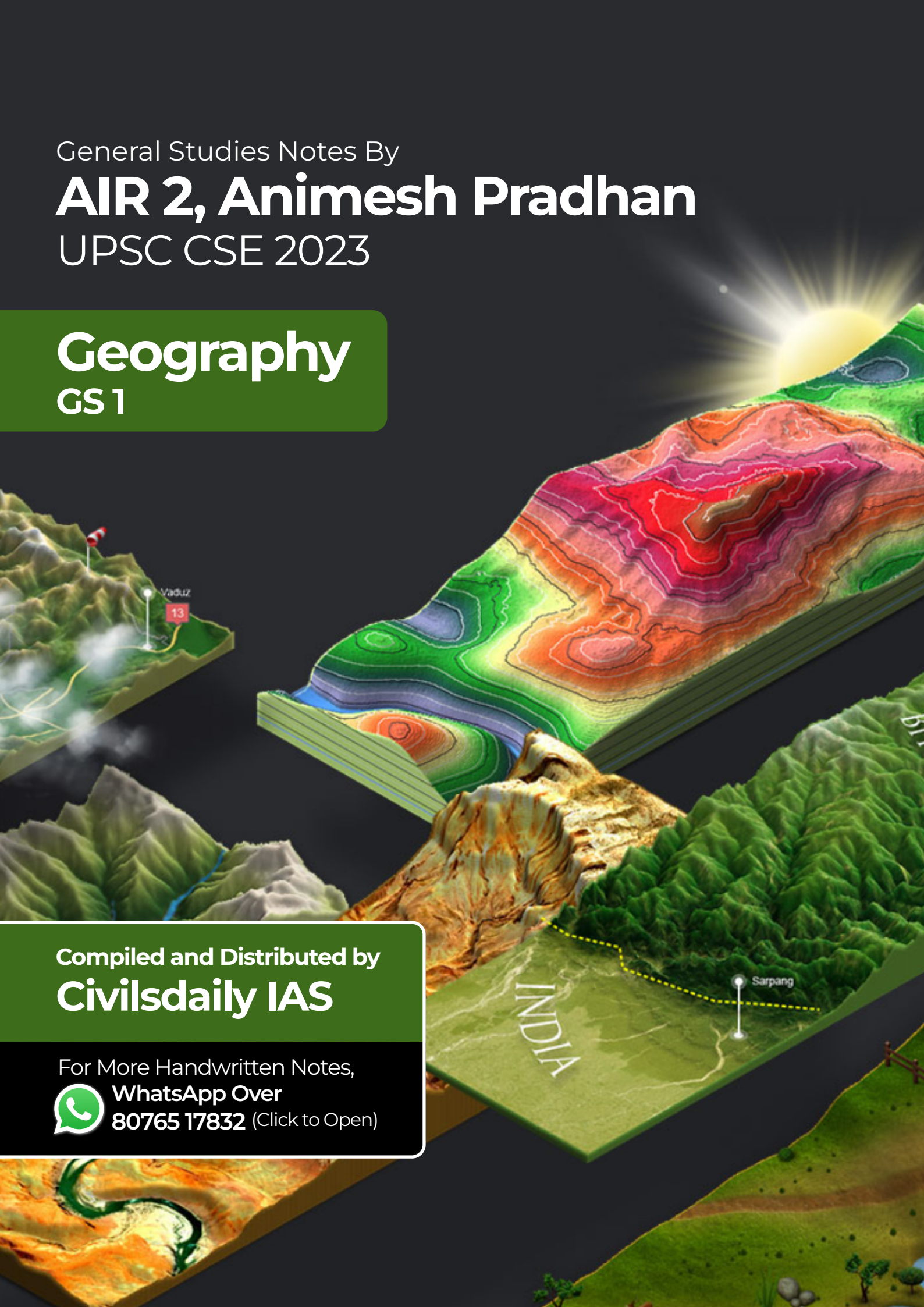
General Studies Notes By

AIR 2, Animesh Pradhan

UPSC CSE 2023

Geography

GS 1



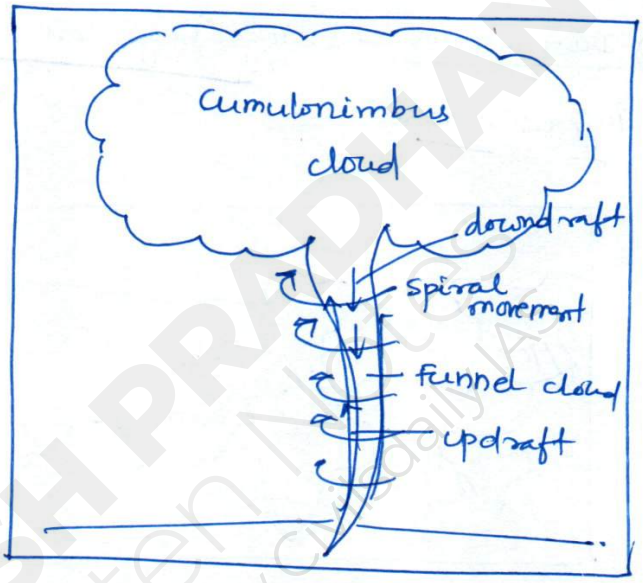
Compiled and Distributed by

Civilsdaily IAS

Geography

What are tornadoes? How do they originate? Why are they so destructive?

Tornadoes are violently rotating vortex of air touching ground, usually attached to the base of a thunderstorm.



- Generally occur in middle latitudes because of convergence of warm & cold air masses.

ORIGIN

Tornado formation typically needs:

a) Wind shear
b) Lift
c) Instability
d) Moisture

Steps involved

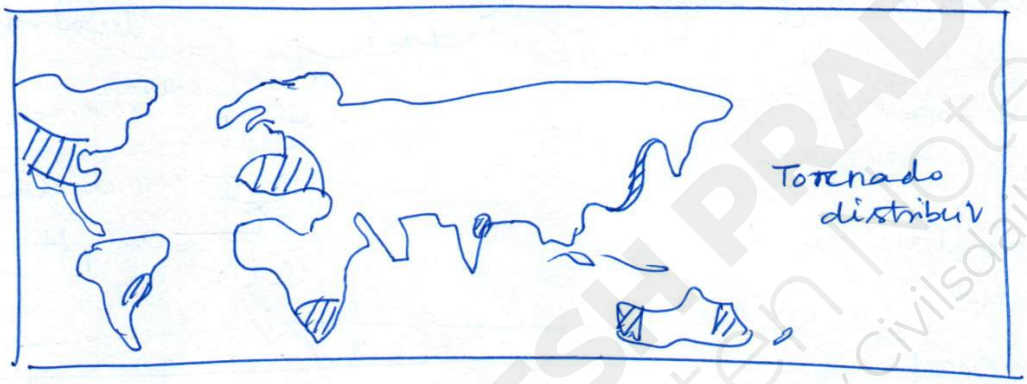
i) Winds begin to roll into a horizontal column of air
↓
ii) strong updraft of air transport from the ground to the atmosphere, resulting into column of air becoming vertical with swirling effect
↓
iii) storm turns into a supercell thunderstorm which are ~~are~~ separate discrete cells that are not part of line of storms
↓
iv) vertical rotating column of air ✓ + supercell thunderstorm ✓
↓
TORNADO FORMATION

They are destructive because —

a) Speed: They can reach beyond 500 km/hr uprooting trees, shredding buildings etc.

b) Presence over land – Unlike tropical cyclones, tornadoes can survive over land that raises its destruc^n power.

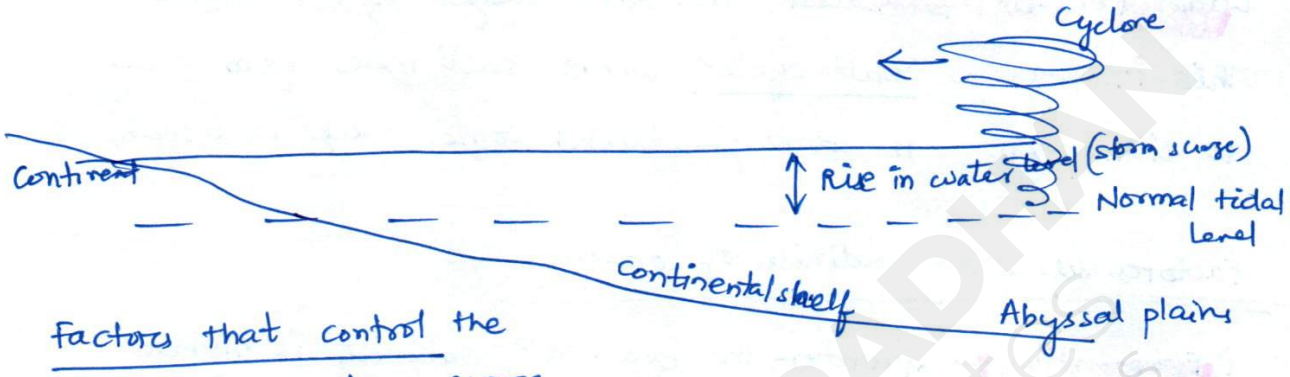
c) Dust storms – brings huge loss of agricultural crops, infrastructure



Tornadoes although destructive has few advantages like deposition of new fertile soils, brings rains, helps nitrogen fixa^n through thunder.

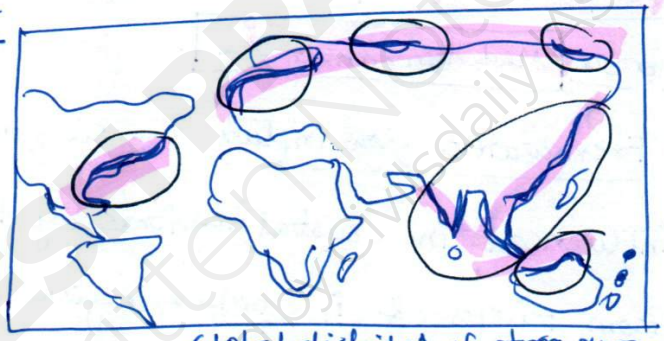
Q. What is storm surge ? What factors control the magnitude of a storm surge ?

Storm surge is an abnormal rise of sea level (above normal tidal level) near the coast caused by a severe tropical cyclone



Factors that control the magnitude of storm surge

a) Topography - storm surges becomes severe in gentle slopes than steep slopes.


Global distribu' of storm surge

Ex Eastern coast of India (Odisha, WB) - gentle slope - severe storm surge.

b) Intensity of cyclone - Supercyclones can create severe storm surges. higher tidal bulge

c) Latitude - lower latitudes will have higher tidal bulges creating frequent storm surges

d) Extent & depth of continental shelf - A wider extent, shallow continent shelf can bring higher magnitude storm surges. Ex in Nordic regions

Despite humongous adversaries created by storm surge, it brings fertile oceanic oozes to land & brings fish popula' near to shore.

Q. What do you understand by 'salt budget'? Examine the factors that affect the salinity of oceans.

Total salt in the ocean water remains the same over a larger duration is called the salt budget of the ocean. This involves a 'salt cycle' where salt moves from ocean to lithosphere, to atmosphere and comes back to oceans.

Factors affecting salinity of oceans —

1) Evaporation – Greater the evapora^n, salinity is higher, forex Mediterranean Sea

2) Freshwater flow influx – surface salinity is greatly influenced in coastal regions by the freshwater flow from rivers & in polar regions by the processes of freezing and thawing of ice.

Ex Bay of Bengal (inflow of fresh water from rivers) low salinity. Arctic Ocean (because of thawing of ice)

3) Temperature & density – are interrelated with salinity. Higher temperature are less dense → low salinity.

4) Ocean currents – The warm currents near the equatorial region push away the salts from eastern margin of ocean & accumulate them near the western margin.

- Ocean currents in the temperate regions increase the salinity of ocean water near eastern margins.

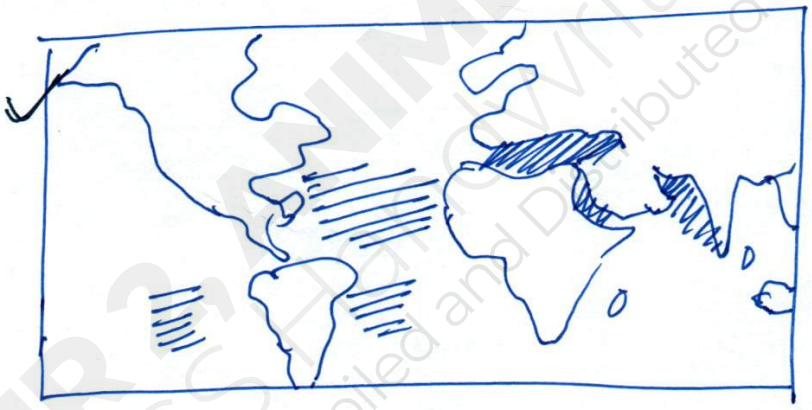
Ex Gulf stream in North Atlantic Ocean increases the salinity of ocean ~~water~~.

5) Precipitation - inversely proportional ; Ex Equatorial region Low salinity

6) Atmospheric pressure & wind direction - anti-cyclonic conditions with stable air & high temp. increase salinity of surface water of oceans.

- Wind also influences salinity of an area by transferring water to other areas.

- Regions of high salinity coincide with ~~(low temp)~~ high pressure cells where there is hardly any rain and subsiding dry winds cause lots of evaporation.

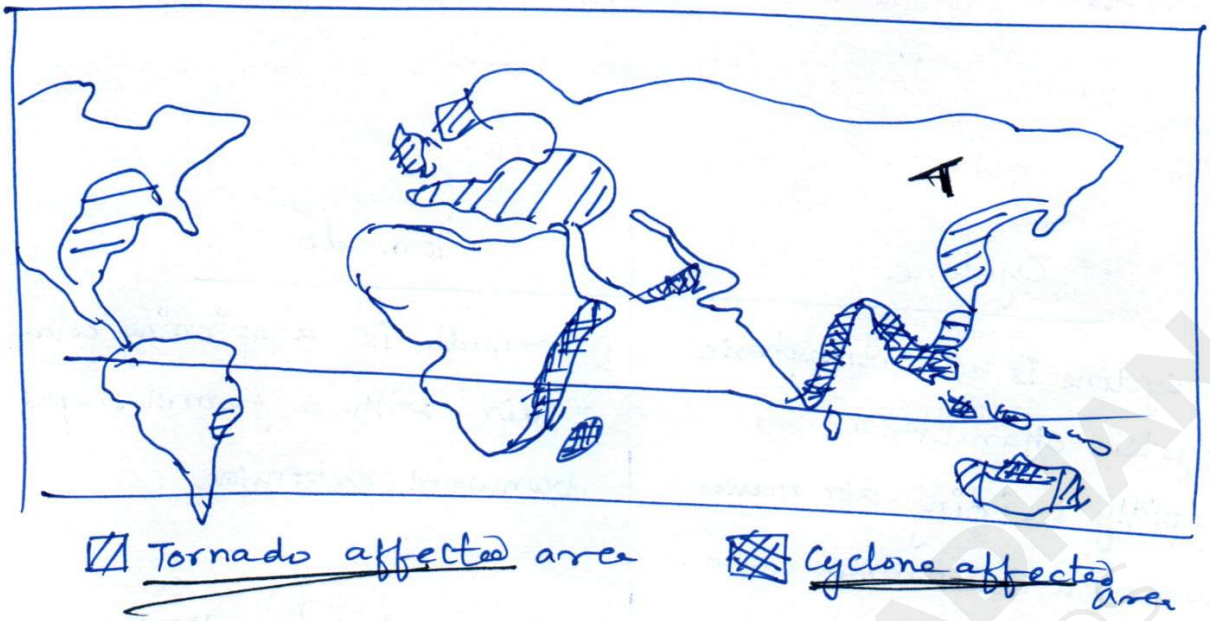


Areas of high salinity

Q. Differentiate between cyclones and tornadoes? In terms of occurrence, do you find a difference between the global distribⁿ of cyclones & tornadoes?

Cyclone	Tornado
1) Cyclone is an atmospheric system characterized by rapidly swirling air masses around a low pressure centre.	1) Tornado is a spinning colum of air with a funnel shaped downward extension
2) Formed by intense heating (>27°C) of sea waterc creating a low pressure system.	2) Formed due to collision between cold & hot air.
3) Formed in oceans, seas (water only).	3) Forms in both water & land,
4) They have a wide circum -ferance.	4) They have a smaller diameter
5) Formation of clouds - Nimbus & cumulonimbus with thunderclouds.	5) less cloud formation and low intensity thundere & lightning
6) Region of occurence - in Tropical belt - 5° to 20° North & south of the equatore	6) Regional & local in characte - Gulf of Mexico, Florida, Northest USA - Usually in mid latitudes
7) Extent - Lasts for weeks or extend for a month	7) Extends for a day or two - shot lived.

Variation in occurence



- Tornadoes occur beyond 20° N & S of equator, both in land & seas and influence continental interiors.

  Regions - Gulf of Mexico, western Europe, near Atlantic Coast of North sea, western & Eastern Australia.

- Cyclones are limited to 5 - 20° N of S of equator in coastal regions of India, Myanmar, Bangladesh, Indonesia, North & North East Australia, Vietnam, Phillipines etc.

So, cyclones & tornadoes are examples of unstable weather events which is getting intensified with climate change. Both depends on pressure variations & other factors including vertical wind sheer and temperature.

Aithi Target 10

Q. How ocean currents originate? Discuss how ocean currecents impact trade & commerce?

Ocean currents are large masses of surface waters that circulate in regular patterns around the ocean.

Factors behind origin

1) Planetary winds : Ex N-E Trade winds move North Equatorial current, Florida current, Gulf Stream to southern and eastern coasts of USA. (Monsoon → change)

2) Temperature - Warm water from equator (lighter) rises and move towards poles, cold water from poles (denser) sinks & move towards equator.

3) Salinity - More saline water with higher density flow at bottom to waters of low salinity & vice versa.

4) Earth's rotation - Coriolis force: deflects in clockwise direct in North Hemisphere and anticlockwise in south. Hemisphere

5) Land - obstructs & diverts a current. Ex Tip of Southern Chile diverts part of the West wind Drift northwards as Peruvian Current. → gravity

Ocean currents' Impact on Trade & commerce

1) Fishing - Mixing of cold and warm ocean currents bear richest fishing grounds in the world.

Ex Grand Banks in Newfoundland (Cold Labrador + warm Gulf Stream)

2) Places along cold currents are unsuitable for agri-cultural product^n and forms desert. Ex Atacama desert in Peru.

3) Naviga^n – ships usually follow routes aided by ocean currents. Sargasso sea obstructs naviga^n

4) Freight movement – Ex Norwegian current that keeps ocean north of Norway free from ice for movement of cargo.

5) Warm ocean current pile up warm water in tropics of leading to tropical cyclone affecting the general economic activities.

Q. What is an air mass ? How does it get formed ? In what ways does it affect the local climate condⁿ ?

Air mass is a large volume of air in the atmosphere that is mostly uniform in temperature & moisture.

Formation of air mass

- When the air remains over a homogenous area for a sufficiently longer time, it acquires the characteristics of the area.
- Air masses acquires these attributes through heat & moisture exchanges with the surface.
- Furthermore, uneven warming & cooling of the earth's surface by the sun gives rise to air masses.

Ex → The warm air masses form over the equator or desert areas where solar radiaⁿ is maximum.

→ cold air masses form near the poles where solar radiaⁿ is minimum.

Based on origin, air masses are : 1) Maritime Tropical (mT), 2) Continental Tropical (cT) 3) Maritime Polar (mP), 4) Continental Polar 5) Continental Arctic (cA)

Air masses affect local climate condⁿ :

1) Precipitaⁿ → Ex mT air over Atlantic Ocean,

Caribbean sea is a major reason for precipitn east of Rocky mountains.

2) Temperature – mP air affects the coastal temp. in subtropical & arctic regions.

3) cyclones & anti-cyclones – stormy cyclones form near the cold + air mass fronts. Similarly, warm mT air mass will provide the energy for tropical cyclones.

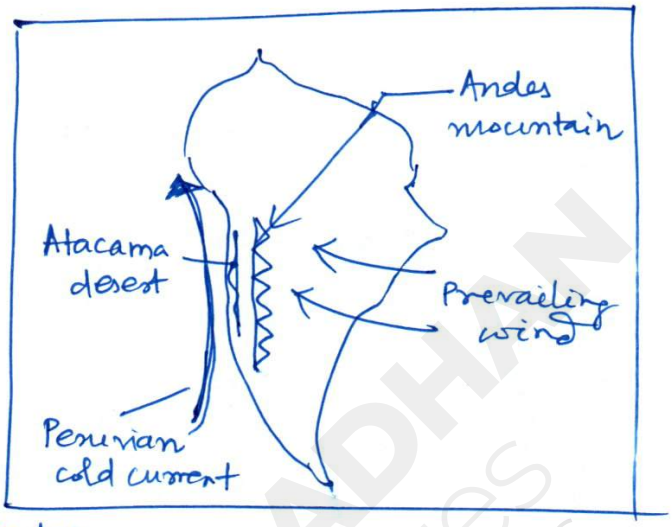
4) Drought – result of hot, dry air mass

5) At the boundaries between air masses, the clash of masses of air with different characteristics can lead to dynamic weather like hail, tornadoes, high winds or ice storms. Ex tropical cyclones formed in East China sea.

So, air masses spread across massive region up to 1600 km or more. They exercise a considerable influence on the climatic condn of the region over which they lodge & carry with them distinctive climatic features of their source region.

Q. Examine the factors that lead to extremely arid conditions in the Atacama.

Atacama desert, located in the western coast of South America in Chile is one of the most arid places in the world, with <2cm annual rainfall



Reasons

a) Rainshadow effect of Andes

b) Cold Peruvian current that induces upwelling of cold water due to Walker circulation creates dessicating effect and makes it more drier.

c) Winds - Trade winds are off shore that does not bring the needed moisture. Westerlies blow to the south of Capricorn, hence no moisture gets transfered.

d) Location - Its location in the tropics & elevation causes high insolation & high rate of evaporation

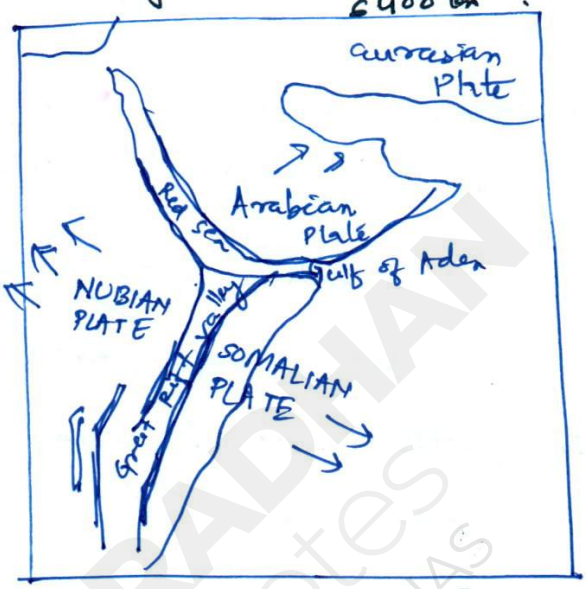
e) Increasing global warming & adverse impact of climate change has made Atacama desert more drier

Hence, Atacama desert remains an interesting point of geographical interest because of its specific geographical characteristics.

Q. What is the Great Rift Valley and where is it Located? Why is it significant geographically? Discuss. (10)

The Great Rift Valley is a geographical feature running north to south (6400 km) from northern (Begaa valley in Lebanon) Syria to central Mozambique in East Africa.

N. Syria – Central Mozambique
6400 km



This formed due to divergent tectonic plates leading to faults creating a rift system.

Geographical Significance

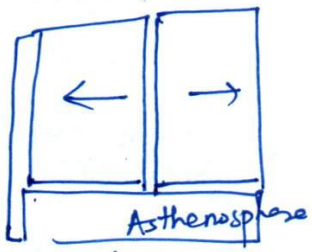
1) Rich source of fossils allowing study of human evolⁿ, especially in Piedmont.
2) The greenlands contain a greater concentraⁿ of wild animals including mountain gorilla.
3) Includes some of the oldest, largest & deepest lakes (fresh-water lakes). Eg Lakes of Albertine Rift, Lake Victoria
4) The volcanic activity leads to concentraⁿ of hotspots including Mt. Kilimanjaro, Mt. Kenya, Mt. Meru as well as Crater Highlands in Tanzania.
5) East African Rift, as its extension is the divergent section dividing Africa into Nubian Plate (Africa) & Somalia Plate

Hence, the great African Rift valley culminates various geographical features explaining various changing geological observations of the planet.

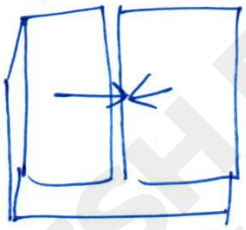
Q. If you observe the map of the world, you will realise that the volcanic activity in the oceans is almost parallel to the coastlines. Why? Explain with the help of suitable examples.

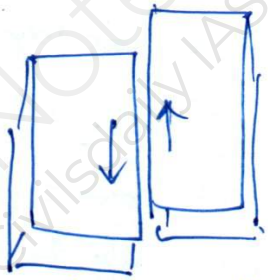
A volcano on earth is a vent/fissure on the planet's crust through which lava, ash, rocks & gases erupt.

According to the plate tectonic theory, earth's crust is divided into several major & minor tectonic plates. The plates movement lead to convergent or divergent or transverse boundaries



(Divergent)


(Convergent)


(Transverse)

Reason why volcanic activity in the oceans is almost parallel to the coastlines →

1. Divergent Plate Boundaries
   - The tectonic plates move apart where magma continuously moves up building new material (constructive edge).
   - Atlantic Ocean is home to Mid Atlantic Ridge formed due to divergence of North American & Eurasian plate.
   - These divergence gives way to magma coming from asthenosphere due to buoyant force & on subsequent cooling creates high ridges → longest volcanic mountain range in the world.

Example 2 : East African Rift along the Horn of Africa, due to divergence of Nubian & Somalia plate giving way to volcanoes like Mt. Kilimanjaro & Mt. Kenya.

2) Convergent Plate Boundaries

- Two tectonic plates converge where the denser plate subducts (sinks) over the less denser plate creating trenches.

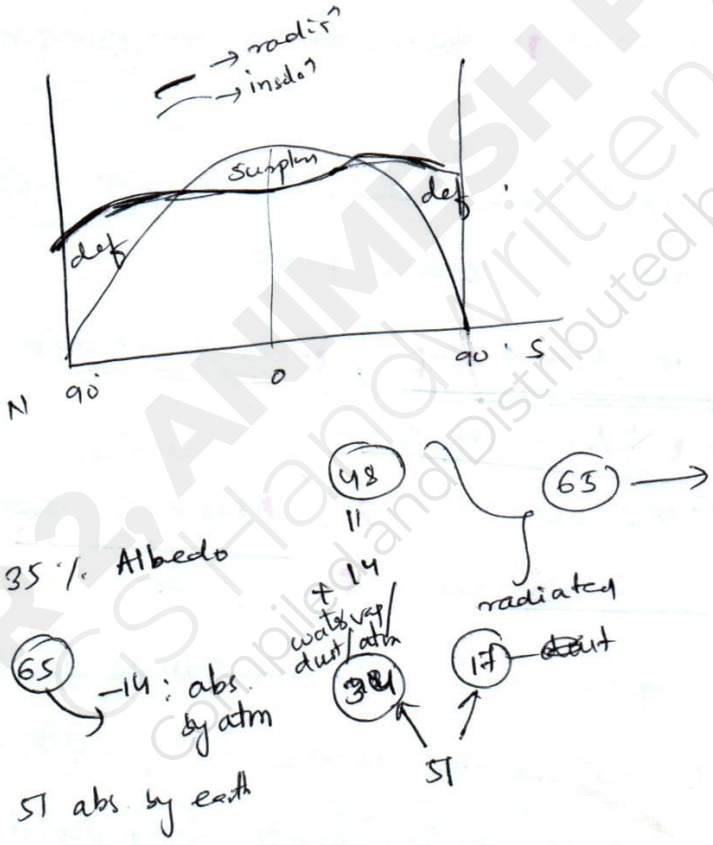
- In case of Ocean-Ocean plate convergence or Ocean - Continental plate convergence, the rocks of denser plate that subducts is subjected to great pressure & heat that forms a part of magma and metamorphizes.

The buoyant force leads the way to volcanoes coming out of the less denser plate.

Ex - Volcanic arcs in Ring of fire (Pacific Ocean plate subducts under N. American plate)

- Volcanic mountains across Andes (Nazca plate subducts under S. American plate).

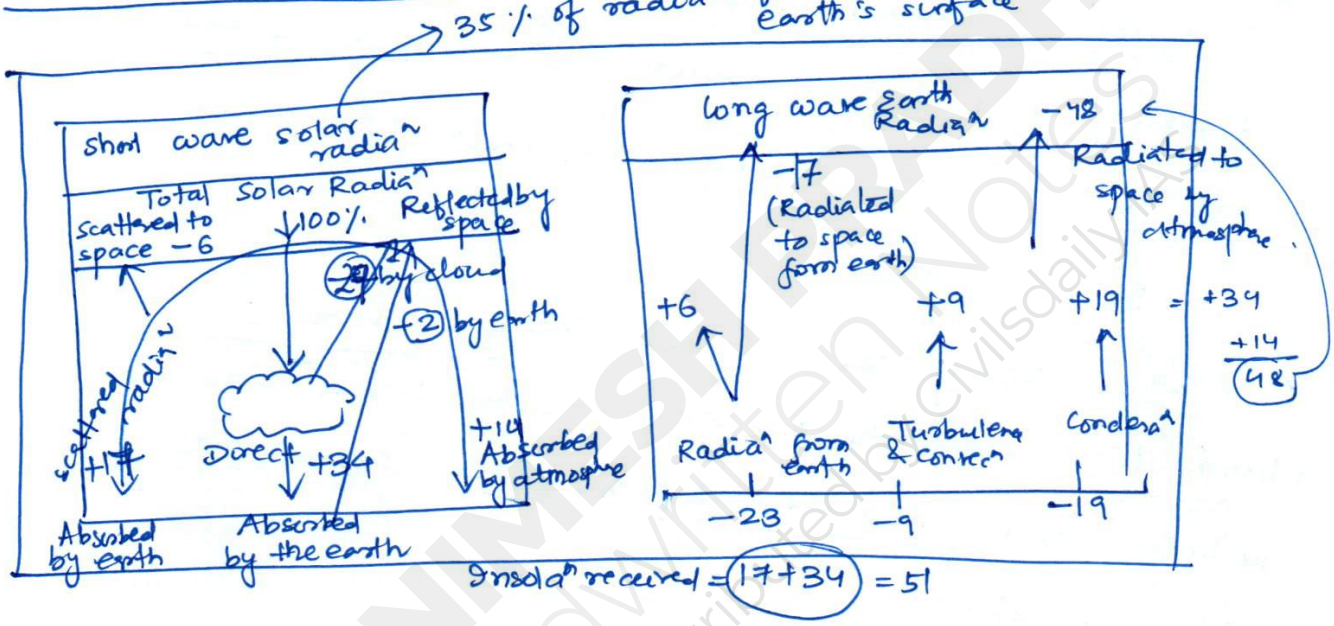
So, the volcanic activity observed parallel to the coastline across the world is mainly due to the divergent & convergent plate boundaries explained by plate tectonics theory.



Q. Illustrating the heat budget of earth, explain the mechanisms through which redistribution of heat takes place between latitudes on earth.

320 watt/m^2
−70 watt/m^2

The heat budget of the earth means that the earth as a whole maintains its temperature as it neither accumulates nor loses heat. The amount of heat received in the form of insolation equals the amount lost by the earth through terrestrial radiation.



The redistribution of surplus heat (from tropics) to deficit heat areas (higher latitudes) is called meridional heat transfer that occurs via:

a) Atmospheric system – convective cells are formed which creates band of low and high pressure. Ex Hadley cell makes hot air in tropics to rise (equator) and ~~descend~~ descend in subtropical high. Ferrel cell in mid latitudes constitutes air that flows along the surface towards high latitudes where a subpolar low occurs near 45–60°. Polar cell occurs at polar latitudes where cold dense air descends blowing towards middle lat. (polar easterlies).

b) Local winds which are seasonal in nature, including sea breeze - Land breeze transfer heat from one region to other.

c) Oceanic system - Cold ocean currents bring cold waters into warm water areas, usually flowing in west coast in lower & middle latitudes in N. hemisphere & east coast in higher lat. Warm currents bring warm water into cold water areas & are usually observed on the east coast of continents in the low & middle lat.; west coast in high lat.

Ex Warm ocean currents like Gulf Stream & North Atlantic drift make the Northern Atlantic Ocean warmer. Similarly, warm Kuroshio current makes Japan's ports navigable in winter.

So, this collective mechanism of the atmospheric & oceanic system is known as Earth's heat engine balancing heat on earth.

Q. Give a brief account of temperature distribution of ocean water, highlight the factors responsible for the same.

Temperature distribution of ocean water is explained in two profiles : Horizontal & Vertical distribution.

Average ocean temp. 27°C.

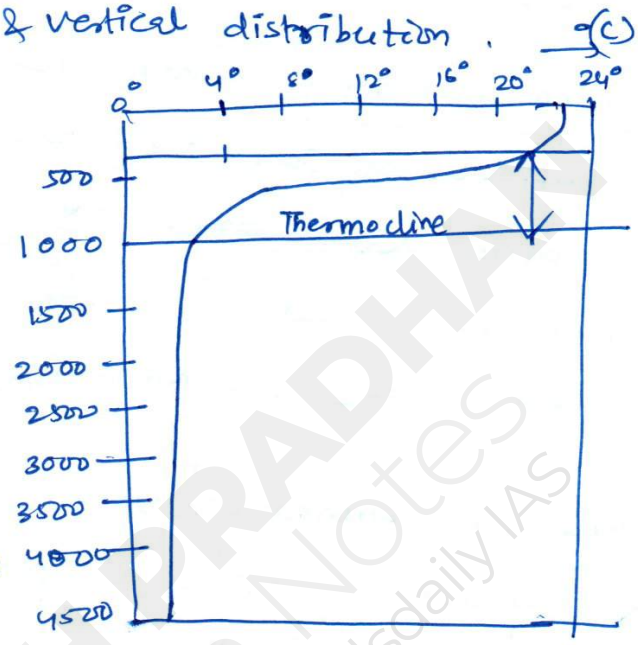
Vertical distribution

Temperature decreases with increasing depth in 3 layers :

i) 1st layer - warm oceanic water (500 m) with temperature 20 - 25°C

ii) 2nd layer - 'thermocline layer' marked by rapid decrease in temp. with increasing depth. (500 - 1000 m thick)

iii) 3rd layer - very cold & extends up to the deep ocean floor.



Horizontal distribn

Avg. temperature of surface water of oceans is 27°C & it gradually decreases from the equator towards the poles.

- Rate of decrease is 0.5°C / latitude.

Factors responsible for the distribn of ocean temp. are :

1) Latitude : The temp. of surface water decreases from the equator towards the poles because the amount of insolan decreases poleward.

2) Unequal dist. of land & water : Oceans in N. hemisphere receive more heat due to their contact with larger extent of land than S. hemisphere.

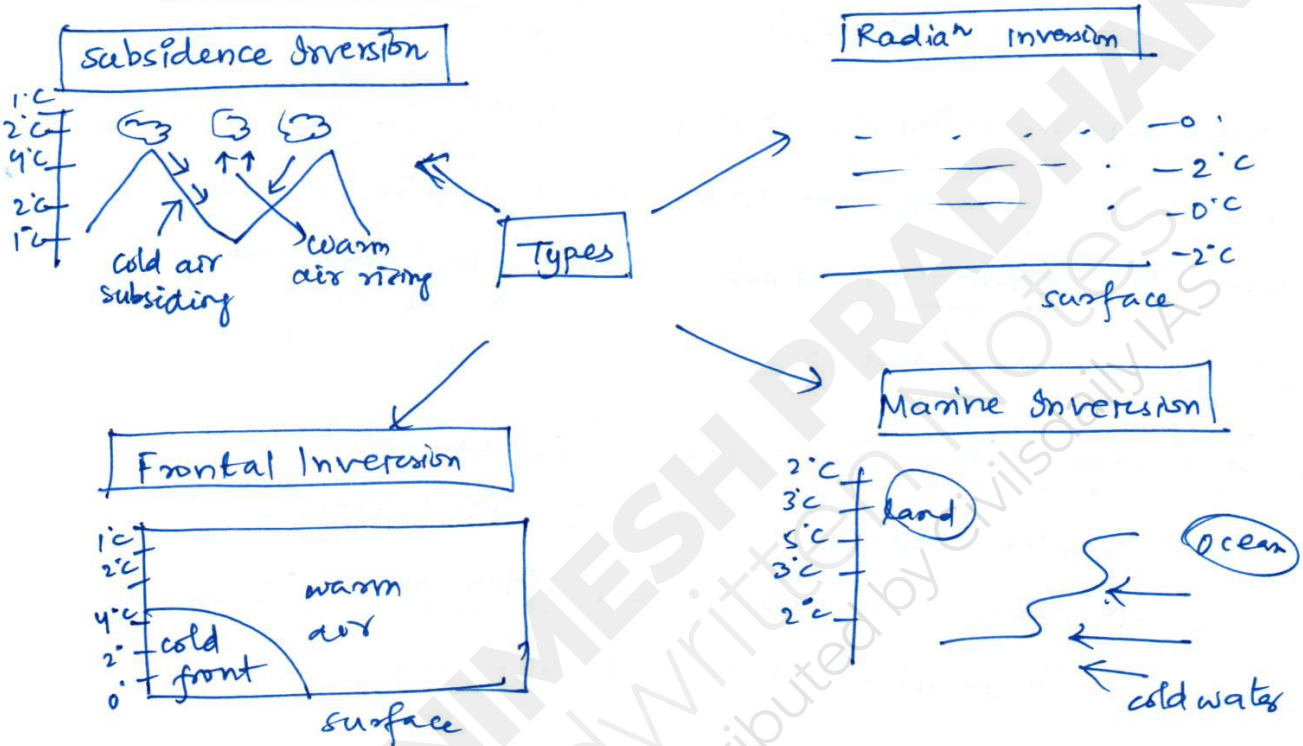
3) Prevailing winds - blowing from the land towards the oceans drag warm water away from the coast resulting in upwelling of cold waters from below.

4) Ocean currents - warm ocean currents raise the temp in cold areas while cold ocean currents decrease the temp. in warm ocean areas. Ex Gulfstream (warm) raises temp near eastern coast of N. America while Labrador (current) lowers temp. near North eastern coast of N. America.

Hence, this temperature distribution of ocean water significantly helps in the prevailing ecosystem in ocean.

Q. Define the phenomenon of temperature inversion. What are the factors for it to take place? Also, enumerate its prominent effects.

Temperature inversion refers to phenomenon of increase in in temperature with increase in height as opposed to normal lapse rate (6.5°C decrease / 1 km rise in height)



Factors required for it to take place

1) Long winter nights aided by mountain topography allow cold air on the mountains (high prenund to descend; this pushes warm air upwards, giving rise to temp. inversion.

2) Cloudless clear sky allows the unobstructed escape of readiation. In the night the ground becomes cooler while the air above it retains the heat & is warmer.

3) Calm & stable atmosphere restricts the cold air near the ground & prevents the blowing & mixing of the warm & cold air.

4) Upwelling of cold water in the coastal regions can decrease surface air temp.

Effects

1) Increased air pollution and reduced visibility : Inversion prevents movement of smoke, dust particles & other pollutants & keeps them trapped in lower layer.

2) Reduced precipitation : Due to stability in the lower atmospheric layers & resultant lack of vertical movement of moist air, convective clouds do not grow high enough for rainfall to take place.

3) Loss of vegetation : The temp. of the air at the valley bottom reaches below freezing point. As a result, the trees along the lower slopes are bitten by frost, whereas those at higher levels are free from it.

4) Habitation pattern : To avoid cold & foggy valley, people in the intermontane valley tend to settle along upper slop. Coffee plantn in Brazil & apple growers of Himalayas in India avoid lower slope.

5) Thunderstorms & tornadoes because of intense energy released after an inversion blocks an area's normal convection pattern.

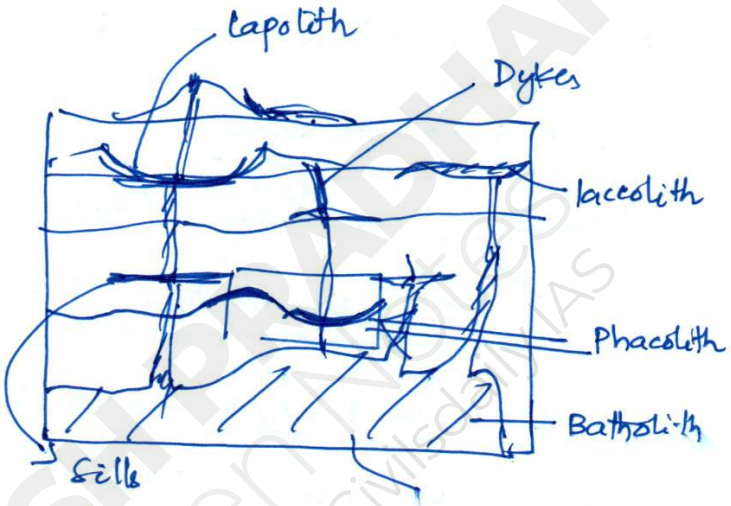
6) Formn of smog & associated health hazards.

Hence, temperature inversion is the short term & common phenomenon mostly occurs in winter cond'.

Q. With the help of diagram, give an account of various landforms resulting from intrusive and extrusive igneous activities.

Based on whether magma cools within crust (intrusive) or lava cools above crust (extrusive), volcanic landforms are formed.

Intrusive land forms



a) Batholiths – large body of magmatic material cooled at deeper depths.

b) Laccoliths – dome shaped bodies with level base & connected by a pipe like conduit.

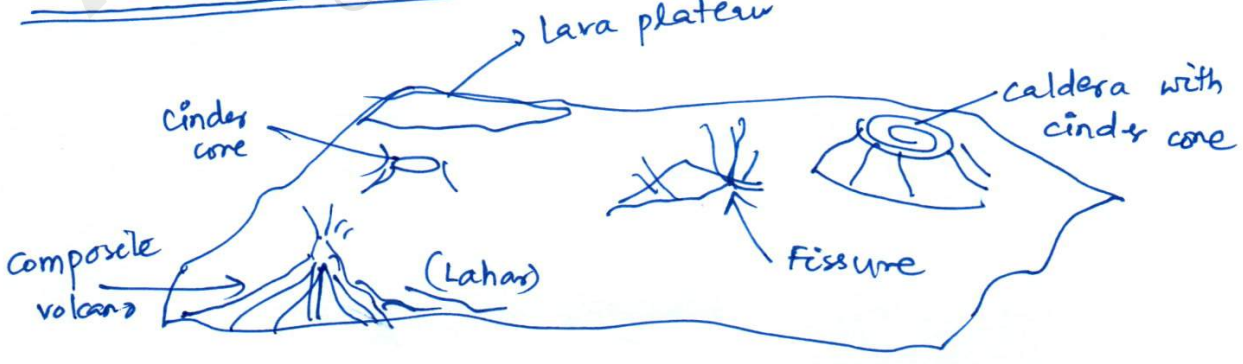
c) Lapolith : saucer shape, concave to the sky body

d) Phacolith : wave like structure formed at synclines & anticlynes

e) Sills : Simple horizontal sheet like formation

f) Dyke : Only vertical formation solidifies perpendicular to ground

Extrusive landforms



1) Mid oceanic ranges Volcanoes – stretches for more than 70,000 km across all the ocean basins

2) Composite type volcanic landforms –
formed by convergent tectonic actions, more vicious lava with high quantities of pyroclastic material
Ex Mt. Stromboli, Mt. Vesuvius, Mt. Fuji

3) Shield type volcanoes
formed by low viscous lava (basaltic lava), hottest lava.
Ex Mt. Loa, Mauna Kea, Hawaiian volcanoes

4) Flood Basalt Provinces – when lava flows for long distances.
Ex Deccan Traps, Siberian Traps

5) Calderca : collapsed depressions of highly explosive volcanoes. Ex. Mt. Mazama, Mt. Toba

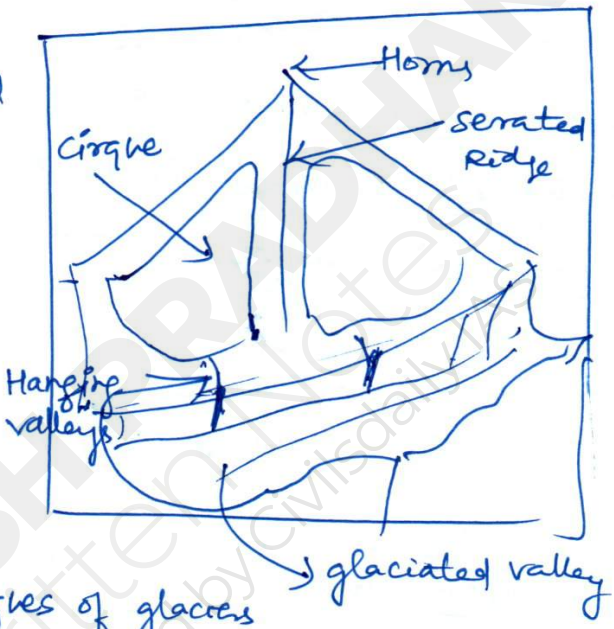
6) Lava Dome – mound shaped protrusion where magma piles up.

So, these structures of volcanic eruptions are large source of minerals and prominent in economic activities.

Q. With examples of erosional and depositional landforms formed during its lifecycle, explain the role of glaciers as a geomorphic agent.

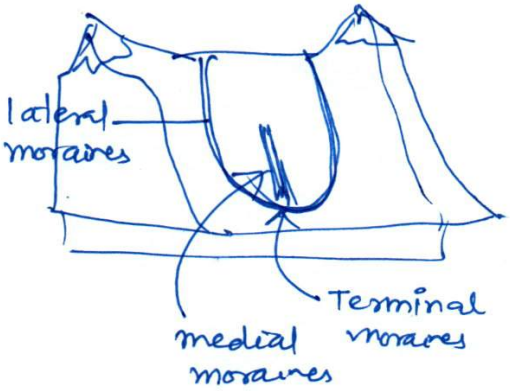
A glacier plays the combined role of erosion, transportation & deposition throughout its course forming various landforms.

Erosional landforms

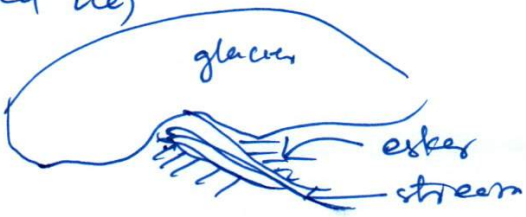


1) Cirque : deep, long troughs formed by downward movement of glaciers
2) Cirque or tarn lake - lake of water in cirque
3) Horns - 3 or more radiating glaciers headward until their cirque meet
4) Serrated ridge - divides b/w cirques of glaciers
5) Glaciated valley - U shaped with broad floor with steep sides along with hanging valleys.
6) Fjords - deep glacial troughs with sea water (Ex. found in Norway)

Depositional landforms

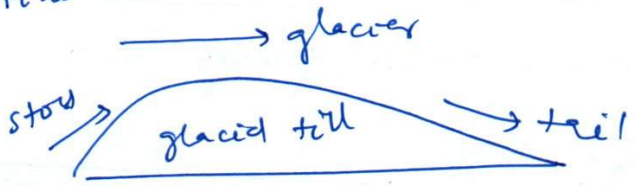


1) Moraines - long ridges of deposits of glacial till
2) Eskers - winding ridge of sand in lateral side of stream flowing (melted ice)



3) Outwash plains – plains at the foot of the glacial mountains covered with glacio-fluvial deposits

4) Drumlins – oval shaped ridge like feature made of glacial till.



Hence, glaciers have played an important role in the shaping of landscape in the middle and high latitudes & in alpine environments.

Q. What are the conditions required for frontogenesis? Highlighting the characteristics of fronts, discuss their distribⁿ pattern across the world.

Frontogenesis is formation of fronts, which are a boundary separating air masses with contrasting characteristics like temperature, density, relative humidity, wind direction & pressure.

Necessary condⁿ for formaⁿ

1) Temperature difference → reason why frontogenesis does not occur in the equatorial regions.

2) Convergence of air masses → when two air masses having diff. temp. converge, they try to invade the space of each other leading to front formⁿ.

Characteristics of fronts

1) Temperature – Fronts are characterized by temp. inversion layer because of warm air over a wedge of dense cold air.

2) Frontal slope – depend upon latitude of front, wind speed & temp diff. In general, cold fronts are steeper than warm fronts. The steeper the slope → more intense lifting → vertical motion of warm air → intense weather.

3) Clouds & weather – associated with cloudiness & precipitaⁿ because of ascent & condensaⁿ of warm air

4) Turbulence – Frontal intensity is determined by turbulence. This leads to strong winds & thunderstorms & temperate cyclones.

Distribution pattern of fronts

1) **Atlantic Polar Front** is formed when maritime tropical air mass meet continental polar air mass (in winter)

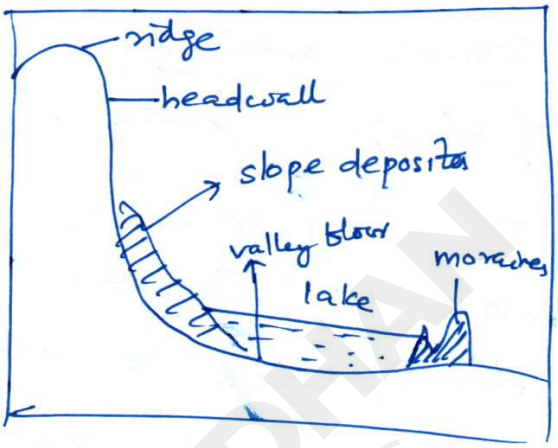
2) **Atlantic Arctic Front** maritime polar air mass + air mass developed along boundary of Arctic source region

3) **Pacific Arctic Front** along Rockies – Great lakes region

4) **Pacific Polar Front** along coasts of N. America & Asia in winters leading to rainfall.

5) **Mediterranean Front** cold polar air mass of Europe + winter air mass of Africa.

Q. Explain the phenomenon of Glacial Lake Outburst Floods (GLOFs). Discuss its impact & suggest measures to tackle this hazard.



Glacial lakes are formed when glacial ice or moraines or natural depressions impound water. When the lake is watertight, melt water will accumulate in the basin until seepage or overflow limits the lake level. The impoundment of the melt may become unstable leading to sudden release of large quantities of stored water causing flash floods called GLOFs.

Major factor → rapid slope movt. like slides, avalanches into lake, other include heavy precipitation, earthquakes, volcanic eruptions & anthropogenic activities.

Impact

1) Catastrophic societal impacts - as experienced in Andes & in Hindu Kush - Himalaya region

2) Ocean circulation - by reducing salinity of surface layer of the ocean & influence global climate

3) Impact on geomorphology - influence ~~erosional-accum~~ erosion-accumulation interaction and sediment dynamics like bank & depth erosion of the river/stream, meander shift, formation of erosional terraces.

Measures to tackle

1) Access to early warning system & timely information

2) Continous monitoring to understand changing dynamics of Himalayan glaciers. (ISRO is engaged in lake monitoring)

3) To identify hazardous lakes, remotely sened data-based methods can be installed.

4) Prevention/mitigation by dam remediation like artificial dams, tunnels, open cuts, concrete outflows, flood protection walls.

5) Community preparedness, hazard mapping, vulnerability assessment, identification of safe evacuation sites etc.

So, GLOFs major concern in Himalayan states (Earthquake Zone V and zone IV) → Uttarakhand, HP, J&K with 200 potentially dangerous glacial lakes.

Q. In light of various recent studies, discuss how climate change is affecting the jet streams.

Jet streams are concentrated narrow bands of fast flowing and strong winds mostly in the tropopause at heights of 8-15 km. They are active in middle latitudes, in both hemisphere.

Various types of jet streams —

a) ~~Tropic~~ Polar jet stream — forming b/w Ferrel and Polar cells at about 60°

b) Subtropical jet stream — forming b/w Hadley & Ferrel cells at 30°

c) Temporary jet stream — Ex Somali jet stream, Tropical Easterly Jet stream.

Climate change and jet streams

1) Studies have linked a warming Arctic to the polar vortex, a swirling low-pressure center at the North & South pole. An unstable polar vortex can expand & send cold Arctic air into the jet stream, leading to frigid winter weather and storms southward.

Ex In January 2019, a severe cold wave was caused by a weakened jet stream around the Arctic polar vortex which hit mid-western USA & Eastern Canada.

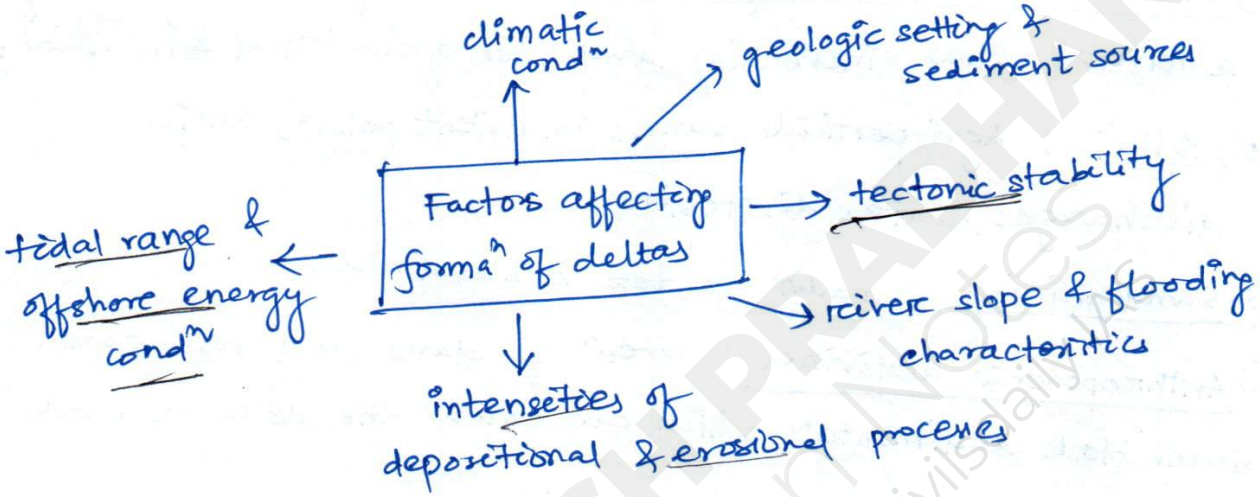
2) Slower & weaker North Atlantic jet streams have been linked to rapidly melting ice & rising temp in Greenland.

3) GHGs are increasingly disrupting the jet stream in North America and Europe. This results in frequent summer droughts, floods & wildfires.

Ex severe flooding in the north of England in Nov. 2019 was due to shift of Northern Hemisphere jet stream.

Q. State the factors which affect the formation of deltas. Highlight their significance, mention the threats faced by deltas across the world.

Delta is a low-lying plain composed of stream-borne sediments deposited by a river at its mouth.



Significance

1) Economic activities

a) Important for trade and commerce. City of Vancouver, sits on the delta of the Fraser River. The Pearl River delta is one of the fastest growing centres of China's economy. Yangtze River Delta, Greater Tokyo Area.

Vancouver / Fraser River Delta

b) Site for sand & gravel ✓

c) Much of the world's petroleum resources are found in ancient deltaic rocks ✓

2) Agricultural Activities - Ex Ganga - Brahmaputra delta provides rice, tea, fish & other seafood as the leading agricultural products.

3) Biodiversity - Plants and fishes, crustaceans, birds and even predators like tiger & bears. Ex Sundarbans

4) Cultural – Major ancient civilisatn grew along deltas of Nile and Tigris-Euphrates. Some are even recognised by UNESCO.

Threats

1) Extensive river management – monitoring & administering a river's flow, increasing land for agricultural & industrial purpose.

2) Pollutn : Agri pesticide runoff, nutrient pollutn, toxic discharges, water diversions

3) Sand mining : leading to ~~loss~~ sea level rise.

4) Anthropogenic activities : creatn of dams and reservoirs. Dams block sedimentatn which can cause the delta to erode away.

5) Climate change induced rising sea levels – susceptible to flooding.

Q. Describing its formation, delineate the region that is commonly referred to as 'Permafrost'. Also, discuss the concerns associated with the melting of permafrost.

Permafrost is a perenially frozen ground that remains at or below 0°C for 2 or more years.

Formation

- In areas where the mean annual air temperature becomes colder than 0°C, the water trapped in sediment, soil, and the cracks, crevices, & pores of rocks turns to ice.
- Some of the ground frozen in the winter does not get completely thawed in the summer, therefore a layer of permafrost forms and continues to grow downward.

About 25% of entire Northern Hemisphere consists of permafrost. It is widespread in the Arctic regions of Siberia, Canada, Greenland & Alaska, Tibetan plateau, Andes, Southern Alps, Antarctica.

Concerns associated with the melting of Permafrost

1) Loss of GHG stores - Permafrost does not let the microbial decomposition of plants and animals happen & thus acts as a carbon sink. Ex Thawing of permafrost → release 92 Billion tonnes of carbon by 2100 → 92 BT

2) Release of toxic mercury - risk of releasing & biomagnifying almost 15 million gallons of natural

mercury → 2x of Hg found in ocean + atmosphere + soil.

3) Threat to infrastructure – Melting of permafrost would damage the accordingly planned infrastructure. Risk of oil & gas leaks from Arctic.

'Thermokarsts'

4) Creation of altered landscape – can create 'Thermokarsts' (areas of sagging ground and shallow ponds). Make land more vulnerable to landslides, rise in sea level lead to flooding.

5) Diseases – thawing of permafrost may release harmful pathogens. The 2016 anthrax outbreak in Siberia is linked to the melting of permafrost.

Hence, Arctic permafrost can increase global warming by 0.27°C by 2100 & 0.42°C by 2300, hence a major global concern.

Q. Explain the formation of tropical cyclones. Also, illustrate the global distribⁿ of these cyclones.

A tropical cyclone is a rotational low pressure system that develops over tropics with organized deep convection, closed wind circulation about a well-defined centre.

Condⁿ for formaⁿ

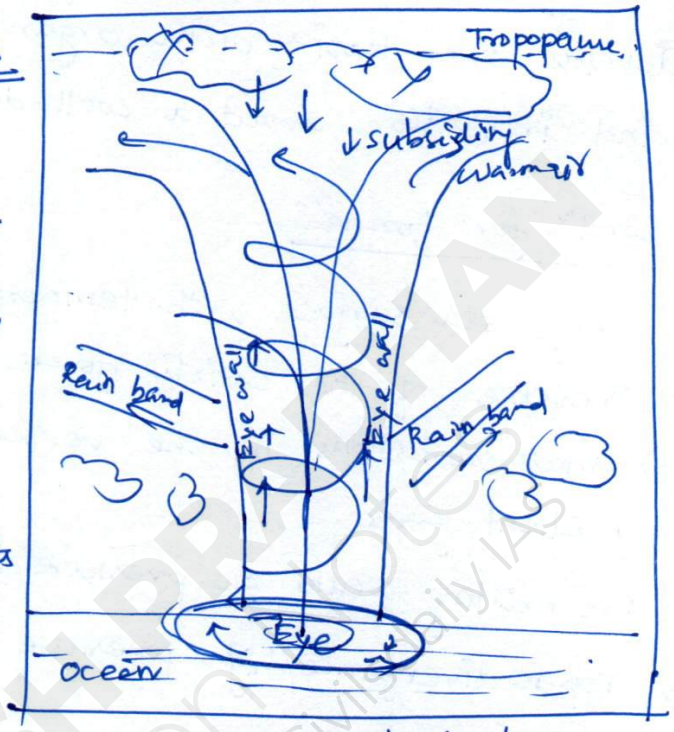
1) Large sea surface with temperature > 27°C
2) Presence of the Coriolis force
3) Small variations in the vertical wind speed / strong pressure gradient force.
4) Pre existing weak low pressure area
5) Upper divergence/high pressure above the sea level system.

Steps of formaⁿ

1) Over tropical watas, due to high temperature, the moist air over the ocean gets warm and starts rising upward, creating a lower pressure zone.
2) The air from surrounding HP areas pushes into the LP area, this air gets heated and rises, creating a cycle of intense LP centre.
3) With storm rotating faster, 'eye' of cyclone develops in centre (calm and low pressure). Around the eye 'eye wall' develops where strong spiralling ascent of air occurs till tropopause.
4) As the warmed & moist air rises and cools, the water in the air forms towering cumulonimbus clouds.

5) On reaching the land, the moisture supply is cut off & storm dissipates making 'landfall'.

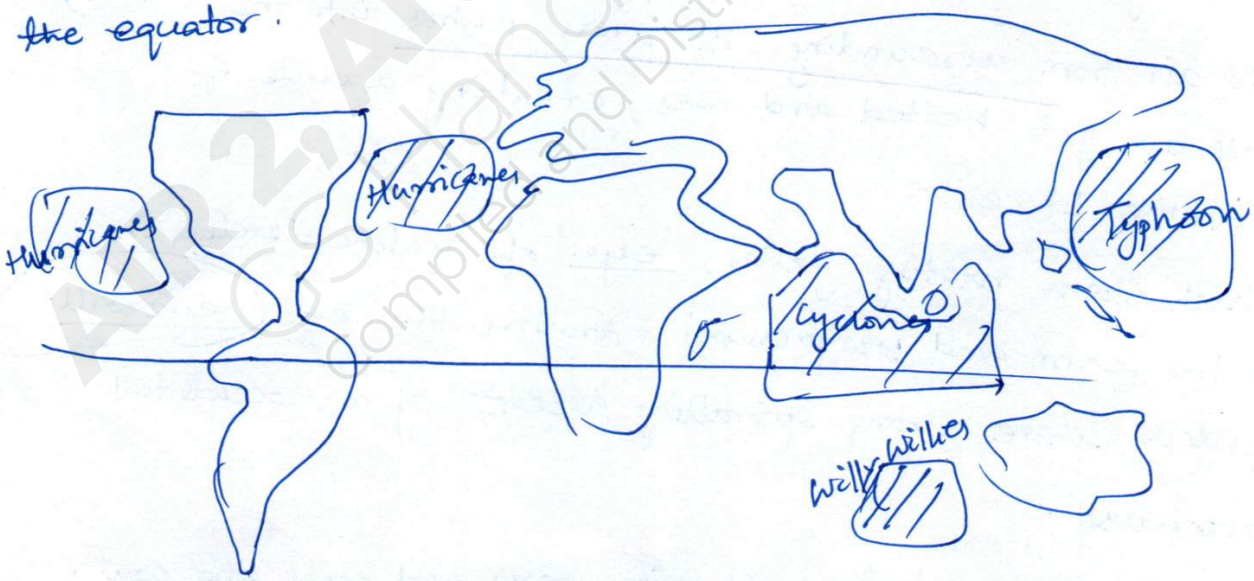
Global distribution of cyclones



- Limited to warm tropical areas with vast ocean surface.
- Mostly originate on the western margins of the oceans because cold currents lower the surface temperatures of the eastern parts of the tropical oceans.

Ex Presence of peru Current on eastern margin of S. America reduces temp. of ocean waters.

→ Due to absence of coriolis force, they do not occur at the equator.



Q. Dead zones are emerging as a serious threat to world's oceans. Analyze the causes and impacts of dead zones. What solutions do you suggest to curb this growing menace?

Dead zones (Hypoxic zone) are areas of water bodies where few acquatic animals can survive because of low oxygen levels. They emerge in ocean depths of 650 – 2600 feet when influxes of chemical nutrients spur algae growth sucking up oxygen.

Causes

- Naturally: as drifting of the routine patterns of water and wind.
- Human activities
  i) Nutrient pollution – causing overgrowth of algae which consumes oxygen in decomposition process.
  ii) Intensive farming is the practice most commonly linked to dead zones.
- Warming sea temperatures – increase the stratification of the ocean & weaken overturning circulation in the water.
  ⇒ less oxygen can enter from atmosphere and surface water to down in the ocean.
- Rising global temp. decreases oxygen solubility in water.

Impact:

1) Economic loss – Impacts fishery product & tourism.
   Ex Gulf of Mexico, with flourishing industry facing

challenges as has one of the largest dead zones of the world.

2) Harmful to human life – Harmful algal bloom like red tide and golden algae, produce toxins when they decay, killing marine life & making the creatures poisonous to humans.

3) Food insecurity – due to depletion of fish supply.

Solution

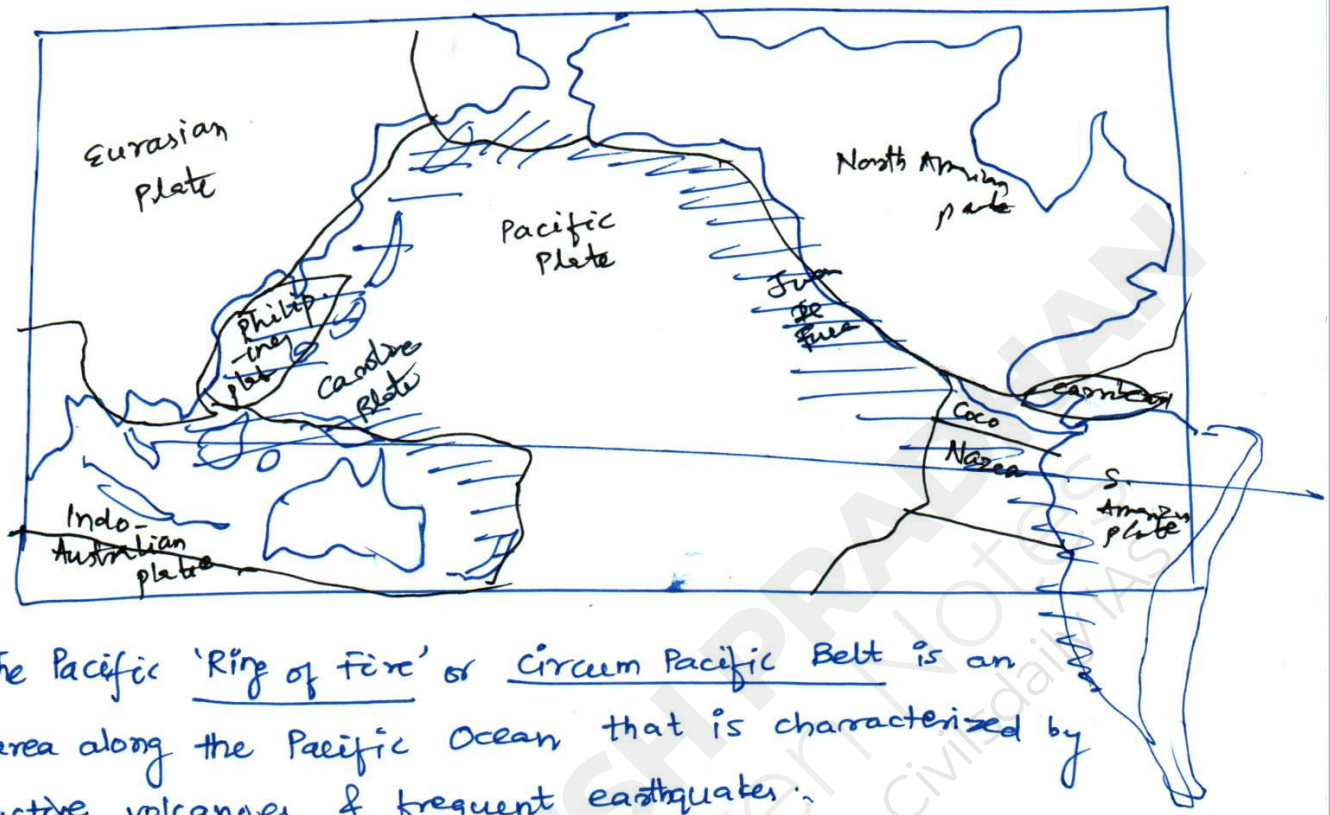
1) Using fewer fertilizers – to reduce the amount of runoff that is wasted into the sea.

2) Better practices to discharge chemicals – treat waste, alternate disposal methods.

3) Alternative method to sewage system – R&D.

Dead zones formation is a reversible process. The Black Sea dead zone is an example of what was once a large problematic region of dead zones, ultimately became a clean sea again.

Q. Discuss the geographical/geophysical characteristics of circum-Pacific zone.



The Pacific 'Ring of fire' or Circum Pacific Belt is an area along the Pacific Ocean that is characterized by active volcanoes & frequent earthquakes.

- 75% of world's volcanoes & 90% of world's earthquakes.
- Its length is over 40,000 km & traces from New Zealand clockwise in an almost circular arc covering Tonga, Kermadec Islands, Indonesia

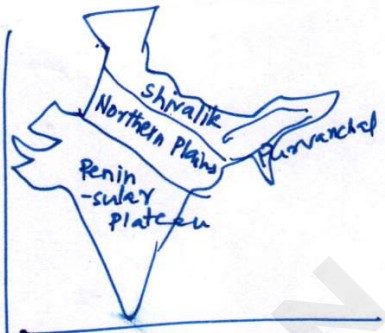
Formation – due to the repeated subduction of the oceanic lithosphere beneath the continents & the islands that surround the Pacific ocean.

- result of plate tectonics (Convergent, Divergent, Transform)

⇒ Important volcanoes: Mt. Fuji (Japan), Aleutian Island (US), Krakatau Island Volcano (Indonesia)

⇒ Formation of hotspots – areas deep within the Earth's mantle from which heat rises.

Northern Plains – 3200km from east to west ; 150 - 300 km width, 1-2km depth.



Bhabar
~~Khadar~~ Tarai
Bhangar
Khadar

Formation

1) deposition of alluvium brought by the rivers. (Indus, Brahmaputra, Ganga)

2) There was shallow trough or geosyncline b/w Himalayas & Deccan

3) Due to the uplift of the Himalayas in the Tethys sea, Indian Peninsula subsided & formed large basin. That basin was filled with sediments from the rivers which came from north & from the peninsula in the south.

Drainage system Evolut

Himalayan

1) Shivalik / Indo-Brahma traversed entire Himalaya (Assam - Punjab) during Miocene period (5-24 mya)

2) Indus | Ganga | Brahmputra

(delhi ridge) Potwar Plateau ↑ upheaval (Pleistocene)

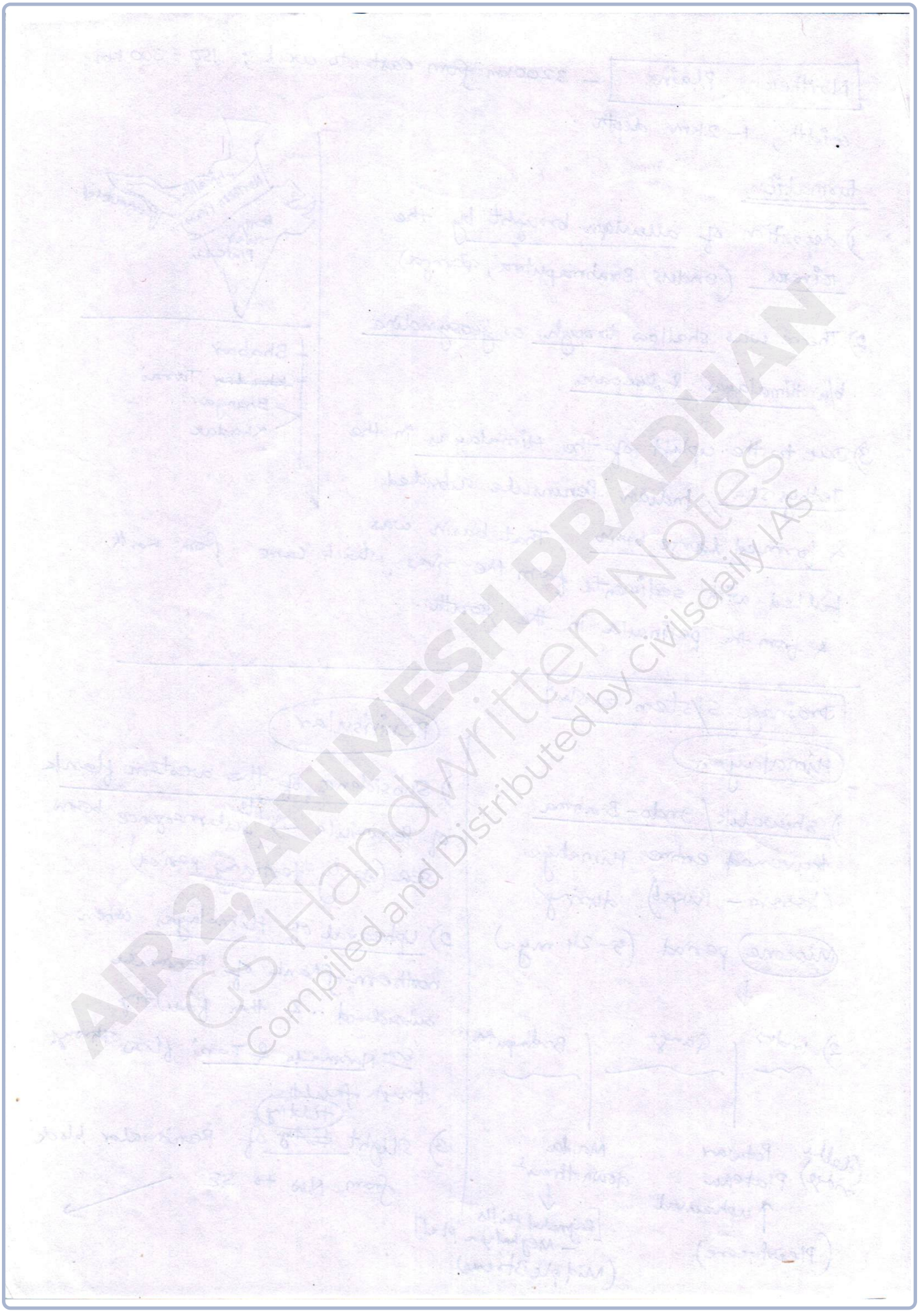
Malda down thrust ↓ [Rajmahal Hills – Meghalaya plat] (Mid pleistocene)

Peninsular

1) Subsidence of the western flank of Peninsula → its submergence below sea (early tertiary period)

2) Upheaval of Himalayas when northern flank of Peninsula subsidence .. & then faulting Ex Narmada & Tapi flow through trough fault

3) Slight ~~tilting~~ tilting of Peninsular block from NW to SE →



Orogenesis of Himalayan Mt

India started her northward journey 200 million years ago & at the time of which Pangea broke.

India collided with Asia about 40-50 million years ago.

Stage 1: Collision Oceanic - Oceanic crusts & formation of festoons or Island arcs (Oceanic crust of Indian plate + Oceanic crust of Eurasian plate & Later being heavier subducted.

→ Island arcs in Tethys sea ⇒ formed part of Ladakh & Tibet.

Stage 2: Oceanic crust of Indian plate → subducted Eurasian continent

⇒ young fold mt. on margin of the Eurasian land mass in the form of Karakoram Range.

Stage 3: Continent - continent → folding of sediments of Tethys sea

Evidences

1) Island arcs in Drass sector of Himalayas
2) Karakoram ranges are volcanic of origin.
3) Karewas in valley prove that valley was lake in pleistocene epoch
4) Discovery of hippopotamus skull at Ladakh → till recently the Himalayan region was a warm, low-lying swampy region
5) Evidence of stone age man in high reach ⇒ mountains rapid rise recent
6) Himalayas still rising. (Swarms of earthquakes & periods of quietude occur just before a giant earthquake)

Faults — Strike slip (Transform) — San Andreas (Pacific + N. America)
— Normal (Divergent)
— Reverse (Convergent)

Auroras → charged e^- particles from sun + ($O_2 + N_2$) earth's upper atm.
(fast moving)

Borealis (North) Australis (south)

$e^- \longrightarrow O_2 + N_2 \longrightarrow$ excited → emit photons when come back

- color : depends on which gas

N_2 : blue | high energy $e^- + O_2$ → green
low " $+O_2$ → red

Tropical Cyclone

1) large sea surface (>27°C)
2) upper level air divergence
3) coriolis force
4) pre existing low pressure system
5) low vertical wind speed variⁿ

	Tropical Cyclone	Temperate cyclone
1) Origin	Thermal	Air masses, front systems
2) latitude	10°–30° N/S	35–65° N/S; more in N hemi due to greater temp. contrast
3) Frontal system	Absent	Yes, due to formaⁿ of frontogenesis (occluded fronts)
4) Season	late summers (Aug – Oct)	Irregular; summer less & winters more
5) Size	Small area	large area
6) Shape	Elliptical	Inverted V
7) Rainfall	Heavy, but does not last long	Slow rainfall but for many days
8) Wind velocity & destrucⁿ	Much greater (100–250 km/h) greater destrucⁿ due to winds, storm surges & torrential rain	Comparatively low. 30–150 km/h less destrucⁿ due to winds; more due to floods
9) Isobars	Complete circles, pressure gradient is steep	Usually V shaped & pressure gradient is low
10) Lifetime	not more than a week	2–3 weeks
11) Path	East to west	west to East
12) Calm region	Centre (eye) – no rainfall	No such
13) Jet stream influence	Not clear	✓
14) Clouds	Fewer varieties – cumulonimbus, nimbostratus	– variety at various elevaⁿ

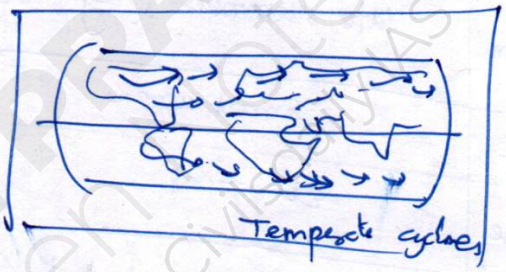
Distribution pattern of temperate cyclone

1) Atlantic - Arctic Front – N. Atlantic warmer than Arctic. It causes cyclone move towards NE direc^n & reach western Europe.

2) N. America - Polar Front – air mass of N. America + North polar air mass = convergence in Great Lake Region.

3) Mediterranean front – leads to western disturbance

4) Southern Hemi – does not have big landmass = no temp. contrast = lesser intensity (35°–65° S) & trends in SE direc^n



Earth's Magnetic Field

Dynamo theory – convection in the outer core + coriolis effect → Earth's magnetic field.

Heat source → energy released by compression of core; energy released at the inner core; radioactivity of K, U and Th

↓

diff. in temp, pressure → convec current

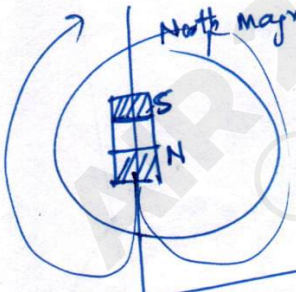
↓

flow of liquid Fe → electric current

↓

spiral motion of charged particle (coriolis) → all magnetic fields aligned in same direc to add up to one vast magnetic field

→ Earth's **North Magnetic Pole** – South Pole of its Magnetic field.



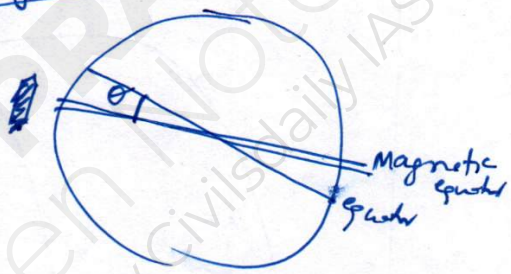
Geomagnetic poles are intersec of earth's surface and axis of a bar magnet hypothetically placed at centre of the Earth

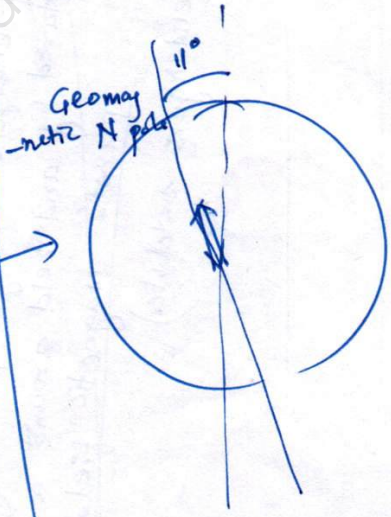
→ **Magnetic poles** are points at which magnetic needles become vertical.

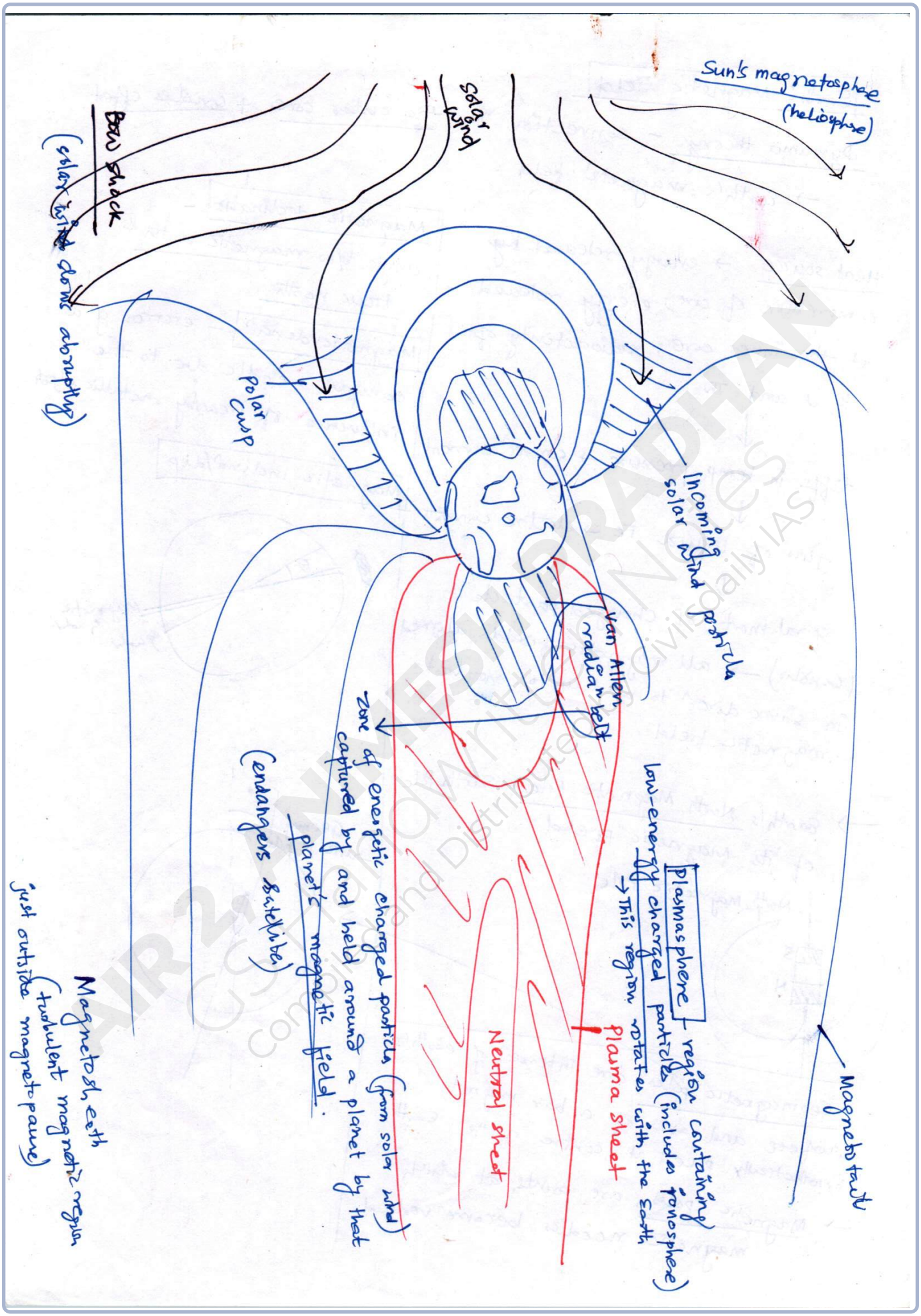
Magnetic declination – angle b/w magnetic north & true north

Magnetic declin – error of a compass needle due to the influence of nearby metallic objects

Magnetic inclina/dip







Coffee Cultivation

4% of world's total coffee production
6th largest in coffee produc

Coffee
- 16-28°C
- 150-250 cm
- tropical
- well drained slopes
- slopes ht. of 900-1800 m
- Bad → low temp, frost, dry weather for a long time & harsh sunshine
- Laterite soils

- Karnataka > Kerala > TN

4 lakh empty growers

Challenges

1) Impact of climate change - dry spells, unseasonal heavy rains, floods, landslides
2) Impact of heavy rains - fruit rot, stalk rot, root rot
3) Emergence of new diseases
4) No adequate fund suppt - not to coffee research stations
5) Volatility in market prices marginalizing producers → rapidly turning out to be a buyer-driven commodity market.
6) Impact of Exports on cost competitiveness
   77% exported
7) High cost of financing - small/medium c/o collateral; international low interest (labour change) (65%, Brazil ↓ 25%)
8) Increasing cost of inputs
9) No pricing mechanism → traders and curos are calling the shots
10) Identity crisis for Indian coffee
11) Hard terrain & topography

Case study

Chikkamagaluru → growing avocados, mangosteen, oranges, guava - intercropping with coffee.

☆ Coffee Act & Coffee (Promotion & Dev) Bill, 2022

Jute Industry

15/60 mills in WB shut down.

Data

- India largest producer, then Bangladesh
- In terms of acreage and trade, Bangladesh lead – 3/4th of global jute exports in comparison to India's 7%
- direct employment to 4 lakh people

Issues

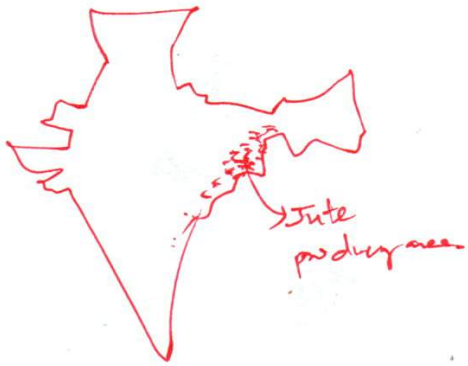
1) High prices – mills are procuring raw jute at higher than what they are selling them at after processing
2) Mills do not acquire their raw material directly from the farmers.
3) cyclone amphan & subsequent rain
4) low quality of jute fibre as water-logging (CACP)
5) India lags behind Bangladesh in producing superior quality of jute fibre due to infra constraints, lack of certified seeds, & varieties suitable for the country's agro-climate
6) Increased availability of cheaper synthetic substitutes
7) low competitiveness as Bangladesh provides cash subsidies for semi-finished & finished products.
8) High cost of produc°, low power supply
9) low demand: Jute used for manufacturing furnishing mat., fashion accessories, floor coverings → declined from 15.5% to 9.7%

Steps taken

- Jute Packaging Material Act, 1987 (JPM Act) → 100% produc° of foodgrains & 20% sugar produc° must be packaged in jute bags.
- Jute ICare – for distribu° of subsidized seeds.
- National Jute Manufactures Corp. Ltd taken over mgt. of sick Jute mills,
- Growing awareness for enviso nment concerns.

Schemes

Jute Diversifica° scheme, Jute Retail Outlets, PLI support on Jute Product Diversifica°



Wetland areas of marsh or peatland with water that is static or flowing, fresh, brackish or saline, artificial/natural whose depth @ low tides does not exceed 6m.

Importance — Ecological / Economic

1) Ecosystem services – regulate water quantity + groundwater recharge → US $ 47 Bn
2) Barrier against flood and storm
3) Nutrient recycling + act as filter trapping suspended mud + absorb/trap & detoxify pollutants
4) Productive areas for plant/animal & wetland agri → water birds + migratory species
5) Fisheries
6) Recreation + culture
7) Carbon sink
   (*) 30% of land-based carbon in peatlands (A)
8) Eco → >1 Bn depend

Riparian buffer

Threats:
- Salinize (GW more removed)
- Urbaniz^n
- Sand mining
- Agriculture
- Invasive species
- (*) 64% disappeared last cent.
- Pollu^n
- Climate change
- Eutrophic^n
- dredging
- Overfishing

Efforts

- Ramsar Conven^n (75 in India)
- Wetlands Int.
- Montreux Record
- Nat. Plan for Conserv^n of Aquatic Ecosystems (NPCA) + Nat. wetlands Conserv^n Prog. (NWCP)
- Wetlands (Conserv^n & Mgt.) Rules
  ↳ decentralized.

(*) Artificial regener^n → Hebbagodi lake, Bengaluru.
- Prevent hyacinth growth.

Urban Planning – 31% of India's popula^n

Challenges

1) Uneven urbanisa^n – 75% of urban pop. in 10 states

2) Statutory towns growing w/o Master plans – NITI Aayog – ~50% of India's statutory towns; even delays in master plan

3) suboptimal Utilisa^n of urban land

4) slum – 17% of urban popula^n

5) water scarcity

6) Disast^ Mitiga^n – Parliamentary standing Comm on Home Affairs → encroachment of lakes & riverbeds → urban flooding in Chennai

7) Pressure on coastal habita^ → 14% popula^n

8) Traffic 9) ULBs issue 10) Accidents

Global best practices

1) Garden city movement – In west → decentralise the working environment with push for healthier living spaces, open spaces, public parks etc.

2) Neighbourhood concept – residential house and streets organized around a local school/community center → lowers traffic & high safety roads,

3) 15-min Paris model – Every Parisian should be able to do shopping/work/recreation within 15-min walking distance → less vehicular traffic

4) Investment in pedestrian infra and non motorized transp in TOA zones.

For India

1) Every city with master plan (include poverty mitig^n, affordable housing, urban mgmt)

2) Urban land use

3) Public land availability global average – 40%

4) Flooding, disaster mgt

5) Traffic

6) Renewable

7) climate change – World Bank → GDP reduce by 3% of India due to climate change.

8) Educa^, Town planners, Rfd

3 lakh town plannas reqd. (current – 5000)

NITI Aayog – Citizen outreach prog. – Private player role enhance – Revision of Town & Country planning Acts.

Solar Energy – Installed capacity – ~~47.66 GW~~ (Oct. 2021) 48 GW.

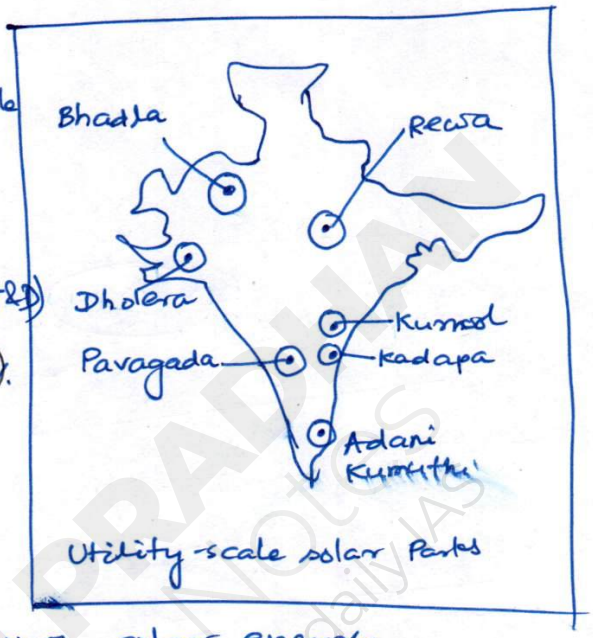
11.2% of total installed capacity

(*) India had a target of (175 GW) of renewable (100 GW – Solar)

challenges in utiliza^n

1) **Intermittency challenge** – Unpredictable & loca^l-specific, diurnal & seasonal varia^n

2) **High cost and Transmission & Distribu^n (T&D) loss** → install^n cost high, T&D loss ~40%.
⇒ less competitive



3) **Manufacturing challenge**

4) **Strain over land resource** – 1 km² of land reqd. to generate every ~~20-50 MW~~ of solar energy.

5) **Storage Isue** – Can't provide on-demand power → issues in grid integra^n & requires efficient battery storage system.

Steps to Increase

1) **National Solar Mission** – 100 GW (40 – Rooftop, 60 – large + Medium grid)

2) **PM KUSUM** – clean energy to 35 lakh farmers, solar projects upto (2 MW) on agri land

3) **Atal Jyoti Yojana** – Solar street lights with (25%) from MPLADs fund

4) **Solar Parks Scheme** – facilitate large-scale grid connected solar projects

5) **Int. solar Alliance** – Mobilize investment of US $ 1000 Bn by 2030
– 1000 GW by 2030

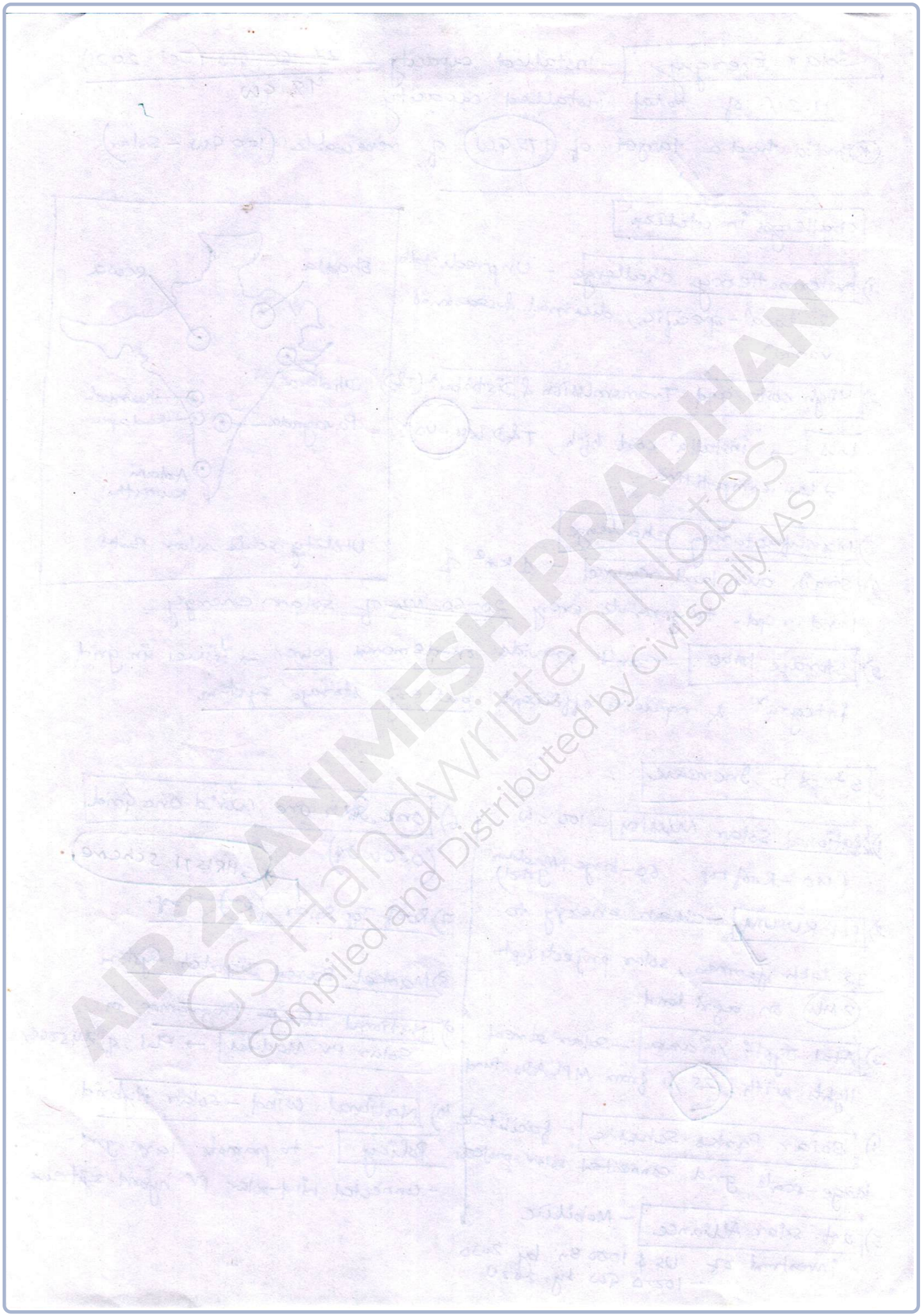
6) **One Sun One World One Grid** (OSOWOG)

7) **Roof Top Solar (RTS) Prog.** → SHRISTI scheme

8) **Market Based Dispatch System**

9) **National ~~Activity~~ Programme on Solar PV Modules** → PLI of ₹4500 Cr

10) **National Wind – Solar Hybrid Policy** – to promote large grid-connected wind-solar PV hybrid systems



Arctic Region

WWF - Arctic Programme → Arctic Region is warming up 2x as fast as world average.

- Since 1980, volume of Arctic sea ice ↓ by 75%.

Ecological Impacts

1. Loss of ice → sea levels, salinity levels, current and precipitation patterns
2. Permafrost thawing - sudden storms are ravaging coastlines & wildfires
3. Carbon sink getting depleted
4. ~~Mercury~~ Ctly (Higher release)
5. Fisheries
6. Biodiversity
7. Home to 40 diff. indigenous group

Northern Sea Route

Energy, shipping ← Commercial Importance → Oil & Gas deposits ↓ 22% of world's unexplored resources

fishes ← Minerals → 25% of global reserves of rare earth minerals - Greenland

Svalbard

- Absence of Treaty

For Antarctica → 1959 Antarctic Treaty

India's Arctic Policy - scientific research, sustainable tourism, mineral oil & gas explorn + climate change.

India's engagement -

→ Svalbard Treaty (1920) - Paris

→ Himadri → Manoon

→ Arctic Council → Observer Status

→ Min. of Earth Sciences → Nat. Centre for Polar & Ocean Research

Arctic Council Countries

1) Canada
2) Denmark
3) Finland
4) Iceland
5) Norway
6) Sweden
7) Russia
8) US

Renewable Energy - 26.53% installed gen. capacity

Aspire circle - $212 Bn revenue, create 3.4 million jobs, impact 919 million lives by 2030

- India - 3rd biggest renewable energy producer (136 GW / 373 GW)
- Solar (49.34 GW); Hydro (51 GW), Wind (40 GW), Biopower (10.61 GW)

Benefits

1) Private sector involvement - to reach 450 GW renewable (Ex Reliance power - ₹5 lakh cr in green energy)
2) low cost of maintenance - wind/solar/bio
3) Bio friendly
4) fulfill several govt. objectives - Panchamrit / SDG / NDC of Paris Climate Agreement
5) Decentralized - Biogas plant, rooftop solar plant → Ex UT Daman - get its energy completely from solar energy generated inside & in the vicinity of city → no dependence on power grid

Achievements

1) Investment - In last 6 years → ₹4.7 Crore investment (FDI - ₹42,700 Crore)
2) Growth - CAGR 20% in renewable gen. since FY16. Installed capacity (4th largest) → 286% growth in 7.5 years

1 Bn Tonnes by 2030, reduce the carbon intensity by <45%.

3) cost - cost of solar energy ↓ from ₹2.5/kWh compared to ₹12/kWh in 2010
4) Highest ever wind capacity ~~103,000 MW~~ 22,645 MW

challenges

1) High initial cost - Coal based ₹4 Crore/MW, for a wind based plant with 25% capacity utilize → ₹6 Crore/MW
2) Reliability - geography
3) Storage infra
4) Poor DISCOMs and
5) Funding
6) ~~solar~~ Low social acceptance → low solar panels in farms, rooftop solars
7) weak domestic manufacturing capability
8) Integra' into the national grid.

Govt. Policies

1) RE certificate - compliance of RPO.

2) Release of Green H_2 mission
5 MT by 2030

3) PLI – on Battery storage, infra

4) Green Term Ahead market (GTAM) – for selling off the power by renewable developers in the open market without getting into long term PPAs.

5) International efforts – USA ($1000 Bn Investment)

6) Set up of Solar Energy Corporation of India (SECI)
– National Solar Mission

7) Waive off inter-state transmission charges for sale of solar & wind power

8) FDI in RE sector → 100%.

9) National offshore wind Energy Policy (2015)
– promote the deployment of offshore wind farms in EEZs.

10) Setting up of Ultra Mega RE Parks → Plug & Play model

Long term planning

Way Forward
- stable policy
- New regulatory framework → single RE regulator
- upgrade technology

5 Is: Intent, Infra, Inclusiveness, RE, Investment, Innovation

Solar – PM KUSUM & Atal Jyoti Yojana (50.10 Bn units in 2019-20)

Wind – 30.37 GW (2020) capacity

MNRE → Offshore – 30 GW by 2030, 5 GW by 2022

Bioenergy – 5000 Compressed Biogas plants across India by 2023. → New National Biogas and Organic Manure Programme (NMBOMP)

Wind:
- Generation Based Incentive (GBI)
- Concessional custom duty exemption on components for wind electric gen. equipment
- Technical support by Nat. Inst. of wind Energy, Chennai

"Groundwater: Making the Invisible Visible"

Groundwater depletion in India

Facts

- India has 18% of world's popula but only 4% of world's water resource
- Annual per capita availability of water in m^3 (1 m^3 = 1000 L): 6042 (1947) → 1140 (2050); 6042 − 1140; 1340 (2025)
- Stage of ground water development = GW use / GW availability = 62%
- 54% of India faces high to extreme high water stress (+ 14% over exploited annual recharge limit)
- 85% rural & 50% urban popula dependent on GW
- 89% of GW for irriga (domestic − 9%, Industry − 2%)
- NITI Aayog − 40% of India's pop → no access to drinking water by 2030 (40 Crore facing acute water shortages)
- 5th Minor Irriga Census − GW declined by 61% (2007 − 2017)
- Extrac target − 70% by 2030

Reasons for depletion

- High water demanding crop (rice) → increased demand
- Limited storage facilities
- Green Revolu
- Frequent pumping of water
- Subsidies on electricity & high MSP for water intensive crops
- Natural causes: deforesta, unscientific methods of agri
- Water contamin
- Inadequate regula

Impact

- 70% India's water contamin
- 75% households do not have drinking water on premises
- 84% of rural households do not have access to piped water.
- 386/718 → nitrate
- 718 districts with contaminated ground water with heavy metals.
- → lowering of water table
- → reduc in streams & lakes
- → subsidence of land
- → increased cost for water extrct
- → contamin of ground water
- → constraints in food supply
- → limita to biodiversity & creation of sinkholes
- 120/122 → Water quality Index
- Only 1/3rd of India's waste water is currently treated

Policy challenges

- → Estima of groundwater resources
- → Crop pricing & water intensive crop
- → Energy subsidies
- → Inadequate regula
- → lack of local mgt

Govt. Initiatives

1. National water Policy (2012) focuses on Rainwater harvesting and conservation of water
2. Crea of new Ministry of Jal Shakti
3. Atal Bhujal Yojana (Atal Jal) GW mgt. by community participa
4. Micro, DRIP, more drop/crop, PM KSY

(5) Use of tensiometer → visual info about the availability of soil moisture

(6) Jal Shakti Abhiyan

Way Forward

1) Routine survey at regulare inte -revals
2) Assessment of land use patterns
3) changes in farming methods
4) Community participa^n
5) Reforms in power subsidies
6) Control ground water pollu^n
7) Bring water to Concurrent list
8) Recycling & waste water mgt
9) Mihir Shah Com. → 2016 → shift from supply to demand mgt.
   Central water comm + Central G. wate comm → unified

- Rajendra Singh - waterman of India - revive several dead rivers.

'One H_2O approach'

Succes story - 165 CRORE lit. water saved by Pune Engineer Gunvant Sonawane (with Seva Sahyog NGO) in 26 villages of MH.

Soil Erosion & Conservan

Soil erosion is a naturally occuring process of wearing away of topsoil by natural forces of water & wind or tillage activities.

Agents

Water:
- Raindrop
- sheet
- Rill
- Steam banks
- landslides
- Coastal

Wind
- Siltan (blown by wind in a series of bounces)
- Suspension (over long dist.)
- Surface creep (@ ground level)

Human activities
- deforestan
- farmy — faulty agri practice, mono culture
- mining
- settlements / constructn
- grazing

Consequences

- Wind erosion - removing fine textile soil leaving land uncultivable
- Removal of seeds / seedlings → bare soil
- siltan of rivers
- Gully erosion - limits land use & disrupt farm activities
- Streambank - change river course
- Mass mvt / landslides - can cause mostly
- Coastal erosion - changes in sea level, high siltan

Conservan

1) Afforestan
2) Checking overgrazing
3) Agrn
   - Crop rotan
   - strip croping
   - No till farmy
   - Contour ploughy
   - Terrace farmy
   - check shifting cultn
   - wind breaks
4) In arid-semi arid → shelter belts of trees & agro forestry.

Stabilise sand dunes by Central Arid Zone Research Institute

5) Use of natural fertilizers
6) Crop diversifican

Schemes

- Soil Health Card scheme
- Rashtriya Krishi Vigyan Yojana (RKVY)
- NABARD Loan - Soil & water Conservn Scheme
- ZBNF, No Tillage, Precision Agri
- Watershed Development Project in shifting Cultivn Areas (WDPSCA)
- Accelerated Irrign Benefits Prog (AIBP)

→ NM Sustainable Agri (NMSA)

→ FAO's initiatives

Land Degradation

Desertification is the process by which the biological productivity of drylands is reduced due to natural/manmade factors. [NOT expansion of existing deserts]

(*) 29.7% underwent land degradation during 2018-19 (ISRO)

- Overgrazing
- loss of soil cover (cutting forests)
- Climate change
- **causes** → Vegetation degradation
- Wind erosion
- Water erosion (= Badland topography)
- Burning of crop residue

Impact
- Threatens agri productivity
- Rights of Indigenous People (Madhavis in Banni grasslands)
- Water scarcity
- climate change (degraded land loses its capacity to absorb CO_2)

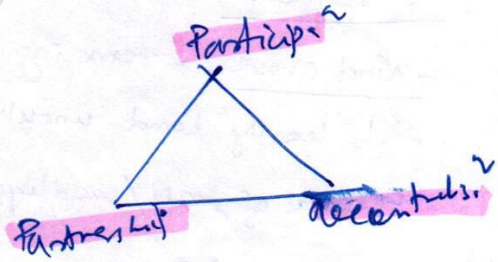
Measures
- PMKSY
- Soil Health Card
- Legally binding
1) Integrated Watershed Mgt. Prog
2) Desert Dev. Prog.
3) UNCCD → 26 Million hectares of degraded land to be restored by 2030 India
4) National Afforestation Prog
5) National Action Prog. to Combat Desertification
6) Nat. Mission on Green India

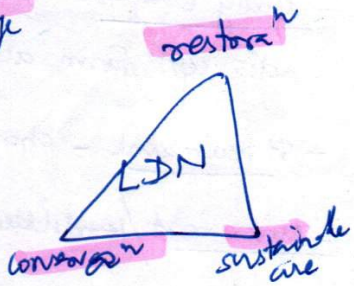
- 350 million hectares by 2030 globally → Bonn challenge
- Great Green Wall initiative → AU - Sahel

(*) Land Degradation Neutrality (LDN)

(SDG 15.3)

- National Mission for Sustainable Agri
- Soil Impact → 2nd largest carbon sink after ocean
- World Soil Day (Dec 5) → 'Soils: where food begins'.
- Pro PM Krishi Sinchayi Yojana.
- FAO → uses data analytics.





→ ecosystem services → US$800 Bn/year → IUCN + UNDP → Mangroves for Future

Mangroves - ecotone b/w marine and terrestrial ecosystem

UNESCO - disappearing (3-5x) than forests

Buttresses (large, wide support roots on all sides of tree)

Succulent leaves

Prop roots (Rhizophora) → Stilt roots

Sunken stomata

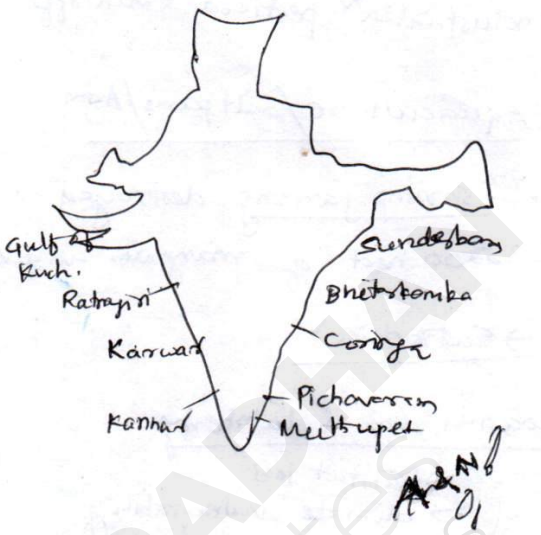
Adaptive Mechanisms

leaves with salt secreting glands

Viviparity

Aerial breathing roots (pneumatophores)

Ex: Avicennia



Global status - 123 countries tropical & subtropical

→ 15 million heet (1% of tropical rain forest)

- Asia largest (40% S/S-E Asia) * India 3% of South Asia

COP27 → MAC

Global Mangrove Alliance - B/w 2010 & 2020 → 600 sq. km of mangroves were lost of which more than (62%) were due to direct human impact.

Importance

1. Carbon sink - potential is 3-5x higher than tropical upland forest
2. Coastal protec^n - 5x more effective than grey infra like breakwaters, helps against tsunamis, cyclones, storm surges
3. Water filtra^n - Acts as riparian buffer & trap heavy metal contaminants
   Ex 2-5 hect. → treats effluents of 1 heet. aquaculture
4. Livelihood - (12 crore) fisheries
5. Biodiversity - 3000 fish species, shrimps, mud crabs
6. Prevents soil erosion - acts as zone of land accre^n by enhancing sediment deposition.
7. Tourism - >2000 mangrove related attrac^n (boat tours, boardwalks, fishing, kayaking)
8. Wood - density apt for timber & fuel

Threats to Mangrove

1) Anthropogenic activities - Urbanizatn/ Industrialisatn, pesticide run off

2) Aquaculture/Salt pans/Agri
ex shrimp farming destroyed 35000 hect. of mangroves worldwide
↳ Eutrophicatn

3) Coastal dev & Lumbering
→ habitat loss
→ climate vulnerability
→ loss in genetic diversity

4) Agri - 40% of mangroves on west coast converted to farmlands in last 3 decades.

5) Climate change - sea level ↑

6) Charcoal & timber industries

7) ↑ Ocean temperature

(*) Climate change → WWF - Sundarbans will sink entirely in 2070.

- Royal Bengal Tiger (EN)
- Saltwater crocodile (LC)
- Olive ridley (VU)
- Ganges river dolphin (EN

MAC - Mangrove Alliance for Climate
→ led by UAE-Indonesia [includes - India/SL/Australia/Japan/Spain]

COP26 → plant 100 million mangroves by 2030

Conservatn

Case-1 : Gujarat → direct seed sowing, raised bed plantatn & fish bone channel plantatn

Case-2 : Andhra → established Eco-Dev Committees & Van Samrakshan Samiti

Case 3 : Apollo Tyres + Wildlife Trust of India → Kerala's Kannur distt
→ UNESCO designated site
- Inclusion in Biosphere Reserves, World Heritage site & UNESCO Global Geoparks
- Int. Society for Mangrove Ecosystem (ISME) - NGO
- Blue Carbon Initiative ✓
- Int. Day for Conservatn of Mangrove Ecosystem - July 26
- Mangroves for the Future Initiative - IUCN + UNDP (includes India)
- Nat. Mangrove Comm → 1976
- Mangrove Alliance for Climate COP-26

Case 4 : Guyana Mangrove Restorath Project - 'Mangrove Corps' society involving women at forefront

Blizzards & Snowstorms

A blizzard is a severe snowstorm with strong & powerful winds in excess of 35 miles/hour for > 3 hrs.

Origin
- ↳ warm air from equator + cold from polar → front
- ↳ warm air rises up a mountain top, it can cool as it rises, forming clouds & blizzard snows.

[warm air must rise over cold air for blizzard to happen]

- possible to occur in condition of clear skies when no snow is falling if cond^n are conducive to the most.

Ex 2019 - Russia - 'Blizzard of the Century'

Gold China 1st

S. Africa – Wit watersand (Johannesburg) Boksburg

Canada – Ontario & British Columbia (largest)

Aus : W^n Aus, Queensland, Victoria

India – Kolar, Sonanadi (Singhbhum), Ramagiri (Andhra), Panna & Chaldyar Puzha (Kerala)

Silver ore: stephanite, pyrargyrite, proustite

- Bharat (Raj), Zawar mines
- KGF & Hutti Gold mines (KA)

Mexico, Peru, China, US, Canada, Myanmar (Asia)

Platinum – canada (60%)

Diamonds – S. Africa – before (Kimberley)

Now Congo ✓

– Ghana, Sierra Leone, Liberia, Angola, Tanzania

Copper Cu+Ni → Monel Metal

Cu+Zn → Brass, Tin → Bronze

1) Katanga mines of Congo

2) Chile (largest producer) → near Andes

3) India (Khetri, ~~Dari~~ MP, Singhbhum, Hazaribagh – JH, ~~Kanchar~~ Balaghat, Palamau)

4) US – Arizona, Utah

5) Canada – Sudbury (Ontario)

6) Russia – Ural

Manganese – BRIK

– S. Africa (1st) + Russia (Ural) + Kazakisthan, China, Aus.

India →

- Gondite deposits → MP (Balaghat + Chind wara)
  - → MH (Bhandara & Nagpur)
  - → Sundergarh
- Rodunite / Khondalite – Odisha (Koraput), Andhra (Srikakulam)

Molybdenum → green steel

- strength, ductility, resistance to shock of steel
- Jet engine of gas turbine

US – Monopoly, China, Chile, Russia Canada.

Tungsten

China (1st), Russia

Aus, USA, Brazil

Tin (20%)

Kinta Valley (Malaysia)

– Phuket

China, Russia, Bolivia

Chromium

Odisha – 96%.

– Kazakhstan (1st reserve)

– S. Africa (1st producer)

– BRICS → Congo (Katanga mines)

Nickel

– Canada – ~~Sudb~~ Sudbury of Ontario

– Russia – Ural

– S. Africa

– Indonesia (1st)

Odisha (93%)

Natural Gas

Russia	west siberia, Gulf of Ob (Arctic) - Urengoy, Volga-Urals
N. America	Hugoton - Oklahoma, Texas, Kansas; Alberta (Canada), Gulf of Mexico
Europe	North Sea
Africa	Algeria, Niger Delta
Middle east	Iran, Qatar
India	KG basin, Assam, Khambat, Cuddalore (TN), Barmer

Coalbed Methane

- very little heavier hydrocarbons

CBM: Jharia (JK), Raniganj, Sohagpur (MP)

Shale Gas

- Lot of CH_4, little Ethane / Propane / Butane
- Gas locked in non porous shale → low permeability

Extrac^n - Fracking / Hydraulic fracturing by injecting fluid at extreme high pressure to rock

Reserves - China > USA > Argentina

India - cambay, Ganga valley, Assam, KG, Cauvery, Raj & Vindhya basins

Issues - forest
- chemical inject
- water

Tight Gas

- low permeability rocks on sandstone / limestone

Shale → sedimentary shale rocks.

Bauxite

↑ rich areas

1. western & central Africa (Guinea)
2. S. America (Brazil, Venezuela)
3. Carribean (Jamaica)
4. SE Asia & Oceania (India, Aus)
5. China
6. Mediterranean (Greece, Turkey)
7. Urals.

Australia ① production

India → 1) Odisha (Koraput, Kalahandi, Rayagada)
2) CH (Maikala, Bilaspur, Amarkantak)
3) JK, Guj, MH, MP, TN

Lead

→ bad conductor, low MP.
→ Galena

- lead-acid storage batteries
- anti friction metal
- resists corrosion
- plumbing material

India: Zawari mines - Udaipur - RJ.

US, Aus, China, Peru

Zinc

- Hindustan Zinc Ltd (Raj)

Pb + Zn - found in ores

(same as Lead)

Petroleum & Mineral oil

1) Middle East – Saudi Arabia (Al Ghawar)
Iraq, Iran, Kuwait (Al Burgan)
Bahrain } 60%.

2) Russia – western Siberia & Yenisey Khatanga
– Kamchatka peninsula & Sakhalin Island

3) N. America – Texas, Oklahama, Kansas → USA
Canada → Athabasca & Newfoundland

4) Caucasian Region – near Caspian sea
Georgia, Armenia, Azerbaijan
Volga basin of Ural + Sakhalin Island

5) Europe – North Sea, Barrents Sea

6) Africa – Libya, Algeria, Egypt, Sudan, Nigeria

7) Japan – Honshu

OPEC (14)
- Algeria
- Angola
- Ecuador
- Equatorial Guinea
- Gabon
- Iran
- Iraq
- Kuwait
- Libya
- Nigeria
- Congo
- S. Arabia
- UAE
- Venezuela

[Indonesia/ Qatar (Ex)]

India

Onshore
- Assam : Digboi, Naharkatiya
- Guj : Ankleshwar, Khambat, Mehsana, Bartol
- Raj : Barmer

Offshore
- western Coast – Bombay High, Aliabet, Bassein
- Eastern : KG basin, Kaveri

Reliance Jamnagar

~Gulf of Kach

Raw Material	– Sikka all weather Port
Tech	capacity ~ 600,000 barrels of crude/day
Energy	own thermal plants in dist
Labour	skilled & unskilled
Transport	NH – 8 State Highways – A'bad, Vanode, Bharuch – Sikka Port

Coal — Gondwana (250 million years); Tertiary (60–15 million years)

Coal Reserves: US > Russia > Aus
Coal Prod^n: China > USA > India

Coking coal: Jharkhand > WB > MP

Jharkhand	Bokaro, Jharia, Dhanbad, Deltenganj, Palamu
Odisha	Talcher, Sambalpur
CH	Korba (river Hasdo – Mahanadi trib)
WB	Raniganj (largest reserve)
MP	Singrauli, Jhingurda, Satpura, Pench Kanhan
Telangana & AP	Singareni, Godavari valley
MH	Kamptee & Wardha
TN	S. Arcot & Neyveli
Rajasthan	Palani & Khari – Lignite
J&K	Shaliganga, Handwara, Barramulla, Udampur

USA	Allegheny & Appalachian, Great lakes – Wyoming Powder River Basin – Rochelle Coal Mine
China	largest producer/consumer Shanxi, Shandong
Russia	Ural, Donbass, Kuznetsk (Siberia)
Europe	Ruhr & Rhineland Britain – Lanchashire, Bristol, Wales, Yorkshire, Manchester France – Lorraine
Canada	Saskatchewan area (Cypress)
S. Africa	Highveld Coalfields
Aus	South Maitland Coalfields, Queensland

Announced Reforms

1. Commercial mining of coal allowed – with 50 blocks to be offered to private sector
2. Entry norms liberalised – regul^n requiring power plants to use 'washed' coal done away with
3. Coal blocks to be offered to private companies on revenue sharing basis
4. Coal gasification/Liquefaction incentivised
5. Coal bed methane extraction rights to be auctioned from Coal India's coal mines.

2) Transportation

- Near coastal areas

Ex Osaka – Kobe (Japan)

USA → Buffalo, Cleveland, Detroit

- Vishakhapatnam, Ratnagiri & Mangalore

3) Transportn Cost Minimizn

Bokaro – Rourkela

Fe ore from Rourkela & wagons on return take coal

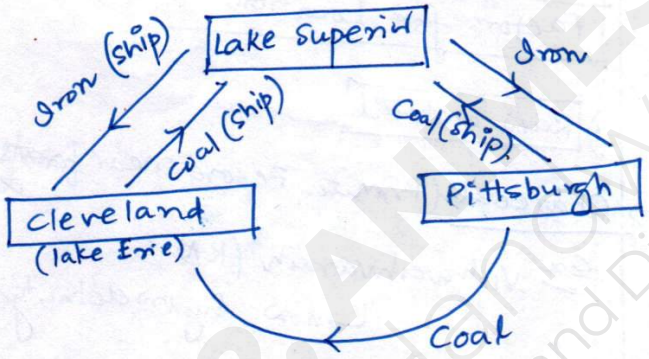
Ural – Kuznetsk

Fe coal

4) Access to markets – Mini Steel plants

- scrap metal

5) Economies of Linkages & Agglomern



6) Competition – China

7) Technology

8) Cheap labour

9) Industrial inertia – even after coal mines exhausted

Ex Ruhr, Pittsburg, Lanchashire

10) Rules & Regulan – POSCO (Odisha)

also from KA & MH

11) Govt. policies

- Bhilai & Rourkela (Germany) (Russia) Durgapur (UK)

South India

Vizag, Vijaynagar, Salem

Iron & steel

- Magnetite (Fe_3O_4) – Dharwad & Cuddapah (KA), Andhra
- Haematite (Fe_2O_3) – Odisha, Jharkhand, CH, Andhra
- Limonite – Damuda (Raniganj), Garhwal (UK), Mirzapur, Kangra
- Siderite ($FeCO_3$)

(*) AUS – largest producer (35%); KA – India [~210MT]

Africa → Transvaal (S. Africa)

China → low grade (Imports good ones from Aus, Braz, Rus)
– Manchuria, Sinkiang, Si-kiang, Shandog Peninsula

Europe – Ruhr, South Whale, Krivoy Rog (Ukraine), Bilbao, Lorraine

Russia – Urals, Magnetogorsk (Kazakhstan)

N. America – Great Lakes (Mesabi Region), Labradore

S. America – Carajas (BRAZIL) → largest
– Itabira, Minas Geriais

Australia – Pilbara
– Iron Knob & Iron Duke

India

Odisha	Barabil-Koira
CH	Bailadila
JK	Singhbhum, Noamandi, Magnetite – Palamu
KA	Babudan hills (Magnetite) Sandur & Hospet (Haematite) in Bellary
Andhra	Rayalaseema
MH	Sindhudurg, Chandrapur, Ratnagiri
TN	Salem, Trichy, Coimbatore, Madurai

Coal + Fe ore + $CaCO_3$ (flux) → Liquid slag, Lq. iron (pig iron) + CO + CO_2

Pig Iron (Fe: 93-95%, C – 4 – 4.4%)

Cast Fe – C > 2%.

steel – upto 2.1% C

Stainless steel – Min. 10.5% Chromium

wrought Fe – very low C, less prone to rusting, less tough, softer than cast Fe.

Factors for location

1) Raw Material

→ Charcoal (Britain Fe ore near forests)

Ex Vishveshvarraih (KA) → now hydroelectricity

→ Near Coalfields

Ruhr Valley – Germany

Lanchashire, Yorkshire & South Whale – Britain

Appalachian – Great lakes – US

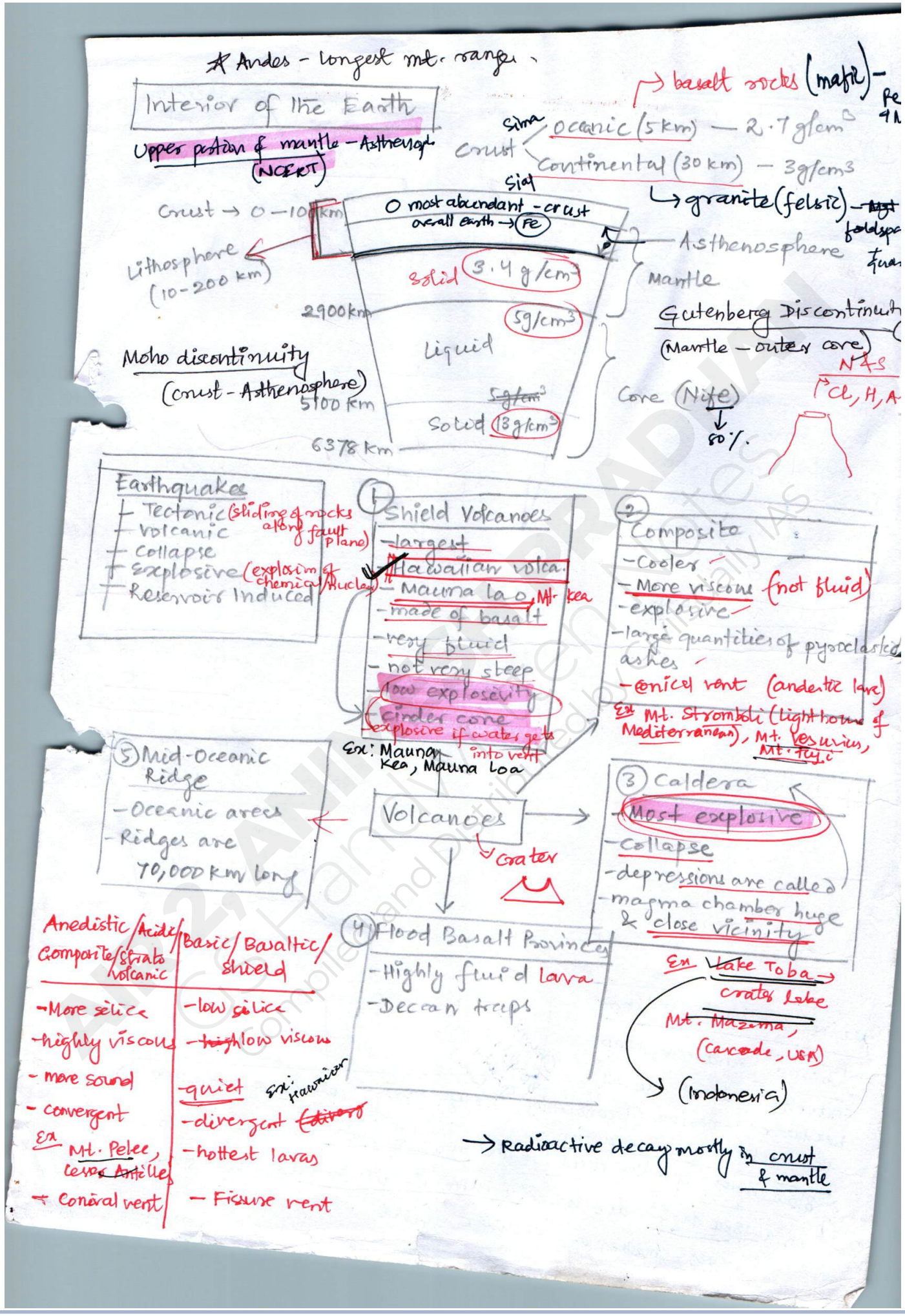
New South Wales – AUS

Wuhan, Anshan, Chongqing – China

Rourkela [coal from Jharia]

Bhilai [Korba]

Durgapur [Raniganj & Jharia]



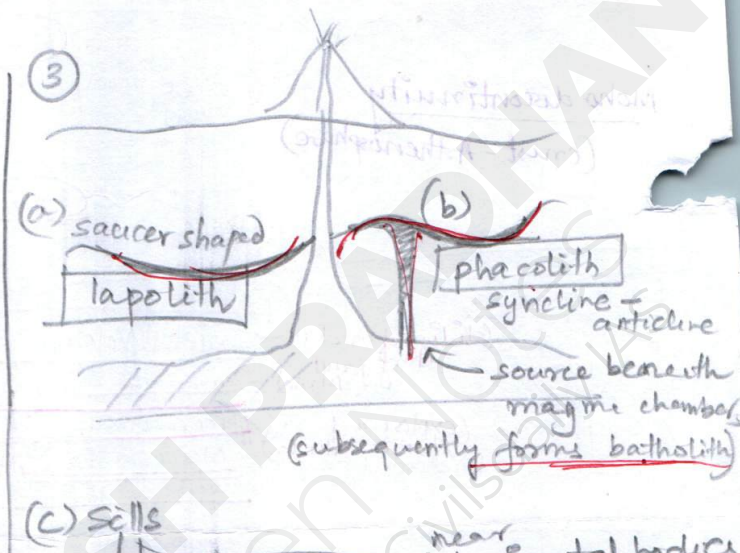
olcanic Landforms

(1) Batholith

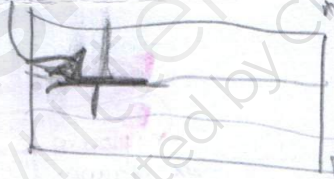
- magmatic material cools deeper depth of crust
- granitic body
- appear on surface due to denudation

(2) Lacolith

- dome shaped intrusive with level base
- connected by a pipe like conduit from below
- resembles composite volcano
- localised source of lava
- Karnataka plateau



(c) Sills



near horizontal bodies of intrusive igneous rocks.

Sills – high th
sheet – thin

(4) Dykes

when lava coming upwards, solidifies almost ⊥ to the ground.

- western Maharashtran area
- Feeders for the eruption that led to Deccan traps.

Marine Erosional landform

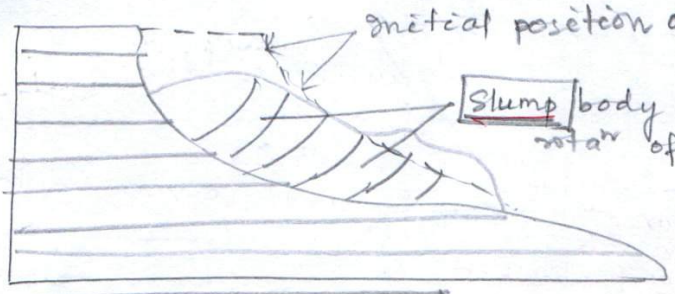
1) Chasms – narrow, deep inden^n carved due to headward erosion (doconcutting) the rocks by wave action.

Chasms
Blowholes
Sprouting horns

2) Blow Holes / Sprouting Horns – The burst of water through a small hole on a sea cave due to compression of air in cave by strong waves, makes a peculiar noise.

through vertical planes of weakness in

Geomorphic Process



(* If not backward rotation, known as debris slide)

Landforms & their Evolution

Independent factors influencing evolution of landforms –

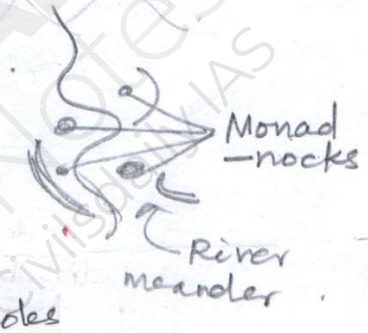
1) stability in sea level
2) tectonic stability of Landmass
3) Climate

Running waters — overland / linear flow

1) Overland flow causes sheet erosion
2) Minor/Major quantities of materials from surface are removed
3) rills are formed
4) gullies
5) gullies deeper/wider/unite → valley

Lowland of faint relief with some loo resistant remnant → monadnocks

6) peneplain formation



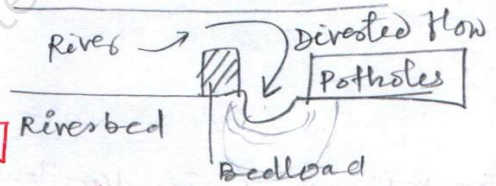
Erosional landforms

1) Valleys

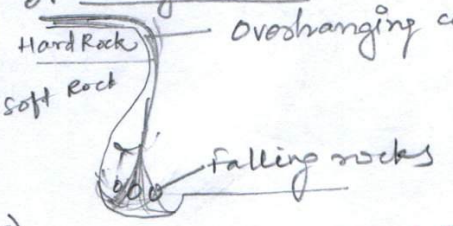
form in hard rocks

form in horizontal bedded sedimentary rocks

2a. Potholes ← circular depression



b. Plunge Pools



3) Incised Meanders → found in hard rocks.

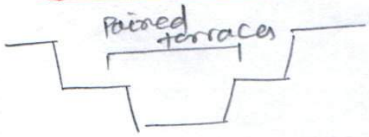
Vertical erosion ↑

But in meanders at delta & floodplain, Lateral erosion ↑

→ streams over steep gradients

4. River Terraces

- vertical erosion



Unpaired terraces reasons —

1) receding water after a peak flow
2) change in hydrological regime due to climate changes
3) tectonic uplift of land
4) sea level changes

Depositional landforms

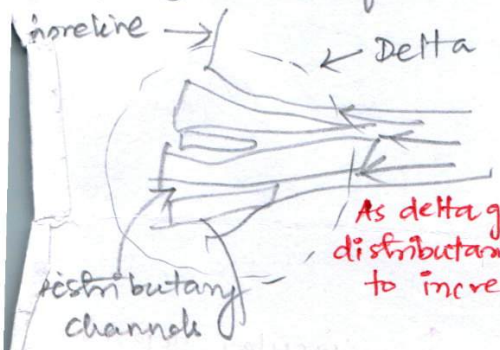
1) Alluvial fans

coarse load deposited
- cone like structure

Humid area: low cones with gentle slope from head to toe
Arid: high cones with steep slope

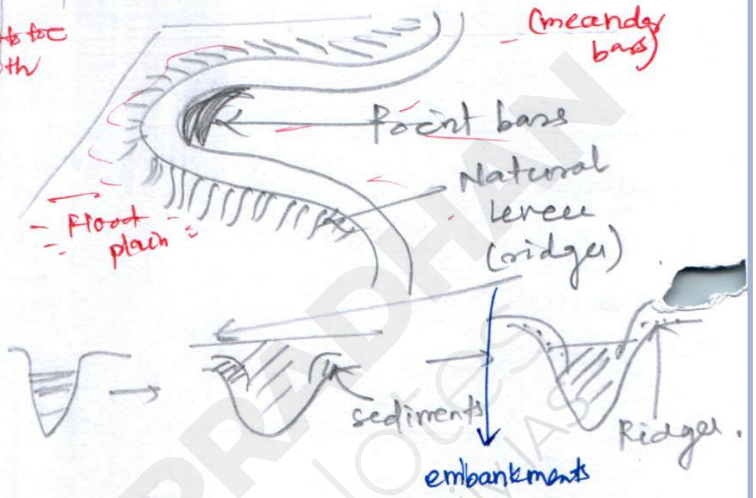
2) Deltas

- alluvial fans but accumulates as low cones
- clear stratification of material, unlike alluvial fans

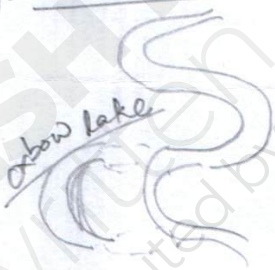


As delta grows, distributaries continue to increase.

3.b/c Natural Levees & Point bars

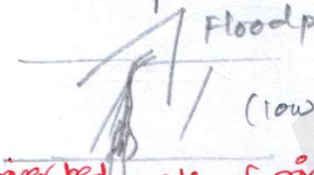


4. Meanders

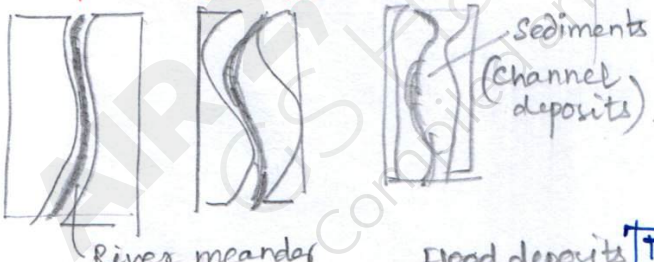


active deposition along concave bank & undercutting along convex bank.

3)a. Floodplains



- A river bed made of river deposits → active floodplain
- Floodplain above the bank is → inactive "



Running waters

Erosional	Depositional
- valley/gorge/canyon	- Alluvial fan
- Pothole, plunge pool	- Deltas
- Incised meander	- Floodplain
- River Terrace	- natural levees
	- point bars
	- meanders, oxbow lake

Types of delta

① Arcuate / Fanshaped (Curved)

light deposit give rise to shallow, shifting distributaries & a general fan shaped profile. Ex Nile, Ganga, Indus

Groundwater → depos" → erosion – sinkhole, doline, uvala, lapies, limestone pavement, cave → stalagmites, stalactites, pillar.

Erosional landforms

1. a) sinkholes

limestone & dolomite

sinkhole.

soil mantle

↳ collapse leaving a large hole opening into a cave or void below

→ collapse sink. (dolines)

sinkhole/doline/uvala/lapies/cockpit

sinkhole

Uvala (combined sinkhole) & dolines

b) lapies

surface eaten away ← $CaCO_3$

c) limestone pavements ← smooth, limestone (lapies →)

2. caves

cave opening

chalk, L.S., limestone, sandstone, quartzite, dolomite

Depositional landforms

stalactite

pillar

stalagmite

Glaciers — abrasion, plucking

Erosional landforms

1) cirque (wide troughs/basins) (cup shaped cuts in valley)

Horn

serated Ridge (arete)

Aretes

cirque.

(after disapp. of ice)

cirque, horn, lakes

2) Horns & serated Ridge.

3) Glacial Valleys / Troughs

U-shaped.

Glacial trough

discordant

Hanging valleys (as discordant tributary)

→ Very deep glacial troughs filled with sea water and making up shorelines (in high latitudes) are called fjords/fiords.

Glacier → depos"

erosion
- cirque
- Horns & Ridges
- Glacial valleys/Troughs

Moraines
eskers
outwash plain
drumlins

- The unassorted coarse and fine debris dropped by the melting glaciers is called glacial till.

Depositional landforms

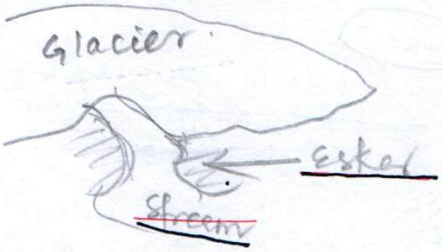
Glacio-fluvial deposits → outwash deposits

1) Moraines

long ridges of glacial till deposits.

Many valley glaciers retreating rapidly leave an irregular sheet of till over valley floors → ground moraine

2) Eskers

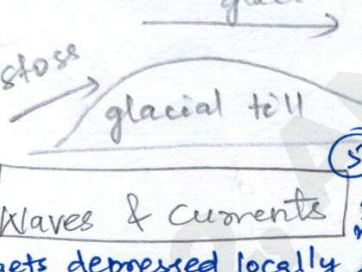


3) Outwash plains

foot of glacial mountains - covered with glacio-fluvial deposits.

Till → glacial origin, alluvium → fluvial origin

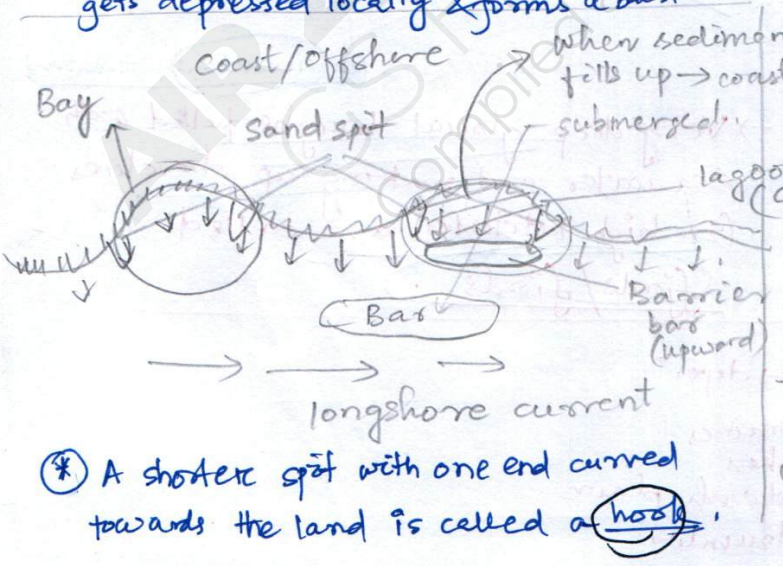
4) Drumlins



5) Kettle holes

formed when deposited material in a till plain gets depressed locally & forms a basin.

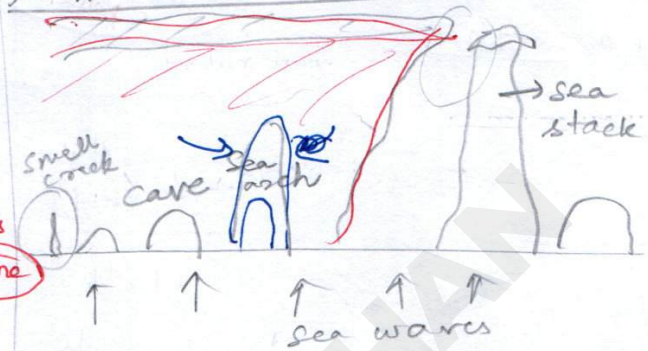
Waves & currents



(*) A shorter spit with one end curved towards the land is called a hook.

Waves & currents — Erosional landforms

1) Cliffs, terraces, caves & stacks



Depositional landforms

1) Beaches & dunes

Shingle beaches → contain excessively small pebbles & even cobbles.

2) Bars, Barriers & Spits

Bay — Bay is the broad inlet of sea where the land curves inwards.

Winds (Aeolian erosion)

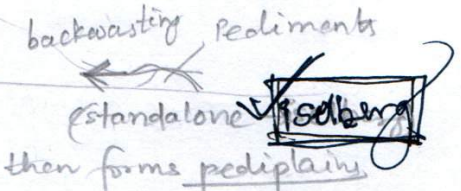
→ Pediments, pediplains
→ Playas
→ Deflation hollows, caves
→ Table, mushroom & Pedestal rocks

Erosional landforms

1) Pediments & Pediplains

↑ Rock cut surface at foot of mountains

rocky floors close to mountain at their foot with/without a thin cover of debris.



2) Playas — evaporation → salinas

shallow lake in desert covered by alkali flats.

3) Deflation Hollows & Caves

(shallow depressions) blowouts → caves.

blowouts → more

4) Mushroom, Table & Pedestal Rocks

Arid
Mesa
Butte

Process of Wind Transport
suspension
wind
saltation
creep

② Bird's foot Delta (Elongated)
- emerges when limestone sediments deposit do not allow downward seepage of water
- currents & tides weak & no. of distributaries less as compared to sediments
Ex: Mississippi

Bajadas - moderately sloping depositional plains located b/w mountains & playa

Depositional (wind)

① (steep) ← wind direction (Barchan dune) ← sand movement

① Seif ← wind

① ← wind (longer & narrower than barchans) (Parabolic dune) ← sand movement

(sandy surface partially covered with vegetation)

① Bolsons (erosional) - intermontane basins in dry region

① Star dunes

Traverse ← wind (wind direction constant & the source of sand is an elongated feature at right angle to wind direction)

① (steep) ← wind (gentle) longitudinal (parallel to wind) (sand ⊥ wind)

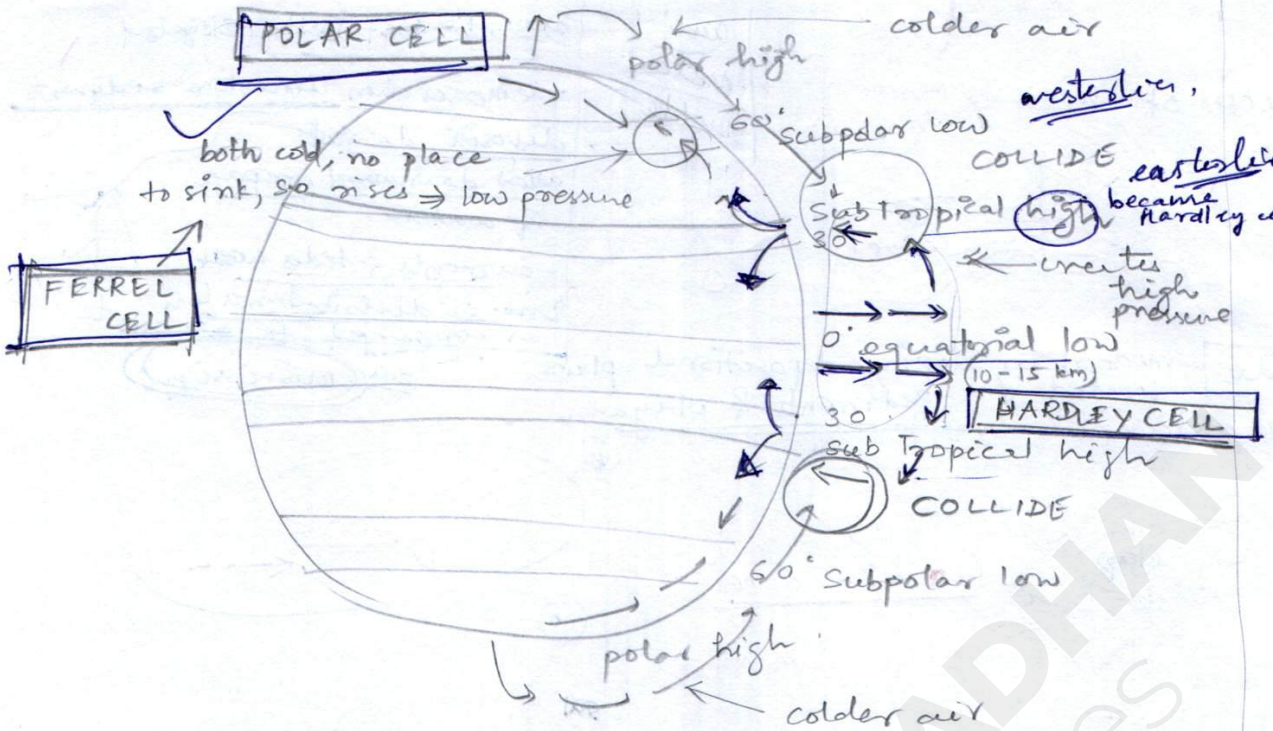
(supply of sand is poor & wind direction constant)

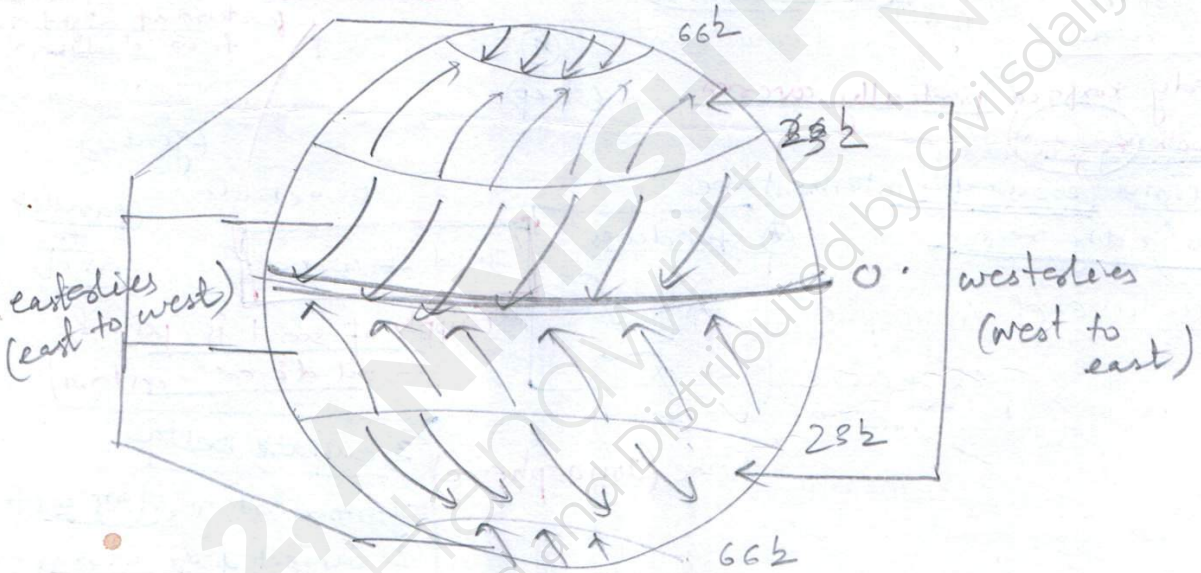
Structure of Atmosphere

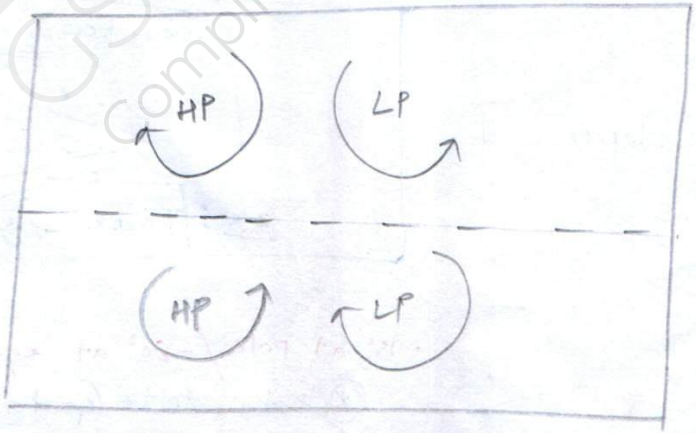
exosphere
400
Thermosphere (Ionosphere)
80 Mesopause -100°
Mesosphere
50 Stratopause
stratosphere
ozone
10 Tropopause -45° at poles / -80° at equator
Troposphere
0
-100 -80 -60 -40 -20 0 20

③ cuspate Delta
- formed along storm coasts & subjected to strong wave action
- very few or no dist.
Ex: Tiber / Italy

① lobate delta (Godavari) = density of river water = density of sea water







Drainage Systems

- Concordant (path depend on slope & topography)
- Discordant / Insequent

ESOR

Concordant

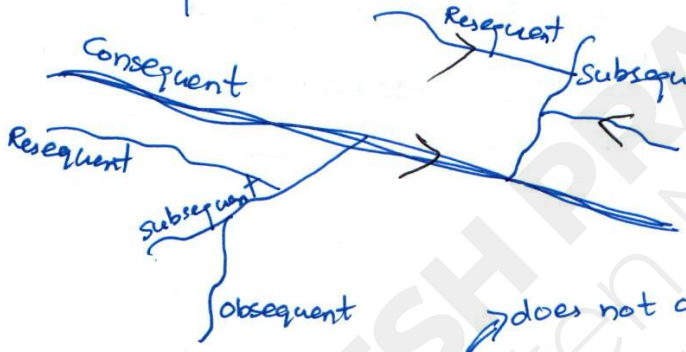
Consequent
follow general direc^n of slope
Ex Godavari, Krishna and Cauvery

Subsequent
Tributary system formed by headward erosion along an underlying rock after consequent river (main) is established
Ex Chambal, Sind, Ken, Betwa, Tons & Son

Obsequent
Aflg ① & ②, these rivers ⊥ to subsequent, hence opp. direc^ to ①

Resequent
same direc^ as ①, originate at much later stage.

Con
Sub
Obse
Reseq



Discordant / Insequent

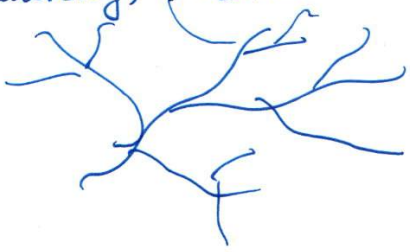
does not correlate to topography & geography

Antecedent / Inconsequent
Part of reiver slope & surrounding area gets uplifted, & the river sticks to its original slope, cutting through that (vertical erosion) → form gorges.
Ex Indus, Sutlej, Brahmaputra & other Himalayan rivers older than Himalayas itself

Superimposed / Epigenetic / Superinduced
When river flowing over softer rock stratum reaches harder basal rocks but continues to follow initial slope
Ex Damodar, Subarnarekha, Chambal, Banas & rivers flowing at Rewa Plateau

Other

1) **Dendritic / Pinnate**
Indus, Godavari, Mahanadi, Cauvery, Krishna



2) **Trellis**
Short subsequent streams meet main stream at 90°
Ex old folded mts. of Singhbhum (Chotanagpur plat.) & Seine & its tributaries in Paris basin

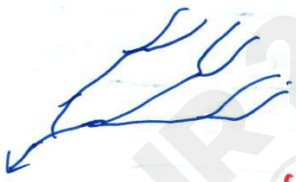
③ Angular Drainage
at acute angle
Ex Himalayan

④ Rectangular Drainage
mainstream bends at 90° & tributaries join " .
Ex Colorado (USA)
streams in Vindhyan Mts.

⑤ Radial Drainage
- Tributaries from summit in all direc^{n}
Ex Streams of Saurashtra, Amarkantak Mt. rivers, central French Plateau, Mt. Kilimanjaro
(Narmada, Son, Mahanadi)

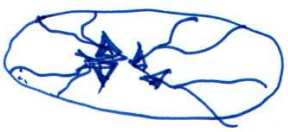
⑥ Annular
tributaries in circular fashion
Ex Black Hill in South Dakota
Ex Pithoragarh (Uttarakhand)
Nilgiri Hills in TN & Kerala

⑦ Parallel
tributaries parallel



(opp. of radial)

⑧ Centripetal
streams converge from all sides
Ex streams of Ladakh, Tibet & the Baghmati and its tributaries in Nepal.



⑨ Deranged
uncoordinated pattern in region recently vacated by an ice sheet
Ex on Karakoram

⑩ Barbed
- confluence of a tributary with main river is characterized by a discordant junc^{n} - as if the tributary intends to flow upstream & not down-stream.
Ex Arun River (Nepal), tributary of Kosi

Kosi

delta - coagula in presence of salt water

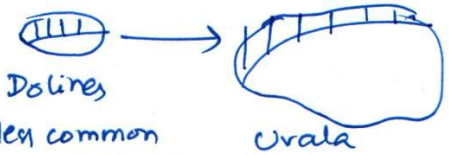
Karst Topography

1) Sinkhole / Swallow Hole

funnel shaped depressions developed by enlargement of the cracks found in porous water soluble rocks

Karst window → when adjoining sink holes collapse, they form an open, broad area called karst window.

2) Polje / Blind Valley



→ lapies
↓ limestone parent

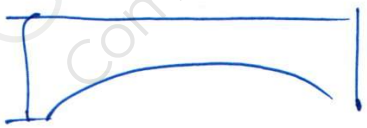
→ U shaped valley
(Polje)
(Blind Valley)

3) Cavern

Caves. Ex in Bastar, Dehradun, shillong plateau

4) Arch / Natural Bridge

When a part of the cavern collapses the portion, which keeps standing forms an arch.



5) Sinking Creeks / Bogas

In karst valley, the water often gets lost through cracks & fissures in the bed. These are called sinking creeks & if their tops are open, called bogas.

6) Stalactites & stelagmite

←

7) Dry Valley / Hanging Valley / Bourne

Sometimes, a stream erodes so much that it goes very deep. Tributaries start seeing the subterranean drainage & get dried up.

Distribution

Major Karst areas → caucuses region of southern France, Spanish Andalusia, northern Puerto Rico, western Cuba, Jamaica, Central Florida of USA.

Minor karst areas - Carlsbad area of USA, chalk area of England & France, parts of Alps

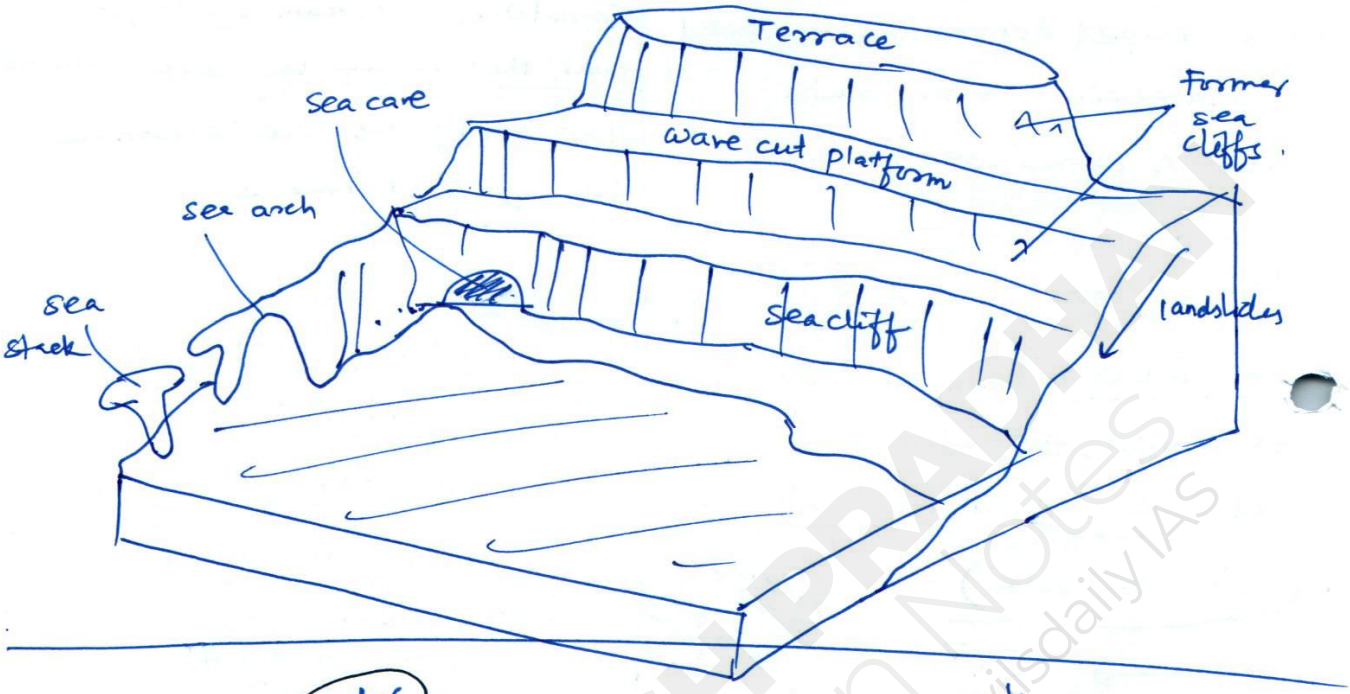
In India - Panchmarhi, Bastar, coastal Vishakhapatnam, Meghalaya, Himalayas in J&K & Dehradun

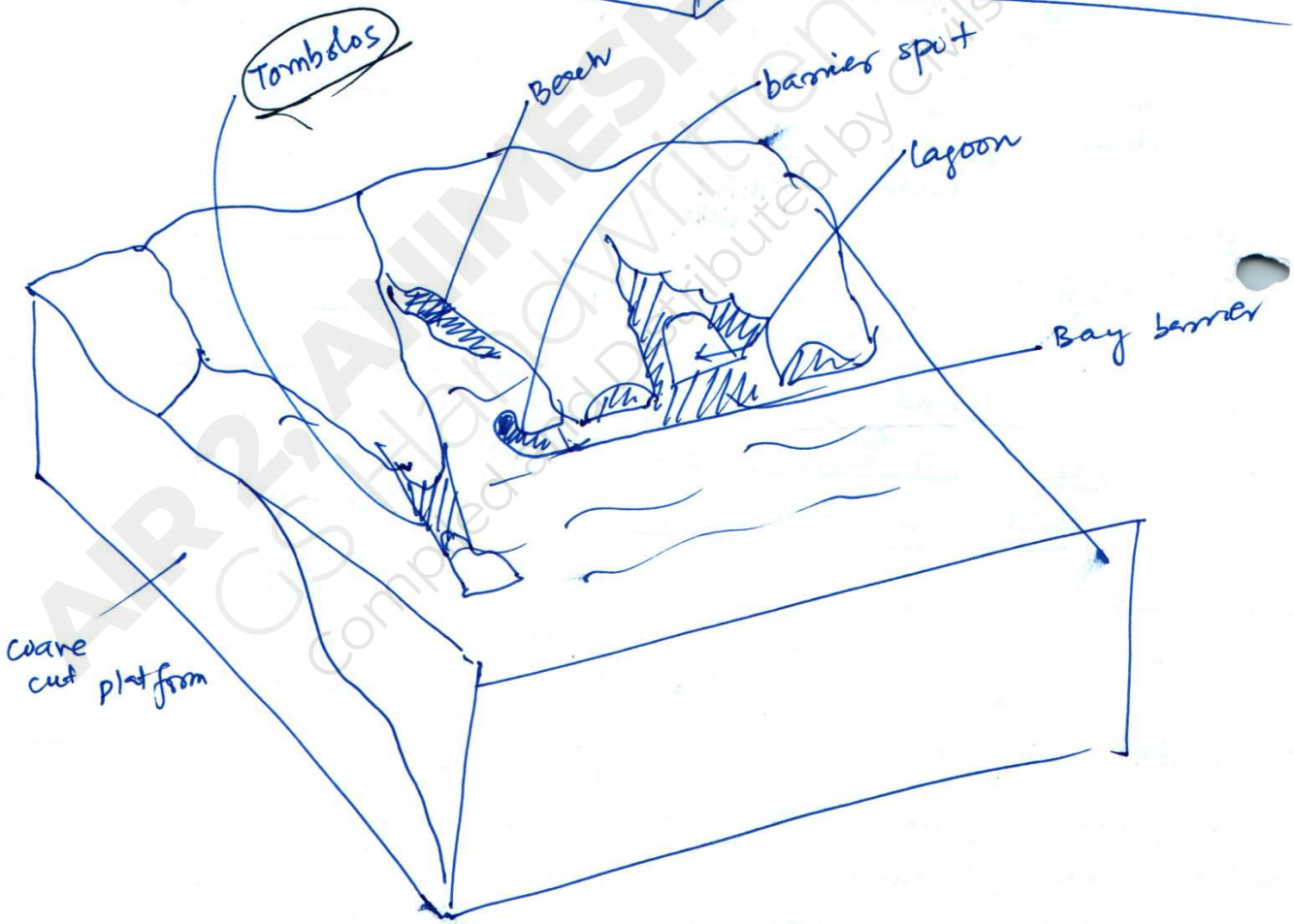
(*) 20% of earth's surface consist of karst topographies. 25% of world's drinking water comes from here.

- 100 million in karst tourism
- 50+ karst & cave local under UNESCO world Heritage list.

(*) Blow holes or Spouting Horns

The burst of water through a small hole on a sea cave due to the compression of air in the cave by strong waves → peculiar noise





Coastlines

The boundary between the coast (the part of the land adjoining or near the sea) & the shore (the land along the edge of a sea) is called coastline

(1) Coastlines of Emergence

formed either by an uplift of the land or by the lowering of the sea level.

- Coramandal coast (TN) → coastline of emergence
- Malabar coast (Kerala) → "
- Konkan Coast (MH & Goa) → coastline of submergence

(2) Coastline of Submergence

- produced either by subsidence of land or by a rise in sea level.

Features

i) Ria → when stream dissect a region into a system of valleys & divides, submergence produces a highly irregular shoreline

Ex South west Ireland

ii) Fjord - very deep glacial troughs filled with sea water and making up shorelines (in high latitude) - coasts have long & narrow inlets with very steep sides.

Ex fjord coasts of Norway

iii) Dalmatian

result by submergence of mountain ridges with alternating crests and troughs which run parallel to the sea coast.

Ex Dalmatian coast of Yugoslavia

iv) Drowned Lowland is low & free from indenta", as the submergence of a low-lying area forms it.

- characterized by a series of bars running parallel to the coast, enclosing lagoons

Ex Baltic coast of Eastern Germany

(3) Neutral coastline

- no relative change b/w the level of the sea & the coastal region of the continent.
- coastlines formed as a result of new materials being built out into the water.

Ex Alluvial fan-shaped coastline, delta coastline, volcano coastline & coral reef coastline

(4) Compound coastlines - combine" of above

Ex coastline of Norway & Sweden

(5) Fault coastline - unusual feature

& result from the submergence of a down thrown block along a fault, such that the uplifted block has its steep side (faultline) standing against the sea

Arid Landforms (wind eroded)

(1) Deflation basins (blowouts) – hollows formed by removal of particles by wind.

(2) Mushroom rock

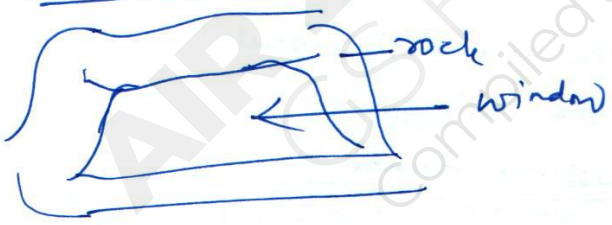
(3) Inselbergs – (monadnock) is an isolated hill or small mountain that rises abruptly from a gently sloping or virtually level surrounding plain.

(4) Demoiselles – rock pillars which stand as resistant rocks above soft rocks as a result of differential erosion of hard & soft rocks.

(5) Zeugen – Table shaped area of rock formed when more resistant rock is reduced at a slower rate than softer rocks around it.

(6) Yardangs – Ridge of rock, formed by the action of the wind, usually parallel to the prevailing wind direction

(7) Window bridges & windows



Depositional

1) Ripple marks formed by saltation (transport of hard particles over an uneven surface in a turbulent flow of air/water)

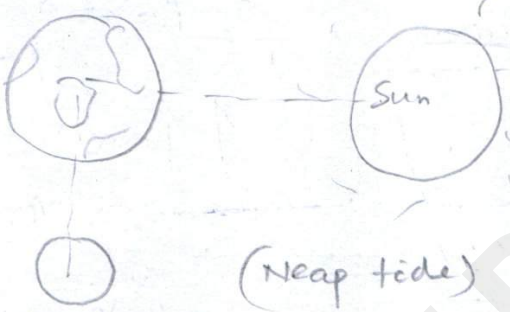
2) Sand dunes

3) Loess

Windblown dust & silt blanket the land. This layer of fine, mineral rich material is called loess.

Ex near Missouri River (US → Iowa), Yellow River (China)

Movements of Ocean Water



Godavari - Lobate
Krishna, Nile, Indus,
Ganga - Brahmaputra - Arcuate
Kaveri - Quadrilateral

Factors affecting Movement of Ocean water

Temperature
Salinity
Wind - waterlies (w to e) & trade winds (east to west)
Coriolis force
Sun
Topography of Ocean floor

How is Bay Formed

- Tectonic activity
- Overflow of ocean
- Erosion
- Glacial activity

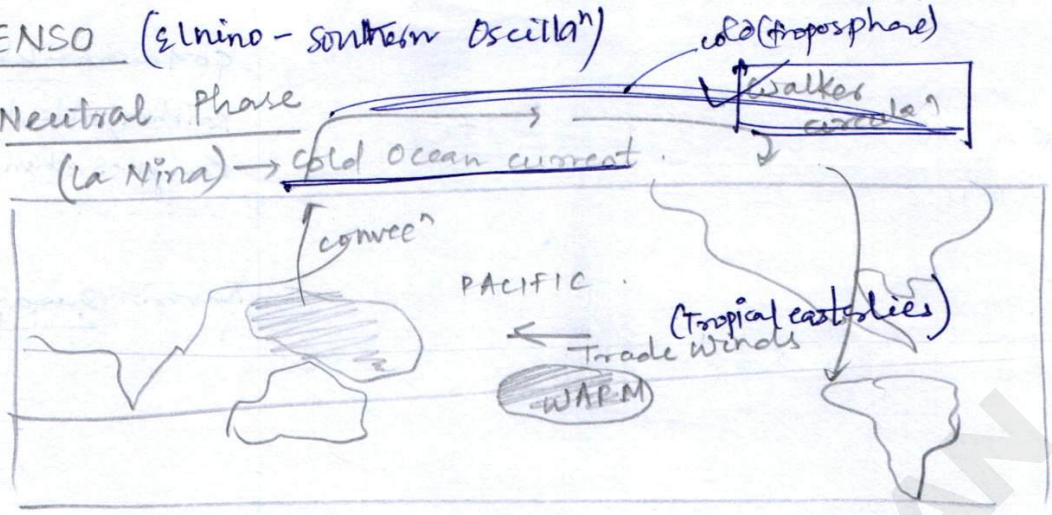
(4) High-constructive deltas -
Elongate & lobate → Godavari
- fluvial ac^{n} & depositional process dominate
→ Mississippi
→ river water is as dense as sea water
↳ coagule^{n} immediately

(5) High destructive deltas
- shoreline energy is high and much of the sediment delivered by the river is reworked by wave action or currents before it is finally deposited. Ex Nile & Rhone

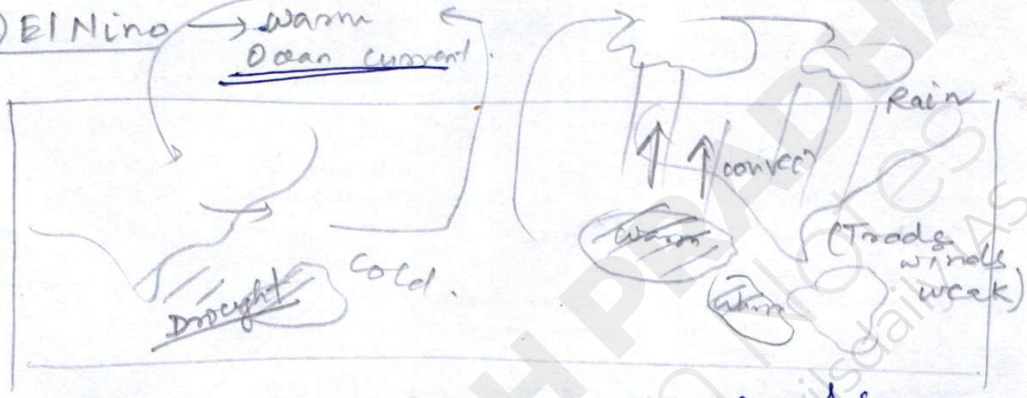
ENSO (El Nino - Southern Oscillation)

1) Neutral Phase

(La Nina) → cold Ocean current.

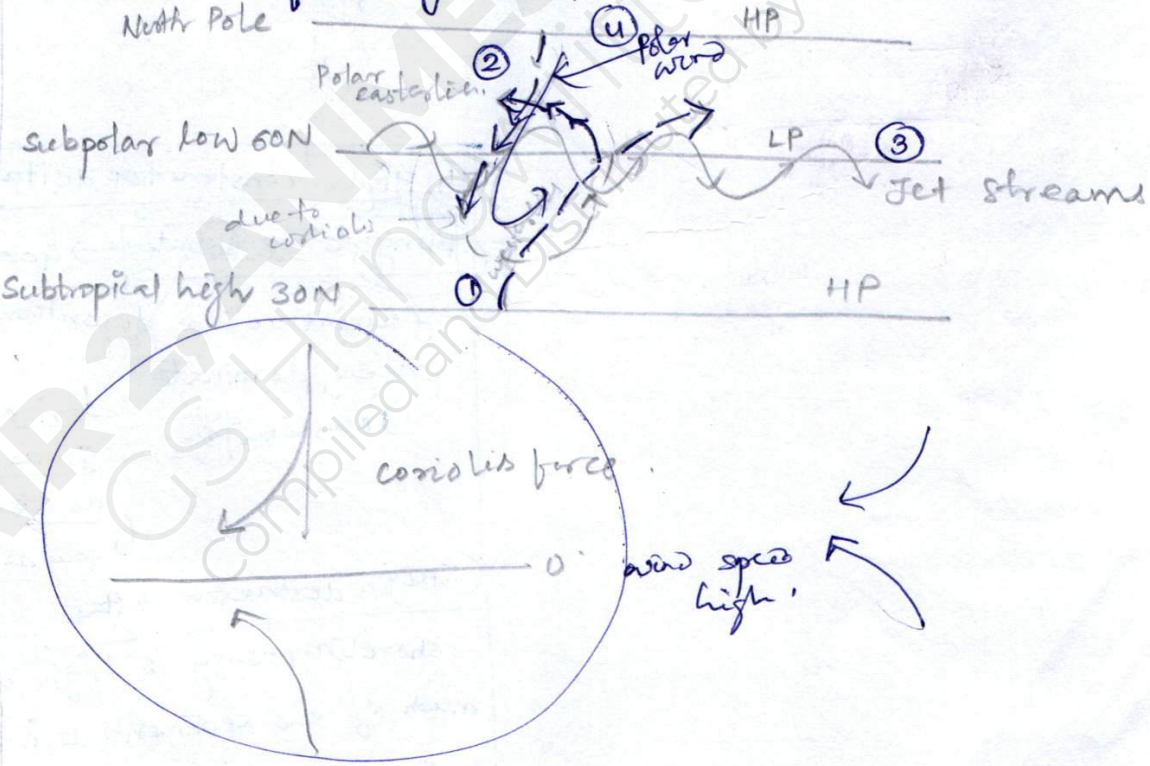


2) El Nino → Warm Ocean current



Extratropical cyclones occur in 30°–60° N & S. (mid latitude)

form along POLAR front.



2.7 trillion
4.6 billion

Coral Reefs

Significance → Tropical rainforest of oceans

- Support 25% of marine biodiversity, including fish, turtles & lobsters, even they only take up 1% of the sea floor
- fuels global fishing industry
- $2.7 trillion economic value through goods, service, tourism
- Australia - $4.6 billion, 6000 people
- protect from storm waves
- carbon sinks.

Protection Measures

- Included in schedule-I list of Wildlife Protection Act, 1972
- CRZ 1991, 2011 → outlaws coral mining in India
- Marine Protected Areas (MPAs) to preserve the certain areas of nation's waters, including coral reefs.

Global Measures

1) Aichi Target 10 → which concerns reducing pressures on coral reefs & other vulnerable ecosystems impacted by climate change or ocean acidification
2) The Global Coral Reef Monitoring N/W (GCRMN) → of ICRI (Int. Coral Reef Initiative)
- Global Coral Reef R&D Accelerator Platform
- International Coral Reef Initiative (ICRI)
- creating coral nurseries & coral transplantation
  - 16 coral colonies in Mumbai
- National Coastal Mission Programme

SDG 14 → life below water

Impact

IPCC: 8% reduction in last decade due to climate change.

- epizootics
- climate change → low tide → subaerial exposure.
- ocean acidification

Lakes

Tectonic lake – Lake Titicaca & caspian sea

Rift Valley lake – Tanganyika, Malawi, Rudolf, Edward, Tibet

Glacial lake in Finland (land of lakes)

Crater → Lake Toba (Indonesia)

wind deflated lakes – Great Basin of Utah, USA

Manmade lake – Lake Mead over Hoover Dam, Colorado River (USA)

Highest lake – Crater lake of Ojos del Salado, Andes

Highest large lake – Purnoyoory Tso, Tibet

world's highest commercially navigable – Lake Titicaca, Peru-Bolivia

Lowest lake – Dead sea

SMHOE

Superior (1) Michigan (3) Huron (2) Erie (4) Ontario (5)

NAM → largest → smallest

Largest continent wise

Australia – Eyre
N. America – Great Lake
S. America – Titicaca
Antarctica – Vostok
Europe – Ladoga – (2nd Onega)
Asia – Baikal
Africa – Victoria

By volume

Largest – Caspian Sea (saline)
Baikal (fresh)
Tanganyika (fresh)

Deepest – Baikal
2nd = Tanganyika – Longest freshwater

S waves

long wavelength
– low freq.
transverse waves

Love waves – fastest surface wave & more theground side to side

P waves	S waves
– Primary	Secs.
– longitudinal (like sound)	– transverse (like ripples on H_2O)
– fastest (recorded first on seismograph)	– only solids
– displacement of medium ∥ propgn of wave	
– least destructive	
– high freq/mag	
– all mediums	
Shadow zone 103 – 142°	Shadow zone > 103°

Volcanism Types

(*) Earth's magnetic field → convec^n current in outer core → protects from harmful solar wind.

1) Exhalative (vapour or fumes) – discharge in gaseous form –
steam, fumes, HCl, NH_4Cl, SO_2, CO_2, CO, H_2S, H_2, N_2
– volcano reaching extinct
– sinter mounds, cones of precipitated minerals & mud volcanoes.

2) Effusive (Lava outpouring)
– abundant outpourings of basaltic lava
– Deccan traps.

3) Explosive (violent ejec^n of solid material)

Tephra: all fragmented ejects from the volcanoes
Lapili – gravel sized particles either in molten/solid state
Tuff – layers of volcanic dust & ashes
Blocks & Bombs → Large.

4) Subaqueous – below the surface of the water

Eruptive Volcanism Types

1) Hawaiian Eruption
– calmest – shield volcano diverged
– effusive
– low gas

Volcanic Intensity index 0 → 8

2. Icelandic Erup^n
– long, parallel fissure.
– build lava plateaus
Ex Deccan Traps, Siberian Traps

3. Strombolian Eruption → lighthouse of Medit.
– Stromboli (Lipari Islands, Italy)
– explosive erup^n
Ex Anak Krakatoa most explosive 1883.

4. Vulcanian erup^n
– intermediate viscous magma within volcano → difficult for gases to escape.
– more explosive than (3)

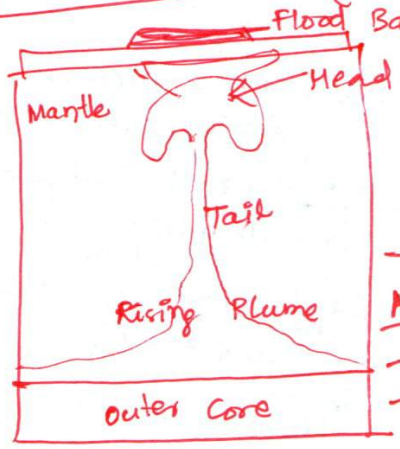
5. Pelean Erup^n
Mt. Pelee in Martinique
– erup^n results in very viscous, gas-rich, acidic lava breaking out laterally & flowing violently

5. Plinian/Vesuvian erup^n
(Mt. Vesuvius – 79 AD buried Roman town of Pompeii)
– volatile gas channelled through narrow conduit → Stratovolcano
Ex Mt. St Helens, Cascade Mt. Tambora, Lesser Sunda Islands of Indonesia

(Year w/o a summer → 1815)

Hotspot Volcanism

Interior, because of abnormally hot centres in the mantle → mantle plumes (Hawaiian Hotspot, Yellowstone, Reunion Hotspot)



- led to extensive accumulation of flood basalts

Hotspot volcano ex Mt. Mauna Kea → shield volcano

Active volcano	Dormant	Extinct
- Anak Krakatu - Barren Islands	Kilimanjaro	Kenya

Igneous	Sedimentary	Metamorphic
Granite → Si+Al	Sandstone, shale	Sandstone → quartzite
Granite, Basalt tuff, Volcanic breccia, Pegmatite, Gabbro	Mechanically formed → Sandstone, conglomerate, limestone, claystone, shale, loess	limestone → marble
Gabbro, Basalt	Chemically formed → Stalactite, stalagmite (chalk, coal, geyserite, limestone)	granite → gneiss
Intrusive (Plutonic) Granite / Extrusive (volcanic) Basalt / Intermediate	Organically formed → coal, potash, $CaCO_3$ chert, halite, limestone, Tufite, Breccia, Borax	clay/shale → schist, slate
Acidic → quartz & feldspar (more silica) - Granite, Quartz, Feldspar		- Gneissoid, Phyllite → from clay shale
Basic - Basalt, Gabbro, Dolerite (low silica)		

Cinnabar → ~~H_2S~~ Hg_2S

Olivine → Mg / Fe / Si

Pyroxene → Ca / Al / Mg / Fe / Si

all mediums

Body waves: P (longitudinal – sound, direction of propagation) → only solid → more destructive

S (transverse – surface ripple on Pg axis) → motion of medium ⊥ propagation of the wave

★ velocity of P waves: solids > liquids > gases

Surface Waves → most destructive → Love, Rayleigh

P Shadow zone 103° – 142°

S shadow zone – beyond 103°

Atlas - highest peak @ Toubkal

Mountains

Precambrian Mountains (>4 billion years)

Ex Laurentian / Algoman Mountains (N. America)

Caledonian Mountains (430 million – 380 million)

- late Silurian & early Devonian

Ex Appalachians, Aravallis, Mahadeo

Hercynian Mountains (340 – 225 million)

- upper Carboniferous to Permian Period

Ex Vosges & the Black Forest, Altai, Tien Shan Mt. of Asia, Ural Mts.

Alpine system (65 – 7 million)

- Tertiary period

Ex Rockies, Atlas, Himalayas

Longest Mt. Range
- Andes
- Rockies → Arabus
- Great Dividing Range
- Mt. Aconcagua

Cascade Range
N. American plate
Juan de Fuca (Ocean)

Based on origin

A. Original / Tectonic mountains
- fold mt. (Himalayas, Rockies, Andes)
- fault block mt. (Vosges in France, Black Forest, Vindhya & Satpura)
- volcanic mt. (Cascade Range in USA, Mt. Kenya, Mt. Kilimanjaro, Mt. Fujiyama)

B. Circumerosional / Relict / Residual
- Aravallis, Urals

Dissected plateaus → Highlands of Scotland, Scandinavia & the Deccan Plateau.

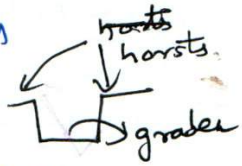
Fold Mountains

on the basis of origin
- Very old (>5 Bn) ⇒ Appalachians, Urals
- old (before tertiary) ⇒ Aravalli
- Alpine — Rockies, Himalayas, Alps, Andes

Block Mountains

uplifted blocks (horsts) & lowered blocks (graben)

→ Great African Rift valley (graben)
Rhine valley (graben), Vosges (horsts)

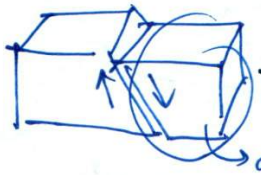


Types → Tilted
→ Lifted

earth crust bend → fold
cracks → fault

Types of faults

strike slip (transcurrent fault)



Dipslip → divergent
(normal) ⇒ tensile
→ displaced block

Reverse ⇒ compressive force
→ convergent

Rift valley lakes

Lake Baikal – deepest, largest (by volume) → fresh

Tanganyika – 2nd largest (by volume), longest fresh.

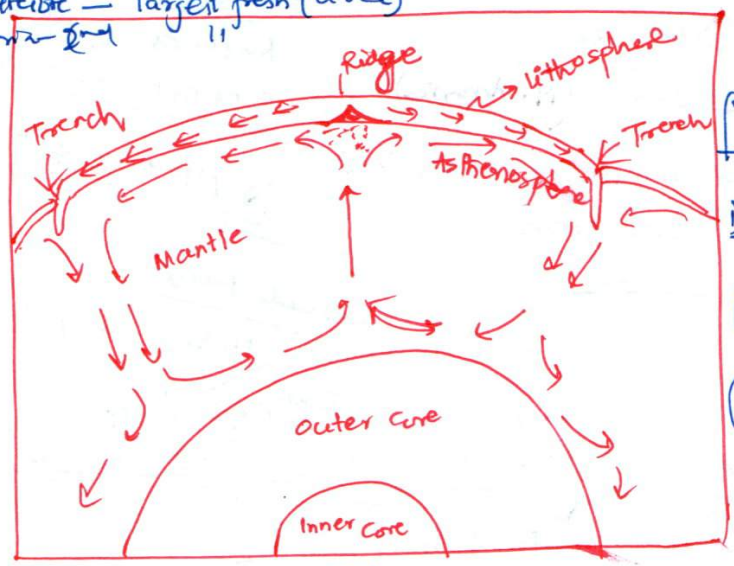
Superior – largest fresh (area)

Victoria – 2nd " "

★ Mariana Trench

Mariana plate

Pacific Plate



Ocean – continent (Cordilleran convergence)

1) Andes

Nazca — South American

ocean — Peru-Chile Trench

Ojos del Salado — highest volcano

Mt. Aconcagua (6960 m) (extinct volcano).

Island Arc (Ocean - Ocean)

Philippine Island Arc – Philippine Sea plate | Sunda Plate (Philippine Trench)

Indonesian Archipelago — sunda is light

Indo Australian | Sunda (Sunda Trench)

Anak Krakatau

Caribbean Islands — Puerto Rico Trench

Caribbean plate — N. American plate

(Transform) — South America

Caribbean plate — Lesser Antilles

S. American

Mt. Pelee — active volcano

Isthmus of Panama

Pacific - Farallon plate | Caribbean & S. American plates

Japan

Eurasian — Honshu — 1) Japan Trench — Pacific

2) Izu Trench

3) Ryukyu Trench

Philippine

2) Rockies ← N. America

Juan de Fuca + Pacific → less steep subduction

Continent - Continent

Himalayas, Alps, Urals, Appalachians & Atlas

1) Himalayas — Eurasian — Indian

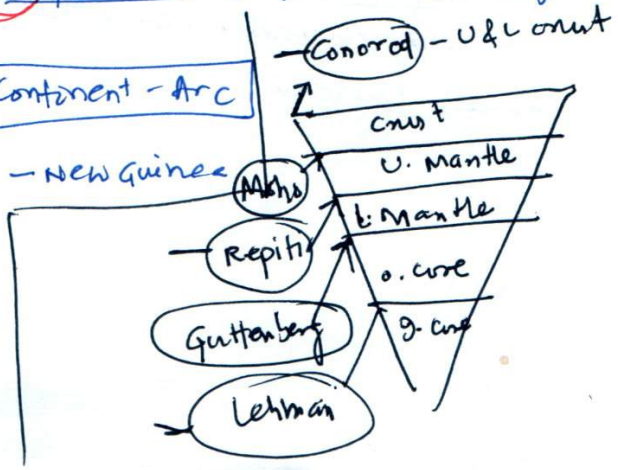
2) Alps — African — Eurasian

3) Atlas

4) Ural (very old fold mt.) – Europe – Asia

5) Appalachians (") → N. Amer – Europe

Continent - Arc

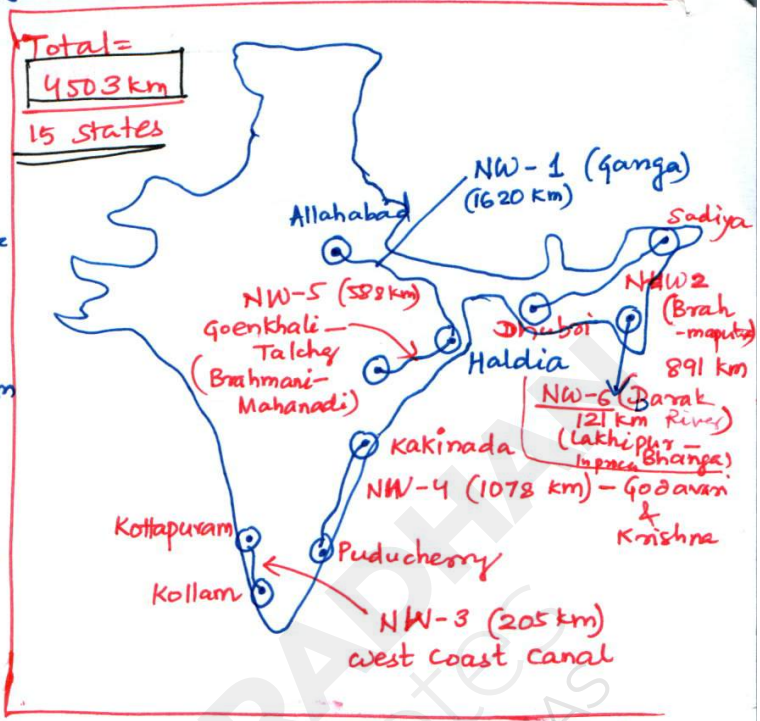


– New Guinea

Inland Water Transport System

Potential Benefits

1) Low cost
2) Least energy consumpⁿ
3) Fewerc emissions
4) Capacity : for bulk cargo, coal etc
5) Navigable : 14,500 km of river channels navigable, 2000 km used
6) Growth : Industry, logistics, tourism
7) Fewer accidents
8) Accessibility - Ex NE states get coal, food grains through IWT



Challenges

- Seasonal fall in water level in rainfed areas
- less flow due to water diversion for irrigaⁿ (Ex : Ganga)
- Reduced navigability due to silta", waterfall, salinity etc.
- Deforestaⁿ in hill ranges → erosion & accumulaⁿ of silt
- lack of adequate navigaⁿ system leading to unsafe passage & high travel time . lack of enough terminal/berthing facility at loading & unloading points
- lack of investment & infra
- fuel cost

Environmental Impacts

⇒ **Dredging** leads to
- damage river beds & affect aquatic habitats
- acquifers along the river
- lead to entry of excess saline water into creek or rivers
- removal of mangrove, trees, forests
- require dam construcⁿ → ecological imbalance
- oil & leakage spillage

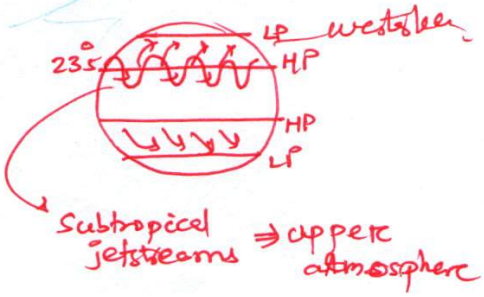
Social Impacts - Displacement & loss of livelihood (tribals, fisher community)

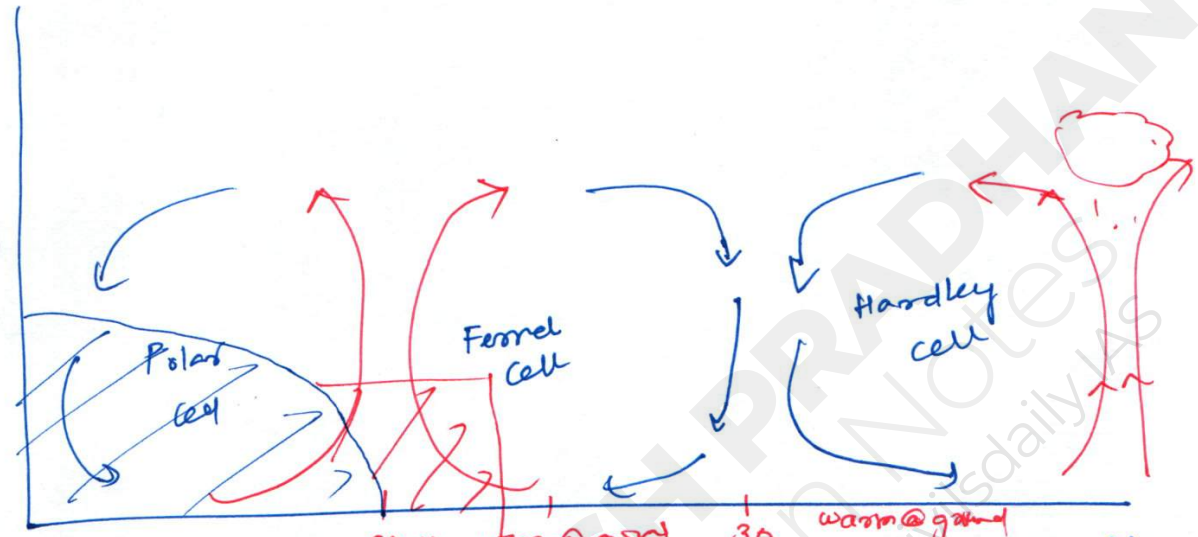
Measures Taken

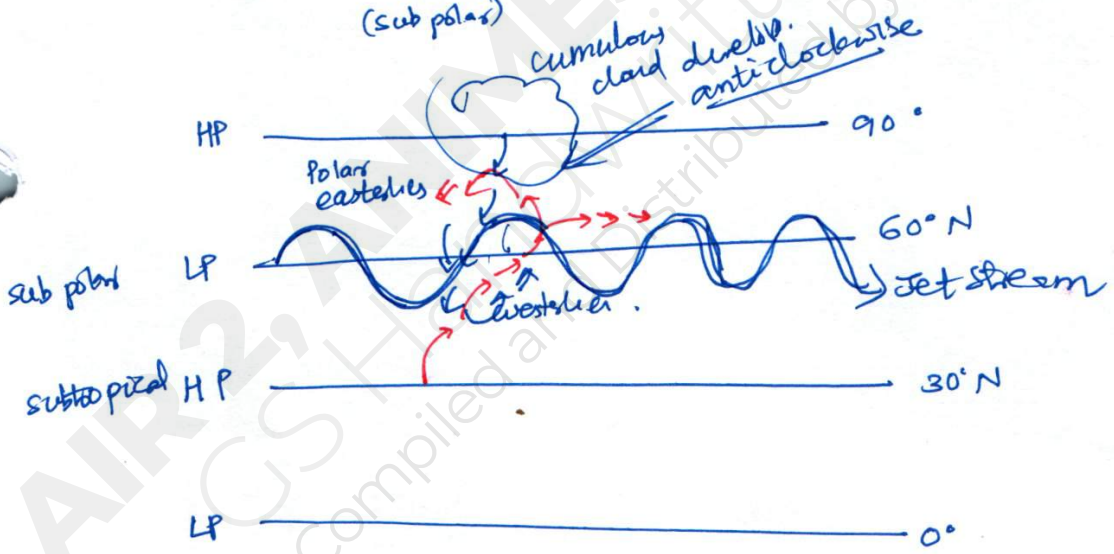
- Inland Waterways Authority of India Act, 1985
- Indian Vessels Act, 1917 (amended in 2007) talks about survey & reg. of inland vessels, navigaⁿ & control polluⁿ
- Inland water Transport Policy, 2017 large scale private partnership
- National Waterways Act, 2016 → 111 rivers / stretches as National (inland) water ways.
- EIA, 2006, CRZ 2011, Env. Protect Act 1986
- Jal Marg Vikas Project (JMVP) - improve NW-1
- Sagarmala Project → minimize logistic cost by increasing share of domestic waterways from current 6% in modal mix
- River interlinking project

Occluded front – warm air mass is trapped b/w two colder air masses & forced aloft.

Extratropical cyclone (mid latitudes)







When cold front takes over warm front – occluded front & cyclone disappear (both sea & land)

Pressure systems

Cyclonic Anticyclonic

N L H

S

Ferrel's law

P_H

V 704 mb

C 708 mb

P_H

V 704 mb

C 708 mb

C - Coriolis force
V - Geostrophic wind
P_H = Horizontal pressure gradient

Converging sinking (High)

Foehn - Alps
Chinook - Rockies (LR)
Mistral - France (cld)
Sirocco - (medit.)

High Polar easterlies
60°N Sub - Polar Low westerlies
35°N Sub - Tropical High (Horse latitudes)
30°N N-E Trade winds NE
0° Equatorial Low (Doldrums)
SE Trade winds SE
30°S Sub - Tropical High (Horse Latitude)
35°S westerlies
60° Sub polar Low Easterlies
High

Troposphere
Collide
WARM AIR
HADLEY CELL
23½
Collide
Low
Cold cold
rise
Ferrel cell
Collide
0°

Tropical cyclone
- large sea surface temp > 27°C
- low wind sheer → diff b/w wind speeds at diff. altitudes
- Coriolis force
- pre existing weak low pressure (Easterly wave disturbance) area
- Upper level divergence

↓

In temperate region, wind sheer is high due to westerlies

eye – highest temp, no precip, clear sky

< 63 km/h	: Tropical depression		
63 < < 119 km/h	: " storm		
> 119 km/h	: " cyclone		

eye wall – fastest, + cong, max precipitation

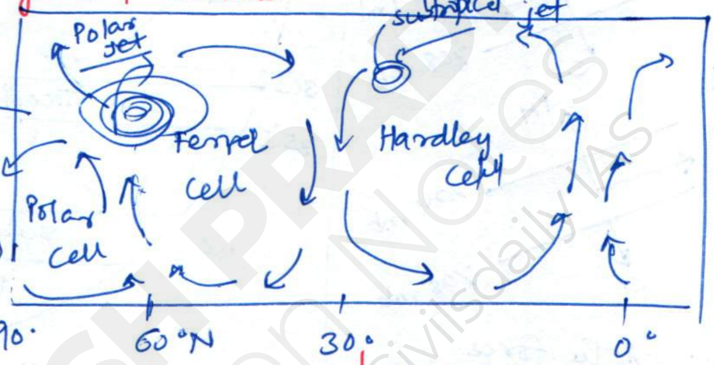
Cat	tropical cyclone	
I	120 – 150	Minimal
II	150 – 180	Moderate
III	180 – 210	extensive
IV	210 – 250	extreme
V	250 +	catastrophic

Alert
- Yellow (48 hr)
- ↓ Orange (24 hr)
- ↓ Red (12 hr)

Indian meteorology – > 222+ km/h (wave ht 14+ m) → super cyclone

Naming of cyclones – WMO (World Meteorological org.) → regional bodies.

Jet Stream 320 km/hr → formed because of geostrophic winds



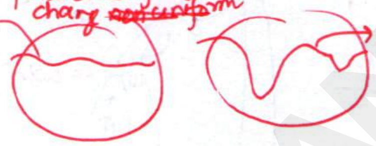
Polar jet streams (→ strongest) – temperate to polar

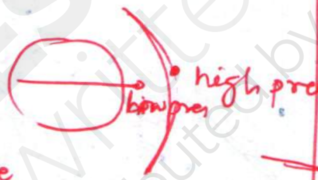
Subtropical – subtropics to temperate

→ upper level of atmosphere

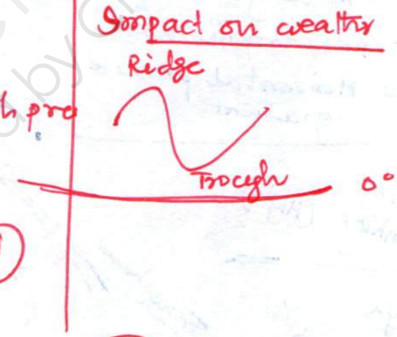
↳ pressure reverses

temperature change uniform



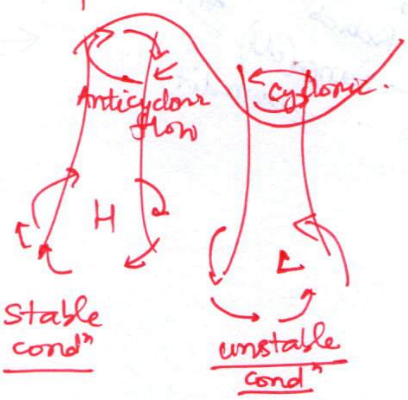


① Impact on weather

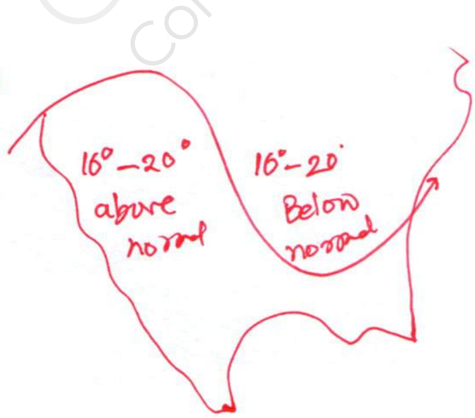


Polar → winter

Subtropical – summer



②



③ Influences aviaⁿ.

Japan ⟶ San Fran : follow jetstream

Japan ⟵ " : reverse

Effects of Ocean currents

Pycnocline

1) Desert Formation
   a) Cold ocean current → desert in west coast of tropical & subtropical
   b) There is fog and most of the areas are arid due to desicating effect (loss of moisture — fog or temp. inversion inhibits convec^n)

2) Rains
   a) Warm ocean currents bring rain in coastal & even interior
      Ex Summers Rainfall in British Type Climate (North Atlantic Drift)
   b) Warm — parallel to east in tropical & subtropical → warm & rainy climate

3) Moderating effect
   North Atlantic Drift brings warmness to England & canary cold current brings cooling effect to Spain, Portugal etc.

4) Fishing
   Grand Banks in Newfoundland (cold Labrador + warm Gulf stream)
   NE coast of Japan (cold Oyashio + warm Kuroshio)

5) Drizzle — Mixing of cold & warm currents create foggy weather where precipita^n occurs in the form of drizzle (Newfoundland)

6) ~~Climate~~ Tropical cyclones — They pile up warm waters in tropics → force behind tropical cyclones.

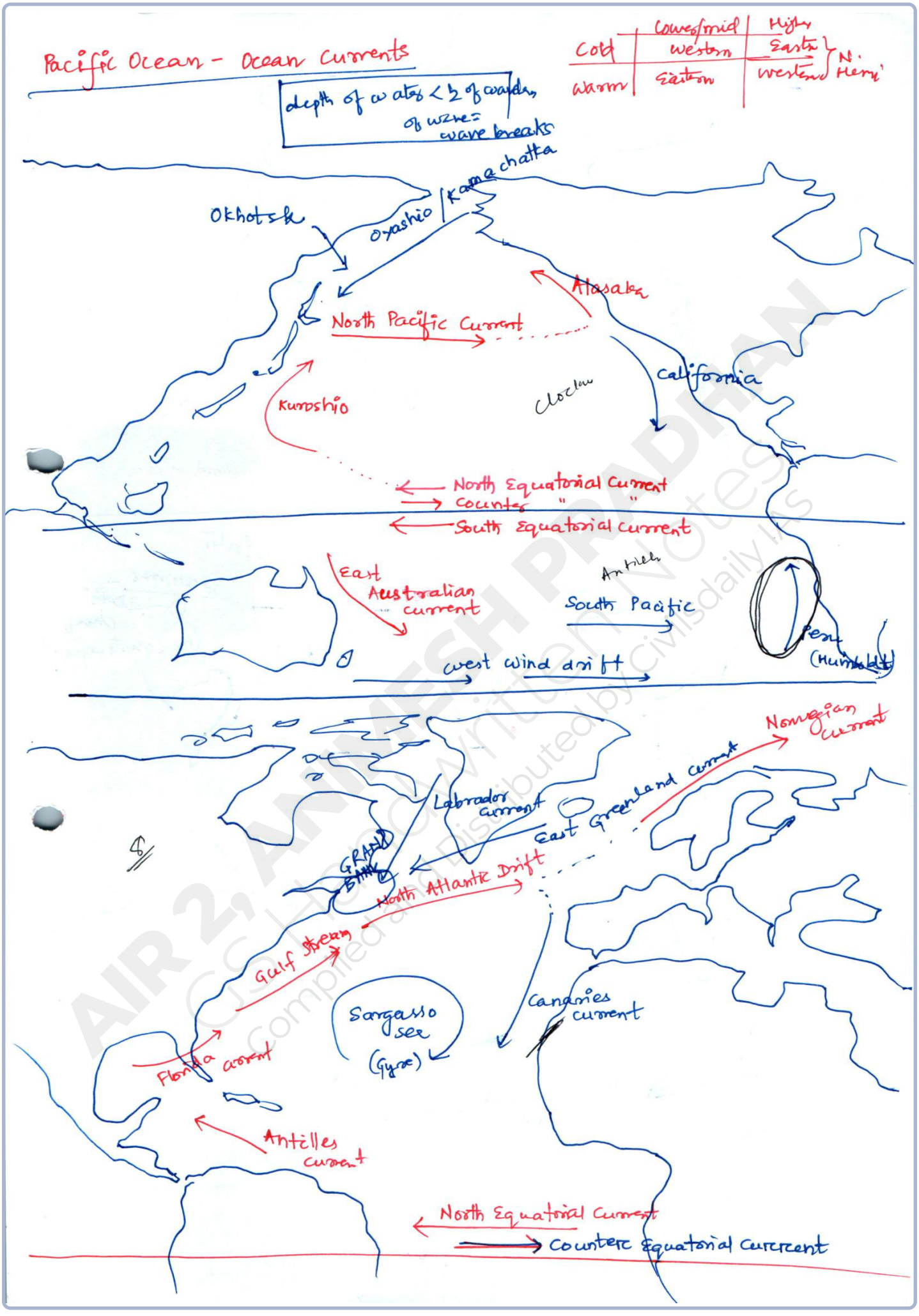
7) Naviga^n — ships usually follow routes which are aided by ocean currents & winds.

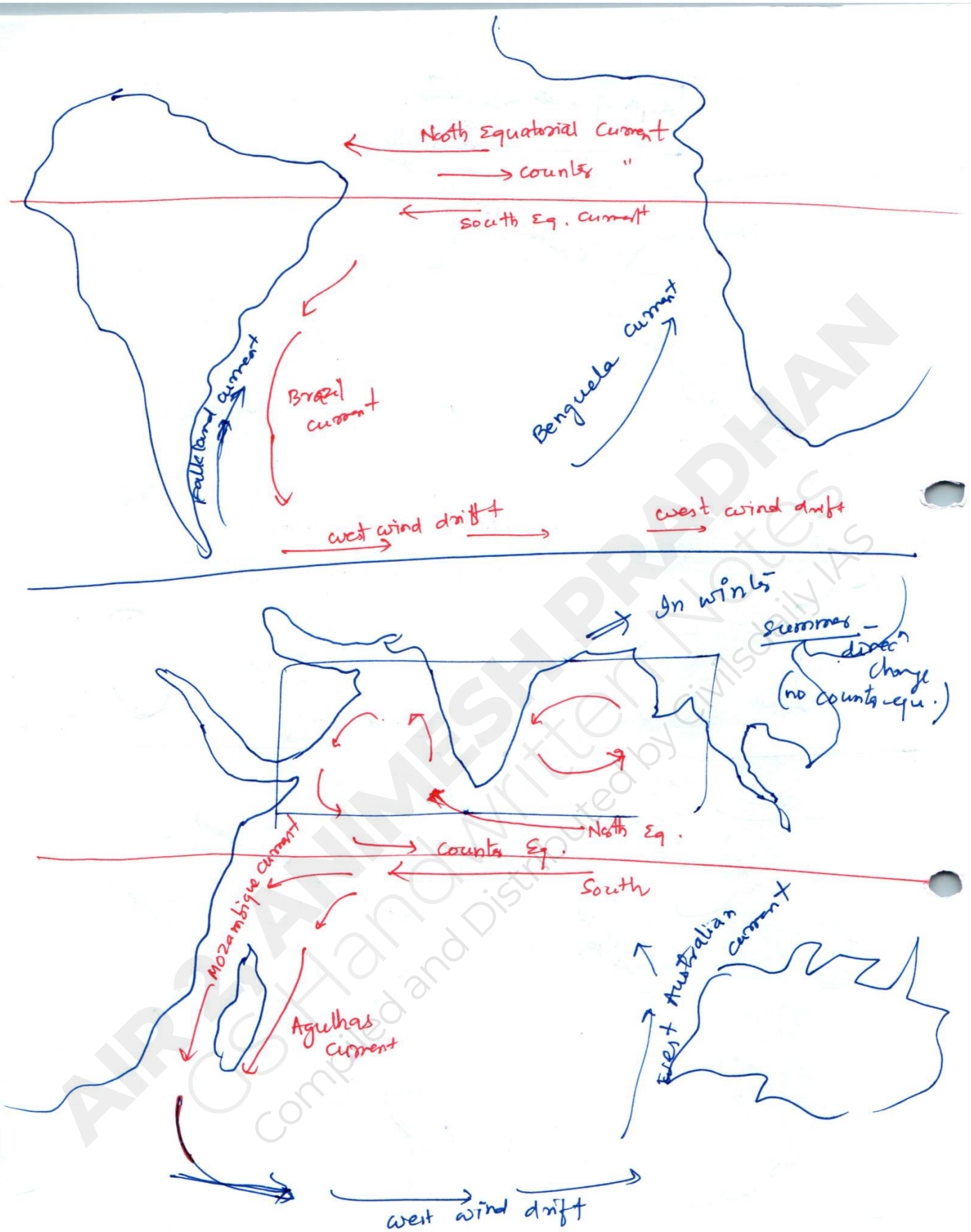
05 Types of Continental shelves

- Dendritic (Hudson)
- Large Rivers (Nile)
- Glacial (Greenland)
- Coral (Queensland)
- young mt. ranges (Hawaiian Islands)

3 types of Canyons

- Small gorge (edge of continental shelf to very deep depth) ⇒ New England
  - → Oceanography Canyon
- Indus Canyon
  - begin at mouth of river & extend over the shelf
- Dendritic appearance & deeply cut into edge of shelf & slope (South California)





Kuroshio — Oyashio
(warm) (cold)

Koppen classifica^n

* ACDE – humid, B – dry
* seasons of dryness:
  f – no dry season/wet climate
  m – monsoon
  s – summer dry season
  w – winter "
* h – tropical
  k – mid lat.
* a, b, c, d – degree of severity of temp
* (Dry) – S (steppe/semiarid)
  – W (deserts)

grasslands & deserts

B → BSh – Subtropical/all savanna grassland
BSk – Temperate steppe grasslands

BWh – Hot deserts
BWk – Temperate deserts

BWh – trade wind deserts
Sahara / Great Australian Desert, Iranian Dest, Thar Desert, Kalahari & Namib
Atacama/Peruvian desert

BWk → mines
BSk →
BSh →

A – Tropical – avg. of coldest month ≥ 18°C
B – Dry climate – Evapcn > Precipitn
C – Warm Temperate – avg. of coldest mnt −3°C < x < 18°C
D – Cold Snow Forest – " < −3°C
E – cold climate – avg. of all months < 10°C
H – Highland – cold due to elevn

Tropical (A) → Af, Am, Aw
Aw → Savanna → no distinct rainy season → poor laterite soil

Taungya (Myanmar)
Milpa
Jhum, Chena
Malaysia (Lackin)

Cs → winter maxima
dry summer → Mediterranean Sea, central Chile

Cfa – f – no dry season
a – hot summer (20° – 35° N S) – east coast

Gulf Type
China Type → Temperate Monsoon climate
Natal Type

Cf – Cool Temperate western Margin climate/British Type climate → Temperate cyclones
→ winter maxima

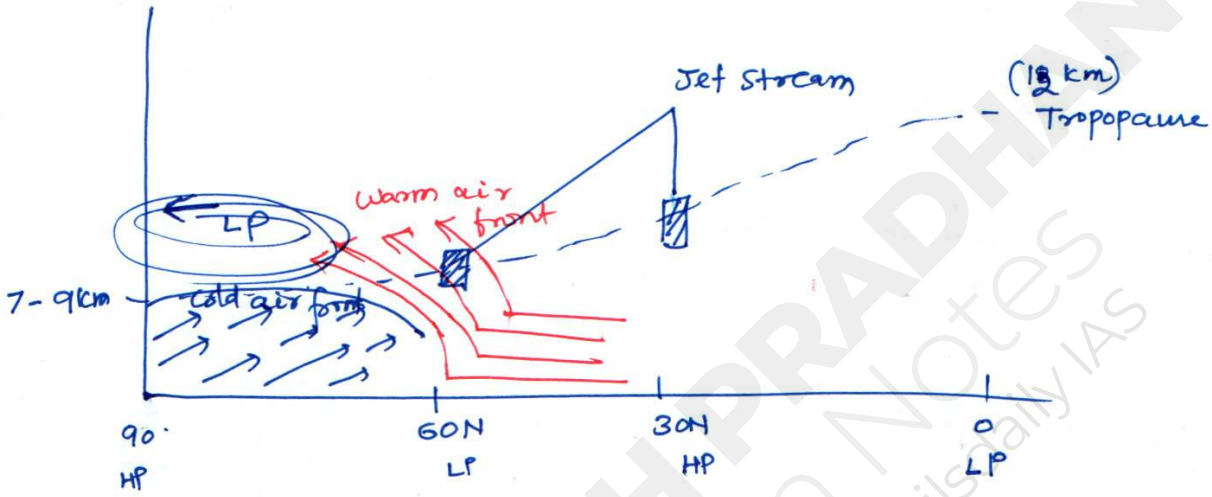
Warm Temperate (C)
Cf (No dry season, warm & cool summers)
Cfa (No dry season, warm summers)
Cs (Dry hot summers)
→ Mediterranean

Taiga
D → Df(C) (Taiga climate/Boreal climate) → cold summer
Only N hemi
summer maxima
Df(b) → Laurentian climate (Cool Temperate Eastern Marine)
only in NE USA & (Eastern Siberia, North China, Manchuria, Korea, Northern Japan)
— summer maxima

Polar Vertex

Circular motion

- Start at tropopause till stratosphere (can extend to meso)
- Low pressure (@ poles) ⇒ contradictory



- Both Jet streams stronger in winter because unequal temp. difference

↓

Polar vortex also stronger.

Polar stratospheric Clouds (PSCs)

- nacreous clouds extending 12-22 km above surface
- mainly formed during polar vortex in winter, more intense at South pole
- PSCs convert reservoir compounds into reactive free radicals (Cl and ClO) ⇒ reactive halogen radicals increase ⇒ ozone depletion enhanced.

phical Time Scale of Earth

Eons → Era → Period → Epoch → Ages

nerozoic (Present to 570 million yrs ago)
ryptozoic (570 M to 3500 M) → invertebrates & cryptograms
Azoic (3500M to 4600 M)

→ Proterozoic (era) 570 – 2500 M → marine invertebrate, some with shells
→ Archeozoic (era) 2500 – 3500 → earliest part

Phanerozoic (Eon)
- Cainozonic Era (65 M to present)
  - Quaternary Period → Holocene (0 – 10,000 years) / Pleistocene (10,000 – 2M)
  - Tertiary Period → Pliocene, Miocene, Oligocene, Eocene, Palaeocene → epochs
- Mesozoic (65 to 245 M)
  - Cretaceous Period – Extinction of dino
  - Jurassic – Age of dino
  - Triassic
- Palaeozoic (245 to 570)
  - Permian
  - Carboniferous
  - Devonian
  - Silurian
  - Ordovician
  - Cambrian

Cainozoic → Tertiary
- Epoch → Quaternary
  - Holocene (10,000) – Modern man
  - Pleistocene (2) – Homosapiens
- Pliocene (5) – Early human
- Miocene (24) – Flowering plants
- Oligocene (38) – Ape, cats, dogs, camels
- Eocene (55) – Rabits
- Palaeocene (63) – Small Mammals

Mesozoic
- Cretaceous (138 million) – Extinction
- Jurassic (205 million) – dinosaurs
- Triassic (240 million) – Frogs & turtles

PHANEROZOIC

Paleozoic
- Permian – (2.9 B) – Reptile domin
- Carboniferous (3.6 B) – Reptiles
- Devonian (4.10 B) – Amphibians
- Silurian (4.35 B) → corals
- Ordovician (5 Billion) – marine algae → 500 million
- Cambian (5.7 Billion) → 570 million

Era / Period

Proterozoic, Archean, Hadean } Pre cambian → bacteria (4.5 – 5 billion years ago)

Interior of Earth

Body waves — P
— S

P wave	S wave
- faster	- slower
- moves in solid, liquid, gas	- only solid
- shadow zone : 105° to 145°	- beyond 105°
- moves parallel to wave direc	- perpendicular

Era

Please Pay My Children

Precambrian — Palaezoic — Mesozoic — Cainozoic

Period

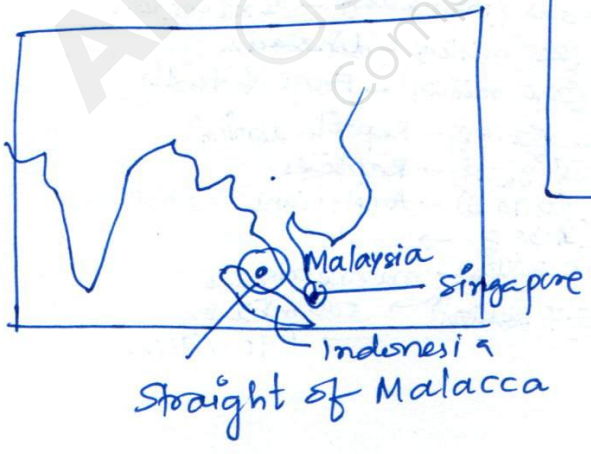
Camels often Sit down carefully, Peraphs their Joints Creak

Cambrian — Ordovician — Silurian — Devonian — Carboniferous — Permian — Triassic — Jurassic — Cretaceous

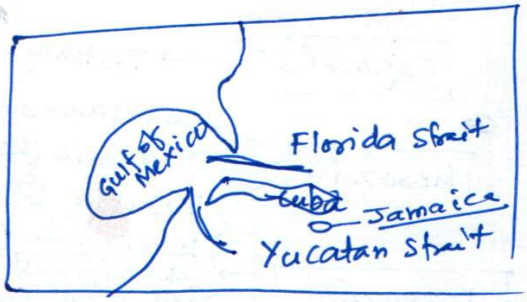
Epoch

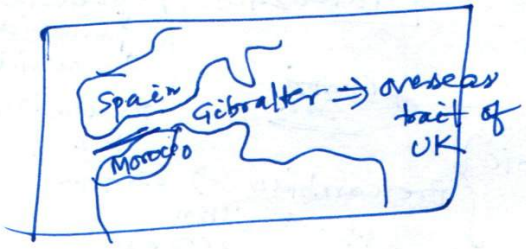
Put Eggs On My Plate, Please Honey

Palaeocene — Eocene — Oligocene — Miocene — Pliocene — Pleistocene — Holocene



Straight of Malacca





Distribution of Oceans & Continents

Ocean Floor Configuration
- → Continental Margin (Continental shelf = slope = rise = deep oceanic trenches)
- → Deepsea basin (plains)
- → Mid oceanic ridges.

→ Continental Drift Theory : Alfred Wegener
→ Convectional Current " : Arthur Holmes
→ Sea Floor Spreading : Hess

(heat from i) radioactive decay & ii) residual heat)

7 Major plates

1. Antarctica & the surrounding oceanic plate
2. North American (with western Atlantic floor separated from S-American plate along the carribbean islands) plate
3. South American (with western Atlantic floor separated from the N-American plate along the carribean islands) plate
4. Pacific plate
5. India - Australia - NZ plate
6. Africaa with the eastern Atlantic floor plate
7. Eurasia & the adjacent oceanic plate.

Minor plates

i) Cocos plate
ii) Nazca plate
iii) Arabian plate
iv) Philippine plate
v) Caroline plate
vi) Fuji plate

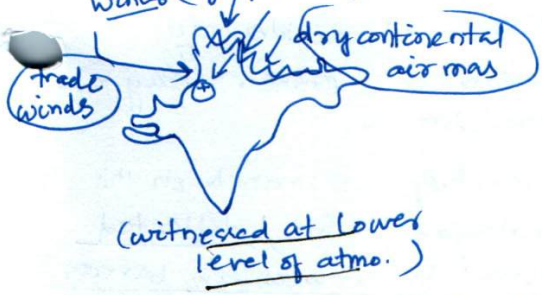
CLIMATE

factors determining the climate of India :

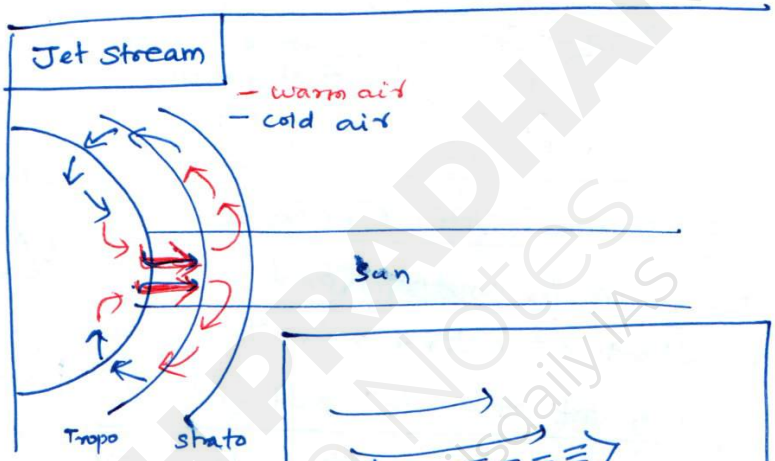
Related to location & Relief :
- latitude
- Himalayan Mountains
- Distribution of land & water
- Distance from sea
- Altitude
- Relief

Related to Air Pressure & relief
- Surface pressure & winds
- Jet stream & Upper Air circula^n
- Western cyclonic Disturbance & Tropical cyclones

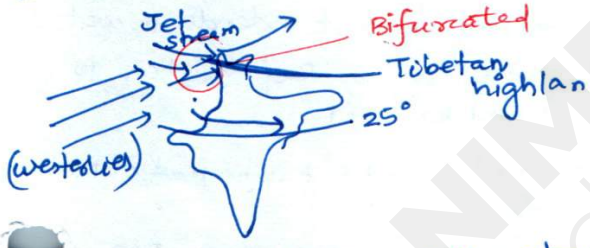
Surface Pressure & Winds

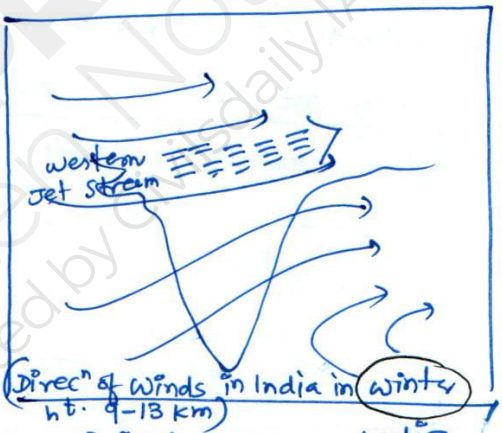


Jet Stream

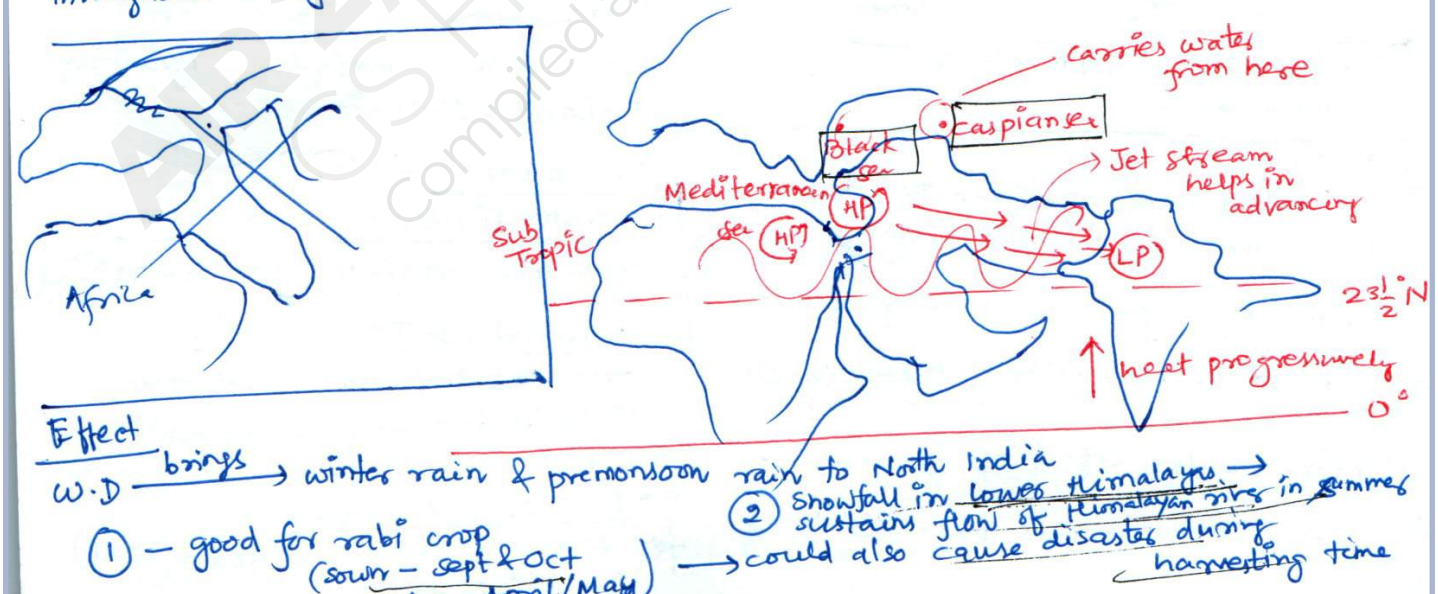


Jet Stream & Upper Air circula^n





Western Disturbance : an atmospheric or climatic influence on India that arises due to strong winds coming from the western direction. Throughout the year but peak in Jan & Feb.



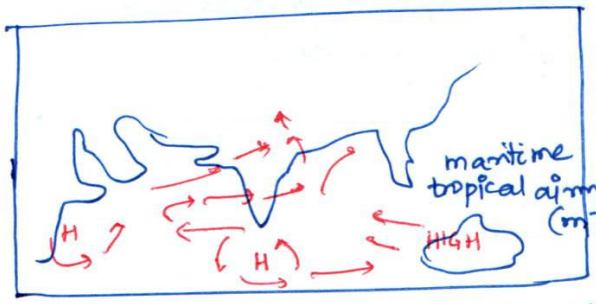
Effect

W.D brings → winter rain & premonsoon rain to North India
- (1) – good for rabi crop (sowr – sept & Oct → could also cause disastes during harvesting time
- (2) Snowfall in lower Himalayas → sustains flow of Himalayan rivers in summer

Mechanism of weather in Summer

1. Surface Pressure and Winds :

ITCZ moves north (20°–25°) (lower tropo)
↓
westerly jet stream withdraw
↓

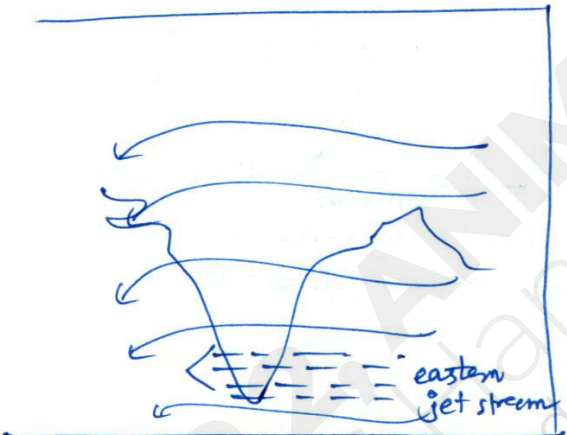


2. Jet Streams & Upper Air Circulation

- Easterlies in southern part.
(normally do not extend to 30° N)

3. Easterly Jet Stream & Tropical cyclones

↳ this stimulates the tropical depressions



Direct of winds at 13Km alt. in summer season.

BOB Branch

(i) → Crosses Ganga-Brahmaputra delta & reaches Meghalaya (Cherrapunji, Mawsynram)

(ii) → Himalayan foothills to ganga plain

TN coast remains relatively dry during SW monsoon :

a) rain shadow effect of A·S current

b) BOB current flows parallel to the coast.

Nature of Indian Monsoon

1. Onset of the Monsoon

Intense heat in north of Indian Ocean
↓
LP in N-W part (HP in Southern)
↓
SE trade travels from HP to LP
↓
helps in northward shift of ITCZ
↓
also westerly jet stream withdraws.
So, Easterly Jet Stream responsible.

After the onset, divides into
i) Arabian sea branch & ii) Bay of Bengal branch

ii) On reaching BOB branch on the Himalayan foothills, deflected westward by Himalayan barrier
- Two branches meet in Delhi
- combined current extends to west UP, Haryana, Punjab, Raj. & then to HP and Kashmir
- by mid July to Kashmir & remaining parts.

(*) A·S branch stronger than BOB :

i) A·S is larger than BOB

ii) entire A·S current advances towards India, whereas only a part of BOB enters India, remainder to Myanmar, Thailand & Malaysia.

A·S branch

→ Perpendicular to western ghat
orographic rainfall (400–500cm on windward side)
→ Narmada & Tapi troughs
reach central India, not much heavy due to absence of orographic feature (Ex. Nagpur)
→ Parallel to Aravalli
→ some orographic (Mt. Abu = 170cm)
→ so, Raj. is dry

Break in the SW Monsoon

- second week of August, last for a week
Because i) Monsoon trough (min. low pressure cell in ITCZ) moves northward in Himalayan areas → more rainfall here
ii) Over the west coast the dry spells are associated with days when winds blow parallel to the coast.

A. Cold weather Season

Excessive cold became
a) Punjab, Haryana and Raj. are not under moderating influence of sea
b) Snowfall in nearby Himalayan ranges
c) Around Feb, cold winds coming from Caspian sea & Turkmenistan bring cold wave along with frost & fog.

Pressure & Winds

- feeble HP cond^n over northern plain
- In South India, air pressure slightly ↓
- So, winds start blowing from NW HP to LP over Indian ocean.

* Westerly / N-Westerly : Ganga valley
Northerly → Ganga - Brahmaputra valley
N - easterly → Bay of Bengal.

Rainfall

- NW due to western disturbances
- Central India, Northern parts of S. peninsula occasionally
- Arunachal & Assam (25 mm - 50 mm)
- During October & November, retreating NE monsoon, picks up moisture & causes rainfall over TN coast, S. AP, SE Kerala & SE Karnataka

B. Hot Weather Season

Temp. increases from coast to inside

Pressure & Wind

ITCZ in 25°N July
↓
attracts South westerly on west coast as well as WB & Bangladesh.
⇒ They are easterly or S-easterly in N. Bengal & Bihar.

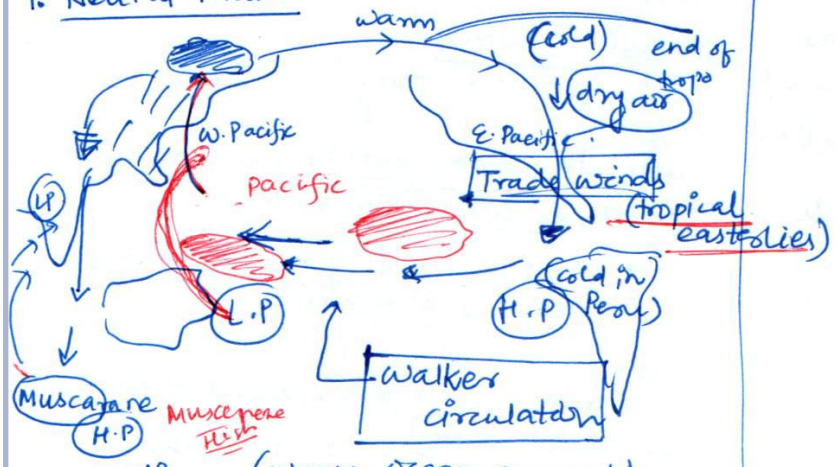
Loo

- originate over Iranian, Baloch & Thar deserts (dry & hot winds), 30-40 km/hr.
→ Dust storms resulting from convective phenomena → called andhis (blinding storm)
→ common in Punjab, Haryana, East. Raj, UP (in May in evening)
- Bring showers & light rains.
- occasionally, moisture-laden winds are attracted towards the periphery of the trough. A sudden contact b/w dry & moist air mass → local storms of ↑ intensity
Nor'westers & Thunderstorms in Summer
→ In WB, Jharkhand, Odisha & Assam; direc^n of squalls is mainly N-W so called 'norwesters'.
→ violent (60-80 km/hr); hailstorms
→ heavy damage to crops & loss of lives
→ best useful for tea, jute & rice cultiva. In Assam, called 'Barodoli Chheesha'
→ Max. occurrence in Vaisakh (mid-March to mid April) → Kalabaisakhis

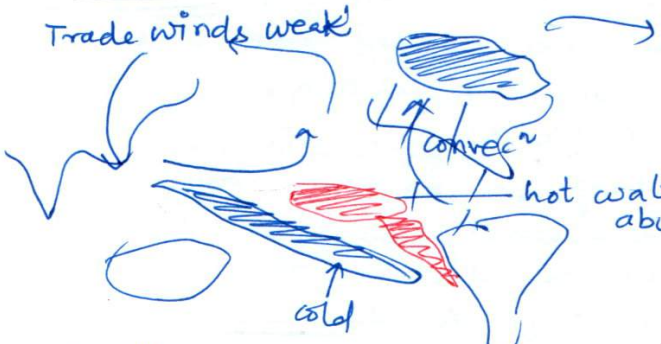
Mango Shower : Pre monsoon, towards end of summer, common in Kerala & coastal KA → help early ripening of mangoes
Blossom shower: coffee flowers blossom in Kerala & nearby areas.
Coffee

ENSO

1. Neutral Phase



2. ElNino (warm ocean current)



3. La Nina (same as neutral phase)

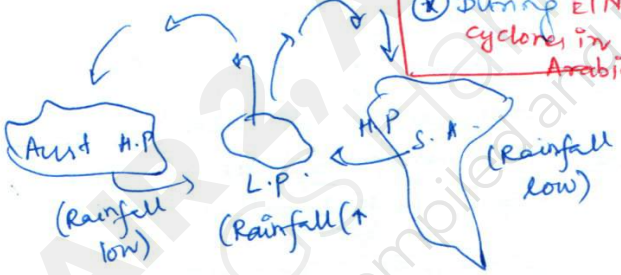
(cold ocean current)

- stronger walker circulation

① Low Southern Oscillation → EN-SO

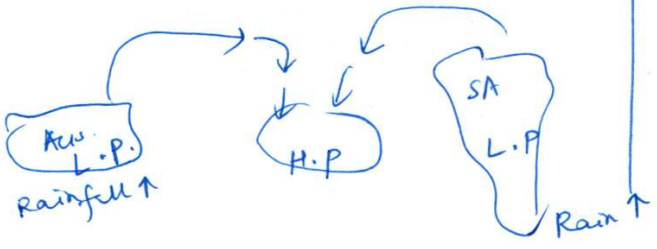
② During El Nino, cyclones in Arabian Sea.

El Nino Modaki



- ve effect on Indian monsoon

La Nina Modaki



Why more cyclones hit eastern coast of India?

1) Impact of El Nino & La Nina.
In neutral/La Nina phase - favourable for cyclone formation in Bay of Bengal.

2) The temperature of the sea surface and humidity are the most important factors responsible for the formation of cyclones. The avg. rainfall seen by the Bay of Bengal is very high & hence the probability of the formation of cyclones in this region is also correspondingly very high.

3) Tropical depression is a predominant occurence in the Indo-Gangetic Plains & this natural phenomenon is highly responsible for the cyclone formation in the BOB.

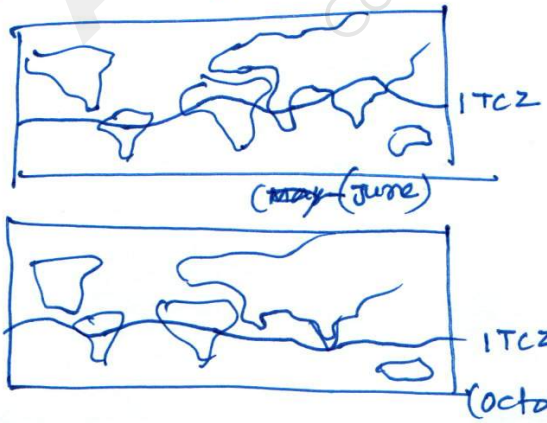
4) BOB witnesses an average temp. of 28°C. Warm air & the fresh water pouring into the bay from the rivers in the region increase the surface temp. of the sea further resulting in tropical depression.

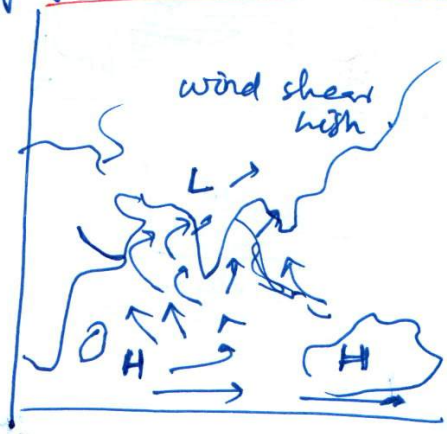
5) Cyclonic winds from other water bodies are transfered by BOB. The lack of landmass in the BOB basin means that the cyclones occuring in the region do not weaken & easily move towards the eastern coastline.

Why are very few Tropical cyclones during SE monsoon season?

1) The southwest monsoon is characterized by greater wind shear.

2) ITCZ in land in the month of Jun-Jul





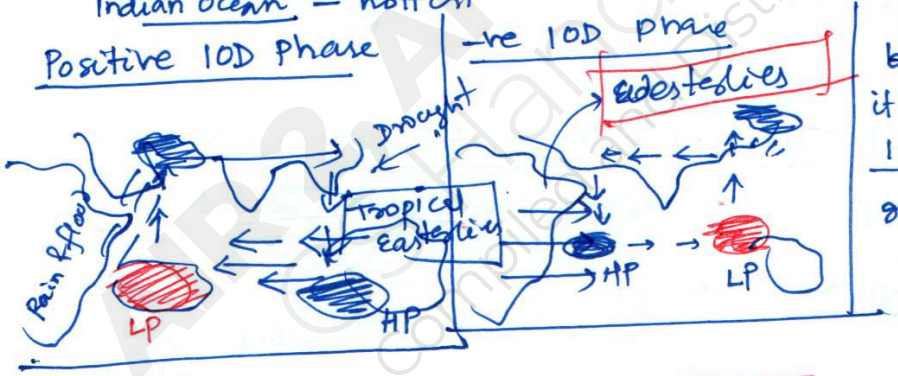
Fewer cyclones over Arabian Sea as compared to BOB

- Cyclones in BOB either in situ over southeast BOB or remnants of typhoons over N-W Pacific
- As frequency of typhoons over NW Pacific is quite high (about 35% of the global avg.), BOB also gets its increased quota.
- Cyclones over A. Sea either originate insitu over S.E Arabian Sea or remnants of cyclones from BOB that move across south peninsula.
- As majority of cyclones over BOB weaken over land after landfall, frequency of migrⁿ into Arabian Sea is low.
- BOB more river coming preventing mixing of cold water of ocean & hot water of rivers, so dedicated hot water of 50-70m available conducive for cyclone formⁿ; but in Arabian Sea, vertical mixing is high. (Evaporⁿ → near-surface stratificⁿ)
- Monsoon → Wind shear (Arabian greater wind shear)
- Walker circulⁿ

Indian Ocean Dipole — The shift of temperature in western & eastern side of Indian Ocean

Indian Ocean — hottest

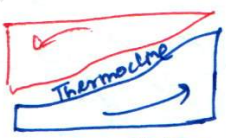
Positive IOD Phase



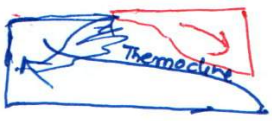
-ve IOD phase

Positive IOD beneficial for India because it pushes rain to India.

-ve IOD, drought happens in India.



Upwelling

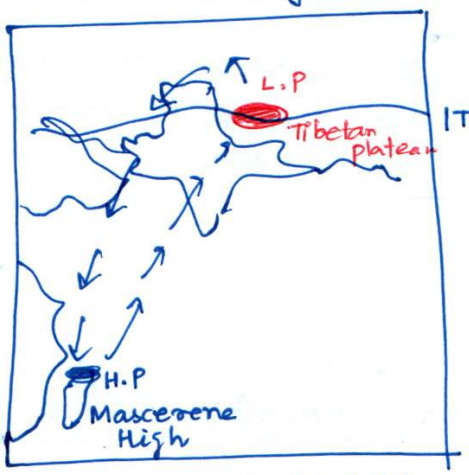


Indian Monsoon

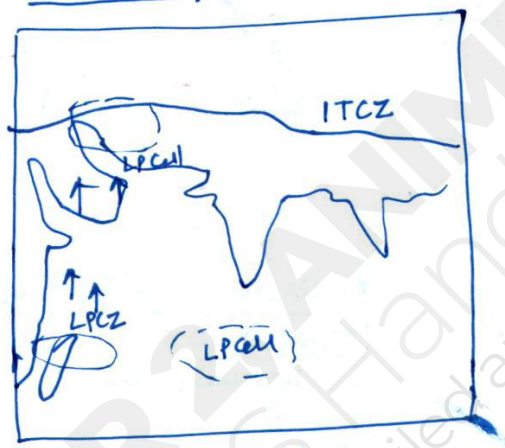
Unique features :
- Sudden onset
- Gradual advance
- Gradual retreat
- Variation – regional & temporal

Mechanism

1. Tropical Easterly Jet (temporary)

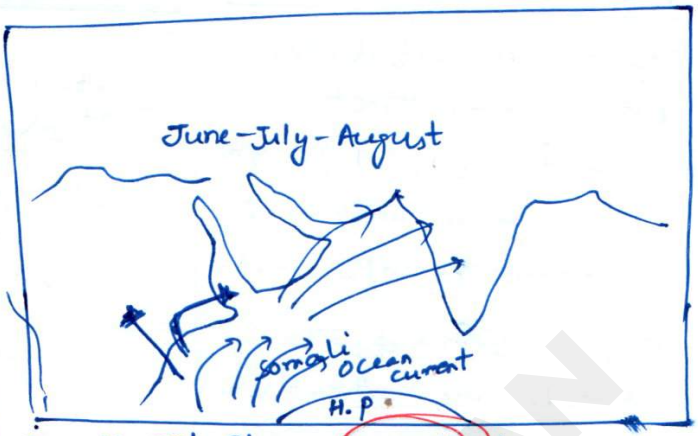


2. Second equatorial high



When 2nd equatorial trough (LP cell of ITCZ) merges with main ITCZ – strengthen the LP of ITCZ
- attracts more monsoon winds towards India

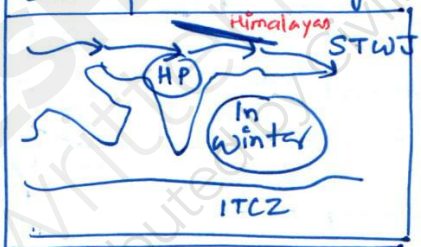
3. Somali current & somali jet stream



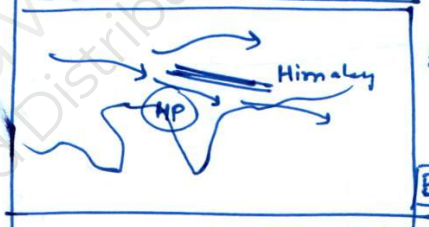
Somali Jet Stream – low level, appear only in summer.
- Intensify somali ocean current
- somali jet stream pushes monsoon winds towards India
- Stronger the somali current, better the monsoon.

4. Permanent Jet Stream

Subtropical westerly Jet

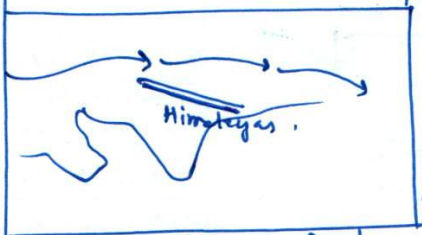


Winter



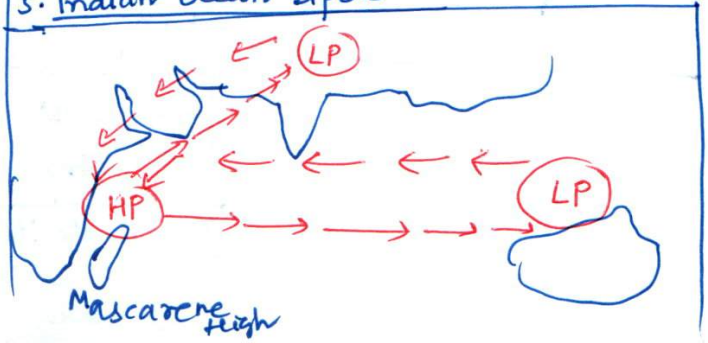
Bifurcation happens

Early summer



Late summer

5. Indian Ocean Dipole



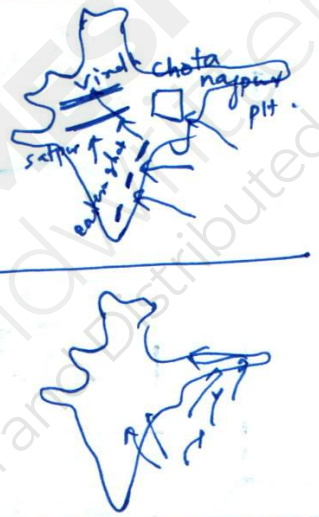
① Fluctuation in Monsoon

1) If ITCZ does not develop properly over Tibet
2) If 2nd equatorial trough does not merge with ITCZ or changes pos^n after onset
3) Southern branch of STWJ reestablish over northern plain
4) Inadequate heating of Tibetan plateau
5) Weak Mascarene High pressure cell
6) Intensifica^n of Indian ocean dipole / El-Nino event

② Monsoon : Arabian Branch

- western ghats blocks
- Rainfall in windward side
- South KA plateau, Rayalseema of AP remain dry

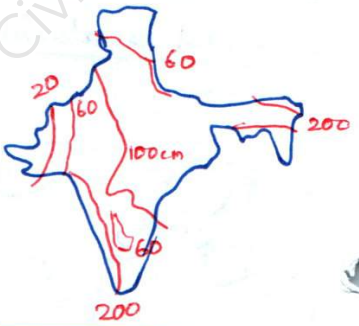
③ Monsoon : BOB Branch



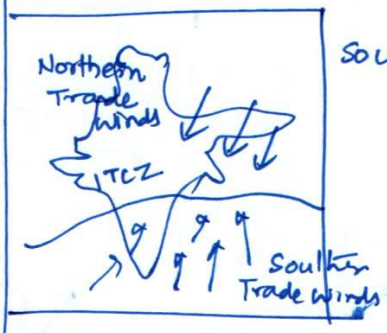
Purvanchal – Meghalaya plateau – becaus Funneling effect (of close hills)
- High rainfall
- Rainfall decreas from east to west
- Most of the rain from eastern branch

v) Ice climate : Mean temp of warmest month is under 10°C

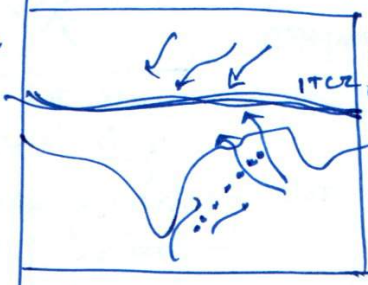
④ Rainfall Pattern



⑤ Retreating Monsoon



Southward movt of ITCZ



Possibility of tropical cyclone

Retreating SW monsoon branch drag them towards Eastern coast

⑥ Climatic classifica^n (Koeppen)

i) Tropical climate : mean monthly temp. throughout is over 18°C

ii) Dry climate : precipete^n is very low in comparison to temp. of dryness is less, it is semi-arid (S) ; if it is more, climate is arid (W).

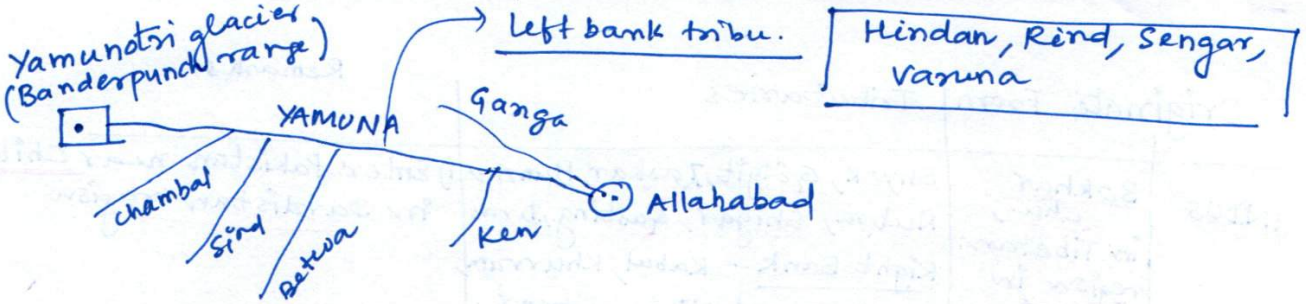
iii) Warm temperate climate : mean temp of the coldest month is between 18°C & (-3°C)

iv) Cool temperate : mean of warmest mo. :- (>10°C)
coolest " :- <(-3°C)

Originate From		Tributaries	Remarks
INDUS	Bokhar Chu, in Tibetan region in Kailash	Shyok, Gilgit, Zaskar, Hunza, Nubra, Shigar, Gasting, Dras Right Bank – Kabul, Khurram, Tochi, Gomal, Viboa, Sangar (all originate – Sulaiman rg.) Panjnad – Jhelum, Chenab, Ravi, Beas, Satluj Singhi Khabab	1) Enters Pakistan near Chilas in Dardistan region
JHELUM	Verinag foot of Pir-Panjal		1) Joins Chenab near Jhang in Pakistan
CHENAB			1) largest trib. of Indus 2) formed by Chandra + Bhaga joining at near Tandi near Keylong in HP
RAVI	west of Rohtang pass in Kullu hills of HP		1) Joins Chenab near Sarai Sidhu 2) Drains area b/w SE part of PirPanjal & Dhauladhar ranges
BEAS	Beas Kund near Rohtang pass		1) forms gorge at Kati & Largi in Dhauladhar ranges 2) Meets Satluj near Harike
SATLUJ	Raksastal near Mansarovar	Vishnu Nanda prayag, Karna Rudra Devprayag.	1) Also known as 'Langchen Khambab' 2) Comes out of gorge at Rupar 3) antecedent river 4) feeds Bhakra Nangal proj'ct

GANGA ORIGIN

1. Gangotri Glacier near Gaumukh, Uttarkashi Dist; Uttaranchal
   - (Bhagirathi) → Devprayag
   - Dhauli → Joshimath or Vishnu Prayag
   - Vishnu Ganga → Joshimath or Vishnu Prayag
   - Joshimath or Vishnu Prayag → Vishnu Prayag → Devprayag
   - Pindar → Karna Prayag → Devprayag
   - Devprayag → Ganga emerging in plains in Haridwar
2. Satopath glacier, above Badrinath (Alaknanda source)
   - Alaknanda → Rudra Prayag → Devprayag
   - Kedarnath → Mandakini / Kali Ganga → Rudra Prayag

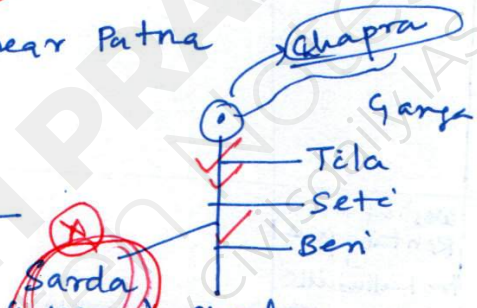


→ Left bank tribu. | Hindan, Rind, Sengar, Varuna

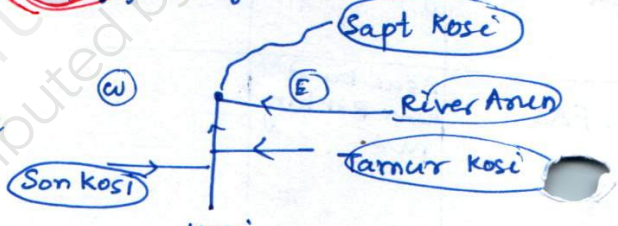
CHAMBAL Rises near Mhow in Malwa plateau in MP
- flows till Kota where Gandhisagar dam constructed (MP → Raj → UP)
- famous for its badland topography → chambal ravines

GANDAK = Kaligandak + Trishulganga (Nepal → Bihar → UP → Bihar)
- Rises in Nepal Himalayas b/w Dhaulagiri & Mt. Everest
- Enters Ganga plain — champaran
  Ganga — Sonepur near Patna

GHAGHARA
- Rises: Glacier of Mapchachungo
- deep gorge at Shishapani
- meets Ganga — Chhapra (UP/Bihar)



KOSI (Antecedent river)
Source: North of Mt. Everest in Tibet

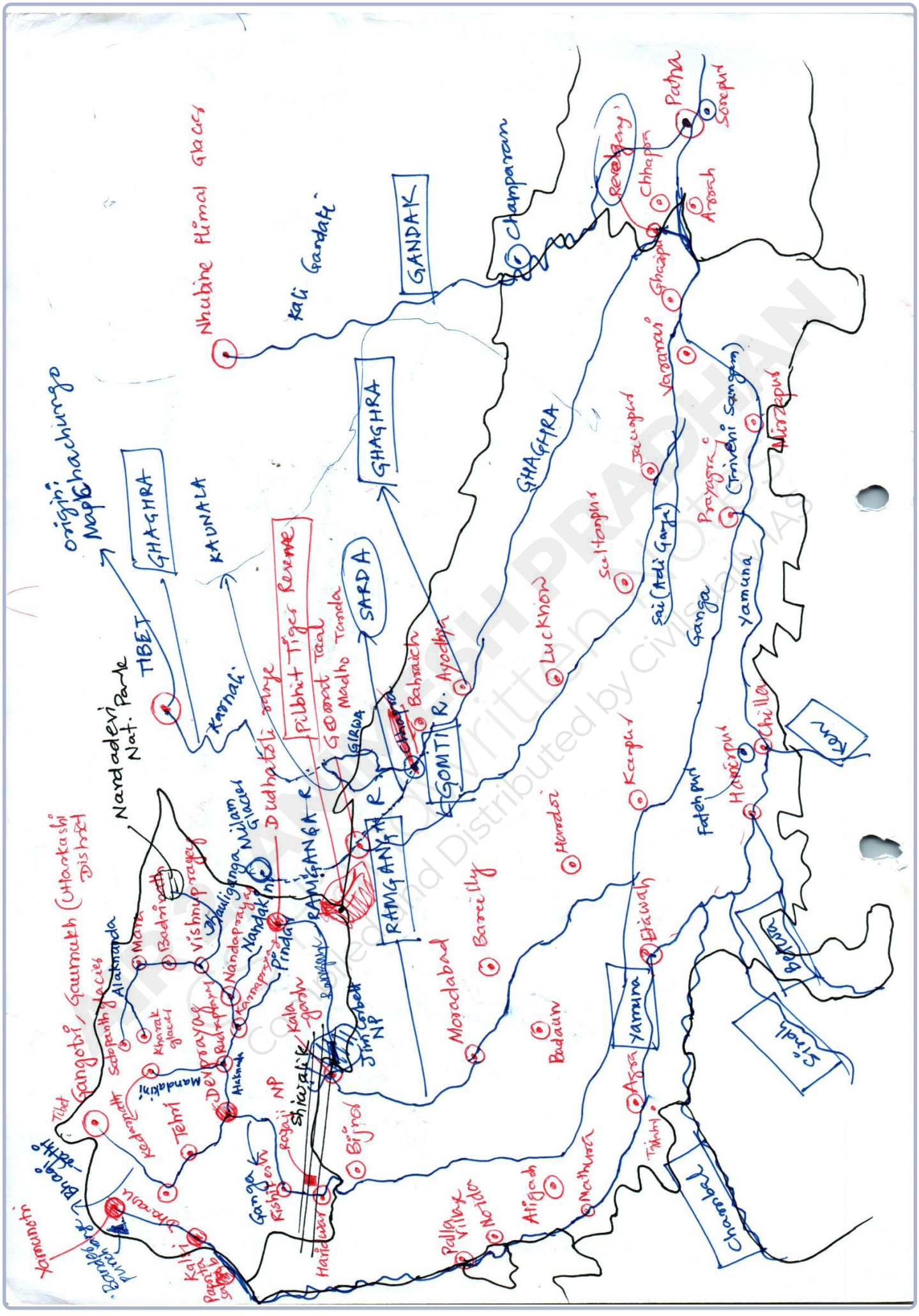


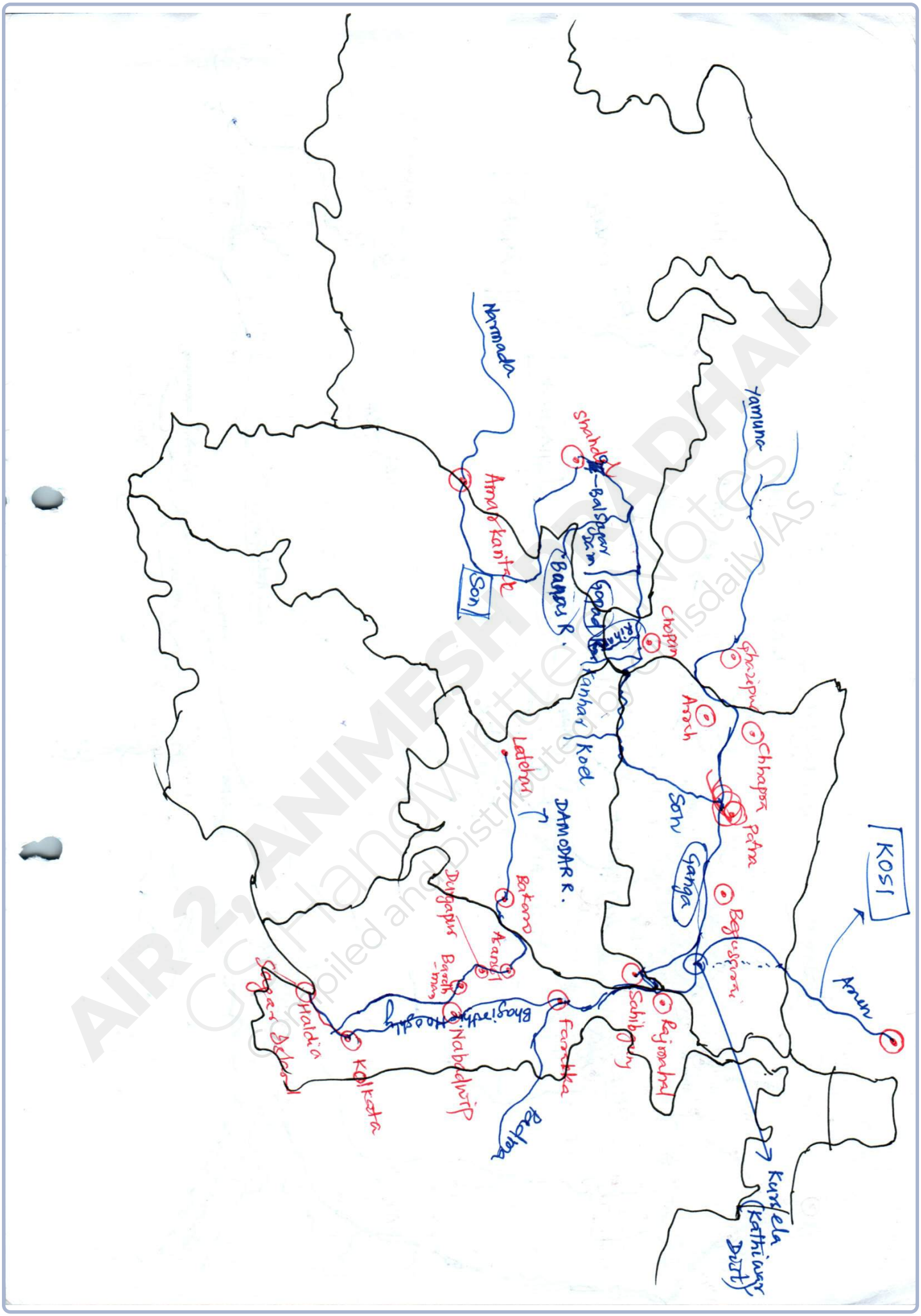
RAMGANGA Source: Garhwal hills near Gairsain
Enters plain: Najibabad, UP
Joins Ganga: Kannauj

DAMODAR Joins Hugli, Barakar main tributary

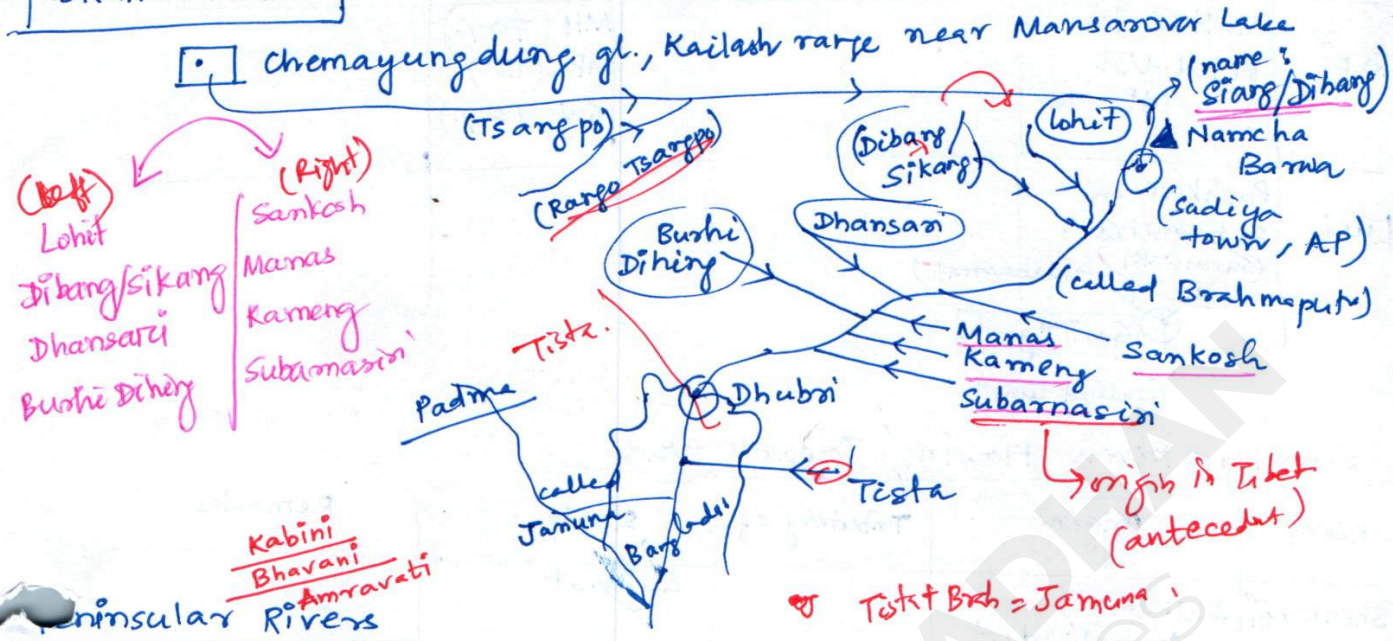
SARDA (Sanyu river) → in Nepal called Goriganga
Rises: Milam glacier in Nepal Himalayas
Indo Nepal called → Kali or Chauk where meets Ghaghra

MAHANANDA Rises: Darjiling hills
Joins ganga → West Bengal (as last left bank tributary of Ganga)





BRAHMAPUTRA



Peninsular Rivers

Kabini
Bhavani
Amravati

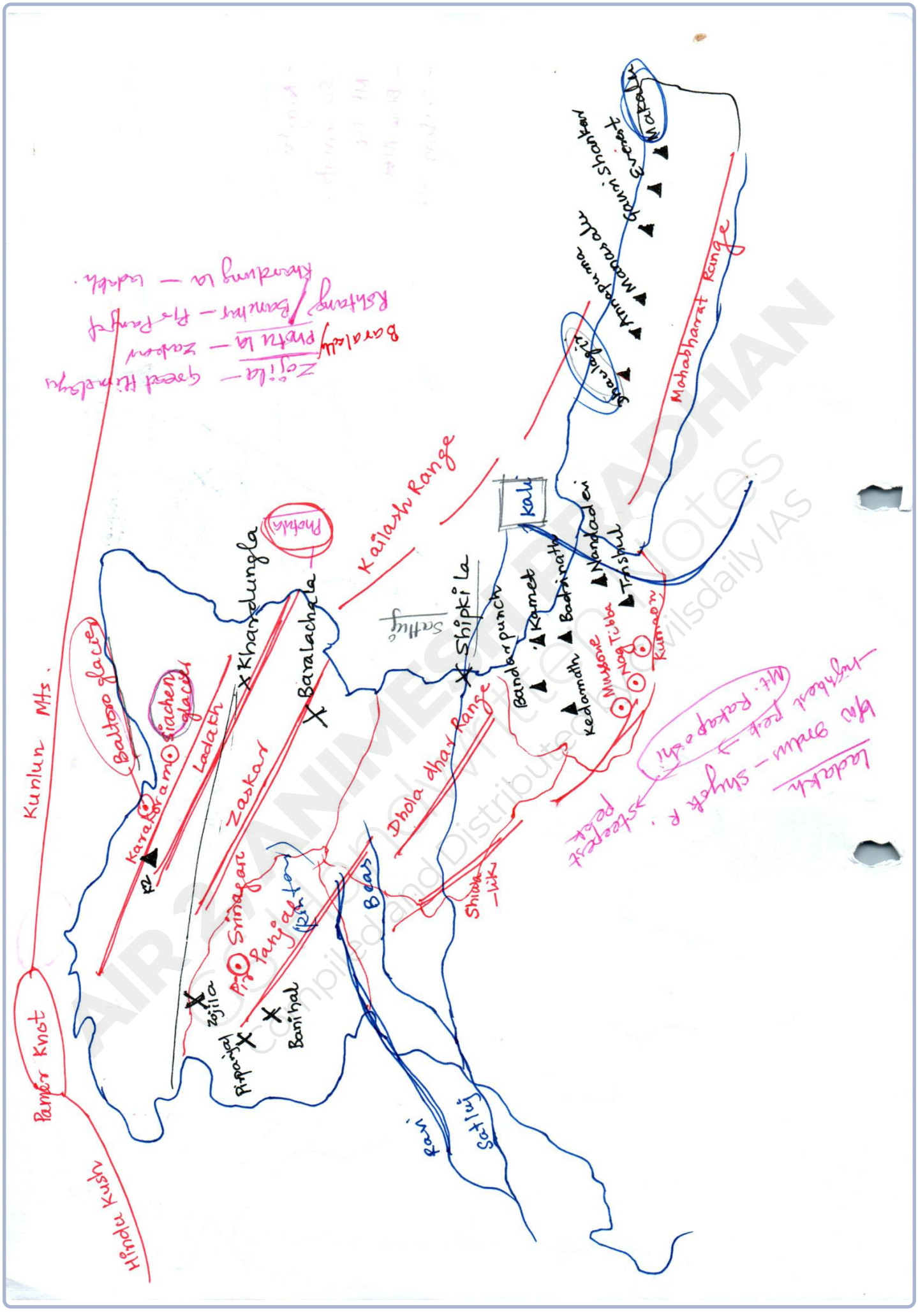
River	Origin	Tributaries	States (& Chhattisgarh)	Features
MAHANADI	Sihawa, Raipur		MP (53%), Odisha (47%)	
GODAVARI	Nasik, MH	Penganga, Indravati, Pranhita & Manjra Wainganga	MH (49%) MP (20%) tchhatt. rest in AP	navigable only in deltaic region
KRISHNA	Mahabaleswar, Sahyadri	Koyna, Tungabhadra, Bhima	Karnataka (44%) MH (27%) AP+Telangana (29%)	
Kaveri	Brahmagiri Hills of Kogadu dist; KA	Kabini, Bhavani, Amravati	TN (56%) KA (41%) Kerala (3%)	Mostly perennial became upper part from S-W monsoon & lower part N-E monsoon.
Narmada	Amarkantak Plateau			1) gorge in marble rock & Dhuandhar waterfall → Jabalpur 2) meets Arabian sea → Bharuch (forms estuary) 3) Sardar Sarovar Project

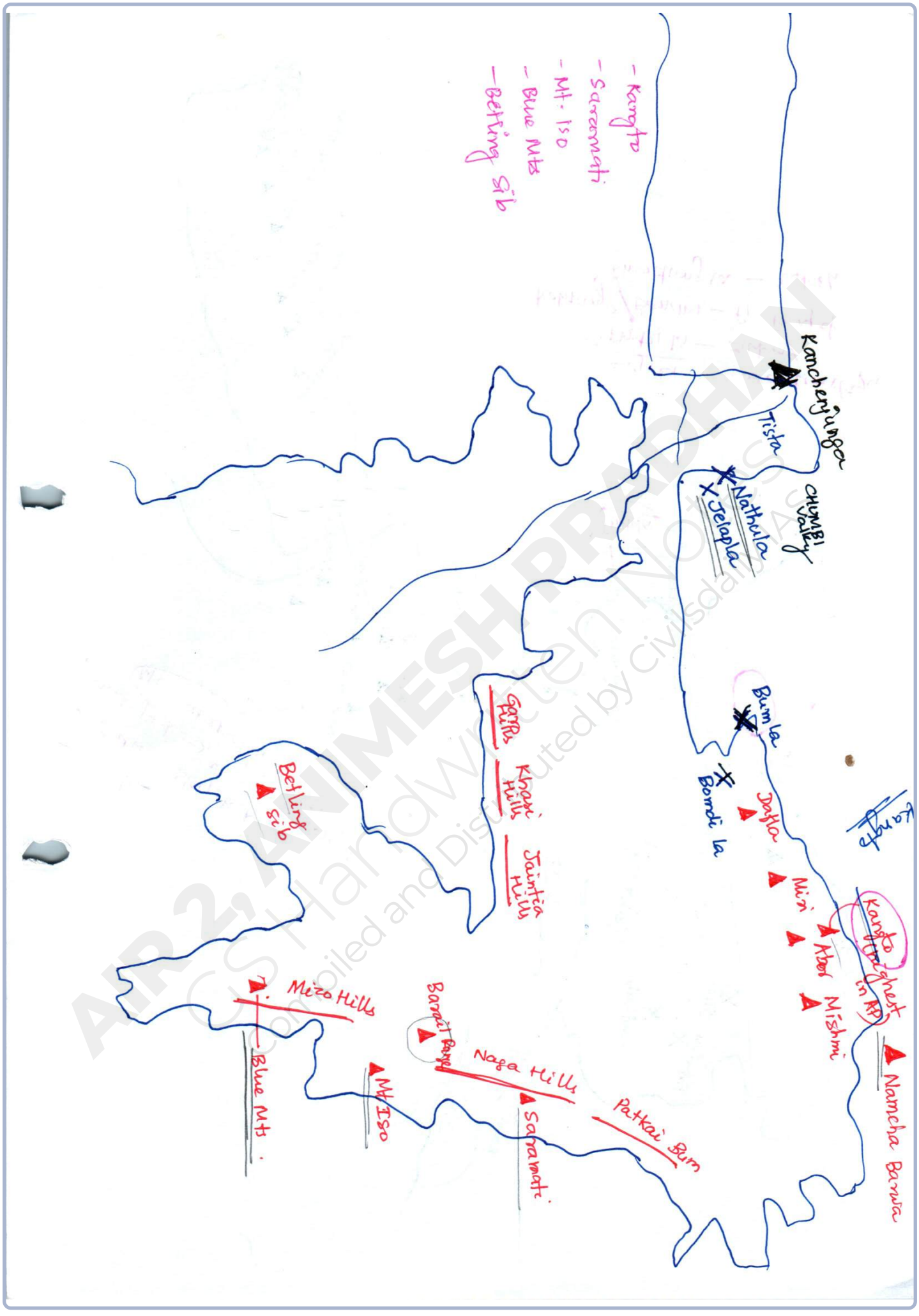
River	Origin	Tributaries	State	Features
Tapi	Multai in Betul dist, MP		MH (79%) MP (15%) Guj (6%)	
Luni	Pushkar in 2 branches: (Saraswati) (Sabarmati) → Govindgarh (called luni)			

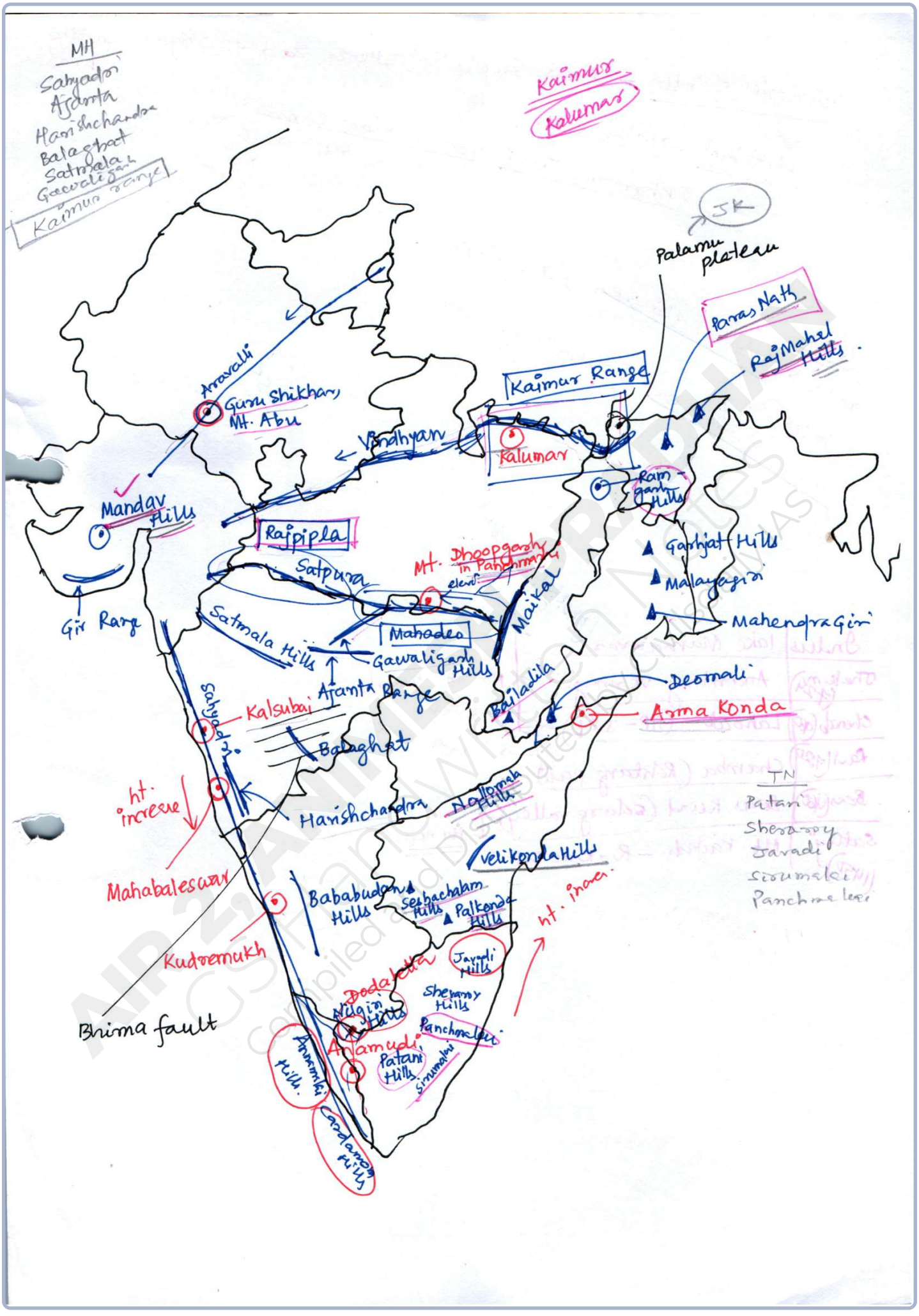
Pambet (Kerala) → vembanad lake

Smaller Rivers Flowing Towards West

River	Origin	Tributary of	State	Remarks
Shetrunjji	Dalkahwa, Amreli dist		Gujarat	
Bhadra	Aniali village, Rajkot dist		Gujarat	
Dhadhar	Ghantar village, Panchmahal dist.		Gujarat	
Sabarmati	Udaipur		Raj → Gujarat	Kalibel peeth
Mahi			MP → Gujarat ✓	
Vaitarna	Trimbak hills, Nasik dist		MH	
Kalinadi	Belgaum dist (falls in Kanwar Bay)		Karnataka	- Pamba - vembanad lake - Periyar
Bedti	Hubli Dharwar		Karnataka	
Shararati	Shimoga dist, KA		Karnataka ✓	
Mandovi			Goa	
Juari			Goa	
Bharathap-uzha	Annamalai hills			- also called Ponnani






MH
Sahyadri
Ajanta
Harishchandra
Balaghat
Satmala
Gawaligarh
Kaimur range
Kaimur
Kaimur
JK
Palamu plateau
Paras Nath
Raj Mahal Hills
Aravali
Guru Shikhar
Mt. Abu
Vindhyan
Kaimur Range
Kalumar
Ram-garh Hills
Mandav Hills
Rajpipla
Satpura
Mt. Dhoopgarh in Panchmarhi
elevation
Maikal
Garhjat Hills
Malayagiri
Mahendragiri
Gir Range
Satmala Hills
Mahadeo
Gawaligarh Hills
Deomali
Bailadila
Arma Konda
Sahyadri
Kalsubai
Ajanta Range
Balaghat
TN
Patan
Sheravoy
Javadi
Sirumalai
Panchmalai
ht. increase
Harishchandra
Nallamala Hills
Velikonda Hills
Mahabaleswar
Bababudan Hills
Sesachalam Hills
Palkonda Hills
ht. increase
Kudremukh
Javadi Hills
Dodabetta
Nilgiri Hills
Shevaroy Hills
Panchmalai
Anamudi
Patani Hills
Sirumalai
Anaimalai Hills
Cardamom Hills
Bhima fault

Tributaries of Indus – Shyok, Gilgit, Nubra, Hunza, Zaskar, Shigar, Gasting, Dras

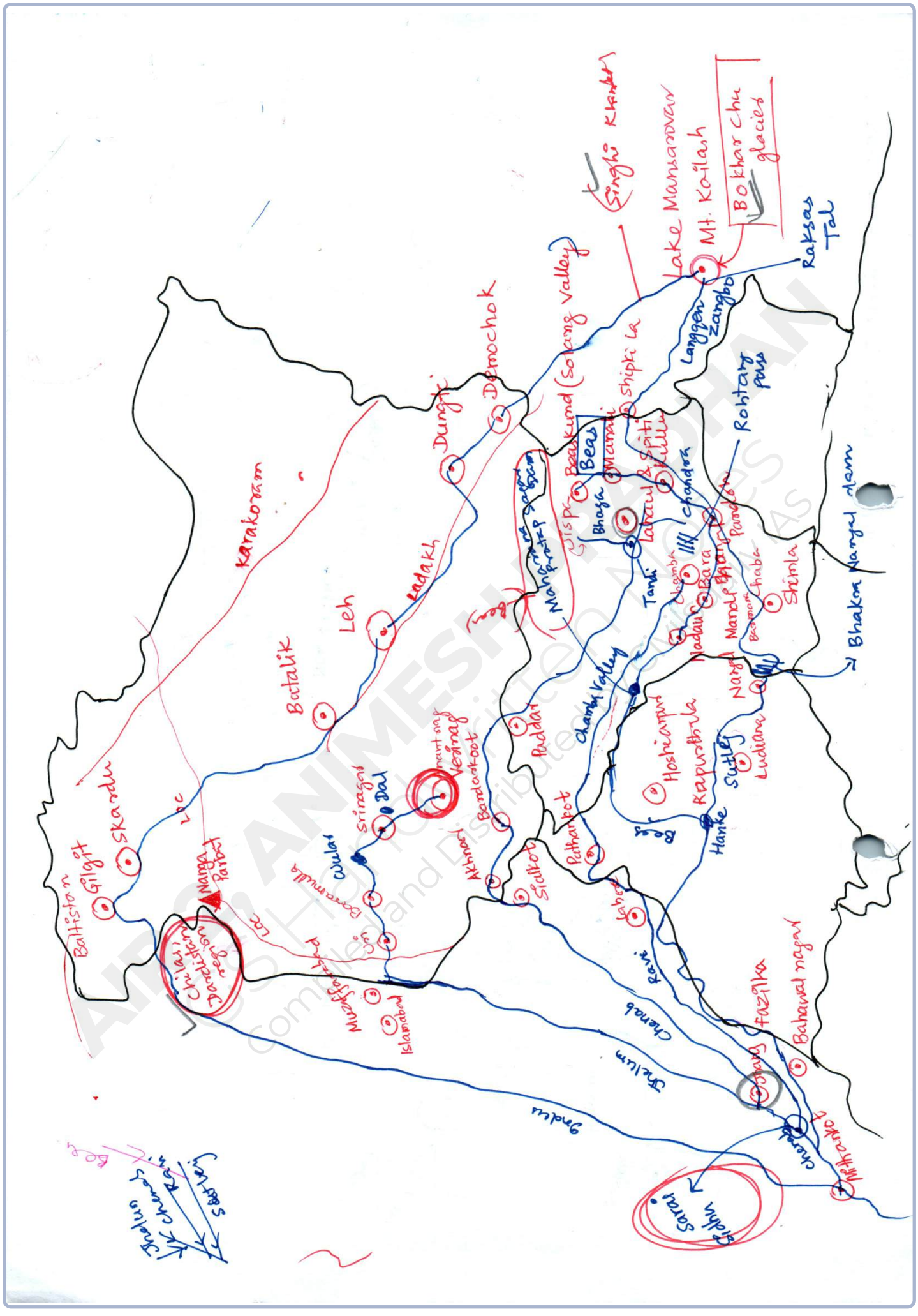
Right bank → Kabul river
→ Khurram, Tochi, Gomal, Viboa, Sangar (Sulaiman ranges)

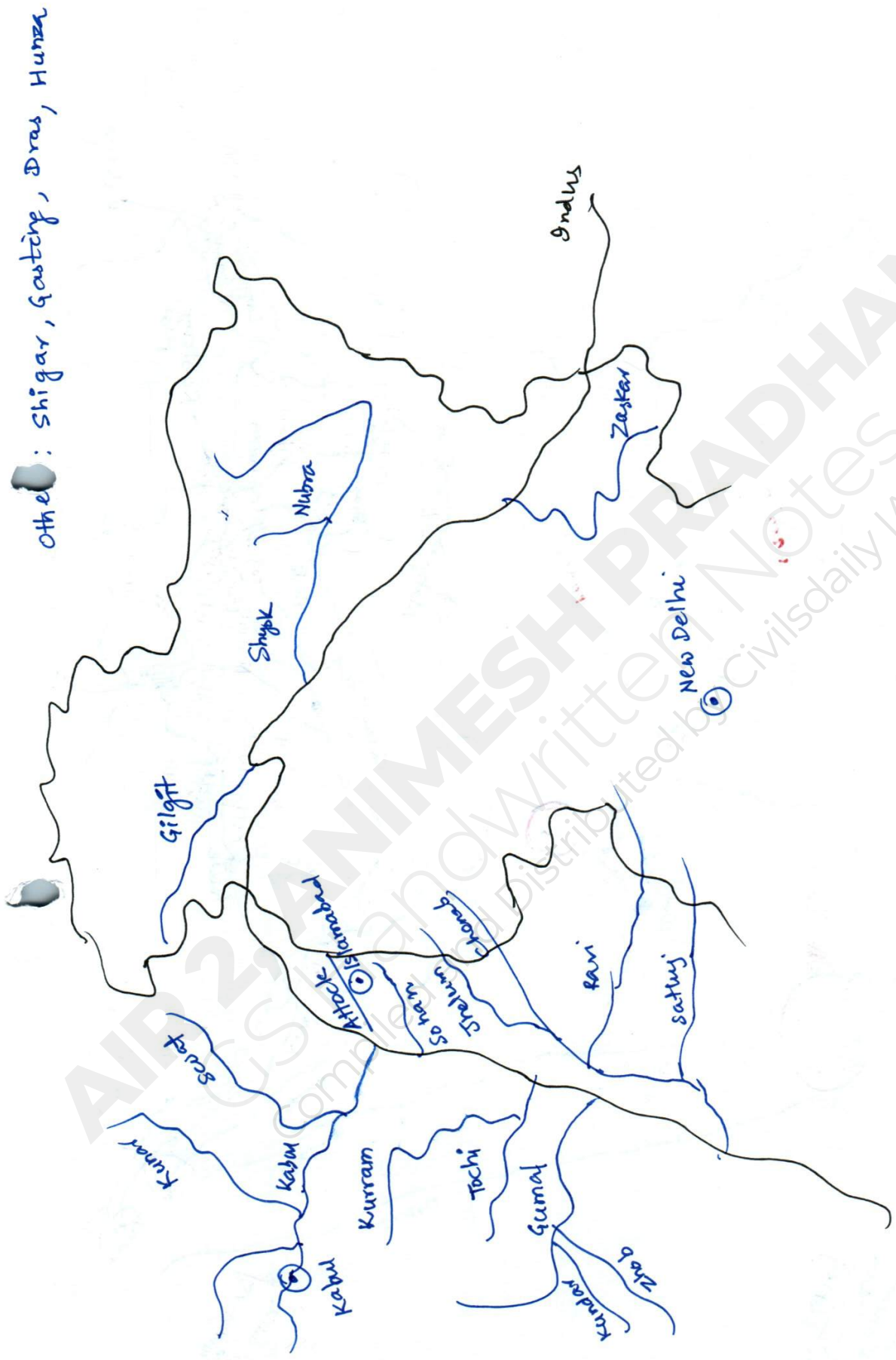
Length
Indus > Chenab > Satluj > Ravi > Jhelum (725) > Beas (720)
In India
Chenab > Satluj > Ravi > Jhelum > Indus (710) > Beas

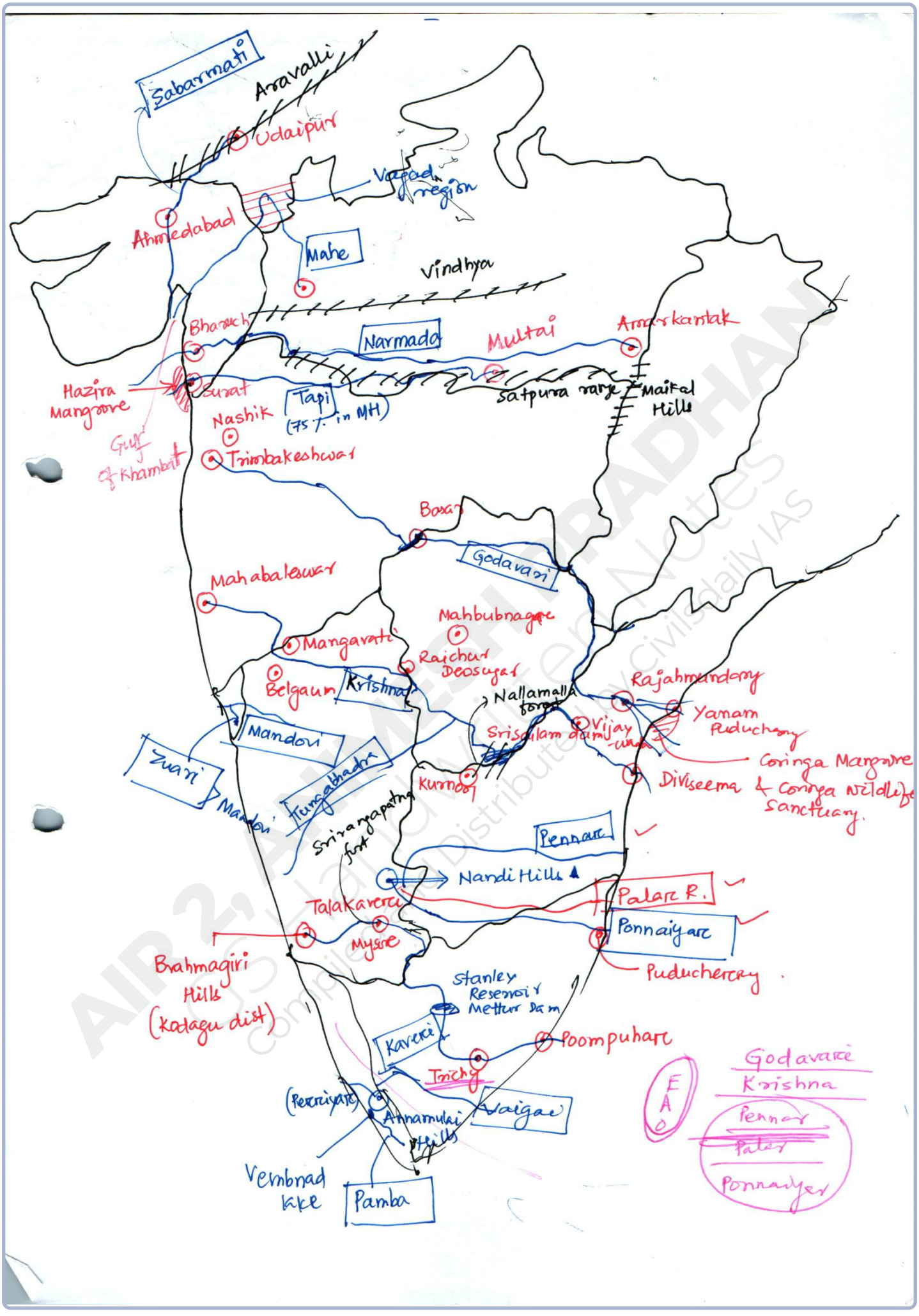
CSR

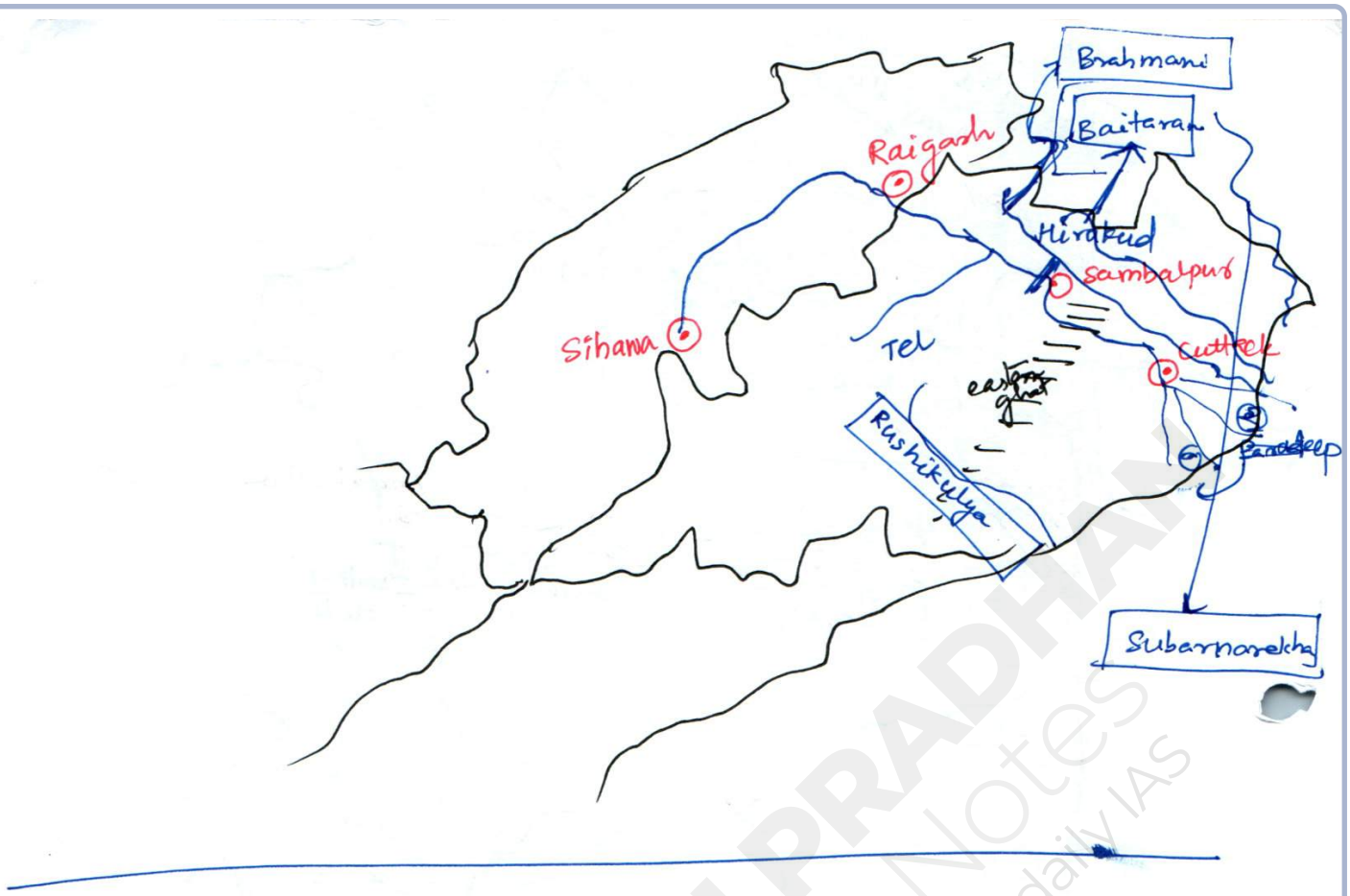
Indus	Lake Mansarovar (Bhaktar Chu glacier)		
Jhelum (725)	Anantnag Verinag (Pir Panjal)	Not in Punjab	
Chenab (960)	Lahoul (HP – J & K)	→ Jhang	
Ravi (720)	Chamba (Rohtang pass)	→ Sarai Sidhu	
Beas (460)	Beas Kund (Solang valley)	Hanke	
Satluj (1450)	Mt. Kailash – Rakas Tal		

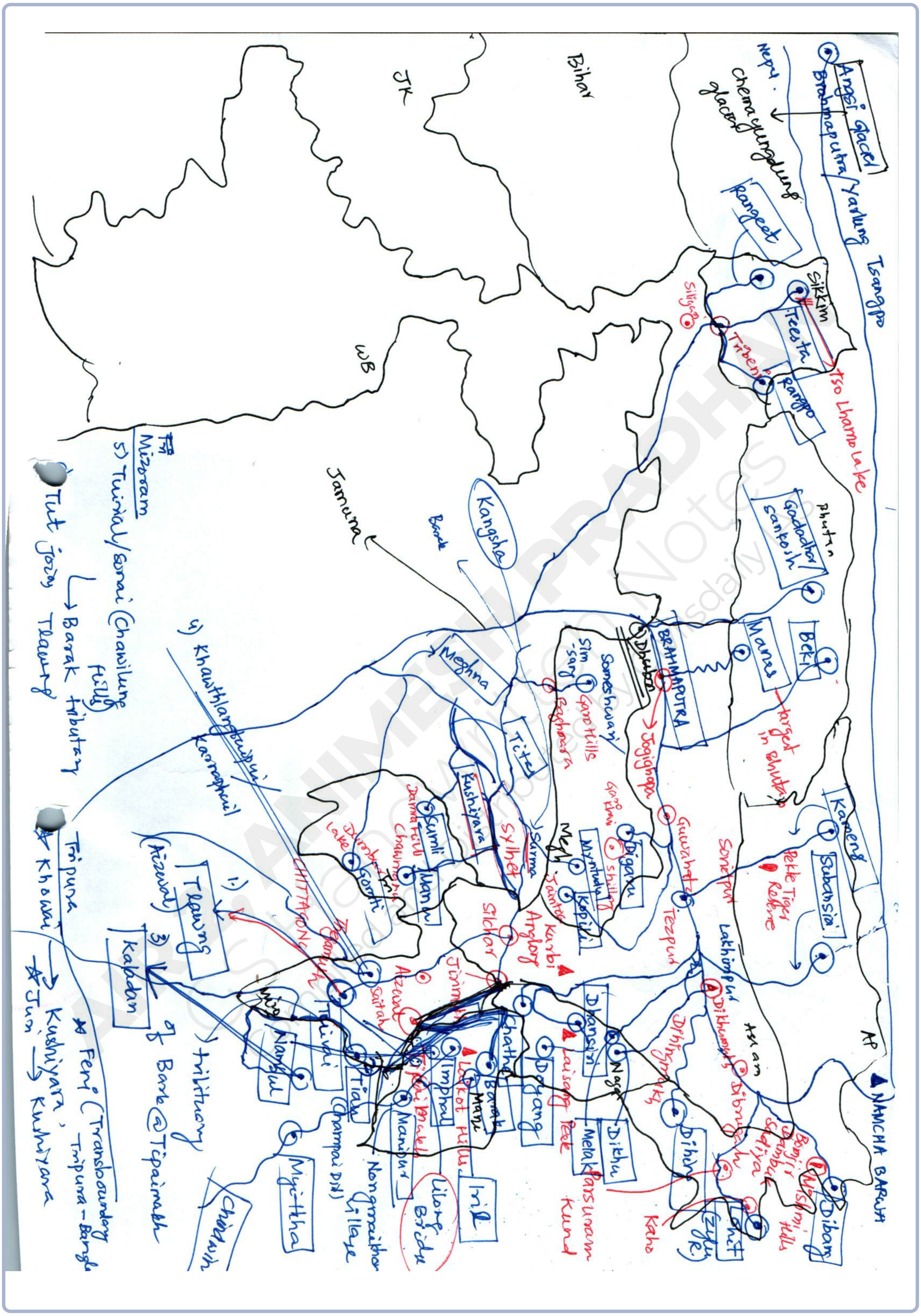
→ Langchen Khamb

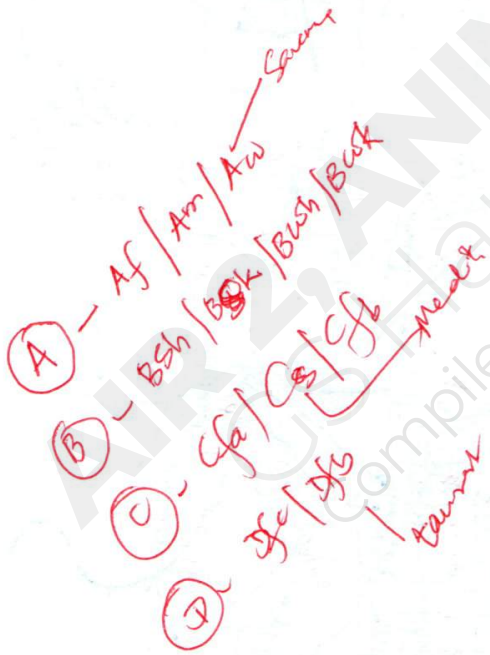









Angsi glacier
Brahmaputra/Yarlung Tsangpo
Nepal
Chemayungdung glacier
Bihar
JK
WB
Rangeet
Sikkim
Teesta
Siliguri
Tribeni
Rangpo
Tso Lhamo Lake
Bhutan
Godadhar
Santosh
Manas
Beki
Kameng
Subansiri
Jamuna
Kangsha
Meghna
Dhubri
BRAHMAPUTRA
Jogighopa
Garo Hills
Titas
Kushiyara
Sylhet
Surma
Guwahati
Sonitpur
Tezpur
Lakhimpur
Kopili
Dhansiri
Doyang
Dibang
Lohit
Dihing
Imphal
Manipur
Barak
Loktak Lake
Silchar
Jiri
NAMCHA BARWA
AP
Assam
Mizoram
4) Khawthlangtuipui/Karnaphuli
5) Tuirial/Sonai (Chanilung falls)
Barak tributary
Tlawng
Kaladan
Tripura
Khowai
Feni
Juri
Tiau
Myittha
Chindwin



River	Origin	Tributaries	Outlet	States	NP/MI.	Remarks
Periyar (West) (second largest Kerala)	western ghats (Sivagiri Hills) (TN)		Arabian sea	TN → Kerala	- Periyar WS	- Idukki Dam - Periyar lake
Pamba (3rd of Kerala)	Pulachimalai hill, Peerumedu plat. (western ghats)		Vembnad lake	Kerala		- Anjana Temple - Alappuzha - Sabarimala Temple called - Dakshina Bhageerathi & River Baris
Mahadayi (Mandovi) Zuari - Goa	Degaon village, Belagavi dist of KA	Mapusa Zuari + Mandovi @ Cabo Aguada	Arabian sea	Karnataka - Goa		- Dudhsagar Falls - Panaji - Varapoha Falls
Zuari (largest Goa)	Hemad - Barshem		Arabian sea	Goa		- Tidal river - Vasco da Gama
Tungabhadra	Tunga + Bhudra from Gangamoola, Central Sahyadri	left: Tunga, Kumudvati, Varada Right: Bhadra, Vedavathi, Handri	Krishna	Karnataka → AP	Malaprabha.	- Hampi, Kurnool
Malaprabha	Kanakumbi, Belgaum dist.		Krishna @ Kudalasanga-ama in Bagalkot dist.	Karnataka		- Hubli city - deity Yellamma temple - temple of Aihole, Pattadakal & Badami
Kabani	Pakramthalam Hills, Wayanad dist.		Kaveri	Kerala - Karnataka		

River	origin	Tributaries	outlet	States	Mt./NP	Remarks
Sharavati	Shimoga dist, KA		Arabian sea	Karnataka		- Jog Falls.
Narmada	Maikala Range Amarkantak	Kolar, Shakkar, Dudhi, Tawa, Hiran, Orsang, Barna, Kolar	Gulf of Khambat	Gujarat, MP Maharashtra.	Hydro Power Project - Indira sagar, Sardar sarovar, Omkareshwar, Bargi & Maheshwar	- Mandhar & Dardi Falls - Sahasradhara Falls - Aliabet Island
Tapi	Multai, MP	Right : Suki, Gomai, Amravati & Aner Left : Vaghur, Amravati, Burray, Panjhra, Bori, Girna, Purna, Mona & Sipna	Gulf of Khambat	MP → MH → Guj	Multai Reserve forest Satpura range Mahadev hills → Ajanta & Satmala Range Hills	- Plain area (Khandesh) - Hathnur Dam (MH) - Girna Dam, Dahigam weir (MH) - Kakrapar weir & Ukai Dam (Guj) - cut Tropic of Cancer twice - Mahi Bajaj sagar dam, Kadana Dam - VADODARA
Mahi	Dhar dist; Vindhyas	Anas (left)	Gulf of Khambat.	MP → Raj → Guj	Mahikanta Hills Aravalli Malwa Vindhyas	
Tawa	Betul, Satpura Range.		Narmada (largest tribute) @ Hoshangabad dist.	MP		
Sabarmati	Tepur in Udaipur			Raj → Guj		Sabar + Hathmati - Sabarmati Reservoir
Luni (Sagarmati)	Western slopes of Aravalli (near Ajmer)					- endorheic River (no outflow)

River	Tributaries	Origin	Outlet	States	Mt./NP	Remarks
Mahanadi	~~Sihawa~~ left bank : Sheonath, Hasdo, Mand Right : Tel, Jonk, Ong	Sihawa	Bay of Bengal	Chhattisgarh → Odisha		Hirakud Dam
Subarna-rekha	Kharkai, Roro, Kanchi, Harmu Nadi, Damra, Karru, Chinguru, Karakari, Gurma Garra, Singaduba, Kodia, Dulunga & Khaijuri	Ranchi Plat., Jharkhand	Bay of Bengal	JK – WB – Odisha		Boundary b/w WB-Odisha - forms estuary b/w Ganga & Mahanadi delta - Hundru falls
Brahmani				JK – Chhattisgarh & Odisha		Koel + Sankh @ Rourkela - Delta @ Dhamra with Mahanadi & Baitarani - Rengali bridge
Baitarani		Keonjhar near Mankarancho village		~~JK~~ – Odisha	Guptaganga Hills	
Godavari ~~Damodar~~ (1465 km)	~~Trimbakeshwar, Nasik~~ Left → Dharna, Penganga, Wainganga, Wardha, Pranahita, Pench, Kanhan, Sabari, Indravati Right – Pravara, Mula, Manjra, Peddavagu, Maner	Trimbakeshwar, Nashik		MH – Telangana – Chhattisgarh – AP	Satmala hills, Ajanta range, Mahadeo Hills @ north Coringa WS	Distributaries – Gautami Godavari (east) Vashishta Godavari (west) - Coringa Mangrove - Pollavaram Dam

River	Tributaries	Origin	Outlet	States	Mt./NP	Remarks
Krishna	Left: Bhima, Musi, Munneru Right: Ghatprabha, Malprabha, Tungabhadra - Koyna	Mahabaleshwar, Satara	Bay of Bengal	MH → Karnataka → Telangana → AP	Balaghat Hills & Nath - Nagarjuna Sagar Dam - Pure city Satmala Godavari	* Bhima from Matheran Hills and joins Krishna @ Raichur. * Tunga + Bhadra = TungaBhadra from Gangamula in Central Sahyadri * Musi river → Hyderabad.
Pennar	Left: Jayamangali, Kunderu Right: Chiravati, Papagani		Bay of Bengal	Karnataka – AP	Erramala Range Nallamala & Velikonda of East. ghati Seshachalam (famous for Red Sanders) & Palikonda Range	- Somasila Project.
Kaveri	Left: Harangi, Hemavati, Shimsha & Arkavati Right: Lakshmantirtha, Kabbani, Suvarnavati, Bhavani, Noyil & Amravato	Brahmagiri Hills, Kodagu district	Bay of Bengal	Karnataka – TN	- Metteur Dam - Sivasamudram waterfalls, Karnataka - Hogennekal Falls	
Ponnaiyar Hills	Right: Pambar	Nandi Hills, Chikkaballapura	Bay of Bengal	Karnataka – AP – TN		- Vattaparai Falls
Vaigai		Varusanadu Hills, Periyar Plat. of western Ghats	Bay of Bengal	TN		IUCN: endangered - no delta - Olive Ridley Turtles
Rushikulya	Baghua, Dhanei, Badanadi	Kandhamal (Dasingbadi)	Bay of Bengal @ Purana Bandha in Ganjam	Odisha		

River	Origin	Tributaries	Outlet	States	MH/NP/WS	Features
Yamuna	Yamunotri (Banderpunch Range), UK	Right → Chambal, Sindh, Betwa, Ken Left → Hindan, Rind, Sengar, Varuna	Ganga @ Prayagraj	Uttarakhand → Haryana, Delhi UP	Banderpunch Range	
Chambal	Mhow (Malwa Plat.)	Kaligandak + Trishulganga	Yamuna	MP → UP	Gandhisagar dam, Kota	Badland topography
Gandak (Int.)	Nhubine Hiral Glaciers (Nepal Himalaya)	Kaligandak + Trishulganga	Ganga @ Sonepur, Patna	Nepal → Bihar/UP → Bihar		
Ghaghra (Int.)	Mapchachungo	Tila, Seti, Beri Karnali = Kauriala + Girwa = Ghaghra Sarda (Kali Ganga) @ Chapra	Ganga @ Revelganj (Bihar)	Tibet → UP → Bihar	deep gorge @ Shisha pani	
Kosi (Int.)		Son Kosi (W) → Tamur Kosi, Arun → Sapt Kosi	Yamuna Ganga @ Kursela, Kathiwar Dist	Nepal → Bihar		Antecedent
Ramganga	Dudhatoli Range, Garhwal hills (UK)		Ganga @ Kannauj	~~Nepal~~ UK → UP	Jim Corbett	
Damodar	Latehar (JK)	Barakar, Konar, Bokaro, Haharo	Hooghly @ SW Kolkata	JK → WB		
Sarda (Int.)	Milam glacier, Nepal Him. (Gorigarga)		Ghaghra @ Chapra	Nepal → UP		
Mahana nda	Darjiling hills.		Ganga (left bank) in WB	Ch/MP → Ch → MP → UP → Bihar/JK → Bihar	Balasagar Dam near Shahdol (MP)	Hindan Rind Sengar Varuna.
Son	Amarkantak	Banas, Gopad, Rihand, Kanhar, Koel	Yamuna near Arah, Patna			

Koeppen Classification

(A) – Tropical Climate – average of coldest month ≥ 18°C

i) (Af) → Tropical Wet Climate
- 1 type of season
- Tropical evergreen
- Max. temp day – 30°C, min – 20°C

ii) (Am) → Tropical Monsoon
- Rains heavily only during high summer days.
- Deciduous forests – shed leaves during dry season
- Teak & Rosewood

iii) (Aw) → Tropical wet and dry climate
- 2 seasons: wet (in summer); Dry (winter) → longer.
- Temp. high throughout year.
- exists outer edges of (Af)
- Deciduous forest, vast grasslands, shrubs
- (*) – Savanna (no distinct rainy season) → poor laterite soil.
- Both herbivores & carnivores.

A|C|D|E – humid, B – dry
f – no dry season; s – summer dry; m – monsoon; w – winter dry
h – tropical; k – mid lat.
a, b, c, d – degree of severity of temp
B → S (steppe/semiarid); W (desert)
A definite wet & dry

(B) – Dry Climate – Evapora^n > precipita^n
→ 15 – 60° N & S
- subtropical steppe
- " desert
- Mid latitude steppe
- " desert.

i) (BSh) → subtropical savanna grassland — ~~Raj Thar desert~~
- 25 to 45° N & S
- vegeta^n that consume less water.

ii) BSk → Temperate Steppe grassland
- Pustaz – Hungary
- Prairies – N. America
- Pampas – Argentina
- Bush-veld (tropical) – N. South Afr
- High veld (temperate) S. "

- 30° to 60° N & S
- found on outer limits of mid latitude deserts
- Doon – Austral (Murray Darli basin)
- Canterbury – New Zealan
- rain shadow region
- Precipita^n 100 – 300 m in a year
- Temp – range (–40°C in winter, > 40°C in summer) (rain shadow o S. Alps)

iii) BWh → Subtropical desert

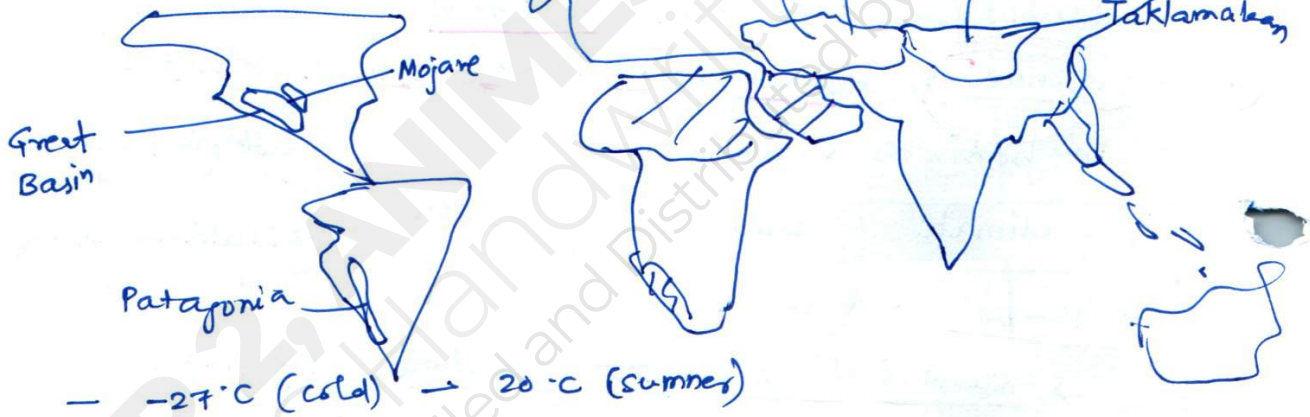
- Rainfall is short, intense leading to less moisture in soil because existence of subtropical HP belt.
- Annual precipitation 0 – 25 cm
- Temperature during daytime >= 40°C

Fog desert – Atacama desert on Pacific shores of Chile & Peru, Baja california Desert of Mexico, Namib Desert in Namibia, Arabian Peninsula coastal fog desert.

iv) BWK → Temperate desert

- found in interior of continents.

1. North (Asia) – Gobi, Taklamakan, Kazakhstan (Greater Barsuki & Aral Karakum), Uzbekistan (Kyzylkum, Ustyurt, Aralkum)
2. North (N. America) – Great Basin, Mojave
3. South – Patagonia



- –27°C (cold) → 20°C (summer)
- Humidity is low
- mines

C → Warm Temperate, avg. coldest month $-3^{\circ}C < x < 18^{\circ}C$

~~Humid~~ Sub → Eastern → under westerlies influence.

i) Cfa – No dry season, warm summers

- southernmost portions of ~~temperate~~ temperate zone.
- Maritime tropical air mases (warm currents) originate from eastern side of continents.
- Annual precipitation = 254 cm (coast) & interior 75 cm cm
- hurricane & storm
- Vegetation = evergreen trees, shrubs, bushes, palm tree & fern
- China Type climate → Temperate Monsoon (China type)
  - Natal Type – New South Wales (Aus), Natal (S. Africa), Parana – Paraguay – Uruguay basin (S. America)
  - receives rainfall from on shore Trade winds all year
- Gulf Type – south east USA, less intense monsoon
  - no complete seasonal wind reversal

Cfa, Cs, Cfb

ii) Cs – Mediterranean

- 30 - 45° C N & S (more in N)
- western coast (subtropical high during summer & westerlies wind during winter
- winter maxima | dry summer
- Vegetation – Pine & Cypress (evergreen), deciduous – Oak, grapes, figs, olives, citrus fruits
- local winds – Sirocco – dry – Sahara
  - Mistral – cold – Rhone valley

Cfb – North western (Marine west coast climate) (British type)

- influence of westerlies all round year
- temperate cyclones
- British Type Climate (winter maxima)
- four distinct seasons | summer rarely 25°C
- oak, elm, ash, birch, beech, poplar
- willows (Kashmir)
- presence of mountains block incoming humid air.

D. Cold Snow Forest ← avg. of coldest month < −3°C

i) Dfc – f-no dry season | c – cold summer

– Taiga climate (only N. hemi) / Boreal climate / Sibenian / Cool Temperate continental / continental sub-Polar

– 50° – 70° N

– Summer maxima

– Evergreen coniferous forest

– Pine, fir, spruce, larch

– poor leached soil, acidic, low humus

– lumbering

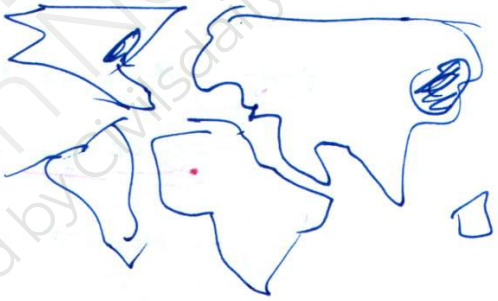
1. b –
2. b –
3. d –
4. d –
5. d –
6. c –
7. – d
8. a –
9. ~~b~~ a

ii) Dfb → Laurentian / Cool Temperate Eastern Marine

– Intermediate between British Type & Taiga

– both maritime & continental

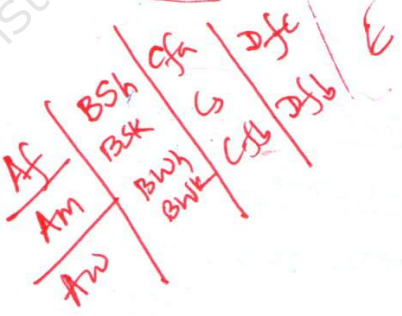
– Summer maxima



E. Cold Climate – avg. of all months < 10°C

Tundra / Polar / Arctic

– ground remains solidly frozen & is inaccessible to plants



NATURAL VEGETATION

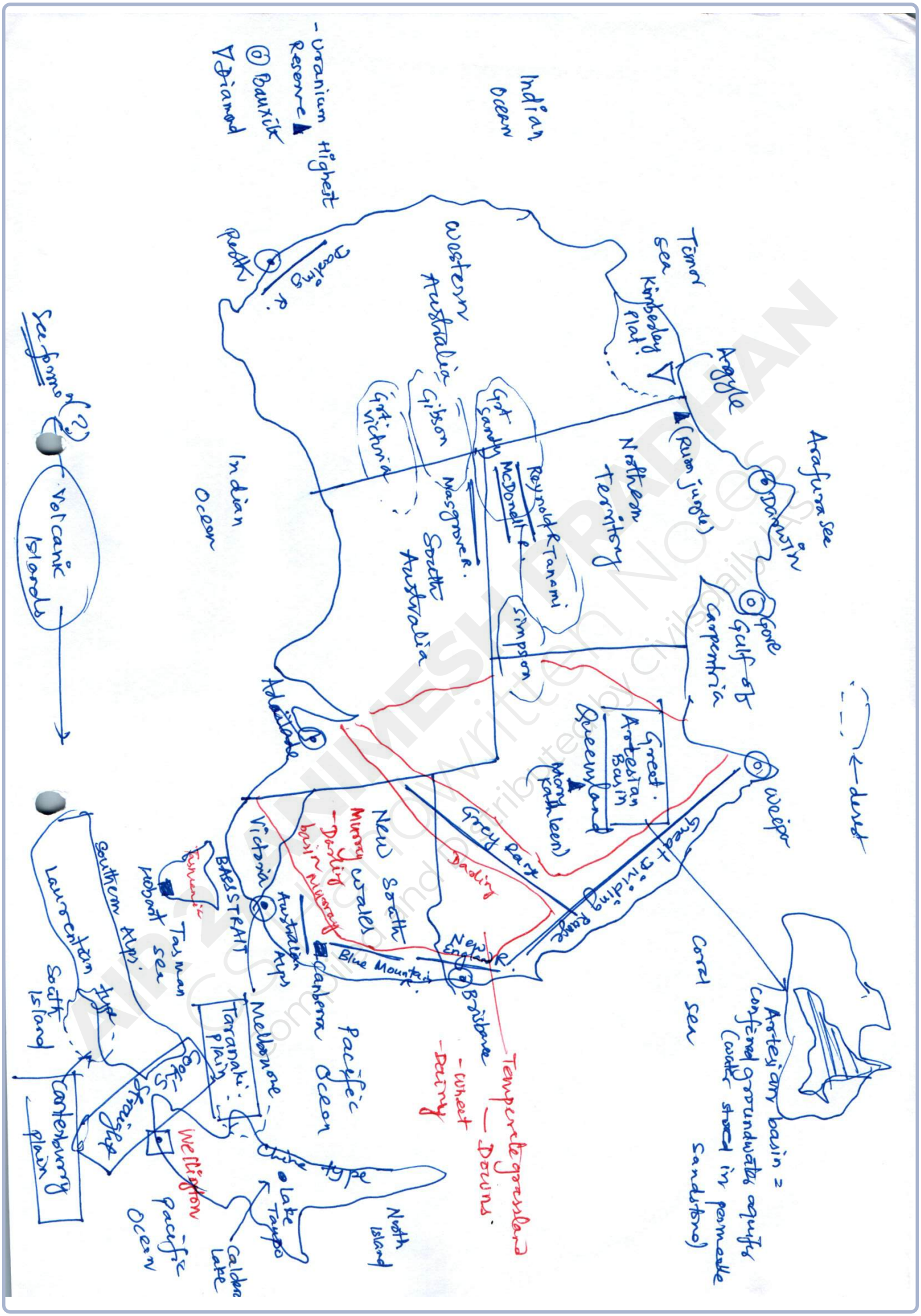
Forest	Found At	Temp/Rainfall	Trees	Features
Tropical Evergreen	Western Ghat (west slope), NE region, A&N islands	200cm/22°C	Rosewood, Mahogany, Aini, ebony etc.	
Semi-evergreen	less rainy part of above region		White cedar, hollock, Kail	
Tropical deciduous		70-200 cm		called monsoon forest
↳ (Moist)	Eastern slope of western ghat, NE state along foothills of himalayas, ODISHA	100-200cm	Teak, sal, shisham, hurra, mahua, amla, semul, kusum, Sandalwood	
↳ (Dry)	Rainier areas of the Peninsula & the plains of UP & Bihar	70-100cm	Tendu, palas, amaltas, bel, khair, axlewood etc.	
Tropical Thorn	Punjab, Haryana, Rajasthan, Guj, MP & UP	<50 cm	Babool, Ber, wild date palm, khair, neem, khejri, palas etc.	
Montane 1) (Northern mountainous)	altitude			
foot hill	1000-2000m	1500-1750	2225-3048	3000-4000
deciduous	wet temperate (oak & chestnut)	Pine, Deodar, Chinar, Walnut	Blue pine & spruce (temp. grasslands too)	Silver firs, junipers, pines, Birch & Rhododendron (Alpine) → mosses & lichens
2) Southern mountainous	western ghats, Vindhyas & Nilgris, Satpura & Maikal		Magnolia, laurel, Cinchona & wattle	Temperate forests called Sholas in Nilgiris, Anaimalai & Palani Hills

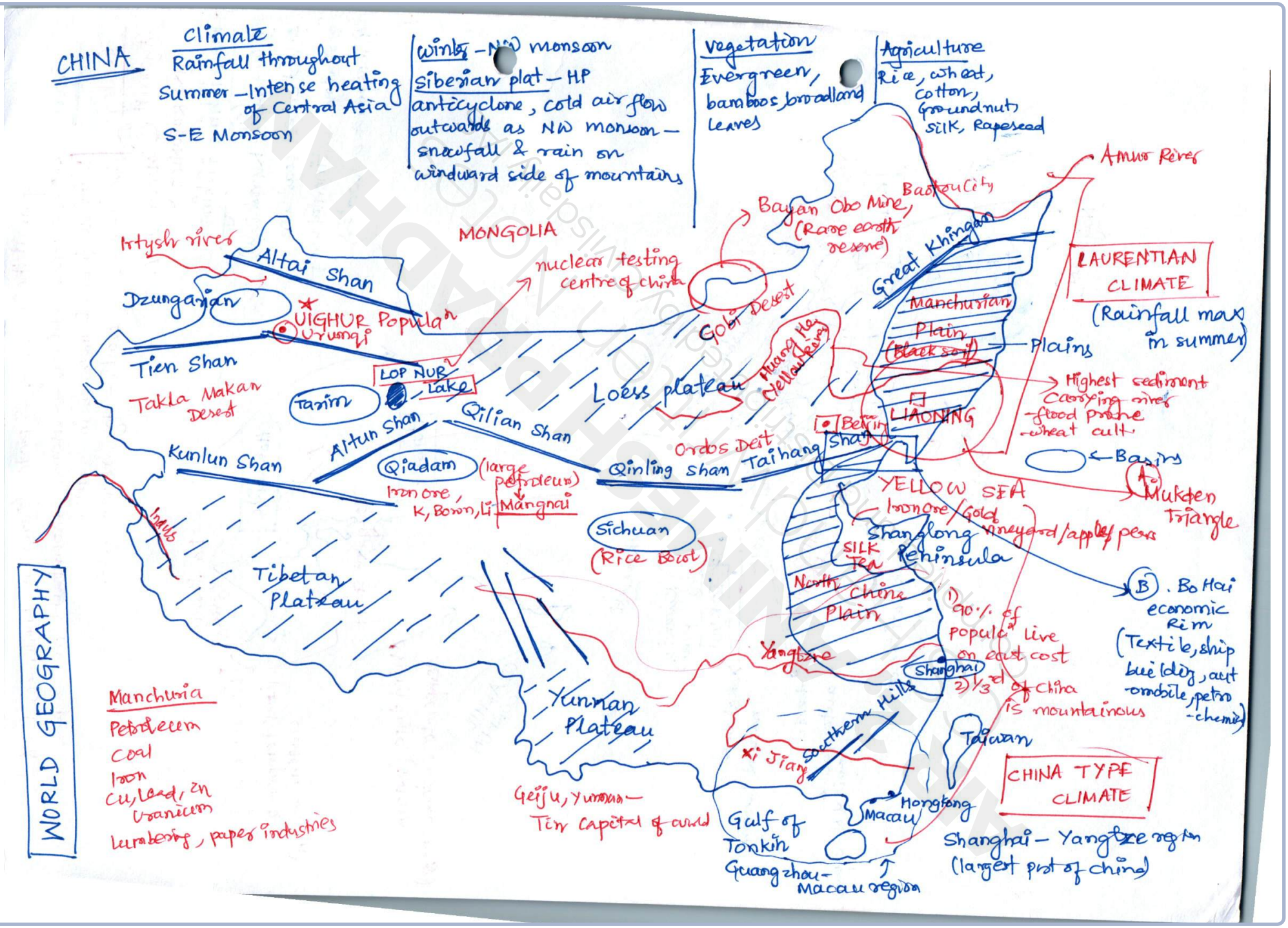
ML(a)

Magnolia
laurel
Cinchona
wattle

SOILS

Soil	Found At	Chemical compos^n	Color	Features
Alluvial	Northern plains, river valleys, deltas of the east coast (40% total land)	Rich in potash, poor in P	light grey to ash grey	Khadar (new), Bhanger (old); both contain calcareous concretions (kankar) - sand content decreases from W to E - sandy loamy to clayey.
Black Soil	Deccan plateau including MH, MP, Guj, AP, some TN)	Rich: lime, iron, magnesia, alumina Also Potash Poor: Organic matter P, N (!)	deep black to grey	- called 'Regur soil' / 'Black cotton soil' - generally clayey, deep & impermeable - self ploughing - retains moisture longer ✓
Red & Yellow (low rainfall)	Eastern & southern Deccan plateau, Odisha, Chhattisgarh & in southern parts of middle Ganga plain	Poor: Humus, N, P		- looks yellow when hydrated - fine grained: fertile, coarse grained: poor in fertility
Laterite	KA, Kerala, TN, MP, hilly areas of Odisha & Assam	Excess: Iron Oxide, Potash (*) Poor: N, P, Calcium, Organic matter		- High terap & high rainfall areas; intense leaching - used for brick - not suitable for cultivⁿ - good for cashewnut
Arid ✓	western Rajasthan	Par: Humus & Organic matter Rich: N-insufficient, P-normal	Red to Brown	- lower horizons occupied by 'kankar' layers (↑ Ca concentrⁿ), hence restricts infiltrⁿ of water ⇒ with irrigⁿ growth possible
Saline (Usara soils)	- western Guj, deltas of Eastern Coast, Sunderbans, Rann of Kuchchh	Rich: Na, K, Mg lack: N & Ca	Sandy	- Sandy to loamy - excessive irrigⁿ - add gypsum to solve salinity
Peaty	North Bihar, South Uttarakhand, coastal areas of WB, Odisha & TN	High humus & organic content	Black	- Heavy rainfall & high humidity - Heavy - at many places, alkaline also
Forest	forest areas with sufficient rainfall		~~Loam~~	loamy & silty – valley side; coarse grained – upper slopes - Snow Bound: experience denudaⁿ, poor in humus content





Japan

Geology

Japan at the junction of 3 plates (Eurasian, Phillipine, Pacific)
- Ocean-Ocean collision — volcanic mountains in Japan

Agriculture

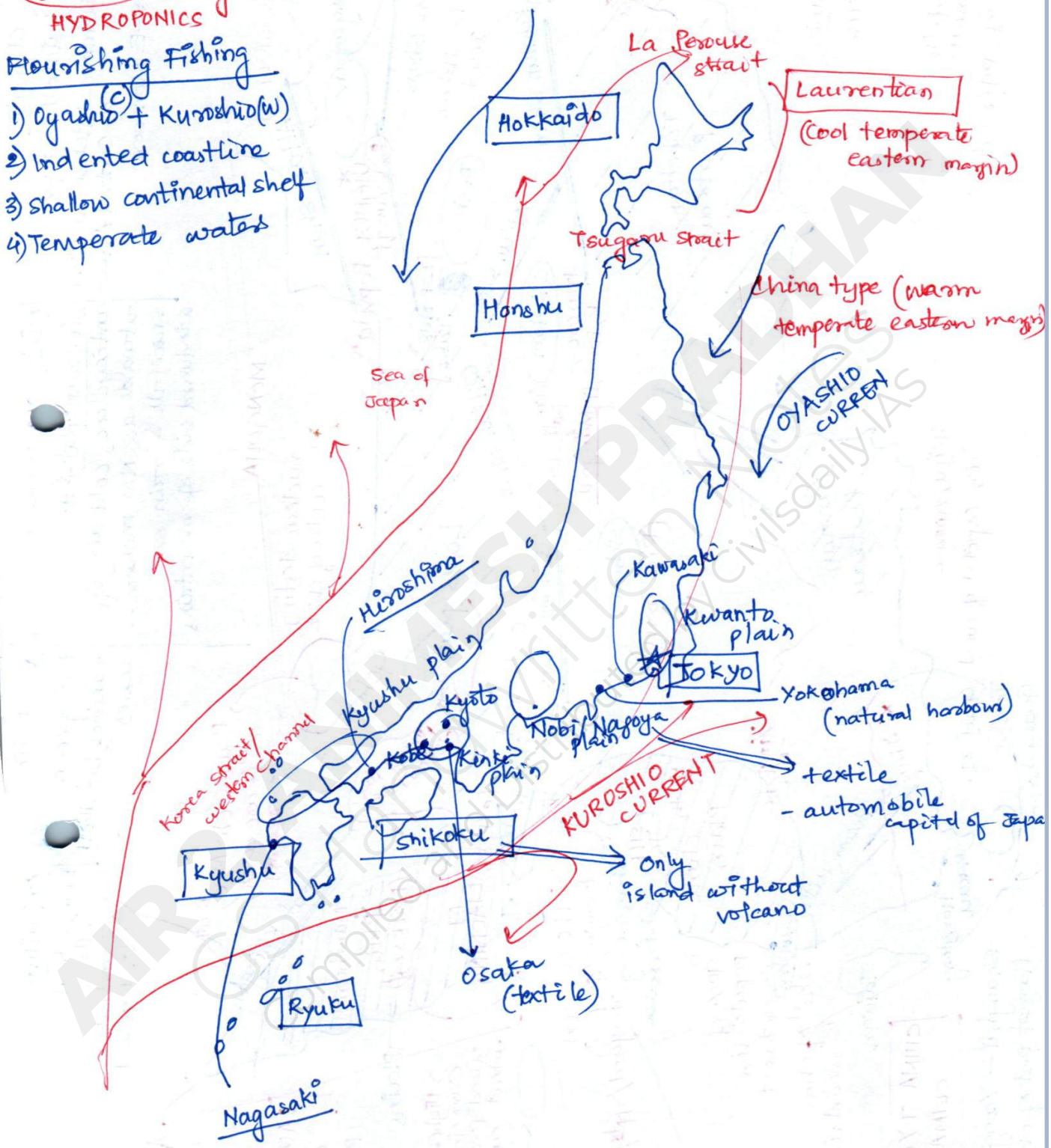
Rainfall from SE monsoon in summer
NW monsoon in winter - dry wind from Siberia

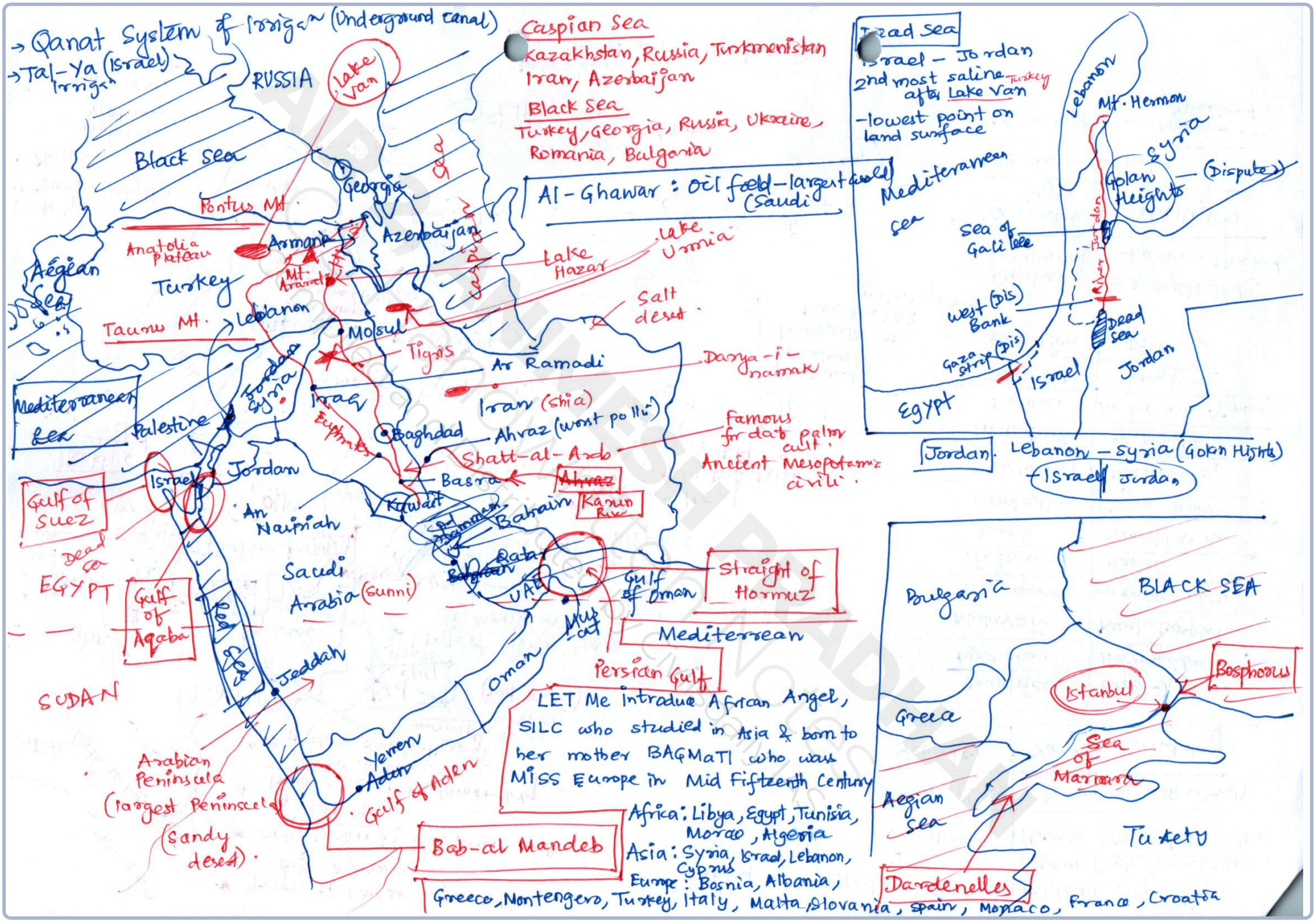
→ only 20%.

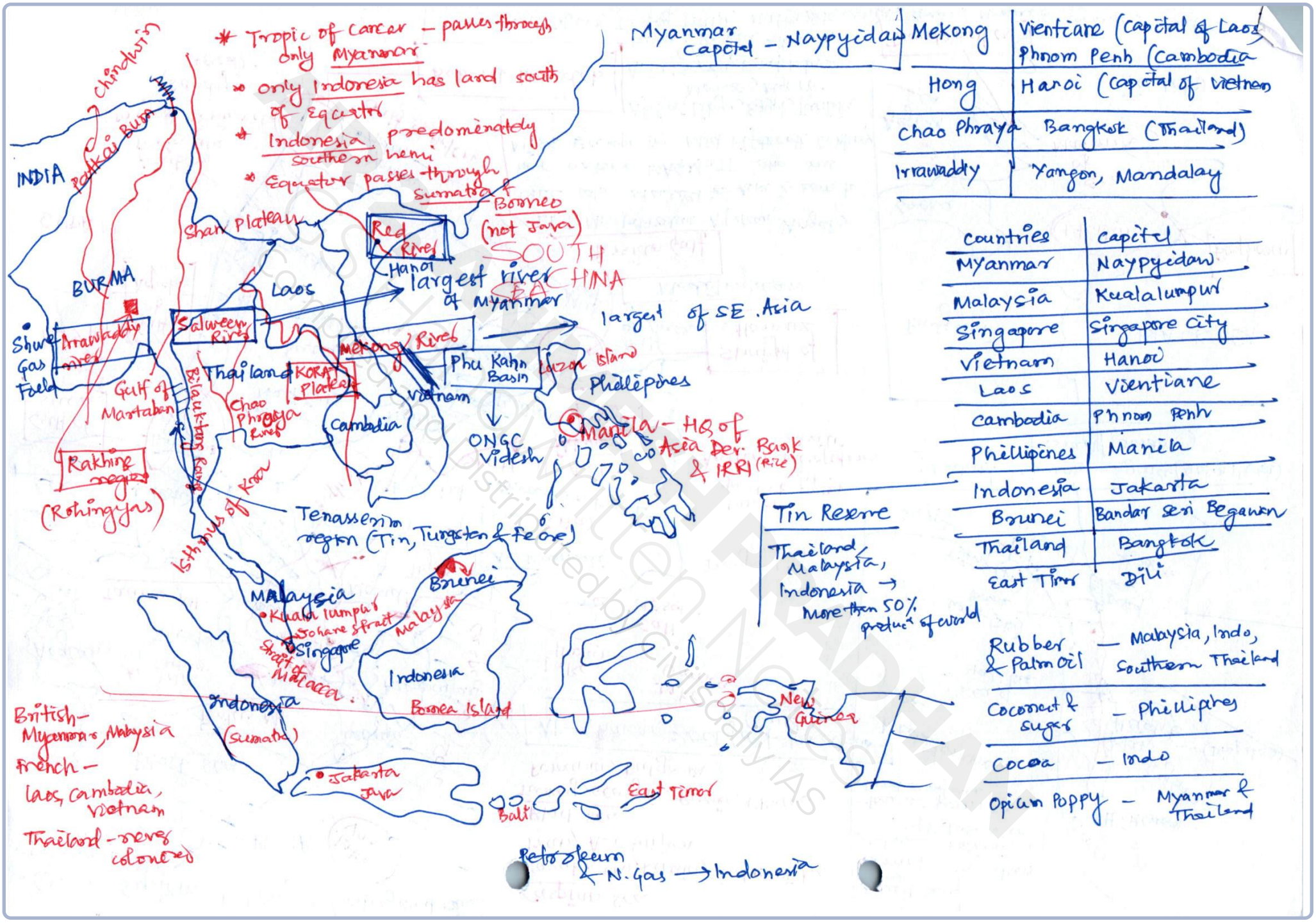
HYDROPONICS

Flourishing Fishing

1) Oyashio (C) + Kuroshio (W)
2) Indented coastline
3) Shallow continental shelf
4) Temperate waters





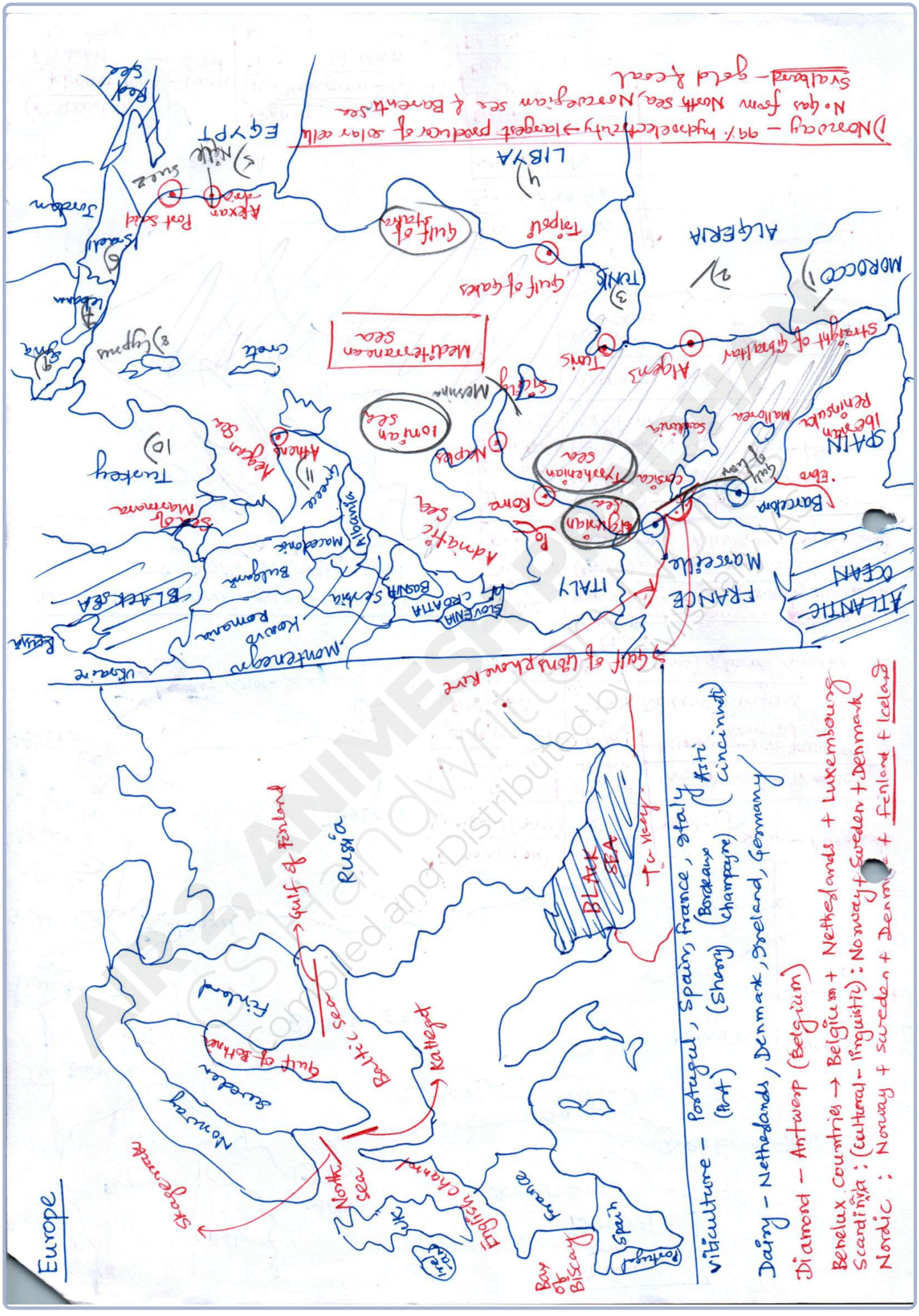


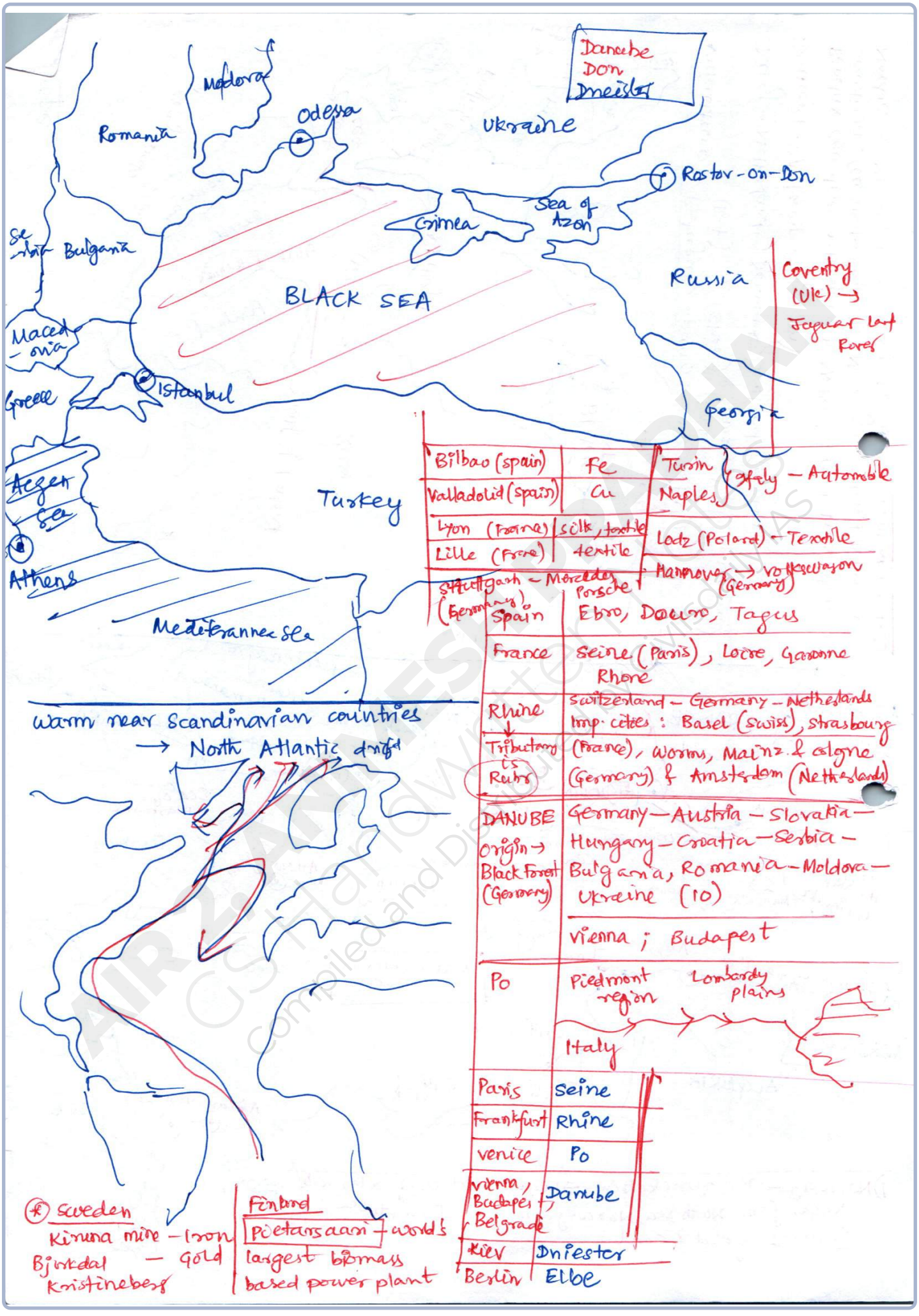
Myanmar capital – Naypyidaw	
Mekong	Vientiane (capital of Laos), Phnom Penh (Cambodia)
Hong	Hanoi (capital of Vietnam)
Chao Phraya	Bangkok (Thailand)
Irrawaddy	Yangon, Mandalay

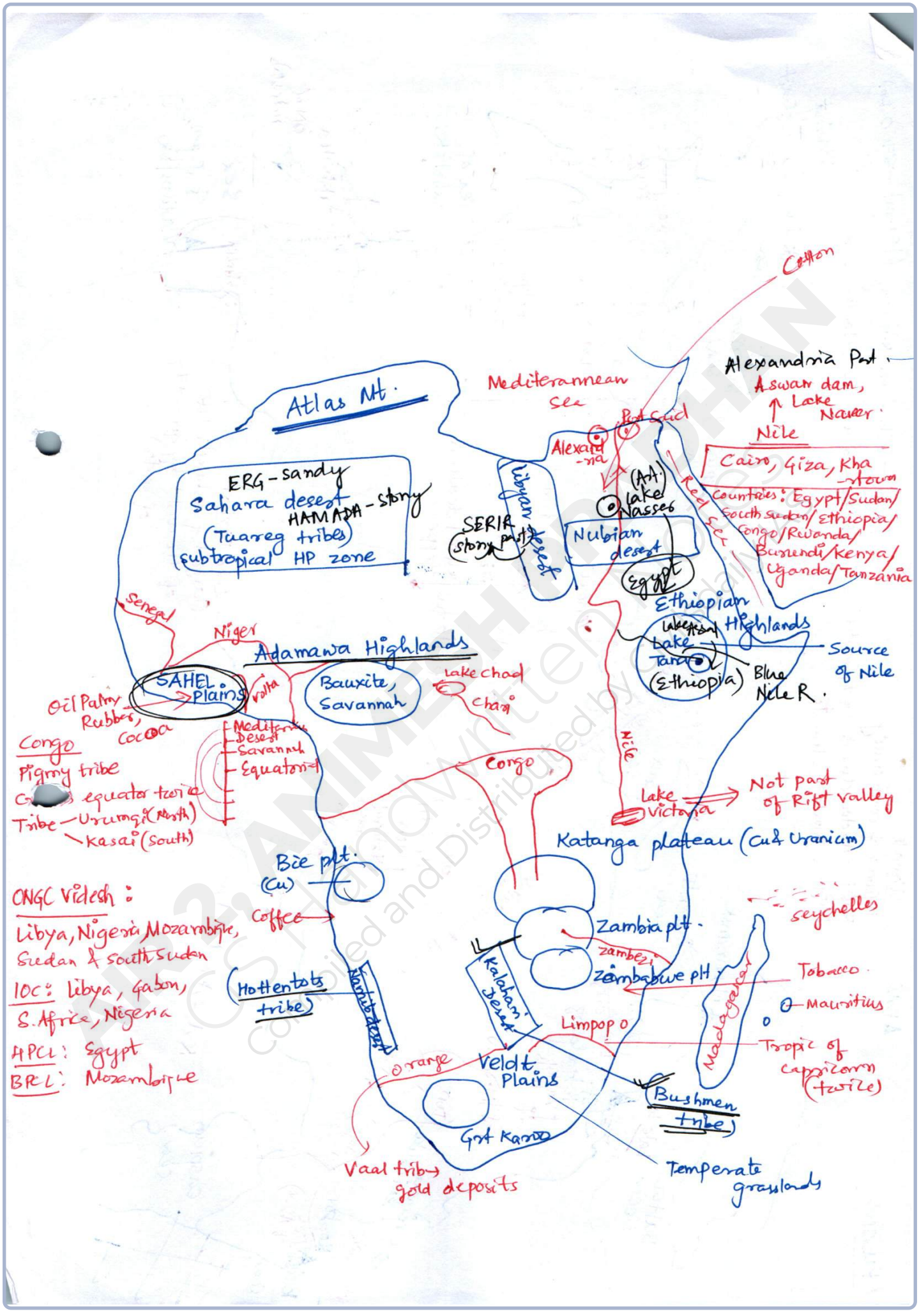
countries	capital
Myanmar	Naypyidaw
Malaysia	Kualalumpur
Singapore	Singapore city
Vietnam	Hanoi
Laos	Vientiane
cambodia	Phnom Penh
Phillipines	Manila
Indonesia	Jakarta
Brunei	Bandar seri Begawan
Thailand	Bangkok
East Timor	Dili

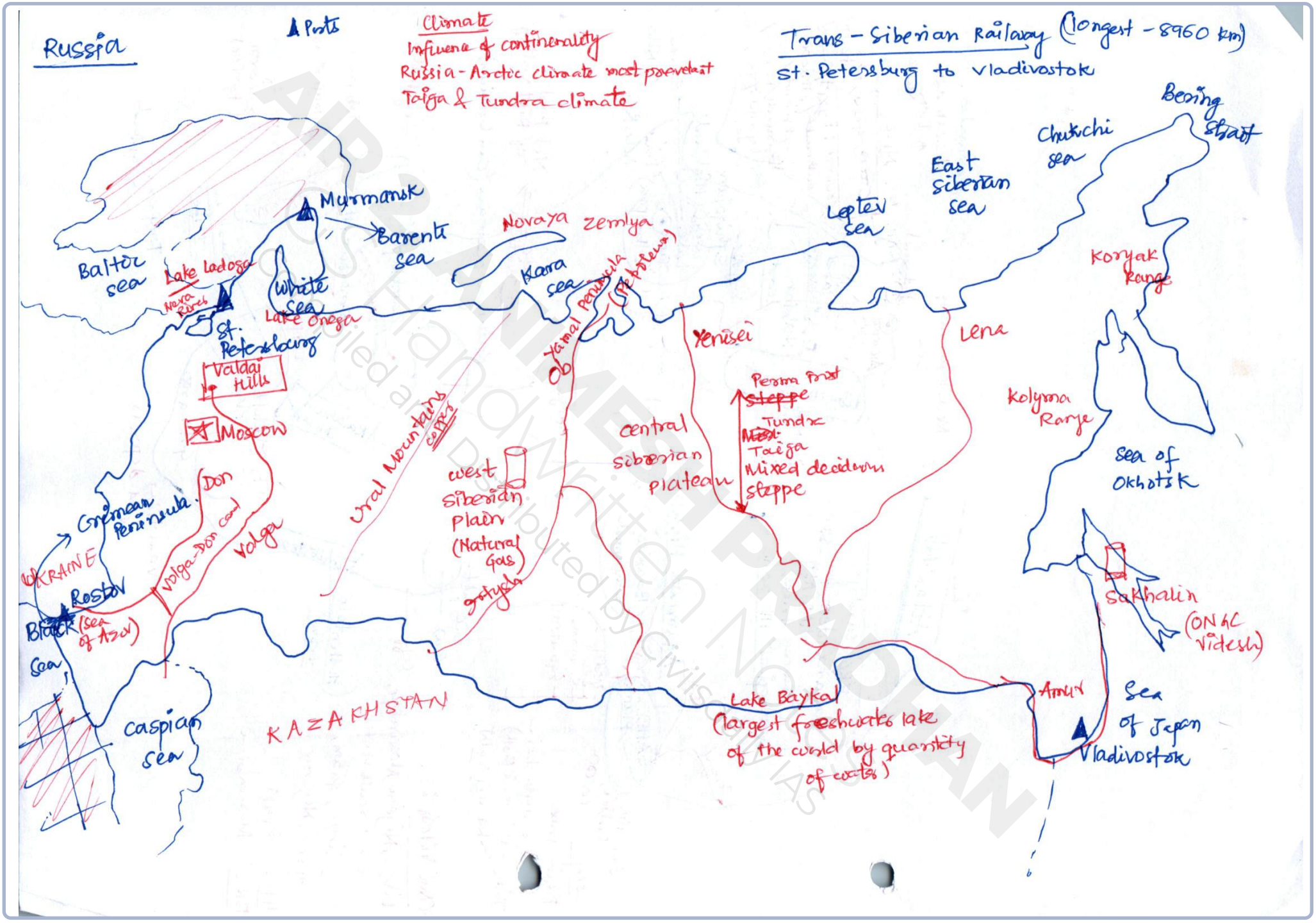
Tin Reserve
Thailand, Malaysia, Indonesia → More than 50% produce of world

Rubber & Palm Oil	– Malaysia, Indo, Southern Thailand
Coconut & sugar	– Phillipines
Cocoa	– Indo
Opium Poppy	– Myanmar & Thailand









Morocco	Casablanca – Port Marrakesh	Malawi (L)	Lilongewe (Cap.)
Algeria	Algiers – capital (Port)	Mozambique	Maputo – Cap.
Tunisia	Tunis – Capital	Zambia (L)	Lusaka (Cap.)
Libya	Al-Azizah (hottest place) Benghazi (Port) Tripoli (capital)	Zimbabwe (L)	Harare
Egypt	Cairo – Nile River → Port Alexandria (Sinai Peninsula) – Mediterranean Sea ★ Suez Canal – Red Sea ↳ Port Said	Botswana	Gaborone
		South Africa – Pretoria (Cap.) — Johannesburg (Gold) — Kimberley (diamond) Ports – Cape Town, East London, Port Elizabeth, Durban	
Sudan	Khartoum – capital	Namibia	Windhoek (Cap)
Eritrea	Asmara – capital Massawa → Port	Angola	Luanda
Somalia	Berbera / Mogadishu (capital) → Port ↓ Port	DR Congo (not L)	Kinshasha
		Congo	Brazzaville
South Sudan (L)	Juba (Capital)	Lesotho (L) Swaziland	Maseru
Ethiopia (L)	Sudan / Eritrea / Djibouti / Somalia / Kenya S. Sudan — Ethiopia ADDIS ABABA		
		Cameroon → Yaounde	
Kenya	Nairobi Mombasa – Port	Nigere → Niamey Nigeria → Abuja (Port Lagos, Port Harcourt)	
Burundi (L) Rwanda (L) Uganda (L)	Kigali Kampala	Mali — Bamako Niger River G T B (Ghana) (Togo) (Benin)	
Tanzania	Dodoma – capital Dar es Salaam – PORT Pemba, Zanzibar } Island ⇒ clove	Accra	
		HORN – SEED – Somalia, Ethiopia, Eritrea, Djibouti	

Lakes

1) Nasser (Artificial) – Egypt → Nile
2) Tana – Ethiopia – Blue Nile
3) Assal – Ethiopia
4) Turkana – Kenya (Rift valley lake)
5) Albert, Edward – Uganda – DRC
6) Victoria (largest - Africa) UKT → Tanzania, Uganda, Kenya
   - not Rift Valley
   - equator passes
   - White Nile
7) Tanganyika (longest lake - Africa) DRC – Tanzania
8) Malawi lake (Nyasa)
9) Lake Kariba (Zambia & Zimbabwe)
10) Volta – Ghana
11) Chad – Chad, Niger, Nigeria, Cameroon

Rift valley
Turkana
Albert
Edward
Tanganayika
Malawi

Great lakes – N. America

Name	Separates	Connects
1) Gibraltor	Europe (Spain) – Africa (Morocco)	Mediterranean – Atlantic Ocean (Alboran Sea)
2) Bab-el-Mandeb	Djibouti – Yemen	Red Sea – Gulf of Aden
3) Dover	North Sea – Celtic Sea (Atlantic)	UK – France
4) Bonifasio	Mediterranean – Tyrrhenian	Corsica (France) – Sardinia (Italy)
5) Messina		Sicily – Italy
Otranto →	Adriatic – Ion (Italy – Albania/Greece)	
4) Dardanelles	Aegean Sea – Sea of Marmara	Turkey (Asia – Europe)
5) Bosphorous	Sea of Marmara – Black Sea	
6) Nares	Ellesmeral (Canada) – Greenland (Denmark)	Arctic Ocean – Baffin Bay
7) Davis	Baffin (Canada) – Greenland (Denmark)	Baffin Bay – Labrador Sea
8) Hudson	Baffin (Canada) – Ungava Peninsula (Canada)	Hudson Bay – Baffin Bay
9) Florida Strait	Florida – Cuba	Gulf of Mexico – Atlantic Ocean (Sargasso)
10) Juan de Fuca	Canada – USA	Pacific
11) Torres	Cape York Peninsula (Australia) – Papua New Guinea (Asia)	Arafura sea – Coral sea
12) Bass	Tasmania – Australia	Southern ocean – Tasman sea (Pacific)
13) Bering	Russia (Asia) – Alaska (US)	Arctic Ocean / Pacific Ocean
14) Tastary	Russia – Sakhalin Islands	Sea of Okhotsk
15) Le Perouse (Soya)	Sakhalin (Russia) – Hokkaido (Japan)	East Sea (Sea of Japan)
		Sea of Japan – Sea of Okhotsk

Name	Separate	connect
16) Korean strait	South Korea – Kyushu (Japan) = Tsushima Basin	East sea (sea of Japan) – East China Sea.
17) Formosa	Taiwan – china	East China sea – South China sea
18) Luzon	Phillipines – Taiwan	South China – Pacific Ocean
19) Makassar	Boneo – celebes	Celebes sea – Java Sea
20) Sunda	Sumatra – Java	Indian Ocean – Pacific Ocean
21) Malacca	Sumatra – Malaysia	Indian Ocean – Java sea
22) Johar	Malaysia – Singapore	–
23) Palk	India – Srilanka	–
24) Strait of Hormuz	Iran – Oman	Persian Gulf – Gulf of Oman
25) Baba-el-Mandeb	Djibouti (Africa) – Yemen (Asia)	Red Sea – Gulf of Aden
26) Magellan		

Lakes

exorheic lake – ~~one~~ atleast one natural outflow

endorheic lake – no

(1) Freshwater lake – fed by rivers
Ex Great Lakes of N. America
Ex. Baikal, Tanganyika

(2) saline lake – no natural outlet
– intense evaporn
Ex Dead Sea, Great Salt Lake, Utah (USA)
Aral Sea (Kazakhstan) (Playas too)

(3) Tectonic lake due to depressions created by warping, subsidence, bending, fracturing
Ex Lake Titicaca & the Caspian Sea

(4) Rift valley lakes
sunken land b/w 2 parallel faults or when 2 blocks diverge
Ex In East African Rift Valley: Lakes Tanganyika, Malawi, Rudolf, Edward, Albert

(5) cirque lakes (tarns)

(6) Rock hollow lakes – glacial lake
formed by ice – scouring (eroding) when ice sheets scoop out (dig) hollows on the surface.
Ex In Finland (land of lakes)

(7) Volcanic lakes
i) Crater & caldera lake
Ex Lake Toba (Indonesia)
Lonar in Maharashtra

(8) Karst lakes
due to solvent ac^{n} of rainwater on limestone.

(9) Wind deflated lakes
wind creates hollows that reach groundwater which seeps.
Ex Great Basin of Utah, USA

(10) Oxbow lake – in flood plains of lower Mississippi, lower Ganges etc.

(11) due to Marine deposits (lagoons)
Ex Chilika

(12) due to damming of water (barrier lakes) → landslides, avalanches block valleys so that rivers are dammed.
Ex In shiwaliks, Dehradun

(13) Man made lakes
Ex Lake Mead above Hoover Dam on Colorado River, USA.
– Also mining activities (tin mining in West Malaysia) → lakes

largest lake (surface area)

Aus – Eyre
Africa – Victoria
Antarctica – Vostok
Asia – Baikal
Europe – Ladoga
N. America – Superior
S. America – Titicaca

Overall Caspian Sea → salive

Deepest – Baikal

largest freshwater – Superior.

N. Gas — Reserve: Russia; Export: Produce: USA; Consume:

Russia	West siberia, Gulf of ob largest world – Urengoy Volga-Urals
N. America	Hugoton (USA); Gulf of Mexico; Alberta (Canada)
Europe	Dutch coast & North sea
Africa	Algeria & Niger Delta
Middle East	Arabian-Iranian peninsula
Asia	North Sumatra of Indonesia
India	KG Basin, Gulf Khambat, Barmer, Cudd-alore dist of TN

Oil + Gas → Associated/wet gas
only gas → Non-Assoc / Dry gas
H_2S in gas → Sour gas
coalbed methane → Sweet gas (no H_2S)

Coalbed methan → Jharkhand

Shale Gas — lot of methane + little ethane, propane, butan + CO_2 + N + H_2S
↓ Chira (reserve highest)
by Hydro-fracturing / Fracking
– India has water scarcity
– Environmental concern
– groundwater
– no clarity on reserves
– eastern India lack pipeling

Cambay	
Ganga valley	
Assam & Assam-Arakan	
KG onland	
Cauvery	
Raj & Vindhya Basin	

Tight Gas — same as shale but tight
shale rocks ← sandstone/limestone
In KG-PG, Cauvery & cambay basins

Bauxite – Laterite soil – Al_2O_3

Reserve	Produc^n
1) Odisha (51%)	1) Odisha (52%)
2) AP (16%)	2) Jharkhand (14%)

Odisha	Koraput, Kalahandi, Rayagada
Chr.	Maikala, Durg, Amarkantak
MH	Kolhapur
Jharkhand	Ranchi, Lohardaga, Palamu, Gumla
Guj.	Gulf of Kach – Jam/Bhavnagar
MP	Maikala range – Shandol, Mandla
TN	Nilgiri, Salem

World – Bauxite

Reserve	Produc^n
1) Guinea	1) Australia
2) Australia	2) China

Lead → batteries; non corrosive material (casing); paint, ammuni; brass, bronze; aeroplane, wire, automobile.
plumbing material
→ blue grey → ductile
→ low MP → malleable
→ GALENA (PbS)
→ lead conductor

Zinc – Sphalerite (ZnS)
– corrosion free (galvanize steel)
– Bronze & Brass
– Rubber, chemical, agri, paint

Rajasthan – Zn & Pb (89%) → Bhilwara, Ajmer

World – Zn & Pb

Reserve	Produc^n
1) Australia 2) China	1) China 2) Pb-Aus, Zn-Peru

Pyrites – FeS_2 – fertilizer, textile, battery
– Sulphuric acid
– explosives
– insecticides
– vulcanized of rubber

Native Sulphur deposits → Puga valley

Reserves – Bihar (94%), Raj (5%)

We Import – UAE, Qatar, S. Arab

Gold — Interms of metal content: 1) Karnataka, 2) Raj
Gold ore – Bihar (44%) → 99% Produc^n

KA → Kolar, Dharwad, Raichur (Hatti), Hassan

Jharkhand – Subarnarekha, Sonanadi (Singhbhum)

Reserve	Produc^n
1) Australia (9.8%)	1) China (13%)
2) S. Africa (6%)	2) Australia (9%)

Silver
– highest elect./thermal conduct.
– electroplating
– Cl & Iodide → photographic what.
– Solar cells (paste form)

Rajasthan (87%) Reserve (cating) Jharkhand (5%)
Native → Bharrak deposit Raj.

We Import – Hongkong, UK, Russia, China.

Reserve	Produc^n
1) Peru	1) Mexico
2) Poland	2) Peru

Manganese
1) Stephanite
2) Pyrargyrite
3) Proustite

Manganese
1) Pyrolusite 2) psilomelane
3) Manganite 4) Braunite
★ Iron ore ★ Aluminium cans
★ Ferromagnet

Reserve	Produc^n
1) Odisha	1) MP

Reserve	Produc^n
1) S. Africa	1) S. Africa

We Import – S. Africa, Australia, Gabon

★ Gondite deposit –
MP (Balaghat, Chindwara)
MH (Bhandara, Nagpur)
Odisha (Sundergarh)
★ Kondurite & Khondolite –
Odisha (Koraput)
AP (Srikakulam)

Australia – Kalgoorlie, Boddington mine
Uzbekistan – Murruntau
Indonesia – Grasberg
S. Africa – Mponeng

Magnetite (Fe_3O_4) (black) 72% → Dharwad & Cuddapah systems (KA)
Haematite (Fe_2O_3) 25-30% < 40% → No S/P
Siderite ($FeCO_3$) → Reddish → taconite (60-70%)
Limonite → yellowish (40-60%) → abundant

Distribution

Africa	Transval, Liberia (South Africa)
China	Manchuria region, Shandong Peninsula, sinkiang, sikiang
Europe	Krivoy Rog (Ukraine), Ruhr, Southwales, Lorraine, Bilbao
Russia	Ural, Magnetogosk (~~UK~~ Kazakhstan)
N. America	Great lakes (Mesabi Region), Labrador
S. America	Carajas Mines (largest Feore mine), Itabira, Minas Gerais (Brazil)
Australia	Pilbara region, Iron Duke, Iron Knob

Largest Producers → Australia ~~or China~~ (?)
Reserves

Haematite	Magnetite
Odisha (33%)	Karnataka (73%)
Jharkhand (26%)	AP (14%)
Singhbhum (Jh)	Chikmagalur - Kudremukh (Bababudan hills) in KA
Keonjhar (Odisha)	Salem
Bellary Hospet (KA)	N. Arcot
Bastar (Ch) → Barabil - Koira valley	
→ Bailadila mine (mechanized)	
Nagamundi	

Coal – carboniferous (350 M. yrs ago) → India → Gondwana (250 Myo)
Peat (40-55% C)
lignite (" - brown coal)
Bituminous (40-80%) → aberdant
Anthracite (80-95%) → J&K

Jharkhand	90% coking coal | Jharia, Bokaro, Giridih (Karharbari)
odisha	Sambalpur, Anjul
Chattisgarh	Korba (River Hasdo)
WB	1st coal mine – 1774 (Raniganj)
MP	Singrauli, Jhingurda, Pench - Kanhen
AP	Singareni
TN	80% of lignite

Coal – World Great lakes – Appalachians region

USA	North Antelope Rochelle coal mine in Wyoming's Powder River Basin – largest
Russia	Donbass & Ural
~~Europe~~ Germany	Ruhr & Rhineland; southwales, yorkshire
Largest Producer & consumer	→ CHINA
Reserve	→ USA (22%)

On shore Oil

Assam	Digboi, Naharkatia, Moran - Hugrijan
Gujarat	Ankleshwar, Khambat
Raj.	Barmer → (largest reserve inland)

Off shore

Wester coast	Mumbai - High / Bassein / Aliabet
East.	Rawafeeld (Krishna - Godavari)

1st Pipeline – Naharkatia - Nunmati - Barauni
World's largest undersea – (HBJ) Hajira - Bijapur - Jagdishpur
Longest LPG – Jamnagar - Loni
Oil Top – Producer, consumer } USA
Reserve – Venezuela (19%)
Export – Saudi Arabia (16%)

OPEC (14)
Founding – 5 – Iran, Iraq, Kuwait, Saudi, Venezuela (VIIKS)

Algeria	Nigeria
Angola	Congo
Ecuador	UAE
Equatorial Guinea	
Gabon	
Libya	

* Indonesia & Qatar former

Tertiary coal

MH	Kamptee, wardha } Nagpur
TN	Neyveli, S. Arcot
Raj.	Palana, Khari
Assam	Makum coalfield, Namchik - Namrup

Reserves	Producer
1) Jharkhand (40%)	1) Odisha
2) Odisha (25%)	2) Chattisgarh
3) Ch.	3) Jharkhand

Tungsten — wolframite, Scheelite — Highest MP/BP, High density, elastic/tensile/ductile
1) Steel making 2) Corrosion resistant alloys
3) Tungsten carbide – metal working
4) Military 5) Superalloys for turbine blades
6) X-ray, incandescent bulbs, radiation shields, arc welding, super alloy

Reserve	Production
China	China

Reserve: Karnataka (42%), Raj (27%)
Import – China, Austria, Korea

Copper — Fe+Ni+Cu+Chromite+... → Stainless steel; Cu+Zn → Brass; Cu+Ni → Monel Metal; Cu+Tin → Bronze; Cu+Al → Duralumin

Reserve	Production
1) Raj (54%)	1) MP
2) Jharkhand	2) Raj

Reserve	Production
1) Chile	1) Chile
2) Australia	2) Peru (Ag ↑)

Nickel — alloys; Armoured plates; Bullet jackets; Rupee coins (Ni + Cu/Ag)
Ni-Al : Aeroplanes & Internal combustion engines
Ni – Batteries & catalyst for hydrogenation

Odisha	Oxide	Sukinda valley
Jharkhand	Sulphide	East Singhbhum
Jharkhand	Uranium	Jaduguda

Odisha (93%)

Production	Reserve
1) Indonesia	1) Indonesia

We Import → 1) Guinea 2) Australia

Molybdenum — green technology – electrical & electronic; alloying material
Tamil Nadu – Highest; China – Reserve, Production, ~~Molybdenite~~

Chromite — Iron Chromium oxide
– Stainless steel / Anti-corrosion alloy
96% → Odisha (Jajpur, Kendujhar, Dhenkanal)
Import → South Africa (99%)

Reserve	Production
1) Kazakhstan	1) S. Africa

Cobalt — Super alloy; ferromagnetic; cutting tools; cathodes in rechargeable batteries
Reserve → Odisha (69%) → Kendujhar | Jajpur
Imports → USA & Canada (13%), Belgium (12%)
(*) Essential for electric mobility

Reserve	Production
Congo	Congo

Lithium — Aircraft, battery; Low MP, High BP

Reserve	Production
1) Chile	1) Australia

KABIL – Khanij Bidesh India Ltd.

Graphite — Blacklead; most stable form of C; resistant to heat, unreactive
1) Refractories 2) Batteries (anode) 3) Brake 4) Steel making 5) Lubricants 6) Pencil lead
Jharkhand (52%) → Palamu dist.

Reserve	Production
1) Turkey	1) China (80%)

We import → China

Diamond — MP. Panna belt → Reserve + Production
Russia
Botswana – largest by value

Limestone — flux making – cement; tile – pulverised $CaCO_3$ – neutralise acidic soil
– suppress CH_4 explosion in UG mines
– fuel gas desulphurisation reagent – airpol control

Reserve	Production
1) Karnataka	1) Rajasthan

Dolomite — limestone > 10% of Mg
Reserve → MP Production → Odisha

Magnesite ($MgCO_3$) – Refractory bricks – tiles, cement
Reserve → Uttarakhand (59%); Chalk Hills (Salem)
Prod → TN

Mica — AP → Production + Reserve. We mainly EXPORT
– good insulator; electrical/electronics; fuse

Asbestos — Chrysotile (serpentine) ✓, Amphibole

Rajasthan	Russia

Kyanite – stand high temp.
– sparkling plugs in automobile
India – largest deposit
Jharkhand → Singhbhum

Sillimanite – Odisha (Ganjam)

Gypsum – Hydrated sulphate of Ca
– Ammonia sulphate fertilizer
– cement industry
– agriculture
– Rajasthan (99%)

Uranium U-92

Isotopes → U-238 U-235

Reserves	Produ^n → Chu-Sarysu Basin
1) Australia	1) Kazakhstan (chromite ores)

Kerala - Monazite
Jhar. - Jadugeda
Bihar - Gaya
AP - Cuddapah
Meghalaya - Mahadek

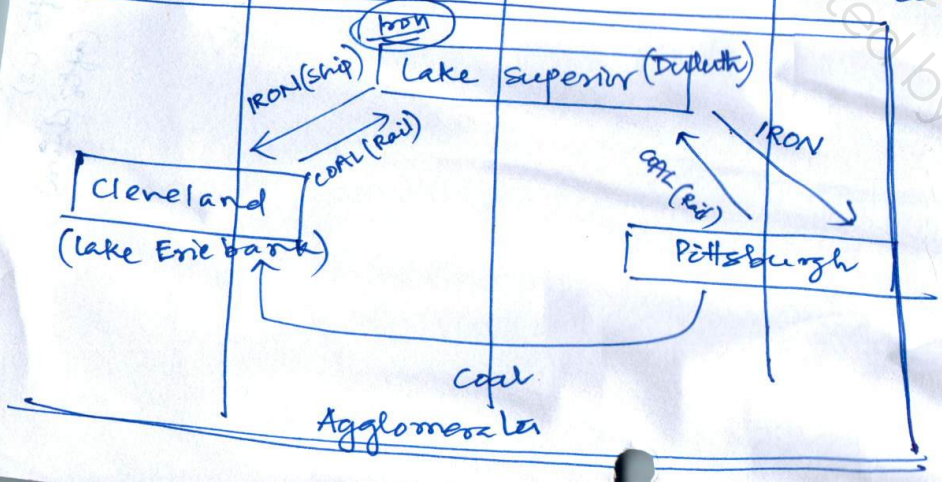
AP - largest produ

Thorium Th-90 Th-235 — most stable

Monazite sand - Kerala.

Reserve
1) India — AP ✓ (reserve)

Steel Plant	Iron Ore	Coke/coal	Water	Transport	Other raw mat.	features
TISCO	Noamundi & Badampahar	Coal – Jodа mines coke – Jharia & west Bokaro	Subarnarekha Kharkai	Mumbai – Kolkata (Rail) Kolkata – Port	limestone – Bimlitrapur	
IISCO	Singhbhum	Damodar valley coal fields (Jharia, Raniganj & Ramgarh)	Barakar River (tributary of Damodar)	Kolkata – Asansol (Rail)	11	1st factory – Hirapur (MP); Kulti & Burnpur (WB)
Visvesvaraiya Iron & Steel works	Kemmangundi in Bababudan hills	–	Bhadravathi			Jog Falls (Sharavati) hydel power - 3rd largest integrata steel plant - Initially called Mysore Iron & Steel Works
Rourkela Steel Plant	Sundargarh & Keonjhar	Jharia Power → Hirakud	Koel & Sankh		Bimlitrapur – $CaCO_3$	Germany collab -1973 (Sail set up) | 2nd 5 year plan (1956-61)
Bhilai Steel plant (in Durg dist.)	Dalli – Rajhara	Korba & Kargali Power – Korba Thermal	Tanduladam	Kolkata – Mumbai (Rail)		Russian collab - caters to Hindustan shipyard, Vishakhapatnam
Durgapur steel plant	Noamundi	Raniganj & Jharia	Damodar valley Corp.	Kolkata – Delhi		UK collab



(*) National Steel Policy (2017) Target – 300 million tonnes ... 2030-31

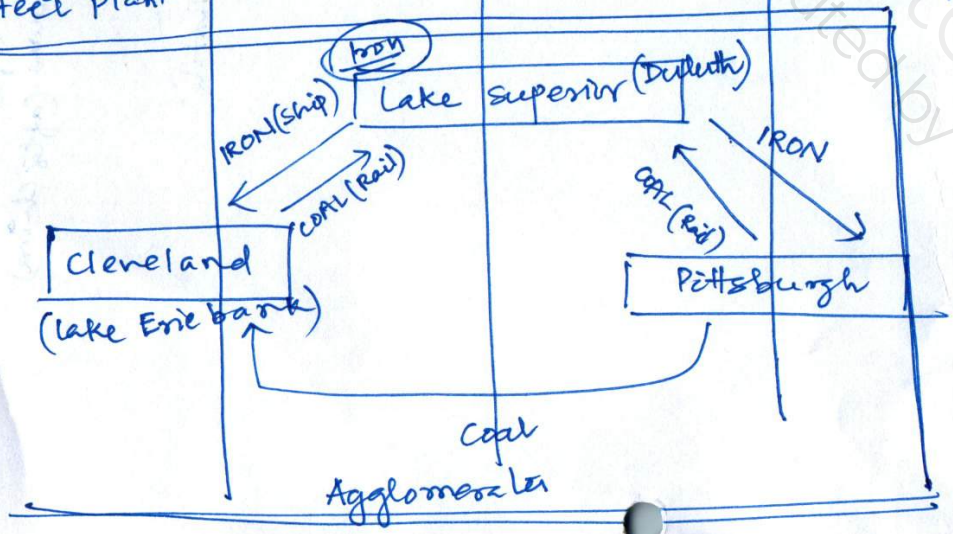
Cotton
Largest – India – 2nd export (after US)
2nd – China – 2nd consume (after China)

Top Importer – China ←
Top exporter of Apparel & Textile

- Raw Materials
- Power
- Labour
- Climate
- Transport
- Market
- Govt. Policy
- Allied Industry
- Water
- Technology – Spinning Jenny, Cotton Gin, Steam Engine, Flying shuttle.
- Capital
- Early start*
- Historical Aspect

Steel Plant	Iron Ore	Coke/coal	Water	Transport	Other raw mat.	features
TISCO	Noamundi & Badampahar	Coal - Jodа mines Coke - Jharia & west Bokaro	Subarnarekha Kharkai	Mumbai - Kolkata (Rail) Kolkata - Port	Limestone - Bimitrapur	
IISCO	Singhbhum	Damodar valley coal fields (Jharia, Raniganj & Ramgarh)	Barakar River (tributary of Damodar)	Kolkata - Asansol (Rail)	11	1st factory - Hirapur (MP); Kulti & Burnpur (WB)
Visvesvaraiya Iron & Steel works	Kemangundi in Bababudan hills	–	Bhadravathi			Jog Falls (Sharavati) hydel power - 3rd largest integrated steel plant - Initially called Mysore Iron & Steel Works
Rourkela Steel Plant	Sundargarh & Keonjhar	Jharia Power → Hirakud	Koel & Sankh		Bimitrapur - $CaCO_3$	Germany collab - 1973 (Sail set up) | 2nd 5 yr plan (1956-61)
Bhilai Steel plant (in Durg dist.)	Dalli - Rajhara	Korba & Korjali Power - Korba Thermal	Tandula dam	Kolkata - Mumbai (Rail)		Russian collab - caters to Hindustan Shipyard, Vishakhapatnam
Durgapur steel Plant	Noamundi	Raniganj & Jharia	Damodar valley Corp.	Kolkata - Delhi		UK collab

(*) National Steel Policy (2017) ⇒ Target of 300 million tonnes of product capacity by 2030-31



Cotton

Largest - India - 2nd export (after US)
2nd - China - 2nd consume (after China)

Top Importer - China ←
Top exporter of Apparel & Textile

- Raw Materials
- Power
- Labour
- Climate
- Transport
- Market
- Govt. Policy
- Allied Industry
- Water
- Technology — Spinning Jenny, Cotton Gin, Steam Engine, Flying shuttle.
- Capital
- Early start*
- Historical Aspect

Handwritten Notes.
Exclusive collection.