GS1: Geography

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About Us

Madhav Agarwal and Ratnesh Agrawal *— two friends, one mission, and a bond forged through shared dreams. From school classrooms to college corridors, their journey was always side by side. United by a common goal of cracking the UPSC, they spent over 300 hours on video calls — dissecting concepts, solving doubts, and building the notes that would become the backbone of their preparation.*

Madhav went on to secure AIR 211 in CSE-2023 and then soared to ***AIR 16 in CSE-2024****. Now set to join the* ***Indian Administrative Service****, he is living proof that quiet determination, when sustained with laser focus, can turn even the toughest dreams into destiny.*

Ratnesh, who reached the ***UPSC interview stage in CSE-2023****, chose a different but equally powerful path. With the same intensity and sharp thinking that marked his preparation, he stepped into the world of real estate. Today, he's a* ***dynamic builder in Indore*** *— shaping skylines and lives with a vision rooted in public purpose and entrepreneurial fire.*

These notes are a result of their shared struggle, deep friendship, and uncompromising pursuit of excellence — a ***gift to future aspirants****, from two dreamers who refused to settle for average, each leaving a mark in his own way.*

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Note: These notes are the result of a group effort over the past few years. You'll find pink (or other coloured) highlights at the start of many topics—these usually mark key terms, definitions, quotes, etc., based on our memory cues at the time. While most content is updated, some sections—especially in GS3—may contain older material, so do cross-check and update where needed. Don't get confused by the highlights; use what's useful and feel free to build your own notes from them.

Geography Notes: This file mainly covers PYQs and their model answers, as most static content is already available in standard books, which you can refer to separately. In my final attempt, I also made short 4–5 page notes for static concepts I tended to forget—you can do the same based on your own needs.

GS-1 Geography

The global climate system is an interactive system consisting of five major components: the atmosphere, the hydrosphere, the cryosphere, the land surface and the biosphere

Key:

- Overall Topic
    - Actual Mains UPSC question asked
        - In this sub-category we're writing any other topic based on Main UPSC question

Syllabus:

Salient features of world's physical geography

Distribution of key natural resources across the world (including South Asia and the Indian sub-continent)

Factors responsible for the location of primary, secondary, and tertiary sector industries in various parts of the world (including India)

Important Geophysical phenomena such as earthquakes, Tsunami, Volcanic activity, cyclone etc., geographical features and their **location-changes** in critical geographical features (including **water-bodies and ice-caps**) and in flora and fauna and the ***effects*** of such changes

PYQS - Physical Geography

1. Geomorphology - Earth (Origin, Theories, Shape, Movements, Interiors, Crust)
    a. 2022 - 4. Describe the characteristics and types of primary rocks. (Answer in 150 words) 10
        i. 2 demands - Characteristics and types
        ii. Intro: Primary are the Igenous Rocks (primary as first set of rocks to be ever created - by cooling down of lavas) eg: Granite, Gneiss, etc
        iii. Characteristics:
            1. Majorly found in peninsular India
            2. Zero fossils but rich in mineral deposits
            3. Economic significance in terms of minerals/mining but not much usage in agriculture
            4. Mineral deposits found in veins and lodes

iv. Intrusive and Extensive Primary rocks
    1. Rate of cooling is high in extrusive leading to smaller crystals and vice versa for intrusive (have larger grain size)
    2. Felsic (silica rich thus lighter in color) and mafic (rich in Mg and Iron)
v. Concl: Study of these igneous rocks helps us understand our planet better

b. 2018- Define Mantal plume and explain role in plate tectonics
c. 2017- How does Juno mission of NASA help to understand origin and evolution of earth
d. 2013- Define Theory of continental drift, evidences in its support?
e. Formation of thousands of islands (in Indonesian and Philippines)

2. Landforms (Evolution, Running water, Glaciation, Desert and Arid, Limestone and Chalk, Coastal
    a. 2022 - 16. Mention the significance of straits and isthmus in international trade. (Answer in 250 words) 15
        i. Context of ship getting blocked in Suez Canal which led to global issues + using choke points as strategic leverage
        ii. Define both the terms and draw diagrams and world map to mark their points (#IPAD)
        iii. Strait of Hormuz (oil supplies), Strait of Gibraltar (access to markets, goods, RM), Taiwan strait (vulerability also comes with these straits)
        iv. Isthmus of Suez (reduce price of goods), Isthmus of Panama, Isthmus of Kra (China planning to build a canal to bypass St of Malacca), 90% trade happen by ocean, dev of port cities eg: Singapore
        v. Trade can also get threatened - Blockades lead to conflicts, Strategic adv (Malacca dilemma), Canal construction by China
    b. 2022 - 6. Discuss the natural resource potentials of 'Deccan trap'. (Answer in 150 words) 10 (also somewhat linked to Human geograpahy)
        i. **Introduction**: Highlight the spread of the deccan traps + Evolution [Volcanic eruptions of Reunion islands — > Formed flood basalts → disintegrated to form black soil]
        ii. Natural resources: Mineral distribution, Soil, River system, Crops also
        iii. **Black soil** - retian moisture used for cotton; Sugarcane and ground nut also done
        iv. **Minerals**
            1. Iron (Chandrapur belt MH, Ratnagiri belts), Gold
            2. Rock construction material (Cuddapah Granite rocks)
            3. Petroleum/Gas potential due to large river basin (prospects by ONGC)

4. Ground water trapped between layers - drinking waters, farming
5. Golconda diamonds, quartz, agate also found

v. **Forest** - Tropical dry decidious forests - timer wood, tendu leaves, Red Sanders (commercial cultivation)
vi. **Rivers** - Krishna, tungabhadra, Godavari - led to fertile doabs
vii. **Conclusion:** *try to provide an humanistic linkage eg: Discuss consequences of excessive GW and mineral extraction on the region*

c. 2021 - Q: Why India is considered as a subcontinent? Elaborate your answer (10m)
   i. Indian subcontinent called - India, BG, Nepal, Bhutan (sub-continent means is smaller in size)
   ii. Mighty mountains to coast lines, Cherapunjee to Thar desert, Salty marshes of Kuttch to Lush green Indo-Gangetic plains, Modern cosmopolitan cities to untouched tribals, Large rivers like BH, Ganga, KG; Forested hills of NE, WGs
   iii. Different climatic conditions: Cold to hot weather
   iv. Varied biodiversity: Biological hotspots
   v. Cultural diversity: In every few 100 kms, lang/culture/habits changes (more than 100 languages)
   vi. **Geographer Dudley Stamp** "there is perhaps no mainland part of the world better marked off by nature as a region or a 'realm' by itself than the Indian subcontinent."
d. 2021 - Q15. How do the melting of the Arctic ice and glaciers of the Antarctic differently affect the weather patterns and human activities on the Earth? Explain. (Answer in 250 words) 15
   i. Both lie at the extremes of the earth at the poles - feature differences
   ii. **Arctic** - Ice sheet on a water body; Antarctica - continent over which we have glaciers (thus melting is more signif in arctic) Similarly Arctic vs Antarctica: upto 10ft ice vs 9000 ft ice; More colder in Antarctic, Human inhabitants minimal in Antarctic
   iii. **Impacts:** Slowing down of Jet stream as high pressure on the region weakens, Increase in Rf in middle latitudes, Reversal of wind direction, Slowing down of AMOC (stagnation of water at one placing leading to prolonged heatings → More cyclone and storms), Effect on Antarctica Circumpolar Current (ACC), Driver of storms
      1. Effect on human activities: impact on fisheries, slowing of expedition due to free flowing icebergs, endangers coastal communities, Damage of food crops, Saltwater intrusion
   iv. IPCC - By 2050 predicted that we might witness Artic without ice atleast once

e. 2021 - Q14. Briefly mention the alignment of major mountain ranges of the world and explain their impact on local weather conditions, with examples. (Answer in 250 words) 15
   i. Mountains rise prominently above their surrounding; **Features** (orographic Rf, Creation of shadow areas, local winds, Influencing wind patterns eg: Himalaya to western disturbance)
   ii. Himalayas: Onset of monsoon, Winter rains when they hit soils, Prevent cold polar winds from Siberia
   iii. WGs create orographic Rf, coolder conditions
   iv. Alps: Local wind called Fohn (warm), warmer condition in Switzerland
   v. Rockies: Local winds Chinooks, N-S direction block marine winds causing rainfalls (for both Rockies, Andes), Rainshadow areas created leading to deserts

f. 2021 - Q7. Mention the global occurrence of volcanic eruptions in 2021 and their impact on regional environment. (Answer in 150 words) 10
   i. What volcanism is?
   ii. **Name them**: Semeru volcan (indonesia), Mt Stromboli, Etna (both in Italy), La Palma in Canary islands, Iceland, etc
   iii. **Impact on regional environment**: Economy stands to still (tour, travel, airline traffic), Huge amount of ash is released and deposits on leafs and affects their photosynthesis leading to plant loss; Huge CO2 is released leading to GHG warmings; Release of SO2 which combine with water vapour to form aerosols which create cooling; Immediate acid rain to release of so many particles; Dust particles rub against each other leading to lightining, Impact on local communities
   iv. WF: Approaches of zonation, evacuation and bldg reinforcement

g. 2014- Why Location of world fold mountains on margin of continents? Give association b/w the global distribution of fold mountains and the EQ and volcanoes
   i. LFs formed by techtonic plates (read in detail eg: Islands)

h. 2020: Discuss the geophysical characteristics of Circum-Pacific Zone

i. Mountain ecosystem - negative impact of development initiatives and tourism
   i. What other forms of ecosystem are there? Study them

j. 2017- How does cryosphere affect the global climate?

k. 2014- Relationship btw shrinking Himalayan glaciers and the symptoms of climate change in Indian subcontinent

l. 2020: How will the melting of Himalayan glaciers have a far-reaching impact on the water resources of India?

m. 2020: The process of desertification does not have climatic boundaries. Justify with examples.

n. 2013- Major hot deserts in northern hemisphere are located between 20-30 N latitudes and on the western sides of the continents. Why?
    i. Read all landforms within the framework of Causes for formation, reasons for specific location across the world and in India as well; Also study outcomes of global planetary wind movements
o. 2005, 1990, 1984: Soil Erosion: Causes,Types in Inda and distribution, Govt. steps, Way fwd; Soli distibution map of India

3. Oceanography - Oceans, Islands, Coral Reefs
    a. 2022 - 14. What are the forces that influence ocean currents? Describe their role in fishing industry of the world. (Answer in 250 words) 15
        i. Ideal fishing grounds: mixing of warm and cold currents (New foundland where gulf and labrador meet, Doggers bank where Kuroshio and Oyahsio cold current meet)
            1. Also upwelling action of current leads to fishing eg: Peru
            2. Helps in nutrient circulation aiding
        ii. **Concl**: Need understanding to evaluate the impacts of climate change on these ocean currents as economic livelihood of millions of marine farmers is at stake
    b. Difference in impacts of ocean currents and water masses on marine life and coastal environment? Examples?
    c. Impact of global warming on coral life system with examples
    d. 2017- Account for variations in oceanic salinity and discuss its Multi-dimensional effects.
    e. 2014- Explain the factors responsible for the origin of ocean currents How do they influence regional climates, fishing and navigation
    f. Causes of depletion of mangroves and their significance
4. Indian Drainage Systems
    a. 2021 - Q6. what are the environmental implications of the reclamation of the water bodies into urban land use? Explain with examples. (Answer in 150 words) 10
        i. Intro: Role of waterbodies - ecological services like water supply, waste treatment, local climate regulation, flood control
        ii. Leads to low percolation of water down to acquifers (lesser area of natural water and poor acquifer recharge) → leading to water scarcity; Drought can come even if Rf late by 5-10 days
        iii. Urban Floods - as their overflowing instead of percolating downwards (Kerela floods - had immediate floods and as Rf stopped led to droughts/water shortage)
        iv. Damage to urban biodiversity (birds, animals)
        v. Leads to rising desertification as vegetaion at surface has lack of underground water
        vi. Other implications: Pollution (Deepor Beel in Assam used to dump wastes); Coastal city of Mumbai (which was not always the case)

vii. Measures - Restoration of wetland and mainstream ecosystem services by wetlands; Mandatory EIA; Participation of local communities through feedback; Scientific maps; Well defined 'National Urban Water Policy' is needed
viii. Concl: rate of urbanisation threatens its own survival we need to abide by goals of SDG 11

b. 2020: The interlinking of rivers can provide viable solutions to the multi-dimensional inter-related problems of droughts, floods and interrupted navigation. Critically examine.
c. 2015- India well endowed with fresh water resouces. Critically examine why it still suffers from Water scarcity?
    i. Regional differences? Facts on various water levels (ground water, river water) in India
d. 2018- Ideal solution of depleting ground water resources in India is water harvesting system. How can it made effective in urban areas?
e. 2016- Present account of IWT and its Ecological, economic and political implications of IWT
f. 2013- No formation of deltas by rivers on the Western Ghats. Why? Repeat in 2006
g. Analysis of fresh water resources, status, steps required
h. Comparison of rivers of peninsular and and their characterstics(2003, 1995)
i. 1995- Irrigation: Drip Irrigation and why considered most efficient ?1998- What is Minor irrigation project? 1993- soundness of large valley projects with high dams vis-a-vis small river valley projects

5. Climatology - Atmosphere, Weather, Monsoon, Cyclones, Anti-Cyclones, Winds, Precipitation
    a. 2022 - 17. Troposphere is a very significant atmospheric layer that determines weather processes. How? (Answer in 250 words) 15
        i. Features: 85% of atmos weight is in it; Normal lapse rate (temp reduces); Composed of gases/vapour/dusts; Tropopause → Stratosphere (negative lapse rate thus warmer air that rises from ground surface won't rise above tropopause leading to tri-cellular model of circulation), Variable height at poles and equator, Hugs the ground surface
        ii. Diagram of atmosphere with temp curve, rough diagram of tri-cellular model
        iii. Explain: Convection (leads to turbulence), Advection, Cloud formation (leading to thunder), Other conditions such as cyclones, Rf, etc
        iv. Concl: Very vital continuation of life is today affected by GHGs which needs to be curtailed

b. 2022 - 5. Discuss the meaning of colour-coded weather warnings for cyclone prone areas given by India Meteorological department. (Answer in 150 words) 10
    i. Increase the level of awareness to save life/property; Gear up the admin to carry out rescue and rehab
    ii. 4 stages of warning: Pre-cylone watch, Cyclone alert (when system intensifies), Cyclone warning, Post landfall outlook (area to be affected)
    iii. **Map**: Cylone map just pencil line sketch of areas in GJ, Bharuch, Goa and whole Easter coastline (refer #IPAD)
    iv. Wind speed is crucial in cyclones: as it determines storm surge (which can lead to coastal flooding, floods in river channels) as well as overall intensity of cyclone
    v. Refer image: (G → Y → O → R)

1. 

c. Monsoon: Origin(1997), causes(2001), characteristics (2017), impact of agriculture/food security, 2015- how far due to agree that behaviour of monsoon changing due to humanizing landscape, efforts made in India by IMD for monsoon prediction(1991), ways the country can be prepared to fight the vagaries of the monsoon(1982)
d. 2020: Examine the status of forest resources of India and its resultant impact on climate change
e. 2013- Causes of formation of urban heat islands of the world
    i. (collect some world examples along with indian ones)
f. 2016- Concept of air mass and role in macroclimatic changes
g. 2014- Most of unusual climatic happenings due to EL Nino effect. Do you agree?(1998 too)
    i. Outcomes of ENSO/MJO/IOD/Modoki
h. 2014- Tropical cyclones confined to SCS,BOB and Gulf of Mexico. Why?
    i. Analyse on national and global level wrt location of cyclones, eq, volcanoes, tsunami along with reasons

i. 2013- Recent cyclone called -Phallin, Process of naming of cyclones across the world?
j. 2008- Relationship btw North india Winter rains and jet streams and western disturbances;
k. 2013- Phenomenon of temperature inversion and impact on weather/habitants
l. 2007- Significance of Himalayas and Tibetan highland on SW monsoon, 2001 if no himalya -effect of North India winter

6. Earthquakes, Volcanoes, Landslides, Floods, Droughts, Tsunamis (Questions from Disaster Management - GS III)
    a. **Floods:2017-** How to convert floods into sustainable source of irrigation and all-weather inland navigation (Hint for answers: canals, river interlinking); Causes (Why a recurrent feature?), mitigation, Urban Floods (also linked to Urbanisation in GS-1 Society Notes)
    b. Urban floods: Comparitive analysis of cities
        i. 2020: Account for the huge flooding of million cities in India including the smart oneslike Hyderabad and Pune. Suggest lasting remedial measures.
            1. 2016- Major cities of India vulnerable to flood conditions. Discuss
        ii. Jan-2020: Also cover role of IMD in monsoon prediction in these states
        iii. Understanding various mitigation measures in detail (along with diagrams) as questions have become specific; Also develop a general framework of advantages so that it helps in all measures
    c. **Landslides**:2017 Himalayas highly prone to landslides, Causes and measures of mitigation
        i. 2013- Causes of more landslides in Himalayas then W. Ghats; Hazard zonation mapping; NDMA Guidelines
    d. 2021 - Q4. Differentiate the causes of landslides in the Himalayan region and Western Ghats. (Answer in 150 words) 10
        i. Intro: must flow from the question - explain landslide (fast movt of rock/debris down the slope). India has varied topography making it prone to landslide, specially in these 2 areas (15% prone to landslides)
        ii. Draw the map: use small triangle to mark areas of landslide
        iii. Differences: HR is tectonically active, hogback topography (southern slope is very steep in nature), frequent occurence of EQs in the region, young age, many rivers can lead to flooding (Mandakni GLOFs), Unsustainable construction of himalayas (border roads), Glacial activity, Unsustainable tourism (as leads to flattening of the slopes)

1. WGs have eroded and stable but increased amount of Rf, construction somewhat in control, WGs has dense vegetation which binds the unconsolidated soil/surface, WGs has limtied and seasonal rivers

iv. 3 controlling factors: Gradient of slope, Volume of Water, Amont of material which can slide down

v. Conclusion: Measures to take care of landslides, respect local geological conditions, sustainable development

e. **Drought: 2016-** In what ways Micro-watershed Development projects help in water conservation in drought prone and semi arid regionbs of India? (Also 2019 question on National Watershed Project); 1989- Methods for controlling water evaporation from large surfaces (eg. Ponds and tanks) and improving the waterholding capacity of soil, norms for identification, Causes, Mitigation, NDMA 2010; Preparedness wrt El Nino and La Nina fallouts

i. *Refer Watershed Development - From Mains 365 2020 - Topic 6.6*

7. **Disaster Management - GS III**
   a. 2020: Discuss the recent measures initiated in disaster management by the Government of India departing from the earlier reactive approach
   b. 2019: How and in what ways can vulnerability to disasters be characterized? Discuss different types of vulnerability?
   c. 2013: Importance of vulnerability and risk assessment for pre-disaster management; Key areas to focus on in *Disaster Management System* as an administrator
   d. Challenges/Problems to DM; Along with solutions
   e. Sendai Framework vs Hyogo Framework; Measures taken in India before and after signing Sendai
   f. **Tsunami**: Factors responsible for occurrence, Effects, NDMA guidelines,
   g. **EQ**: Mitigation and gaps in our preparedness
      i. Cover gaps/lessons from other major disasters of the past eg: 2004 Tsunami, Bhuj floods

PYQS - Human & Economic Geography

1. 2022 - 15. Describing the distribution of **rubber** producing countries, indicate the major environmental issues faced by them. (Answer in 250 words) 15
   a. Rubber plantation crop, introduced during colonial period, tropical regions (#IPAD)
   b. Ideal conditions: Soil needs to drained, Warm humid climate above 20 degree, No stagnant water

   c. Env issues: Reduce biodiversity (reduced in Thailand) by clearing large tracts of forests thus boosting to climate change, excessive usage of water resources, contamination, Soil prone to sheet erosion, Monoculture affects natural vegetation eg: Kerala, etc
2. 2022 - 7. Examine the potential of wind energy in India and explain the reasons for their limited spatial spread. (Answer in 150 words) 10
   a. Intro: Using of turbine to generate electricity
   b. Potential:
      i. Draw a map
      ii. Estimated 302 GW and installed in 40 GW (thus scope is immense) - refer map in #IPAD
      iii. Offshore- 7000 km + water bodies coastline provides steady movt of winds
      iv. Onshore- Arid regions with no frictions on ground surface = GJ, RJ, MH (frictional resistance is less, wind speed is great → greater productivity)
      v. Even Island territories of A&N, Lakshadweep can be made; Use eastern ghats hilly tracks
   c. Limited spread:
      i. Huge economic expenditure to set up
      ii. Lacking enabling grid infrastructure
      iii. Intermittent supply due to not being continous
      iv. Maintenance, repair and overhaul is very costly (reduce viability)
      v. Large portions of land + issued of land acquisitions
      vi. Other forms of energy such as solar have picked up very significantly
   d. Concl: Can aid to achieve the lofty committments made in UNFCCC for which we need greater R&D in this field by National Institute of Wind Energy
3. 2021 - Q16. Discuss the multi-dimensional implications of uneven distribution of mineral oil in the world. (Answer in 250 words) 15
   a. More than half reserves in Middle East; Rest of world have less amounts which creates an imbalance
   b. Political (weak demo inst as oil takes care of economy, env hzards), Economic (cartel, high trade deficit), Social (wealth concentration in these areas become tax haven)
   c. WF to tackle implications: Indv (strategic reserves built by India, developing RE); Global (ISS, Paris deal)
4. 2021 - Q5. Despite India being one of the countries of the Gondwanaland, its mining industry contributes much less to its Gross Domestic Product (GDP) in percentage. Discuss.(Answer in 150 words) 10
   a. Gondwanaland - super continent from which India broke apart 140 mn years ago and driften north

   b. About mineral wealth of Gondwanaland - gold, copper, diamonds, iron, coal can be seen in Aus, Africa, SA, India
   c. Contribution about 2.6% to GDP FY16
   d. Mining as a whole is inefficient in the country and plagues with issues (Exploration needs to be accurate and pin-pointed, advance technique of extraction which are efficient, Taking care of environment, Older technology used leads to costlier process as compared to other)
   e. Historical - mining as a activity is less preferred; Less demand side potential due to low share of manufacturing (as its a major consumer of minerals); Governance issues (illegal activitiy, syndicates, rat hole markets), Untapped resources (inaccessible), Environmental litigations, Cheaper imports, Poor logisitc and obsolete techniques in mining; Also grade of coal is not very good
   f. Sustainable mining with R&D, encouragement to FDI and pvt investment
5. Regional-resource based manufacturing vis-a-vis employment
   a. Prepare map of india covering major resources vis-a-vis industries in each state/region of India
6. 2020: India has immense potential of solar energy though there are regional variations in its development. Elaborate.
7. 2018- Reasons for India's interest in the Arctic; 2015- Economic signif and env consequences of discovery of oil in Arctic Sea.
8. 2018- Consequences of spreading of Dead Zones on marine ecosystem
   a. Learn negatives wrt to Oceanography, Climatography so that -ve concept such as dead zone can be linked to other negative concepts affecting oceanography such as algal blooms
9. 2018- Industrial Corridors: Significance,give examples and their characterstics
   a. (status, gaps,(Read in News Today dated 03/12/2020)
10. 2017- Inspite of adverse env impact, coal mining is still inevitbale for development. Discuss
11. 2017- Petroleum refineries not neccesarily located nearer to crude oil producing areas particularly in many developing countries. Explain its implications
12. 2016- SCS assumed great geopolitical significance in present context. Comment
13. 2016- Effective mgmt of land and water resources will drastically reduce the human miseries. Explain
14. 2015- States of JK,HP,UK reaching limits of ecological carrying capacity due to tourism. Critically evaluate
15. 2014- Account for change in the spatial pattern of the Iron and Steel industry across the world (cover the world angle continent wise rather than country wise)
16. 2020: Account for the present location of iron and steel industries away from the source of raw material, by giving examples.

17. 2014- Critically evaluate various resources of the oceans which can be harnessed for meeting resource crisis faced by world
18. 2014- Economic space of rising natural resources rich Africa - How does India sees its place
19. 2013- Analyse the factors for the highly decentralised cotton textile industry in India
20. 2013- With growing scarcity of fossil fuels, the Atomic energy is gaining more and more significance in India. Discuss availabilty of raw material required for generation of AE in India and world
21. 2013- Said that India has substantial reserves of shale oil and gas which can feed the needs of country for quarter century. However tapping of resources does not appear to be high on agenda. Discuss critically the availability and issues involved ,2004- Examine distribution of oil refineries in India
    a. (Identifying and mapping land resources (study upar upar se))
22. 2019- Localization of agro-based food processing in western india (link it with food processing syllabus line in GS-3)
    a. Cover the location of FPI (which comes in GS 3 here itself)
23. 2018- Defining Blue revolution explain the problems and strategies of pisciculture developement in India
    a. Read Govt. schemes of the 2 agri, animal, fishery ministry
24. 2017- Mention advantages of the cultivation of pulses because of which 2016 is celebrated as Int year of Pulses
    a. Read about International Year of United Nations
25. 2016- Enumerate the problems and prospects of inland water transport in India
    a. Transport: current status
26. 2014- British planters had developed tea gardens all along Shivaliks and Lesser Himalayas from Assam to HP, but they did not succeed beyond the Darjeeling area. Explain
27. 2014- Why did Green Revolution by-passed eastern region despite fertile soil and good availability of water
28. 1996- Dry farming- relevance of augmenting food supply in India, dryland agriculture - Importance
29. 1989- Which part of India has develpod comparitively more marine-based industries and why?
30. 1985- Imp wheat growing region in India, are we growing enough to meet our needs?
31. 1996- Shifting cultivation:Characterstics with reference to India,1981- Consequences, steps taken
32. 1991-Factors affecting distribution of population in India, bringing out variation in density over space
33. Problems related to deforestation
34. Location of Gem, jewellery industry (indian jewellery accounts for 29% of global jewellery consumption)

35. Check what all types of industries are covered in NCERT of Human Geography (see back of ncert quesitons)

Solutions - Physical Geography

- Key to score marks (examples, cyclic diagrams, location map can be simple also eg: Corals in A&N, Gulf of Kutch)
- Practice drawing world and India map (twice each)
- Static question can be addressed by explaining concept in points
- To analyse Impact Physical Geography: Biospheres: Lithosphere, Hydrosphere, Cryosphere, Atmosphere
    - **L**ithosphere: Land degradation, Water scarcity, Soil (bio-chemical cycles in soil), GW recharge, STD (Salinity, temperature and density)
    - Hydrosphere: Coral reefs, Blue economy, Chemistry (HTPS-Humidity, Temp, Pressure, Salinity), Wetland, Mangroves, Sea Level Rise (20 cm since 1900), Eutrophication
    - Atmosphere: Climatology (ITCZ), El-Nino, Regional climates, Atmospheric/wind and oceanic circulation, Moisture, Clouds, Precipitation, Global Heat Budget, Jet Streams, Planetary winds
    - Cryosphere: Polar vortex, Arctic Ampli, Albedo reduces due to soots (+ve feedback loop), Methane sink, Role as carbon sink, New viruses released, AMOC, Antarctica Circumpolar Current (ocean current)
    - Fauna angle (sperm produc falls; migration exposes to new predators, loss of pollinator birds)
    - Misc: Economy, Food security, Human Geography, Tipping points
- Forces driving “changes”
    - Lithosphere (Land Deg - UNCCD 3 elements: Salinisation, Desertification, Soil erosion; Deforestation, Industrialization of Agriculture-S&B/overgrazing/water intensive crops, Urbanisation, Mining, IAS) - DUMAI (Deforestation, Urbanisation, Mining, Agriculture,Industrialisation)
        - Deforestation-Timber mafia in MH; Destruction of grasslands in GJ, Urbanisation-bangalore/Dal lake, Mining, Agriculture+slash & burn agri, Infra dev, Eutrophication, Land use changes
    - Hydrosphere (Eutrophication, Ocean acidification, Dam bldg, Waste dumping, IAS, etc)
        - Ocean Acidification (rise in Co2; As per IPCC AR6, more than 90% of heat generated by GHG is trapped in oceans as atmos capacity to aborb is ltd), Rise in BoD (Biological Oxygen demand)

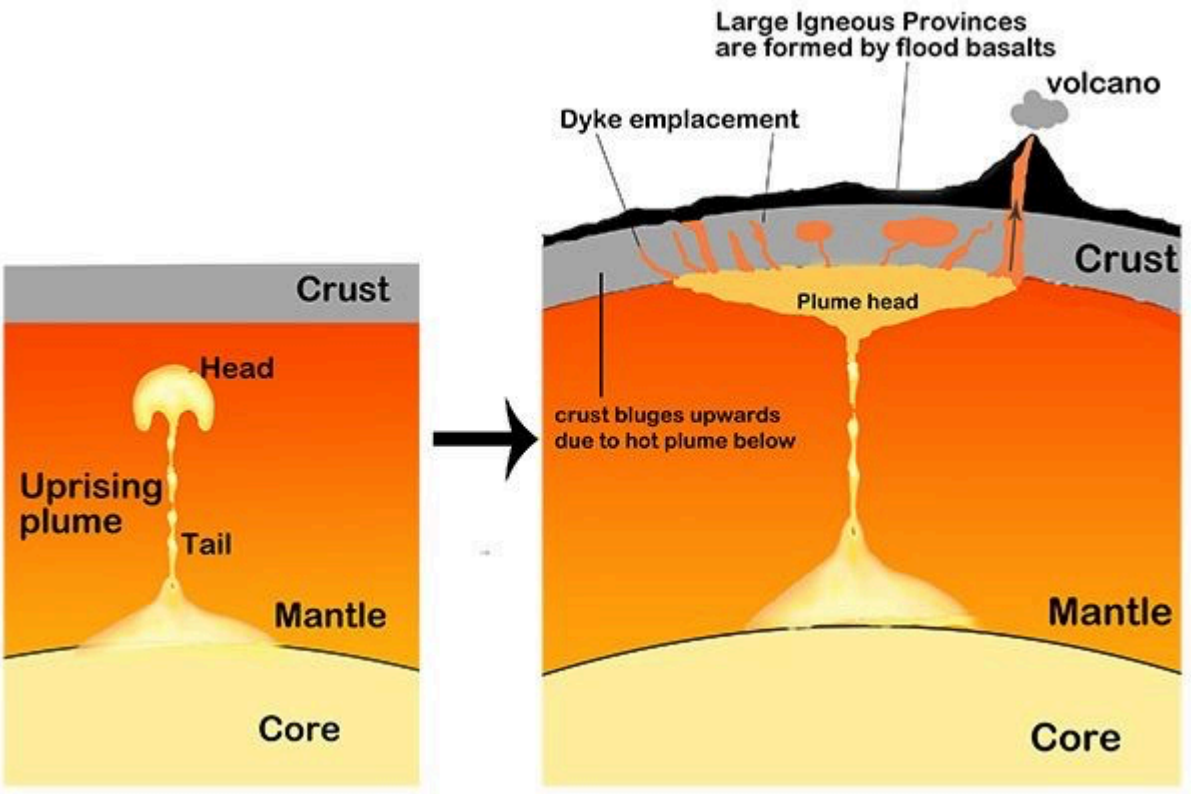
        - Normal notion-wind affect oceans and oceans affect wind
    - Climate Change/GW (Sea level rise, ⬆️ freq of disasters; Dead zones; Eutrophication; Ocean acidification; Ocean chemistry eg: Global W impact on corals then use these points, Unseasonal rains, IAS)
- **Miscellaneous pts: #readagain**
    - Corals generate $2.7 trillion pa in trade and tourism; Protection against disasters; Study of the provide record of climatic events
    - Western disturbances are temperate cyclonic waves originating in the Mediterranean Sea region due to formation of fronts. The clouds formed by theses front are carried to India by jet streams
    - **Distribution of earthquakes/volcanoes:** 68% Ring of Fire; 21% Mid-Continental belt and Balance in Mid-Atlantic Ridge
    - Coal - Gondwana Belt (98%): JH (Bokaro, Raniganj, Jharia), Son-Damodar Valley, Korba in CG, Neyveli in TN, Ranigarh, Makum (north east)
    - **Natural Gas**: **Siberian Basin** in Russia, **Persian Gulf**, **Turkmenistan** (TAPI), **Hugoton** in USA
    - **Critical Minerals - India:**
        - **V**anadium in Karnataka; **L**ithium traces (Mandya in Karnataka + Reasi J&K); **C**obalt in JH; India has Light **R**EEs; **M**onazite sand in Kerala; **N**ickel in Odisha (**VLC-RMN**)
        - **Critical includes lithium, REE as well (broadest category)**
        - **Global: C**obalt in D.R.**C**ongo; Lithium in Australia; **N**ickel in Indo**n**esia; Rare earth minerals by 60% res/production by China while Vitenam+Brazil in REE reserves and US/Aus (ie. Quad :p) in REE production; Platinum in South Africa
    - **India 2nd largest producer of Iron after China (also 2nd highest in cement); India has the largest iron ore reserves in Asia; 2 types found - Hematite, Magnetite**
    - **Water scarcity in megacities**: WF: Demand side (Greywater usage as done by California; Innovative solutions - desalinsation plants in Perth Aus; Supply: Revitalise lakes; Integrated water mgmt of Cavery river; **Concl**: In **Narmada Bachao Andolan v Union of India (2000)**, the Court concluded that water is part of the right to life enshrined in Article 21 of the Constitution
    - **Large Solar plants**: Examples (Rewa, Belgavi in KR, Bhadla solar plant in RJ); **WF to balance with env**: Site selection (barren lands used in Rewa); Promote Agrivoltaics; Advanced cleaning methods to save water
- **POINTS FROM TRYST WITH DESTINY #readagain**
    - **Data**: As per IPCC 6th ARC: Current ice cover of glaciers lowest since 1850, Arctic to be ice-free atleast once before 2050;
    - **Example/Case Study based introduction to an answers** → Case of rampant illegal sand mining at National Chambal Sanctuary

    - **Contexual intros:** Forest fires mentions karo, rise of temp mention karo; More no. of dimensions will get you more marks; **Classification of measures** (pvt, public, NGO, global, etc)
    - Volcanoes - apart from 3 zones → **MEDITERRANEAN REGION - *Stromboli, Vesuvius, Etna;* HIMALAYAN REGION - the Barren Island; HOTSPOTS - Hawaiian** Islands
    - GEOLOGICAL FEATURES - **Fault Lines, Soil types, Minerals, Tectonic Activity, Rivers, Temp, Rf;**
    - **Sedimentary Rocks** - *denudational agents, mechinical/chemical breakdown of rocks; Eg: Sandstone, shale, Limestone, Gypsum, Rock salt, Coal;* ***ECONOMIC SIGNIFICANCE -*** Construction (red standstone in bldgs), Petrol & NG (is trapped in sandstone and limestone), water resources, Geological studies, Industrial (limestone-cement, gypsum used for plaster), Mineral resources (iron ore, phosphate)
    - **Anticyclones** - HP, Outward flow, Clockwise direction in NH, Descending air (rather than rising), Clear skies fair weather; Impact on Indian subcontinent: heat waves and delayed monsoons, arid regions of thar when formed in arabian sea, Clear skies in winter promotes sunlight insulation, Temperature inversion
- Angles to be covered Human Geography:
    - Resources, Transportation, **Communication**, **Human resource development**, Climate, **International trade**, **Employment,** Navigation, **Tourism**, **Migration**, MR-TLC PW + Capital/Tech/Agglomeration Effect+Industrial Inertia
- Environment performs four function, namely, supplies resources, assimilates wastes, sustains life by providing genetic and bio-diversity and provides aesthetic services
- Divide Causes into:
    - Natural and Anthropogenic (in env and geog questions)
- Conclusion:
    - SDG 13 (Climate action), SDG 14 (Life below water), SDG 15 (Life above land-Land degradation)
    - Article 48A and Article 51A(g);
    - Industrial Location: India is going through a phase of resource optimisation. Thus, location of industry needs to be optimally aligned to Weber's idea of Least cost location to achieve the goal of 5 trillion economy.
    - Our efforts towards ____ will contribute Decade for Ecosystem restoration 2021-30;
    - Due to their profound impact on climate and agriculture of India, _____ need to be studied in much more detail;
    - Stregthen ocean-science policy framework (UNESCO suggested)
    - Recent 30x30 target set by Kunming-Montreal Protocol of CBD

- India committed to Ocean Clean Seas Campaign (reduce SUP plastic);
- Write sth obvious (then mention IPCC Assessment Report eg: Sea level is rising or Glaciers are melting)

- **2024**: Use → #readagain

Geomorphology - Earth (Origin, Theories, Shape, Movements, Interiors, Crust)

1. **2018- Define Mantle plume and explain role in plate tectonics**
   a. **MP** are narrow, almost a **vertical, column of super heated mantle rocks** which is rising up & finally reaching the core-mantle boundary. At the boundary it forms a mushroom-shaped cap/head. The **upsurgence is unrelated** to plate movements.
   b. **Origin of MP**: The plumes are thought to originate at the **outer core/lower mantle boundary**, rising upwards to the base of the lithosphere over many millions of years. (thus they come from 2900 km deep)
   c. 

   d. Role in plate tectonics:
      i. **Hotspots (intra plate - localised volcanism)** are the crustal expression of mantle plumes. They explain the **formation of EQs away from plate boundaries** eg: 2017 Botswana EQ, 2001 **Bhuj EQ (was 300 km away** from plate boundaries)

   ii. As the plume remains anchored at the core-mantle boundary and it does not shift position over time, a string of volcanoes is created when the lithospheric plate moves above it. (MP is stationary/anchored where as the plates above it keep moving. This thus creates series of structures over the earth surface) **Eg: Hawaiian Islands** (nearest plate margin being 3,200 km away), Iceland [*Note: Both of these sites are not on plate boundaries thus their formation cannot be explained by plate boundaries but rather by MP]*

2. **2017- How does Juno mission of NASA help to understand origin and evolution of earth**
   a. In the inner solar nebula, the terrestrial planets (Mercury, Venus, Earth, Mars) were too hot to hold the volatile gases. Hence their composition is (1) core: is metallic (2) mantle: is silicate (3) atmospheres: is thin. But, In the outer solar nebula, temperatures were cool enough for the abundant gases to accumulate. As a result, the Jovian planets (Jupiter, Saturn, Uranus, and Neptune) are gas giants- made up of hydrogen, helium, ammonia and methane. But, we don't know much about their core and mantle.
   b. Additional Knowledge: There are three stages in the evolution of the present atmosphere:
      i. 1st stage: Primordial (early) atmosphere made up of hydrogen and helium was stripped off due to solar winds
      ii. 2nd stage: Gases (N, CO2, Methane, ammonia, very less O2) and water vapour were released from the interior solid earth through process of degassing (volcanoes also helped); As earth cooled, water vapour condensed and led to formation of oceans
      iii. 3rd stage: atmosphere was modified by the living world - eg: through photosyntheis, Cyanobacteria producing the oxygen (event called Great Oxidation Event 2000 mn yrs ago)
   c. How Juno helps: (Think of diff spheres; Metals that may have existed (lithosphere), Understand atmosphere, Oceans/riverbeds/Hydrogen of Jupiter became its ocean, Gravitation of that planet, Planet-satellite r'ship, Study aurora of that and earth, Insights analysing quakes on Mars, Volcanic analysis, Sign of life, Remove debris, Landing base, Origin and evolution of earth, Write significance of planet - eg: Jupiter is largest planet, Mass of Jupiter (major part of the solar system), Mars closest in Jovian planet,
      i. Jupiter took most of the mass that blew away from nebula. It has large amount of combined material comapared to other bodies in the solar system- Key to unlocking the heavy elements which are no longer in Earth's system but were originally present.

ii. Unlike Earth, the solar winds couldn't blow away Jupiter's hydrogen and helium- because of the distance. So, Jupiter's atmosphere ought to have evolved from a mechanism other than 'degassing'. Studying this refines our own ideas of how Earth's atmosphere was born?
iii. Due to extreme atmospheric pressure, Jupiter's hydrogen turned liquid and formed large oceans. Studying them for our ocean knowledge
iv. Jupiter's gravitational influence is said to be so enormous that it affects orbits of all planets. JUNO Mission's gravitational readings will refine our understanding of Earth's annual journey around the Sun.
v. Jupiter has strongest aurora emissions in the entire solar system- study them to deepen our understanding of Earth's own northern and southern lights.
vi. Effect of Jupiter's gravity and magnetism on its moons and vice-versa- Studying these interrelations will enhance our understanding of Earth-Moon relationship.
vii. Common dimensions of any space mission
    1. Origins & evolution of earth - through sample analysis
    2. Impact of climate change, wind pressures, atmosphere
    3. Significance of the landing place/planet eg: After Sun, Jupiter has the largest mass in our solar system
    4. Disater predictions and mitigatin strategies- eg Insights analysing quakes on Mars, volcanic analysis
    5. Sign of life- Curiousity rover found methane of mars
    6. Interstellear studies
    7. Remove debris
    8. Exoplanets within goldilocks zone

3. **2013- Define Theory of continental drift, evidences in its support?**
    a. There was a super **continent Pangea** and a **mega ocean Panthalassa**. **Tethys sea divided** the Pangaea into two huge landmasses known as **Laurasia** to the north and **Gondwanaland** to the south of Tethys. **Drift started around 200 million years ago**, and continents began to break up and drift away from one another. **Alfred Wegener suggested Continental Drift Theory in the 1920's and marked tidal force as a reason**behind the drift theory.
    b. **Evidence:** Jigsaw fit model, Lemur fossils found in India+Madagascar+Africa; Gold in the Ghana coast and the absolute absence of source; Tilite which sedimentary rock formed out of glacial deposit in Africa
        i. Shorelines match (Jigsaw fit model): South America and Africa seem to fit in with each other, especially, the bulge of Brazil fits

into the Gulf of Guinea. North and South America on one side and Africa and Europe on the other fit along the mid-Atlantic ridge.

ii. Fossils: Lemurs occur in India, Madagascar and Africa led some to consider a contiguous landmass Lemuria linking these three landmasses. Similar botanical evidences are available for 'glossopteris' vegetation found in India, Australia, South Africa, Antarctica - thus linking all of them

iii. Placer deposits: The occurrence of rich deposits of gold in the Ghana coast and the absolute absence of source rock in the region. Source rock is present in Brazil

iv. Ancient rocks: Using radioactive dating technique it was found that ancient rocks of brazil coast match with those from western Africa in texture and composition.

v. Tilite: A sedimentary rock formed out of deposits of glaciers. These are found to exist in Africa, Madagascar, Antarctica, Falkland island and Australia besides India.

c. **Drawbacks of continental drift theory:** Buoyancy, tidal currents and gravity are too weak; failed to explain why the drift began only in Mesozoic era; doesn't take oceans into consideration (whereas plate tectonics clarify that oceans along with continents are part of lithospheric plates which move); Rock of same age can be found at unrelated places as well; No explanation for formation of Islands ahead of continent;

   i. Forces like buoyancy, tidal currents and gravity are too weak to be able to move continents.
   ii. Could not explain the formation of Islands ahead of the continent
   iii. Proofs heavily depend on assumptions and are very general in nature. (as similar vegetation, rock of same age can be found in unrelated areas as well; Several other combinations of fitting in of unrelated landforms could be attempted)
   iv. Wegener failed to explain why the drift began only in Mesozoic era and not before.
   v. The theory doesn't take oceans into consideration (whereas plate tectonics clarify that oceans along with continents are part of lithospheric plates which move)
   vi. Modern theories accept the existence of Pangaea and related landmasses but give a very different explanation to the causes of drift

d. Though scientifically unsound on various grounds, Wegener's theory is a significant milestone in the study of tectonics, and it laid a strong foundation for future the theories like seafloor spreading and plate tectonics.

4. **Paleomagnetism**

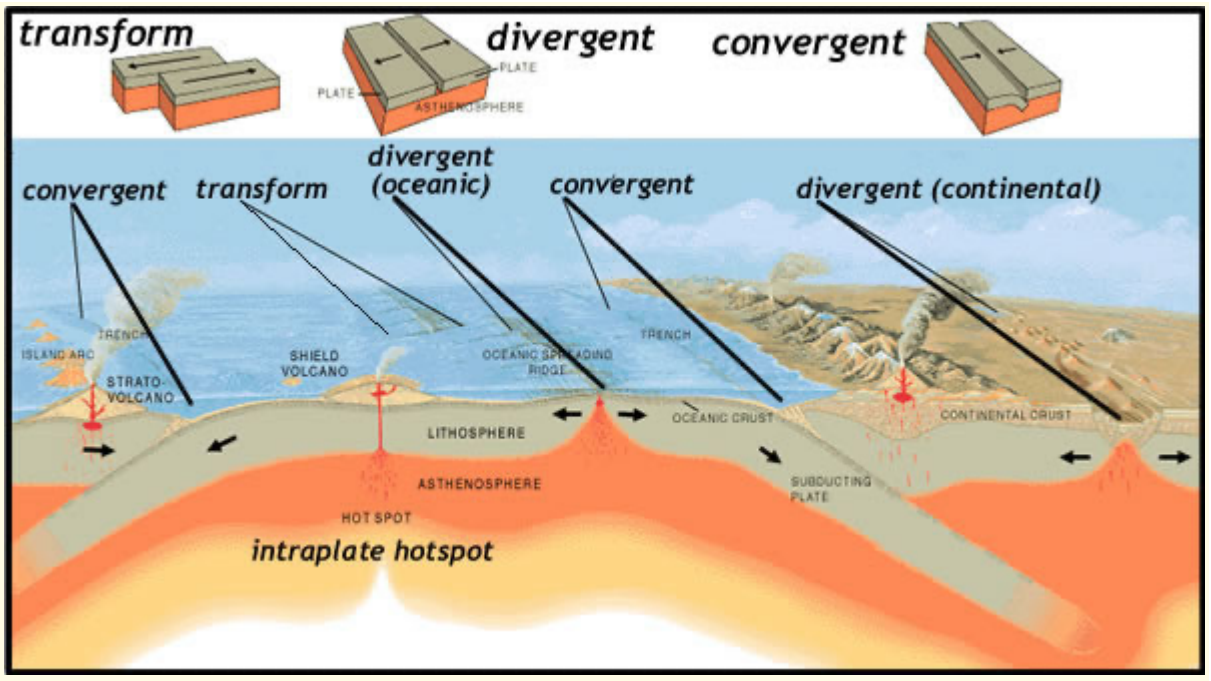
a. It studies the **magnetic properties of ancient rocks** to understand the **historical behaviour of Earth's magnetic field**. It provides key evidence for plate tectonics by revealing patterns of sea floor spreading, continental drift, drift, and plate movements.
b. Formation of Magnetic Records: Magnetic **minerals (ferrous)** in rocks, such as **magnetite, align with the Earth's magnetic field** when the rocks form. This alignment gets locked in as the **rocks cool and solidify, preserving the magnetic orientation**
c. Magnetic Polarity Reversals: The Earth's **magnetic field has periodically reversed**, switching the magnetic north and south poles. These **reversals are recorded in rocks** and provide a timeline of past magnetic field changes.
d. Magnetic Anomalies and Stripes: Mapping the ocean floor reveals **symmetrical magnetic stripes on either side of mid-ocean ridges**. These stripes **reflect alternating patterns** of normal and reversed **magnetic polarity**, indicating sea floor spreading
e. Applications in Plate Tectonics: Paleomagnetism helps track historical tectonic plate movements. By **examining magnetic signatures in rocks from different continents**, geologists can **reconstruct past positions of continents** and the configuration of tectonic plates

5. **2014: Explain the formation of thousands of islands in Indonesian and Philippines archipelagos**
   a. Explain in brief about **Plate tectonics** (generally accepted scientific theory that considers the Earth's lithosphere to comprise a number of large tectonic plates which have been slowly moving), types of plates, convergence and divergence (Refer Static Content Section at end of notes for more detail)
   b. The **concept of Ocean-Ocean Convergence helps us understand** the formation of **Japanese Island Arc,Indonesian Archipelago**, Philippine Island Arc and **Caribbean Islands**
   c. Dense plate subducts → rocks undergo **metamorphosis → magma → solidifies to form landform → process continues arc is formed;** Only the plates change then (Philippine and Sunda plate for Phillipines, Indo-Aus and Sunda for Indonesian - Note: Indo-Aus is diff and Eurasian is diff)
      i. In ocean-ocean convergence, two oceanic plates converge or collide. The denser plate subducts into the asthenosphere below the convergence zone and forms a trench at the surface. This region below the convergence zone is called the zone of subduction
      ii. In the zone of subduction, due to high temperature and pressure, the rocks undergo metamorphosis and the sediments in the

oceanic plate melt to form magma. The magma solidifies creating a volcanic layer

iii. Constant volcanism above the subduction zone creates layers of rocks. As this process continues for millions of years, a volcanic landform is created which in some cases rises above the ocean waters
iv. Such volcanic landforms all along the boundary form a chain of volcanic islands which are collectively called as Island Arcs
v. Additional concept for knowledge: Over time the mountains merge, and the oceanic crust gets transformed into continental crust
    1. For example, new islands are born around Japan in every few years. After some million years Japan will be a single landmass because continental crust formation is constantly replacing the oceanic crust (more and more volcanism creates much bigger landform)
vi. This is how Indonesian archipelago and Philippine archipelago were formed.
vii. This explanation is common for all the island arc formations (ocean-ocean convergence). We only need to know the plates involved with respect to each island formation
    1. Philippine Island Arc system is formed due to subduction of **Philippine Sea plate** under the **Sunda Plate** (part of Eurasian plate). The trench formed here is called Philippine Trench.
    2. In the case of Indonesian Archipelago, the **Indo-Australian plate** is subducting below **Sunda Plate** (part of Eurasian Plate). The trench formed here is called Sunda trench
    3. Japanese Islands are formed due to interaction of **3 combination of plate** forming arcs which **meet at a triple junction on the island of Honshu** (Pacific Plate under the Eurasian Plate, Pacific Plate under the Philippine Plate, Philippine Plate under the Eurasian Plate)
    4. Caribbean Islands are formed to simultaneous pushing by **Cocos and Nazca plate** from one side to the **Caribbean plate** on other side

The below image cover all types of plate movts (Details of these convergences is covered in answers as well as static content at the end of document) -**Use it to draw simple diagrams**



Landforms (Evolution, Running water, Glaciation, Desert and Arid, Limestone and Chalk, Coastal

1. **2014- Why Location of world fold mountains on margin of continents? Give association b/w the global distribution of fold mountains and the EQ and volcanoes**
    a. Fold Mountains are the mountains formed from the folding of the earth's crust. Fold mountains are formed due to **convergence between two continental plates (Himalayas, Alps) or between an oceanic and a continental plate (the Rockies, Andes).** Reasons for plate movts is the stress which may be caused due to increased load of overlying rocks, flow movements in the mantle, magmatic intrusions, etc
    b. Folding creates a series of **upfolded & downfolded waves called anticlines and synclines** respectively (draw diagram of anticlines and synclines)
    c. In Continent-Continent (C-C) convergence, oceanic sediments are squeezed and up thrust between the plates and these squeezed sediments appear as fold mountains along the plate margins after a lot of erosional activity
        i. The Himalayas are formed at the convergent boundary of the Indian plate (part of Indo-Aus plate) and Eurasian continental plate. **Both plates are continental ones, and so can neither sink nor be destroyed**. The material between them is therefore forced upwards to form the mountains.
    d. In Continent-Ocean (C-O) convergence, the continental volcanic arc formed along the continental plate margin is compressed and is uplifted

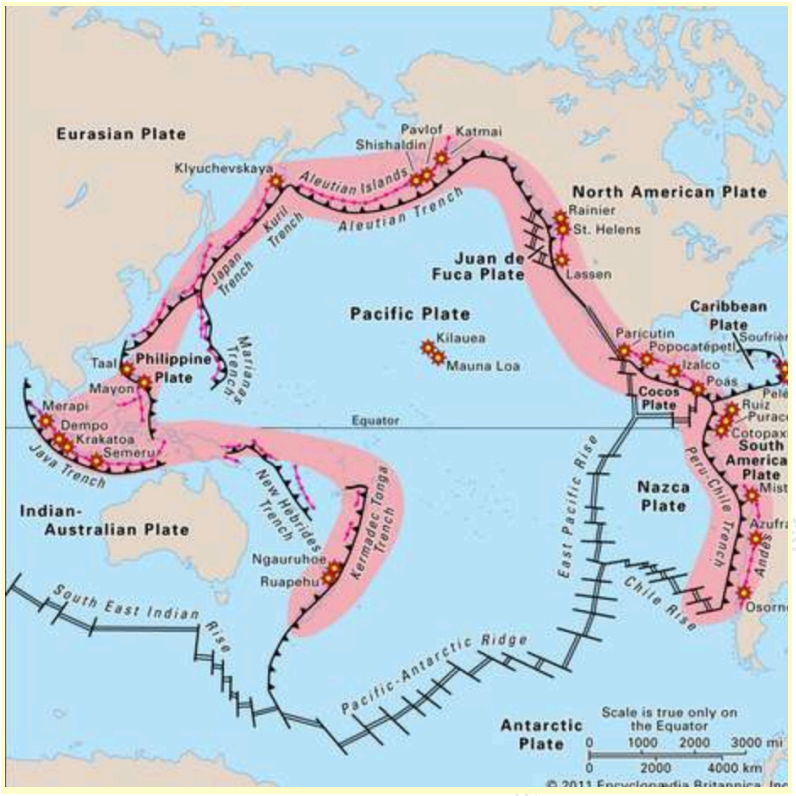
by the colliding oceanic plate giving rise to fold mountains along the continental plate margin.

i. **For Rockies: NA plate and Pacific plate**
ii. **For Andes - Oceanic Nazca plate and Continental South American plate**

e. **Relation with Earthquakes**
   i. In both C-C convergence and C-O convergence, there is the formation of fold mountains and frequent occurrence of earthquakes. This is **because of the sudden release of friction between the subducting plate** and up thrust plate
      1. In **C-C convergence**, the denser plate pushes into the less dense plate **creating a fault zone**along the margin. Further collision leads to the sudden release of energy along this fault zone generating disastrous earthquakes (**shallow-focus** earthquakes)
      2. In **C-O regions** the subducting oceanic plate grinds against the surrounding denser medium producing mostly **shallow-focus earthquakes**, and deep in the subduction zone **deep-focus**earthquakes occur

f. **Relation with Volcanism**
   i. Volcanism is observed **only in C-O convergence** and is **almost absent in C-C convergence (due to thick crust and insignif trenching)**
      1. This is because of the thick continental crust in C-C convergence which prevents the outflow of magma. Magma here lies stocked within the crust
   ii. In **C-O convergence,** metamorphosed sediments and melting of the subducting plate form magma which escapes to the surface through the less thick continental crust. **eg: Mt Cotopaxi, Ojos del Salado**

2. **2020: Discuss the geophysical characteristics of Circum-Pacific Zone**
   a. The Circum-Pacific Belt, also referred to as **The Ring of Fire**, is a **path along the Pacific Ocean**characterized by active volcanoes and frequent earthquakes.
   b. **Pacific plate circular part around it undergoes convergences either with ocean or with continent leading to formation of new structures + make diagrams for both + mention volcanic hotspots/trenching/EQ/Subduction zone as heavier plate goes down**

i. 

c. **Geo-physical characteristics:**
d. Location: A nearly continuous chain of volcanoes surrounds the Pacific Ocean. The chain passes along the west coast of NA/SA, from the Aleutian Islands to the south of Japan, from Indonesia to the Tonga Islands, and New Zealand (*Horse-shoe shaped; describe verbally or make a map)*
e. <u>Formation due to plate tectonics</u>: This Circum-Pacific chain of volcanoes and the mountain ranges associated with it owe their formation to the repeated subduction of the oceanic lithosphere beneath the continents and the islands that surround the Pacific Ocean
    i. **Make diagram for** Ocean-Continent plate boundaries, thus **forming fold mts** of North America, South America
    ii. **Convergence of O-O plates** forming the island of phillipines and indonesia
    iii. Volcanism linked with plate tectonics. **List of some volcanoes Mount Fuji of Japan, The Aleutian Islands of US, Krakatoa Island** Volcano in Indonesia
    iv. **Various trenches** are formed eg: **Mariana Trench** (mariana plate and pacific plate), **Japan** Trench, **Phillipine** Trench, etc.
f. Harbors majority of volcano & earthquakes: 75% of Earth's volcanoes—more than 450 volcanoes—are located along the Ring of Fire. 90% of earth's earthquakes (**EQ%>Volcanoes in % E comes before V**) occur along its path, including the planet's most violent and dramatic seismic events

g. Formation of Hot Spots: The Ring of Fire is also home to hot spots, areas deep within the Earth's mantle from which heat rises. **Hot spots are an area on Earth over a mantle plumes**. They **explain volcanoes away from plate boundaries eg: Mount Erebus in Antartica**. Mantle Plume also explains the concept of formation of Hawaiin Islands
h. As the Circum-Pacific Belt harbors the majority of global Volcanic eruptions & Earthquakes, it holds immense **significance regarding the study of the earth's interior.** (*how it helps as understand about surface as well as interior of earth*)

3. **2015- States of JK, HP, UK reaching limits of ecological carrying capacity due to tourism. Critically evaluate**
   a. Natural beauty states- huge interest for tourism- but inc in tourism reaching **eco carrying capacity (implies the maximum population size that the ecosystem could sustain indefinitely**). The mountains are the **most resilient**; **yet, ironically**, their inhabitants are **vulnerable**
   b. **Reasons**: Bldg activities led to EQ risk; Traffic-Yellowing of snow; Dal lake encroached due to haphazard urbanisation, drastic loss of pollinator birds, Glacial melt reduced albedo; DUMA
      i. (Infra dev) Imbalance btw tourist demand and physical capacity led to rush of building activity for hotels etc-earthquake risks when construction on steep slopes
         1. For instance, to handle the growing tourist industry, the Dal Lake in Srinagar has been encroached, through haphazard urbanisation
      ii. (Air Pollution) Increased vehicular traffic- yellowing of snow, air pollution issues (affects glaciers,natural springs etc) ,congestion, accidents (thats why Bhutan oppose BBIN agreement)
         1. Eg- Case of Uttarakhand, which has places of religious significance and attracts lots of followers annually led to development of roads and bridges
      iii. (Land Pollution) Deforestation + land use change/degradation- landslides, flooding risks, Issues of irresponsible tourists- waste littering without regard to enviroment- inc plastics, use of firewood for cooking for inc demand of tourists
      iv. Degraded forests as well as urbanised sites have led to drastic loss of pollinator birds; Also there is rapid invasion of non-native species in western himalayas such as black kites, pigeons (which are not seen at such heights)
      v. Faster glacial melting due to decreased albedo affect as well as increase in air temperature (black carbon from burning fuels is a major contributor)
      vi. (Water Pollution) Damming of rivers, rivers being polluted

vii. However- not full states reaching CC limits, for eg In HP areas of less commercial hill stations still pristine(less then 5%tourists in areas other than Kullu,Shimla,Dharamshala), Jammu and Kashmir, it is confined to Ladakh, Srinagar and Jammu district. In Uttarakhand, it is mostly confined to the Western part which is full of religious places like Badrinath, Kedarnath, Haridwar, Rishikesh, etc.

viii. Way forward

1. Regulating no. of tourists visiting according to carrying capacity, designated camp sites to be decided for mass tourists, involvement of locals as guides for caring for env, destination specific policies acc to tourism data, promoting eco-tourism(advertisement etc), vehicle limits
2. There is a need to confine hydro power projects to areas with least impact or use run-of-the river projects instead; (Mountain ecosystem is suffering with landslides, seismicity, dam induced microseismicity, landslides and floods)
3. Payment for Ecosystem Services: Palampur in Himachal has a model in place
4. World Bank Report suggests regional integration & collaboration as a way to address the glacial melting
5. Solutions: Organic farming methods, Local food systems need to be revived, Region-specific water security and cleaner energy solutions, People's role-especially that of the women should not be ignored (as they're left behind post migration by youth)

4. **2017- How does cryosphere affect the global climate?**
   a. The frozen water present in different forms (snow, sea ice, lake and river ice, glaciers, ice sheets, icebergs and frozen ground) altogether within the climate system is called as the 'Cryosphere'
   b. It is an integral part of the global climate system with important linkages generated through its influence on surface energy and moisture, clouds, precipitation, hydrology, atmospheric and oceanic circulation.
   c. A recent report published in journal Nature has predicted that Antarctica is headed for a climate tipping point by 2060 if emissions aren't curbed. (Tipping points are thresholds where a tiny change could push a earth's system into a completely irreversible change/ new state; Other eg of TP are Amazon rainforest; Arctic sea ice, Atlantic circulation; Boreal forests; Coral reefs, etc)
   d. Albedo is the measurement of reflectivity of an object. In case of crysophere refectibity of solar radiation.
   e. Impacts of Cryosphere on global climate: (Albedo of Snow, Global Ocean Conveyor belt due to STD changes in artic ocean due to melting-affects

regional climates, **Polar votex** & Ozone**,** Wind circulation due to changed pressure differences in Arctic area, Glaciers act as carbon sink which after melting can reduce methane gases (**blue carbon**); Artic Amplification)

i. The Albedo of snow/ice sheet is high and plays important role in solar radiation because it reflects much of the insolation, which helps in cooling of the earth. (90% gets reflected back) But due to global warming ice sheets melting and affecting the heat budget of earth
ii. Changes in Arctic sea ice and snow cover may affect the mid-latitude atmospheric wind circulation due to pressure differences
iii. Artic Amplification: global warming and climate change are impacting the Arctic more than the rest of the world
    1. National Centre for Polar & Ocean Reasearch found that extreme rain events are increasing in India due to melting artic ice
iv. The polar region acts as carbon sink. If glaciers, ice sheets, icebergs and frozen ground melts then it will release in form of methane- a powerful greenhouse gas- which will induce global warming
v. When seawater is condense into sea ice at Polar region then the surrounding water gets saltier. Saltier water has higher density; it sinks and initiates thermohaline circulation patterns across the oceans of the world. These Ocean currents act like a Global Ocean conveyer belt, transporting warm water from the equator toward the poles and cold water from the poles back to the tropics. Thus, currents regulate global climate. Some of these currents affect rain and drought situation via El-Nino La-Nina effect.
vi. If the frozen form of water melts, then the volume of water in the oceans will be affected. So any changes in the water cycle, affects global energy/ heat budget, and thereby global climate.
vii. Polar Vortex distubed leading to changes in ozone Hole in Arctic while traditional Ozone hole of Antartica is healing; Destruction of food chain;
viii. IPCC-5th Assessment Report states that there has been a continued net loss of ice from the cryosphere
ix. Write relations btw Himalayan glaciers and CC too covered below
x. Hence, we can say that Cryosphere has direct and indirect bearing on the global climate. Therefore, if we want to protect the biosphere then we must protect the Cryosphere.

5. **2014- Relationship btw shrinking Himalayan glaciers and the symptoms of climate change in Indian subcontinent**

a. **Glacier is a dense body of ice** that has been formed where the accumulation of snow exceeds its ablation over many years. Glaciers aren't formed instantly. **They need centuries for their formation. Hence their melting must raise a concern.**
b. (As per a report by **ICIMOD a 1.5 degree rise globally means 2.1 degree** rise for Hindu Kush (third pole due to **elevation dependent warming** and reduced albedo)
    i. According to Hindu Kush Himalayan assesment report, even the most ambitious goal set by the Paris Agreement to limit global warming would lead to melting of 1/3rd of the region's glaciers by 2100 (in future even 2/3rd), potentially destabilizing Asia's rivers. HKH region called "Third Pole" due to largest amount of ice after both poles
    ii. It is home to 4 global biodiversity hotspots, several important bird areas, and hundreds of mountain peaks. It provides ecosystem services (water, food, energy, etc) to nearly 2 billion people through its river basins.
c. **Major consequences (**GLOFs/flash floods, Biodiversity loss-Snow leopards, Ladakh's agri depends on glacial melts, **International-conflict with border nations, Top Soil removal as witnessed in Scandinavian, Low lying islands, cities and infra down below impacted)**
    i. Faster snow and glacier melting due to warming is already manifesting in formation of glacial lakes. Glacial lake outburst floods (GLOF) are becoming frequent and causing huge casualties and loss to local infrastructures (recently in Uttarakhand) - Glaciers causing greater water flows in rivers - Normal flood disasters
        1. Climate change is bringing rising incidents of disasters like avalanches, flash floods, droughts(when river water reduces in long term), floods, etc.
        2. Deluge in the rivers during the monsoon season while the flows are likely to plummet during the dry seasons
    ii. Biodiversity is in steep decline driven by human development, pollution, over-exploitation of resources and climate change. Along with species loss (eg impacts on Snow Leapord) this will mean the loss of the key environmental services the region provides
    iii. Glacier induced rapid rise in sea level in recent years has threatened low-lying islands and coastal cities.- salt water intrusion into GW and coastal areas- affecting agri etc
    iv. Agri- detrimental to cultivating rice and jute in eastern areas in long term; Irrigation in Ladakh is dependent on glacial melts → thus it can impact the region's food security
    v. Constantly flowing water from glaciers that are melting in producing electricity- affects energy security

vi. Global example- In hilly regions such as the mountain slopes of Scandinavia, ice sheets and Glaciers removal- removed most of the top soil, leaving them quite bear of vegetation.

d. **Govt measures-** Namami Gange, Paris Climate commitments, **ISA**; **NAPCC- National mission for sustaining the Himalayan Ecosystem**

e. **Way Forward**: Modern centre for Glaciology, Platform for Himalayan states to interact; PES (Palampur, HP can be a model)

i. **World Bank** Report suggests **regional integration & collaboration** as a way to address the **glacial melting**

6. **2020: How will the melting of Himalayan glaciers have a far-reaching impact on the water resources of India?**

a. Himalayas: **lifeline to 2 bn** people of world (whether for drinking, agriculture, energy, or other purposes)Melting glaciers shown by IPCC report/ICIMOD Report

b. Water Dimensions: **GW/Aquifers recharging affected** as more people now extract GW as rivers reduce + may expose to arsenic contaminated water; Hydrological deserts (first rise in water level then desert); **Energy Security (hydel power)**, Fauna (Susu), Coastal salt water intrusion due to sea level rise, Major activities like drinking water/irrigation/animal husbandry depend on rivers (from Himalayas); Albedo would decrease as ice melts; Stressed on farm income/yield per acre

i. Drinking Water- reducing water for indus and agri uses
ii. Ground water-Himalayan glaciers not only contribute towards rivers but also helps in recharging groundwater aquifers in the region (Affects that)
iii. River - Inc floods in short run and drought and desertification later (hydrological deserts)
iv. Coastal areas- sea level rise- salt water intrusion
v. Energy security - affect hydel power due to insufficient flow
vi. The Gangotri Glacier, one of the largest glaciers in the Himalayan Mountains, is the source of the Ganga River- apart from water benfits will affect religious aspects of people if gets drier in long run
vii. International- Issues with neighboring countries like China on river water mgmt, with nepal,bhutan on hydro issues will increase
viii. Impact on inland fishery- National Fish 'Susu'
ix. International co-op- Success in meeting the Paris Climate Pact's target might not be enough - more realistic targets specific to the region are needed, with the consensus of all the nations surrounding this part of the Himalayan region

c. Govt measures- Namami Gange, Paris Climate commitments, ISA; NAPCC- National mission for sustaining the Himalayan Ecosystem

d. Way Forward: Modern centre for Glaciology, Platform for Himalayan states to interact
    i. World Bank Report suggests regional integration & collaboration as a way to address the glacial melting
    ii. Human and knowledge capacities- appointing trained personnel who can capture, store and apply knowledge relating to vulnerability and changes in the region.
    iii. Institutional capacities- creating capability to conduct long term observations, studies to understand and warn of changes in the Himalayan ecosystem
    iv. Evidence based policy building and governance- creating a platform for Himalayan states and the Centre to interact with various bodies.
    v. Establishing of a modern centre of Glaciology, standardisation of data collection to ensure interoperability and mapping of natural resources in the area

7. **2020: The process of desertification does not have climatic boundaries. Justify with examples.**
    a. Acc to UNCCD, desertification refers to land degradation in the drylands (arid,semi arid,dry sub humid areas) and not connote expansion of deserts. Soil erosion, desertification and salinisation are various components of land degradation
    b. **Process:**
    c. **Factors**: Over-irrigation + excessive fertilizers in HY/UP/PJ; **Overgrazing** exposes top soil → erosion → desertification; **Excessive rains (Cherrapunji, Mawsynram leading to sheet erosion)**, Deforestation (timber mafia of MH)
        i. Drop a point highlighting the location of cold and hot deserts. Then say however, the land degradation today is not confined to climatic boundaries and has become a global phenomenon due to:
        ii. Deforestation induces increase in GHGs which then impacts rainfall patterns. The errratic Rf leads to de-vegetation and thus desertification eg: as done by timber mafia in MH
        iii. Over exploitation of resources and urbanisation (demand for resources increases, drawing more resources and leaving lands that easily succumb to desertification)
        iv. Agriculture & allied: Overgrazing has led to Destruction of grasslands in GJ, salinization by over irrigation in PJ/HY, Slash and burn agriculture (eg: eg: NE region and Central india)
        v. Water intensive cropping patterns: Marathwada growing water intensive crops (such as sugarcane rather than oilseed) depsite not being supported by ecology

vi. The effect of Climate change is also a significant factor in increasing desertification (eg: worsening extreme weather events, . e.g. Water table in Barkitand village of Giridih district (JH) has fallen from 8 metre below the ground level in 2013 to about 10 m in 2017

vii. Rampant mining and expanding urbanisation eg: impact on the state of Goa, Mining threat looms over Aravalis in Haryana. The dust from the mining areas settles and retards water infiltration. Jharkhand, Chhattisgarh and Orissa

d. **Above are manmade causes to desertification**, whereas we also have various natural causes leading to desertification such as erosion by water (leading to badland topography in Chambal); as well as landslides, forest fires, flash floods (all these drain away the top soil leading to desertification) and wind erosion leading to removal of top soil which takes years to get restore; Glacial retreat causing top soil to become bare

e. Measures to tackle: Prevention of soil erosion; improved **early warning system** and water resource management; **Sustainable pasture,** forest and livestock management; **Aero-seeding** over shifting sand dunes; narrow strip planting, **windbreaks and shelter-belts** of live plants; **Agroforestry** ecosystems (increases farmer incomes - **ISHA Agro Movement**); **Afforestation and Reforestation (as desertification mainly caused by vegetation loss)**; introduction of new species and varieties with a capacity to tolerate salinity and/or aridity; and environmentally sound human settlements #readagain

f. India has adopted the goal of achieving **Land Degradation Neutrality (LDN) by 2030** as adopted under SDG 15 (or Bonn Challenge)

8. **2013- Major hot deserts in northern hemisphere are located between 20-30 N latitudes and on the western sides of the continents. Why?**

a. Air rises from the equator and starts to descend near the 30 degree latitudes (called as horse latitudes or subtropical high pressure belt) to complete the hadley cell. This decendance of winds, unlike rising wind, is not ideal for precipitation. This descending winds gets warmer due to compresional heating. Warmer air further encourages evaporation and dryness.

b. Other reasons: Presence of **cold current → Low Rf or Desiccating effect** (**Atacama** Desert is not more than 1.3 cm); **Rain shadow regions** due to high mountains (**Mojave Desert**, California's Death Valley, Atacama);**Parallel to rain clouds (Thar Desert**); **Rain-bearing Trade Winds blow off-shore**; Other deserts - W.Aus desert, Namibian, Kalahari Deserts (refer map below)

i. The rain-bearing Trade Winds blow off-shore (from east to west) and the Westerlies that are on-shore (west to east) blow after 35 degree latitude (thus outside desert regions)

ii. The **relative humidity is extremely low**, decreasing from 60 per cent in coastal districts to less than 30 per cent in the desert interiors. Under such conditions, **every bit of moisture is evaporated** and the deserts are thus regions of permanent drought. Precipitation is both scarce and most unreliable

iii. On the western coasts, the **presence of cold currents** gives rise to mists and fogs by chilling the on-coming air. This air is later warmed by contact with the hot land, and little rain falls. The desiccating effect (extreme drying) of the cold Peruvian Current along the Chilean coast is so pronounced that the mean annual rainfall for the **Atacama Desert** is not more than **1.3 cm;** Similar other cold currents - California C, W. Australian C, Canaries C, Benguela C

iv. Western coasts have have **high mountains** which often block the moisture carrying winds and thus the **leeward side** is thus a desert eg: Atacama Desert facing rain shadow effect of Andes as winds are Easterlies, The **Mojave Desert, California's Death Valley**

v. Eg: of Hot deserts which are explained by above phenonmenon are - Sahara Desert, **Great Australian Desert, Arabian Desert**, Iranian Desert, **Thar Desert**, **Kalahari and Namib Deserts**, Mojave Desert

c.

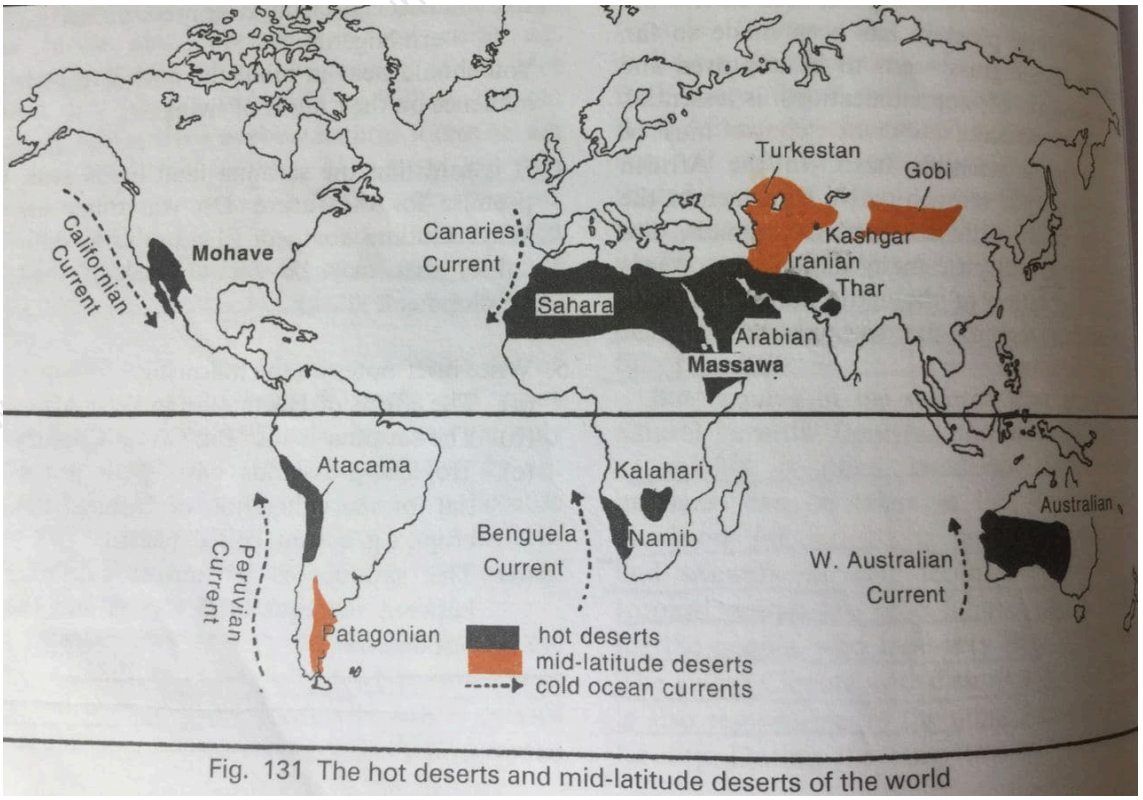


Fig. 131 The hot deserts and mid-latitude deserts of the world

d. Other type of desert is **mid-latitude desert or Cold Deserts**: The temperate deserts are **rainless because of 3 things:**

i. Examples of continentiality: **Ladakh**, Turkestan, **Taklamakan and Gobi deserts** of Central Asia
ii. Examples of rain-shadow effect: **Patagonian Desert is more due to its rain-shadow** position on the leeward side of the lofty Andes than to continentiality (winds here are westerlies)
iii. Location near poles (Polar deserts) in Northern **Greenland, Arctic and Antartica**

1. 

e. Read all landforms within the framework of Causes for formation, reasons for specific location across the world and in India as well; Also study outcomes of global planetary wind movements

9. **2005, 1990, 1984: Soil Erosion: Causes, Types in India and distribution, Govt. steps, Way fwd; Soil distibution map of India**

- **Soils -** okay
  - Soil is the top layer of earth surface made up of organic and inorganic materials. Soil erosion is movement of soil from one place to another due to wind, water or some other erosion agents. According to a 2015 report of Indian institute of remote sensing, 147 million hectares of land is eroded in India. Every year India loses 6800 crore rupees due to soil erosion according to the National Remote Sensing Agency (NRSA)
  - Factors controlling formation of soils
    - Parent material, Topography: decides amount of exposure of a surface to sunlight and drainage. Soils will be thin on steep slopes and thick over flat upland areas,
    - Precipitation: Precipitation gives soil moisture content,
    - Temperature: Chemical activity is increased in higher temperatures. Eg tropical soils show deeper profiles and in the frozen tundra regions soils contain broken materials

        - Biological activity: Humus accumulates in cold climates as bacterial growth is slow. In humid tropical, leaching is intense leaving very low humus content in the soil. Further, bacteria (Rhizobium) fix gaseous nitrogen.
        - Time: Determines maturation of soils and profile development, younger soil- poorly developed horizons.
    - Soil profile
        - Horizon A: It is the topmost zone, where organic materials have got incorporated with the mineral matter, nutrients and water which are necessary for the growth of plants.
        - Horizon B: It is a transition zone between the horizon A and horizon C, and contains matter derived from below as well as from above.
        - Horizon C: It is composed of the loose parent material. This layer is the first stage which forms the above two layers.
    - Different types of soils
        - Alluvial soil- 40% of total area, depositional soil in river valleys
        - Black soil -Deccan trap soil, cotton soil(Maha,MP,Guj,AP)
        - Peaty soil- Heavy rain, high humidity, rich humus,alkaline- in Bihar
        - Arid soil -- In areas of high temperature and accelerated evaporation.
        - Red soils - on Igneous rock of low rainfall, in rain shadow areas of WG, yellow when hydrated form
        - Laterite soil -- Areas of high temperature and high rainfall- require high manure,fertilizer for cultivation ,suitable for crops like cashew nut, Tapica(Sabudana), Bricks use
        - Saline soils -- Occur in arid and semi-arid regions(like Gujarat), and in water- logged and swampy areas.(Sundarbans), Intensive irrigation in Punjab,Haryana making soils saline due to capillary action(farmers advised to add Gypsum)
    - Types and causes of soil erosion: Due to water run off, Saltation, Landslides, Deforestation, Anthro-mining, indus activities
        - Water Erosion: It is caused by the action of water, which removes the soil by falling on as rain drops as well as by its surface flow action.
            - Types- Sheet erosion: The removed soil is like a thin covering from large area, Rill erosion: well defined finger-shaped structures when higher force ,Gully erosion: due to convergence of several rills
        - Wind erosion: It is common in dry (arid) region where soil is chiefly sandy and the vegetation is very poor- soil blown off in the form of dust storm and sand storm.

        - Types- Saltation: In the arid regions of low rainfall- Water evaporates quickly leaving behind the salts. Suspension: The wind throws away smallest soil particles into air, which moves with the wind to long distances.
    - Landslides or slip erosion: The hydraulic pressure caused by heavy rains increases the weight of rocks at cliffs which come under the gravitational force and finally slip or fall off.
    - Deforestation and over-grazing: Deforestation makes soil cover vulnerable for wind and water erosion. Over grazing is a major hazard affecting pastures, forests, and mountains- destroys the little cover and enhances wind and water erosion.
    - Faulty methods of agriculture, over–irrigation, shifting agriculture etc; Other anthropogenic factors viz. mining, industrial **activities** etc.
  - Effects of soil erosion
    - Agriculture production is reduced. It will increase hunger and poverty, so one of the SDG to be achieved by 2030 will be missed. It will lead to hike in food prices, Decrease in farmer's income.
    - Large scale soil erosion may lead to ravine topography like Chambal river and land becomes waste land.
    - Due to soil erosion top layer organic matter is lost so water holding capacity of soil is reduced. It may lead to reduced underground water table and decreasing soil moisture.
    - Loss of fertile top soil,Drying of vegetation and extension of arid lands, Increase in the frequency of droughts and floods(due to river bank erosion), Recurrence of landslides
    - Other issues of desertification
- Ways to address soil erosion: Mulching, Zero Tilling, Terrace Farming, Strip Farming (strip of grass between to stop wind flow), afforestation, Micro-irigation; Steps such Soil Health card are in right direction; SAVE THE SOIL - SADHGURU
  - **Mulching:** The bare ground between plants is covered with a layer of organic matter like straw. It helps to retain soil moisture.
  - Careful tilling or **Zero Tilling**: Since tilling destroys the top soil.
  - Contourbarriers,**Contourploughing**,Rockdams and **Terrace farming**: They can reduce surface run-off and soil erosion.
  - Inter-cropping: Different crops are grown in alternate rows and are sown at different times to protect the soil from rain wash.
  - **Shelter belts**: In the coastal and dry regions, rows of trees are planted to check the wind movement to protect soil cover. These shelter belts have contributed significantly to the stabilisation of sand dunes and in **stabilising the desert in western India**, Mangrove cover at Coastal regions.

- **Strip farming**: Large fields can be divided into strips. **Strips of grass are left to grow** between the crops. This **breaks up the force of the wind**. This method is known as strip cropping.
- **Afforestation: Tree roots bind with the soil** which in turn reduces soil erosion. Check over-grazing: Over-grazing normally leads to loss of top soil. This will help in preventing soil erosion.
- **Irrigation technique: Micro-irrigation methods** like sprinkling can reduce soil erosion.**Various government initiative like Vanotsva, soil health card are steps in right direction to save the gift of nature**

Oceanography - Oceans, Islands, Coral Reefs

Terms: Ocean Acidification (rise in Co2; As per IPCC AR6, more than 90% of heat generated by GHG is trapped in oceans as atmos capacity to aborb is ltd; Leading to extreme events, glacial melting), Nutrient Recycling, **Ocean deoxygenation** (hypoxic zones), Eutrophication; Sea Level Rise (20 cm since 1900)

1. **2019- How do ocean currents and water masses differ in their impacts on marine life and coastal environment? Give suitable examples.**
   a. Ocean currents (surface or deep ocean currents) are **streams of water flowing constantly in definite path**and direction, for example, Gulf Stream (warm current) and Labrador current (cold current)
   b. **Water masses** are the extensive homogeneous body of immense volume of ocean water in terms of temperature and salinity. These are generally **characterised by** the the downwelling of denser cold water and upwelling of less dense water, for example, the North Atlantic Deep water mass in the Norwegian Sea.(similarly Antartic cold dense water which sinks and flows northwards)
   c. **Impacts of water masses:** Upwelling bring nutrients, Downwelling doesn't have high marine productivity, Impact of growth of planktons is there, Affects humidity and pressure above leading to change in circulation of winds (normal notion-wind affect oceans and oceans affect wind eg- ENSO is nothing but ocean-atmospheric linkage); Cyclonic formation is impacted; Coral living environment is affected
      i. Upwelling of water masses- It is beneficial to the rich marine life because dissolved oxygen and nutrients are brought to the surface through upwelling. For example, the upwelling of nutrient rich cold water off the coast of Peru has made the region one of the richest fishing grounds.
      ii. Downwelling of water masses- Areas of downwelling of water masses are not conducive to marine life - areas of low marine productivity.

iii. Water masses determine hydrological conditions of water which influence production and growth of plankton- eg survival of corals dependent on stable conditions of water masses
iv. WM impact humidity and pressure of air above its surface- affects circulation of winds affecting coastal enviroment- eg impact of land and sea breeze

d. Global warming is disrupting the sinking of cold, salty water as a result of increased melting of glaciers and sea ice. This could slow or even stop the circulation of ocean waters, which could result in potentially drastic impact on marine life and coastal environment. Thus, arresting global warming is the need of the hour.
e. Ocean currents- given below

2. **2014- Explain the factors responsible for the origin of ocean currents How do they influence regional climates, fishing and navigation**
   a. Basic: Ocean currents are continuous mass movements of water in the ocean flowing in a definite direction, kind of rivers in the ocean
      i. There are two type of Ocean Currents, Based on depth, viz. surface currents (surface circulation- which make up about 10% of all the water in the ocean) and deep water currents (thermohaline circulation- which make up the other 90% of the ocean). Based on temperature, Ocean currents are classified into two types: cold currents (Labrador Current) and warm currents (Kuroshio current) [**Location of cold currents: Usually found on the west coast in the low and middle latitudes and on the east coast in the higher latitudes in the Northern Hemisphere]**
   b. **Factors for origin as well as other modifying factors:** Planetary Winds (principal cause), Salinity & density differences (high density sinks while low salinity flows on surface), Earth's Rotation (Coriolis Force influences direction clokwise in NH, while anti-clockwise in SH), Ocean bottom topography, Heating by sun (water expands by 8cm higher; slight gradient-water moves down the slope), Gravitational pull, Shape of the coastline (gulf current)
      i. Planetary winds: Planetary winds are the principal cause of the origin of ocean currents. Such winds drive surface water along with them Ex: Ocean currents in the Indian ocean changes with the direction of Monsoon winds
      ii. Gravity: Gravity tends to pull the water down to pile and create gradient variation (as affect of gravity is diff for diff places on earth)
      iii. Salinity & density: Water of high salinity sinks (as higher density) and water of low salinity flows on the surface.
         1. Upwelling and downwelling: Upward movement of cold water as near the Peruvian coast and downward drift of

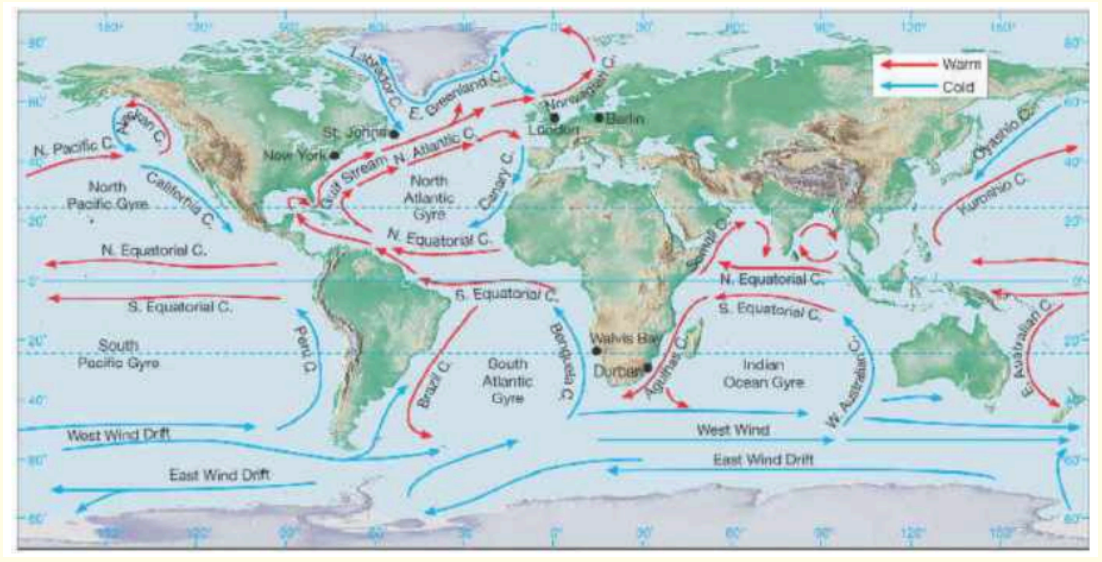
water where salinity or density is high influence the water circulation as a whole system.

iv. Earth's rotation: Because of rotation, every object on the Earth comes under influence of Coriolis force, including ocean currents. In Northern Hemisphere, ocean currents are deflected towards right, so they sets in a Clock wise circulation.
v. Heating by solar energy: Heating by solar energy causes the water to expand. That is why, near the equator the ocean water is about 8 cm higher in level than in the middle latitudes. This causes a very slight gradient and water tends to flow down the slope.
vi. Land: A land mass always obstructs and diverts a current. For example, a tip of southern Chile diverts part of the West Wind Drift northwards as the Peruvian Current, Similarly Gulf stream moves along the gulf of mexico
vii. Ocean bottom topography: Ocean bottom topography also affect the circulation of oceanic water. Such as huge mid-oceanic ridges in the Atlantic and Pacific ocean, seamounts and guyots

c. Impact of OCs
    i. **On Regional Climate:**
        1. Warm and Cold currents affect the local climate of a region. E.g.: the **North Atlantic Drift keeps the coasts of North Sea (western coast of Europe) warm which is unusual for such high latitudes**. Similarly, the warm waters of the Kuroshio current in the North Pacific ocean keep the ports of the Alaskan coast ice-free in winter. The **California (cold) current, which flows along the western coast of USA, makes the region much cooler** than other places in the west coast on the same latitude
        2. **Warm currents** flow along the east coast of continents resulting in **warm and rainy climates**while **cold currents** flow along the west coast of continents which **aid in desertification**(desiccating effect or extreme drying)
    ii. **On Navigation**: They give free navigation. The north eastern arm of Gulf Stream keeps ports and **harbours of Russia & Scandinavia navigable**. Also, **ships sailing with a current gain speed** which helps in saving fuel and time
        1. But in case of mixing of cold and hot- fog leads to difficult navigation
    iii. **On Fishing**: The **mixing of warm and cold currents** help to replenish the oxygen and favour the growth of planktons, the primary food for fish population. The best fishing grounds of the world exist mainly in these mixing zones Eg: **Dogger's Bank (Europe - Gulf stream and North sea), Honushu Isl (Japan),**

Newfoundland/George Bank in NA (meeting of gulf stream and Labrador Current)

iv. **Other impacts:**
   1. Maintains the **Global Hydrostatic Balance** (they manages the temp; bring eq. warmth to polar and polar to eq. region- **maintain latitudinal heat balance**)
   2. **Tropical cyclones**: They pile up warm waters in tropics and this warm water is the major force behind tropical cyclones.
   3. Aids in **distribution of minerals, species of fishes**

v. 

3. **2019- Assess the impact of global warming on coral life system with examples**
   a. **Coral Reefs** - symbiotic relationship between zooxanthellae & corals
      i. Coral reefs- result of symbiotic relationship between zooxanthellae & corals in an oceanic ecosystem. Corals give shelter to algae in exchange of nutrients which algae produce by photosynthesis process. These corals secrete calcium carbonates which become hardened after their death and new corals make this skeletons their home. Barrier reef, fringing reef and atolls are three types of coral reefs
      ii. In India- Gulf of Kutch, Andaman and Nicobar islands, Lakshadweep islands, Gulf of Mannar, etc.
      iii. Coral reefs not conducive in cold ocean currents areas. Presence of warm currents- corals are present far to the North. Pacific and Indian oceans have most of the corals.
   b. **Examples: In India**: **Gulf of Kutch**, **Andaman and Nicobar** islands, **Lakshadweep islands**, **Gulf of Mannar**, etc.; Coral Traingle, Amazon Reefs, Great Barrier Reef (talks of downgrade)
   c. **Conditions for survival: Shallow water as sunlight needed by algae; Warm water (20-32°), Saline but clear water**

   i. Shallow water: Algae, in corals, needs sunlight to survive- rarely develop in water deeper than 50 meters,
   ii. Warm water: live in water temperatures of 20–32° C.
   iii. Salty water: Saline water preffered but clear for sunlight
   iv. No pollution: Sediment can get deposited on corals, blocking out the sun and harming the polyps. Wastewater may contain too many nutrients that cause seaweeds to overgrow the reef.

d. **Importance of Corals** -**Absorbing carbon dioxide to form calcium carbonate, water purification,** Tipping point-small change will lead to irreversible consequences; Coral reefs support over 25% of marine biodiversity. They generate $2.7 trillion pa in trade and tourism; Protection against disasters; **Study of the provide record of climatic events**; Coral **associated photosynthetic cyanobacteria plays a role in Marine Nitrogen Cycle**; **Rainforests of the oceans** (*sponges, oysters, clams, crabs, sea stars*); **Provide resources**(like sand, Medicinal products)
   i. Reason for thriving biodiversity in the ocean- (Rainforests of Ocean eg: Coral Triangle) give shelter to various species who depend on corals for food, source of nitrogen and other essential nutrients for marine food chains. The fishing industry depends on coral reefs because many fish spawn there (nursery for fishes)
   ii. Great Barrier reef-protection against floods, tsunami, protect from coastal erosion
   iii. Coastal population depends on corals as these provide tourism and recreational activities (aesthetic)
   iv. They regulate the carbon dioxide content in the oceans by absorbing carbon dioxide to form calcium carbonate for their structures.
   v. Provides services like recycling and purification of water and air, the break down of pollutants, etc.
   vi. The study of coral reefs provide a clear, scientifically testable record of climatic events over the past million years or so. This includes records of recent major storms and human impacts that are recorded by the changes in coral growth patterns.

e. Factors **threatening Corals** (Use conditions for survival for natural activities) - IAS species Snowflake corals, **rising Carbon Compensation Depth (CCD)** levels due to atmos warming; Other Human activities (**fishing, pollution, coral mining for bricks, oil spills**); Ocean acidification (rise in Co2); **Unsustainable Fishing (like** dynamite fishing, bottom trawling); **Unscientific tourism (resorts on corals, release of grey water by cruise ships); Natural reasons (cyclones, tidal movt, El-Nino)**
   i. Temperature: Corals survive in very narrow range of temperature and are adopted to live in warm waters. Slight change in

temperature because of solar radiation variation cause coral bleaching (corals to expel tiny photosynthetic algae, draining them of their color) eg: Great Barrier Reed experiencing a mass bleaching event

1. A 2021 study by the Global Coral Reef Monitoring Network (GCRMN), which is supported by the United Nations, showed that 14% of the world's coral on reefs had been lost between 2009 and 2018, with most of the loss attributed to coral bleaching.

ii. Human activities: Human activities such as fishing, ocean pollution such as oil spills etc., are serious threat to their existence.

1. Coastal construction and shoreline development results in heavy sedimentation, which can lead to coral reef destruction.
2. Introduction of invasive species in ocean (snowflake coral) by humans too lead to change in the coral ecosystem.
3. Coral mining: Live coral is removed from reefs for use as bricks etc.
4. The rising Carbon Compensation Depth (CCD) levels due to increased anthropogenic warming

iii. Fresh-water dilution: Fresh water from runoffs cause dilution of fresh water. As corals are adapted to saline water, they react adversely in such circumstances.

iv. Pollution: Sediments, industrial garbage disposal in ocean have caused chemicals accumulation in ocean water, thus hampering the growth of corals.

f. Impact of **global warming** (PYQ): Temp rise- mass coral bleaching, **Ocean acidification (CO_2 is absorbed)-** affects **sea water chemistry** for coral formation, **more frequent tropical storms** due to GW- affects corals, **results in sea level rise**- inc sedimentation in reefs, affects circulation pattern- hampers traditional coral locations

i. Eg- Great Barrier reef (UNESCO status downgrade talks), Amazon reef bleaching due to GW

g. Measures taken for Coral Restoration: ZSI Bio rock technology, Coral Bleaching Alert System (CBAS) by INCOIS, CRZ Norms, International Coral Reef Initiative

i. Global Measures

1. International Coral Reef Initiative (ICRI)- is an informal partnership between UN and organizations which strives to preserve coral reefs- declared 2018 as the third International Year of the Reef (IYOR) to strengthen awareness

ii. Measures taken in India

1. Notified Coastal Regulation Zones (CRZ) and has setup National Coastal Zone Management Authority and State Coastal Zone Management Authority to protect coral reefs
2. Coral Bleaching Alert System (CBAS)- a service initiated from INCOIS , ReefWatch India- An NGO, has taken up two projects —Re(ef)Build and Re(ef)Grow - to conserve the reefs
3. ZSI - Bio rock technology- electro accumulation of minerals dissolved in seawater on steel structures that are lowered onto the sea- bed and are connected to a power source.- faster growth of calciums for coral formation
4. Government of India has taken steps to protect its coral reefs under Coastal Ocean Monitoring and Prediction system (COMAPS), Land Ocean Interactions in Coastal zones (LOICZ) and Integrated Coastal and Marine Area Management (ICMAM)

iii. WF

1. Preserving mangroves may be one in a portfolio of strategies to help corals survive the effects of climate change
2. Other CC/GW reducing points

4. **2017- Account for variations in oceanic salinity and discuss its multi-dimensional effects**
   a. **Salinity** is the the **total amount of dissolved salts** in sea water- generally **expressed as parts per thousand**(ppt).The **average salinity of the oceans is 33-37** parts per thousand. (Highest salinity - Lake Van (Turkey)330ppt- salt lake,density so high that impossible to sink.
   b. But the **exact levels in each ocean are not same**, due to the effect of following **factors:** Evaporation Rate (high salinity if high evaporation); Fresh water added to ocean; Current mixing regular or not (agar regular hoti hai oceans mein toh 35 ppt; nahi hoti jaise closed caspian sea/medi sea then salnity is not avg), Precipitation
      i. Evaporation rate:- Oceans between 20 to 30 degree North and south(areas of trade wind deserts) have high salinity because of high temperature and low humidity. Temperate oceans have lower salinity due to lower temperature
      ii. Amount of Fresh water added in ocean: Equatorial waters have lower salinity due to heavy rainfall and high humidity. Oceans fed by large rivers like Amazon, Congo, Ganges, Mekong etc have lower salinity due to dilution of salinity
         1. Melting of icebergs and resultant fresh water intake into Baltic, Arctic and Antarctic ocean waters makes them less

saline. Thus, global warming and greenhouse gas effect has indirectly affects the salinity levels of the oceans.

iii. Currents Mixing: In open oceans, currents mix and flow freely, hence salinity is average 35ppt or lower. Whereas in the Caspian sea, Mediterranean sea, Red sea and other wholly / partially enclosed seas – the fresh water doesn't mix freely with ocean water hence salinity is higher.

iv. Salinity, temperature and density (STD) of water are interrelated. Hence, any change in the temperature or density influences the salinity of an area.

c. Multidimensional effects: Without salts oceans would freeze in winters, Salinity affects a ship's buoyancy-uses less fuel; Keeps Planktons float due to sea density difference, Whales/Sharks body fats will reduce, Circulation of water currents will get affected, indirect role in Earth's overall climate

i. Effect on temperature, rainfall: without salts oceans would freeze in winters, Salnity plays a role in oceanic currents,

1. This high density is related to salinity and temperature and means that objects that might sink in freshwater are able to float in seawater. This has a big effect on life in the sea. For example:
    a. Despite having no fins, the plankton are kept perpetually afloat due to the density of seawater. Without plankton, entire marine ecosystem will collapse, the atmospheric levels of oxygen will be altered- posing threat to all forms of life even on land.
2. Whales, sharks, sea-cows and other marine species can grow to be so much bigger in size than the ordinary animals on land (Salinity affects body fat)
3. Salt affects water's freezing point and salinity affects circulation of cold and warm currents. The marine organisms have accordingly adapted to a particular level of temperature, pH and salinity. Human-induced changes in oceanic salinity threatens their survival.
4. Because of density difference: (1) High salinity seawater sinks below the lower salinity water and; (2) Cold water sinks below the warm water.(both denser)- salinity has a great role to play in the formation and circulation of oceanic currents and water masses via the thermohaline process.
5. As water of high salinity moves sinks below water of low salinity due to density differences- example higher saline water of mediterrean move undersea to Atlantic and Atlantic sea water to med on surface

6. Since Earth's temperature and rainfall is affected by currents, the level of salinity has indirect role in Earth's overall climate.
7. Salt water has a much lower freezing temperature and without salt more of the oceans would freeze during winter- affecting the movements of both fish-schools and cargo ships.

ii. Marine Biodiversity, survival of the species - Planktons float due to sea density difference, Whales/Sharks body fats will reduce
   1. This high density is related to salinity and temperature and means that objects that might sink in freshwater are able to float in seawater. This has a big effect on life in the sea. For example:
      a. Despite having no fins, the plankton are kept perpetually afloat due to the density of seawater. Without plankton, entire marine ecosystem will collapse, the atmospheric levels of oxygen will be altered- posing threat to all forms of life even on land.
   2. Whales, sharks, sea-cows and other marine species can grow to be so much bigger in size than the ordinary animals on land (Salinity affects body fat)
   3. Salt affects water's freezing point and salinity affects circulation of cold and warm currents. The marine organisms have accordingly adapted to a particular level of temperature, pH and salinity. Human-induced changes in oceanic salinity threatens their survival.

iii. Salinity affects a ship's buoyancy. Ships will float deeper in fresh water than in salt water. Thus if oceans were madeup of fresh water, ships would consume much more time and fuel to move forward. Thus, it's suffice to say oceanic salinity plays a crucial role in the survival of both marine and terrestrial lifeforms on Earth

5. **2019: Causes of depletion of mangroves and their significance**
   a. Mangroves are salt-tolerant vegetation (trees and shrub) that grows in **intertidal regions** of rivers and estuaries. They are referred to as 'tidal forests'. Mangrove forests **only grow at tropical and subtropical latitudes near the equator** because they cannot withstand freezing temperatures. They have **aerial root**specialized for gaseous exchange.; eg: *Rhizophora*
   b. Geographical factors that determine location: High Rf and High temp as tropical/sub-trop; Tides as they bring nutrients; Some mangroves need fresh water flux; Sediment deposition hence at river mouths;

c. Current State: According to the Indian State of Forest Report, 2021, the total mangrove cover in India is almost **4992** sq km (highest in WB then GJ); **More than 35% of the world's mangroves are already depleted**.
    i. More than 35% of the world's mangroves are already depleted. The figure is as high as 50% in some countries
    ii. As per **UNEP Report** titled "The Importance of Mangroves: A Call to Action", Destruction of **mangroves causes damages** of up to **$42 billion** each year
    iii. Some of the mangrove species like *Bruguiera cylindrica* and *Sonneratia acida* are at the verge of extinction

d.

e. 

f. **Significance:** Ecotone/Edge effect eg: Fishing cat, Shock absorbes (WB-Amphan), Nursery grounds, NASA-said carbon scrubbers (as reduce Co2), Ecological functions such as nutrient recycling, Cultural-Bon Bibi forest goddess
    i. The structural complexities of mangrove vegetation create unique environments which provide ecological niches for a wide variety of organisms. (mangroves show edge effect) eg: Royal Bengal Tigers, salt water crocodiles, fishing cat
    ii. Mangroves give protection to the coastline and minimize disasters due to cyclones and tsunami. (eg: WB protected from Cyclone Amphan) They reduce high tides and waves and help prevent soil erosion by acting as shock absorbers

iii. Mangroves roots serve as breeding, feeding and nursery grounds for most of the commercial fishes and crustaceans on which thousands of people depend for their livelihood
iv. Mangroves can counter ocean acidification (OA= educing PH of ocean water due to absorption of Co2) by releasing alkalinity into surrounding water (thus increasing the PH from acidic to basic)
v. NASA has termed them 'the best carbon scrubbers' because of their role as a significant carbon sink. They store more carbon dioxide than most of the other forest types.
vi. They perform important ecological functions like nutrient cycling, hydrological regime, coastal protection, fish-fauna production, etc.

g. **Threats:** IAS are inc (Water hyacinth - Terror of Bengal), Sea level rising, Marine pollution/discharge into sea, Shrimp farming in India,, Timber, Use DUMA, Increased disaster due to CC
    i. Sea levels are rising due to global warming which are submerging mangroves
    ii. Climate change has increased the frequency of disaster which are impacting mangroves
    iii. Reduction of river water due to dams has caused destruction of mangroves. Mangroves need fine balance between salt and sweet water to survive
    iv. Destruction caused by introduction of alien invasive species which has led to imbalance in ecological structure
    v. Mangrove forests have often been seen as unproductive and smelly, and so cleared to make room for agricultural land, human settlements and infrastructure (such as harbours), and industrial areas including tourism
    vi. Overharvesting: Mangrove trees are used for differennt types of woods such as firewood, construction woods or animal fodder
    vii. Pollution: Mangroves also face severe threats due to fertilisers, pesticides, discharge of domestic sewage and industrial effluents carried down by the river systems
    viii. Due to shrimp farming, about 35,000 ha of mangroves have been lost in India.
h. **Efforts:** Partnership by BOBLME led by FAO, MANGROVE BOARDWALK PANAJI, 5 crore tree pledge by WB govt, Salt tolerant variety of grass at Sunderban, Wetland protection under Ramsar, Heritage site decl by UNESCO eg: Sunderban Natural site, **MISHTI** Scheme
    i. In 2018, India along with 7 other countries of the Bay of Bengal region came together to protect the mangroves under the BOBLME (Bay of Bengal Large Marine Ecosystem) project led by FAO

   ii. Declration of heritage site by UNESCO, protection of wetlands under Ramsar
   iii. MANGROVE BOARDWALK PANAJI, GOA - Aimed at creating green spaces, tourism while educating people about importance of mangroves
   iv. Restoration at Sunderbans was done by planting of salt tolerant variety of Grass. This provided nutrients/ microbes to soil helping mangroves and further prevented soil erosion
   v. In 2016, the Maharashtra government declared over 15,000 hectares of mangroves as reserve forests
i. **Way Fwd:** Environmental monitoring, Train forest officials, Zero liquid discharge, Leverage cultural advantages; *For e.g., the **fish-bone technique** of conservation is used in coastal areas to help in the regeneration of mangroves; Recent Mangrove Alliance for Climate at COP27*
   i. Environmental monitoring in the existing mangrove areas should be taken periodically
   ii. Suitable sites need to be identified for planting mangrove species. Eg: State of W. Bengal plans to plant 50 million mangrove trees but is facing space crunch
   iii. Training of forest department officials wrt taxonomy, biology and ecology of mangroves
   iv. Cultural advantages can be leveraged in mangrove conservation. Eg: Bon Bibi is a forest goddess worshipped by people in
   v. Coastal industries and private owners need to be persuaded to actively participate in protecting and developing mangrove biodiversity

6. **2018-Consequences of spreading of Dead Zones on marine ecosystem**
   a. **Dead zones** are low-oxygen, or **hypoxic, areas** in the world's **oceans and lakes** in which **organisms can' t survive** (hence the name- dead) (diff from dead sea- salt wala)
      i. Eg- Western coasts of North and South America, Namibia and **India in the Arabian Sea**. Recently a dead zone **found in Bay of Bengal**
      ii. Climate change induced reduction in oxygen threatening vast swaths of marine life (**Ocean deoxygenation**)
   b. **Causes for formation of dead zones**: Eutrophication/algal bloom due to chem/indus/agri waste; CC impacting conveyor belts that play a role in oxygen replinishment due to mixing; Ocean wind pattern affect formation of dead zones
      i. Eutrophication and Algal Bloom: Increase in chemical nutrients - excessive blooms of algae - consumes oxygen and depletion of underwater oxygen levels- affects marine life

ii. Agricultural runoff and Industrial/ Transport emmisions: Lead to eutrophication and other cases such as Oil spills
iii. Climate change: Global warming (impacts conveyor belts and inter-mixing) melts ice- which releases fresh water that rests on the surface of the more dense salt water generally found in oceans. Affects intermixing- which is the only way that the deeper parts of the ocean have their oxygen stores replenished
iv. Oceanographic phenomenon: Ocean and wind current patterns also effect the formation of dead zones

c. **Consequences** of dead zones: Dead species due to algal blooms; Migrate to O2 rich=new predators; Invisible trap for fishes; Diff for male to produce sperm/female unable to bear egg; Blue Economy; Coral reef threatened
    i. Issus with algal blooms- dead species, harmful poisoning env, threat to food
    ii. It forces species to migrate to more oxygen-rich areas, exposing them to new predators while disrupting the already existing ecosystem. Polar regions in recent years have suffered an invasion of species from lower latitudes seeking to escape increasingly inhospitable areas.
    iii. Ocean dead zone acts as invisible trap- once fish enters hard to escape- leads to losing ability to hear and see and eventually death
    iv. Oxygen-poor waters make it more difficult for male fish to produce sperm and female fish unable to produce eggs. Poses long-term threats to the sustainability of sea creature populations
    v. Blue Economy: Hundreds of millions of human beings who use fish as a primary source of food and make their livelihood from fishing will suffer
    vi. Dead zones affect dozens of coral reefs around the world and threaten hundreds more
d. Way forward:
    i. Better regulation of ocean transport- Stop letting so many chemicals find their way into the ocean
    ii. Sewage dischrage and wastes: As humans, we need to pay attention to where we let our sewage go and remedial measures and conservation as treating the ocean like a large trash negatively affects us
    iii. Addressing climate change, organic farming, recycle and reuse, wetlands and floodplains conservation are needed
    iv. Industrial waste regulation, Innovative measures - Zero liquid discharge like nutrient trading on lines of carbon trading
        1. Form of a mandatory cap on the total quantity of nutrients entering the water- goal could be a percentage reduction in

nutrients entering. The total amount of allowable pollution is then allocated among the sources that will participate in the trading program.

v. (Learn negatives wrt to Oceanography, Climatography so that -ve concept such as dead zone can be linked to other negative concepts affecting oceanography such as algal blooms)

7. **Global Ocean Conveyor Belt:**
    a. **AMOC** (Atlantic Meridional Overturning Circulation) is a part of ocean conveyor belt - it distributes heat and nutrients throughout the world; 2 elements-salty warm water moves from Gulf of Mexico → Cools at high latitudes and sinks → Towards tropics and Antarctic areas
    b. Significance for marine ecosystems: **Sink for CO2**, Facilitates **Nutrient** circulation, **Oxygen enrichment** (by facilitating mixing warm and cold currents), **Global Hydrostatic Balance (heat, salt budget maintained)**

Indian Drainage Systems

- **2020: The interlinking of rivers can provide viable solutions to the multi-dimensional inter-related problems of droughts, floods and interrupted navigation. Critically examine.**
    - Take all content from River linking - GS3 Environment Notes
    - Give introduction: about National River Linking Project
    - **Need for inter-linking**: Temporal distribution rf is concentrated, water for irrigation/drinking purposes, Boost inland navigation (connecting hinterlands) **Criticism:** Ecological damage (quote Ken-Betwa use simple 2 river diagram and make Panna TR, maone flood prone), Human costs displacement, Federal issues (Karnataka, TN), International issues (Teesta, Indus IWT disputes), Nature of freshwater habitat on niche species like Susu; Cost (need to spend $183 bn), Excess sediments causing a blockage problem (problem to movt, navigation) **WF:** Its a immense oppportunity to solve current and future problems of water shortages + we need water harvesting management, tech inputs (as water stress is systemic problem)
    - Cover benefits of river linking by addressing key issues of drought, flood, navigation. Also cover other benefits in brief
    - Cover issues wrt interlinking of rivers, End with way forward
- **2015- India well endowed with fresh water resouces. Critically examine why it still suffers from Water scarcity?**
    - India is not a water short country as it has an average annual rainfall of 119 cm while world average is 99cm. however, the spatial and seasonal distribution of rainfall, along with inefficient use of available water makes water a precious resource with a growing need to conserve it

- Cover issues, best practices, way forward from: Water Conservation Topic - GS3 Environment
- **Regional Differences**: Scarce areas such as Marathawada, Bundelkhand, Rayalseema whereas water excess areas such as river basins areas such as gangetic valleys (however they too are getting polluted)
- Way Fwd: Dublin Principles advocated for participatory approach, central role of women for water conservation and highlights the economic value

- **2018- Ideal solution of depleting ground water resources in India is water harvesting system. How can it made effective in urban areas?**
  - **Measures taken:** National Water Policy (2012) advocates rainwater harvesting; Tamil Nadu made water harvesting compulsory; The 'Catch the Rain' campaign; Traditional rain water harvesting followed such as Kund or Tanka in RJ; Barmer Distt rain water harvesting
  - **Making it effective**: Capacity bldg on line of Surya Mitras; Rewards; Start with new bldg and gradually absorb old ones; Inter-ward competition; Integrating in govt schemes such as PM-Awas; Make model houses; Use NGOs to spread awareness
  - **New Measures + Best Practices:** Jain Irrigation-micro irrigation tools, Chauka System (square shaped embankments) in RJ, Urban Forests of Pune
    - Traditional rain water harvesting followed such as Kund or Tanka in RJ, stepwells in GJ, Zings (found in Ladakh, are small tanks that collect melting glacier water)
    - Making rain water harvesting system compulsory in new building and making it a part of building code. Gradually older building need to be brought into fold of water harvesting
    - Capacity building of personnel eg: on line of Surya Mitra initiative for solar panel installation we need personnel for water harvesting strucutre
  - Extra points
    - Introduction - Stats: from GS-3 data highlighting falling per capita availability of water and water scacity data of NITI aayog for cities
    - Though **there are many ways to check the further depletion** of ground water and increase the level of water such as limit of water-extraction, **change in crop-patterns, diverting river streams, building reservoirs** and plantation drives **but water harvesting system provides ideal solution** for the problem.
    - Water harvesting is a **method to capture and storage of rainwater** along with surface runoff for various uses. It is a low cost and eco-friendly technique for preserving every drop of water by guiding the rain water to bore well, pits and wells
    - Cover few of the +ve impact from this list: recharge groundwater aquifers, increases water availability, checks the declining ground

water table, improves the quality of groundwater through dilution of contaminants like fluoride and nitrates, prevents soil erosion and flooding, save energy to pump groundwater as recharge leads to rise in groundwater table, reduce community dependence on groundwater (eg: using dried up tubewells to recharge deeper acquifiers)

- **Traditional rain water harvesting** followed such as **Kund or Tanka in RJ, stepwells in GJ**, **Zings (found in Ladakh**, are small tanks that collect **melting glacier water**)
- Two types of urban rainwater harvesting: One where surface runoff water is stored for future use and Second where the water is used for Groudwater recharge
- **How can it be made effective in urban areas?**
  - **Leading by example:** Govt. building and properties must adopt rain water harvesting, rain water harvesting be made part of PM-Awas Yojana and other schemes
  - Making rain water harvesting system **compulsory in new building** and making it a part of building code. **Gradually older building** need to be brought into fold of water harvesting
  - **Incentives, support and recongition** need to be provided to all citizens
  - **Capacity building of personnel eg: on line of Surya Mitra** initiative for solar panel installation we need personnel for water harvesting strucutre
  - **Awareness campaigning** by involving role models, youth models, college drives, school to school initiative
  - **Community based approach** need to be adoped so that cost of construction can be shared. **Urban local bodies need to be empowered** to take this initiative to masses
- Efforts taken:
  - **PM has written letter to all sarpanches** regarding the importance of water conservation and harvesting
  - **National Water Policy (2012) advocates rainwater harvesting; Tamil Nadu** made water harvesting **compulsory; The 'Catch the Rain' campaign**
  - Watershed Development Component (WDC) of the **Pradhan Mantri Krishi Sinchayee Yojana**(PMKSY) under which Department of Land Resources is currently implementing 8214 **watershed development projects** in 28 States
  - Model Building Bye Laws, 2016 circulated by Ministry of Urban Development include the provision of Rainwater

Harvesting in all new buildings on plots of 100 sq.m and above

- 🔥🔥 **2016- Present an account of IWT and its Ecological, economic and political implications of IWT in the context of changing bilateral relations**
    - The Indus Water Treaty is **brokered by WB** between India and Pakistan (60th anniversary on 19th September 2020); 3 western rivers with Pak and other 3 with India
        - Partition- The three 'western rivers' (Indus, Jhelum and Chenab) went to Pakistan and the three 'eastern rivers' (Sutlej, Ravi and Beas) were portioned to India. **India is even allowed to use 20% water of the western rivers for irrigation, power generation and transport purposes**.(IWT granted 3.6 million acre-feet (MAF) of "permissible storage capacity" to India on the western rivers but due to poor water development projects, 2-3 MAF of water easily flows into Pakistan.)
    - **International Relation Angle**
        - **India** also gave Rs. 83 crore in pounds sterling to Pakistan to help build replacement canals from the western rivers, **conceded its upper riparian position on the western rivers for the complete rights on the eastern rivers**.
        - It was important to get the waters of the 'eastern rivers' for the Indira Gandhi Canal in Rajasthan and the Bhakra Dam on Sutlej in Himachal Pradesh) without which both Punjab and Rajasthan would be left dry, severely hampering India's food production.
        - Pakistan's Responses: Sees as **unfinished business**
            - The **Pakistan leadership considers** the sharing of the waters with India an **unfinished business**- not comfortable with the fact that India got away with the total flow on eastern rivers, while it had to share the waters of western rivers.
            - Being a lower riparian state, Pakistan's scepticism of India allows it to increasingly politicise the issue. It maintains high troop levels and alertness around the canals on the eastern front, fearing that India will try to take control of the western rivers.
            - **Protests every project on western rivers even after 20% share agreed**
    - Changing Perspectives in India:
        - **Frequent uproar in India** for **abrogating the IWT** as a response to **Pakistan's cross-borderterrorism** and tenacity.
        - **Ecological implication** The treaty regulates proper usage of water and stops unilateral decision by upstream country- ensures that

the ecological flow of river system is maintained, If the river flow goes below certain level, the area can turn into a desert.

- **Economic implications**: The Indus river and its tributaries are considered the heartbeat of Pakistan's agrarian economy. About **60% of its population depends on Indus**. If water flow is decreased by constructing dams in upstream areas, Pakistani economy will be in tatters
- **Political implications:** India has been vocal about its desire to **use Indus water treaty as a bargaining chip** to tackle Pakistan on strategic issues. **Using for diplomacy** is an option **but abrogation wil undermine int image** (like china PCA disobey on SCS)
- **Terror attacks could have prompted India**, within the Vienna Convention on the Law of Treaties, **to withdraw** from the IWT. However, on each occasion, **India chose not to do so.**
    - It is because **India respects its signature and values trans-boundary rivers** as an important connector in the region in terms of both diplomacy and economic prosperity.

- Way forward
    - Currently, with a new set of hydrological realities, **advanced engineering methods in dam construction and de-siltation, there is an urgent need to modify the treaty**.
    - **Article XII of the IWT** says that it "**may from time to time be modified**" but carefully notes "by a duly ratified treaty concluded for that purpose between the two governments".
        - Difficult to modify treaty due to differences so best option would be to optimise the provisions of the treaty.
    - On the developments on western rivers, the **permissible storage capacity on the western rivers needs to be urgently utilised**. **Ujh Dam project J&K on Ravi river (facing land issues, viability); For western ones - such as Kishanganaga and Ratle;**
        - **(Currently 95% of eastern rivers are utilised) India recently called to modify the treaty -** as Pak was not cooperating for Ratle and Kishnganga projects (both in J&K - it went directly to arbitration which is a break of IWT which calls first for WB appointed neutral expert) + also need to factor in issues such as climate change into IWT
        - Out of the total estimated capacity of 11406 MW electricity that can be harnessed from the three western rivers in Kashmir, only 3034 MW has been tapped so far, which also needs to be looked into.
        - Tulbul Navigation project on Jhelum, Ratle and Bagliha hydro projects on Chenab, Bursar hydroelectric project (first

project to have storage infra) on one of the tributaries of the Chenab in Jammu and Kashmir are few of the projects to utilise the waters of western rivers.
        - India has **fast-tracked** the work on **Shahpur Kandi dam project**, a second Sutlej-Beas link in Punjab and the **Ujh Dam project** in Jammu and Kashmir to fully utilise the waters of eastern rivers.
    - **Conclusion**
        - The role of India, as a **responsible upper riparian abiding by the provisions of the treaty, has been remarkable**. IWT is often cited as an example of the possibilities of peaceful coexistence that exist despite the troubled relationship between both neighbouring countries (Recent meeting by Indus water commision after ceasefire truce in 2021) - **Even Terror attacks did not force India to take coercive actions through IWT**
- **2013: No formation of deltas by rivers on the Western Ghats. Why? Repeated from 2006**
    - **Why no delta by west flowing rivers** - High speed of western rivers + rift valleys; Submergence of coast; Face tides, West coast is narrow; Peninsular plateau is hard **so not sediment** for deposition; Rivers not long enough
        - Peninsular plateau has hard rock surface and lacks alluvial material. So west flowing rivers do not carry large amount of sediments.
        - West flowing rivers flow at high speed through rift valleys because of higher gradient so no deposition of silt, while east flowing rivers are slow and deposit
            - Submergence of western coast whereas their is emergence of eastern coast which slows speed of river (aiding in delta formation)
        - Western coast is narrower which inhibits formation of deltas.
        - West flowing rivers from western ghat are not long enough compared to rivers originating from the Eastern side of the Eastern Ghats
        - Rivers arriving into a sea with high tidal range will not form deltas because the changes in the tidal area will wash away the sediments brought by the river.
    - **Conditions favourable for deltas:** Greater vertical/lateral erosion in upper course, Tideless coast, No strong current at right angle, Broad coasts, etc
        - Active vertical and lateral erosion in the upper course of river to provide extensive sediments to be eventually deposited as deltas.
        - The coast should be sheltered, preferably tideless.

        - The sea adjoining the delta should be shallow or else the load will disappear in the deep waters.
        - There should be no large lakes in the river course to filter off the sediments.
        - There should be no strong current running at right angles to the river mouth, washing away the sediments.
- **Analysis of fresh water resources, status, steps required**
    - India is **not a water short country** as it has an **average annual rainfall of 119 cm** while **world average is 99cm**. however, the spatial and seasonal distribution of rainfall, along with inefficient use of available water makes water a precious resource with a growing need to conserve it
    - Spatial & Temporal-Approx 1/3rd water resources for 2/3rd peninsular india (leading to droughts) and vice versa for north; 80% Rf during SW monsoons; Only 8% rain captured
        - Covered in water conservation notes of GS-3 Environment
        - **Skewed spatial** and **temporal distribution** of freshwater in India
        - **Spatial/River flow:** Given that precipitation is relatively high in the catchment areas of the Ganga, the Brahmaputra and Barak rivers, these rivers, although account for only about one-third of the total area in the country, have about 60 per cent of the total surface water resources. Approximately 29% of water resources are available to 64% of the area in peninsular India, leading to droughts.
        - **Variation in rainfall**: About **80 percent of the river flow occurs during the southwest monsoons**, and there is wide variation in precipitation across different regions. Presently, India captures **only eight per cent** of its annual rainfall
- **Comparison of rivers of Peninsular and Himalayan and their characterstics (2003, 1995)**

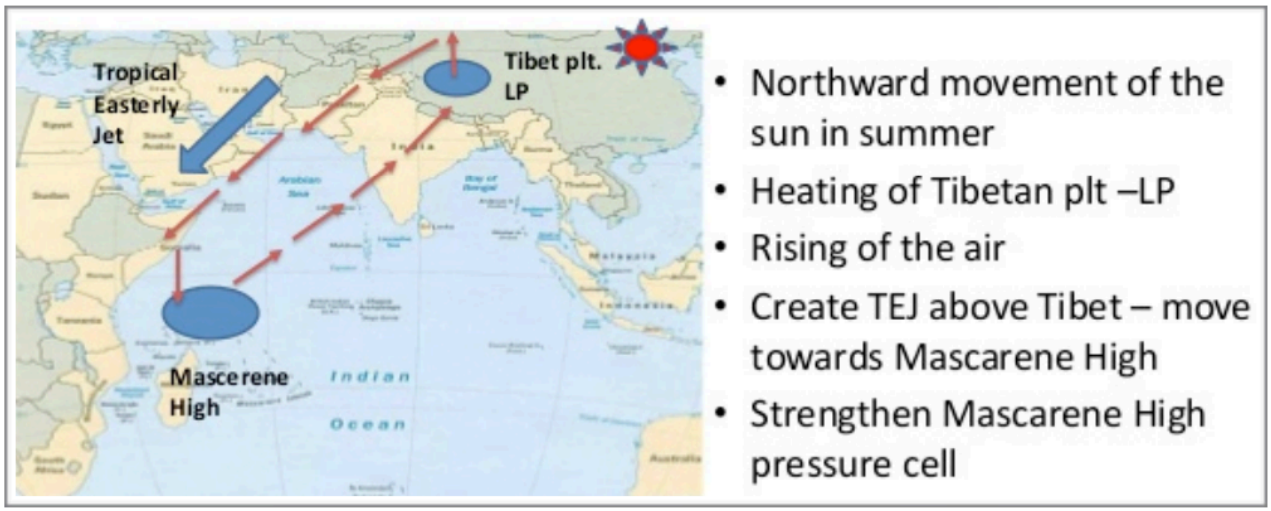
Criterion	Himalayan Rivers	Peninsular rivers
1. **Place of origin**	Himalayan mountain covered with glaciers	Peninsular plateau and central highland
2. **Basin Size**	These rivers have very large basins and catchment areas.	Small basins and catchment areas.
3. **Type of drainage**	Antecedent and consequent leading to dendritic pattern in plains	Super imposed, rejuvenated resulting in trellis, radial and rectangular patterns
4. **Valleys**	The Himalayan rivers flow through steep sided V-shaped valleys .	These flow in comparitively shallow valleys. These are more or less graded valleys i.e. the rivers have little erosional activities to perform.
5. **Water flow**	Perennial; receive water from glacier and rainfall	Seasonal; dependent on monsoon rainfall
6. **Stage**	These rivers flow across the young fold mountains and are still in a youthful stage.	These rivers have been flowing in one of the oldest plateaus/shields and have almost reached their base levels of erosion.
7. **Meanders**	When these rivers enter the plains, there is a sudden reduction in the speed of the flow of water. Under these circumstances, these rivers form meanders and often shift their beds.	The hard rock surfaces and non-alluvial character of the plateau permits little scope for the formation of meanders. The rivers of the peninsular plateau have more or less straight courses.
8. **Delta formation and Estuaries**	These rivers make only deltas. The Sundarbans delta is the largest in the world.	These rivers make deltas (Krishna, Kaveri and Godavari) and estuaries like Narmada and Tapi.

-
    - Other differences:
        - Himalayan rivers **create great plains suitable** for agriculture, urbanisation and industrialisation. These are some of the most densely populated areas in the country
        - **Himalayan rivers flow in levelled Northern plains, so quite useful for navigation**. While peninsular flow on uneven rocky surface, so not useful for navigation

Climatology - Atmosphere, Weather, Monsoon, Cyclones, Anti-Cyclones, Winds, Precipitation

- **Monsoon: Origin (1997), causes (2001), characteristics assigned to monsoon that succeed in feeding more than 50% population residing in Monsoon asia (2017), impact of agriculture/food security, 2015- how far due to agree that behaviour of monsoon changing due to humanizing landscape, efforts made in India by IMD for monsoon prediction (1991), ways the country can be prepared to fight the vagaries of the monsoon (1982)**
    - In no continent, monsoon affects life of people as in Asia

- Generally across the world **monsoons experienced in the tropical area** roughly **between 20° N and 20° S.**In Asia found mainly in the south and the southeast (Indian climate called monsoon type)
  - The southwest monsoon season - Rainfall between June and September, The retreating monsoon season - during October and November in specified parts (other seasons in monsoon typ - cool and dry winters and hot and dry summers)
- **Terms to use: 3 key factors for rf onset (ITCZ shift, Westerly JS withdraws leading to Low pressure in India, and TEJ enters)**
  - Shift in **position of ITCZ northward (sun in NH)** due to intense heating during summer creating monsoon trough, **Tibetan Heat Engine due** this northward movt of sun in summer, **Westerly Jet stream withdraws** which creates low pressure in India; **Tropical easterly JS (TEJ) starts** from Tibet (See map) and **creates burst of monsoon,** Masacerene High pressure cell strengthened, '**breaks' in rainfall**, **Retreating monsoon (October heat, Coromandel coast**), **2 branches** - AS branch and BoB branch



- **Features** of Monsoon Rainfall: Breaks due to cyclonic depression, declining trend with increasing distance from the sea (**Kolkata 110+cm, Delhi around 55cm**); Temporal and spatial distribution too
  - Temporal distribution: June and September
  - Spatial distribution: Rf of RJ versus NE and Western ghats
  - 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
  - **Breaks in rainfall are related to the cyclonic depressions** mainly formed at the head of the Bay of Bengal
  - Weaker rains in NE India translates to higher Rf in central india (general pattern)
- **Causes of Monsoon**

- The shift of the position of Inter Tropical Convergence Zone (ITCZ) northward in summer due to intense heating (low pressure when sun shines vertically at tropic of cancer), over the Ganga plain (this is the equatorial trough normally positioned about 5°N of the equator. It is also known as the monsoon-trough during the monsoon season).
- Withdrawl of sub-tropical westerly Jet in summer: In summers, entire STWJ is beyond Himalayas and hence low pressure is maintained over India. In winters, Sub Tropical Westerly Jet (STWJ) gets bifurcated and its one strand causes high pressure in India.
- Tropical Easterly Jet stream (after westerly jet stream withdraws, known for burst in monsoon in india) steers tropical depressions from mascerene high (above Madagascar) to India, these tracks areas of heavy rainfall during monsoon
- Somali Jet stream in summer: Somali Jet streams appear in summer and intensify the Somali ocean current. This pushes monsoon winds towards India. (they reverse every six months therefore they also play a role in retreat of monsoon)
    - Note: Read about jet streams in static content below
- Indian Ocean dipole: The Indian ocean dipole between Western Pacific Pool and Mascarene High pushes monsoon winds towards India. El Nino year, this push is weak whereas in La Nina year it is strong.
- Impact of El Nino Southern oscillation- affects monsoon winds to India

- Mechanism of Monsoon
    - Retreating Monsoon Season- Starts with October heat (trapped heat not able to release due to monsoons in previous months) then eventual cooling in north but rain in the eastern part of the Peninsula.(eg in coroamandal coast) Here, October and November are the rainiest months of the year.
        - The widespread rain in this season is associated with the passage of cyclonic depressions which originate over the Andaman Sea and manage to cross the eastern coast of the southern Peninsula. These tropical cyclones are very destructive.
        - Unlike the rest of the country, which receives rain in the southwest monsoon season between June and September, the retreating or northeast monsoon is crucial for farming and water security in the south.
        - Retreat of monsoon is also aided by one of the bifurcated strand of STWJ

- The monsoon approaches the Indian landmass in two branches: The Arabian Sea branch - The monsoon winds originating over the Arabian Sea. The Bay of Bengal branch - 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.
- Another phenomenon associated with the monsoon is 'breaks' in rainfall(rains take place only for a few days at a time.- due to the movement of the monsoon trough.

- Impact of Monsoons on Life in India
  - **Positive**: Recharge dams and reservoirs + hydel power; Climatic diversity brings crop diversity - rabi, cash crops, rabi crops; Variation also bring festival/food/clothes variation; Dependence of agriculture on rains
    - About 64% of people in India depend on agriculture for their livelihood . Their prosperity depends on timely and adequately distributed rainfall. If it fails, agriculture is adversely affected particularly in those regions where means of irrigation are not developed
    - Regional variations in monsoon climate help in growing various types of crops- Kharif crops as well as crops like jowar,bajra,ragi in dry seasons. Winter rainfall by temperate cyclones in north India is highly beneficial for Rabi crops,high rain in NE/Western ghats favours cash crops such as tea, jute etc
    - Regional monsoon variation in India is reflected in the vast variety of harvest festivals, food, clothes and house types.
    - Monsoon rain helps recharge dams and reservoirs, which is further used for the generation of hydro-electric power.
  - **Negative:** Variability (eg: Assam Rf highly variable leading to recent floods), Sudden burst → soil erosion, Becomes cause of land erosion, Landslide in hilly areas, Increases risks of Urban floods
    - Variability of rainfall brings droughts or floods every year in some parts of the country.
    - Sudden monsoon burst creates a problem of soil erosion over large areas in India.
    - In hilly areas sudden rainfall brings landslide which damages natural and physical infrastructure subsequently disrupting human life economically as well as socially.
    - Impact of CC on monsoon- drier regions getting rains and vice versa- affecting farmer crops

- **Changing monsoon: (PYQ 2015)** Urban flood due to heat island; Concentrated Rf in narrow band of days; Swapping trend in districts (Rf is reducing some place and increasing at other); CC leading to freq low pressure areas & thus heavy Rf; Biomass burning → Aerosols → reduce low intensity Rf and inc heavy Rf (said IIT Guwahati Study), Monsoon affected due to other trad change agents as well (land deg, de-forests), Greater effect of global phenomenon (MJO, etc)
- Monsoon Prediction In India - by IMD through **automatic radars, 3 satellites**
  - The IMD collects weather data like temperature, humidity, wind and precipitation through 679 automatic weather stations, surface observatories, radars and three satellites.
  - At the moment, the IMD provides district-wise weather data but it's not sufficient;
  - Contemporary scenes of Rf in India: Since 2019, India is witnessing surplus Rf as compared to LTA of 88 cm
- **Factors → Inaccurate Monsoon Forecast:** Lack of monitoring stations; Stations bought from west not fine tuned; Lack of supercomputers; Soil moisture/Dust are inadeq monitored; Changing monsoon factors (Vidharbha etc have witnessed consecutive drought years);
  - The **lack of data due to insufficient monitoring stations**. Currently, highly advanced dynamical models need supercomputers. Automatic weather stations are of substandard quality.
  - **Inability to predict clearly onset of floods** in many cities and states
  - The **models** that we have **brought from the west** have been developed by western scientists to forecast in their region, **little progress** has been made is the **fine-tuning of weather models to suit Indian** conditions.
  - Dust, aerosols, **soil moisture** and maritime conditions are **inadequately monitored**.
- **Recent Indian Initiatives:** Monsoon Mission of India to boost capacity of IMD, National Supercomputing Mission, ICAR provides vernacular advisories, Collab of IMD with CWC for flood warning
  - **Monsoon Mission of India**: This initiative of Ministry of Earth Sciences, launched in 2012- aim- forecast skill gets quantitatively improved further for forecasting services of India Meteorological Department (IMD).
  - **National Supercomputing Mission** for timely and accurate monsoon forecasts.
  - IMD in collaboration with Indian Council of Agricultural Research (**ICAR**) provides **district-level agro-meteorological advisories** to

farmers in **vernacular languages**.
These advisories are used for critical farm operations such as: Management of sowing (delayed onset of rains); Changing crop variety (delay in rainfall); Spraying Pesticides for disease control (occurrence of rainfall); Managing Irrigation (Heavy rainfall Forecast).
    - India Meteorological Department **(IMD) provides** meteorological **support to the Central Water Commission** (CWC) for issuing flood warnings, managing dams in case of high rainfalls
    - Recent proposal to change monsoon dates by IMD due to changing monsons
  - **Way Forward**: India needs to invest more resources in better prediction of Monsoon forecast in order to achieve reliability and sustainability.
    - The population of India is increasing and to provide food security to the population, a large part of the monsoon water which is currently unutilized should be held at suitable locations for irrigation and power generation purposes.
    - India needs to invest more resources in better prediction of Monsoon forecast in order to achieve reliability and sustainability.
    - With a warming climate, more moisture will be held in the atmosphere, leading to heavier rainfall, consequently, inter-annual variability of the monsoon will increase in future. The country needs to prepare for this change at national and global level to combat CC.
    - More analysis needed to get clarity on global warming impact on natural climate variability (such as El Niño).(not sure currently)
- **2020: Examine the status of forest resources of India and its resultant impact on climate change?**
  - Intro: Diversity of India's forest resources due to wide climatic conditions and rainfall spread
  - The **Total Forest and Tree cover is 24.56%** of the geographical area of the country. (of which 21.67% is forest cover and 2.89% is tree cover)- **target 33% (National Forest Policy of India, 1988) - increase of 0.65% of forest and tree cover put together, at the national level compared to ISFR 2017)**
  - Mangrove cover in the country has increased by 1.10% (54 sq km) as compared to the previous assessment
  - Mention states with highest forest cover (MP), Largest wetland (GJ), Largest mangroves (WB); **Mangrove**cover in the country has **increased by 1.10%** (54 sq km);
    -
  - Status of forest resources in India:

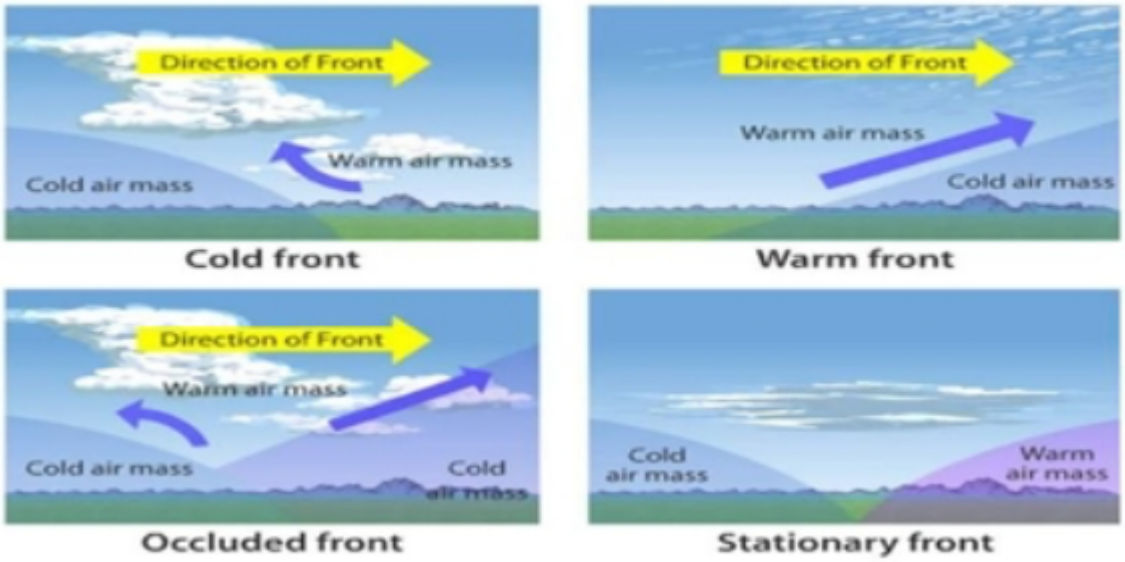
        - ISFR is a biennial publication of FSI, an organization under the MoEFCC. The ISFR assesses the forest and tree cover, bamboo resources, carbon stock and forest fires.
        - The **Total Forest and Tree cover is 24.56%** of the geographical area of the country. (of which 21.67% is forest cover and 2.89% is tree cover)- target 33%
        - **Mangrove** cover in the country has **increased by 1.10%** (54 sq km) as compared to the previous assessment
        - Mention states with **highest forest cover** (MP), **Largest wetland (**GJ), **largest mangroves** (WB)
        - In the country as a whole there are 62,466 wetlands covering 3.83% of the area within the RFA/GW areas of the country
        - As compared to ISFR 2017 the current assessment shows an increase of 0.65% of forest and tree cover put together, at the national level
        - Total forest cover in the North Eastern region is 65.05% of its geographical area. Except Assam and Tripura, all the States in the region show decrease in forest cover
        - National Forest Policy of India, 1988 envisages a goal of achieving 33% of geographical area of the country under forest and tree cover. India is yet to reach the target.
            - Cover threats faced by forests - from environmental notes such as deforestation, agriculture expansion, mining, dams, forest fires
        - Resultant **impact of forests on climate change**: Positve Impact can also be written
            - **Unseasonal rains**, **regional weather** getting **hotter**, **extinction of species** which are dependent on the forest ecosystem, aggravate CC when forests reduce due to forest acting as carbon sinks, economic impact (forest degradation causing reduction in GDP by 1.4% as per TERI)
            - Positive impacts: Carbon stocks, Mangroves as disaster risk reduction, Help tackle issue of air pollution
        - Impact of CC on forests
            - Forest fires (Australian bush fires, Amazon fires) , Drying of forests and wetlands, increased disaster such as glacial lake outburst impact montane forests, livelihood of tribals,
    - Cover measures taken: Social forestry, CAMPA, Bonn Challenge, plantation drives; **Harit Haram, Tree City, New York Declaration**
    - Measures needed: More and more decentralised approach to plantation and afforestation, international cooperation, partnership with states to achieve goals of paris agreement and SDG 13 (Climate action)
- **2013 Causes of formation of urban heat islands of the world**

- Urban Heat Island effect (**micro climate phenomenon**) is defined as the presence of significantly higher temperatures in urban areas compared to the temperatures in surrounding rural zones mainly due to human factors. **Average temperature is greater than 2 degree celcius** as compared to suburban or rural areas (Eg: Bangalore, Hyderabad, New York)
  - Mumbai lost 40% of its green cover b/w 1991 & 2018 (Report by Aligarh Muslin Univ and others) → led to 2 degree rise → Urban heat island
  - These can affect communities by increasing summertime peak energy demand, air conditioning costs, air pollution and greenhouse gas emissions, heat-related illness and mortality
- **Reasons:**
  - Material for pavements, roads and roofs such as concrete, tar and bricks have higher heat absorption capacity unlike rural areas which has more open lands;
  - **Deforestation & Encroachment of wetlands**: **Mumbai** lost **40%** of its green cover**,** Wetlands encroached in **Bangalore**
    - Also due **lack of evapotranspiration** (evaporation + transpiration is **less due to lack of trees)**
  - Urban Canyon effect: street is flanked by buildings on both sides, which traps heats rather than allowing it to escape
  - Excessive use of air conditioners **creates a cycle of more energy demand**, more power generation plants, and more pollution and heating
  - Usage of **individual transportation** rather than **mass** transportation
- Solution: Making road surface greyish or pinkish (as in USA); Rooftops as green; Planting as many trees as possible but not just for token but nurturing them year after year; Other comforts such as **good ventilation**; **Architectural designs must reduce thermal load** on buildings; Implement **India Cooling Action Plan**; **Reflective paints** rather than dark colours to take advantage of albedo effect

- **2016-Concept of air mass and role in macroclimatic changes**
  - An air mass is a large **volume of air** in the atmosphere that is **mostly uniform in temperature and moisture**
  - Formation of air masses:
    - When the air **remains over a homogenous area** for a sufficiently longer time, it acquires the characteristics of the area through **heat and moisture exchanges** with the surface (surfaces cane be vast ocean surface or vast plains) The homogenous surfaces are called the source regions. The **necessary conditions** for development of an airmass are **large scale subsidence of air**

over the source region. The subsiding air acquires the properties of the source region.
    - **Types:** They are classified based on the source region and air mass modification. Thus there can be **tropical maritime air mass, tropical continental air mass**, **polar maritime air mass, polar continental air mass**
- How it affects climate: (read bolds) ⭐
    - **Cyclones and anti-cyclones**: Stormy cyclones form near the air-mass fronts. The **mixing of air masses** will result in rising air feeding the cyclone formations in the subtropical cyclone. Similarly, the **warm maritime tropical air mass** will provide the energy for tropical cyclones
    - **Temperature inversion**: When a warm air moves over a cold surface, temperature inversion results which inhibits further vertical cooling
    - **Temperature/Cooling effect**: **Maritime air mass** may also bring **moderating effect to coastal areas in the tropics**
    - **Drought**: they are the result of hot, **dry air mass**. This can **destroy natural vegetation** and kill trees. These regions have the **increase** risk of devastating **wildfires**. E.g. California wild fires
    - **Precipitation**: E.g. the maritime-tropical air over Atlantic Ocean, Caribbean Sea is a **major reason for precipitation <u>east</u> of Rocky Mountains**
    - Very **simple diagram** can be drawn ---> **World map and then label airmasses in tropics** as tropical continent and marine, **similar for** polar regions
    -
- **Other content related to fronts:** (not required for addressing the question)
    - When two different air masses meet, the **boundary zone between them is called a front**. The process of formation of the fronts is known as **frontogenesis**. The <u>fronts occur in middle latitudes</u> and they **do <u>not occur in tropical</u>** latitudes; Characterised by **steep gradient in temperature and pressure**
        - They are characterised by steep gradient in temperature and pressure. They bring abrupt changes in temperature and cause the air to rise to form clouds and cause precipitation
    - There can be **four types** of fronts such as **<u>Warm front</u> (WAM over CAM), <u>Cold front</u> (CAM goes below WAM), <u>Stationary front</u> and <u>Occluded front</u> (lifted WAM)**. When warm air mass rises above a cold air mass it is warm front. When the cold air mass forces its way under the warm air mass it is the cold front

        - If **an air mass is fully lifted (occuled means separated)** above the land surface, it is called the occluded front. When the front remains stationary, it is called a stationary front
    - **Note: in diagram CAM is at bottom and HAM is above (not reverse)**

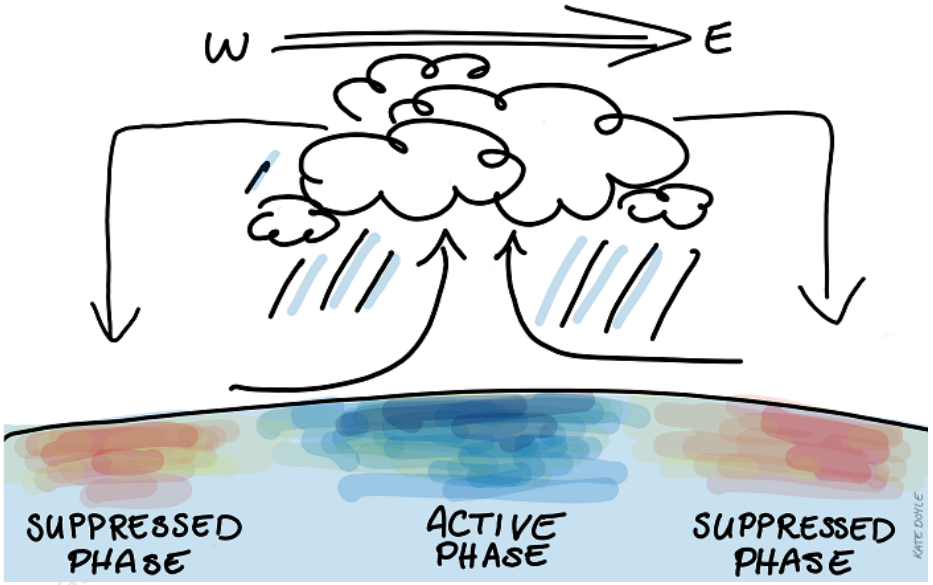


- 🔥🔥**2014- Most of unusual climatic happenings are explained as an outcome of El Nino effect. Do you agree? (1998 too)**
    - **El-Nino (warm phase of ENSO); Walker cell reverses in El-Nino; Use walker cell term at same latitudes as named after founder Gilbert Walker)** is a climate pattern that describes the unusual warming of surface waters in the eastern tropical Pacific Ocean triggering a cascade of global side effects. **La Nina, the "cool phase" of ENSO**, is a pattern that describes the unusual cooling of the tropical eastern Pacific. El nino more frequent then La Nina.
        - Each phase triggers predictable disruptions of temperature, precipitation, and winds disrupting large-scale air movements in the tropics, triggering a cascade of global side effects
        - Extra
            - El Nino has been used to explain unusual climatic changes across the globe
            - The El Nino event is not a regular cycle, they are not predictable and occur irregularly at two- to seven-year intervals. The Southern Oscillation is a change in air pressure over the tropical Pacific Ocean
            - When the linkage between El Nino and climate effects were initially suggested by the British scientist, Gilbert Walker, it was deemed ridiculous that one phenomenon could have an effect on regions as far off as Australia, India etc and Canada. However, the occurrence of El Nino in the past few

decades has proved without a doubt, their far-reaching consequences

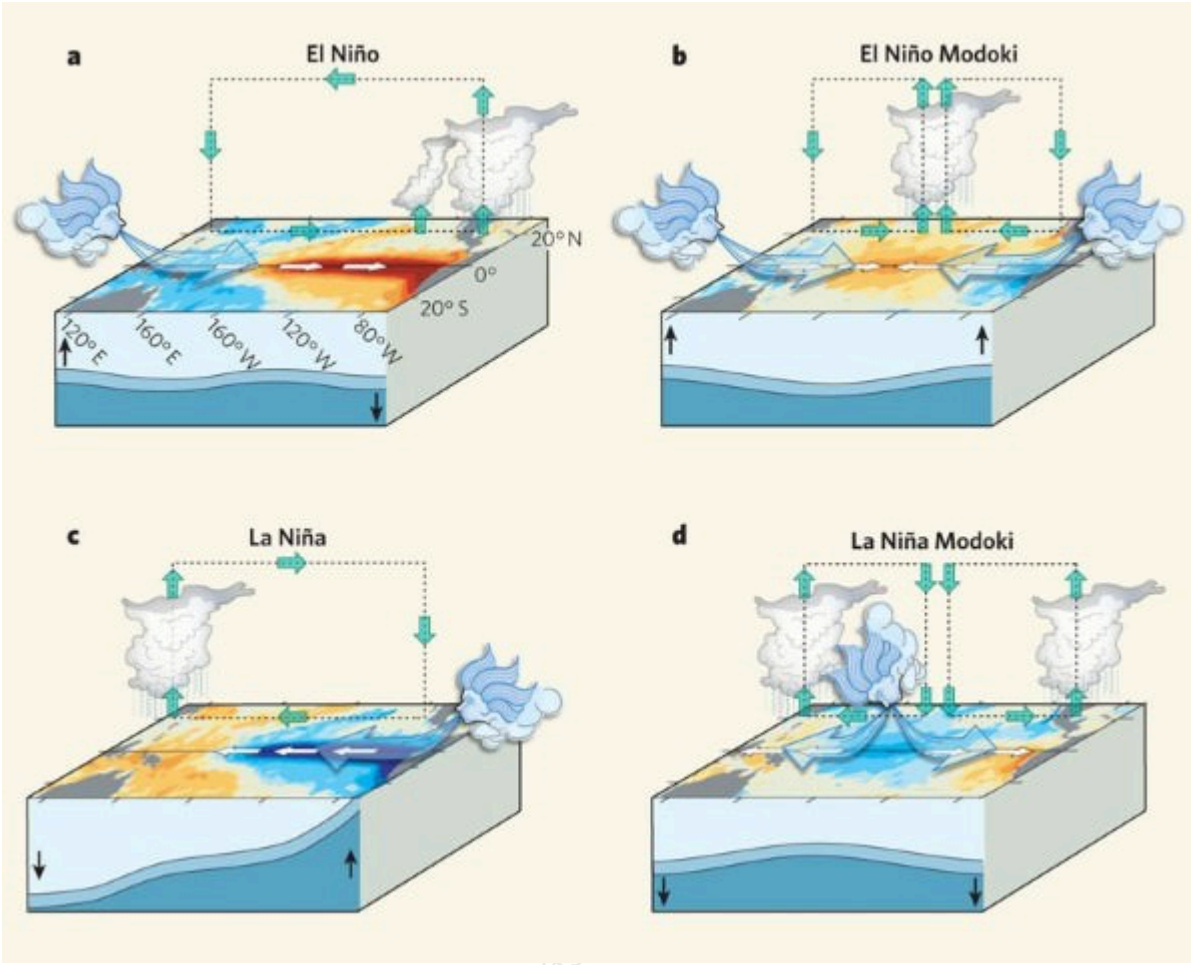
- **Impact of El Nino:** Increases Rf in SA and southern United States, **Indian Rf ⬇️ as affects Mascerene high**, Reverse in AUS-**wild fire/agri loss**, **Cyclones ⬆️ in Arabian Sea** and ⬇️ in BoB
- **(Refer Image at end) Draw simple diagram** of Aus, SA with **Walker Cell emerging** (wind movement; at same latitude unlike other cells) and clouds → showing Rf at SA
  - Impact of El Nino: Increases Rf in SA, Reverse in AUS-wild fire/agri loss, Reduces Rf in India, Cyclones ⬆️ in Arabian Sea and reduced in BoB, wetter weather to the southern United States, Indian Rf ⬇️ as affects Mascerene high
    - (Refer Image at end) Draw simple diagram of Aus, SA with Walker Cell emerging (wind movement; at same latitude unlike other cells) and clouds → showing Rf at SA
    - Increased Rainfall in SA: Rainfall increases drastically in South America (Heating leads to low pressure at South american coast), contributing to coastal flooding and erosion. Also affects fishing at SA coast.
    - Cooler and wetter weather to the southern United States
    - India: Strong El Nino events contribute to weaker monsoons (affects Mascerene high and Aus connection) and even droughts in India Southeast Asia
      - Cyclones ⬆️ in Arabian Sea and reduced in BoB
    - In Australia and wider Western pacific: droughts (Indonesia too) threaten the region's water supplies, as reservoirs dry and rivers carry less water. Agriculture also threatened.Drought can lead to wildfires that create respiratory problems
    - Positive impact: It can sometimes have a positive impact too, for example, El Nino reduces the instances of hurricanes in the Atlantic
    - Impacts the MJO, IOD
- La Nina **(Reverse of El Nino)**
  - La Nina event is observed when the water temperature in the Eastern Pacific gets comparatively colder than normal- leads to strong high pressure over the eastern equatorial Pacific.(SA coast)
  - Impact of La Nina
    - India: In the 'La Nina year', rainfall associated with the summer monsoon in Southeast Asia tends to be greater than normal, especially in northwest India and Bangladesh. It usually brings in colder than normal winters in India- benefits the Indian economy and agri.

        - South America: La Nina causes drought in the South American countries of Peru and Ecuador.
            - But positive impact on the fishing industry of western South America.
        - Australia and Western pacific : It also leads to heavy floods in Australia.(The 2010 La Nina -one of the worst floods in the history of Queensland, Australia)
        - North America: Hurricanes in the Caribbean and central Atlantic area, Greater instances of tornados in various states of the US.
    - **Madden-Julian Oscillation (MJO)** is an oceanic-atmospheric phenomenon which affects weather activities across the globe. It is an **eastward moving 'pulse' of clouds, rainfall, winds and pressure** near the equator that typically recurs every 30 to 60 days. It's a traversing phenomenon and is most prominent over the Indian and Pacific Oceans.; It has **2 phases**: Enhanced rainfall (or **convective) phase** and **Suppressed rainfall**phase; **Shorter the cycle of MJO = better the Indian Monsoon; MJO is traversing (unlike IOD and El Nino)**



        - The journey of MJO goes through eight phases.
            - When it is over the Indian Ocean during the Monsoon season, it brings good rainfall over the Indian subcontinent.
            - Shorter the cycle of MJO, better the Indian Monsoon. Simply because it then visits the Indian Ocean more often during the four-month-long period.
    - **Indian Ocean Dipole** also known as the Indian Niño, is an **irregular oscillation of sea surface temperatures** in which the western Indian Ocean becomes alternately warmer **(positive phase**) and then colder (**negative phase)** than the eastern part of the ocean

- IOD and El Nino remain over their respective positions, while MJO is a traversing phenomenon
    - A positive Indian Ocean Dipole — where the western portions of the Indian Ocean are warmer than the east and thereby push rain-bearing clouds over India
    - IOD and El Nino remain over their respective positions, while MJO is a traversing phenomenon
- ENSO (El Nino Southern Oscillation) refers to the oscillation between the El Nino and the La Nina.
    - **ENSO shifts irregularly back and forth between El Nino and La Niña every two to seven years.**
    - During El-Nino, Walker cell (name of wind cell) coincides with ITCZ. During the same period, there is an increase in cyclones in arabian sea and decreased cyclones in BoB (due to reduced disturbances from south china sea)
- **El-Nino Modoki: (Higher Rf at Centre and low at AUS/SA)** In El-Nino there is only one walker cell (name of the wind cell) which gets reveresed, in El-nino modoki 2 walker cells emerge of which one gets reversed and one stays normal; Effects of the same area:
    - Creates high pressure (cold area) at Australia (west pacific) and S.America (east pacific) leading to reduced rainfall
    - Leads to increased rainfal in areas of central pacific

- 

    - Comparison of all:
        - The IOD, El Nino and MJO are all oceanic and atmospheric phenomena, which affect weather on a large scale. IOD only pertains to the Indian Ocean, but the other two affect weather on a global scale-up to the mid-latitudes.
- **2013: Recent cyclone called -Phallin, Process of naming of cyclones across the world?**
    - The main objective of the **WMO/ESCAP Panel on Tropical Cyclones** is to promote measures to improve tropical cyclone warning systems in the Bay of Bengal and the Arabian Sea. **This panel is one of the five regional tropical cyclone** bodies. For this purpose there are various Regional Specialised Meteorological Centres (RSMC)
    - **IMD, one of the six RSMC** (Regional Specialised Meteorological Centres) **in the world**, is mandated to issue advisories and name tropical cyclones in the north Indian Ocean region
    - There are **13** (recently changed, earlier 8) **WMO/ESCAP member countries** which **give 13 names each.** This makes it a list of **169 names**
        - **eg:** Name **Tauktae given by Oman, Biparjoy (by BG which means disaster)**
    - 13 countries are:

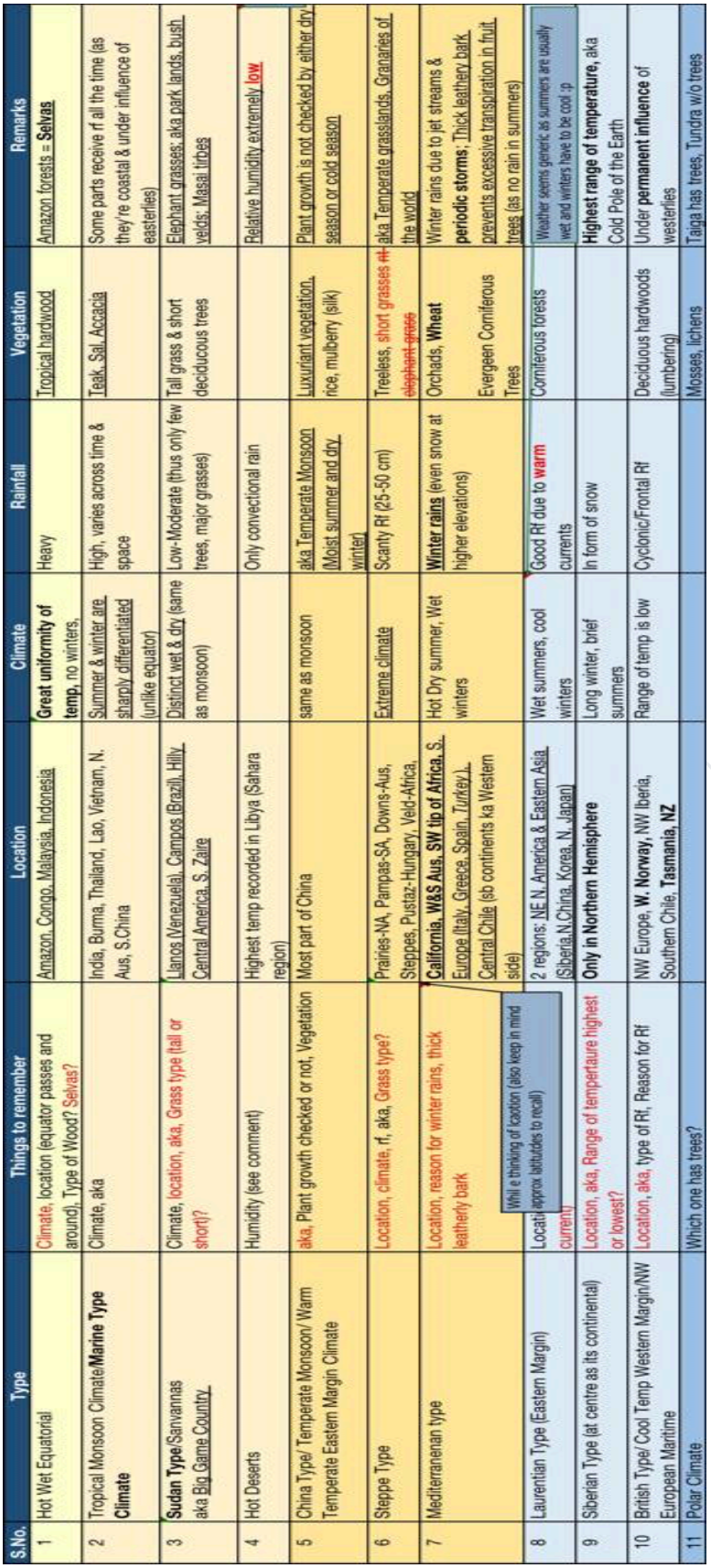
        - 7 from BoB and AS: Bangladesh, India, Maldives, Pakistan, Sri Lanka, Myanmar, Thailand
        - 6 from Persian Gulf: Iran, Oman, Qatar, Saudi Arabia, United Arab Emirates and Yemen
            - (Note: Kuwait, Baharain, Iraq, Indonesia as well as African countries are not part of it)
    - Criteria:
        - The **name should be short** and readily understood when broadcast.
        - Further, the names must **not be culturally sensitive** and should not convey any unintended and potentially inflammatory meaning.
    - **Benefits of naming:**
        - Better media coverage, heightens interest in warnings, and increases community preparedness.
        - Avoids confusion, specially in cases of mulitple cyclones across the water bodies
        - Easier to remember compared to numbers and technical terms
- **2008: The winter rains in North India are largely related to Jet Streams and Western Disturbances. Bring about the relationship**
    - ⭐ **Western disturbances are temperate/extra-tropical cyclones** originating in the Mediterranean Sea region **due to formation of fronts**. The **clouds formed by theses front are carried to India** by jet streams(as due to winter JS is south of himalayas unlike in north of tibet during monsoon)
    - During winter season, westerly jet strem is well established in the south of Himalayan region (unlike in monsoon where it is to the north of tibet) and under the influence of this westerly jet, these cyclonic waves move from West to East
    - Western Disturbances (WDs) are temperate or extra-tropical cyclones originating in the Mediterranean region and are embedded in the mid-latitude sub-tropical westerly jet stream
    - An **increase** in the prevailing night temperature generally indicates an advance in the arrival of these cyclone disturbances. They travel eastwards and enter the Indian sub-continent after crossing over Iraq, Iran and Afghanistan.
    - **Positive impacts**: Good for Rabi crops-wheat/barley/mustard/**saffron**; Good for Skiing Tourism and Glaciers; Himalayan rivers perennial;
        - These western disturbances cause **light rain in the Indo-Gangetic plains** and snowfall in the Northern mountains. After the passage of the Western disturbances, widespread fog and cold waves are experienced. The amount of rainfall received from the Western disturbances is very small, but it is highly useful

for Rabi crops, especially **wheat, mustard and barley** etc.; **Saffron cultivation**
        - **Snowfall in the Northern mountains**, makes the **Himalayan rivers perennial**, which acts as a source of freshwater for agriculture, drinking water, **Skiing Tourism** etc
    - **Negative impacts**: Unreasonable Hail → crop damage; **Natural disasters** like **cloudburst Kasmhir floods 2014**; Civilian deaths **lightining (RJ area)**
        - **Unseasonable** rainfall and **hail** brought about by western disturbances **damages the crops**.
        - **Natural disasters** like cloudburst in Leh (2010), the **Kashmir floods in 2014** and **even 2013 floods in Uttarakhand** were caused by the Western Disturbances. These calamities killed thousands of people and caused a lot of destruction in towns and cities situated on the bank of flooded rivers.
        - It can also cause **death of civilians** due to **lightning** in areas (recently happened in RJ),
    - Good Conclusion: Due to their profound impact on climate and agriculture of India, Western disturbances need to be studied in much more detail. Like tropical cyclones or monsoon, there needs to be an end to end tracking of western disturbances to make it less hazardous.
- **2013- Phenomenon of temperature inversion and impact on weather/habitants**
    - Ideally, with an increase in height, temperature decreases. Eg in troposphere decreases with an increase in the altitude at the rate of **6.5 °C per kilometre** (**called normal lapse rate**). However **contradictory phenomenon in which temp inc with height is called temperature inversion**
    - The **cool layer of air is overridden by a warm layer** of air above in temperature inversion Ideal conditions for temperature inversion- **Calm and stable air**, Long cool nights and **Clear skies**
    - **Types: Frontal Inversion** (HAM above CAM as cold heavier; seen in temperate zones, casuse)**, Mountain Inversion** (cold air on the mountains seeps down, warm pushed above)**; Radiation Inversion** (During **night**, ground and air near it **cools faster than high up)**
        - Frontal Temperature inversion: When warm and cold fronts meet, the warm front rises above and the cold front being heavier sinks. Hence a series of layers are formed. It often occurs in the temperate zone (due to the convergence of warm westerlies and cold polar winds in the northern hemisphere) and causes anticyclonic conditions which result in precipitation in different forms.

        - Mountain inversion: occurs in mountainous areas during winters. During long winter nights, due to high pressure, cold air on the mountains seeps down and occupies valley floors. Hence the warm air is pushed upwards as a consequence. This gives rise to temperature inversion
        - Radiation Inversion: During the day, the sun heats the earth and air near it. At night, the ground and the air near it cool faster than that high up, creating an inversion of temperature
    - **Effects of Temperature Inversion** on weather and habitants of place:
        - **Lower visibility: Fog/smoke/dust particles are trapped** - due to the situation of warm air above and cold air below, and hence Visibility is reduced due to the formation of fog. This causes a lot of problem to the people, particularly in the transportation, as flights and trains are cancelled due to low visibility. Highways get blocked due to the slow movement of vehicles.(**Accidents on Yamuna expressway** every year)
        - **Diffusion of air pollutants is limited** in case of temperature inversion- **major reason for Delhi Smog**
        - **Valleys may become very cold** due to temperature inversion. People have to face cool weather and hence **migrate up to the hills**
        - It may **disturb the radio signals in the region** as more of it is refracted from layers above the cold air
        - Other impacts: **Frost Bites among trees due to low temperature;**
        - Thunderstorms and tornadoes: **Intense thunderstorms and tornadoes (but Rf is not high)** are also associated with inversion of temperature
            - Stops the movement of air: It causes the stability of the atmosphere that stops the downward and upward movement of air.
            - Less rainfall: Convection clouds can not move high upwards so there is less rainfall and no showers. So, it causes a problem for agricultural productivity
            - It causes frost when the condensation of warm air due to its cooling by cold air below occurs at a temperature below freezing point. Temperature Inversion also determines precipitation, cloud forms etc.
- **2007- Significance of Himalayas and Tibetan highland on SW monsoon, 2001 if no himalaya -effect of North India Winter**
    - Formation of Himalayas

    - The Himalayas, one of the **youngest and active mountain** ranges in the world, rose when the North-ward moving Indian tectonic plate rammed against the Asian plate.
    - This **release of energy along the fault lines causes earth quakes**. The **collision of continent-continent** plate convergence produces earthquakes of higher magnitude.
- **Significance of Himalayas**: Rivers originate; Role in Rf-intercept SW monsoon winds; Abode of Biodiversity-Rajaji NP/Hemis NP/Ramsar Sites; Natural barriers for Cold AM from Central Asia; Health resorts/Holy places; Divided westerly JS (affecting monsoon)
    - Many rivers originate from Himalayas. Ex: Ganga, Brahmaputra, etc. The rivers originating from the Himalayas carry fertile soil from the mountains to the plains. They also help in generating hydroelectricity.
    - It is an abode of bio-diversity. Valley of flowers, Hemis-high altitude, Rajaji national park are some of the national parks present in the region. Contains wetlands of international importance. Ex: Tso Moriri, Pangong Tso.
    - Intercept the summer monsoon winds and cause rainfall.
    - They prevent the cold continental air masses of Central Asia from entering into India. Thus it prevents India from becoming a cold desert.(acts as natural climatic barrier)
    - Divide the Sub-Tropical westerly jet stream into northern and southern branches. Only after withdrawal of southern branch does the high pressure system recedes and the monsoon advances.
    - Many health resorts and holy places have been developed, which are visited by thousands of people every year.
    - But Snowfall in the Himalayas causes cold waves in North India.
- **Changes observed**: Rise in annual temp; Precipitation changes; Tree line is moving at higher elevation; Frequency of hazards has ⬆️; Tourism going beyond ecological capacity
    - Average annual temperature has increased in the foothills, middle mountains as well as the higher Himalayas in the past few years.
    - Total annual precipitation changes- decreasing at one site and increasing at a site nearby, indicating erratic nature of rainfall.
    - Reduced snowfall in frequency and amount has caused reduction in extent and duration of snow cover and in flow of rivers
    - Tree lines have been moving to higher elevation due to increasing temperature.
    - Diversion of rivers has affected natural flows.
    - Frequency of hazardous events such as cloud bursts, breach of glacial dammed lakes as well as seismicity has increased.

    - **Anthropogenic causes behind the change:** GHG induced warming; Deposition of soot reduces albedo effect; Dam building impacts water ecology (despite Chopra Committee recommendation)
        - Greenhouse gases induced global warming
        - Deposition of soot and aerosols near the ground has significantly impacted the albedo in Tibetan glaciers.
        - Multiple dams, such as those by China on the Tsangpo or by India on tributaries of Ganga/Yamuna/Indus in the Himalayan region have affected flow of rivers in the area. While dams do act as a buffer to absorb excess water flows, they seriously impact water ecology.
        - Unintended releases can also cause floods in downstream areas. Besides, seepage of water causes loosening of rocks and can cause reservoir induced seismicity
- **Rossby Waves:**
    - When the **arctic jet stream becomes wavy and flows into lower latitudes that meandering is called rossby waves**. They are giant meanders in high-altitude winds that have a major influence on the weather.
    - Occur both in ocean (below the water surface in thermocline regiom; move westward) and atmospheric (moves west to east but not towards the equator)
    - They are influenced by the Coriolis force and pressure gradient (rotation of earth)
    - If there is anamoly (slows down or meanders differently) it can cause large scale destruction: Twin cyclones, Forest fires in Russia, **Recent Pakistan floods, North American Heatwave** 2018, etc
- **Climate regions with location, temperature, rainfall, vegetation, etc**



S.No.	Type	Things to remember	Location	Climate	Rainfall	Vegetation	Remarks
1	Hot Wet Equatorial	Climate, location (equator passes and around), Type of Wood? Selvas?	Amazon, Congo, Malaysia, Indonesia	**Great uniformity of temp,** no winters,	Heavy	Tropical hardwood	Amazon forests = **Selvas**
2	Tropical Monsoon Climate/**Marine Type Climate**	Climate, aka	India, Burma, Thailand, Lao, Vietnam, N. Aus, S.China	Summer & winter are sharply differentiated (unlike equator)	High, varies across time & space	Teak, Sal, Accacia	Some parts receive rf all the time (as they're coastal & under influence of easterlies)
3	**Sudan Type**/Sanvannas aka Big Game Country	Climate, location, aka, Grass type (tall or short)?	Llanos (Venezuela), Campos (Brazil), Hilly Central America, S. Zaire	Distinct wet & dry (same as monsoon)	Low-Moderate (thus only few trees, major grasses)	Tall grass & short deciducous trees	Elephant grasses; aka park lands, bush velds; Masai tirbes
4	Hot Deserts	Humidity (see comment)	Highest temp recorded in Libya (Sahara region)		Only convectional rain		Relative humidity extremely low
5	China Type/ Temperate Monsoon/ Warm Temperate Eastern Margin Climate	aka, Plant growth checked or not, Vegetation	Most part of China	same as monsoon	aka Temperate Monsoon (Moist summer and dry winter)	Luxuriant vegetation, rice, mulberry (silk)	Plant growth is not checked by either dry season or cold season
6	Steppe Type	Location, climate, rf, aka, Grass type?	Prairies-NA, Pampas-SA, Downs-Aus, Steppes, Pustaz-Hungary, Veld-Africa,	Extreme climate	Scanty Rf (25-50 cm)	Treeless, short grasses ~~elephant grass~~	aka Temperate grasslands, Granaries of the world
7	Mediterranenan type	Location, reason for winter rains, thick leatherly bark	**California, W&S Aus, SW tip of Africa**, S. Europe (Italy, Greece, Spain, Turkey), Central Chile (sb continents ka Western side)	Hot Dry summer, Wet winters	**Winter rains** (even snow at higher elevations)	Orchads, **Wheat** Evergeen Corniferous Trees	Winter rains due to jet streams & **periodic storms**; Thick leathery bark prevents excessive transpiration in fruit trees (as no rain in summers)
8	Laurentian Type (Eastern Margin)	Locati	2 regions: NE N. America & Eastern Asia (Siberia,N.China, Korea, N. Japan)	Wet summers, cool winters	Good Rf due to warm currents	Corniferous forests	Weather seems generic as summers are usually wet and winters have to be cool :p
9	Siberian Type (at centre as its continental)	Location, aka, Range of tempertaure highest or lowest?	**Only in Northern Hemisphere**	Long winter, brief summers	In form of snow		**Highest range of temperature,** aka Cold Pole of the Earth
10	British Type/ Cool Temp Western Margin/NW European Maritime	Location, aka, type of Rf, Reason for Rf	NW Europe, **W. Norway,** NW Iberia, Southern Chile, **Tasmania, NZ**	Range of temp is low	Cyclonic/Frontal Rf	Deciduous hardwoods (lumbering)	Under **permanent influence** of westerlies
11	Polar Climate	Which one has trees?				Mosses, lichens	Taiga has trees, Tundra w/o trees

While thinking of location (also keep in mind approx latitudes to recall)

Syllabus: Distribution of key natural resources across the world (including South Asia and the Indian sub-continent)

Factors responsible for the location of primary, secondary, and tertiary sector industries in various parts of the world (including India)

Solutions - Human & Economic Geography

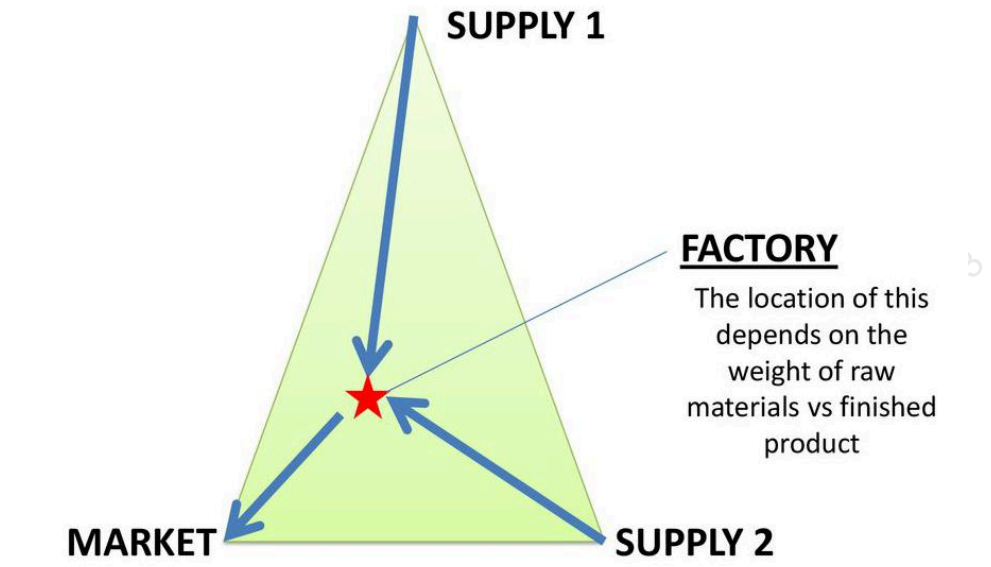
Location Factors

1. **General Points for Location of Industries**
    a. Alfred Weber in his **'Least Cost Theory' Model** - there are **three main factors** influencing industry location which are transportation cost (most imp factor; check whether product is weight gaining or weight losing), labour cost and agglomeration economies [sometimes benefits from last 2 factors can compensate for increased transportation cost]
    b. **Geographical factors** (SF **MR+TLC+PW**- **Market-dom/int or paying capacity of market** eg: FPI near PJ; **RM Index** = W of RM/W of FG; **Transp of RM/FG**-lumbering Canada via rivers/snow; **Golden Quadrilateral/DFC/road infra**; **Lab-**skill/unskill-eg:Diamond cutting at Surat; **Climate**-Dry climate good for FPI, ***humid*** **for cotton**) + **Power** (eg: Vindhyan cement using Indira Sagar hydroelec project) + **Water**-thermal/chem plant near water
        i. Market (domestic/international): Closeness to market, demand in the market, paying capacity of the market are key determinants in location factors. Cotton textile industries are close to urban centres like Mumbai, Ahmedabad, woolen textiles in Punjab, agro food processing near markets; Add names of near by industrial hubs/centres eg: in MP add names of Indore, Jabalpur, etc
        ii. Raw materials: Industries using weight losing raw materials/ heavy and bulky raw material are located close to the raw-material sources. Ex: Sugar mills in India are close to the sugarcane growing areas. Iron and steel industries near coal fields or iron ore mines
            1. Weber has given Material Index = Weight of Raw Material / Weight of finished commodity. If the index number is greater than 1, then get located near to source of raw material (same thing said in a fancier way 😛)
        iii. Transport: Adequate and cheap transport is essential for transport of inputs and finished goods. The Rhine valley in Germany has emerged as a manufacturing hub because of the extensively developed waterway (similarly with St. Lawrence river in North America) Canada paper mills - lumbering in its coniferous forests coupled by cheap transport through the rivers; Write generic transport through several junctions, road infra, DFC, etc

iv. Labour: Cheap labour (both skilled and unskilled) and adequate availability imp. China has seen remarkable growth in manufacturing because of availability of surplus labour and low wages, diamond cutting industry in Surat (labour oriented location)
v. Climate and Topography: The topography, climate of the area is another determinant, Humid conditions necessary for cotton textiles- eg Guj, Maha.
vi. Power: It is a significant factor for energy intensive industries. Iron and steel industry near coal blocks, smelting of aluminium in Canada near hydroelectricity potential areas. eg: Cement plants in Vindhyan region get cement from Indira Sagar Hydroelectric power plant
vii. Water- Iron and steel, chemical textiles- require huge quantity of waters- set up near lakes, rivers, canals etc, also thermal power plants near water sources for cooling.

c. **Non-geographical: Tech**-Silicon valley; **Capital**-near Mumb/Kolk; **Govt Policy-Dev backward regions eg: steel plant in Bhilai/SEZ/Indus corridor**/Legal & Regu Scenario/Green Revol link/Mega Food Parks/Sep dept for FPI by PJ govt; **Industrial Intertia/Agglomeration effect** eg Automobile-cheaper to modernize existing areas)
    i. Technological- IT industries in areas like Silicon valley, Bangalore
    ii. Capital: Reason why many industries near capial intensive regions like Mumbai, Kolkata, Delhi
    iii. Government policy: Establishment of iron and steel industry in Bhilai and Rourkela were based on decision to develop backward tribal areas, govt subsidy benefits, states with better EODB (eg Maharashtra), aim of bridging regional disparities - (eg: of policies that can be used in examples SEZ, indus corridors, income tax benefits for backward regions, Govt policy → Cheap electricity for cold chain for agro processing industries, or linking it with Green Revolution; Legal and Regulatory scenario)
    iv. Industrial inertia: New industries set up where original estb has been set up earlier, companies prefer those locations only. Detroit still boasts automobile companies despite slowing market and labour availability
d. Draw diagram in the answer such as **triangle** **(showing raw material at 2 points and market at one end, according to the question market relevant point for location of industry)** and **agglomeration effect**(below diagram can be made for automobile industry, chemical, technical textile etc. for eg: automobile indus will come at black spot of agglomeration, and other 3 circles cane be 3 industries such as iron & steel, coal industry and textile/chem/glass industry)

i.



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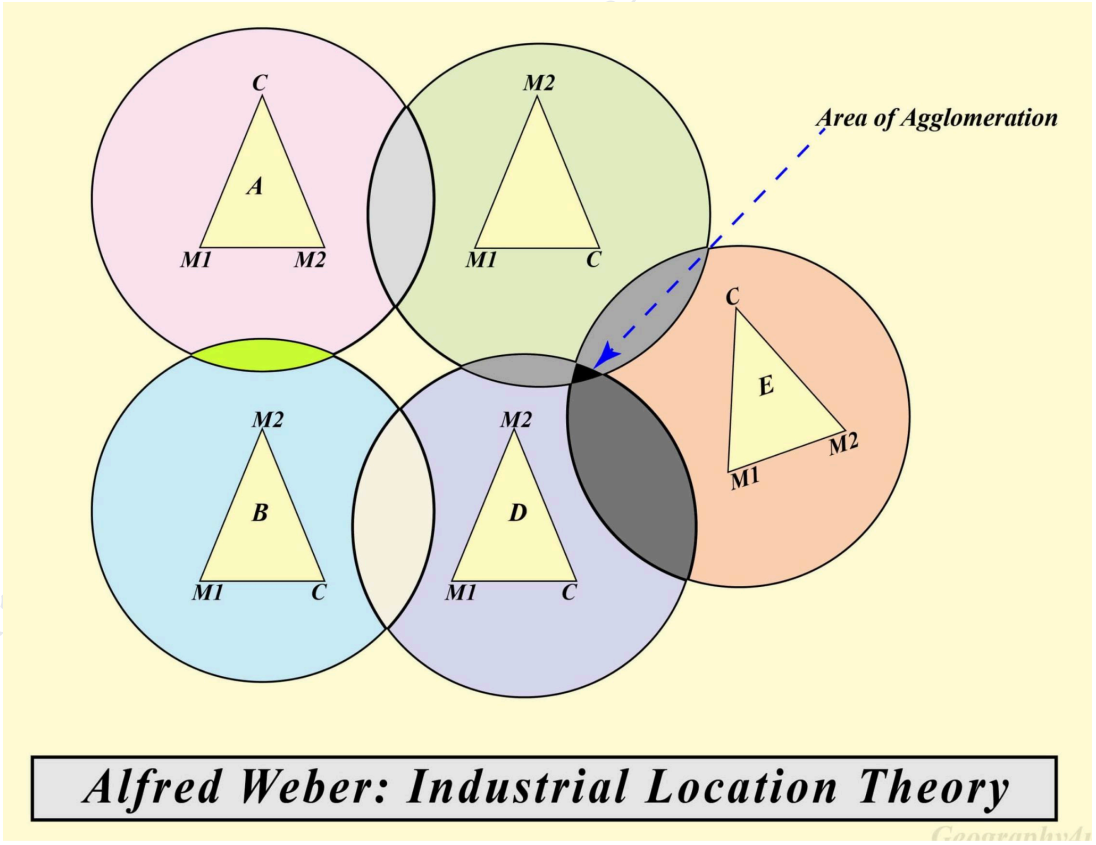


e. Common Conclusion: India is going through a phase of resource optimisation. Thus, location of industry needs to be optimally aligned to Weber's idea of Least cost location to achieve the goal of 5 trillion economy.

2. **2019- Can the strategy of regional-resource based manufacturing help in promoting employment in India?**
   a. Regional resource-based manufacturing means developing industry that can easily utilize the raw material or resource available locally- can avail the advantages from the locals by employing them for security, clerical,

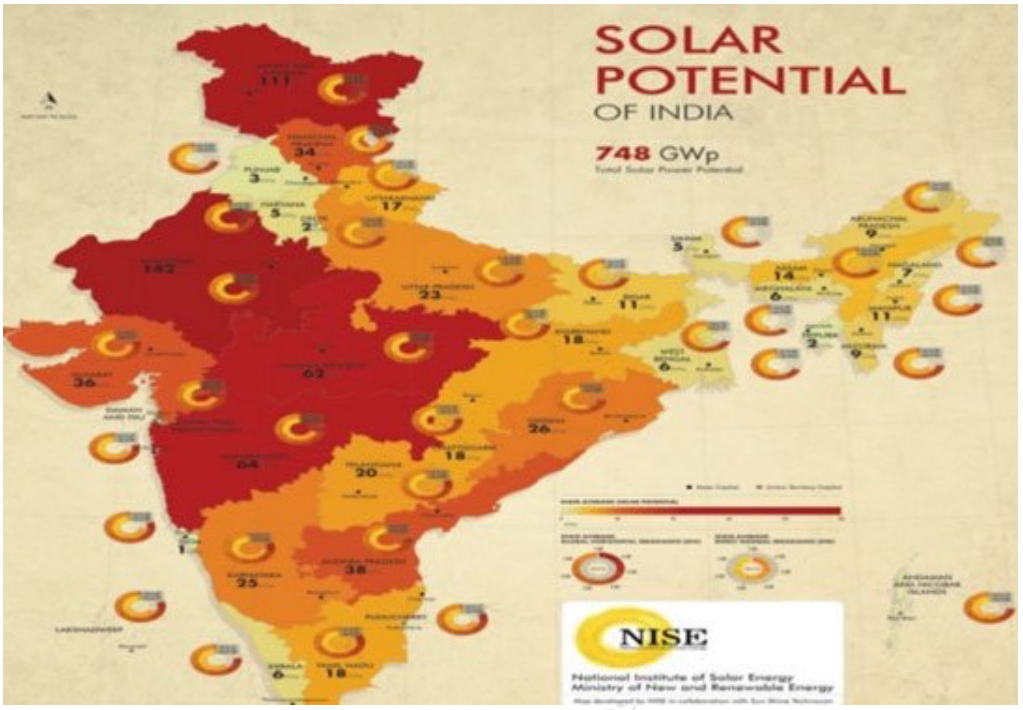
loading/unloading materials, admin and infrastructure creation and maintenance etc

i. Example- Employment has been generated in a great number by the Tata Steel for locals in city of Jamshedpur
    1. Yes it can → Benefits to employement
        a. If the employment generation is being done on a regional basis, then it will reduce the income gap between urban and rural and thereby reducing the distress migration in the country
        b. Unlike other manufacturing utilizing resources imports from the other country, regional resource-based manufacturing utilizes locally available raw materials. Ex- Copper ore extraction in the particular region will promote employment of miners and labourers of that region
        c. Rational use of available resource → as transit waste can be reduced
        d. Cost Cutting- The proximity of raw materials and manufacturing unit will help in reducing the cost of transportation. Ex- Millers in Punjab buy rice from local farmers, thereby providing ready market
        e. Expertise and promotes specialisation- Expertise could be developed in the region itself in the field of manufacturing which would help create more employment.- could become hub for specialisation
        f. Agglomeration Effect → Creating ancillary Industries due to supply chain- MSME's are established that act as suppliers of smaller items to the main Industry. These small industries will help in promoting more employment. Besides this, there is secondary employment opportunists through eateries, hostels and shops Ex: Gurugram in Haryana is dedicated to automobile manufacturing- enabled smaller industries to develop, which supply smaller items like nuts, axles, cranks etc to the large Industry.
        g. Other examples
            i. KVIC promoting khadi and village in rural areas near to cotton industries
            ii. Iron industries- Bokaro, Jamshedpur cities etc
            iii. Dairy industries in Gujarat gives emp to lakhs of dairy farmers
    2. No it cannot → Challenges for regional-based manufacturing such as:

3. Like Jharkhand, Chhattisgarh has abundant of mineral resources, but they weak infrastructure — mainly roads and power — that has been a major roadblock.
4. Prone to state level policies: Haryana, MP laws goes to extreme steps by reserving jobs- hamper EODB for biz
5. In the long run, technology changes can make set up non-viable
6. Recruiting will plateau as the industry stabilizes in its operations (therefore this is no panacea). Only business expansion in the same area to cater to new product lines or increment in the demand of the same products can mean increase the local employment
7. Overemphasis can backfire- stagnation in competitive market- Benefits of cheaper raw materials for production, employement can be created in areas where resource extraction is cheaper

b. **State govt measures: ODOP, NE Industrial Development Scheme (NEIDS); GI Tagged products**
   i. UP government's One District, One Product scheme seeks to promote traditional industries in every district(Also replicated at Centre for food processing sec
   ii. North East Industrial Development Scheme (NEIDS) encourages micro, small, and medium enterprises (MSMEs) to set up in the north-east region.
   iii. Forest-based industries and Tribal Products (by TRIFED) are being encouraged in different states because of its ability to solve the problem of unemployment and poverty.
   iv. Different states and regions harbour GI tagged products that could be manufactured locally and marketed globally.
   v. Regional resource-based manufacturing is good to increase employment and securing a balanced and coordinated development of the decentralized manufacturing economy in each region. This overall can helps in the development of the country.

3. **2020: India has immense potential of solar energy though there are regional variations in its development. Elaborate.**
   a. Introduction: Solar Energy - Potential (tropical country), Significance and Paris agreement targets, current status in energy mix
   b. **Potential**
      i. The National Institute of Solar Energy (**NISE**) has assessed the **Country's solar potential of about 748 GW** assuming 3% (Wind Energy is around 300 GW) of the wasteland area to be covered by Solar PV modules **(Draw Simple map as below)**

ii. 

c. **Regional variations:**
   i. **Rajasthan** has highest potential due to high insolation + **barren lands**
   ii. Currently **highest installed capacity in Karanataka**, followed by **TG, RJ**, AP, TN (top 5)
   iii. **Southern states** are at **advantage** due to **lying below Tropic of Cancer (eastern ghats more suitable as WG experiences heavy Rf)**
   iv. **NE** states have **less potential** due to **monsoon**-cloudy climate + **no large flat terrain**
   v. **Factors: Availability of land fit for pupose (levelled, sunlight, conflict with agriculture); Lack of RMs/technology, Very robust electric distribution system is missing; Political will**
   vi. **Mega parks** are built by the government at concentrated areas eg: **Solar plant at Rewa (Asia's largest)**
   vii. Northern regions have longer winter season, as compared to southern states
   viii. **WF: Need National competitive market for RM,** Promote decentralisation of solar energy via roof top solar (specially for hilly states due to their topography); **achieve One Sun/World/Grid (ISA) so that tech is accessible and affordable to all people; PM Surya Ghar Muft Bijli (receive 300 units of electricity free every month for upto 3kW capacity by putting rooftop solar)**

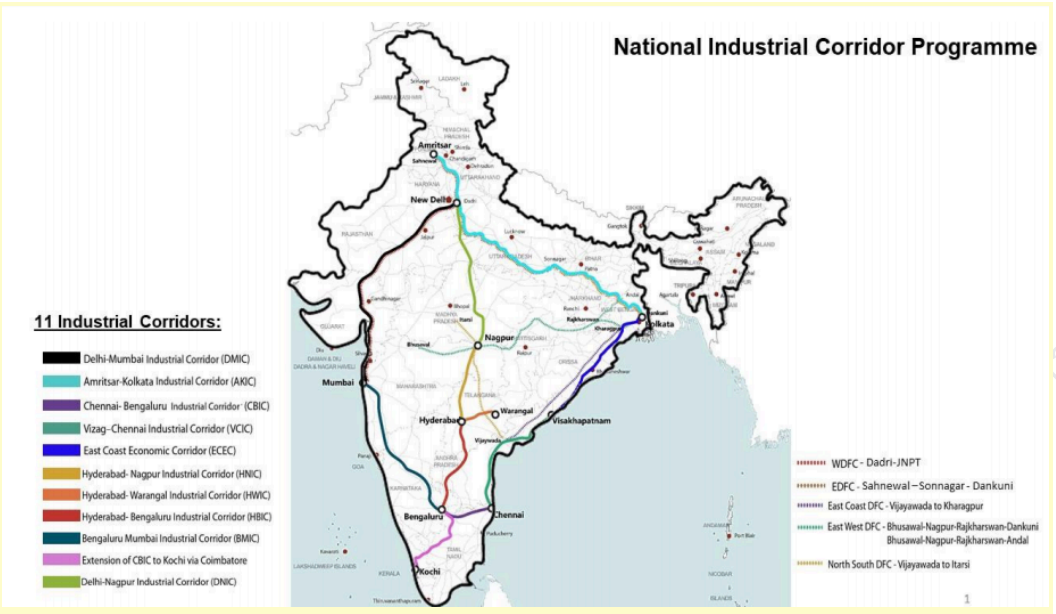
4. **2018- Industrial Corridors: Significance, give examples and their characterstics**
   a. Govt. of India is developing various Industrial Corridor Projects as part of National Industrial Corridor Programme. 11 Industrial Corridors Projects

are being taken up for development with 32 Projects to be developed in 04 phases up to 2024-25

b. Industrial Corridors (ICs) are stretches across the country allocated to a specific geographical area with the intent to stimulate industrial development. It aims to **create an area with a cluster of manufacturing** or other industries and gives an impetus to smart and sustainable cities by leveraging on the high speed, high connectivity transportation system **(don't mix this with DFC); Characteristics (as asked in Question):** Pre-existing infra; Mutli-modal freight connectivity; Smart cities along corridors

c. The Significance of Industrial Corridors in India
    i. Economic Significance
        1. Setting up of industrial townships, educational institutions, roads, railways, airports, hospitals along industrial corridors would generate employment and raise standard of living. People would find job opportunities close to their homes which would curb migration towards cities, thus preventing stress on already burdened urban landscape.
        2. Production costs would come down due to improved transportation system and agglomeration effect, making Indian goods competitive in domestic as well as foreign markets.
        3. Provide necessary logistics infrastructure needed to reap economies of scale, thus enabling firms to focus on their areas of core competence. Create more and more export opportunities
    ii. Env Significance: Prevention of concentration of industries in one particular location would prevent exploitation of environment as well as ensure balanced development in the country (as industries would be developed all along the corridor rather than at once specific region)
    iii. Socio-Economic Significance: The cascading effect of industrial corridors in socio-economic terms are many such as setting up of industrial townships, educational institutions, hospitals.

d. **Various Industrial Corridors of India** (**easy way to remember all 11 ICs - read links below with map**)

e. 

   i. Delhi to Mumbai, Mumbai to Bengaluru
   ii. 3 places from Bengaluru: B To Chennai, B to Kochi, B to Hyderabad
   iii. Hyderbad to Nagpur (not B to Nagpur direct) then Nagpur to Delhi, Hyderabad to Warrnagal
   iv. Chennai to Vizag, East Coast Economic Corridor (ECEC)
   v. Amritsar to Kolkata (overlaps Delhi)

f.

g. The Main Characteristics of Industrial Corridors
   i. Constructed in areas that have **pre-existing infrastructure**, such as ports, highways and railroads
   ii. **Smart cities** are being developed along these corridors
   iii. Dedicated construction of **residential areas, public utilities,** production units, **schools, and hospitals**
   iv. **Freight cargo** would be brought to the industrial corridor via rail and road feeder links that shall provide **last mile connectivity**

h. Challenges:
   i. Land acquisition, Improper economic and financial feasibility, pave the way for large human displacement and destruction of fertile agricultural land, Will need FDIs and foreign tech for the same - thus need to boost investor confidence which is low due to policy uncertainity
   ii. These projects are expected to play a critical role in raising the share of contribution of the manufacturing sector from approximately 16% to 25% by 2025

i. **Other information:**
   i. **National Investment & Manufacturing Zones** (NIMZs) are one of the important instruments of National Manufacturing Policy, 2011. While main objective of Special Economic Zones is promotion of exports, while **NIMZs** are based on the principle of industrial

growth in partnership with States and **focuses on manufacturing growth** and **employment generation. NMIZ** Examples: **Nagpur in MH, Chittoor in Andhra Pradesh, Medak in Telangana,** to name a few

j. **Major industrial regions (Corridors alag hai regions alag hai) of India #readagain (only yellow)**
    i. **Sequence: North to west to south to east to centre**
    ii. **Gurgaon (HY)-Delhi-Meerut (UP) region**
        1. **Light and market oriented** industries such as **software** industry, **electronic** industry; **Mathura is an oil refinery**
    iii. **Ahmedabad-Baroda region**
        1. **Cotton** growing GJ plains, **Petrochemical industry** around **Vadodara and Ankleshwar** (due to oil at gulf of cambay), Location of **Kandla port**, Easy market (due to densely populated northern plains), **Ship-breaking** yard at **Alang**
    iv. **Mumbai-Pune cluster**:
        1. RM (Black soil cotton, sugarcane), **Connectivity (Golden Quadrilateral; Mumbai-Pune Expressway)**, Ports (Mumbai and JNPT), **Energy** (Tata Hydel power station, **Atomic plants** at Trombay and Tarapur), Mumbai as financial centre = capital req; **Human capital (due to IIT,** BARC, Nat Inst. of Virology), Access to western markets, **Historical factors** (first rail line, opening of suez canal)
    v. **Bangalore-Tamil Nadu** region
        1. Hydel power from Pykara reservoir, **heavy engineering industries such as HAL, Bharat Electronics**; Petroleum refinery & Automobile hub at Chennai, iron and steel plant at Salem and fertiliser plants
    vi. **Kollam-Thiruvananthapuram** industrial cluster
        1. **Petroleum Refinery** at Kochi, **Agri products processing &** market oriented dominate **due to being away from mineral** belt eg: cotton, sugar, rubber, coconut, glass, etc
    vii. **Vishakhapatnam-Guntur belt**
        1. Ports is there, **Coalfields** of godavari basin, **ship building industry, iron ore industry** (gets resources from bailadila in CG)
    viii. **Hugli region**
        1. Port at Hugli and access to hinterland via Ganga-BH, **Agro-based (jute, tea, earlier indigo)**, **Historic** (Kolkata as british capital, made hub of INM till 1911), **Resources (from** Damodar valley coal fields, **chotanagpur**)
    ix. **Chottanagpur industrial belt**

1. Availability of **power** from the **Damodar Valley Project**, Discovery of coal and iron in the Bihar-Orissa belt, **cheap labour**, Proximity to **port (Paradwip,** Kolkata)

Iron and Steel Industry

- **Iron ore distribution across the world (these regions also have coal) #readagain**
  - **Germany — Ruhr Valley**, **Saxony region**
  - **US — Appalachian**-Pennsylvania-Great lakes
  - **Britain — Lancashire, York shire**, South wales
  - **China — Wuhan, Anshan**
  - **Australia — New South Wales** region, **Tasmania**
- The three essential inputs for iron and steel industry are **iron ore, coking coal and limestone (raw materials),**water for cooling and energy for heating. In iron and steel industries, iron ore and coal both are weight-losing raw materials (i.e **10 tonne ore but 1 tonnes actual steel**); **India 2nd largest producer of iron after China (also 2nd highest in cement); India has the largest iron ore reserves in Asia; 2 types found - Haematite, Magnetite**

- **Locational factors**
  - **Near iron ore mines**: To reduce the transportation cost, Industries are located near mines with Iron ore, manganese, limestone, dolomite deposits. For example, **Rourkela, Bokaro (also has coal) in India.**
  - **Near coal fields** — In **Britain, iron ore was found embedded with coal seams.** So, same area provided both iron ore and coal. During that era,

to process one ton of iron ore, you needed 8-12 tons of coal. So, weight-wise, it was cheaper to transport iron ore to coalfields rather than transporting coal to iron ore site. Near forest — Visvesvaraya Iron and Steel plant (Karnataka) was setup near jungle to get wood charcoal. **TISCO (JH) near Jharia coalfields**

- **Transportation**: Location near coastal regions reduces the cost of transporting **raw material (usually imported)** from port to factories. For example, **Vishakhapatnam in India, Japan**
- **Labour**: As time progressed, area near coal fields developed into industrial cities. So, there is already a large pool of skilled and experienced workers **eg: from Chota Nagpur region**
- **Water for Cooling: eg: Bokaro steel plant on the bank of river Damodar + Power: TISCO and Bokaro steel plant get hydroelectricity from Damodar Valley**
- **Modern Technology**: Such as electric smelters have helped in shifting of steel industries away from coal and iron-ore reserves by making efficient use of scrap metal & also reducing energy requirement. For example, **Bhushan steel** plant in **Ghaziabad**
- **Industrial Inertia**: Industries continue to be located in the same area despite decline of locational advantages e.g. depletion of raw material. For example, **Ruhr in Germany; Pittsburg in the USA**
  - Factors leading to intertia: Transport: The railroad, transport and communication infrastructure are well developed in the old area, Capital: cheaper to modernise or expand an existing location, Government policy: The industrialists in old area usually have deep pockets and political connections so they lobby to government
- Developmental policies of government for backward regions. For example, Bhilai (CG) and Salem (TN) plants in India.
- Strategic reasons: After WWII, the **USA and the USSR** adopted a policy to **not allow the concentration of the industry** in **one region**. Thus, in the USA some plants were setup in the western region such as California and the USSR in the eastern side towards Pacific coast.
- **Coastal areas**- By **early 20th century the coal and iron ore mines in US-Europe started getting depleted. So, they started importing** iron ore from other countries. **As a result the iron space and steel industry started moving toward coastal sites**- Eg, Steel industry in **Osaka-Kobe of Japan (despite no coal/iron)**, Steel plants at **Vishakhapatnam, Ratnagiri, Mangalore** in India, Malaysia has iron ore but not enough coal. Therefore steel plants located near coastal area to get imported coal at minimum transport cost.

- **Dominance of Chotanagpur plateau region**
  - **Low cost of iron ore** is available, since it is mined in this region.

    - This region is in **proximity to coal** producing states. So cheap raw material available. Other **supplement minerals like manganese, bauxite and limestone** are found in this part of the plateau in abundance.
    - Cheap, hard and skilled **labour** is easily available.
    - These industries have **sea ports** of the Indian peninsula like, **Haldia, Paradip**, Vishakhpatnam, Chennai etc., near to them.
    - **Inland waterways** and good network of roads to **serve domestic** market well
- **Changes in its location over the years**
    - Before 1950s, Ideal location near iron ore mines, coal fields etc. Post 1950s, on large areas of flat land near sea ports due to import of iron ore and market.
    - Over the years, important steel producing centres such as Bhilai, Durgapur, Burnpur, Jamshedpur, Rourkela, Bokaro are situated in a region that spreads over four states — West Bengal, Jharkhand, Odisha and Chhattisgarh. Bhadravati and Vijay Nagar in Karnataka, Visakhapatnam in Andhra Pradesh, Salem in Tamil Nadu are other important steel centres utilising local resources.
- **Cement Industry**
    - RM: Limestone constitutes 60-65%
- **Food Processing Industries**
    - **North west PB, HR** me kaafi located h **beverage industries** → (Proximity to food growing region)
    - **Dairy products (Gujarat -Amul, Karnataka** - **Nandini** Due to **cooperatives**)
    - **Organic food** industries (**Sikkim** and other regions)
    - **Fish, Chicken frozen** products (**Andhra, Kerala** etc)
    - Ek imp factor closer to **market** bhi rhega bhai
    - **Knowledge, GI tag** bhi ek factor rhega for **regional FPIs → Eg. Rasgulla, Bengali sweets**

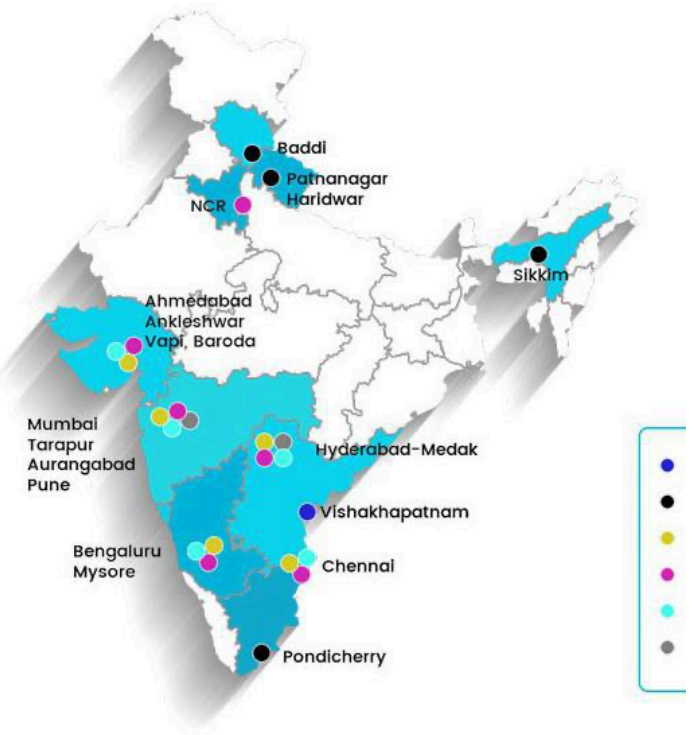
1. **2014- Account for change in the spatial pattern of the Iron and Steel industry across the world (cover the world angle continent wise rather than country wise)**
    a. **Growth and dev of iron and steel** industry- reflection of global economy
    b. In light of contemporary changes in location factors like **labour, transport**, communication revolution, local demands- **spatial pattern** of Iron and steel **shifting from developed to developing countries** (from Europe to Asia)

c. **Earlier- Western Europe** led- along with **US,USSR**- Ruhr, SAAR region, US, Japan made production capacities status quo(so US, Japan imports(recent trump tariffs), **after disintegration USSR lost** its edge
d. **Now- emerging** countries like **China (highest producer** in world, since 1973 in 15 years inc production by 215%),**India** producing at revolutionary scale, **Brazil- massive raw** materials, **Ukraine** after USSR, **Taiwan, Mexico** new entrants
e. Reasons- huge market in developing countries- demand for automobiles, capital infra
    i. Indian ocean and south east asian countries major navigation hubs- easy transport helps in location, imp of ports
    ii. Electric furnace- changing spatial pattern
    iii. Write Japan eg given below

2. **2020: Account for the present location of iron and steel industries away from the source of raw material, by giving examples.**
    a. 19th and early 20th centuries, due to the high amount of weight loss during processing, early iron and steel plants were mostly located where coal was available.
    b. with the passage of time, the depletion of raw material, emergence of **new technologies** (like electric furnaces), and fuel-saving transportation- locating away from the raw material sources. **Bhushan steel** plant in **Ghaziabad**
    c. Apart from the availability of raw materials, **capital and market are also important factors**
        i. **Japan is deficient in both iron ore and coal** and almost all raw materials are to be imported from overseas countries.
        ii. The great 'Tokyo-Yokohama' and iron steel regions are market-based.
        iii. **Industry in Tokyo-Yokohama as well as 'Osaka – Kobe – Heemeji' belt of Japan (despite no coal/iron) - due to market factor**
    d. **Transportation** is another controlling factor of the location of iron and steel industry
        i. the **Vizag Steel Plant**, Visakhapatnam in Andhra Pradesh, is the **first port-based plant** that started operating in 1992.
    e. The raw material-based industries are now facing disadvantages because of depleting reserves of raw material.
        i. **Exhausation of RM - Pittsburg, Durgapur Steel plant [Raniganj coal field of WB declined (Both feminine names Durga-Rani of WB is declined), now coal sourced from JH]**
    f. **Tax breaks -** boost location in economically backward areas
    g. **Strategic purposes -** close to Naval dockyard in France

h. Apart from this, the drastic reduction of coal use and **development of fuel economy** also attracted industries to the areas where transport is cheaper- eg a **cheap water route can bring raw material** easily.
    i. The geographic coincidence of any two factors (raw material,market,transport) however, determines the steel plant site

3. **Pharmaceutical Industry**
    a. India, being the largest provider of generic drugs globally, enjoys an important position in the global pharmaceuticals sector.
    Pharmaceutical industry is a footloose industry
    b. Current location:
        i. **3rd** largest by volume; **14th** by value
        ii. Majorly on **Western coasts of India** (**Vapi, Ankleshwar, Mumbai, Pune, Bangalore**) - **Reasons for the same** are - **Cheaper exports to Africa, Europe**; Nearby **petrochemical hubs**, **Historical reasons**(where we imported bulk drugs for further processing), **Skilled personnel** is available
        iii. **Clusters at Hyderabad and Chennai**: Regions other than western parts **grew as skilled work force**and domestic **demand increased**
        iv. **Hilly regions (HP, Uttrakhand, Sikkim)** - due to incentives such as extension of Special Package of Industrial Incentive, **tax and excise exemptions**, availability of **land banks**; Popularity of **alternative medicine** system has attracted hilly regions



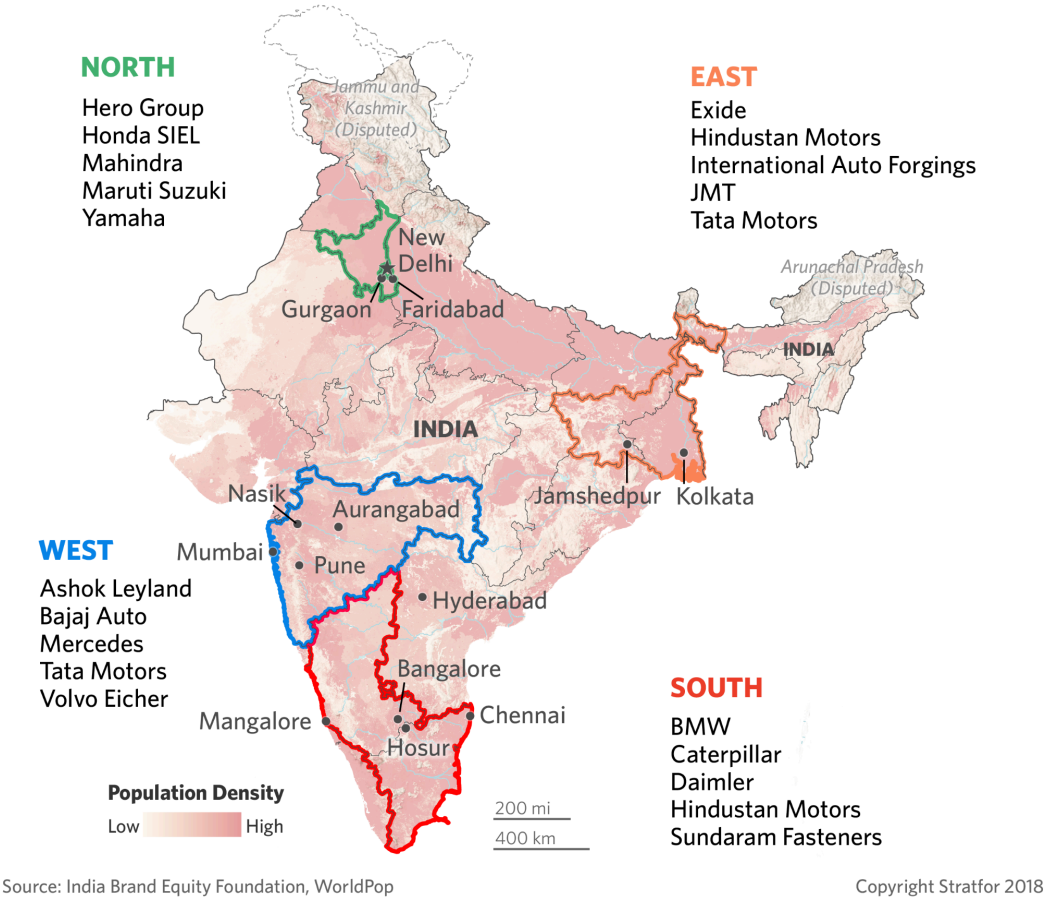
v.

c. Reasons for why India = pharmacy of the world: **Low cost** of production, **Generic** drugs, **Government's Pharma Vision 2020** aims to make India a global leader, **100% FDI** allowed in green field, Flexible patent system (Section 3(d) for checking evergreening and section 84 for compulsory licensing)
d. **Challenges**: Dependence on **API** for imports, **Issues with compliance with global regulatory standards**(eg: **diff to export to Arab areas**), Price Capping issues repel pharma cos, **Fake versions of high volume**brands (Spurious medicines)
e. **Growth prospects**: India's ageing population, vast pool of trained pharmaceutical personnel, medical toursim ($2 billion)

4. **Automobile Industry**
   a. Location:
      i. Automobile industry **requires large variety of raw materials** from other industrial sources namely steel, non-ferrous metals, window **glass**, **plastic, rubber**, wood, paint, textile, electronic cables, seat cushions etc. **Therefore, best location** for automobile industry is the **established industrial region**that has tradition of manufacturing such components
      ii. Remembers 4 location: **Delhi-Gurgaon-Faridabad** (Honda, Hero Group) in the north, **Mumbai-Pune-Nashik-Aurangabad** (Ashok Leyland) in the west, **Chennai-Bengaluru-Hosur** (BMW) in the south and **Jamshedpur-Kolkata** (Tata Motors) in the east
      iii. **Chennai** is nicknamed **"The Detroit of India".** Chennai accounts for 35% of the country's automobile component industry and 60 percent of the country's automotive exports
      iv.
   b. **Factors are generic: MR-TLC**
      i. M: India has ready market for automobile industry **especially metro cites like Delhi, Mumbai** due to factors such as rise in purchasing power, concerns of safety, Poor public transport, etc
      ii. R: Raw Material proximity: Ex: **Chennai** automobile sector is located **near Salem steel plant**
      iii. T: **Availability of ports** helps in import of machinery part and export of final product. thus favourable for Mumbai and Chennai port
      iv. L: India has presence of both cheap skilled as well as unskilled labour. Ex: Automobile center at **Delhi and Mumbai because of presence of cheap skilled labour**
   c. **Issues faced by Automobile industry** in India (**Think issues also on line of MR-TLC etc eg: Market is falling; Finance issue/NBFC Crisis; Tax/Policy issue such BSVI, rushed EV plan; RM-semiconductor chips; etc)**

i. Liquidity crunch in the NBFC industry; Overall economic slowdown in the country
ii. 28% GST charged on cars, motorcycles and scooters → deters purchase (also high RTO and other taxes)
iii. Mandatory transition to the BS VI emission norms - is an irritant
iv. India's Rushed EV Plan where GOI has envisioned a radical push for all vehicles to go fully electric by 2030
v. Shortage of semiconductor chips (due to supply chain shocks)
vi. Rise Of Ride-share Services like OLA, Uber → made customers hesitant to buy a vehicle

d.



Distribution of key natural resources

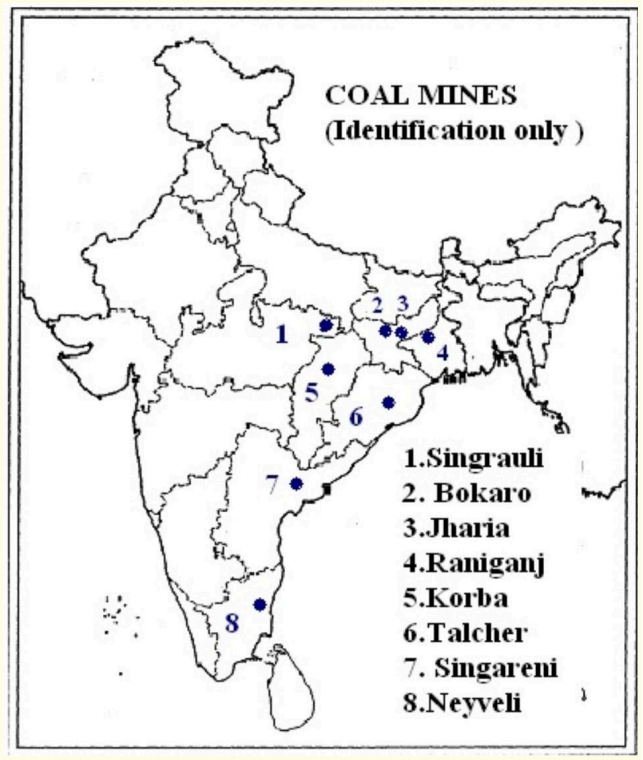
- **Petroleum Refinery: S.Arabia - Ras Tanura, Aramco; Kuwait; USA-East Coast; Japan-Honshu Island; Read India-below in image (all near ports)**

Petroleum Refinery		
	Saudi Arabia	Ras Tanura
	Kuwait	Mina-El-Ahmedi
	USA	East Coast
	Japan	Honshu island
	India	Reliance: Jamnagar, Gujarat) near sikka port, Trombay, Mangalore,Kochi, Chennai, Vishakhapatnam, Haldia
Bauxite		
	Australia	Queensland, Victoria & Tasmania
	USA	Eastern USA: Arkansas, Georgia and Alabama. Western USA: Arizona, Utah, and New Mexico states.
	India	Renkhoot UP, Hirakood Odisha
Automobile		
	USA	Detroit
	Japan	Nagoya region- Toyota
Coffee		
	Brazil	North-Eastern region - Plantation Called Fazendas
	India	Karnataka
Commericial Fishing		
	Northern Europe	Dogger bank, Great Fisher Bank
	USA/Canada	Grand Bank, George bank, Nova Scotia, Newfoundland
	Japan	Honshu
Cotton		
	India	Mumbai, Ahmedabada, Coimbatore
	Japan	Osaka,
	Britain	manchester, Lancashire
	USA	North: New England region, South: Carolina ,Georgia, Alabama, Mississippi.
	China	Shanghai

Industrial Regions of the World		
Iron-Ore		
Near Coalmine	Germany	Ruhr Valley, Saxony region
	Britain	Lancashire, York shire, South Wales
	United States	Appalachian-Pennsylvania-great Lakes
	Australia	New South Wales region
	China	Wuhan, Anshan, Chongqing
Near Sea-Coast	Japan	Imported coal and iron-ore. E.g. steel industry in Osaka-Kobe
	India	Steel plants @Vishakhapatnam, Ratnagiri, Mangalore
	USA	Imported ores from Canada- In the coastal cities of Cleveland, Detroit, Chicago
Steel		
	USA	Pittsburg-Great lakes region
	Canada	St Lawrence Valley
	Germany	Ruhr Valley
	France	Alsace-Lorraine
	Britain	Birmingham, Midlands
	Sweden	Central region
	CIS(Common wealth of Independent nations	Ural Region- Ural-Kuznetsk combine
	China	Manchuria, Yangtze Valley, Northern China (Shantung and Beijing)
Copper		
	Chile	Chuquicamata
	USA	Utah, Montana, Arizona (UMA) states
Phosphate:	USA	Florida, North Carolina, Utah and Idaho
Potash	Canada	Prairie-Saskatchewan region

- **2017- Petroleum refineries not necessarily located nearer to crude oil producing areas particularly in many developing countries. Explain its implications, 2004- Examine distribution of oil refineries in India**
  - Oil is extracted from the oil fields is in its **crude form** and contains many impurities. It is **refined in oil refineries** before use. After refining various products such as kerosene, diesel, petrol, lubricants, bitumen etc are obtained.
  - **Oil fields then discuss "Refineries" #readagain**
    - **West India**:- **Guj (Jamnagar, Ankleshwar,** Lunej, Ahmedabad), **Mumbai High**, **Rajasthan** (inland oil discoveries in **Barmer**)
    - **East** coast**- Godavari, Krishna, Cauvery**
    - **NE India:-** Assam- oldest oil producing state- **Digboi, Guwahati, Naharkatiya**
  - Today approximately 22 **oil refineries** are working in India. Some of these places where they are located are **Guwahati**, **Barauni**, **Haldia, Mathura**, **Digboi**, **Panipat**, Chennai, Mumbai, **Kochi, Bina** etc.
  - **Factors responsible for location**
    - Petroleum refining **does not lead to significant weight loss**. Virtually all the by-products can be used. Therefore,

refineries can be set up near the raw material or near the market or at an intermediate break of the bulk location.
        - The development of large tankers and pipelines (currently 7000 km+) made bulk transportation of petroleum possible. This provides favourable condition for locating refineries and petrochemical industries near the market and near the ports. (**eg: 35AD of IT** act- IT benefits for petroleum and natural gas pipelines)
        - Many petrochemical complexes are **located on the coast to facilitate imports**. Ex: **Reliance** has setup a pipeline to directly transport crude oil from **Sikka port** to its **Jamnagar refinery**
        - Regional growth- Oil refineries used for regional planning and growth in developing countries like Mathura, panipat for jobs, ancillary emp (as no strict raw material factor for location)
        - After refining, the finished petroleum products can be supplied to interior areas **through pipeline (7000km+ connection** and trucks. and refining **does not lead to signif weight loss** as such Ex: **Barauni (Bihar),** Mathura (UP), Panipat (Haryana) (Note: Hazira-Vijaipur-Jagdishpur is **Gas not oil related**)
        - Setting up oil refineries near crude oil producing areas- after depletion- what to do?, env pollution issues like oil spills etc (However Jamnagar, Digboi have near crude oil areas etc)
    - Fertiliser industry
        - The **localisation of fertilizer industry is closely related to petrochemicals**. About 70% of the **fertiliser plants producing nitrogenous fertilizer use Naphtha** as the basic raw material.
        - **Example**, oil and gas from Bombay High, the **Gujarat-Maharashtra region got fertiliser plants** at **Hazira, Mumbai,** Trombay, **Vadodara** etc
        - Basic facts
            - ONGC set up in 1956- oil refining at rapid pace, private sector refinery of reliance at jamnagar
            - Problems of petro industry- depend on imported crude, OPEC politics- price fluctuation, inadquate refining according to demand, old reserves depleting, pollution)
- **Distribution of energy minerals across the world (apart from above image)**

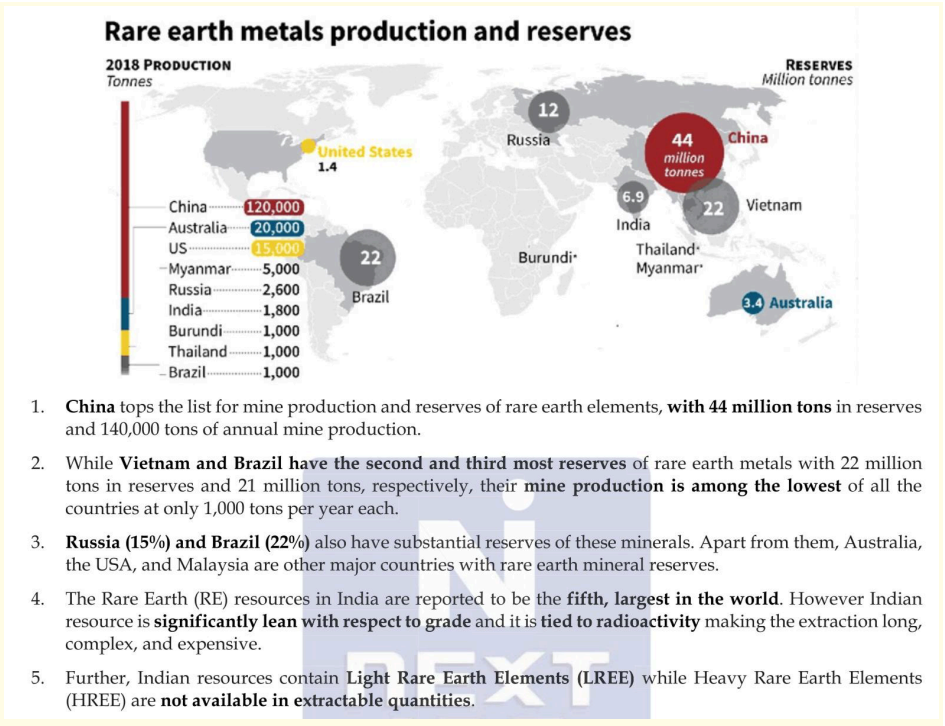
- **Petroleum: Zakum field** in **UAE**, Bolivar coastal fields in **Venezuela**
- **Natural Gas**: **Siberian Basin** in Russia, **Persian Gulf**, **Turkmenistan** (TAPI), **Hugoton** in USA
- **Coal:** Location **coverd above in image wrt Iron-ore near coal fields**
    - Other areas - **Africa (South Africa, Zimbabwe, Zaire, Mozambique)**
    - **Coal in India:** 9th largest reserves but 2nd highest importer (in 2019) 😐 #readagain
        - Gondwana Belt (98%): **Jha**rkhand (**Ra**niganj in WB, **Jha**ria, **Bo**karo - **RaJha Bose**), **Talcher** in Odisha, Son-Damodar Valley, **Korba** in CG, **Neyveli** in TN, Ranigarh, **Makum** (north east)
        - **Tertiary Belt (2%):** Upper Assam, **Garo, Khasi, and Jaintia** hills, **Jammu**
        - 

- 🧨**Critical Minerals:** Minerals **essential for economic dev and security** and **whose lack of availability** due to presence in some geo locations and thus **cause supply chain vulnerability (Critical M = Economic Imp + Supply risk) #readagain**
    - **Both metals and non-metals** vital for economic well being; **Suffering from resource nationalism**(**Indonesia**, China putting export restriction on critical minerals); Geological scarcity
        - Eg: Nickle, Cobalt, Lithium, Rare E Minerals
    - **Application**: **(For Eco dev, For Climate action, Defence/Sec)** for clean tech, EV, solar panels, security (aerospace and defence), fuel

cell, semiconductor, defence such as cobalt, nickel, lithum, graphite (all for battery, import from China of all, lithum from LA), also rare earth minerals-17 in elec and sem

- **Concerns:** Import dependence, Supply chain vuleranbilities, Trade policy issues (Indonesia banned raw nickel export to promote dom indus), Limited assessment in India, Limited recycling
- **India: V**anadium in Karnataka; **L**ithium traces (Mandya in Karnataka + Reasi J&K); **C**obalt in JH; India has Light **R**EEs; **M**onazite sand in Kerala; **N**ickel in Odisha (**VLC-RMN**)
    - **India**- GSI survey, **eg In Reasi distt(JK) lithium found,** Khanji Bidesh India ltd(KABIL) JV in foreign for lithium cobalt, inducted into **Mineral Security Partnership of US** for pvt /public inv (*late mover now need to capitalise*); Govt notified 30 strategic critical minerals
- **Global: C**obalt in D.R.**C**ongo; Lithium in Australia; **N**ickel in Indo**n**esia; Rare earth minerals by 60% res/production by China while Vitenam+Brazil in REE reserves and US/Aus (ie. Quad :p) in REE production; Platinum in South Africa

- **LITHIUM DEPOSITS IN INDIA #readagain**
    - GSI found Lithium **inferred** resources (G3) of **5.9 million** tonnes in Reasi distt(JK)
    - Global Distribution of Lithium: 75% by Lithium Triangle (Argentina, Bolivia, and Chile); While China control half of lithium processing; Australia also major player
    - **+ves**: Reduce **import dependency**; Transformation of Mobility; **Panchamrit**; Boost to manufacturing and exports (battery manuf); **Secure supply china** (today china controls)
    - **-ves**: Himalayan region fragile; **Pollution** (1 tonne = 15 tonnes of CO_2, land degradation due to open-pit); Still in the inferred category; **Water intenive (1 tonne = ~2 million litre water)**
    - **WF: Sustainable mining; Diversification of supply chain; More R&D**
- **Rare Earth Minerals:** These are group of 17 metals which have **unique magnetic, luminescent, and electrochemical** properties. They are called **'rare earth' because earlier it was difficult to extract them from their oxides forms technologically. #readagain**
    - **Distribution:** China (both reserves & production) once made 90% (now about 60% by China); Other major players Vietnam & Brazil in terms of reserves while US/Aus (Quad) in terms of production; India has Light REEs



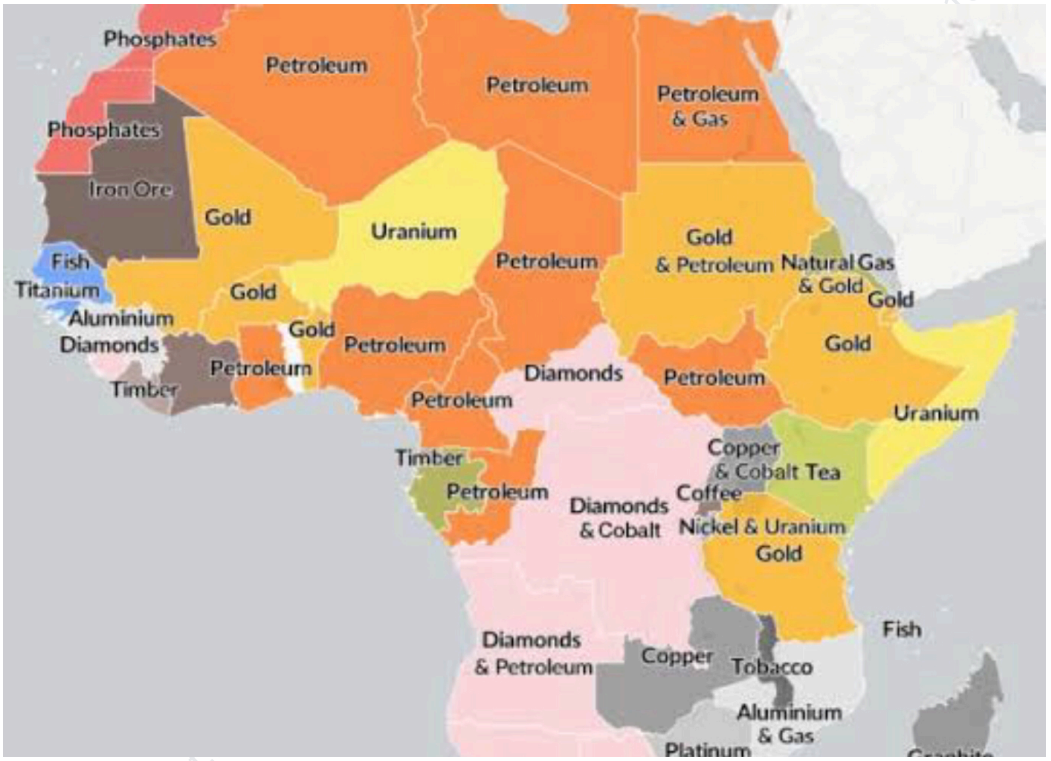
    - **Uses:**
        - **Cerium** in catalytic converters of cars; **Lanthanum** in camera/telescope Lens; **Yttrium** in tv/computer screens
        - Other general app: Consumer electronics, computers and networks, communications, health care, national defense, clean energy technologies
    - **Env Issues**: GHG release (CO2, NOx, CO), Soil acidification, Eutrophication, Water usage, Particulate pollution (dust, chem released)
    - **WF**: **Sustainable extraction practices (env regulation,** minimise pollution); International collaboration, **Recycling and Recovery; Boost R&D**
- **Semi Conductor Industry #readagain**
    - From **availability of raw materials** to **designing and manufacturing**, the global semiconductor supply chain is **highly fragmented**
        - USA held approximately **47% of total semiconductor market share in 2020**
        - More than 85% of **global foundry market (manufacturing)** is concentrated in **Taiwan, China, and South Korea**
        - **Russia** supplies over 40% of the world's palladium and **Ukraine** produces 70% of neon
- **2018- Reasons for India's interest in the Arctic:** 22% of world's unexplored Oil&NG; '**Himadri**' (located at Svalbard, Norway); **Strategic interest-Artic Council** + counter Polar Silk Route; **Drafted a New Arctic policy**; **Development of Northern Sea Route**; Scientific study **('cold**

biology'); Connection b/w poles and Indian monsoon; Business for ONGC Videsh

- Reasons for India's keen interest:
  - Economic Interest:
    - Approx 22% of the world's unexplored Oil and Natural Gas resources lie in the Arctic ocean; Indian is over-dependent on west asia for its imports
    - Potential business in terms of exploration for ONGC Videsh
    - Commercial Navigation: Due to development of new 'Northern Sea Route' which could revolutionise the prospects of trade in Russia and Scandinavian countries (approx 40% shorter than via the Suez Canal or 60% shorter via the Cape of Good Hope)
  - Environmental & Scientific Interest:
    - India's extensive coastline makes it vulnerable to the impact of Arctic warming → due to sea level rise
    - Arctic research will help India's scientific community to study melting rates of the Himalayan glaciers (3rd pole). There is also a believed connection b/w Indian monsoon and glaicial melting at poles
    - Collaborative reasearch with Norway through the research station 'Himadri' (located at Svalbard, Norway)
  - Strategic Interest:
    - Leverage our observor status at the Arctic Council
    - Countering Chinese Influence which is keen in the region as evidenced by Polar Silk Road
    - India drafted a New Arctic policy that aims at expanding scientific research, sustainable tourism and exploration of mineral oil and gas in the Arctic region. It has designated Goa-based National Centre for Polar and Ocean Research to to promote domestic scientific research capacities in Arctic region

- **2015- Economic signif and env consequences of discovery of oil in Arctic Sea**
  - Economic Significance of oil in the region:
    - New energy resources for a energy starved world because of its untapped oil resereves
    - New shipping routes
    - More and more business for oil exploration companies
    - Increased toursim aided by more and more development and investments

        - With new infrastructure, the commercial fishing industry would also develop faster
    - Environmental consequences:
        - Release of trapped carbon reserves within the permafrost
        - Albedo affect will be reduce → global warming
        - Environmental degradation due to possibility of oil spills, polluting extraction process
        - Loss of biodiversity: Imapct habitat of polar bears, seals; It might also lead to exploitation of indigenous tribes
        - Other consequences: more and more militarisation of the region → increased conflicts between players
- **2017- Inspite of adverse env impact, coal mining is still inevitable for development. Discuss**
    - **Coal necessity by ES + RE ke issues likhna padenge (nondispatchable nature, huge land req, tech bottlenecks, India has 9% reserves of coal need to use)**
    - Economic survey suggestions / observations:
        - **Carbon Imperialism** is a modern day type of imperialism wherein the 1st world nations are trying to enforce their views about energy-consumption upon the 3rd nations **with hidden agenda** to 1) To sell their nuclear fuel and technology. 2) To portray the third world in bad light for using coal power and thereby reducing their own culpability for global warming
        - But for India coal based electricity is **a necessary evil** because
            - **Wind and solar power** are **nondispatchable**, meaning electricity can be generated only when there is fast wind blowing or there is appropriate sunshine
            - **Land requirement** for solar based powerplant is **10 times** that of thermal power plant.
            - **Bottlenecks** in acquiring nuclear fuel and Technology
            - **Unemployment** if we shut down coal mining & thermal plants
    - Other issues in renewable energy sector:
        - Uncertainity in power generation through RE → **Fails to attract investments** due to fear of bad investment
        - **Capacity Issues:** It would take **18 solar or wind projects** to generate the same **quantity** of power as **one thermal plant.** More plants leads to higher admin overheads
        - The **average cost per MW** for a thermal plant is about **25% lower** than that of a solar plant

        - **India accounts for about 9% of the world's total coal reserves -** which needs to be tapped to aid economic & social development of the country
        - Cover other points from GS-3 Economic Development - Infra - Energy Notes
- **2014- Economic space of rising natural resources rich Africa - How does India sees its place**
    - **Resources in Africa**
    - 

    - Known to hold **30% of world mineral** resources- epicentre
    - North Africa- Highly rich in **oil production**, Southern Africa- famous for **gold, platinum & diamond**production, Namibia/Malawi- rich in **nuclear fuel**, Tin, East Africa- rich in gold, aluminium, **bauxite**, diamond, **Dense equatorial forest** in **Congo** basin- forest natural resources #readagain
        - India- being emerging country requires almost all natural resources for developement but fierce competition in form of Scramble for Africa 2.0 in form of china and other west countries challenge
        - Other challanges such as internal rifts, civil wars, at some places hostile attitudes towards Indian capitalists, high corruption- competition in form of Scramble for Africa 2.0; India need to overcome this;
    - **Indian Efforts**: India **active in Zimbabwe for coal** and other energy resources- **ONGC Videsh** has 25% **stake** in **Great Nile Petroleum Co in Sudan**, India looking for **Uranium from Malawi**

and Namibia, Co such as **Bharti Airtel; Tata** (**Vehicle assembly** plant in **South Africa**) #readagain

- 🌟 Not only natural resources but Peacekeeping, ITEC
  - Peacekeeping, humanitarian grants, ITEC,other initiatives such as Pan-African e network for tele edu. Medicine, India-africa tech inst in ghana , scholarship to african students in india

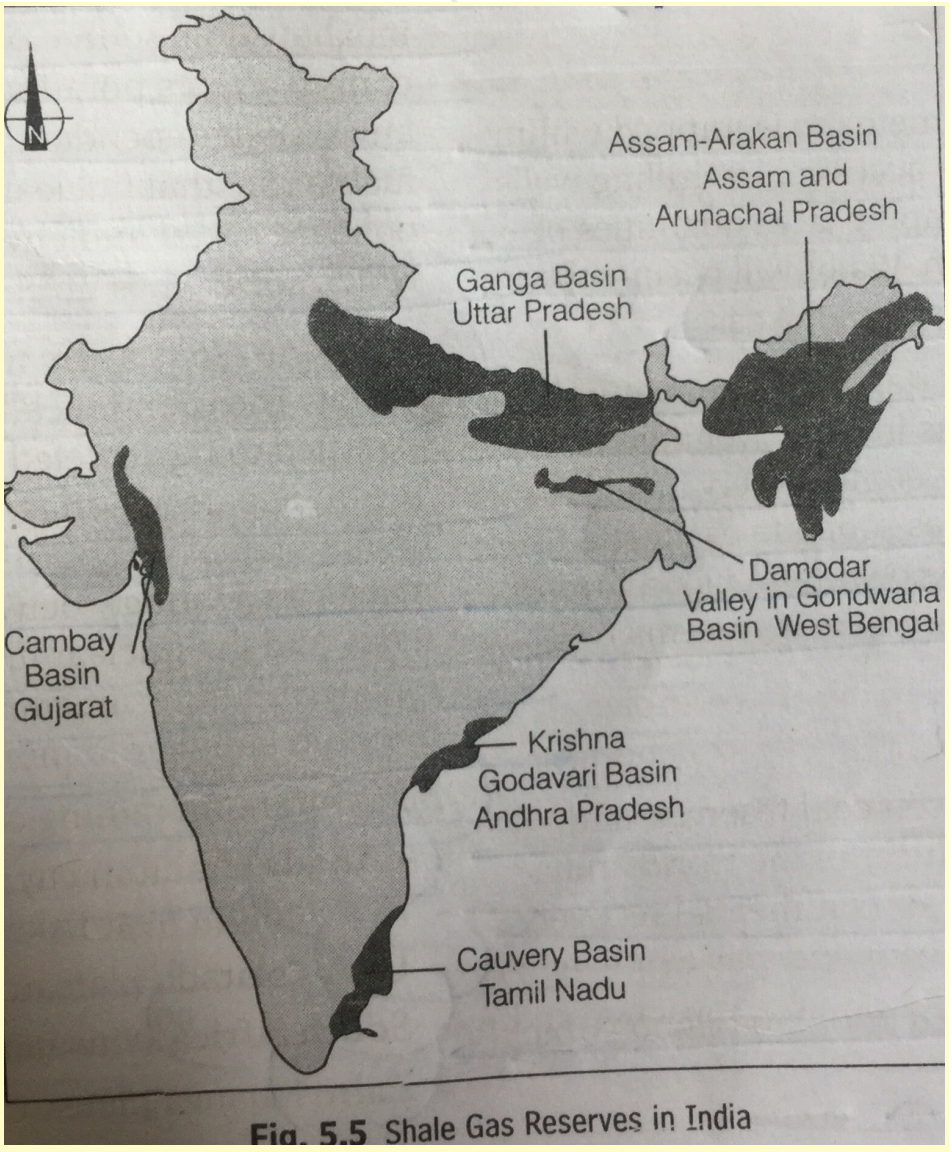
- **2013- Said that India has substantial reserves of shale oil and gas which can feed the needs of country for quarter century. However tapping of resources does not appear to be high on agenda. Discss critically the availability and issues involved**
  - Shale has refers to **NG produced from shale-sedimentary** rock; It is **impermeable hence traps** the gas
  - **Shale Reserves in India:** Ganga Basin, Cambay Basin (GJ), Assam-Arakan Basin, Damodar Valley, Kaveri Basin, KG Basin; **ONGC- India has 90 trillion cubic feet of shale gas**
  - **Global Reserves in India: China, USA, Argentina, Australia**
  - 

    Fig. 5.5 Shale Gas Reserves in India

- Opportunities
  - Acc to ONGC- India has 90 trillion cubic feet of shale gas reserves which can satisfy the country's demand for 26 years compared to conventional gas reserves of 47tcf of which 8tcf is recoverable
  - US learned lessons from 1974 oil crisis by OPEC cut and diversifies its requirements to shale.
  - Other in image
- **Challenges in Shale gas**: Water intensive (hydraulic fracking); Water contimation (acquifier, waste water disposal); Sesismic Zones (III-V); Land Acq/Tech/No scientific resoruce assessment
  - Water intensive: The hydraulic fracking techniques require huge quantities of water to pump the gas to the surface (Shale gas draft policy talk about rainwater harvesting promotion though)
  - Water contamination: Water after hydraulic fracturing is flowed back to the surface and may have high content of dissolved solids and other contaminants, possibility of contamination of aquifiers
  - Land acquisition: Requirements are much greater than conventional gas.(more wells to be drilled compared to conventional)
  - Seismic risks : Zone III-V earthquake prone regions.
  - Other challenges like scientific and credible resource assessment.
- Offers promises and challenges- should focus on fully exploting conventional resources at the same time focussing on sustainable tech for shale gas for demands of future generations

- **2013- Analyse the factors for the highly decentralised cotton textile industry in India;**
  - **Unique Points:** New tech such as **humidifers** no need to stay at coasts; **New energy sources**-hydro elec in TN; Govt policies/Subsidies; Baaki write generic baed on MR-TLC (eg: Mills in Kolkata due to ports); Demands of market influence more (diff tastes)
    - In **ancient India**, cotton textiles were produced with **hand spinning and handloom** weaving techniques (but expensive and time consuming)- could not face the competition from the new textile mills of the West, which produced cheap and good quality fabrics.
    - After **18th century, power looms came into use.** In the early years, the cotton textile industry was concentrated in the cotton growing belt of Maharashtra and Gujarat.

- The Swadeshi movement as well **Gandhi emphasis on Khadi (made of cotton) gave a major impetus** to the industry as there was a call for boycotting all British made goods in favour of Indian goods
- **First mills were set up in Mumbai and Ahmedabad** in the second half of the nineteenth century then after 1921, with the development of the railway network other cotton textile centres - In **southern India**, mills were set up at **Coimbatore, Madurai** and Bangalore. In **central India**, **Nagpur, Indore**, Vadodara.
- Location factors:
    - 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. **Market is imp factor as decides what kind of cloth is to be produced**.
    - While spinning continues to be centralised in Maharashtra, Gujarat and Tamil Nadu, weaving by powerlooms is **highly decentralised** to provide scope for **incorporating traditional skills and designs** of weaving in cotton, silk, zari, embroidery, etc.
    - Cotton textile mills were set up at Kanpur based on local investment. Mills were also set up at **Kolkata due to its port facilities**.
    - The **development of hydro electricity** also favoured the location of the cotton textile mills away from the cotton producing areas. The rapid development of this **industry in Tamil Nadu** is the result of the abundant availability of hydel **power for the cotton mills**.
    - In dry climate, the cotton threads will break quickly during spinning. So, not good for mass production as machines need to be stopped for joining broken threads. On the other hand in **humid climate thread will rarely break**. So, cotton textiles were **setup near costal areas (Mumbai, Osaka, Lancashire). Today we've humidifiers** that can **artificially increase the air-moisture** in factory.
    - Other like govt textiles policies, subsidies etc
    - **Thus** the cotton textile industry is **located in almost every state** (decentralised-PYQ) in India, where one

or more of the locational factors have been favourable.

- **Problems** of cotton textile industry: Shortage of good qlty RM; **Weaving is poor**/fragmented; **Exports by BG/Vietnam**; Obsolete machinery
  - India has **world class** production in **spinning**, but **weaving supplies low quality** of fabric as it cannot use much of the high quality yarn produced in the country as most production in fragmented small units, which cater to the local market. This mismatch is a major drawback for the industry.
  - There is **shortage of raw material** especially of **good quality** cotton to meet the growing demand of the Indian textile industry. Cotton is imported from Sudan,Egypt,USA etc. The high rate of duty on imported cotton has increased the cost of production of clothes which has created problems in selling the cloth in the international market.
  - Most of the Indian textile mills are working with **obsolete machinery**. 70 percent of the spindles are more than 30 years of age. The outdated machinery **cannot compete** with the machinery of countries like China, Japan, etc., Power supply to most of the factories is inadequate
  - **Competition from synthetic fibres** also poses problems to cotton textile industry. The poor people of the country prefer to use synthetic fibre clothes which are more durable and attractive.
  - **Export brilliance** of Bangladesh, Vietnam- affects domestic industries
- Why **Osaka in Japan** developed as textile centre: aka Manchester of Japan; Plains to grow cotton; River Yodo water to mills; Humid climate; Cheap labour; Port to import RM
  - It is an important textile centre of Japan, also known as the Manchester of Japan.
  - The extensive plain around Osaka ensured that land was easily available for the growth of cotton mills., Warm humid climate is well suited to spinning and weaving, The river Yodo provides sufficient water for mills, Availability of cheap labour, Location of port facilitates import of raw cotton and for exporting textiles. The textile industry at Osaka depends completely upon imported raw materials.

- **2019- Factors for localization of agro-based food processing in North-western india (link it with food processing syllabus line in GS-3)**

- Agro-based food processing- take agricultural products as raw material and process it to make more profitable commercial products for human and animal consumption. India's foodgrain production most of which comes from Green-Revolution zone of NW. It means states like Punjab, Haryana, Rajasthan, western Uttar Pradesh (eg MDH in Punjab, Haldiram from Raj)
- Factors for Localization of Agro-based Food Processing industries
    - Climatic Factors- Longer Preservation Period- The climate in North-western India is suitable for preserving food products for a longer duration due to its dry climate whereas peninsular and eastern India are more humid and is not suitable for longevity.
    - Availability of Raw Materials– primarily farm-based economy. Rice, Wheat, Maize along with horticulture production is high in this region. Impact of GR, High Dairy production in Haryana- milk based food processing(biscuits etc)
    - Proximity of Market- closeness to NCR Delhi, UP region, nearest supply to hilly states of JK,HP,UK, high export to canada wale punjabi
    - Cheap labour- Easily available of labour due to migration, also close links with agriculture and provides a living to farmers and workers engaged in ginning, spinning, weaving, dyeing, designing, packaging, tailoring, and sewing.
    - Investment atmosphere- Availability of capital and financial resources helped the industry to grow, Pepsico contract farming in Punjab in 1990's- coming up of lays etc- inspired other co. to follow best practices in supply chain mgmt.
    - Connectivity- Inexpensive water transport, supported by a good network of railways, roadways to far of cities and ports like Mumbai.
    - Government at State and Centre are collaboratively made certain policies for the increment in the food processing Industries- Mega Food Parks, Punjab govt formed separate dept of food processing industries
    - Factors that need immediate attention are-
        - Focus more on domestic sell than export
        - India's total food processing remained below 10% of Production
        - Mega Food parks locations become political issue many time
        - Opposition to Contract Farming act

- **2014- British planters had developed tea gardens all along Shivaliks and Lesser Himalayas from Assam to HP, but they did not succeed beyond the Darjeeling area. Explain**
  - Absence of deep clayey soil in HP; Rugged terrain **east** of Darjeeling; Large indigenous and tribal population reduced the scope of commercial activities like tea, Cheap labour through Plantation Act-lab from BH/WB
    - Though consumption of tea in India has been mentioned in the Ramayana (750-500 BCE) , commercial production of tea did not begin until the arrival of the British East India Company. The Britishers planted tea on large tracts of land all along the Shivaliks and Lesser Himalaya but they did not succeeded beyond the Darjeeling region because of several reasons.
    - The geographical factors which favoured tea cultivation in Darjeeling are- cool climate,deep clayey soil permitting terrace farming,year round rains in the range of 150-250 cm ,low gradient,etc.
    - While cool climate and low gradient were also available in some areas of western Shivaliks(near HP) but absence of deep clayey soil and lack of year round rains led to the failure of tea plantations there.
    - Also in areas east of Darjeeling (Aru,Nagaland etc) - ineffectiveness due to rugged terrain, dense forest, extreme rainfall (tea require 150-250 cm), frequent floods, alienation of tribals areas
    - Moreover economic factors like presence of cheap labour through bonded labourers permitted by Plantation Act which brought labours to work on plantations from Bihar and Bengal also favoured the spread of tea cultivation in Darjeeling. Also relatively better transport facilities and proximity to ports(kolkata- cost effective for export)in Bengal also favoured tea plantations in Darjeeling
    - Moreover cultural factors such as the presence of large indigenous and tribal population in other areas such as Himachal Pradesh, Doon valley etc. reduced the scope of commercial activities like tea plantation.
    - However after independence several steps have been taken to increase the area under tea cultivation especially in the Lesser and Shivalik Himalayas. Providing Geographical Indication status to Kangra tea in 2005 can be cited as one such step.

- **Jute Industry: 2nd exporter of jute goods after BG**; Hugli has well drained alluvial soil (baaki MRTLC); After partition, BG use new tech where we use old obsolete machinery; **Measures: CCEA 100% food grains in Jute; Jute under MSP**; Anti-dumping on import
  - India is the largest producer of raw jute and jute (aka golden fiber) goods and stands at second place as an exporter after Bangladesh. Most of these are located in West Bengal, mainly along the banks of the River Hughli. Other prominent states Bihar, Assam
  - Why Hugli: Jute producing areas (well drained alluvial soils), Water supply for processing, Cheap labour, Kolkata as urban centre (banking, insurance, port)
  - Challenges
    - After partition jute producing areas went to Bangladesh. So Bangladeshis are now using more modern machineries than while we're still using outdated technology. Hence Bangladeshi jute products are better and cheaper than ours in International market
    - Competition from synthetic packaging material such as nylon
    - Lack of marketing strategy to promote jute as eco-friendly among environmentally conscious customers in US and Europe
  - Measures taken to promote:
    - CCEA in 2020, approved that 100% of the foodgrains and 20% of the sugar shall be mandatorily packed in jute bags (Jute Packaging Materials Act, 1987)
    - Anti-Dumping Duty on import of jute goods from Bangladesh and Nepal
    - Jute under MSP, Modernisation in existing and new jute mills, National Jute Board
- **Chemical Industry**
  - The chemical industry forms a **part of the basic goods industry** and is a critical input for industrial and agricultural development. It accounts for about 2.11 percent of GDP
  - **Why** are **inorganic** chemical industries **spread across country**? Fwd linkages (Air Conditioners plant would need chemical plant near to it); More polluting therefore away from residential area; Delicensed except for hazardous chem; RM is light weight
    - Forward linkages - eg: a factory that produces refrigerants near a factory that produces air conditioners and refrigerators

        - Some industries are more polluting than others and must be located far from residential areas
        - Chemical sector is delicensed except for few hazardous chemicals
        - Raw material for it are of light weight, so can be easily transported
    - **Why** the **organic** chemical (chemical which has carbon–hydrogen bonds) industries are located **near oil refineries;** Cannot be transported long-need to be consumed urgently
        - The organic chemical industries get their raw materials from byproducts of mineral oil
        - Organic chemicals cannot be transported over long distance and need to be consumed urgently
    - Significance/Potential of Industry:
        - Raw material to several industries such as iron and steel, textiles, paper, synthetic fibres, rubber, plastics, paints, soaps, pharma, etc
        - Competitive chemical industry will lead to cheaper and better fertilisers, pesticides and seeds to farmers, enhancing viability of the agriculture sector
        - Growing disposable incomes and increasing urbanisation are fuelling the end consumption demand for paints, textiles, adhesives and construction
- **Sugar Industry**
    - **2nd largest producer in world; MH responsible for 1/3rd prod followed by UP (terrai region); *Sugar is one of the fastest-growing industries in the world with Australia, India, Thailand, and Brazil being the top producers in the world***
        - India stands second as a world producer of sugar but occupies the first place in the production of gur and khandsari. In recent years, there is a tendency for the mills to shift from north like UP and concentrate in the southern and western states, especially in Maharashtra.
        - Sugar industry is broadly distributed over two major areas of production- Uttar Pradesh, Bihar, Haryana and Punjab in the north and Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh in the south. MH is responsible for more than 1/3rd of total production of the country, Second is UP (regions in UP - Ganga-Yamuna region and terrai region)
    - **Reasons for southern concentration**: Black lava soil in south; South has no loo/frost; High sucrose; Cooperatives more successful; Climate increases crushing season

- Sugar is a weight losing and perishable crop and needs quick transportation. For sugar, warmer climate gives better yield.
- Black lava soil is fertile and retains water. So, it is good for growth. If labour available are more, cost of production is low
- Also, in South India there is no loo, no frost makes it ideal for sugarcane growth. The cooler climate also ensures a longer crushing season.
- Cooperatives are more successful in western and southern states (as industry is seasonal, sugar farmers pool their resources to process sugarcane themselves and earn better profits)
- Cane produced in western and southern states has a higher sucrose content
- Proximity to ocean can lead to less temperature variations, so it increases the sugar yield and crushing season can be longer
- Water intensive nature of crop: It needs irrigation and is planted in February and harvested in October.

- **Challenges:** FRP + SAP Issues; Highly politicised; Cobweb theory affects production; Cane diverted for khandsari/Gur; Small & uneconomic size of mills
    - Fair and remmunerative Price + SAP Issues (mills pay high FRP/SAP on one side and on other side bear the burnt of low final price of sugar in market) → leads to delay in payment to farmers
    - Highly politicised, Low yield per hectare, Short crushing seasons, Fluctuation production trends (sometime shortage, sometimes bumper harvest), Small & uneconomic size of mills, Sugarcane diverted for use in khandsari and gur

- **2013- Do you agree that there is growing trend of opening new sugar mills in southern states of India? Discuss with justification.**
    - Covered above
- **Knowledge Based Industries**
    - **Tertiary industries** provide a service e.g. teaching and nursing. **Quaternary industry** involves research and development industries e.g. IT
    - **Factors that come into play for tertiary industries**: **Skilled personnel, Educational hubs, Investors, Climate** of the region, **Govt. polices (Karnataka brought 1st IT Polciy; Software parks), Migration** trends
    - Why IT Sector in Bangalore?

        - Seeds for IT have been laid by Patni, Infosys and Texas instruments setting up their offices in Bangalore
        - Bangalore has one of of the best climate in the country
        - Karnataka was the first to announce an IT Policy in 1992; In 1970s itself a large chunk of land was kept for IT industry
        - Education hub
    - **PYQ - 2021: Socio-Economic Implications**
        - IT Sector contribute to approx 8% of India's GDP (compared to 15% by whole agriculture)
        - +ve: Investment (Bangalore Municipal Corp Bonds), Diversification of local economy by promotion of gig economy
        - -ve: Slum areas increase (more ppl rushing to metro cities), Migration, Waste mgmt, Inequality, impacts of FLFP due to digital divide
        - WF: Need to spearhead growth of IT sector in Tier 2 cities to make them inclusive
- **2016- SCS assumed great geopolitical significance in present context. Comment**
    - Covered in IR
- ⭐ **2016- Effective mgmt of land and water resources will drastically reduce the human miseries. Explain**
    - Write in breif problems of land and water issues
    - **Management of land**- by database on land use pattern and ownership, protect wastelend by growing shelter belt, Land reforms for small farmers, **land pooling** for development and making owners partner in dev, **check diversion of agri land** to industrial uses- risk of food security, **sustainable urban planning** to reduce instances of urban floods, **coastal land- protect from seawater intrusion** and subsidence due to CC
    - **Managment of water**- **Rain water harvesting, micro irrigation**, **watershed** mgmt, **water tax** to conserve judiciously, **mapping of aquifers** and their mgmt of GW, river cleaning and management (ganga), manage droughts and water surplus by **river interlinking**, water recycling, **desalination plants**- helps coasts
        - **National Water Policy - Mihir Shah -** Recommendation: Crop diversification, Blue-Green Infra (bioswale, rain garden), Draft Rights of River Act - right to flow/to meet sea; Unified body of National Water Commission
- **2014- Critically evaluate various resources of the oceans which can be harnessed for meeting resource crisis faced by world**
    - Oceans **cover 70%** of Earth's **surface**, host a vast variety of geological processes responsible for the formation and

concentration of various resources. **Resource crisis** faced by the world involves - issues of **Food (**fisheries), **Water** (desalination-Israel) and **Energy** (Poly-metallic nodules, Monazite sands, Mangnesium salts; Tidal/Oceal thermal Energy; Petrol-Mumbai High; Sand/gravel from shelfs/slope; Monazite sand at coasts)

- Food & Water Resources:
  - Oceanic water (97% of total) can be tapped via desalinisation plants - as done by Israel
  - Fisheries and other food resouces has dual pupose of food and livelihood
- Energy & Mineral Resources:
  - Poly metallic nodules on the ocean sea bed can be tapped (Deep Ocean Mission)
  - Presently, approximately 60 percent of the magnesium metal and many of the magnesium salts produced in the United States are extracted from sea water
  - Extraction of Salt, or sodium chloride from sea water
  - Non-renewable sources - such as Tidal energy, Ocean thermal energy
  - Petroleum from sedimentary deposits like Mumbai High
  - Monazite sand (source of thorium) Kerala coast , Sand and gravel from shelfs and slopes
- Issues: Impact on corals, reproduction cycles & migration of fauna, impact on climate change would be aggrevated, global turf wars at oceans (eg: South china sea dispute)

- **2013- With growing scarcity of fossil fuels, the Atomic energy is gaining more and more significance in India. Discuss availabilty of raw material required for generation of AE in India and world**
  - Facts and Fears covered in Nuclear energy GS3
  - Most imp materials for Nuclear Energy- Uranium and Thorium #readagain
  - In India(Not much Uranium(therefore need imports in large quantity) but thorium abundant)
    - **Thorium**- obtained from monazite and ilmenite beach along the coast of Kerela(pallakad, kolam districts) , TN, Vishakhapatnam in AP, Mahanadi near Orissa
    - **Uranium deposits** in **Jaduguda mines (JH), Aravalli Range**, Cuddapah basin (AP), **Mahadek basin (Meghalaya)**
  - Globally

        - **Uranium- Australia, Canada, Kazakhastan, Namibia/Malawi** in Africa, USA (colarado plateau)
        - **Thorium- USA, Australia (ऑस्ट्रेलिया में सब कुछ मिलता है)**, Turkey, Brazil
    - Uranium not a long term candidate (new tech for using depleted uranium required) compared to thorium can work for thousand of years with current estimates
- **2018- Defining Blue revolution explain the problems and strategies of pisciculture developement in India**
    - World Bank - BE = Sustainable use of ocean resources for economic growth, improved livelihood and jobs while preserving the health of marine ecosystem; Emphasised in SDG-14
        - More points have been added there itself - in GS-3 Agriculture notes
- **2017- Mention advantages of the cultivation of pulses because of which 2016 is celebrated as Int year of Pulses?**
    - **Advantages**: Farmer (leguminous-N2, crop residue as fodder, long storage); Consumer (mircronutrients; Gluten fibre); Environment (Pulse in animal feed reduced methane emission; Water efficient; Low GHG)
        - Pulses are a type of leguminous crop harvested for its dry seeds. Common examples include beans, lentils and peas. It has following advantages:
    - To Farmer:
        - Soil: Pulses being leguminous crops are able to fix their own nitrogen into the soil, which increases soil fertility. This reduces cost of artificial fertilizers, and prevents resultant soil pollution
        - **Can be stored for months** without losing nutritional value or selling price.
        - Their **crop residue can be used as animal fodder** to **improve** the **quality** of **milk**
    - To Consumer:
        - Nutrition: Pulses provide **protein and fibre**, as well as a significant **source of micronutrients** vitamins and minerals, such as iron, zinc, folate, and magnesium
        - Health: Pulse consumption also improves serum lipid profiles and positively **affects several other cardiovascular disease risk factors**, such as blood pressure, platelet activity, and inflammation
        - **Gluten free**: therefore **useful for Celiac patients**

        - To Nature: Pulses are water efficient crops. Can be cultivated in arid and poor soil
            - Compared to meat industry, **Lower emission of green house gases** (GHG) per unit of protein produced
            - When pulses residue mixed with animal feed, it **reduces methane emission from ruminants**
    - **Cereals: contain carbohydrates** (unlike pulses which has proteins) eg: wheat, maize, rice, barley, oats, millets (they're also cereals)
        - Additional Knowledge:
        -

2024	**Camelids** (group of Camel species) - Camels are herded by Raika/Rebari community in RJ/GJ - taboo to use their meat
2023	**Millets** (benefits covered in image below) eg: jowar, bajra, ragi, small millets (kodo, kutki) - aka superfood
2022	**Artisanal Fisheries and Aquaculture** (AF means traditional fisheries with small scale, household based (as opposed to commercial cos)
2021	1) Elimination of **Child Labour** 2) **Fruits and Vegetables** 3) Creative Economy for Sustainable Development 4) Peace and Trust
2020	Plant Health, Year for Nurse and the Midwife
2019	1) Indigenous Languages; 2) Moderation; 3) Periodic Table of Chemical Elements
2017	Sustainable Tourism for Development
2016	Pulses
2018–2028	International Decade "Water for Sustainable Development"
2021–2030	United Nations Decade on Ecosystem Restoration
2021–2030	International Decade of Ocean Science for Sustainable Development

- **2016- Enumerate the problems and prospects of inland water transport in India**
    - Covered at IWT GS3 Economic Development Notes
- **2014- Why did Green Revolution by-passed eastern region despite fertile soil and good availability of water**
    - **E and NE region had** - Frequent flooding (damodar river was not tamed till then), Small land holdings, Poor institutional credit and infra but had other advantage in fisheries/ jute
    - **Govt. has launched** Bringing Green Revolution to Eastern India **(BGREI)" in 2010-11** to a more inclusive & sustainable revolution this time
    - **Swaminathan Committee** said there is a need for **2nd GR** which shall target **'viability & sustainability'**rather than food sufficiency
        - NW region had - massive irrigation facilities, wheat based cropping, credit and other infra
        - GR envisaged self-sufficiency in food production rather than regional growth
        - Food crisis during 1960s → LBS gave slogan 'Jai Jawan, Jai Kisan'
- **1996- Dry farming- relevance of augmenting food supply in India, dryland agriculture - Importance**
    - Dryland agriculture is associated with agriculture in absence of irrigation facilities. Thus this type of agriculture is **wholly dependent upon rain**. This type of agriculture is significance from Indian point of view because more that 50% of the cultivable land

fall under rainfed area. A not so well developed canal system and sinking ground water further makes it significant.

- Dryland agriculture is divided into 3 types
  - Dry Farming – Moisture/Precipitation is less than 75 cm annually
  - Dryland Faming – Mositure is more than 75 but less than 100 cm
  - Rainfed Farming – Cultivation of crops in regions receiving more than 115 cm
- **Crops that are grown** in such areas are – **Pulses, Winter Wheat, Millets** like - Bajra, Juar, ragi
- Dry land farming **depends upon the moisture holding capacity of the soil** and many measures are taken to promote this – like mulching, clearing of weeds, contour ploughing etc. However, dry land farming is also more prone to erosion especially wind and water
- These regions grow hardy and drought resistant crops such as pulses, millets like ragi, bajra, and guar (fodder crops) and practise various measures of soil moisture conservation and rain water harvesting
- Statistics for % of gross cropped area
  - Cereals 49% (of which Rice 23%, Wheat 15%, Coarse grains ~11%)
  - Pulses 15%
  - Oil seeds 13%

- **1985- Imp wheat growing region in India, are we growing enough to meet our needs?**
  - Areas for wheat: Majorly above Tropic of Cancer such as UP (🥇), PJ, HY, UT, MP; Minor BH, GJ, RJ
  - Areas for Rice: Leading states WB (🥇), PJ, UP; Others majorly eastern coastal areas, Assam
  - 🥇 Pulses & Coarse Cereals, Total Oilseeds: RJ, But Groudnut- GJ, Sugarcane-UP, Cotton-GJ>TG>MH
- **1991-Factors affecting distribution of population in India, bringing out variation in density over space**
  - Factors: **Terrain** (occupies about 13 per cent of India's land area, supports only 1-2 per cent of the country's population), **Climate** (less density in desert areas), **Soil** (more denser population in alluvial soil, black soil), **Water bodies**, **Industrial** regions (high density in MH, TN, KR) **Mineral resources** (higher population densities in the Chhota Nagpur Plateau of JH and other parts of Odisha)

- Read Watershed Content from Agriculture (Pg 43-46), DM Facts-Voice Clip, Env Facts-Voice Clip (overlapping portions)

Extra Content - Earthquakes, Volcanoes, Landslides, Floods, Droughts, Tsunamis

(Questions from Disaster Management - GS III)

- **Floods:** 2017: How to convert floods into sustainable source of irrigation and all-weather inland navigation (Hint for answers: canals, river interlinking); Causes (Why a recurrent feature?), mitigation, Urban Floods (also linked to Urbanisation in GS-1 Society)
- Urban floods: Comparitive analysis of cities
  - 2020: Account for the huge flooding of million cities in India including the smart ones like Hyderabad and Pune. Suggest lasting remedial measures.
    - 2016- Major cities of India vulnerable to flood conditions. Discuss
  - Jan-2020: Also cover role of IMD in monsoon prediction in these states
  - Understanding various mitigation measures in detail (along with diagrams) as questions have become specific; Also develop a general framework of advantages so that it helps in all measures
  - Chennai floods in 2015 man made, says CAG: Refer link below
    - https://www.livemint.com/Politics/ecmnZEhcVmxz547fgFh2BN/CAG-report-blames-institutional-failure-for-poor-flood-manag.html
- **Landslides**: 2016: Himalayas highly prone to landslides, Causes and measures of mitigation
  - 2013- Causes of more landslides in Himalayas then W. Ghats, ; Hazard zonation mapping; NDMA Guidelines
  - Both question covered and modified in GS3 DM
- **Drought: 2016- Basics (Causes,types,mitigations etc covered in GS3), Watershed management in Agri GS3 File (take key terms and use them- basic idea is water management for PESTEL reasons)**
- In what ways Micro-watershed Development projects help in water conservation in drought prone and semi arid regions of India?
  - Water shed mgmt- broad management over large area (in agri file) in watershed, micro watershed dev- planning at small scale like at village level, district etc
- Also 2019 question on National Watershed Project)
  - 1989- Methods for controlling water evaporation from large surfaces (eg. Ponds and tanks) and improving the waterholding capacity of soil, norms

for identification, Causes, Mitigation, NDMA 2010; Preparedness wrt El Nino and La Nina fallouts
    - *Refer Watershed Development - From Mains 365 2020 - Topic 6.6*

Disaster Management - GS III

- 2020: Discuss the recent measures initiated in disaster management by the Government of India departing from the earlier reactive approach
- 2019: How and in what ways can vulnerability to disasters be characterized? Discuss different types of vulnerability?
- 2013: Importance of vulnerability and risk assessment for pre-disaster management; Key areas to focus on in *Disaster Management System* as an administrator
- Challenges/Problems to DM; Along with solutions
- Sendai Framework vs Hyogo Framework; Measures taken in India before and after signing Sendai
- **Tsunami**: 2016: Factors responsible for occurrence, Effects, NDMA guidelines
- **EQ**: Mitigation and gaps in our preparedness
    - Cover gaps/lessons from other major disasters of the past eg: 2004 Tsunami, Bhuj floods

Static Content

- **Sea Floor Spreading by Harry Hess:** phenomenon of **formation of new oceanic crust through volcanic activity**at the **mid-oceanic ridges** (large submarine mountain chains)
    - The theory of Sea-floor spreading was proposed by Harry Hess. It is the phenomenon of formation of new oceanic crust through volcanic activity at the mid-oceanic ridges (large submarine mountain chains) leading to the movement of oceanic crust on either side of the ridge
    - Prominent evidence in support of sea-floor spreading: rocks equidistant on either side show similarities of magnetic and chemical composition; oldest sediments so far recovered date only to about 200 million years which questions the permanency of the ocean basins;
- **Holme's Convective Current Theory - heat from radioactive decay** causing thermal difference within mantle
    - Due to **heat from radioactive decay and residual heat** within the earth surface, the rocks in the Mantle lying beneath the rigid plate become mobile and start **moving in a convective flow**. The **heated material**

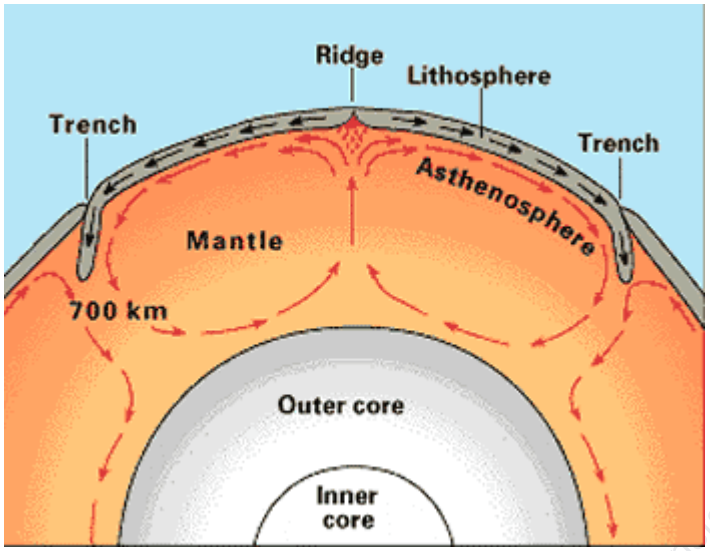
rises to the surface, spreads **and begins to cool and then sinks back** into deeper depths thus **moving the rigid plates** over it

- **Plate Tectonics-what moves is the plate** (**lithosphere on asthenosphere**-upper mantle) not continent; Reason for movt is Convective Currents (circular arrows); See only simple arrow diagrams showing plates from image (3rd type is transform); Talk about trenching, island formation, etc

Plate Boundaries and the Landforms they Create

Boundary	Landforms/Events	Action	Location Example
Convergent: Continental/Continental	fold mountains, mountain ranges, earthquakes	Destructive; Collide and fold	The Himalayan Mountains, Nepal
Convergent: Continental/Oceanic	Continental: volcanoes, mountains, earthquakes Oceanic: trenches, earthquakes, tsunamis	Destructive; Subduction	The Andes Mountains, South America The Cascade Mountains, The United States
Convergent: Oceanic/Oceanic	volcanic island arcs, volcanoes, trenches, earthquakes, tsunamis	Destructive; Subduction	The Aleutian Islands, Alaska, USA
Divergent	Continental: rift valleys, volcanoes, earthquakes Oceanic: mid-ocean ridges, seafloor spreading, volcanoes, earthquakes	Creative; New crust forms	The Great Rift Valley, Africa Mid-Atlantic Ridge, Atlantic Ocean
Transform	fault lines, earthquakes, tsunamis	Neither destructive or creative	The San Andreas Fault, California, USA

  - The advent of Plate Tectonic Theory further supported the Sea floor spreading theory. A tectonic plate is a massive, irregularly shaped slab of solid rock. According to the theory of plate tectonics, the Earth's lithosphere is broken into distinct plates which are floating on asthenosphere (upper mantle). Plates move horizontally over the asthenosphere as rigid units. It is not the continent that moves as believed by Wegener. Continents are part of a plate and what moves is the plate.
  - A plate can be oceanic or continental depending on which of the 2 occupy a larger portion of the plate. There are 7 major and various minor plates.
  - Convection currents in the mantle are the primary reason behind plate movements and give them their direction — divergence and convergence of the lithospheric plates. The rising and falling limbs of convective currents create pressure on lithosphere which leads to divergent/convergent boundaries (observe image below how direction of current and direction of plate is same)

- 

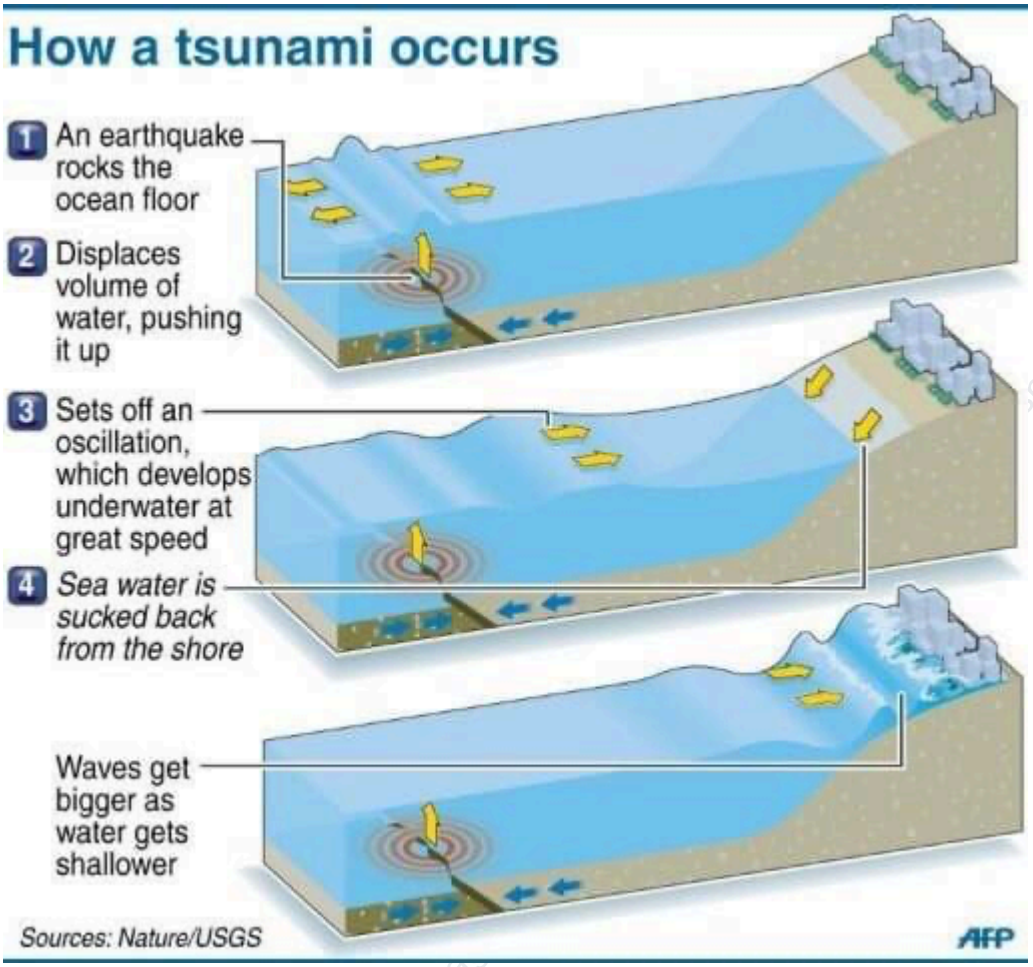
- There are 3 types of plate boundaries:
- Convergence: Places where plates crash together are called convergent boundaries. These are called destructive plate boundaries as they is destructing due to trenching of plate into another. (note: though landforms are formed here too but they're called destructive as first there is destruction) there are subtypes namely: (details of the same have been covered in questions above)
  - Collision of oceanic plates or ocean-ocean convergence (formation of volcanic island arcs and trenches)
  - Collision of continental and oceanic plates or ocean-continent convergence (formation of continental arcs and fold mountains such as Andes, Rockies; In this convergence also we have trenches)
  - Collision of continental plates or continent-continent convergence (formation of fold mountains eg: himalayas, ural mts.; Trenching here is insignif)
- Divergent: In this kind of interaction, the plates move away from each other. The basaltic magma erupts out due to divergence. These are called constructive plate boundaries as new landforms are created
  - Divergent boundaries below the oceans are responsible for the spreading of the seafloor (Seafloor Spreading Theory). This leads to formation of Mid-oceanic ridges. Ex: Mid-Atlantic ridge (American plate(s) are separated by Eurasian and African plates)
  - On continents, East African rift valley is the most important feature formed due to divergence of African and Somali plates. Rifting has formed lakes (which supply water to river

nile) and volcanoes. Similarly, the Red sea is formed due to divergence of arabian plate and african plate

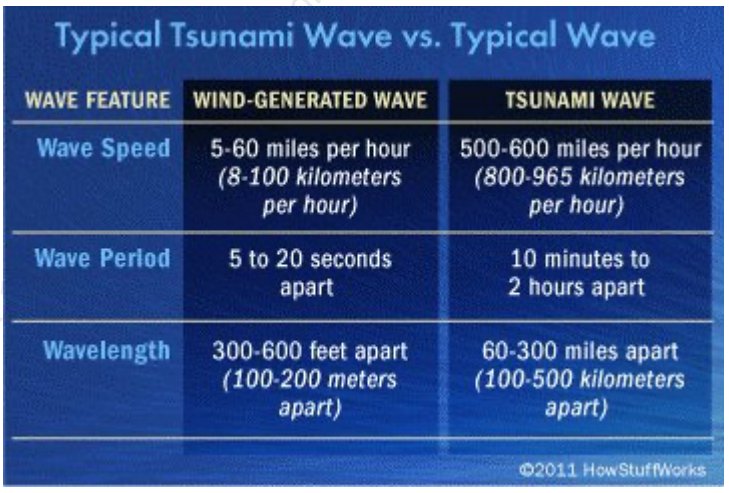
- Transform: In this kind of interaction, two plates grind against each other and there is no creation or destruction of landform but only deformation of the existing landform
  - In oceans, transform faults are planes of separation generally perpendicular to the mid-oceanic ridges.
  - San Andreas Fault along the western coast of USA is the best example for a trans-current edge on continents. Although transform boundaries are not marked by spectacular surface features, their sliding motion causes lots of earthquakes
- Why no volcanos in Himalayas? C-C there is low trenching as not heating; Largest mts therefore crust is thick
  - That is because in the Himalayas, a continental plate is pushed under a continental plate, while in the ring of fire, oceanic plates are submerged. Continental crust is pushed rather flat under the upper continental crust since both crusts have a rather light density, so the surface is not heated up as much and does not sear through the layers above
  - C-C convergence forms largest mountains and the crust becomes so thick that volcanoes cannot come up
- In spite of extensive volcanism, there is no island formation along the divergent boundary (mid-ocean ridge)? - Basaltic magma comes out from here which has less silica; where as convergent has acidic magma
  - Basaltic magma flows out along the divergent edge. Basaltic magma has less silica which has less viscosity. So, it flows over a large distance and hence causes sea floor spreading but not volcanic islands
  - On the other hand, along convergent boundary, acidic magma flows out. Acidic magma has more silica content and hence higher viscosity. So, it doesn't move quick and also solidifies quickly. This helps in building layer over layer in a narrow region, so huge volcanic mountain

- **Jet Stream: Meandering air currents** in flowing generally near the **altitude of the tropopause from W to E**; **Generated due to pressure gradient, temp difference and coriolis force**; 2 **permanent** JS: **Sub**tropical jets (hadley & ferrel); Polar JS (ferrel and polar cells); Also some **temporary** JS like Easterly Jet stream related to Indian Monsoon
  - The Jet stream is very fast blowing air current system in the upper atmosphere (9 to 18 km). It is fast flowing, narrow, meandering air

currents in flowing generally near the altitude of the tropopause from west to east direction. They meander (snake like structure) due to change in coriolis force due to change in latitudes of their movement
    - JS are generated due to pressure gradient, temperature differences and coriolis force
    - There are two permanent jet streams – subtropical jets (hadley and ferrel cell) at lower latitudes and polar front jets (ferrel and polar cell) at mid-latitudes. These are generated at the tropopause areas. Polar JS is stronger due to stronger coriolis force at poles
    - Temporary jet streams are narrow winds with speeds more than 94 kph in the upper, middle and sometimes in lower troposphere. They are few. Important ones are Somali Jet and The African Easterly jet or Tropical Easterly Jet (explained in monsoon segment)
- **Tsunami- Series of long waves caused by displacement of oceans;** eg: 2004 Tsunami due to EQ; Tsunami also due to Krakatoa explosion 1883; Shoaling effect-sudden rise when it reached coast; Series of waves separated by intervals; 950 km/hr (about as fast as jet airplanes); Starts secondary disasters (floods, landslides)
    - Tsunami are series of extremely long waves caused by a large and sudden displacement of the ocean. They have velocities up to 950 km/hr (about as fast as jet airplanes)
    - Causes: Marine earthquakes due to fault movements of sea floor (e.g. 2004 Indian Ocean Tsunami), volcanic eruptions (e.g. tsunami caused by the violent eruption of Krakatoa in 1883), landslides (tsunami caused by the collapse of a section of Anak Krakatoa in 2018), underwater explosions, meteorite impacts, etc. have the potential to generate a tsunami.
    - All the above events majorly cause sudden displacement of a large volume of water which leads to formation of Tsunami waves. As the waves enter shallow water near the coast, there is decrease in speed, the height of the tsunami wave grows (due to conservation of energy). A tsunami which was imperceptible in deep water may grow to many metres high, and this is called the ‘shoaling’ effect.
    - Often, there are several great waves separated by intervals of several minutes or more (and not just single wave)



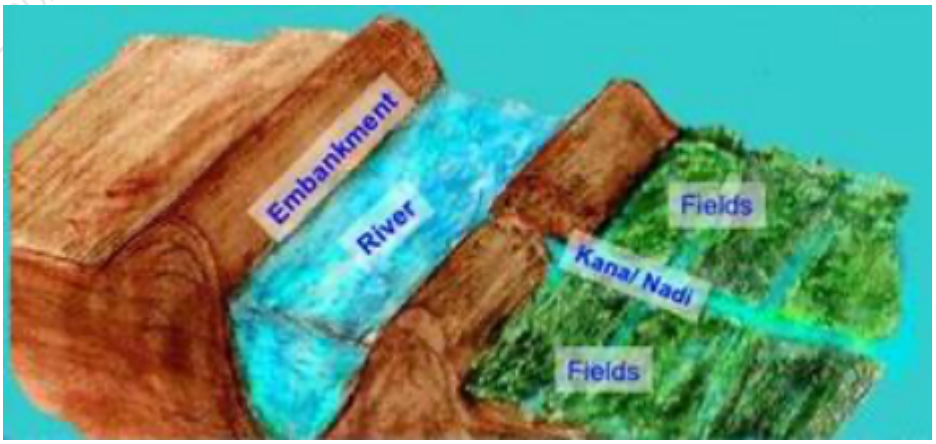
- Comparison of normal waves and tsunami waves:



Typical Tsunami Wave vs. Typical Wave

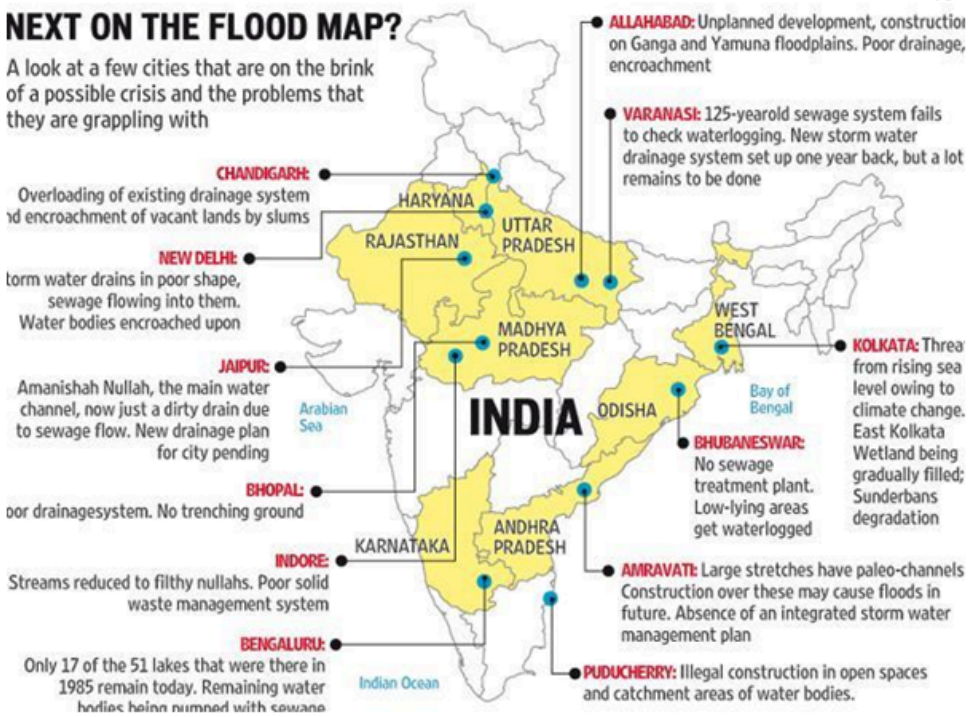
WAVE FEATURE	WIND-GENERATED WAVE	TSUNAMI WAVE
Wave Speed	5-60 miles per hour *(8-100 kilometers per hour)*	500-600 miles per hour *(800-965 kilometers per hour)*
Wave Period	5 to 20 seconds apart	10 minutes to 2 hours apart
Wavelength	300-600 feet apart *(100-200 meters apart)*	60-300 miles apart *(100-500 kilometers apart)*

- Effect on life and economy:
  - Life: Huge losses if sudden and civilians are ill prepared, more impact on vulnerable sections such as old age/children, livelihoods of fishermen community, people are rendered homeless,
  - Economy: Destruction of infra (transport mechanism, communication lines, power lines), Impacts tourism as beaches are destroyed, destruction of crops,
- Preparedness and NDMA guidelines covered in Tsunami GS3: Disaster Management Notes

    - Other risk reduction measures: Building tsunami walls/flood gates (as done by Japan), Mangrove forests and plating rows of tress on coasts, Control of sea mining (of sand and other minerals) as they absorb much of the energy of waves
- Floods:
    - **2017: How to convert floods into sustainable source of irrigation and all-weather inland navigation (Hint for answers: canals, river interlinking)**
    - **Floods as source of irrigation** (Innundation channels of WB, Flood runoff stored in traditional storage tanks-baolis thus irrigation) **As a source of navigation** (using system of dams and locks; Inter-river linking)
        - Introduce the irony of how india faces twin problems of flood and water scarcity. Also give stats related to flood highlighting its potential for below areas
        - Floods as a sustainable source of irrigation
            - Interlinking of rivers will help in Inter-basin water transfer which will lead to solving the the twin problem, thus bringing irrigation to water stress areas eg: Ken-Betwa for Bundelkhand region, or Beas-Satluj link for diverting some water of river Beas into Satluj
            - Innundation channel in bengal can be used to irrigate the fileds using the excess flood waters of rivers (refer image below); It not only bring fresh water but also brings rich and fishes. The fishes fed on mosquito larva and help check malaria
        - 

        - Stream can be channelised to ensure that its follows a straight path rather than meadering all the way - it can reduce floods prone areas and canals formed during channelisation can be used for irrigation
        - Tackling runoff of water by storing them in wells, tanks and tranditional stepwells and baolis

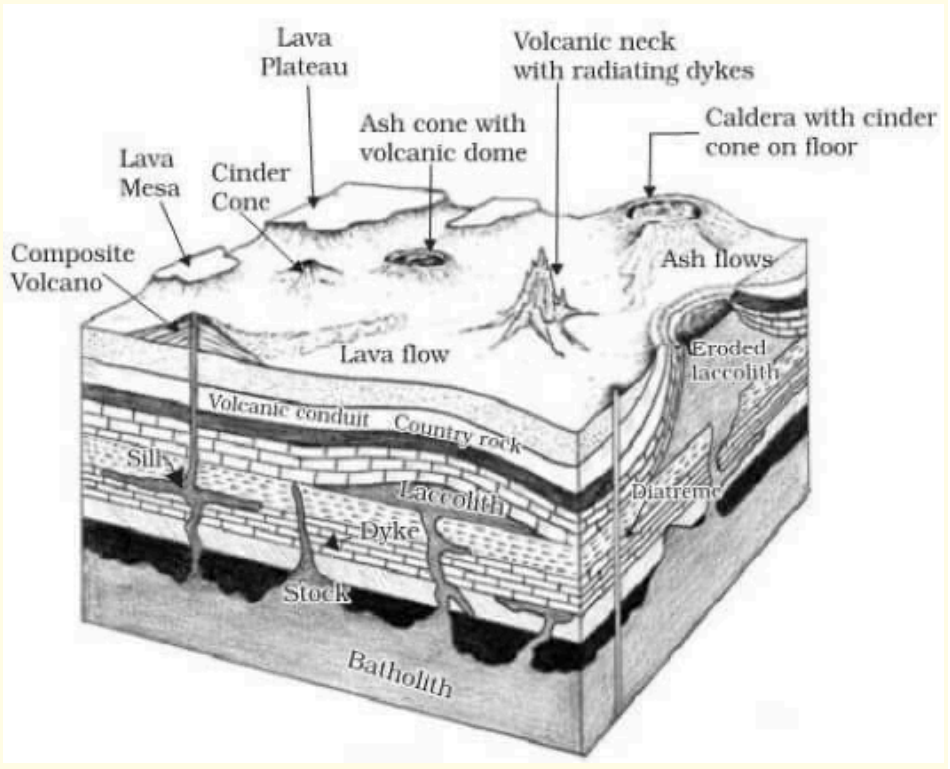
        - Volume of water can be checked by constructing dams and detention basins (which are surface storage basins which can be made in marshy areas, old quarries and mines)
    - Floods aiding in all-weather inland navigation
        - Interlinking of rivers will help in pan India development of inland navigation
        - System of dams and locks can be used to turn rivers and lakes into a navigation system on lines of Great loop navigation of USA which connects northern Pennsylvania state with southern Florida state.
        - Similar potential exists in India e.g. Inland navigation over the river Narmada from Gulf of Cambay, to Gujarat to Madhya Pradesh can help in cheaper transportation of naptha, polymers and wide variety of chemicals for import and export. But that'll require appropriate modifications in the Sardar Sarovar Dam in Gujarat, Indira Sagar and Omkareshwar dams in Madhya Pradesh
- **Why Floods a reccurent feature?** (asked in 1985) - Need to highlight more on the anthropogenic aspect and write natural factors in lesser detail (such as torrential rains); Refer Floods section in Disaster Management Notes
- Urban Floods: okay
    - **2020: Account for the huge flooding of million cities in India including the smart ones like Hyderabad and Pune. Suggest lasting remedial measures.**
        - As climate variability and extreme weather events increase, **urban flooding becomes more and more common in many Indian cities, like Hyderabad (Quote Musi river for hyderabad, Meethi River in Mumbai for authenticity)** While the untimely heavy rains can be attributed to climate variability, the urban flooding is mainly due to unplanned urbanization
        - Causes of Urban Flooding: Refer Urban Floods section in Disaster Management Notes
        - - Stress more on anthropogenic causes and include examples of cities
        - Make a map of cities hit by urban floods (and write key reasons there for 1-2)
        - **Cover impact of Urban floods on health, economy, environment, infrastructure, mental stress for citizens**
        - **Remedial Measures:**
            - Open green spaces, Water harvesting, **bioswales can be built - to ensure city is developed into a sponge city** (which can absorb the water and recharge acquifiers)

        - **Convergent approach** through schemes such as AMRUT, Smart Cities Mission, HRIDAY, etc.
        - Other measures covered in notes
    - **2016- Major cities of India vulnerable to flood conditions. Discuss**
        - Cover reasons and remedial measures from the notes of GS-3
        - **Below map shows potential cities** along with causes for urban floods **(Use cities such as Chandigarh, Indore, Bangalore, Kolkata, Allahabad)**
        - 

- **Volcanism:** A volcano is a **vent (opening) in the earth's crust** through which **molten material erupts suddenly**from a magma chamber below the surface. **Since it is lighter than the solid rock around it, the magma rises;** pyroclastic debris, volcanic bombs, ash and dust; Generally at techtonic plates but can also be intra-plates (Hawaiin Volacno USA; **Volcano in Antartica**); **Only active volcano of India-Barren Islands; Mention examples of volcanoes in 2021** (Fukutoku in Japan, Kilauea USA, Krakatoa Indonesia); **Benefits:** Fertile soils; Geothermal energy; Minerals-Aluminium/Gold/Nickel/Diamond; Scenic beauty; Understand interior; **Hazard**: Air Pollution; Secondary disasters like tsunami, earthquakes, landslides; Volcanic winter
    - Hazard: Air Pollution; Secondary disasters like tsunami, earthquakes, landslides; Volcanic winter
    - Benefits: Fertile soils; Geothermal energy; Minerals-Aluminium/Gold/Nickel/Diamond; Scenic beauty
        - Material that erupts: lava flows, and gases (nitrogen, sulphur, etc.)
        - They are **generally found where tectonic plates** (like Eurasian, Pacific, Somali, etc) diverge or converge. Examples- volcanoes occurring in mid-oceanic ridge (divergence) and Ring of Fire

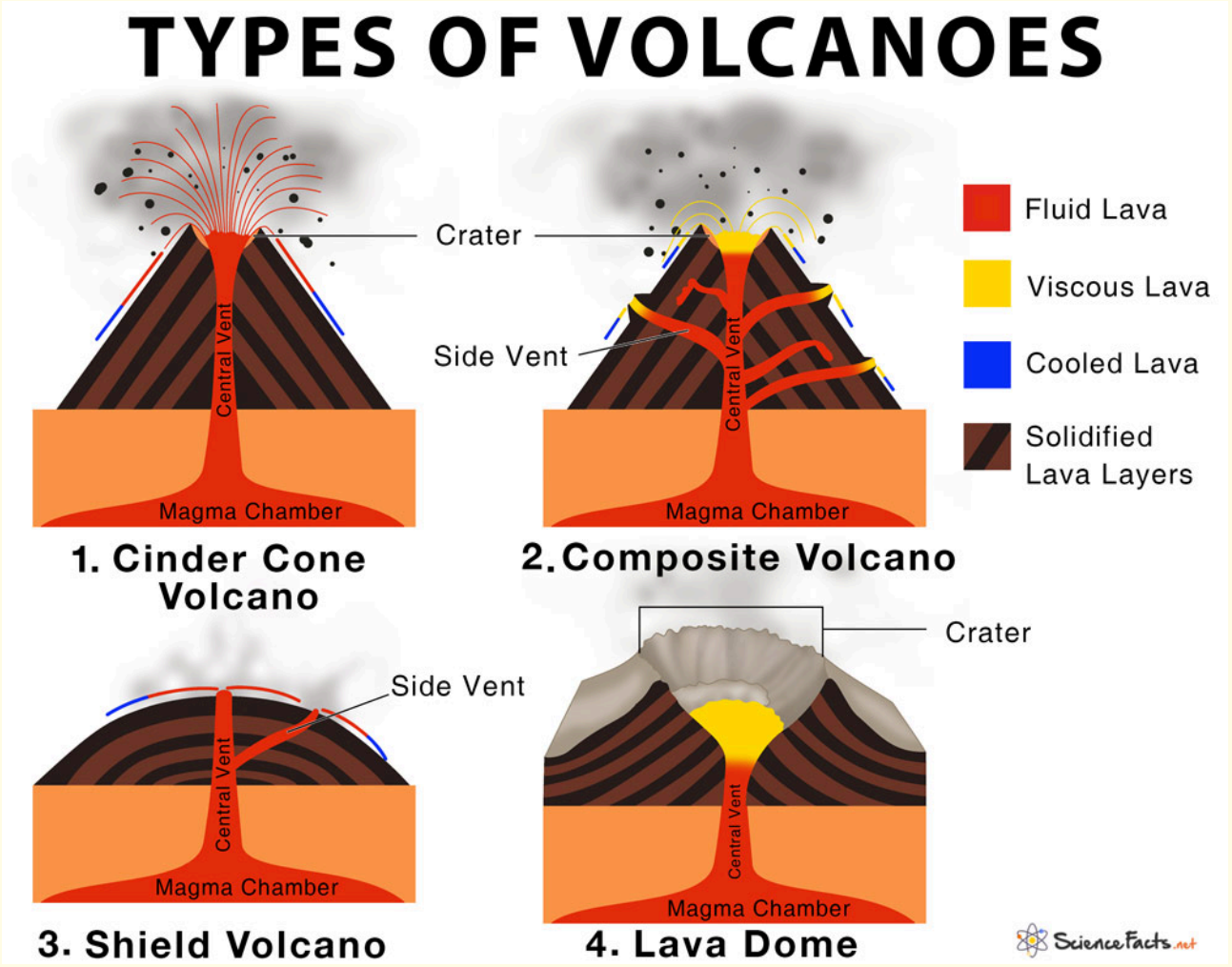
(convergence). However, due to hotspots, **we can also have intra-plate volcanoes** eg: **Hawaiian volcanic** chain in the Pacific plate and the Yellowstone volcanic field in North America

- Types of Volcanoes: In general, Volcanoes can be divided on the basis of Type of Eruption &Periodicity of Eruption.
  - Based on Type of Eruption: The nature of the eruption mainly depends on the viscosity (stickiness) of the magma and are of two types:
    - Basic: The basic magma are dark coloured like basalt, rich in iron and magnesium but poor in silica. They travels far and generates broad shield volcanoes.
    - Acidic: These are are light-coloured, of low density, and have a high percentage of silica and therefore it makes a familiar cone volcano shape.
  - Based on frequency of Eruption:
    - **Active** volcanoes: They erupt frequently and mostly located around Ring of Fire. E.g.: Mount Stromboli is an active volcano and it produces so much of Gas clouds that it is called Light house of Mediterranean, other eg: **Barren Islands (A&N)**
    - **Dormant** Volcano: These are not extinct but have not erupted in recent history. The dormant volcanoes may erupt in future. E.g: Mount Kilimanjaro, Tanzania; **Narcondam Island (A&N)**
    - Extinct or inactive volcanoes have not worked in distant geological past. In most cases the crater of the Volcano is filled with water making it a lake. E.g.: Deccan Traps, India.
- Landforms associated with Volcanoes are broadly of two types:
  - Intrusive Landforms: The commonest intrusive landforms are- Sills, Dykes, Laccolith Lopolith, Phacolith, Batholith



- Extrusive Landforms:
  - Cinder cones: Cinder cones are of low height and are formed of volcanic dust and ashes etc pyroclastic material. Falling under the influence of gravity, these particles accumulate around the vent, in a large pile. The form of a cinder cone is very distinctive, with steep straight sides and a crater (depression) at the top of the hill. E.g.: Volcano Parícutin, Mexico, Barren Island
  - **Composite** cones: (*OFU: composite as it has **features of both cinder and shield***) A composite cone results when formative eruptions are **sometimes effusive and sometimes explosive**. Composite cones are therefore composed of a combination of lava flow and pyroclastic materials. They are also **called stratovolcanoes** because they are constructed of layers (strata) of pyroclastics and lava. They are formed due to deposition of alternate layers lava and fragmental material wherein lava acts as cementing material. E.g.: Mount Fuji in Japan, Ojos del Salado (argentina-chile; also highest active volcano in the world), Krakatoa, Mount Helen, and Vesuvius
  - Shield volcanoes: When numerous successive basaltic lava flow occur in a given region they can eventually pile up into the shape of a large mountain called a shield volcano. E.g.: Mauna Loa, Hawaii

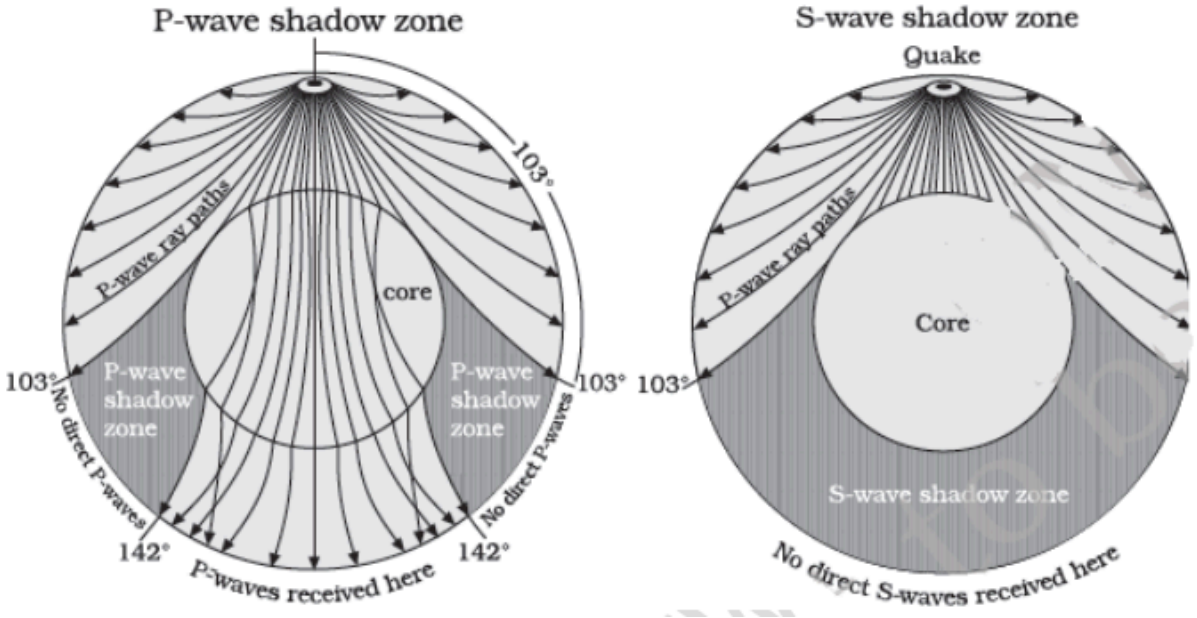
- Calderas: A caldera is a large, basin shaped depression formed by explosive volcanoes which tend to collapse on themselves . E.G.: Crater Lake, USA, Lonar lake in Maharashtra



- Why hazard
  - **Air pollution** and resulting effects on human, livestock, air transport, climate, ozone.
  - Loss of human life and property due to primary effects of lava and ashes, rocks etc. Loss of vegetation and wildlife of the surrounding areas.
  - **Secondary disasters** like tsunami, earthquakes, mud flow, floods etc caused by volcanic eruption.
  - Climate change due to large amount of dust and ash in air which **causes small ice age. (Volcanic winter** = reduction in global temperatures caused by **volcanic** ash and droplets of sulfuric acid/water obscuring the sun and raising Earth's albedo)
  - Increase in temperature of surrounding area during volcanism
- Benefits

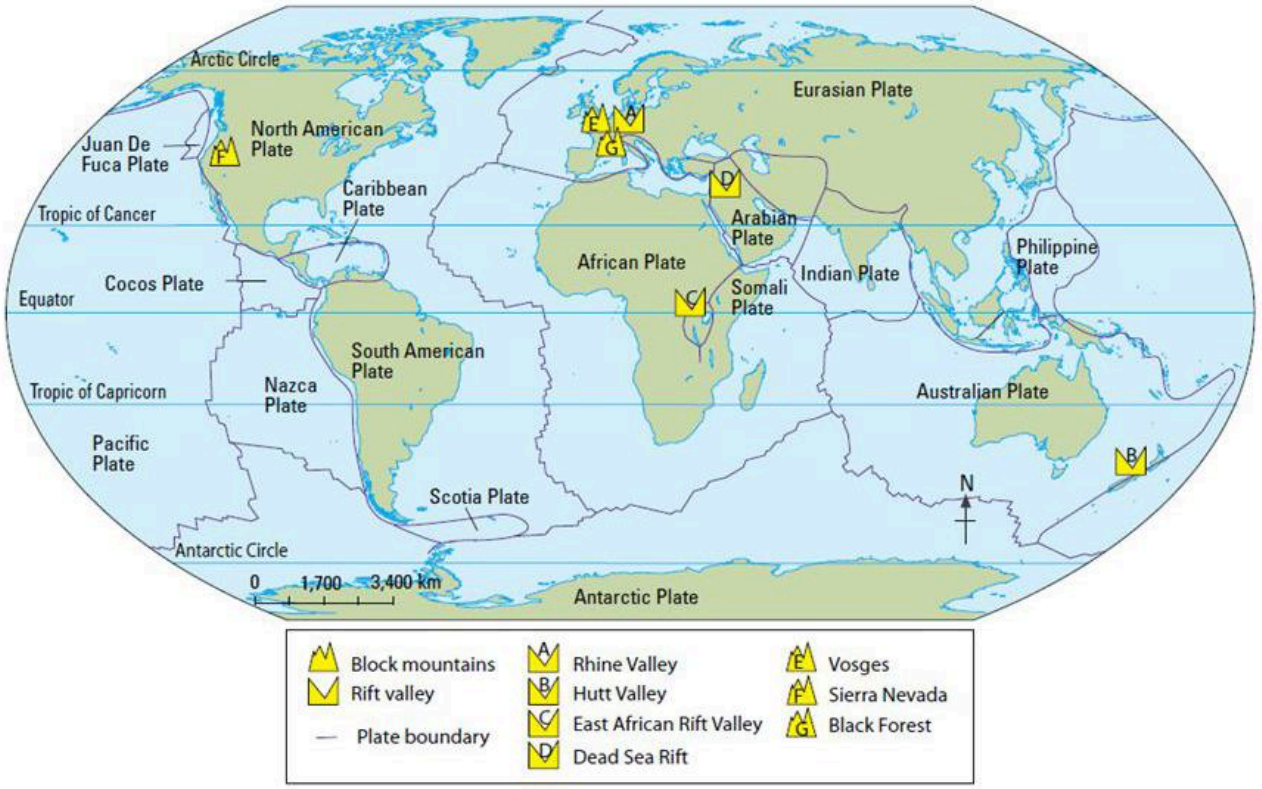
        - Volcanic rocks upon weathering and decomposition can yield **very fertile soils**. The ash and dust are found very fertile for fields and orchards.
        - They have great deal of **scenic beauty** in the form of geysers, springs of hot water. The cinders and clots are sold to tourists visiting such areas, for their fantastic shapes.
        - These geysers (fountains of hot water eg: Yellow stone National park USA) and water springs have potential to be developed as **geothermal electricity**.
        - They add extensive plateaus and volcanic mountains. Volcanoes directly or indirectly produce or host deposits of **valuable minerals** (aluminum, diamonds, gold, nickel, lead) and gases (nitrogen, sulphur, chlorine, hydrogen and argon)
- **Earthquakes:** Generated due to release of strain energy along the fault; Friction locks them and abrupt release causes waves in all direction; Types: Tectonic EQ; Volcanic EQs (occur near volcanoes); Collapse EQs (underground mines collapse - minor tremors); Reservoir induced (Koyna Reservoir-MH); Body waves & Surface waves; **Effects:** Fountains of mud and water appears and destroys crops; **Distribution of earthquakes/volcanoes:** 68% (**2/3rd**) Ring of Fire; **21% Mid-Continental belt (Alpine-Himalayan Belt)** and **Balance in** Mid-AtlanticRidge
    - Earthquakes are generated due to release of strain energy along the fault. A fault is a sharp break in the crustal rocks. Rocks along a fault tend to move in opposite directions. As the overlying rock strata press them, the friction locks them together. Once it overcomes the friction, they slide past one another abruptly and casuse release of energy forming waves in all directions
    - Types of Earthquakes: Tectonic EQs (due to plate tectonics), Volcanic EQs occur near volcanoes, Collapse EQs (underground mines collapse causing minor tremors), Explosion EQs (nuclear/chemical explosion), Reservoir Induced EQs (eg: Koyna reservoir in MH)
    - There are two types of waves:
        - Body Waves: are generated due to the release of energy at the focus and move in all directions travelling through the body of the earth. They are of 2 types:
            - Primary Waves: First to arrive at surface; longitudinal waves, so can pass through solids, liquids and gases; Travel parallel to propagation; Speed is highest in solids then liquid, then gas
            - Secondary Waves: They are transverse waves, so can't pass through liquids. As they vibrate perpendicularly, these waves create crests and troughs

        - Surfaces Waves: The body waves interact with the surface rocks and generate new set of waves called surface waves; More destructive as they move at the surface; Two types:
            - Love (L) waves & Raleigh (R) waves: They are surface waves and don't go deeper into the earth. L waves are faster than R waves. So the sequence of arrival is PSLR. L wave is more destrcutive then R wave
    - Consequences: Damage to property, life, generate Tsunamis (all general points); One unique point covered below
        - Fountains of mud: Due to the intense impact of earthquake, hot water and mud appear on the surface and take a form of fountains. In Bihar earthquake of 1934, the fields of farmer were covered by knee-deep mud and the crops were destroyed
        - It can cause liquefaction (where soil breaks down and literally flows like water - happens when soil is looses and moist)
    - Distribution of earthquakes/ volcanoes: 68% Ring of Fire; 21% Mid-Continental belt and Balance in Mid-Atlantic Ridge
        - 68% - Circumference of the Pacific ocean (ring of fire)
        - 21% - Mid-Continental belt (area over Europe, India, SE Asia)
        - Mid-Atlantic Oceanic Ridge belt
    - Shadow Zone of an Earthquake – Earthquake waves get recorded in seismographs located at far off locations. However, there exist some specific areas where the waves are not reported on seismograph. Such a zone is called the 'shadow zone'. This is mainly due to the inability of earthquake waves to penetrate some areas. For example – S waves cannot travel through molten core and the study of different events reveals that for each earthquake, there exists an altogether different shadow zone



- **Block Mountains:** created when large areas are broken and displaced vertically; Uplifted part horsts and and lower is graben
    - Examples:
        - Mountain ranges of **Satpura and Vindhya** (Narmada and Tapi) in India
        - **Harz Block Mountains, Black Forests** in Germany
        - **Vosges Mts** is in **France**
        - The Great **African Rift Valley** (valley floor is graben)

Distribution of rift valleys and block mountains

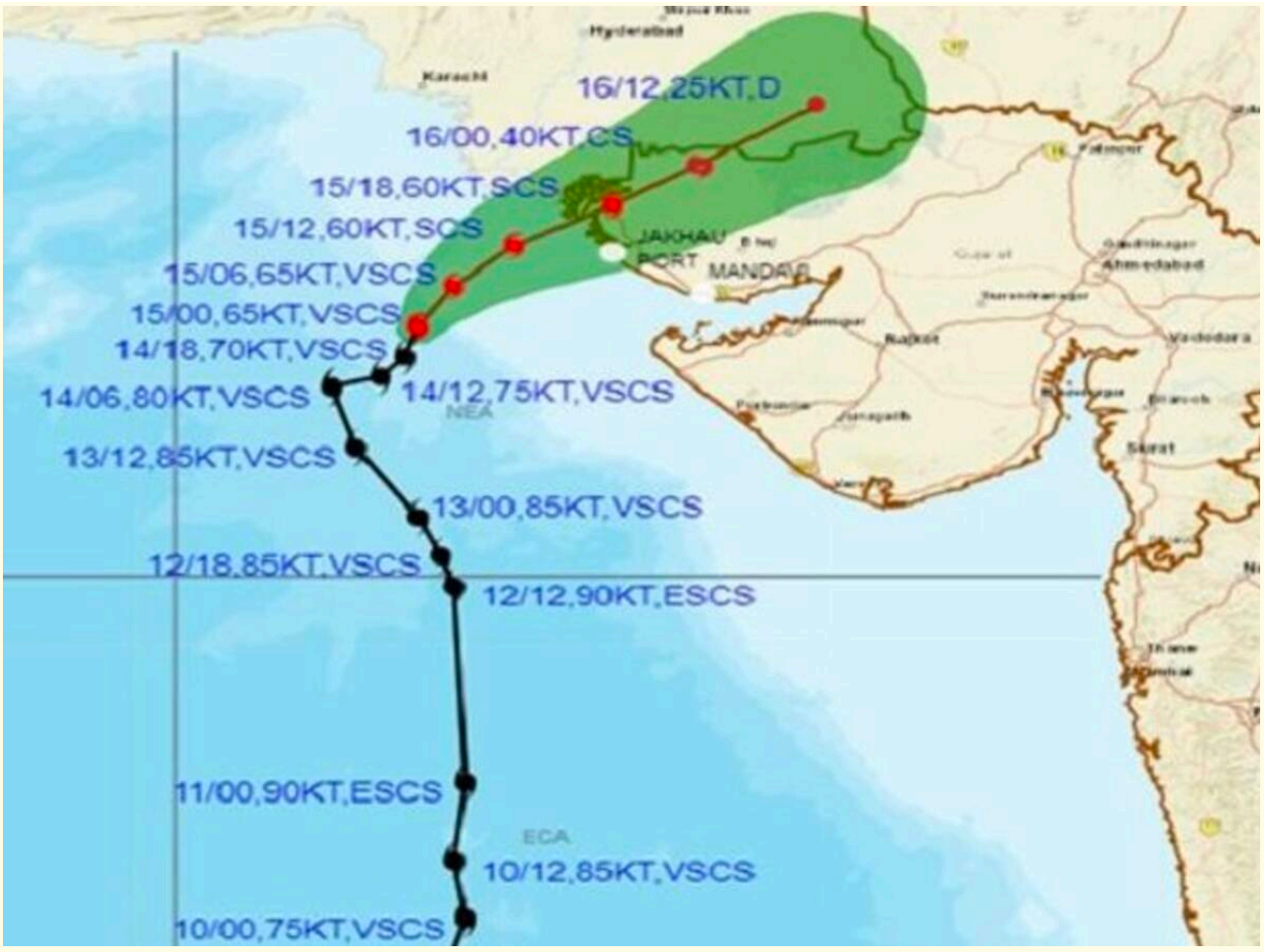


- **Cyclones**
    - Cyclones are **rapid inward air circulation around a low-pressure** area. The air circulates in an **anticlockwise direction in the Northern hemisphere; Formation is due to transfer of water vapour and heat from the warm ocean** (while anticyclone is outward spiralling); Low pressure surrounded by closed isobars and closed air circulation
    - Draw a triangle: Three elements associated with cyclones which cause destruction during its occurrence. Squall (Strong Winds), Torrential rains (cumulonimbus clouds); Storm Surge (inundates low lying areas)
        - Types: Tropical cyclones between the Tropics; Extra tropical cyclones (temperate/frontal)
            - Difference: Tropical cyclone higher speed; but Temperate has larger area and longer duration (15-20 days); Temperate is both on land and water; Area (tropics vs temperate);

Direction (east to west in tropical vs west to east in temperate)

Tropical Cyclone	Temperate Cyclone
tropical cyclones, move from east to west.	These cyclones move from west to east
A tropical cyclone has an effect on a comparatively smaller area than a Temperate cyclone.	Temperate cyclone affect a much larger area
The velocity of wind in a tropical cyclone is much higher and it is more damaging.	The velocity of air is comparatively lower
Tropical Cyclone forms only on seas with temperature more than 26-27degree C and dissipate on reaching the land.	Temperate cyclones can be formed on both land and sea
A tropical cyclone doesn't last for more than 7 days	Temperate cyclone can last for a duration of 15 to 20 days

    - The **conditions favourable for the formation of tropical cyclones** are: #readagain
        - Large sea surface with temperature higher than 27° C.
        - **Small variations in the vertical wind** speed
        - A **pre-existing weak low- pressure** area or low-level-cyclonic circulation
        - **Presence of the Coriolis force** (coriolis force absent at equator)
        - Upper divergence above the sea level system
        - **aka: Typhoons (China), Hurricanes (US,Mexico), Tornados, Willy-willies**
- **Increasing Cyclones in Arabian Sea: Both Cyclone Tauktae, Cyclone Biparjoy (trajectory below) #readagain**
    - This can also be seen that **in 2019, 4 major super-cyclonic storms: Kyarr, Vayu, Hikka, and Maha** formed over the Arabian Sea. In 2020, **cyclone Nisarga** and in 2021 **cyclone Taukhte** formed in the Arabian Sea
    - Earlier, the formation of tropical cyclones in the Arabian Sea was **restricted to Gujarat** but in **recent times, this has also changed.** For e.g., **Cyclone Ockhi** was formed in Kerala and Karnataka

- 

  - **Wind shear is weakening** in the Arabian Sea thereby supporting formation of cyclones
  - Unlike the Bay of Bengal, Arabian Sea receives **very less fresh water** from the rivers which is **preventing the cooling effect**
  - **Positive Indian Ocean Dipole;**
  - The **Arabian Sea receives stronger winds which dissipate the heat** and keep the region cooler. However, with the **weakening of monsoon winds**, the region has **started heating**, promoting the formation of cyclones in the region
  - **Ample Energy**: The **high sea surface temperature** that **too at a greater depth** provides ample energy to the cyclones. This induces rapid intensification of cyclones in the Arabian Sea
    - For e.g. **cyclone Taukhte developed into a severe cyclone in 1-2 days** due to the presence of warm waters at a depth of around 60 meters.
  - **El-Nino or El-Nino modoki conditions** changed atmospheric circulation over Indian ocean → conducive for cyclogenesis in Arabian Sea; (even El-Nino promoted cyclones in AS)
  - Draw diagram of both sides in answers; Conclude with need for close monitoring by IMD
- **2014- Tropical cyclones confined to SCS, BOB and Gulf of Mexico. Why?**

- Temperate cyclones are formed in 35 degree to 60 degree N and S (all 3 not in this)
- Factors of these regions favouring tropical cyclones:
    - Location of SCS, BOB, Gulf of Mexico fall within 80-300 North of equator ,(like other tropical C- both in N and S)- impact of coriolis force
    - falls in **extreme low pressure** areas as come in **vicinity of ITCZ**
    - their sea surface temp is around 25 deegree Celsius,
    - also **free from cold currents** in vicinity,
    - **BoB cyclone reasons: Shape is such** that its surrounded by land from all sides **leading to high heating**; Constant inflow of **fresh warm water** from the **perennial rivers** like Brahmaputra and Ganges makes it further impossible to mix with the cooler water below; **Gets remnants of typhoons over Northwest Pacific**
    - Local winds of these regions have component of Easterlies embeded like Tropical Easterly Jetstream on Indian subcontinent
    - Cause devastation on east coast as they move west
- Also called Typhoon, Tropical cyclones and Hurricanes respectively in SCS, BOB, Gulf of Mexico)