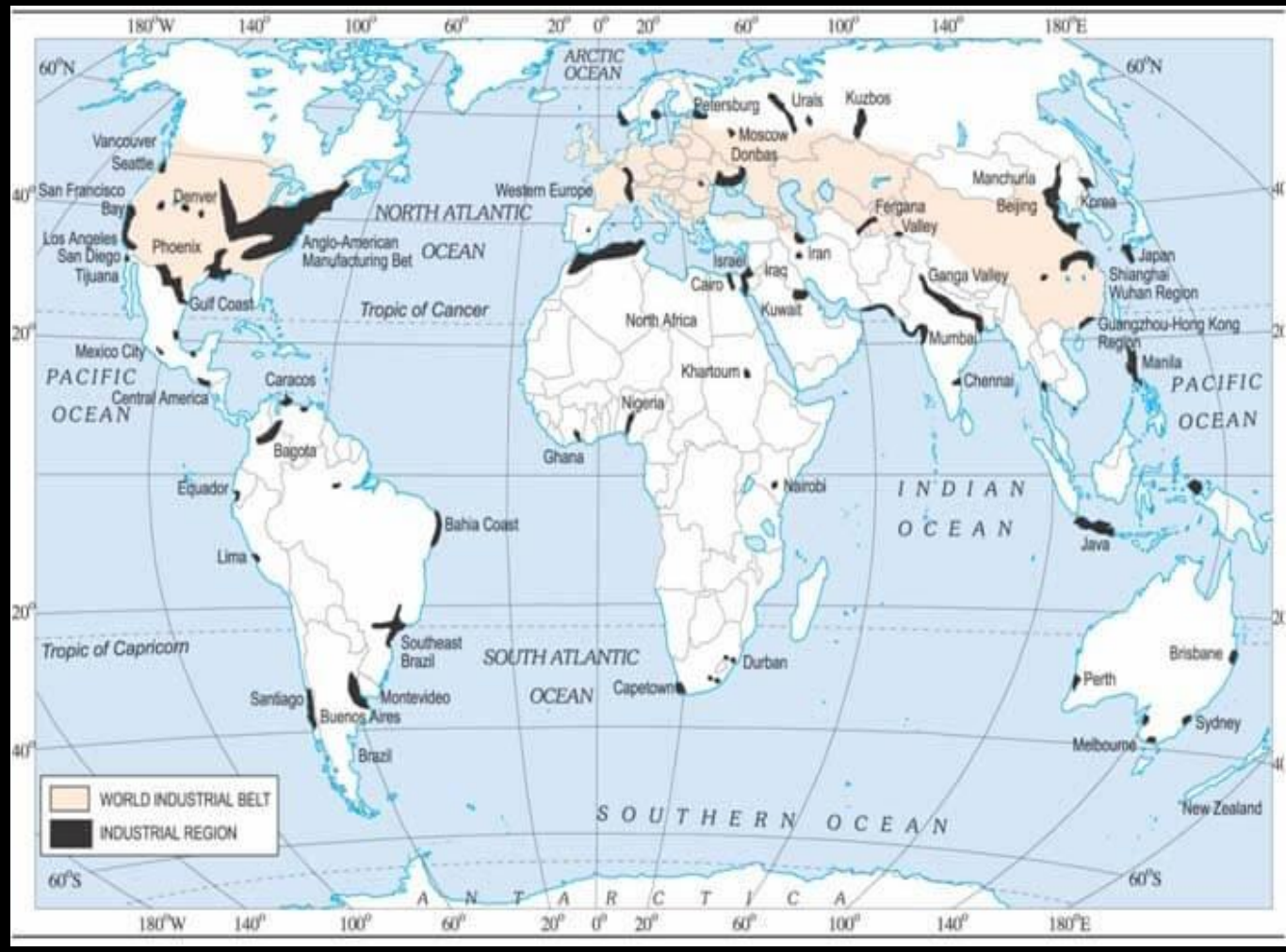
Development of Aluminium Industry in India

- The **Aluminium industry in India** had its early beginnings in 1938 when the **Indian Aluminium Company** established a plant at **Alupuram (Alwaye)**, Kerala.
- In 1942, the **Aluminium Corporation of India** set up a production facility at **Jaykaynagar**, West Bengal.
- After **India's independence**, the aluminium industry experienced significant growth.
- In the **1950s and 60s**, new plants were opened at **Hirakud**, **Renukoot**, and **Mettur.**
- The **1970s and beyond** saw further expansion with the establishment of plants in **Belgaum**, **Korba**, and **Jharsuguda.**

Location	Name of company
Korba (Chhattisgarh)	Bharat Aluminium Co (BALCO)
Alupuram (Kerala)	Hindustan Aluminium Co. (HINDALCO)
Renukoot (Uttar Pradesh)	Hindustan Aluminium Co. (HINDALCO)
Mettur (Tamil Nadu)	Madras Aluminium (MALCO)
Hirakud (Odisha)	Hindustan Aluminium Co. (HINDALCO)
Angul (Odisha)	National Aluminium Co. (NALCO)
Jharsuguda (Odisha)	Vedanta Aluminium Co. (VAL)

Industrial Regions in India

- Industries are not evenly distributed in the country. They tend to concentrate on certain locations because of the favourable locational factors.
- Several indices are used to identify the clustering of industries, important among them are :
  1. The number of industrial units,
  2. Number of industrial workers,
  3. Quantum of power used for industrial purposes,
  4. Total industrial output, and
  5. Value added by manufacturing, etc.



Major industrial regions of INDIA

Major Industrial Regions (8)

1. Mumabi-Pune Region,
2. Hugli Region,
3. Bengaluru-Tamil Nadu Region,
4. Gujarat Region,
5. Chotanagpur Region,
6. Vishakhapatnam-Guntur Region,
7. Gurugram-Delhi-Meerut Region, and
8. Kollam-Thiruvananthapuram Region.

Fig. 8.13 : India – Major Industrial Regions

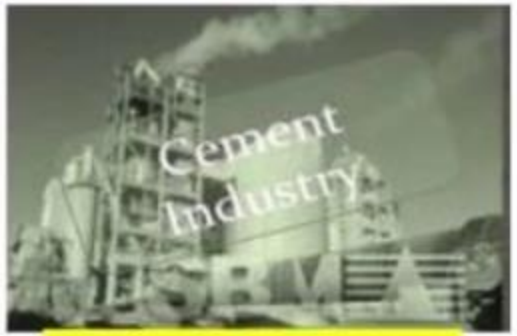
Coal (10.33%)

Crude Oil (8.98%)

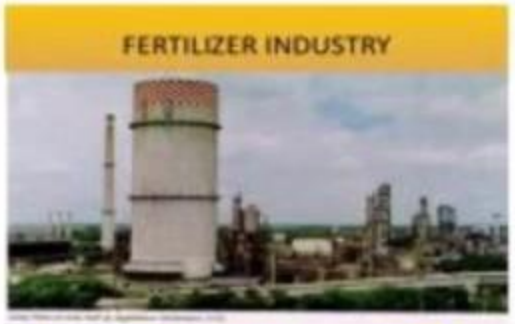
Natural Gas (6.88%)

Refinery (28.04%)

Steel (17.92%)



Cement (5.37%)



Fertilizer (2.63%)

Electricity (19.85%)