India

A sustainable agricultural practice

However, there are regions all over the world where abstraction of groundwater does not require a pump. Once the drilling of bore-hole to the specific aquifer (essentially artesian[2]) is completed, the pressure within the aquifer forces the groundwater to rise above the ground surface naturally without using a pump. These types of wells are known as flowing artesian wells. Flowing wells are an uncommon manifestation of geological activities (Swamee et al: 2000). Expansion of water due to release of pressure and compression of aquifer formation material are responsible for the water flow from such wells (Jacob: 1940). In Uttarakhand, such type of wells - of width up to 25 km and having a general slope less than 1%, is restricted only to the *Tarai* zone. .

The formation of the *Tarai* region is dependent on the evenly sorted finer material that was washed away by the streams from the hilly tracts. The northern limit of the *Tarai* belt is in contact with the *Bhabar* zone which is bound by the lower*Shiwalik* range of Himalayas in the north.

The *Bhabar* zone can also be referred as piedmont alluvial terrain that comprises ill-sorted sediments ranging from big boulders to silt. Since this zone is very porous and permeable it forms the recharge area of the artesian aquifer system in the *Tarai* zone. Moreover, the region between *Bhabar* and *Tarai* belts forms the spring line (the landmass with marshy conditions). This spring line is of the source of various perennial streams in the region. Since the slope of *Bhabar* zone varies from 1-2%, the elevation difference between the recharging area in *Bhabar*zone and water withdrawing position (i.e. well) in *Tarai* zone creates the artesian head in the aquifer which is directly responsible for the existence of flowing wells.

Tarai soils are rich in clay and organic matter and that is why this belt is considered one of the highly productive agricultural areas in India. Availability of irrigation water from flowing wells without spending any energy on its withdrawal is one of the factors that could reduce agricultural costs.. The introduction of highly mechanised agricultural practices since the last two to three decades has encouraged the farmers to adopt the intensive cultivation in the region. Consequently, the demand for irrigation water has increased significantly. The trajectory of water resources development has thus been following a simple principle of “developing”, which in the case of groundwater means extracting more water to produce more grain (Kulkarni and Shah: 2013). Other than this, the rising domestic and industrial needs for water have further stressed the existing groundwater resources. Collectively, it has resulted in the development of more number of bore wells which has increased the density of flowing wells in the *Tarai* belt. As expected, the discharge rates of these wells have drastically decreased and are declining further with time.

Overexploitation and environmental damage

A preliminary study on the thermal characteristics of water sampled from the seven flowing wells located in a radius of more than 15 km has revealed that all the wells are installed in the same aquifer.

Definitely, the installation of more wells in this stretch will directly affect the yield of other wells. It can be judged from the fact that in year 1970, the water pressure of these flowing wells at the ground surface was over 2 kg/cm² (Michael: 2006) which now has dropped to ~ 0.2 kg/cm². Moreover, the figures mentioned are for the monsoon season only which would be lesser than this value during the dry season. Presently, the flowing behaviour of wells in certain pockets of the region have become seasonal (see Figures 1) and few others are completely dried (Figure 2a) and are abandoned now.

Other than the over exploitation of groundwater due to overall development and industrialisation in the *Tarai* zone, haphazard felling of trees for converting forest land into industrial/agricultural land, reduction of water pressure in the artesian aquifers due to increased leakage of water from confined to unconfined aquifers through the increased number of bore-holes for developing tube wells, and unattended flowing of these wells without any beneficial purpose (Figure 2b below) are the additional causes for their changed behaviour. The current scenario will further worsen with the reduction in recharging of these artesian aquifers in *Bhabar* zone due to changed rainfall pattern in Himalayan (Vashisht and Bam: 2013) and *Shiwalik* foothill regions. For proper recharging of the aquifers, rainfall intensity should be less than the water intake capacity of the land surface.

According to a World Bank report, global mean warming is approaching 4°C. This will result in a 10% increase in annual mean monsoon intensity and a 15% increase in a year-to-year variability of Indian summer monsoon precipitation is projected compared to normal levels during the first half of the 20th century (World Bank: 2013). The report further emphasises that these changes imply an extreme wet monsoon. This is projected to occur every 10 years by the end of the century compared to the currently probability of it occurring only once in 100 years. These extremes of weather conditions are likely to affect flowing wells adversely. With the number of flowing wells dwindling, abstraction of water will be dependent on the diesel engine or electric motor operated pumps. This increase in the energy cost will be added to the production cost of the crops. To equalise the profit margin, it is likely that food prices will be increased which will affect the end consumer adversely.
Nevertheless, the impact of the above mentioned factors can be drastically reduced by strengthening the farmers' knowledge regarding the groundwater hydraulics with special attention on the groundwater movement from the recharging zone to flowing artesian wells in their fields. But, the immediate action that is required at this stage is to increase awareness so that the farmers in the region can install control valves on the flowing wells to avoid water loss. The farmers who are aware of the consequences of this water loss have already adopted these measures by using end plugs or end plates for the purpose. However, these measures are not so effective in completely controlling the water loss (see Figure 3 below). Lack of general maintenance of control valves, non-replacement of end-plug gaskets at appropriate intervals, and improper tightening of the nuts and bolts of the pipe are the main reasons of this major water loss.

Additionally, there is a need to demarcate the major recharging zones in *Bhabar* belt and any kind of development other than the construction of water conservation/harvesting structures should be

restricted on it. Environmental isotope techniques can be efficiently used for the purpose (Shivanna et al: 2008). Conserving groundwater resources at this stage is crucial in the *Tarai* and *Bhabar* belt before it's too late.

JANUARY 2014 - CURRENT AFFAIRS - CVIL SERVICES EXAM 2014

Q1 - WRITE A SHORT NOTE ON "SMILE WELLNESS PROGRAMME & ITS SIGNIFICANCE? [50 WORDS]

Q2 - ENUMERATE THE SALIENT FEATURES OF SUPPRESSION OF UNLAWFUL ACTS AGAINST SAFETY OF MARITIME NAVIGATION AND FIXED PLATFORMS ON CONTINENTAL SHELF ACT, 2002? HOW APPLICATION OF SUA ACT IN ITALIAN MARINES CASE MAY AFFECT INDIA-EU RELATIONS [200 words]
Q3 - WHAT DO YOU MEAN BY "DEXTER"? BRIEFLY MENTION THE SIGNIFICANCE OF DEXTER? DISCUSS THE ROLE OF CERT-In? [200 WORDS]
Q4 – WHAT IS "FED TAPERING"? ENUMERATE THE REASONS WHY US HAS STARTED FED TAPERING? WHAT ARE THE IMPLICATIONS OF FED TAPERING ON EMERGING MARKETS LIKE INDIA? [200 words]
Q5 – DEFINE 'AVALANCHES"? HOW IT OCCURS? DESCRIBE THE VARIOUS PREVENTIVE STEPS TAKEN BY GOVERNMENT OF INDIA TO CONTROL AVALANCHES? [200 WORDS]
Q6 – WHAT DO YOU MEAN BY "PONZI SCHEME"? HOW PONZI SCHEME DIFFERS FROM PYRAMID SCHEME? DISCUSS THE ROLE OF SEBI IN CONTROLLING PONZI SCHEMES? [200 WORDS]
Q7 - WHAT DO YOU MEAN BY "EAVESDROPPING"? "INDIA NEEDS EAVESDROPPING SYSTEM LIKE CENTRAL MONITORING SYSTEM" – COMMENT? [200 WORDS]
Q8 - TEESTA RIVER WATER SHARING ISSUE & ITS IMPACT ON INDIA -BANGLADESH RELATIONS [200 WORDS]
Q9 - WHAT DO YOU MEAN BY "QUANTITATIVE EASING"? HOW IT INFLUENCES EMERGING ECONOMIES LIKE INDIA? CAN INDIA FOLLOW QUANTITATIVE EASING POLICY LIKE USA – COMMENT? [200 WORDS]
Q10 -WHAT DO YOU MEAN BY "SPECTRUM"? "SPECTRUM IS CONSIDERED AS A SOVEREIGN ASSET" – CRITICALLY ANALYZE? [200 WORDS]
Q11 - WRITE A SHORT NOTE ON STRUCTURE, MANDATE & FUNCTIONS OF NCPCR? [100 WORDS]
Q 12 – WRITE A SHORT NOTE ON "NAWADCO"? [50 WORDS]
Q13 - SPECIAL ARTICLE "GEOPOLITICAL GAME AROUND A TEMPORARY LINE –"LINE OF CONTROL"
Q14 - INDIA IS OFTEN CALLED "INTANGIBLE CULTURAL HERITAGE" OF THE WORLD. CRITICALLY EVALUATE THE STATEMENT BY USING FOLK DANCES OF INDIA AS AN EXAMPLE [300 WORDS]

Q15 – WHAT DO YOU MEAN BY “ATMOSPHERIC BROWN CLOUD”? DESCRIBE THE REASONS AND ITS IMPACTS ON SOUTH ASIA? [200 words]
Q15 - WHAT IS ASACUSA EXPERIMENT? DISCUSS IN DETAIL THE SIGNIFICANCE OF IT? [100 WORDS]
Q 16 – WRITE A SHORT NOTE ON NATIONAL SPORTS DEVELOPMENT FUND [50 WORDS]
Q17 - WHAT DO YOU MEAN BY “INNOVATION”? THE BOTTOM OF ECONOMIC PYRAMID [SME] NEEDS CAPITAL ASSISTANCE TO ENHANCE THEIR INNOVATION SKILLS.IN THIS BACKGROUND, DISCUSS THE VARIOUS OBJECTIVES AND SIGNIFICANCE OF RECENTLY LAUNCHED INDIA INCLUSION INNOVATION FUND [100 WORDS]
Q18– WHAT DO YOU MEAN BY “RURAL –URBAN CLUSTERS”? THE RECHRISTINED PURA SCHEME WILL ENSURE THE DEVELOPMENT OF RURAL-URBAN CLUSTERS-COMMENT? [200 WORDS]
Q19 - WRITE A SHORT NOTE "NATIONAL COMMUNAL HARMONY AWARDS & ITS SIGNIFICANCE"? [50 WORDS]
Q20 - WHAT DO YOU MEAN BY THE TERM "ABENOMICS"? HOW ABENOMICS IS DIFFERENT FROM 'LIKONOMICS'? DISCUSS IN DETAIL THE IMPLICATIONS OF ABENOMICS TO INDIA? [200 WORDS]

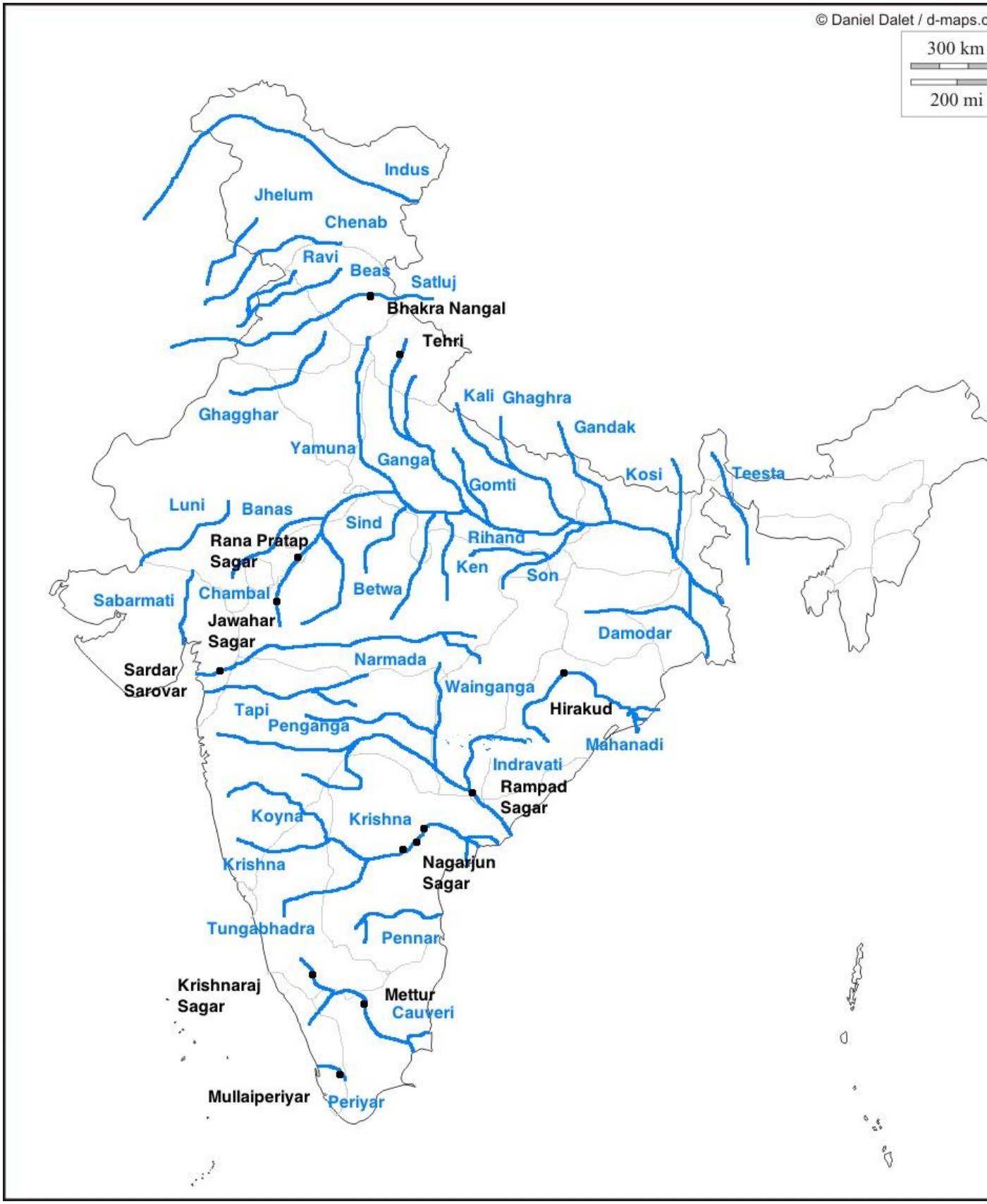
Aluminium industry changes in world

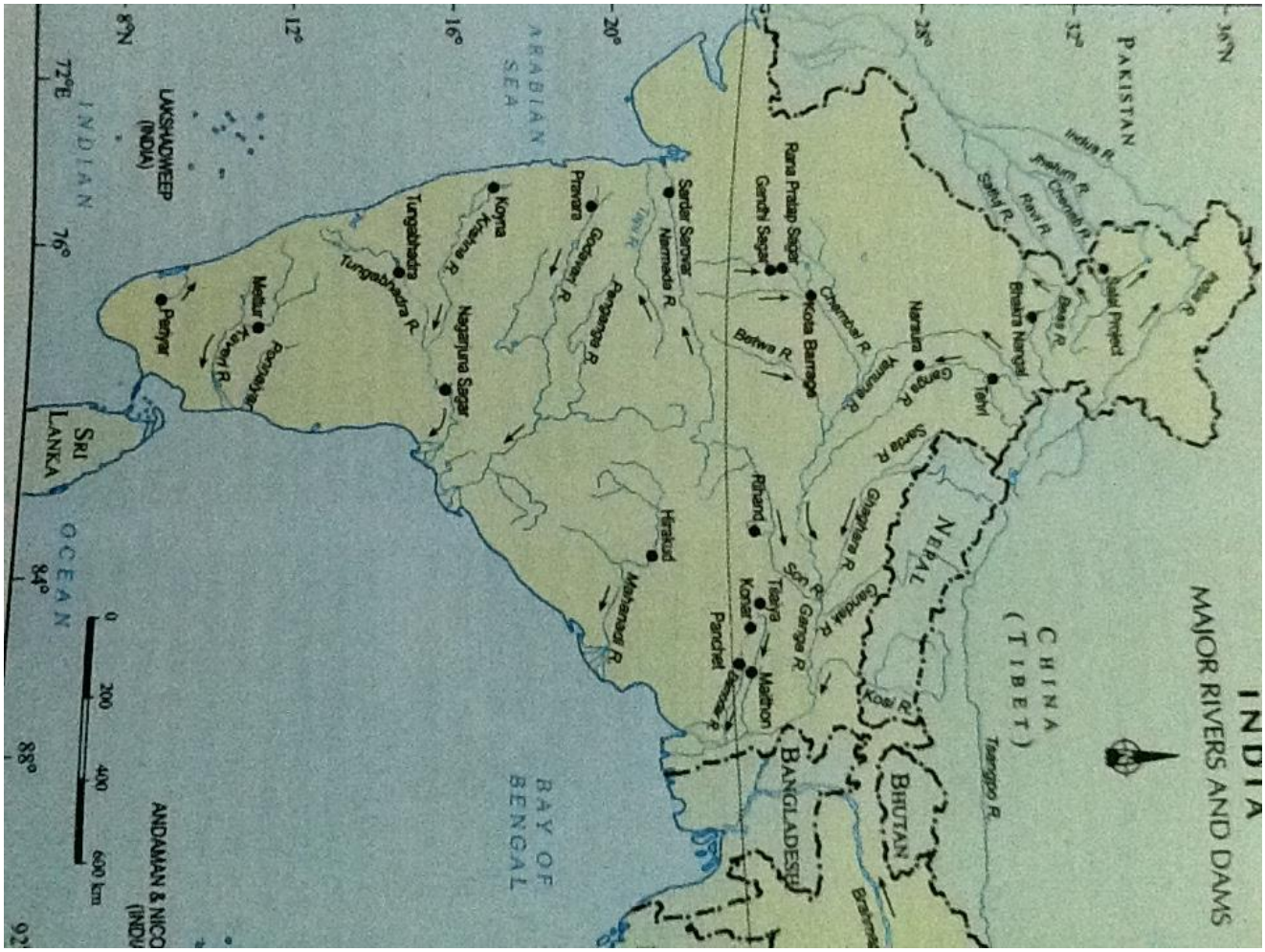
Higher energy prices
Energy shocks of 1973 and 1979, and the surge of energy demand in China, India, Brazil and other fast growing emerging economies in the early years of the new millennium have pushed up prices not only of oil but also of all other forms of energy (Figure 6). Even if discoveries of new energy supply or financial crises have kept prices at bay, the general trend has definitely been upward, thus increasing the price of electricity generation. The latter jump in electricity prices has dramatically altered the international competitiveness and hence location of industries such as aluminium whose production process uses large amounts of electricity. Energy shocks and the soaring energy demand in many emerging economies did not push up the price of electricity equally in all countries. Some nations are endowed with ample supplies of hydropower or low cost coal preventing electricity costs from rising as sharply as in nations more dependent on imported oil-generated power.
The interregional differences in electricity prices and hence in countries’ primary aluminium production costs were exacerbated by the factors mentioned above, accelerating the shift of primary aluminium production centres that began in the 1970s from high cost locations such as

Japan, United States and Western Europe to lower cost regions such as Australia, Canada, Middle East, Russia and China.
In the last 10-15 years, the shift has accelerated, with the Middle East strengthening its position as a leading aluminium production centre; within China, the move is from the high cost areas of the south and south-east to the west and north-west regions.
However, differences in electricity prices do not fully explain the shift in primary aluminium production centres. The impact of public policy — electricity rates below the long-run marginal opportunity cost of production, taxes, exchange rates, trade tariffs, or industry subsidies — also needs to be taken into account. The clear object

US share has gone down from 32% to 4% in last 40 yrs, Japan from 9% to zero.

Drainage Patterns


© Daniel Dalet / d-maps.c
300 km
200 mi
Indus
Jhelum
Chenab
Ravi
Beas
Satluj
Bhakra Nangal
Tehri
Kali
Ghaghra
Ghagghar
Gandak
Yamuna
Ganga
Kosi
Teesta
Gomti
Luni
Banas
Sind
Rihand
Rana Pratap
Sagar
Ken
Son
Sabarmati
Chambal
Betwa
Jawahar
Sagar
Damodar
Narmada
Sardar
Sarovar
Wainganga
Hirakud
Tapi
Penganga
Mahanadi
Indravati
Rampad
Sagar
Koyna
Krishna
Krishna
Nagarjun
Sagar
Tungabhadra
Pennar
Krishnaraj
Sagar
Mettur
Cauveri
Mullaiperiyar
Periyar



Indus Basin

1. Indus: Bokhar Chu glacier.
2. Jhelum: Verinag in Kashmir Valley. Then it flows into Wular lake where Kishenganga project is located.
3. Chenab: Originates in the form of Chandra and Bhaga rivers in HP @ Bara Lacha pass. They meet at Tandi. Salal, Baglihar (in Doda, Kashmir) projects are on this river.
4. Ravi: Originates @ Rohtang pass in HP.
5. Beas: Originates @ Beas Kund, Rohtang pass in HP.
6. Satluj: Originates in Rakas lake in Tibet. It enters HP @ Shipki La.
7. Ghagghar - Hakra: It originates @ Ambala and loses in the desert in Hanumangarh.

Ganga Basin

1. Ganga: Originates @ Gomukh glacier in Uttarakhand. Meets Alakhnanda @ Devprayag. Antecedent.
2. Chambal: Originates @ Mhow Cantt, Indore. Joins Yamuna @ Itawah. Cuts a gorge.
3. Kali: Also called Sharda, originates in Nepal and meets Ghaghra @ Barabanki.
4. Ghaghra: It originates in Nepal, cuts a gorge and joins Ganga near Chapra. Antecedent.
5. Gandak: Enters India @ Champaran and meets Ganga @ Sonpur near Patna.

6. Kosi: It joins Ganga @ Manihari. Originates @ Mt. Everest.
7. Tista: It joins Brahmaputra. Originates @ Mt. Kanchenjunga.
8. Ken: Originates in Malwa plateau, makes a gorge, joins Yamuna @ Banda, UP.
9. Son: It joins Ganga directly. Originates @ Amarkantak in Chattisgarh.

Peninsular Rivers

1. Luni: Originates @ Ajmer, drains west of Aravalis and merges into Rann of Kuchch.
2. Sabarmati: Drains south Aravalis into Gulf of Khambat.
3. Mahi: Originates in Vindhyan hills. Drains into Gulf of Khambat.
4. Narmada: Originates @ Amarkantak in Maikal hills in Chattisgarh. Flows into Gulf of Khambat. Makes an estuary near Bharuch. 1300 km.
5. Tapi: It rises in Satpura hills. Makes an estuary near Surat. 725 km.
6. Subernrekha: Rises near Ranchi and flows east into Bay of Bengal.
7. Brahmani: It merges into Mahanadi and flows into BoB @ Paradip port. Its tributaries Koel and Sankh join @ Rourkela.
8. Mahanadi: It rises in Chattisgarh, Hirakud dam is built @ the gorge where it turns right. Meets BoB @ Cuttack. 850 km.
9. Godavari: Rises in Nasik @ W Ghats. 1465 km.
10. Krishna: Originates in Mahabaleshwar. 1400 km.
11. Pennar: Rises in Kolar.
12. Cauveri: It rises in S Mysore plateau and near Mysore Krishna Sagar dam has been built. 800 km.

Peninsular vs Himalayan Rivers

1. Peninsular rivers are old, have broad channels, slow moving, have hardly any vertical erosion and low carrying capacity. Himalayan rivers on the other hand are in late youth, deep vertical cutting, shallow channels in upper parts, swift as well as sluggish a d huge erosion capacity.

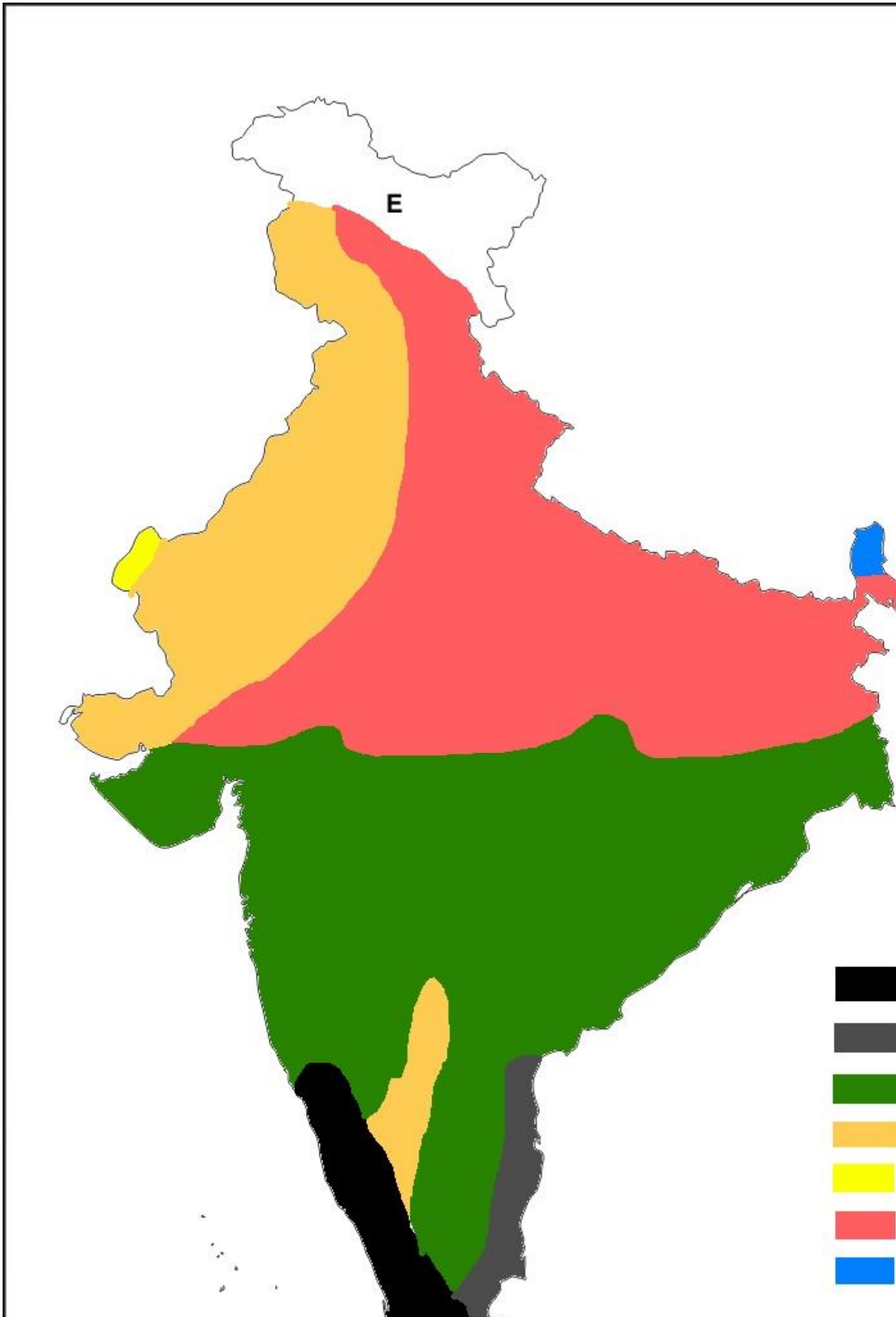
Climatic Regions

-
- (C) Monsoons ki current understanding is that Jet streams play a key role in it. Old theories have all been discarded. Now, it is believed that the upper air circulations are as important as the surface circulations:
- The foolwing are the key players in Monsoon:
- 1. Northward shifting of the Westerly Jet (north of himalayas)
- 2. Tropical Easterly Jet Stream which is associated closely with the burst of monsoon. It is also a major reason why there are no cyclones during Monsoon because the presence of an Easterly jet over the Indian landmass in the upper troposphere prevents vertical circulation of air...which is a pre-condition for formation of cyclones.
- 3. Northward shifting of the ITCZ.
- 4. S-E trade winds from S. hemisphere cross the equator and turn right due to coriolis force.
- 5. The location and shift of ITCZ governs the breaks and pulsating nature of monsoons.
- 6. ElNino/La Nina
- A good source to understand Monsoon would be D D Khullar but I guess you need not go into too much detail for the sake of GS.
- Regarding your other question...
- Also, Tropical cyclones move from east to West.....they are secondary circulations and maintain the larger direction of the planetary winds (i.e Trade winds which blow from East to West).
- So, any cyclones to form in Arabian sea is less likely to affect India.

- Also, another reason that can be given is that the findlater jet of the coast of Somalia causes coastal upwelling and hence cooling of waters in the western Indian ocean...and cooler temperatures would not support the formation of tropical cyclones. However, please note that it would happen only if the Findlater Jet is very strong.

Koeppen Scheme

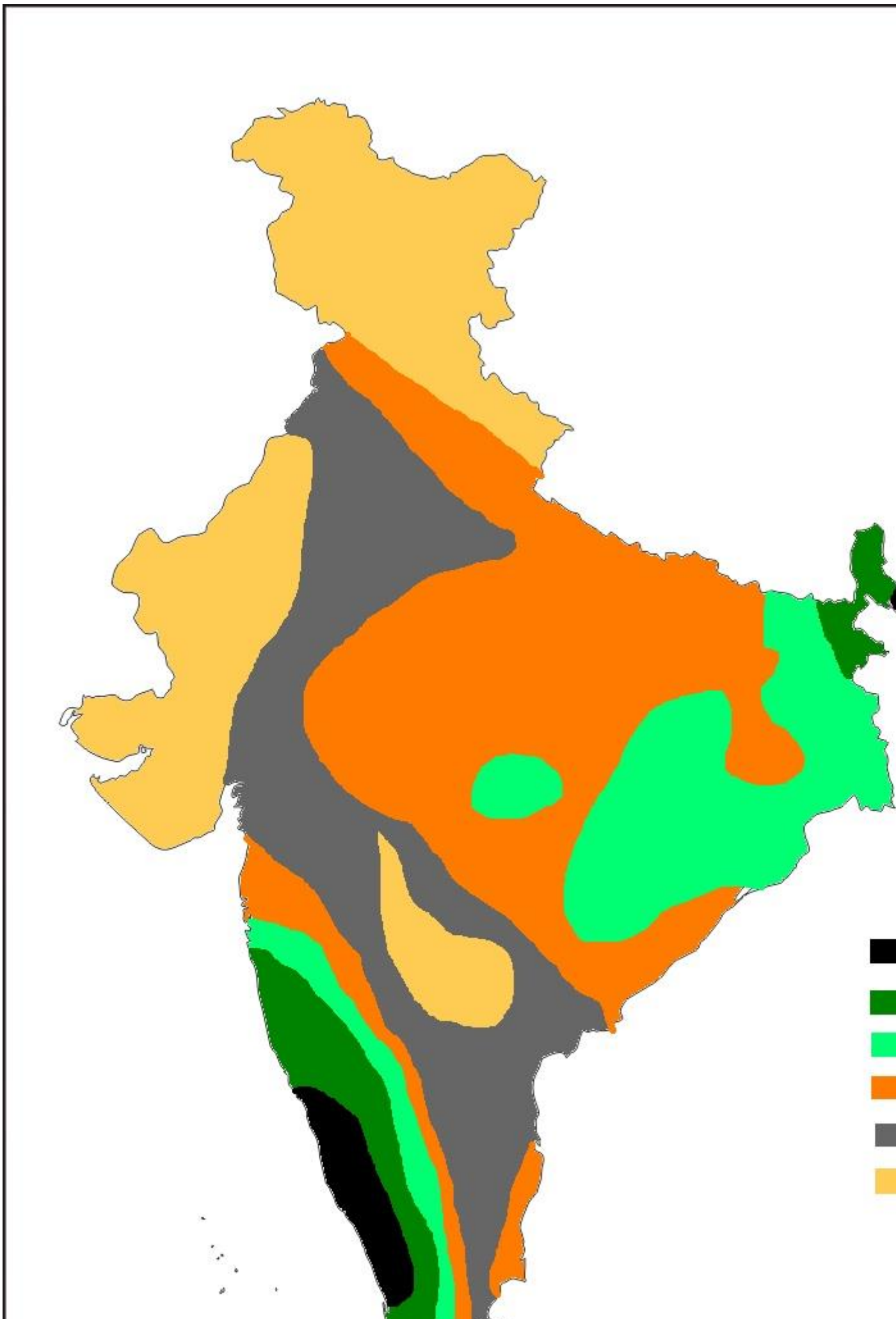
1. It is based on monthly values of temperature and precipitation. A ==> Tropical; B ==> Dry; C ==> Temperate; D ==> Continental; E ==> Polar.
2. These 5 types are divided into subtypes based on seasonal variations in rainfall and temperature. m (monsoon), w (wet and dry or savanna), s (semi-arid: precipitation > 50% of threshold but < threshold), h (low latitude) denote subtypes.


E

1. Amw ==> Tropical monsoon with short dry season. It prevails in western ghats south of Goa.
2. As ==> Tropical monsoon types with dry summers. It prevails in eastern ghats in Coromandel coast.
3. Aw ==> Tropical savanna type.
4. Bshw ==> Semi-arid steppe climate.
5. Bwhw ==> Hot desert type.
6. Cwg ==> Monsoon type with dry winters.
7. Dfc ==> Cold humid winter type.
8. E ==> Polar type.

Thornthwaite Scheme

1. It is based on concept of water balance i.e. rate of precipitation - rate of evaporation. An area is arid if there is water deficiency in all months. An area is humid if it has water surplus in all months.



A ==> Perhumid

B ==> Humid

C ==> Moist sub-humid

C_2 ==> Dry sub-humid

D ==> Semi-arid

E ==> Arid

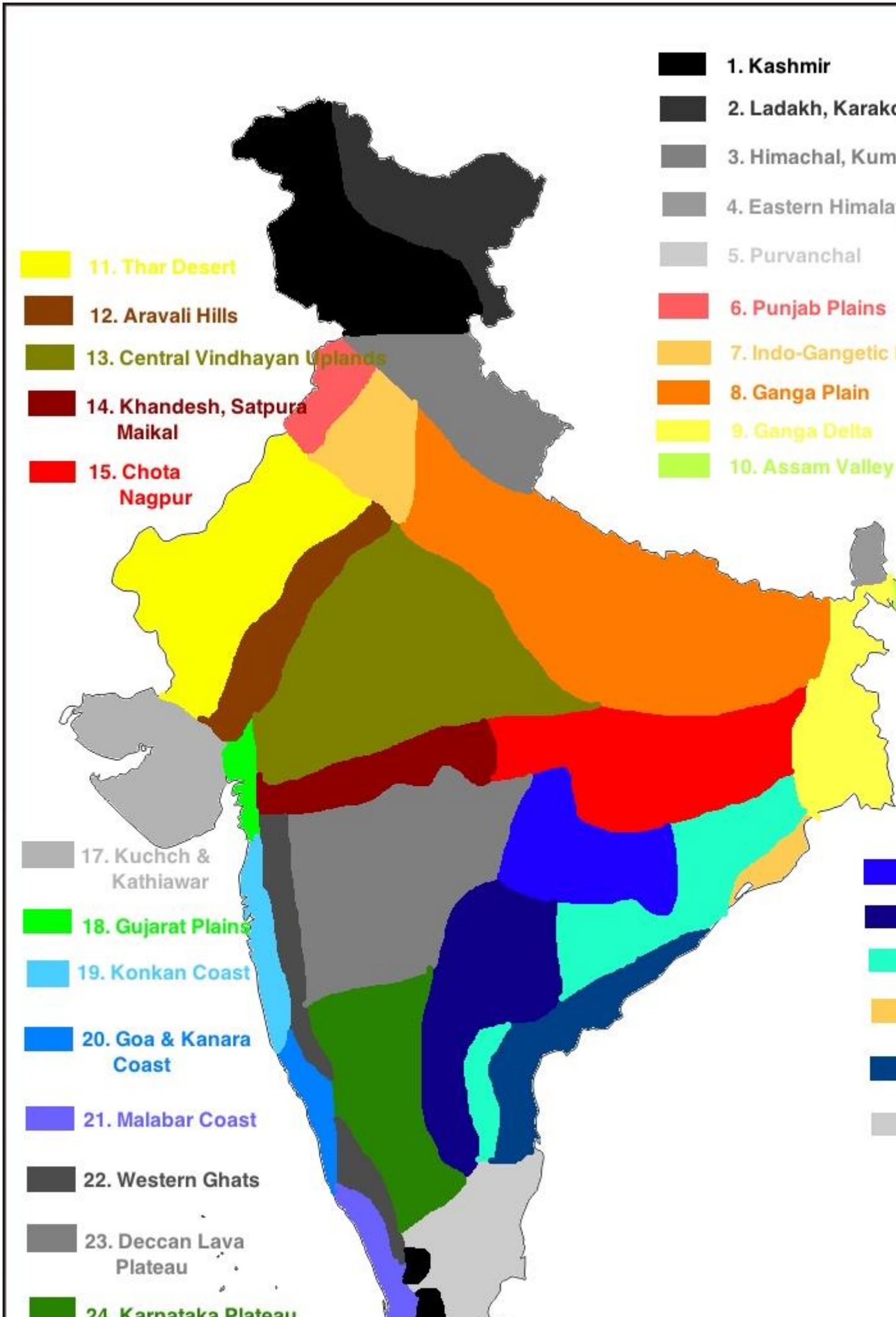
Cyclones

1. They strike in 2 distinct seasons - (a) pre-monsoon months of April-May, and (b) post-monsoon months of October-November. The post-monsoon months have more intense cyclone activity.
2. Cyclones are more dominant in Bay of Bengal compared to Arabian sea. The reasons could be - (a) Trade winds blow from east to west.

Conditions necessary for formation of cyclones

1. Large and continuous supply of warm moist air that can release enormous amount of latent heat.
2. Large coriolis force which can prevent the filling of low pressure.
3. Absence of strong vertical currents which can distribute the latent heat vertically.
4. Unstable conditions in troposphere.

Geographical Regions


1. Kashmir
2. Ladakh, Karako
3. Himachal, Kum
4. Eastern Himala
5. Purvanchal
6. Punjab Plains
7. Indo-Gangetic
8. Ganga Plain
9. Ganga Delta
10. Assam Valley
11. Thar Desert
12. Aravali Hills
13. Central Vindhayan Uplands
14. Khandesh, Satpura Maikal
15. Chota Nagpur
17. Kuchch & Kathiawar
18. Gujarat Plains
19. Konkan Coast
20. Goa & Kanara Coast
21. Malabar Coast
22. Western Ghats
23. Deccan Lava Plateau
24. Karnataka Plateau

Himalayan Regions

1. Kashmir: The valley is surrounded by high mountain ranges and has a temperate climate and alpine vegetation.
2. Karakoram, Ladakh, Baltistan: Here we have high plateaus, mountain ranges and inhabitable terrain.
3. Himachal and Kumaon: It lies to the east of Sutlej gorge. They differ from Kashmir Himalayas in rainfall pattern and vegetation. Rainfall here is higher and trees are tropical in valleys of Kullu, Kangra, Shimla.
4. Eastern himalayas: They receive heavy rainfalls and vegetation is luxuriant.
5. Purvanchal: They have low altitude (< 2000 m) and rainfall is also less. The forest cover is thick though it changes from tropical evergreen to monsoon deciduous type.

Unique Himalayan relieve and structure

Structure refers to geochemical composition and internal features of rocks and their

geomorphic description.
- Relief refers to slope and its nature, angular position, nature of peaks and valleys.
=> **Structure:-**
- Indo-Tsangpo Suture Zone: Convergence boundary of plates.
- Tethyean Himalaya-Sedimentary and fossil rocks.
- Great Himalaya- Assymetrical fold, Archean granite-Gneiss-Schist Absence of volcanic Eruption (Batholith structure.)
- Lesser Himalaya-Metamorphic rocks (Slate, quartzite)
- Shivaliks- almost unbroken range, lime and sand stone
- Absence of volcanic eruption (Batholith structure in inner part.)
- Large number of faults-MBF, MCT, HFF
- Belt of nappe
- Syntaxial Bend, Convex shape of Himalaya
- Orthoclinal plan
=> **Relicf:-**
- Series of high elevation peaks
- V-Shaped valley and deep gorges
- Synclinal valley and anticlinal peaks
- Lack of intermontane plateaus and basins
- Glacial landscape
- River terraces
- Steeper southern slope than northern slope

Plain Regions

1. Punjab plains: It is a part of the Indus plain and has a dry climate. The various doabs are - (a) Bari doab - Beas and Ravi, (b) Bist doab - Beas and Sutlej, (c) Rachna doab - Ravi and Chenab, (d) Chaj doab - Chenab and Jhelum, (e) Sind Sagar doab - Chenab-Jhelum and Indus. Its arid character and dry thorny vegetation distinguishes it from the sub-humid Gangetic plain.

2. Indo-Gangetic divide: It lies mainly in Haryana between Sutlej and Yamuna and is the watershed between Indus and Ganga systems. Parts of it are intruded by Aravalis. It is a transition zone.
3. Gangetic plain: Sub-humid. Rainfall increases to east.
4. Ganga delta: High temperatures and humid climate.
5. Assam valley: Shorter summer, higher rainfall and humidity.

Peninsular Plateau Regions

1. Thar desert: It is an extension of the Vindhayan upland to the west of Aravalis lying underneath the sand.
2. Aravalis: Southern part is higher and has more forest cover. It forms the NW flank of the plateau and is heavily eroded.
3. Central Vindhayan uplands: It consists of Malwa plateau and Bundelkhand gnessis. It is highly dissected and soil cover is shallow. Vegetation varies from tropical dry deciduous to tropical thorny shrubs. It contains the Vindhyas, Kaimur and Bhanver ranges. It offers many natural sites for storage of water. It is made of gneisses and quartzite.
4. Khandesh, Satpura, Maikal ranges: These are scarp plateaus lying to south of Narmada and have steep sides. Tapi trough lies to its south. Ajanta caves are here.
5. Chotanagpur plateau: It is dissected, high rainfall region. It has moist deciduous forests.
6. Meghalaya plateau: It is dissected, high rainfall region. It has evergreen forests. Its general height is 1300 - 1800 meters.
7. Kuchch & Kathiawar: They are lava formations. These are low but highly dissected ranges with salt marshes in the north. Climate is dry.
8. Gujarat coast: Sabarmati, Mahi, Narmada and Tapi have deposited alluvium here. It is a transition zone from humid west coast to arid Gujarat and Rajasthan.
9. Konkan coast: It is narrow and dominated by outlying scarps of W Ghats.
10. Goa & Kanara coast: It is hot and humid and rainy season lengthens as we move south.
11. Malabar coast: It is wider plain and has great diversity of vegetation. Rainfall however decreases towards the southern tip of the peninsula.
12. W Ghats: There general altitude is 900 - 1100 meters and it continues up to Goa. Here the rugged lava topography gives way to smooth granites and gnessis hills. Near Goa their appearance changes from highly dissected lava rocks to smooth granite and gneisses hills. Their height dips to 900 meter but rises against in Nilgiri hills.
13. Deccan lava plateau: It gives rise to the black soil. Its general slope is towards east and south-east.
14. Karnataka plateau: Lava rocks of deccan plateau are replaced by granite and gnessis here. General elevation is 450 - 800 meters and it is divided into Malnad and Maidan plateaus. Malnad is thickly forested.
15. Wainganga and Mahanadi basin: These are low lying basins. Rainfall is lower in Wainganga basin than in Mahanadi basin. Sal forests are found in Wainganga basin and teak forests in Mahanadi basin.

16. Telangana: It is a low, highly dissected plateau. Isolated granite rocks form uplands and are called monadnocks. Otherwise its an open region. Mostly it has grasslands and low rainfall.
17. Southern hills complex: Nilgiris, Anamalais, Palani ranges are here. They have thick vegetation cover.
18. Eastern ghats: They consist of 3 main groups - (a) Northern hills between Jamshedpur and Godavari, (b) Cudappah hills between Godavari and Palkonda, and (c) Tamil Nadu hills lying between Cauveri and Palar.

Island Regions

1. Lakshadweep islands: They have tropical humid climate. They are coral islands.
2. A&N islands: They are volcanic islands.

Relief Features

Plateau

Evolution

1. It was lifted out of the sea in pre-cambrian times and never fell back. It can be compared to a horst.
2. In the initial phases, Aravalis folded up into great mountain ranges and so did Nallamalai hills in south. This is the only incident of folding in peninsular block.
3. Generally it has seen faulting and fracturing only. The recent evidences of uplift are in Palni and Nilgiri hills. Narmada and Tapi are fault valleys.
4. When Himalayas began to rise, the NW part of plateau saw volcanic eruptions leading to the formation of Deccan lava plateau. Then the western part of the plateau subsided below the ocean leading to the prominence of Western Ghats. The eastern coastline has remained largely unchanged. The gap between Rajmahal and Garo is due to downwarping which happened as a result of Himalayan folding.

Relief

1. Slope: The general elevation is 600 - 900 meters. The plateau first slopes towards the north and the east (as suggested by Chambal, Son and Damodar) and then west (Vindhyan, Kaimur, Satpura ranges). Towards the south of Satpura, the general slop is towards the east and the south-east.
2. Southern plateau: It is made of granite and gneiss. Nilgiris, Karnataka plateau and Telangana are examples.
3. Deccan lava plateau: It contains horizontally arranged basaltic lava sheets.
4. Narmada and tapi troughs: They lie between Vindhyas and Satpura.

Himalayas

Evolution

1. It remained under sea level until the recent times. In Mesozoic times, the area was a geosyncline and was under Tethys sea. Then the sediments deposited under the sea began to be folded up ~ 65-70 mya. By 30-60 mya, Tethys' crust began to fracture and by 20-30 mya Himalayas began to emerge.
2. The erosion from the Himalayas began to fill the depression of Tethys. In the first phase, the uplift of central himalayan axis took place which comprised of old sediments and crystalline rocks. Second uplift took place in Miocene which saw the uplift of Potwar region of Pakistan. In the third uplift in pleistocene, Shivaliks emerged. Karakoram ranges emerged before Himalayas.

Relief

1. Longitudinal classification: From Indus gorge to Sutlej gorge they are called Punjab himalayas and run for 560 km. Between Sutlej gorge to Kali gorge they are known as Kumaon himalayas and run for 320 km. Between Kali gorge and Teesta gorge they area called Nepal himalayas (800 km) and between Teesta gorge and Dihang gorge they are called Assam himalayas (720 km). Punjab himalayas can be broken into Kashmir and Himachal himalayas.
2. In the west the himalayas attain height gradually through a successive chain of ranges (sub hills of J&K followed by Pir Panjal and Dhaloadhar followed by Kashmir and Zaskar ranges and finally Karakoram, Kailash and Ladakh ranges). But in east, himalayas attain height suddenly from the plains.
3. Axial classification: Great himalayas (height ~ 6000 m), lesser himalayas (width 80 km and height ~ 4500 m) and Siwaliks (width ~50 km and height ~1000 m). They have longitudinal valleys or plateaus separating them.
4. Syntaxian bends: They occur @ Indus and Dihang gorges. They were formed as Himalayas pressed against the plateau.
5. Orthoclinal structure: They have steep, scarp like face on south and gentler slopes towards north. The north has greater amount of glaciers.
6. Rock based classification: (a) North or the tibetan zone comprises of old sedimentary rocks lying to the north of great himalayas. (b) Central or the himalayan zone comprises of lesser and parts of great himalayas and is composed of crystalline and metamorphic rocks. There is no horizontal displacement of rocks. (c) Nappe zone comprises of Kashmir, Himachal and Garwahl himalayas. They have thrust faults due to over folding. (d) Siwaliks which are composed of recent times sedimentary deposits.

Plains

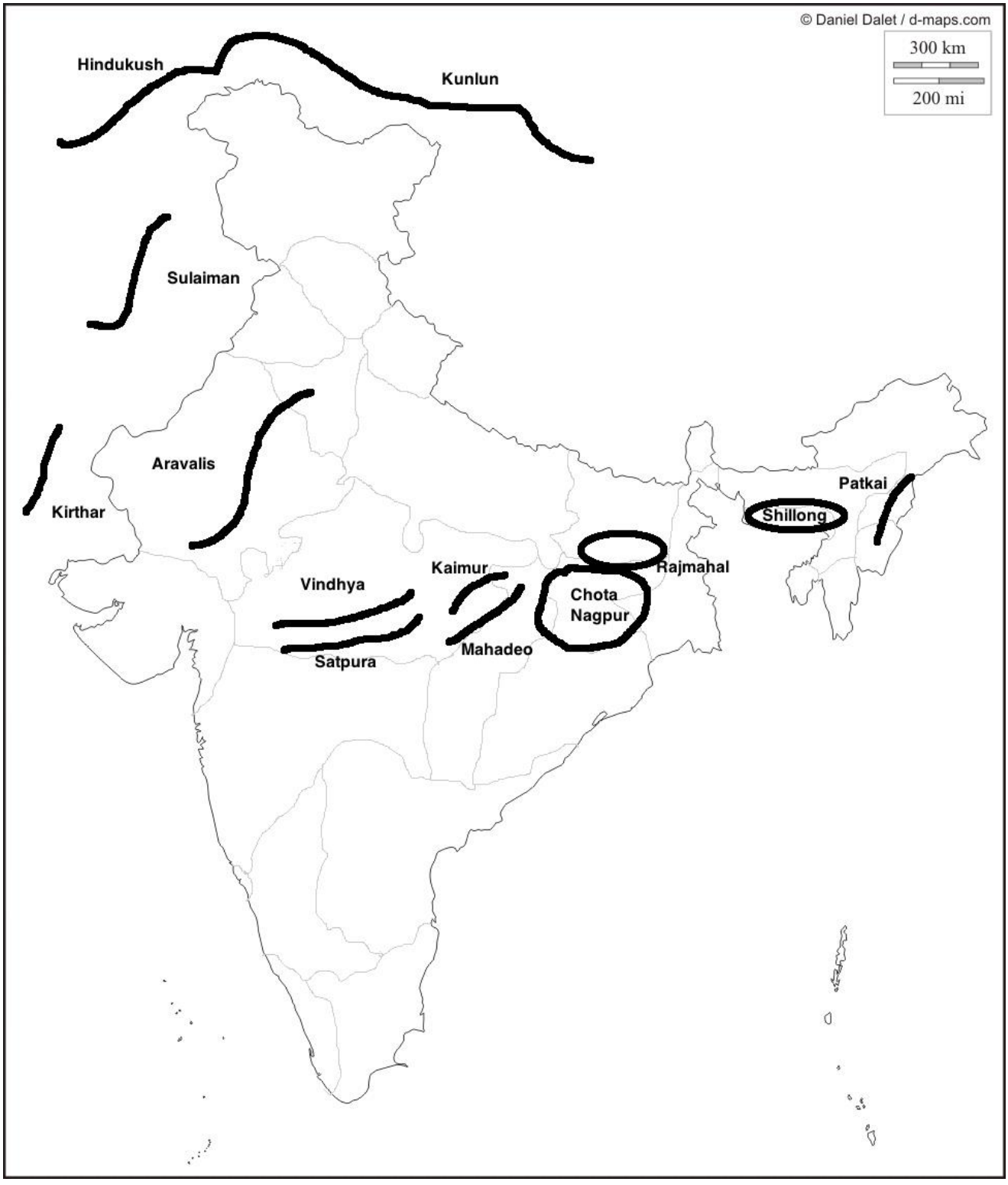
Evolution

1. They were formed due to filling of Tethys by sediments. Perhaps in the mountain building process, the northern part of the plateau subsided. Rajmahal - Garo gap was a depression

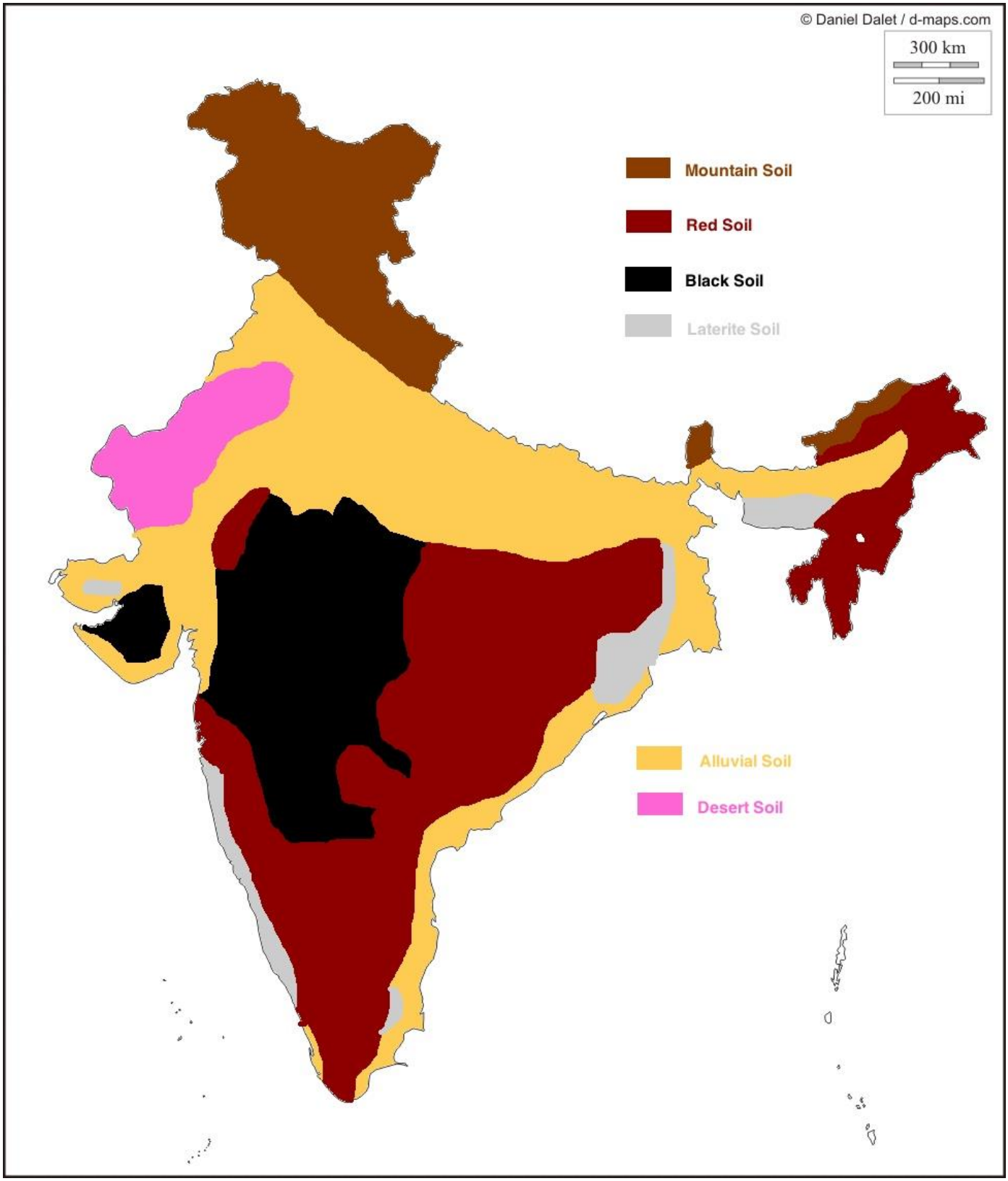
which was created in the same process of downwarping and subsequently got filled with sediments.

Relief

1. Plains are narrowest in Assam (100 km) and increase in width towards the west (160 km in Rajmahal and 280 km in Allahbad).
2. Deltas: Ganga delta extends from Rajmahal to the edge (430 km x 480 km) while Indus delta extends only for 960 km x 160 km from Chenab hills. Ganga's flow increases as it moves while Indus's decreases. Alluvium of Gangetic delta is finer than Indus delta. Gangetic delta is also deeper than Indus delta.
3. Bhabhar, terai, bhangar and khadar: Bhabhar lies along the foot of Siwaliks consistently and is studded with pebbles. Its porosity is so high that all the streams lose themselves underground before reemerging in terai. It is only 8-16 km wide. The terai is damp, has wetlands and excessive forest cover. The older alluvium in the plain is called bhangar while the newer one is called khadar. Bhangar forms alluvial terraces. Calcareous formations on bhangar are called *kankar*. Bhangar formations in deltaic tracts form low uplands called *barinds*.
4. Alluvial cones, intercones and cone foot plains: Alluvial fans or cones are formed when river descends on to plains. All himalayan rivers form cones except Ghagghar. Alluvial fans / cones have convex edges. If the edges are concave they are called intercones. When cones and intercones merge they form cone foot plains. Generally himalayan rivers form simple cones except Beas, Ravi, Teesta which form composite cones. The north Bihar plain is the intersection of 3 cones formed by Gandak, Kosi and Teesta.
5. Indus plains: To the west of the Indus lies bhangar. Its northern part is a clay pat desert while the south is a sandy desert. To the east of Indus is the delta. Old dry river beds are called *dhoros*. Along some of the dhoros occur alkaline lakes called *dhands*. Towards the east, the Indus delta gradually loses itself in the salt wastes of Rann of Kuchch.
6. Punjab plains: The rivers have bluffs along their sides which are called *dhayas*. These bluffs may be heavily gullied. The khadar belt is known as *bet* and is useful for agriculture. The northern part of plains (near Hoshiarpur) has witnessed heavy erosion at the hands of narrow streams called *chos*. These chos rearrange themselves after every flood.
7. Yamuna plains: Its tributaries (specially Chambal) cut a series of gullies and ravines in the plateau and these are called *badlands*.
8. Ganga-Yamuna doab: The bhangar forms uplands which may rise up to 15 - 30 meters and are called *khols*. While Yamuna khols may rise up to 6-115 meters, Ganga khols may be 12 - 20 meters. Such uplands are called *bhurs* in Moradabad and Bijnor. They might be formed as a result of joining of 2 head and channel bars in a braided stream.


© Daniel Dalet / d-maps.com
300 km
200 mi
Hindukush
Kunlun
Sulaiman
Aravalis
Kirthar
Vindhya
Kaimur
Satpura
Mahadeo
Chota
Nagpur
Rajmahal
Shillong
Patkai

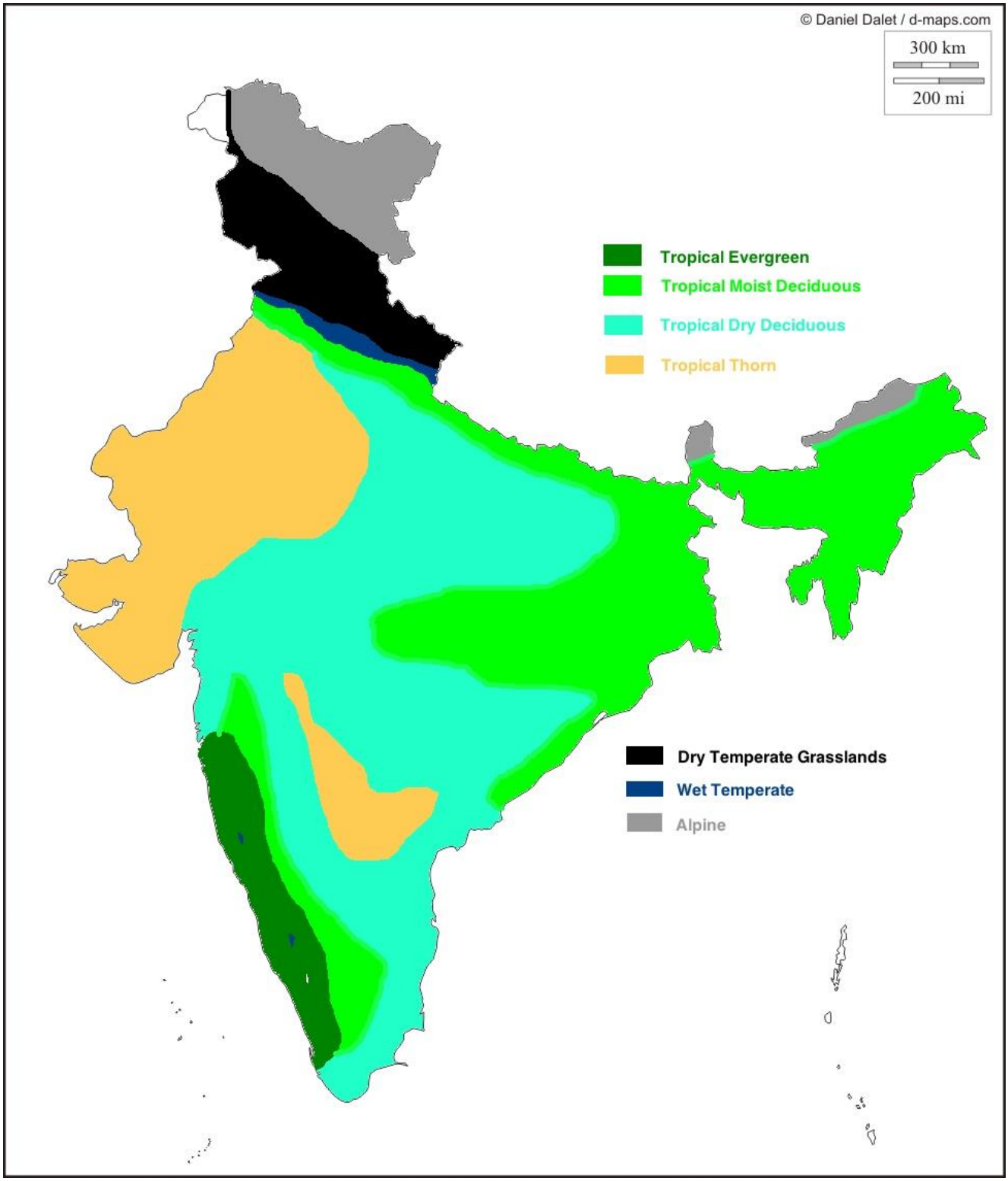
Soils



1. Alluvial soils: In plains, they have been brought down by rivers, in coasts by the tides and in semi-arid areas by the desert winds. Bhangar has a higher clay content than khadar so the water retention capacity of khadar is not good. They are N-P deficient but K rich.

2. Black soils: They are of lava origin, clayey and impermeable. On the uplands they have comparatively lower fertility than the low lands. They are deficient in N-P and organic matter but rich in K, Fe, Mg, Al. They are good for cotton and sugarcane production. They are generally alkaline.
3. Red soils: Red color is due to Fe. Their pH varies from 6.6 to 8 and are poorer than alluvial. They are loamy or sandy and have low water retention capacity. They are deep and fertile in low lands and poor in up lands. They are poor in N-P-K and organic matter.
4. Laterite soils: The alteration of wet and dry season leads to leaching. The soils in higher areas are more acidic than in lower areas as leaching is more there.
5. Mountain soils: They are acidic, loamy and poor in organic matter.
6. Desert soils: They are sandy, alkaline, P-K rich but N and organic matter deficient.

Natural Vegetation



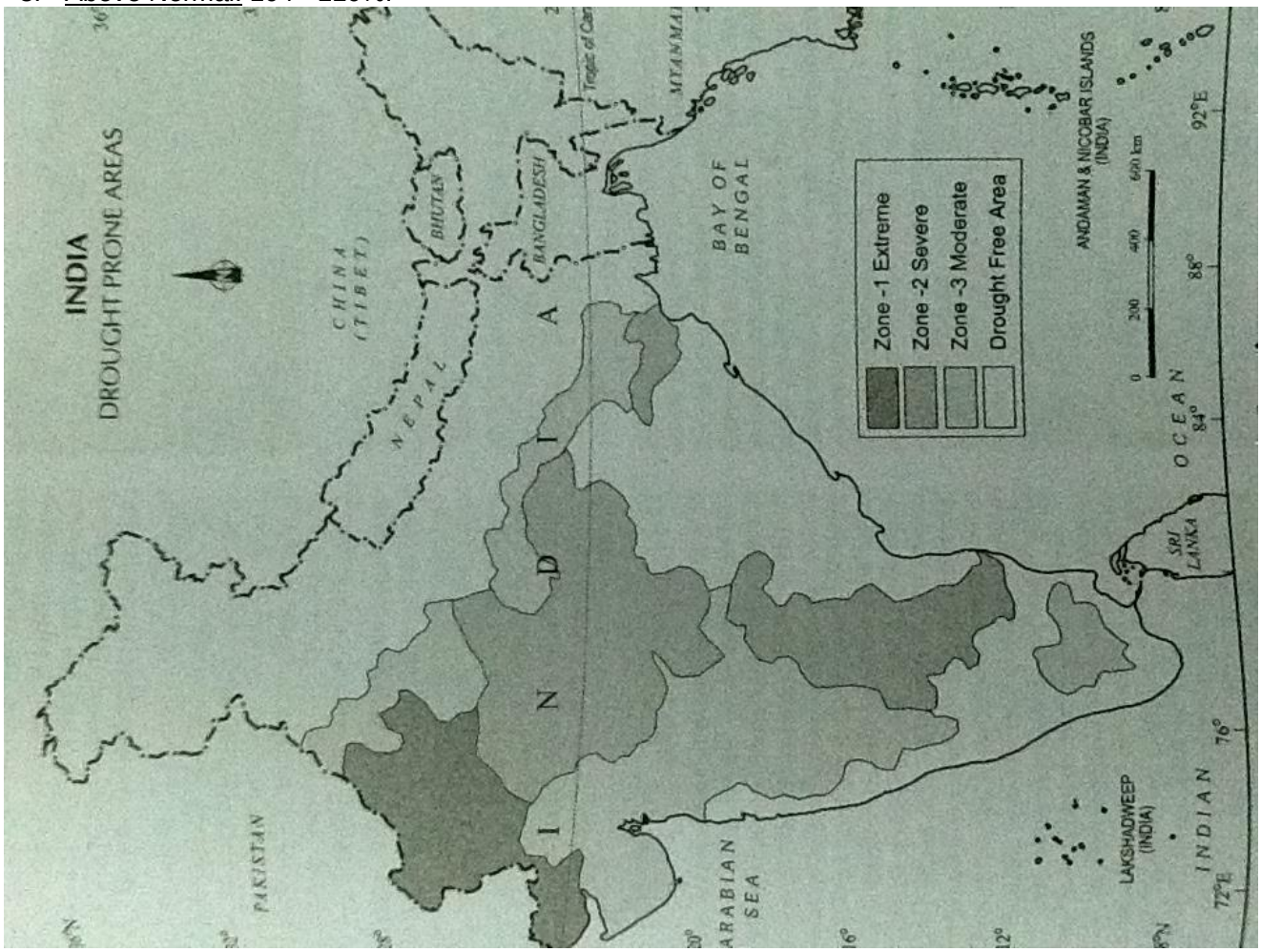
1. <u>Tropical evergreen forests:</u> They are mainly found in W Ghats and Meghalaya. Mahogany, jamun, bamboo are main species.
2. <u>Tropical moist deciduous forests:</u> They are typical monsoon forests. They are found in regions of moderate rainfall (100 - 200 cm). Teak, sal, sandalwood, sheesham are main species.

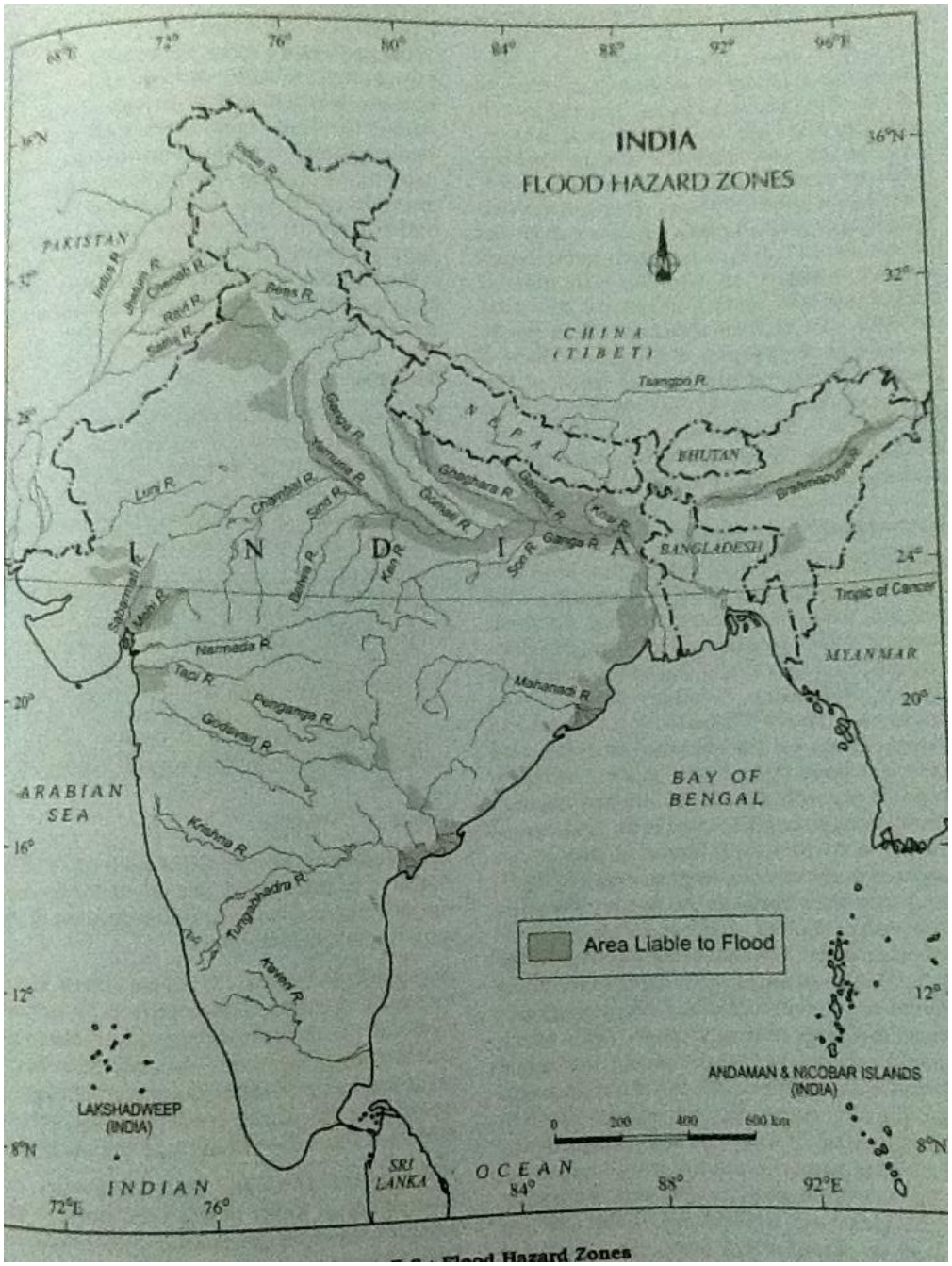
3. Tropical dry deciduous forests: They are found in areas having 70 - 100 cm of rain. In the dry season the trees shed their leaves completely.
4. Tropical thorn forests: They are found in areas with < 70 cm rainfall.

Rainfall and Drought

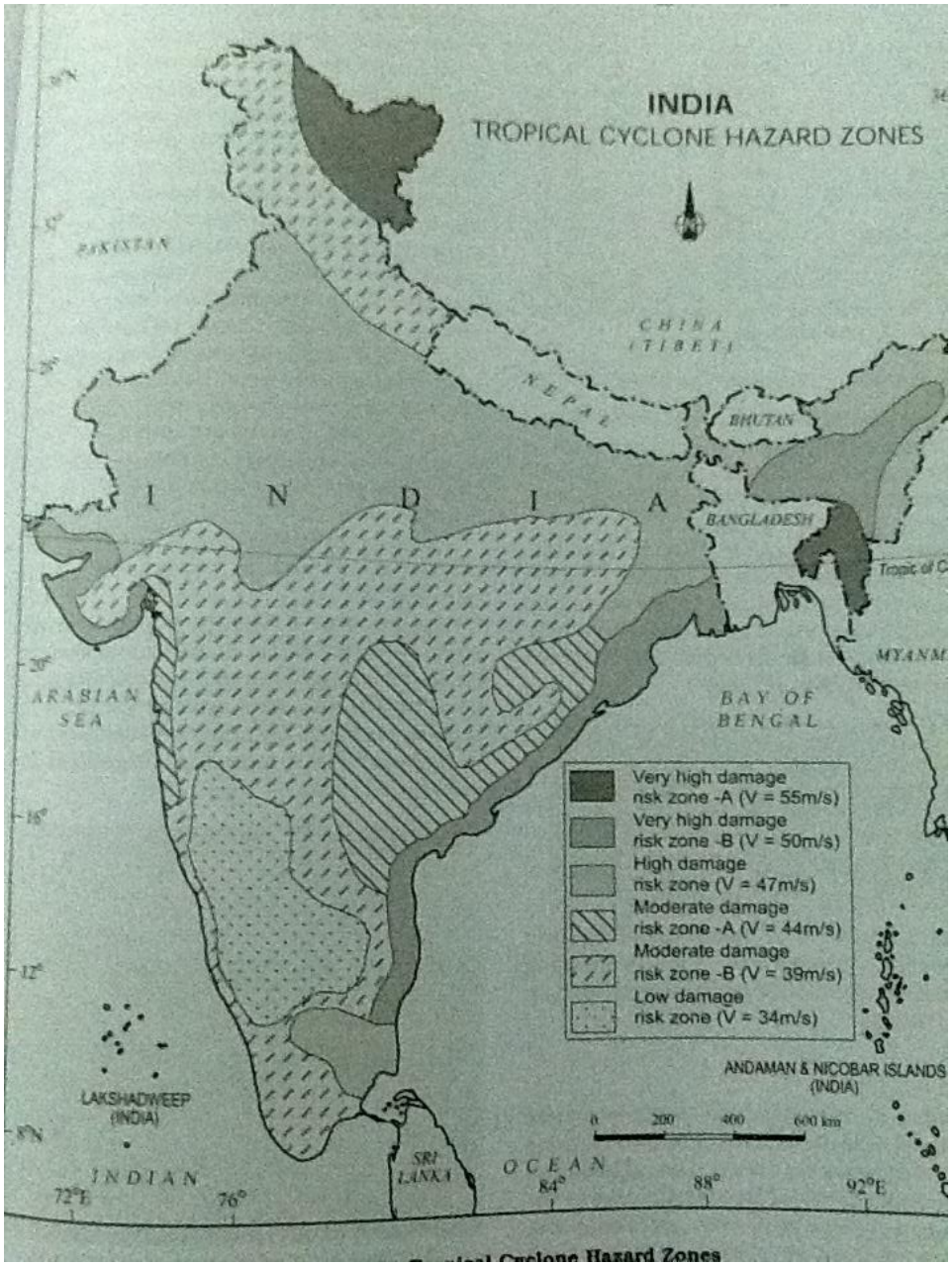
IMD Monsoon Classification Norms

1. Below Normal: 90 - 96%.
2. Normal: 96 - 104%.
3. Above Normal: 104 - 110%.





Flood Hazard Zones


INDIA
TROPICAL CYCLONE HAZARD ZONES
PAKISTAN
CHINA (TIBET)
NEPAL
BHUTAN
I N D I A
BANGLADESH
MYANM
ARABIAN SEA
BAY OF BENGAL
Very high damage risk zone -A (V = 55m/s)
Very high damage risk zone -B (V = 50m/s)
High damage risk zone (V = 47m/s)
Moderate damage risk zone -A (V = 44m/s)
Moderate damage risk zone -B (V = 39m/s)
Low damage risk zone (V = 34m/s)
ANDAMAN & NICOBAR ISLANDS (INDIA)
LAKSHADWEEP (INDIA)
0 200 400 600 km
INDIAN OCEAN
SRI LANKA
72°E
76°
84°
88°
92°E

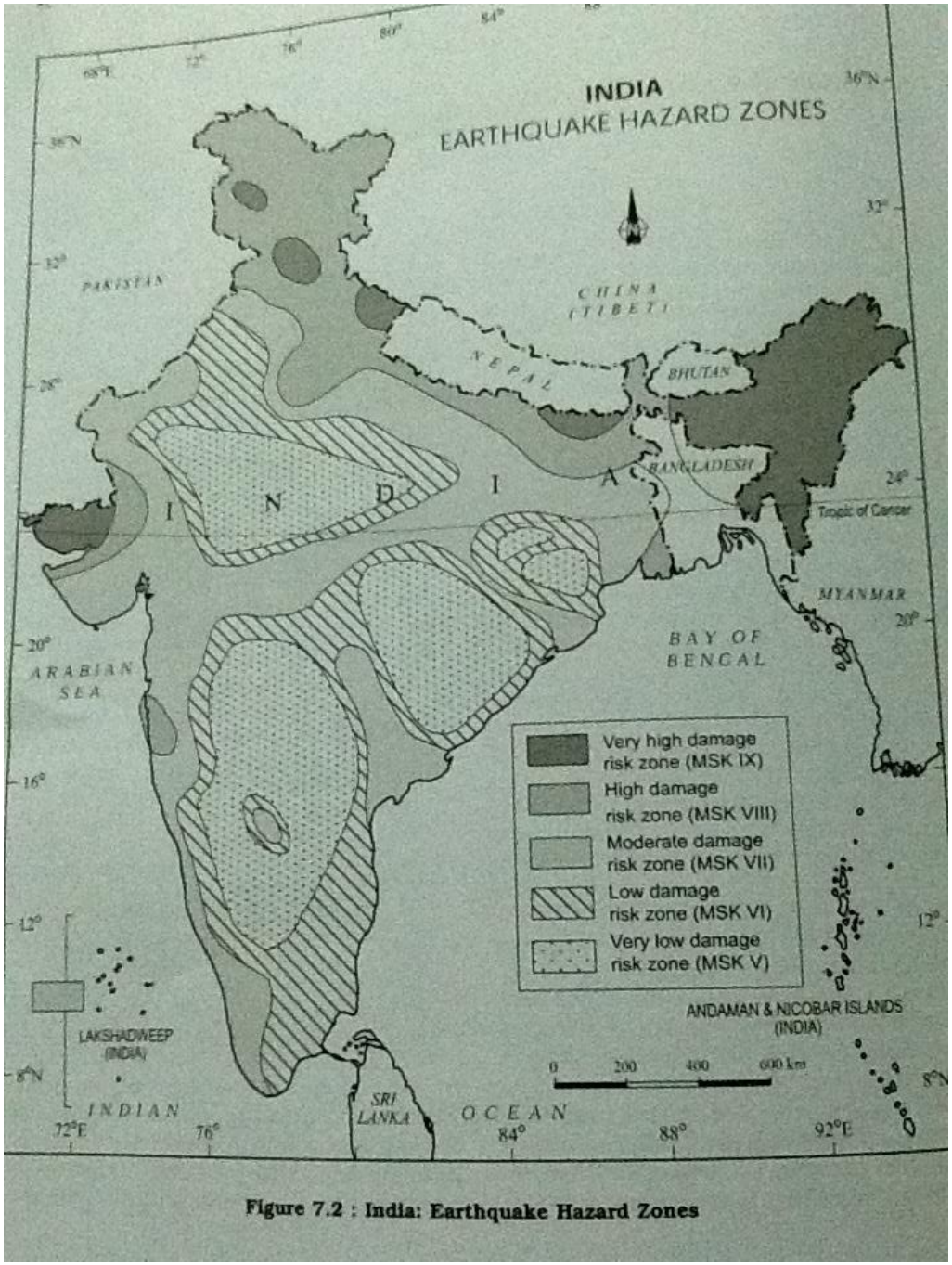
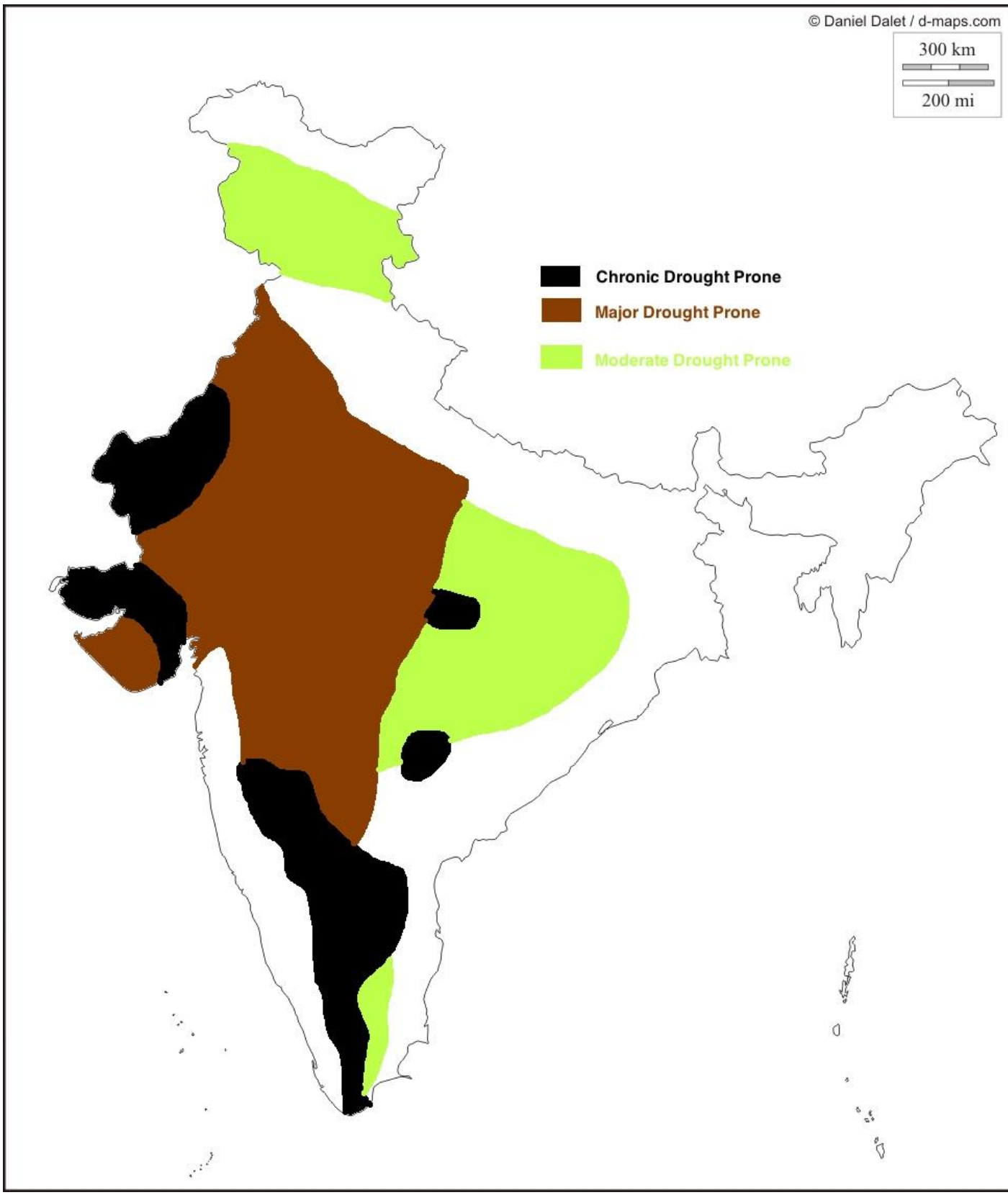
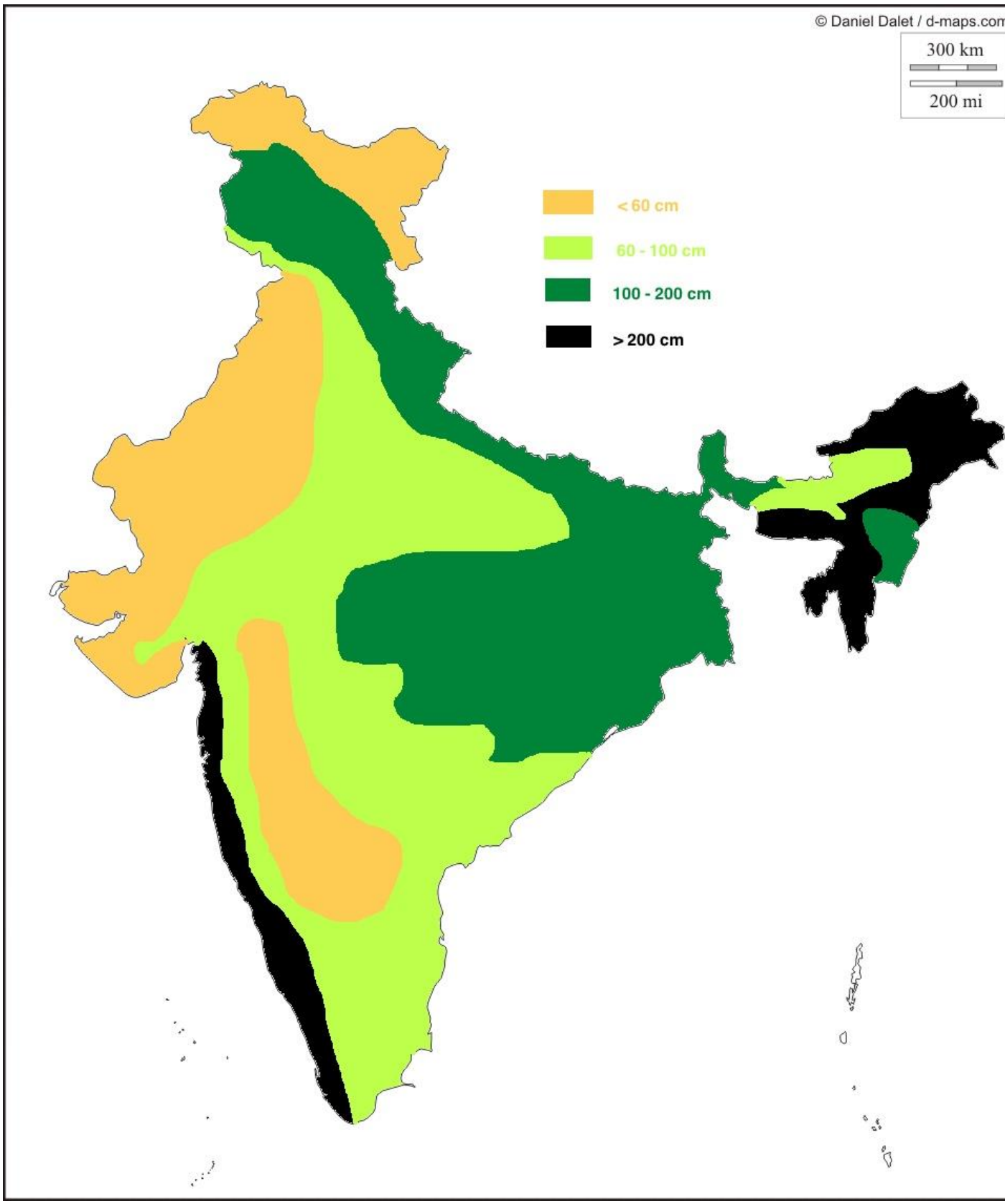
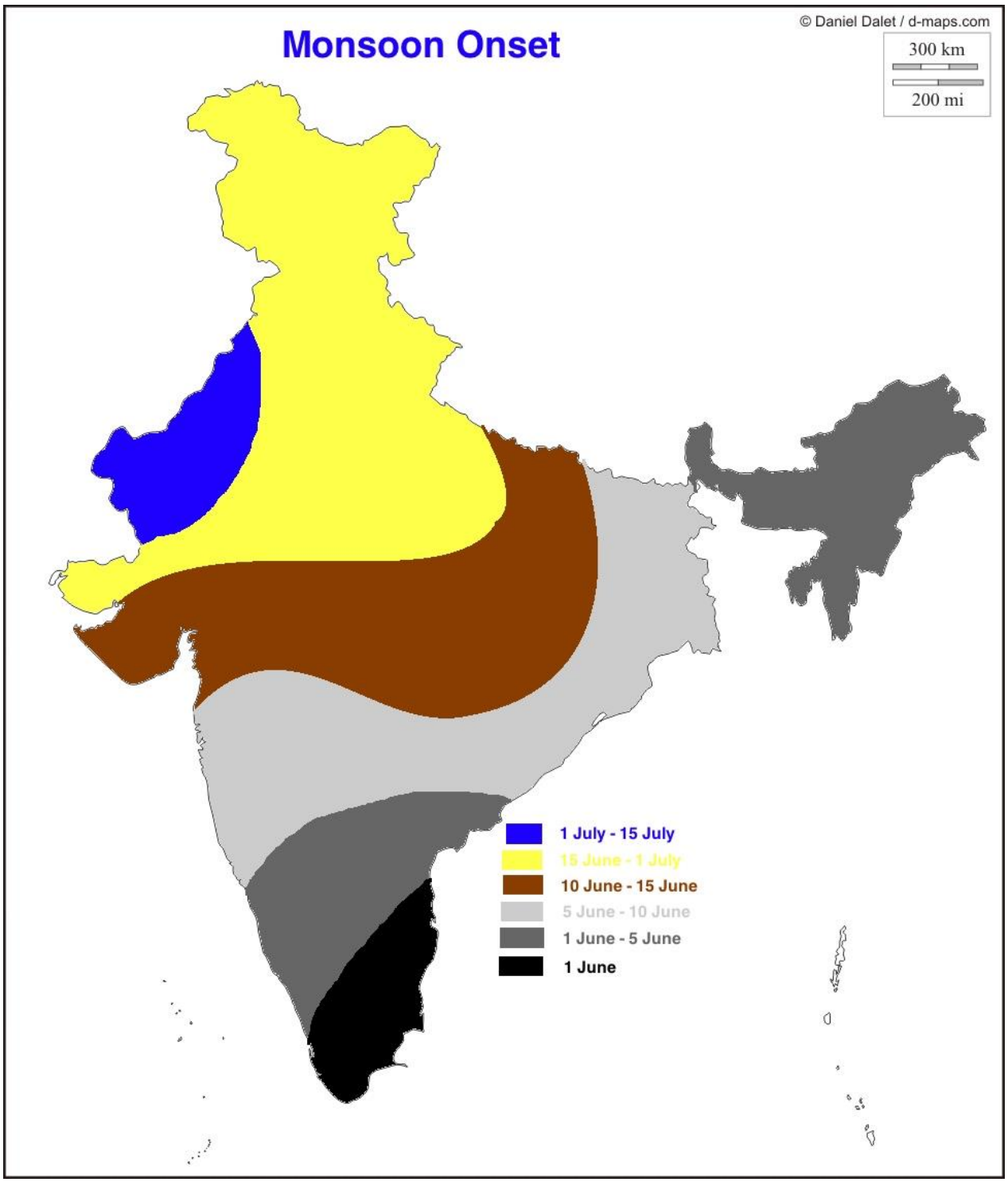
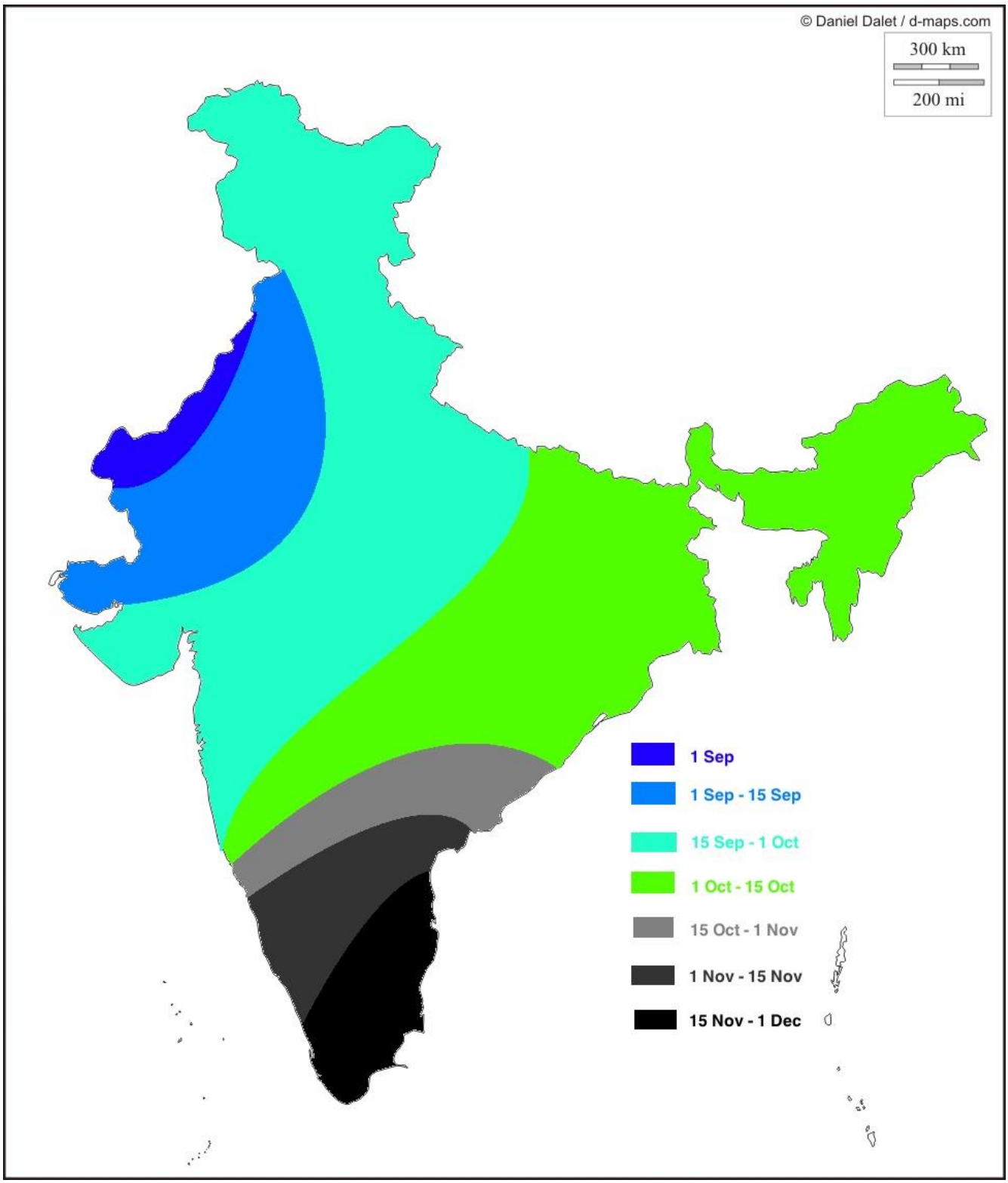


Figure 7.2 : India: Earthquake Hazard Zones


© Daniel Dalet / d-maps.com
300 km
200 mi
Chronic Drought Prone
Major Drought Prone
Moderate Drought Prone

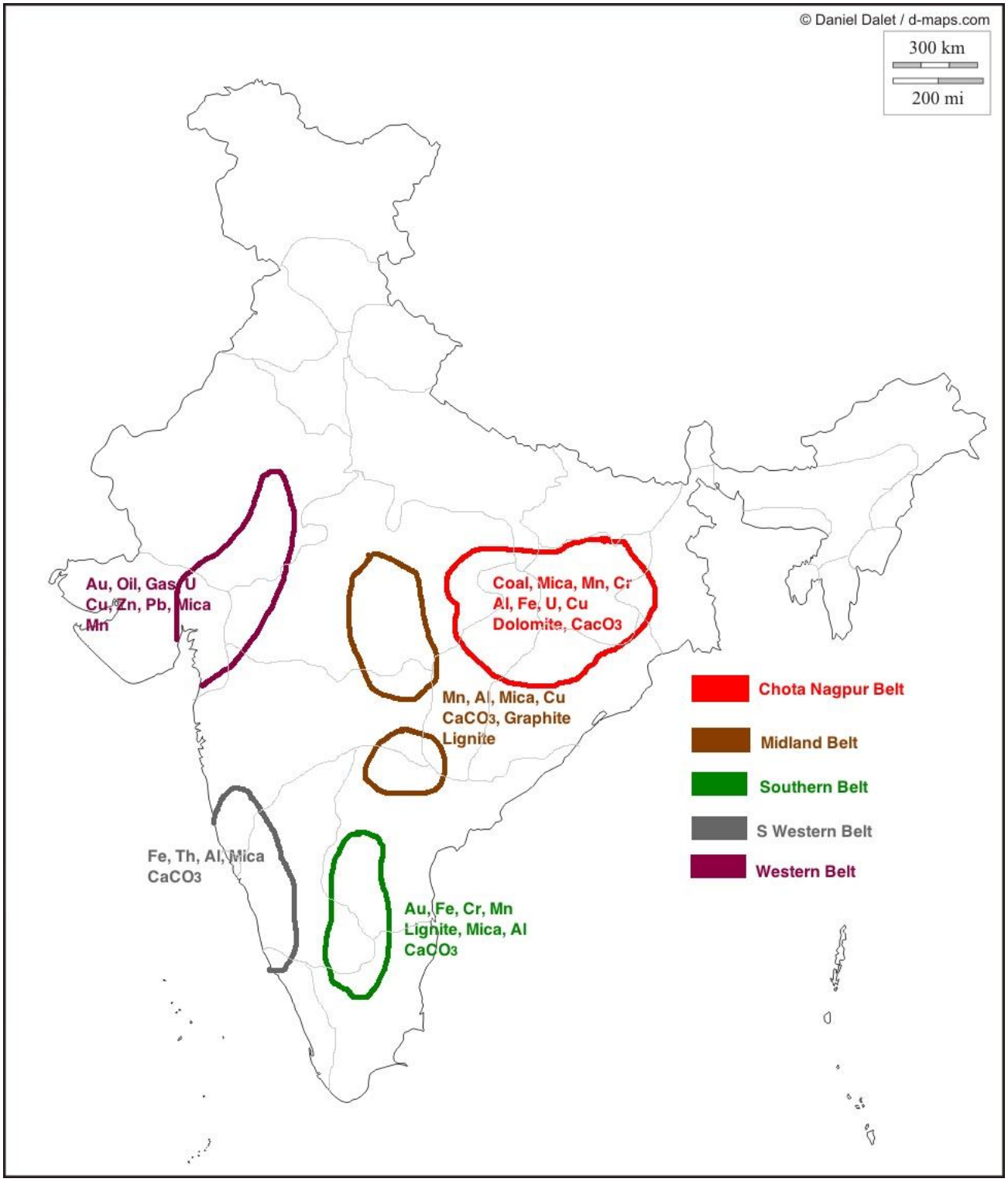

© Daniel Dalet / d-maps.com
300 km
200 mi
< 60 cm
60 - 100 cm
100 - 200 cm
> 200 cm


© Daniel Dalet / d-maps.com
Monsoon Onset
300 km
200 mi
1 July - 15 July
15 June - 1 July
10 June - 15 June
5 June - 10 June
1 June - 5 June
1 June



Economic Geography

Mineral Belts



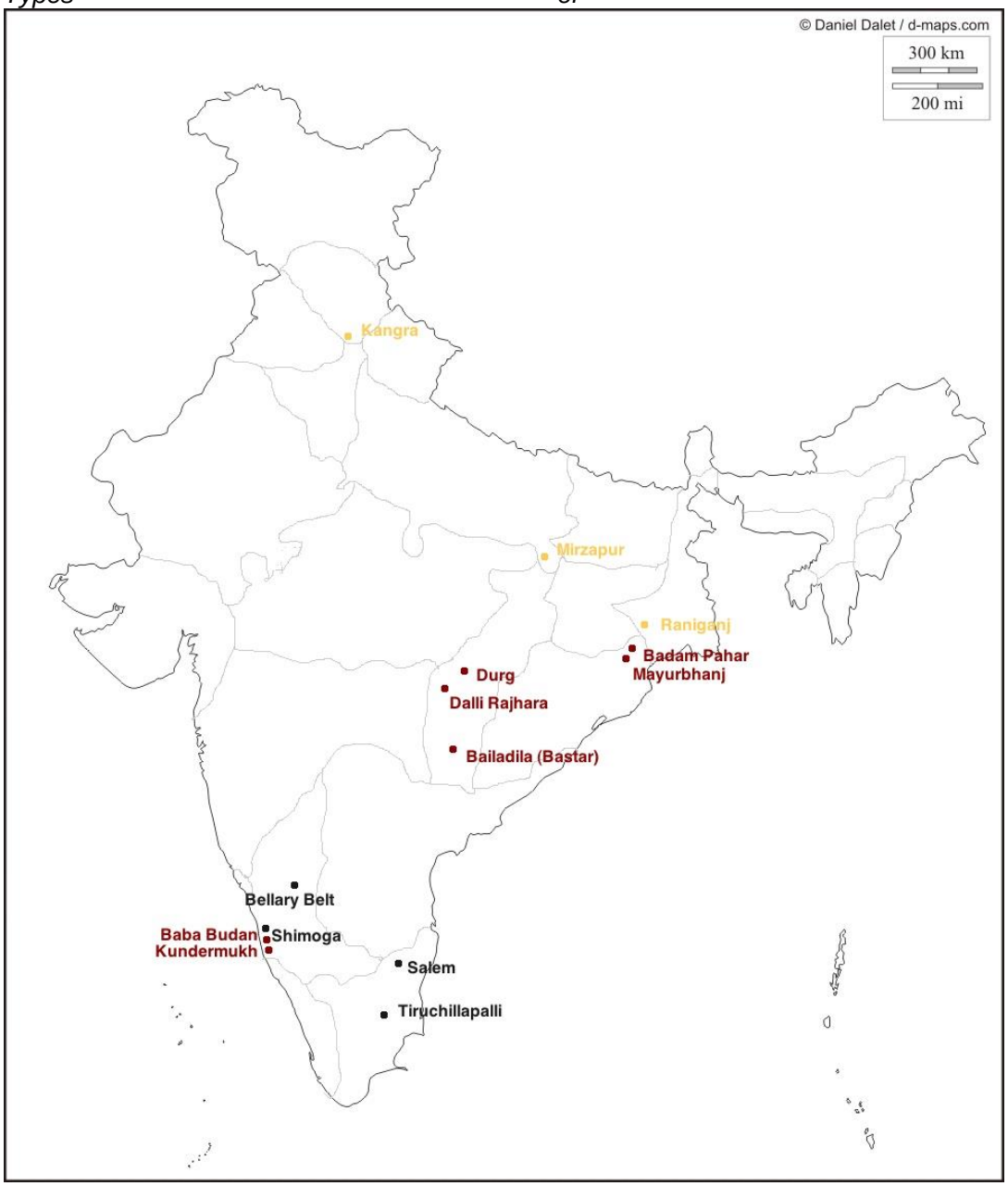
Iron Ore

Distribution & Production

1. India produces 210 MT of iron ore. Domestic consumption is 110 MT. Karnataka (25%) > Odisha (22%) > Chattisgarh (20%) > Goa (18%) > Jharkhand (14%).
2. Total reserves 25 bio tonnes, 14 bio good quality.

3. India is 5th largest iron ore exporter. Japan, China, S Korea major importers.

Types of Ores



1. Hematite: 60-70% Fe. Its reddish in color. Jharkhand, Odisha, Chattisgarh, MP, AP, Goa, Maharastra, Karnataka.
2. Magnetite: 60-65% Fe and black in color, igneous or metamorphic. Karnataka (Dharwar, Shimoga), AP (Bellary), TN (Salem, Tiruchillapalli).
3. Limonite: 35-50% Fe, yellow in color and is hydrated. W Bengal (Raniganj), UP (Mirzapur), Uttarakhand (Garhwal), HP (Kangra).
4. Siderite: 10-30% Fe, carbonate of Fe.

Manganese

Distribution and Production

1. India has 2nd largest reserves (380 MT) after Zimbabwe and 5th largest producer (2 MT) after Brazil, Gabon, SAF, Australia.
2. Odisha (40%), Maharastra (23%), MP (20%), Karnataka (14%) are the main producers.

Uses

1. Steel making, bleaching powder, pesticides, paints, photography.

<u>Copper</u>

Distribution and Production

1. In terms of reserves, Rajasthan > MP > Jharkhand. In terms of production, MP > Rajasthan > Jharkhand.
2. India imports Cu from Zimbabwe, Australia, Japan, USA, Mexico.

Chromite

Distribution and Production

1. It is found in Odisha (99%). It is used in steel industry.

Lead

Distribution and Production

1. Rajasthan (Udaipur, Dungarpur) > AP. India imports 75% of its Pb from Australia, Canada and Myanmar.

Zinc

Distribution and Production

1. Rajasthan produces 99%. India imports 80% of its Zn requirement from Australia, Canada, Zaire.

Bauxite

Distribution and Production

1. Odisha (50%) > Gujarat (16%) > Jharkhand (12%) in production.

Gold

Distribution and Production

1. Karnataka (Kolar and Hutti) > AP (Ramgiri).

Mica

Distribution and Production

1. In reserves, Rajasthan (51%) > AP > Maharastra. In production, AP(Nellore belt) (71%) > Rajasthan (Jaipur - Udaipur belt) (16%) > Jharkhand (12%).
2. India is largest producer and exporter in the world. Japan, USA, UK are the main clients.

Properties & Uses

1. It has insulating properties, can withstand high voltage and low power loss factor.

Limestone

Type

1. Dolomite: Contains ≥ 10% Mg and used in iron and steel industry. Odisha is leading producer (30%) of dolomite followed by Chattisgarh (27%).

Distribution and Production

1. Rajasthan > MP > AP.

Gypsum

Uses

1. It is hydrated calcium sulphate and is used in cement, fertilizers industry. It is used in plaster of paris and ceramics as well.

Distribution and Production

1. Rajasthan is the leading producer (99%).

Cattle

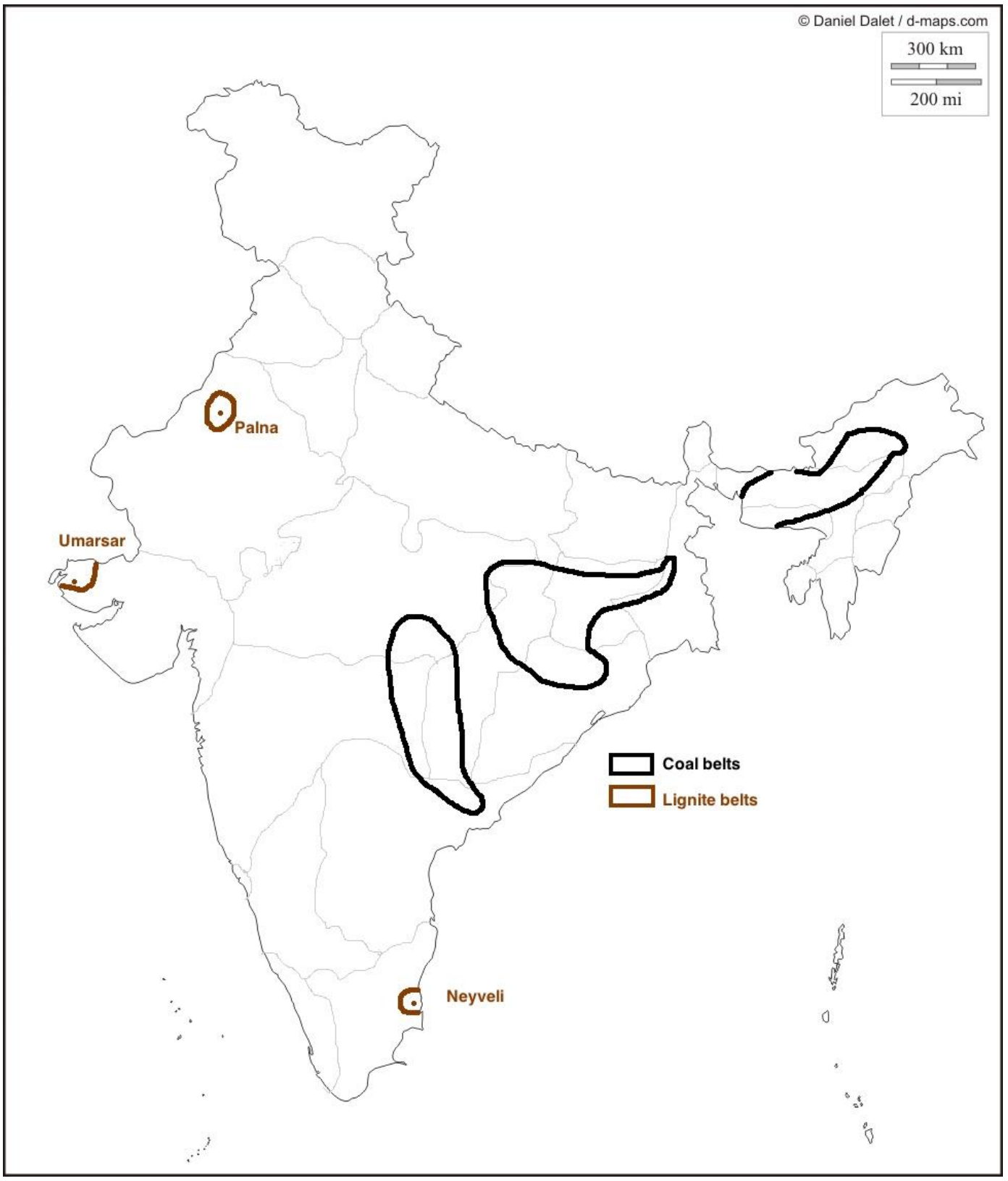
Distribution and Production

1. It has 2nd largest cattle heads (14%) in the world and largest (56%) buffalo heads.
2. MP > UP > Bihar > W Bengal in cattle heads.
3. In goats, Bihar > Rajasthan > W Bengal. Sheep are reared in Rajasthan > AP > TN > Karnataka. In poultry, AP > Bihar > W Bengal > TN.

Coal

Distribution and Production

1. In reserves, Jharkhand (29%) > Odisha (25%) > Chattisgarh (16%) > W Bengal (11%) > MP (8%) > AP (7%).

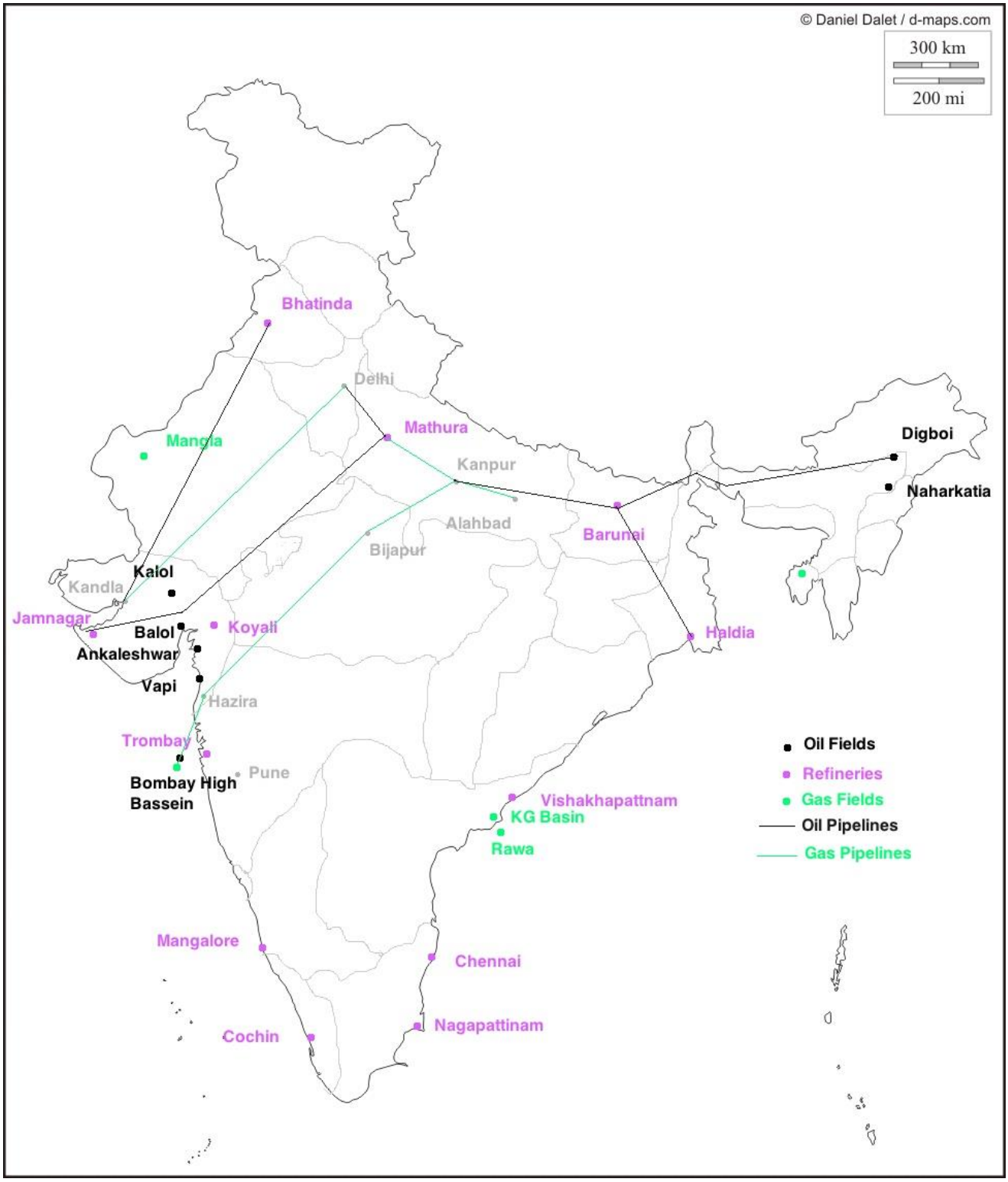


Uses

1. Bituminous coal is used in making coke and coal gas via destructive distillation.

Crude

Production and Distribution



1. Maharastra (65%) > Gujarat (18%) > Assam (15%).
2. Hazara - Bijapur - Jagdishpur pipeline is the longest pipeline in India.
3. Major refineries are at Koyali, Panipat, Mumbai, Manali, Mangalore.

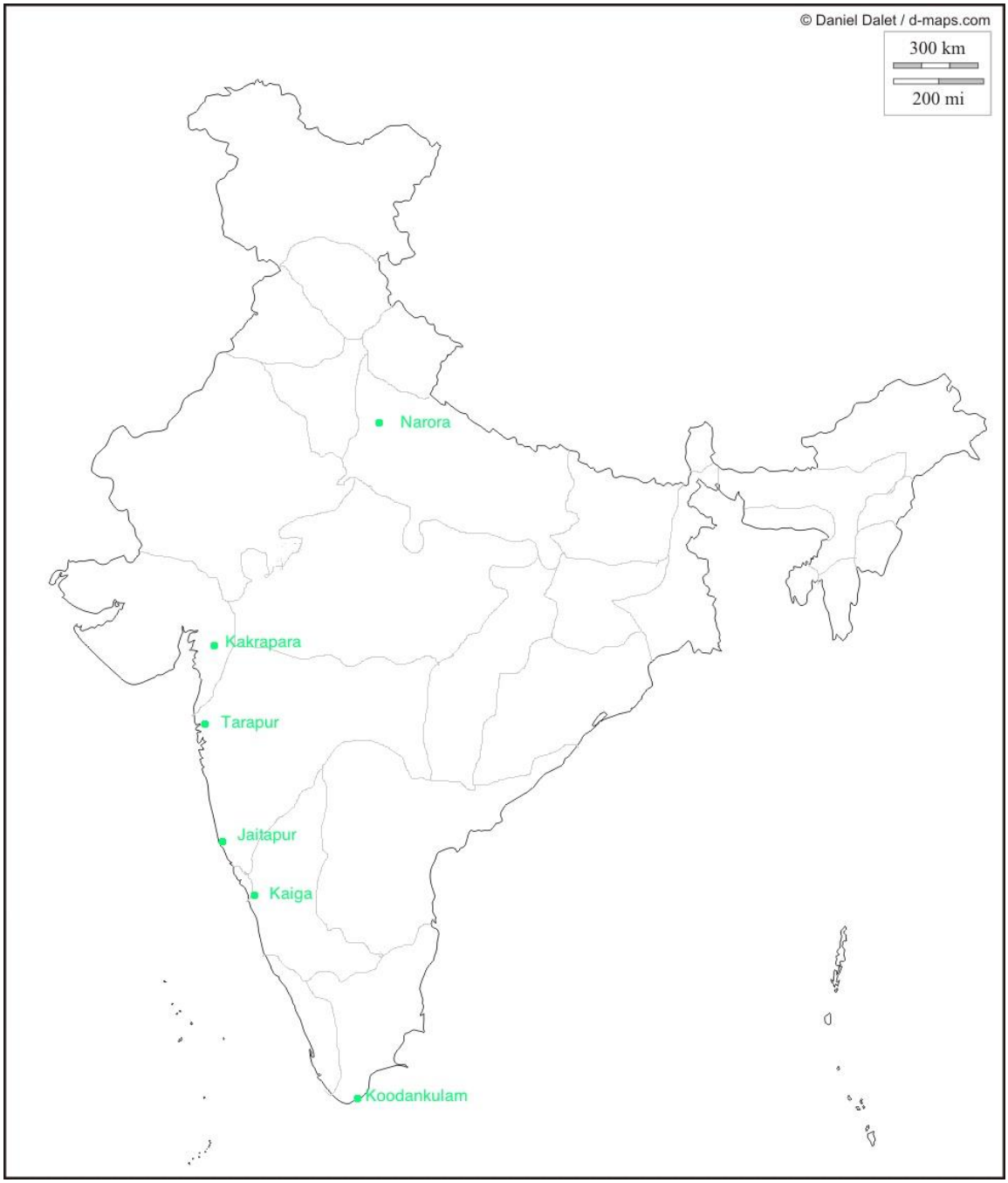
<u>Electricity</u>

Hydro Electricity

1. Hirakud ==> Mahanadi. Gandhi Sagar ==> Chambal. Dool Hasti ==> Chenab in Jammu. Jawahar Sagar ==> Rajasthan. Nagarjun Sagar ==> Krishna.

Nuclear Energy

Srikakulam - new reactor by 2016 in AP

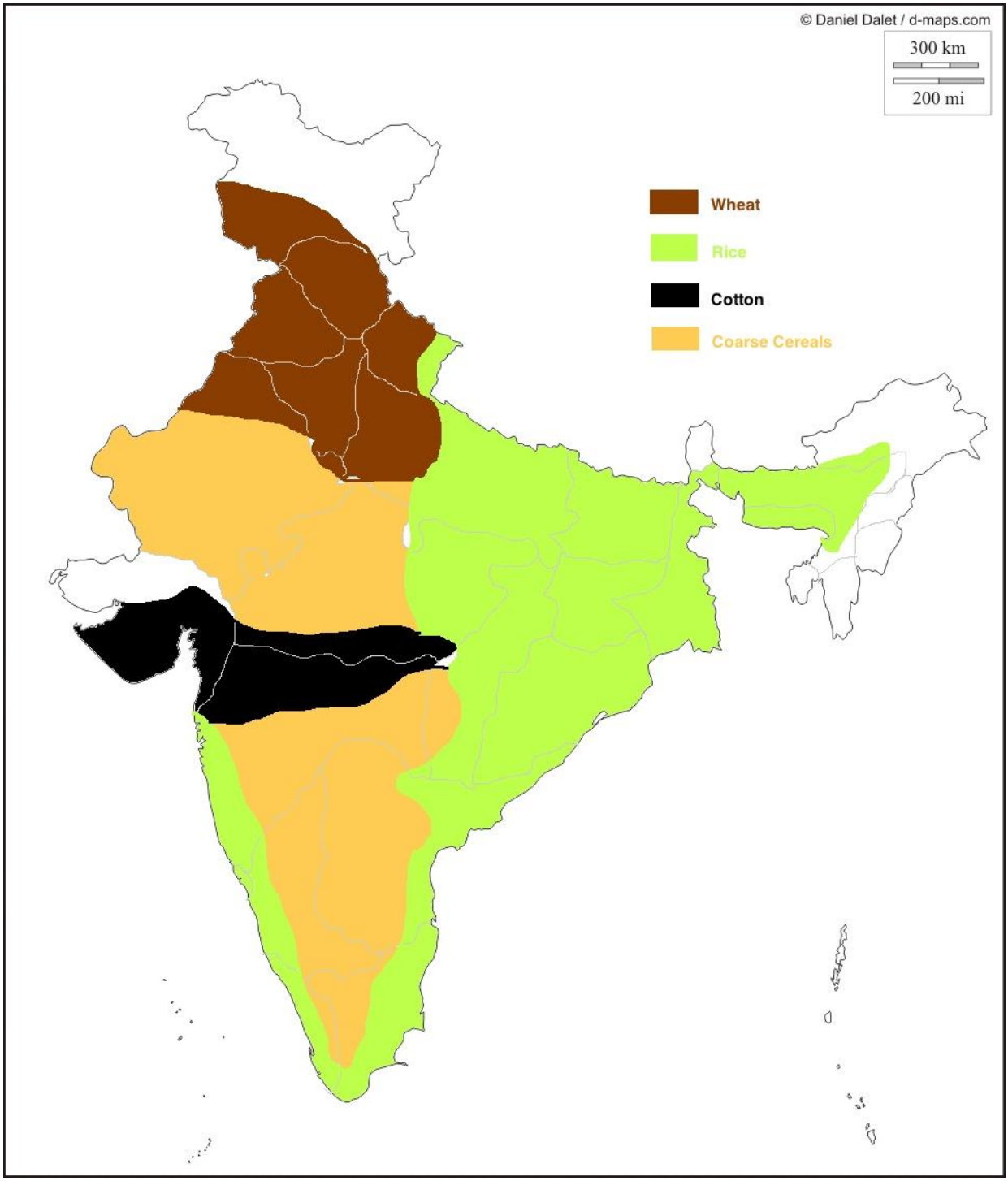


<u>Irrigation</u>

1. In terms of total canal area UP > AP > Haryana. Irrigation in tube wells is UP > Rajasthan > Punjab. Irrigation in tanks is TN > AP > Maharastra.

2. Wells have the highest area under coverage (45%) followed by canals (40%) and tanks (15%).

Agriculture



Agricultural Regions

1. Temperate himalaya region: The eastern himalayas are wet (rainfall > 250 cm) and have thick forest cover. Tea is cultivated on slopes and paddy in valleys. The western himalayas are dry and horticulture crops and dry fruit crops are main crops grown.

2. Northern dry region: Rainfall < 75 cm and includes UP, Rajasthan, west MP, Punjab, Haryana. Wheat is the main crop. Maize, cotton, sugarcane (only in irrigated area) and rice (only in irrigated area) are other crops.
3. Eastern wet region: Rainfall > 150 cm and includes W Bengal, Odisha, AP, TN, Chattisgarh, NE. Paddy.
4. Western wet or malabar region: Rainfall > 200 cm and includes coast of Kerala and Karnataka. Rice, coconut, cashew nuts, spices, rubber are grown.
5. Southern arid region: Rainfall < 100 cm. Coarse cereals like millet, bajra, ragi are grown.

Rice

1. It needs warm, humid climate and well distributed rainfall. Delta and valley soils with high clay content are most suitable.

Wheat

1. It needs cool temperature and moderate rainfall. Well drained loamy soils are ideal.

Maize

1. It requires warm climate with moderate rainfall. Alluvial and red souls are good.
2. UP, Bihar, Rajasthan, Punjab are main producers.

Bajra

1. It needs warm and dry climate. Sandy soils are good.
2. Rajasthan and Gujarat are main producers.

Jowar

1. It needs warm and dry climate but prolonged drought is harmful. Sandy soils are good.
2. Maharastra, Karnataka and MP are main producers.

Cardamom

1. Kerala > Sikkhim ? Karnataka.

Coffee

1. Karnataka (67%) > Kerala > TN.
2. Production has increased from 290K tonnes in 2009-10 to 320K tonnes in 2011-12.

Cotton

1. It needs warm and semi-arid conditions with abundant sunshine. Black soils are ideal.
2. Gujarat, AP and MP are main producers.

Pulses

1. They are dry crops mainly grown in MP, UP, Rajasthan.

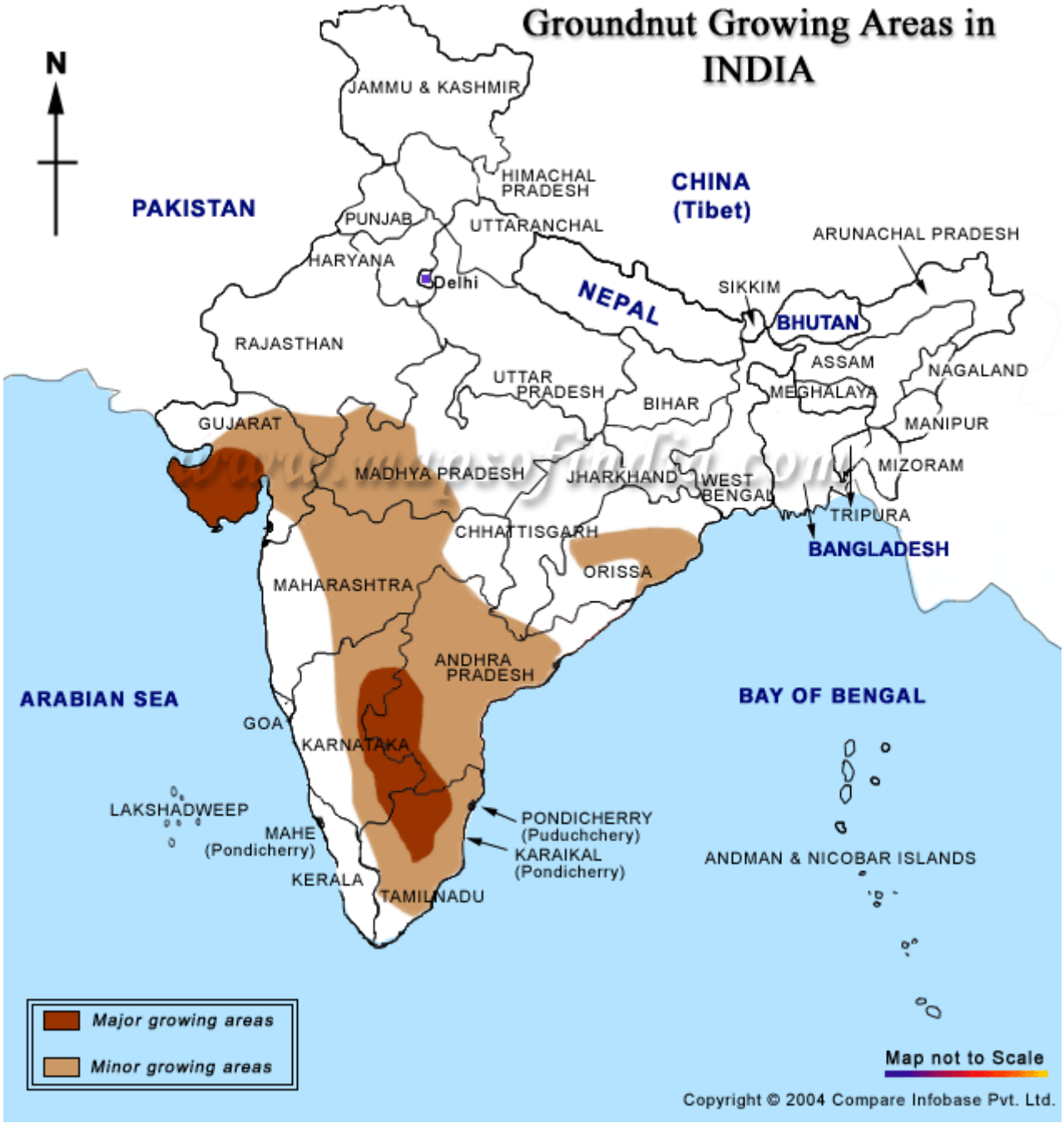
Tea

1. It needs heavy precipitation, good drainage and warm conditions.
2. Assam > W Bengal > TN.

Rubber

1. It needs warm and humid conditions.
2. It is grown in Kerala (90%) > TN.

Groundnut



Tobacco

1. It needs warm and semi-arid conditions.
2. AP > Karnataka.

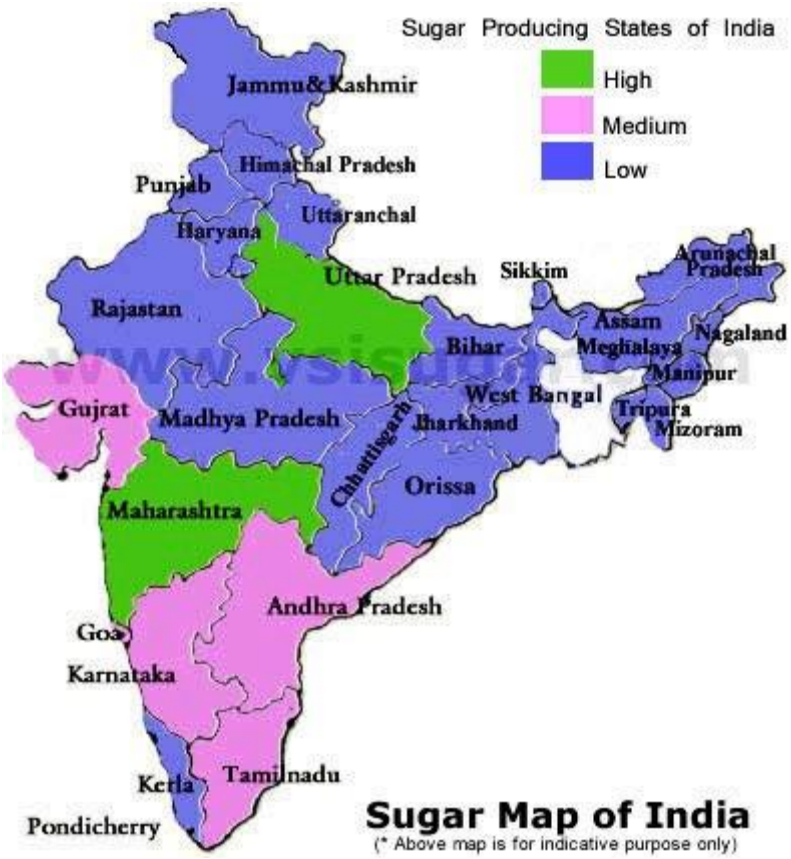
Rapeseed

Silk

1. Karnataka, J&K and AP are main producers.

Sugar

1. It needs irrigation and is planted in February and harvested in October. Monsoonal climate is good. It needs moderate rainfall.



Fisheries

1. Indian coastline is 8100 km, EEZ: 2 mm sq. km (west coast: 0.85 mm, east coast: 0.55 mm, A&N islands: 0.6 mm), continental shelf: 0.5 mm sq. km. Fisheries contribute 5% of agri-GDP and 0.6% of total GDP.
2. W Bengal (1.5 MT) > AP (1 MT) > Gujarat and Kerala (0.7 MT each).
3. In 2010, aquaculture production: 4 MT (3rd highest in the world), marine production: 4 MT. Per fisherman catch = 2 T per annum.

Ports

Mumbai Port

1. It is a natural harbor. A new port @ Nava Sheva has been developed to take off its burden.

Paradip Port

1. It is an artificial, deep water port @ confluence of Mahanadi and BoB. It has a capacity of 20 MT to handle coal and a water draft of 19 m to accommodate capesize vehicles (ships

originally too large to transit Suez canal ~ 150K - 400K deadweight tonnes). Deadweight tonnes is the max weight a ship can carry safely. It handles iron ore and coal.

Tuticorin port

1. It handles coal, fertilizers and iron ore.

Ennore Port

1. It is located near Chennai and is a corporate port (68% centre, 32% Chennai port trust stake). It has a capacity of 12 MT and draft of 13.5 m. It can handle 65K - 80K deadweight tonnes ships. It mainly handles coal.

Kolkata Port

1. Its a riverine port and has a deep water dock at Haldia.

Haldia Port

1. It has been developed to relive Kolkata. It also has an oil refinery and is a riverine port.

Kandla Port

1. It is a natural deep water tidal port. It handles petroleum, chemicals, iron and steel and textiles.

Vishakhpatnam Port

1. It is the largest port and has a capacity of 65 MT. It is the deepest land locked and protected port. It handles petroleum and iron ore.

New Mangalore Port

1. It is a deep water port. It handles iron ore, petroleum products, fertilizers.

Marmagaon Port

1. Located in Goa, it handles iron ore. It is 5th largest port.

Kochi Port

1. It is a natural harbor and handles tea, coffee and spices.

Chennai Port

1. It handles automobiles, iron ore, coal, fertilizers and petroleum products. Its capacity is 60 MT and is 2nd largest port in India. Its maximum draft is 16.5 m. It is a natural port.

<u>Iron & Steel</u>

Distribution & Production

1. India produced 35 MT of sponge iron and is world's largest producer. This is 30% of total steel capacity in India.

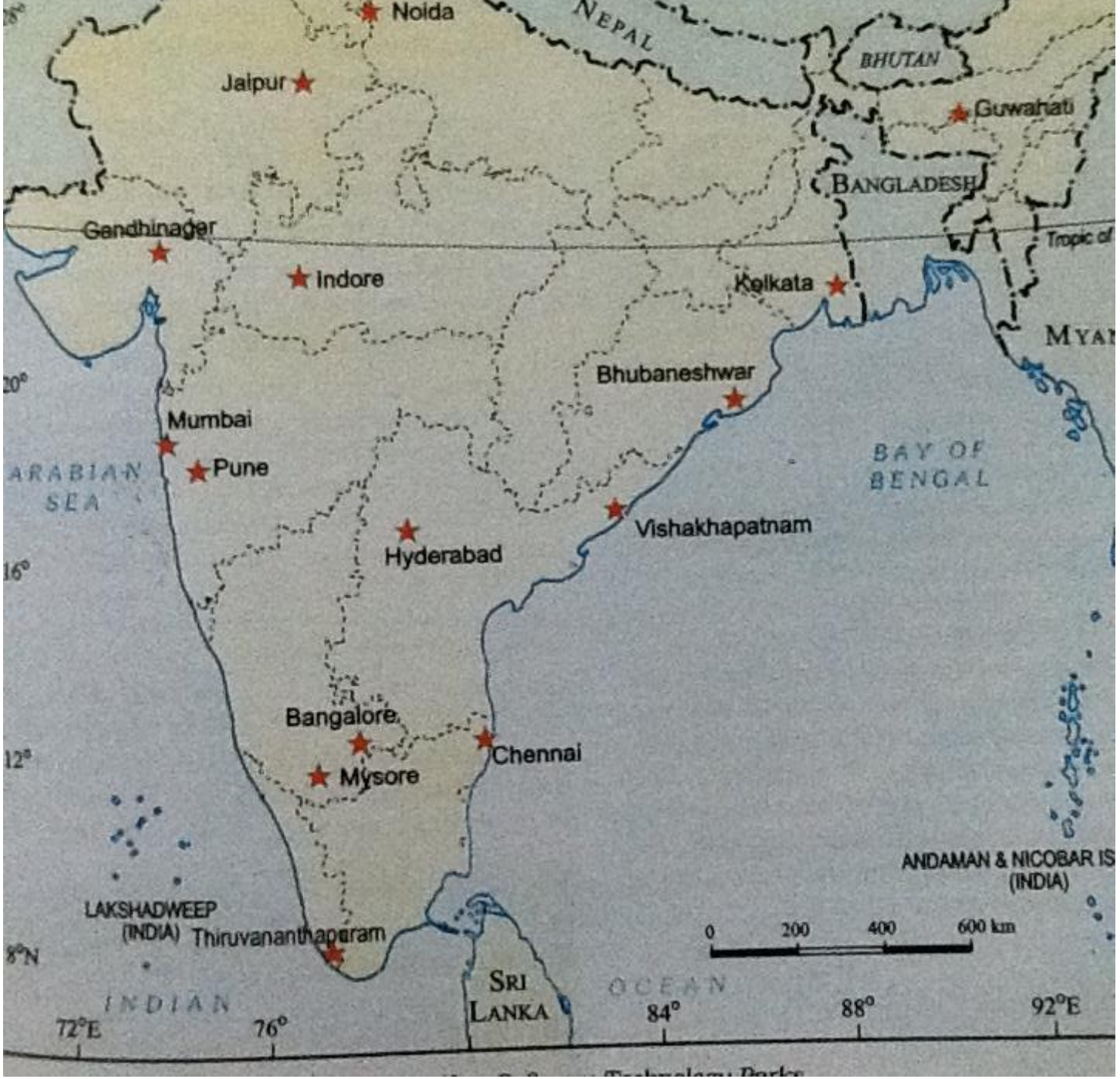

Noida
Jaipur
NEPAL
BHUTAN
Guwahati
BANGLADESH
Gandhinagar
Indore
Kolkata
Tropic of
Bhubaneshwar
Mumbai
Pune
ARABIAN SEA
BAY OF BENGAL
Vishakhapatnam
Hyderabad
Bangalore
Chennai
Mysore
ANDAMAN & NICOBAR IS (INDIA)
LAKSHADWEEP (INDIA)
Thiruvananthapuram
0 200 400 600 km
INDIAN OCEAN
SRI LANKA
72°E
76°
84°
88°
92°E
20°
16°
12°
8°N

Figure 5.7 : Elephants in their Natural Habitat

Apart from this, some other projects such as Crocodile Breeding Project, Project Hangul and conservation of Himalayan Musk deer have also been launched by the Government of India.

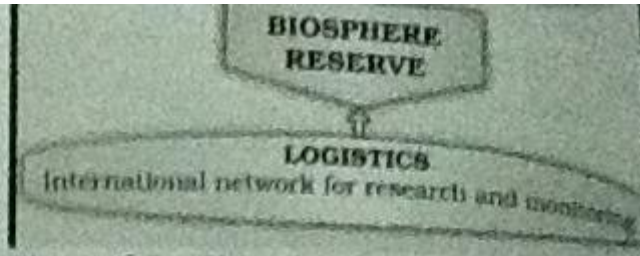
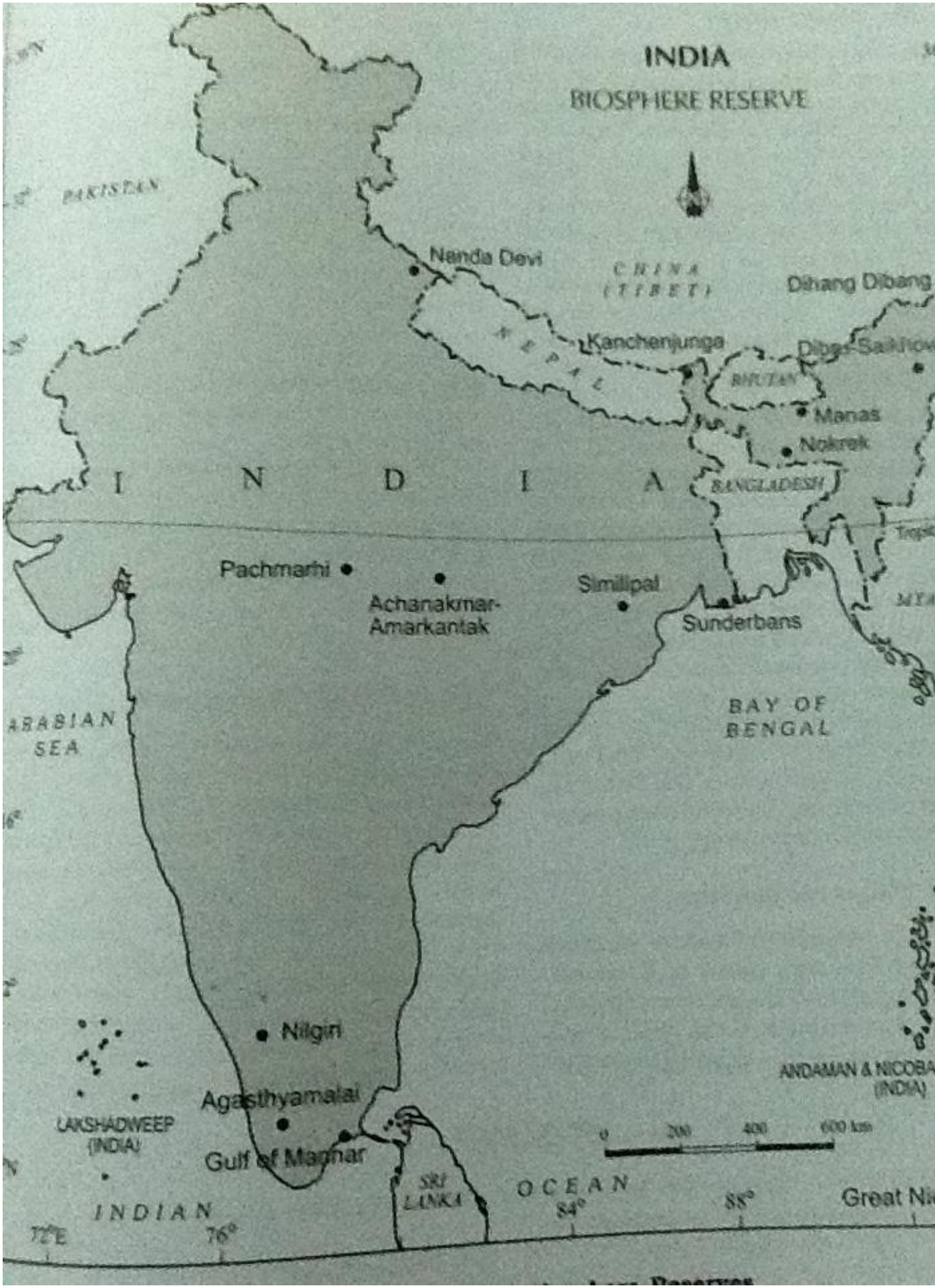


Figure 5.8 : Objectives of a Biosphere Reser

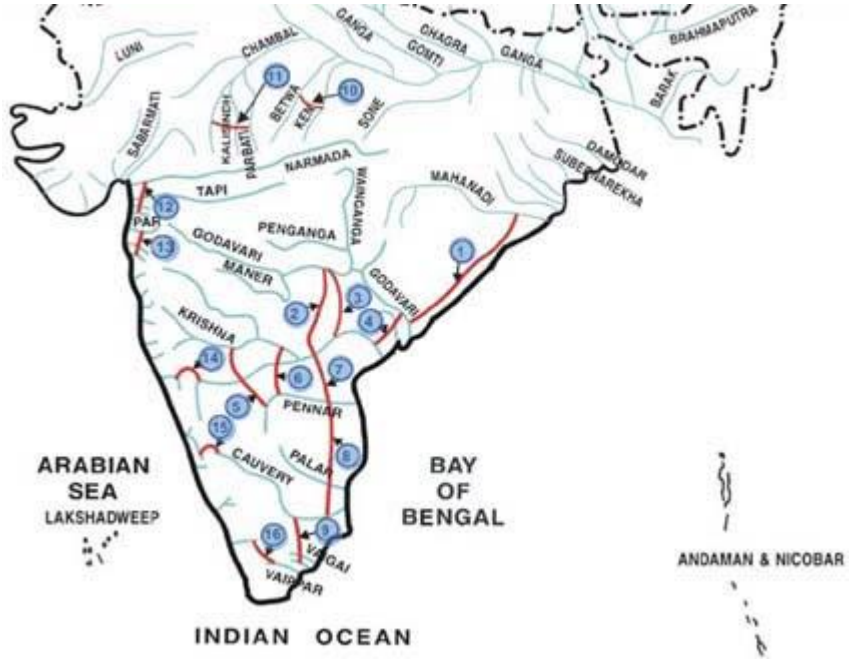
Table 5.1 : List of Biosphere Reserves

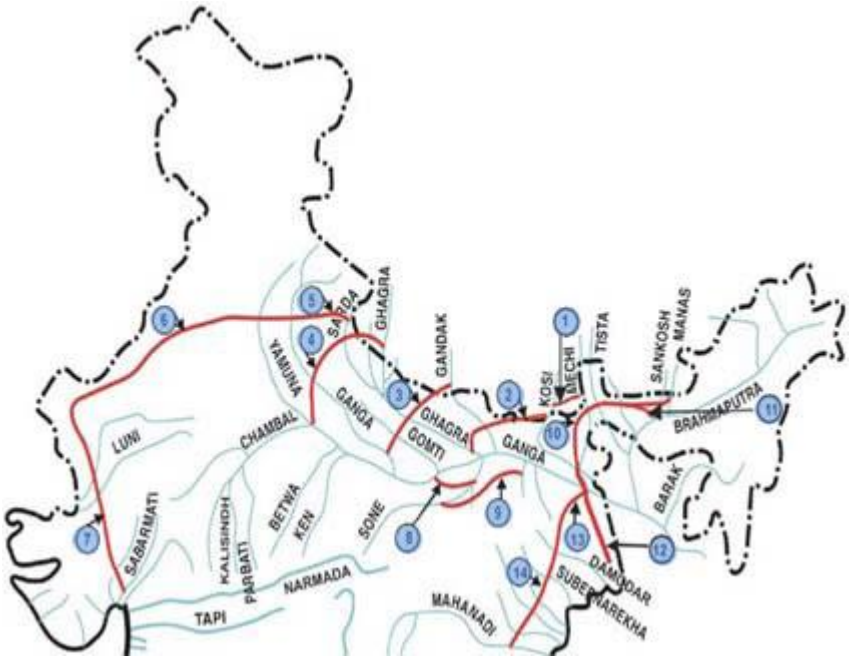
Sl. No.	Name of the Biosphere Reserve	Total Geographical Area (km²)	Location (States)
1.	* Nilgiri	5,520	Part of Wynad, Nagarhole, Bandipur and Mudum Nilambur, Silent Valley and Siruvani Hills (Tamil N Kerala and Karnataka)
2.	* Nanda Devi	2,236.74	Part of Chamoli, Pithoragarh and Almora dist (Uttar Pradesh)**
3.	Nokrek	820	Part of Garo Hills (Meghalaya)
4.	Manas	2,837	Part of Kokrajhar, Bongaigaon, Barpeta, Nalhari, Ka and Darrang districts (Assam)
5.	* Sunderbans	9,630	Part of delta of Ganges and Brahmaputra river system Bengal)
6.	* Gulf of Mannar	10,500	Indian part of Gulf of Mannar between India and Sri L (Tamil Nadu)
7.	Great Nicobar	885	Southernmost islands of the Andaman and Nicobar
8.	Simlipal	4,374	Part of Mayurbhanj district (Orissa)
9.	Dibru-Saikhowa	765	Part of Dibrugarh and Tinsukia districts (Assam)
10.	Dihang Dibang	5,111.5	Part of Siang and Debang valley in Arunachal Prade
11.	Kanchenjunga	2,619.92	Parts of North and West Sikkim
12.	Pachmari	4,926.28	Parts of Betul, Hoshangabad and Chindwara distri Madhya Pradesh
13.	Agasthyamalai	1,701	Agasthyamalai Hills in Kerala
14.	Achanakmar - Amarkantak	3,835.51	Parts of Anupur and Dindori district of Madhya Pr and parts of Bilaspur district of Chhattisgarh

* have been recognised by the UNESCO on World Network of Biosphere Reserves
Source : *Annual Report* (2004-05), Ministry of Environment and Forests, Government of India
** Now Chamoli, Pithoragarh and Almora districts are the part of Uttarakhand.


INDIA
BIOSPHERE RESERVE
PAKISTAN
Nanda Devi
CHINA (TIBET)
Dihang Dibang
NEPAL
Kanchenjunga
BHUTAN
Manas
Nokrek
BANGLADESH
I N D I A
Pachmarhi
Achanakmar-Amarkantak
Simlipal
Sunderbans
ARABIAN SEA
BAY OF BENGAL
Nilgiri
Agasthyamalai
Gulf of Mannar
LAKSHADWEEP (INDIA)
ANDAMAN & NICOBAR (INDIA)
SRI LANKA
INDIAN OCEAN
0 200 400 600 km
72°E
76°
84°
85°

River Linkage Plan





Himalayan development

The northern component would consist of a series of dams built along the Ganga and Brahmaputra rivers in India, Nepal and Bhutan for the purposes of storage. Canals would be built to transfer surplus water from the eastern tributaries of the

Ganga to the west. The Brahmaputra and its tributaries would be linked with the Ganga and the Ganga with the Mahanadi river. This part of the project would provide additional irrigation for about 220,000 square kilometres and generate about 30 gigawatts of electricity. In theory it would provide extra flood control in the Ganga and Brahmaputra river basins. It could also provide excess water for the controversial Farakka Barrage which could be used to flush out the silt at the port of Kolkata.

[edit]Peninsular development

The main part of the project would send water from the eastern part of India to the south and west. The southern development project would consist of four main parts. First, the Mahanadi, Godavari. Krishna and Kaveri rivers would all be linked by canals. Extra water storage dams would be built along the course of these rivers. The purpose of this would be to transfer surplus water from the Mahanadi and Godavari rivers to the south of India. Second, those rivers that flow west to the north of Mumbai and the south of Tapiwould be linked. Due to the irregular fluctuations in water levels in the region, as much storage capacity would be built as possible. The water would be used by the urban areas of Bombay and also to provide irrigation in the coastal areas of Maharashtra. Third the Ken and Chambal rivers would be linked in order to provide better water facilities forMadhya Pradesh and Uttar Pradesh. Finally a number of west-flowing rivers along the Western Ghats simply discharge into the Arabian Sea. As many of these as possible would be diverted for irrigation purposes. The Peninsular part of the project would provide additional irrigation to 130,000 square kilometres and generation an additional 4 gigawatts of power.

National Monsoon Mission

The main objectives of the National Monsoon Mission are:

(i) To build a working partnership between the academic and R&D organisations both national and international and the operational agencies to improve the operational monsoon forecast skill over the country.

(ii) To set up a state of the art dynamic modelling framework for improving the prediction skill of:

a. Seasonal and extended range prediction system (16 days to one season)

b. Short to medium range prediction system (up to 15 days).

The Mission has a budget of Rs.400 crore for five years to support the research work related to the mission.

The National Monsoon Mission after its implementation will help to implement a dynamic prediction system for the prediction of monsoon in all time scales, short range to seasonal time scale at appropriate spatial scales with improved prediction skill. The forecasts based on this prediction system will cater to the needs of various sectors like agriculture, water resources management, power generation, disaster management, tourism and transport.

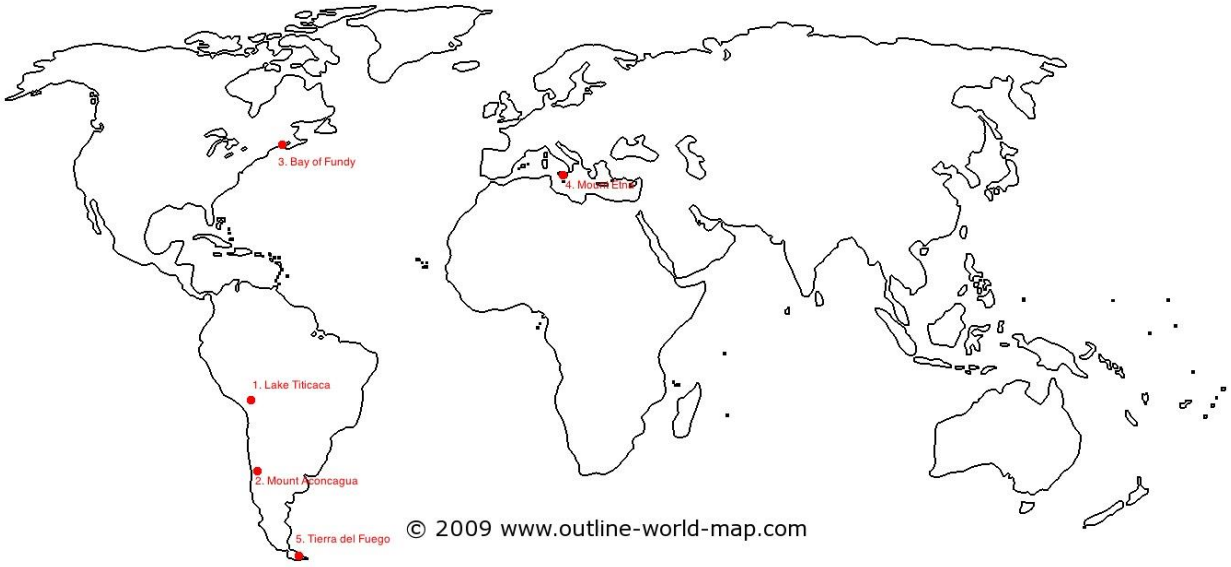
The programme will be undertaken through two sub-missions on two different time scales, (i) extended range to seasonal time scale to be coordinated by the Indian Institute of Tropical Meteorology (IITM) Pune/ESSO and (ii) short to medium range scale, to be coordinated by the National Centre for Medium Range Weather Forecasting (NCMRWF)/ESSO. The Indian National Center for Ocean Information Services (INCOIS)/ESSO will provide the ocean observations for assimilation and the India Meteorological Department/ESSO will implement the research outcome of the efforts in operational mode. The Mission will support focused research by national and international research groups with definitive objectives and deliverables to improve the models in the short, medium, extended and seasonal range scales at appropriate spatial scales. The Mission will also support observational programmes that will result in better understanding of the processes. The progress of the National Monsoon Mission will be reviewed and monitored by two committees. The Scientific Review and Monitoring Committee (SRMC) will review the research proposals from different research groups and monitor the progress of the research work. The Scientific Steering Committee (SSC), which is the apex body will steer the programme, advise and direct midcourse corrections, if any.

World Maps

Map Set 1

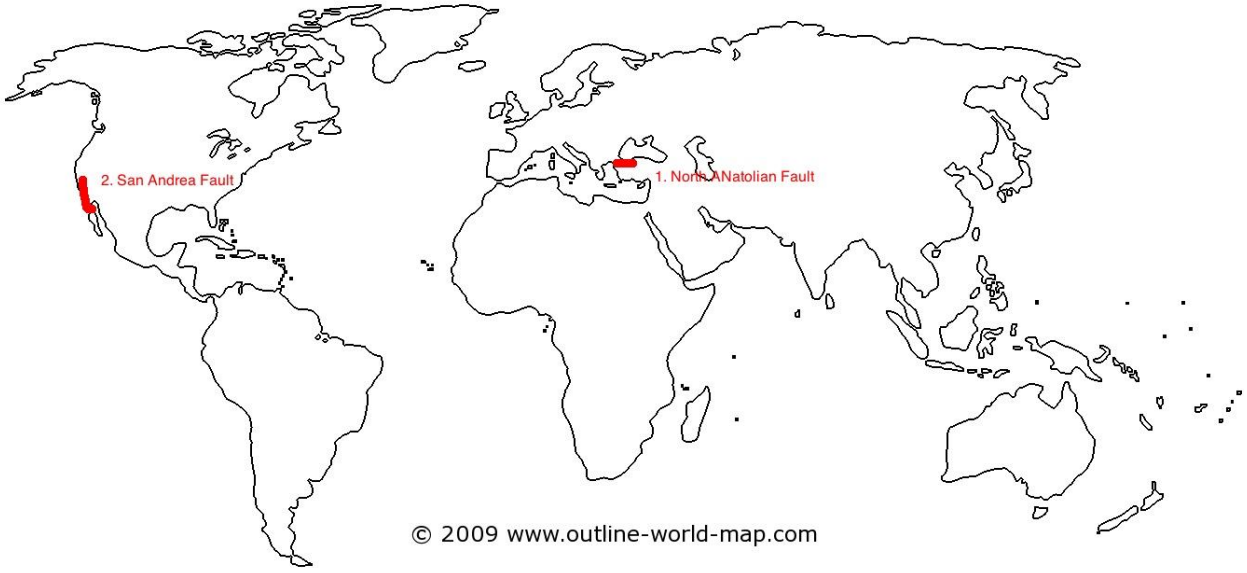
1. Lake Titicaca: Largest lake in the world located on Peru-Bolivia border.

2. Mount Aconcauga: Highest peak outside Asia located in Chile.
3. Bay of Fundy: Highest tidal range in the world located on east coast of Canada below Gulf of Lawrence.
4. Mount Etna: Highest volcano of Europe located in Sicily.
5. Tierra del Fuego: The region has fiord coastline (glaciated).



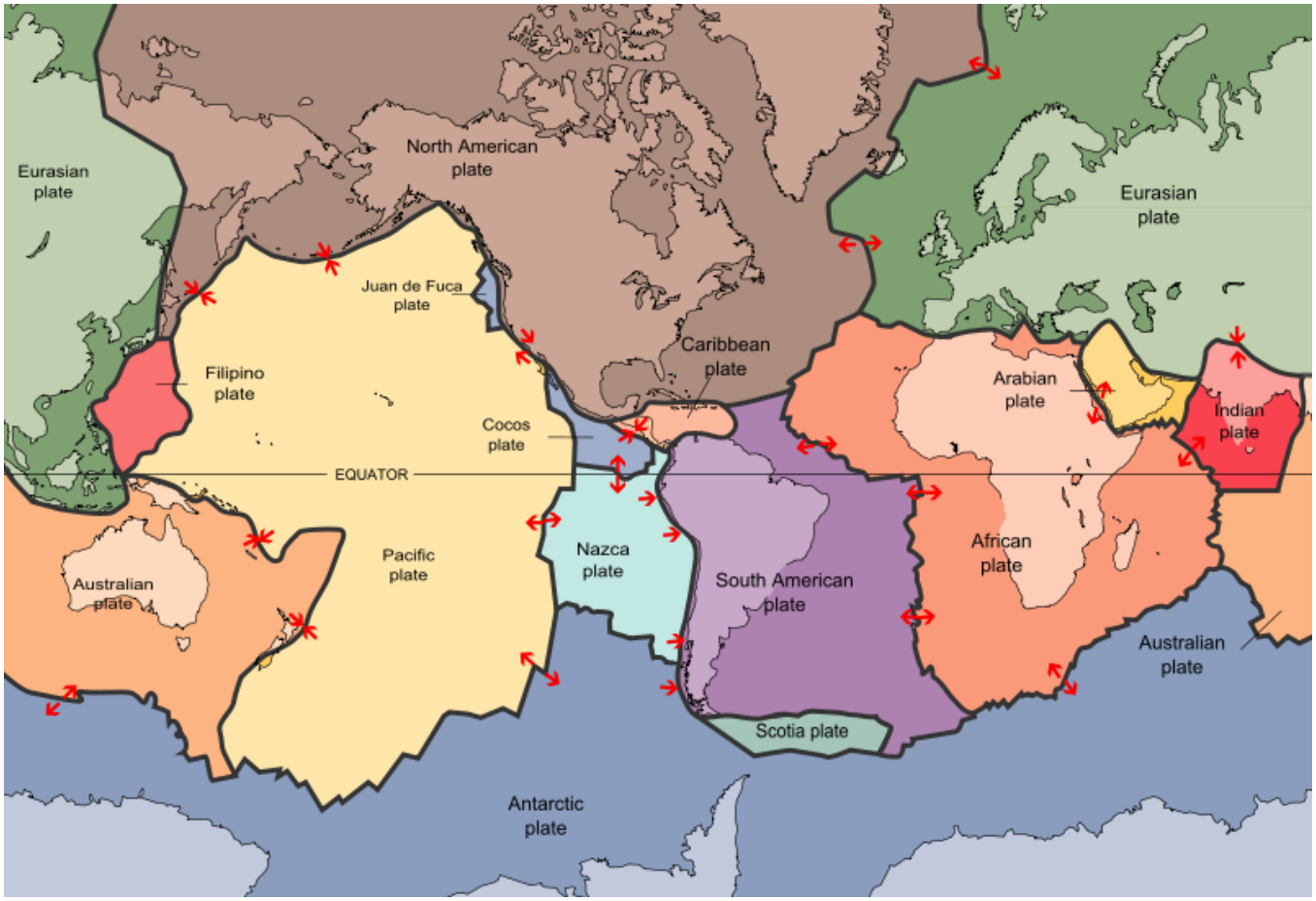
Map Set 2

1. North Anatolian Fault: Below Black sea in N part of Turkey.
2. San Andrea Fault: Runs along California.

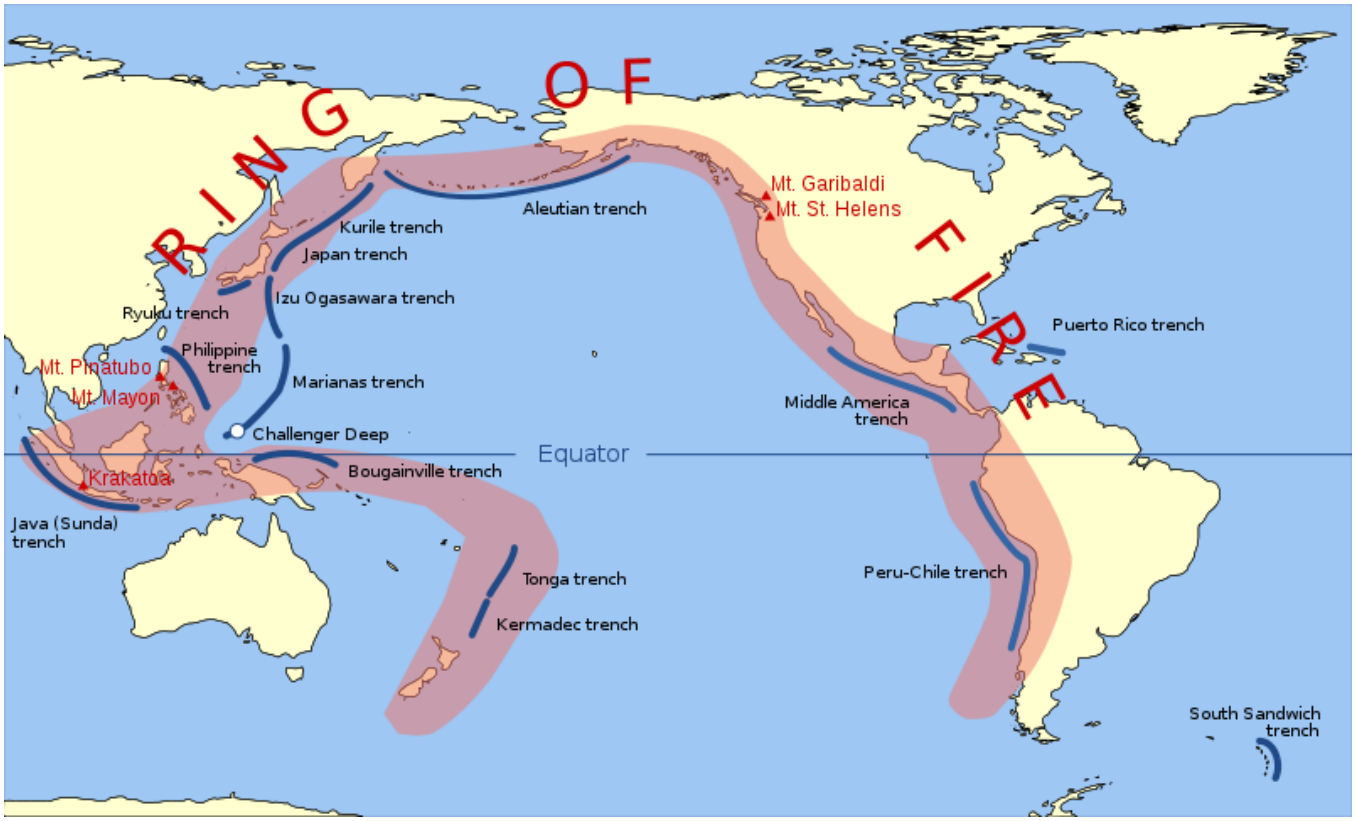


1. Nazca plate, Cocos plate, Caribbean plate, Filipino plate: Movement of S American plate against Nazca plate, movement of caribbean plate against Cocos plate, movement of Pacific plate against N American plate, movement of Pacific plate against the Filipino plate and the Australian plate cause earthquakes and volcanoes on the ring of fire.

Tectonic Plates

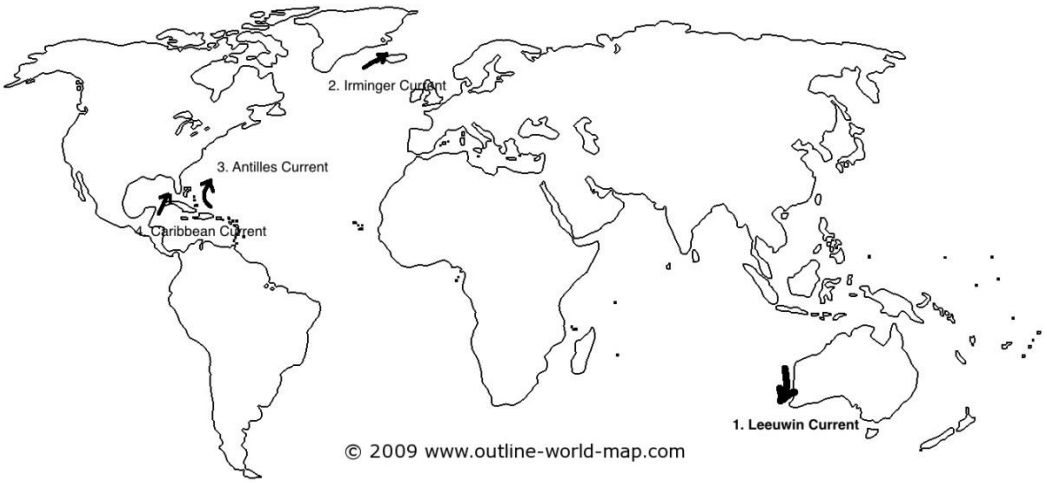

Eurasian plate
North American plate
Eurasian plate
Juan de Fuca plate
Caribbean plate
Filipino plate
Arabian plate
Indian plate
Cocos plate
EQUATOR
Pacific plate
Nazca plate
African plate
Australian plate
South American plate
Australian plate
Scotia plate
Antarctic plate

Ring of Fire



Mapset 3

1. Leeuwin current: It runs counter to west Australian current and weakens during Al-Nino condition.
2. Irminger current: It is an extension of north Atlantic drift towards the west coast of Iceland.
3. Antilles Current: It passes through the Atlantic side of Caribbean.
4.

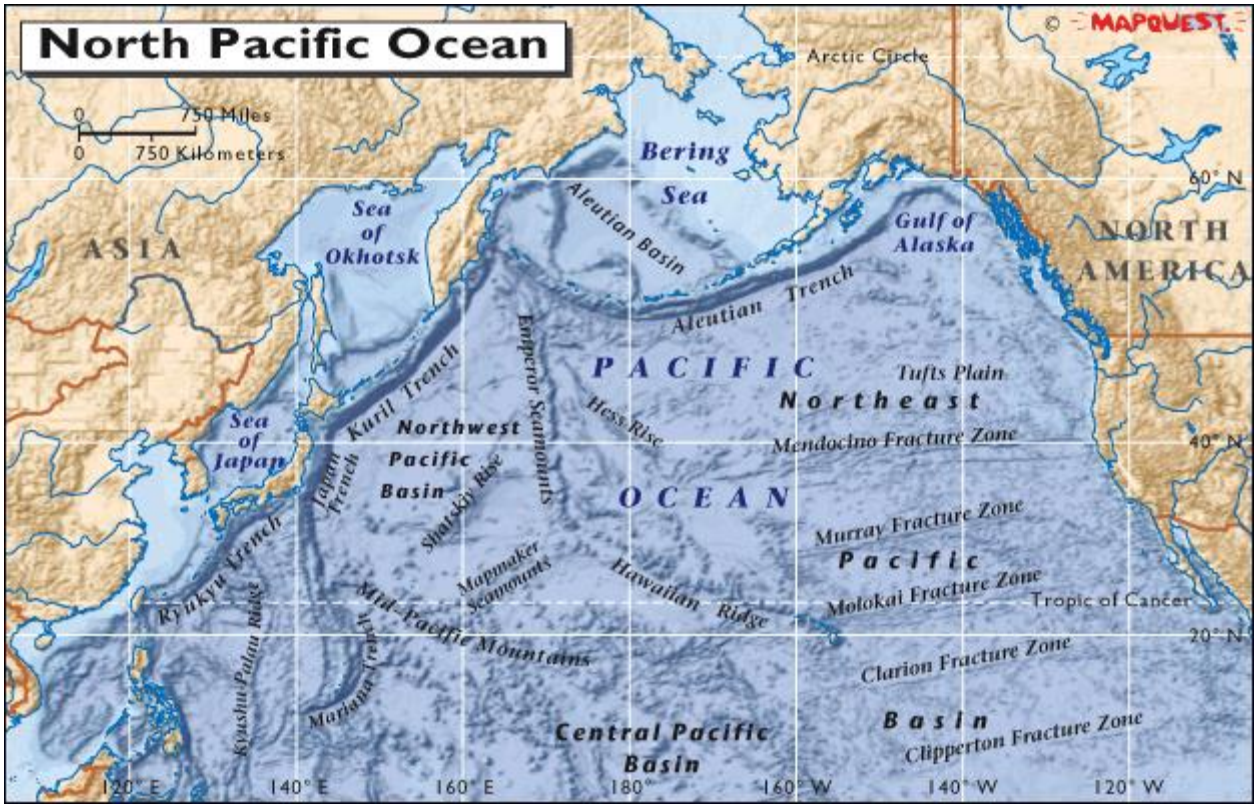


Hydrosphere

Ocean Floor

1. Continental shelf: Angle is 1º, depth is 120-150 m and it extends generally 70 km into the sea. But this varies a lot - in west coast of S America the continental shelf is virtually absent while in east coast of N America it is 120 km wide. In Bay of Bengal, it is very wide as well.
2. Continental slope: @ the end of continental shelf, slope steepens to 5º. Its end marks the end of continental blocks.
3. Continental rise: @ the end of continental slope, slope becomes gentle again to 0.5º to 1º. Its end marks the end of continental margin.
4. Abyssal plains: Slope is 1:1000. They occupy ~40% of the ocean floor. They are more common where land derived sediments are in great supply. The irregular topography gets buried.
5. Abyssal hills, sea mounts & guyots: Sea hills on abyssal plains rising ≤ 1000 meters from the floor are called Abyssal hills. Sea hills on abyssal plains rising > 1000 meters from the floor are called sea mounts. Guyots are seamounts which have flat tops. All of them are generally of volcanic origin.
6. Submarine trenches, deeps and canyons: Long narrow and steep depression on abyssal plain is called a trench. It is usually found alongside a folded hill and results from fault or down folding. The deeper trenches (> 5500 meters) are called deeps. Canyons are deep concave gorges on continental shelf, slope or rise. They are generally of 3 types - (a) beginning @ the edge of continental shelf and extend down the continental slope to great depths. (b) beginning @ the mouth of the river itself and extending over the continental shelf. (c) those which have a dendritic appearance and cut across the shelf and slope as well. Sometimes they form a fan @ the base.
7. Banks, shoals and reefs: A bank is generally a flat topped elevation located in the continental margin. The depth of water over a bank is small but enough for navigation. During the pleistocene ice age, the tops of these banks were eroded by glaciers. Banks are host to most productive fisheries grounds in the world. Shoals are detached elevations @ shallow depth. They are dangerous for navigation. Reefs are organic deposits forming a ridge.
8. Strait, sound / channel: Both straits and channels are narrow pieces of water connecting two larger bodies of water. Straits is narrower than a channel or sound.

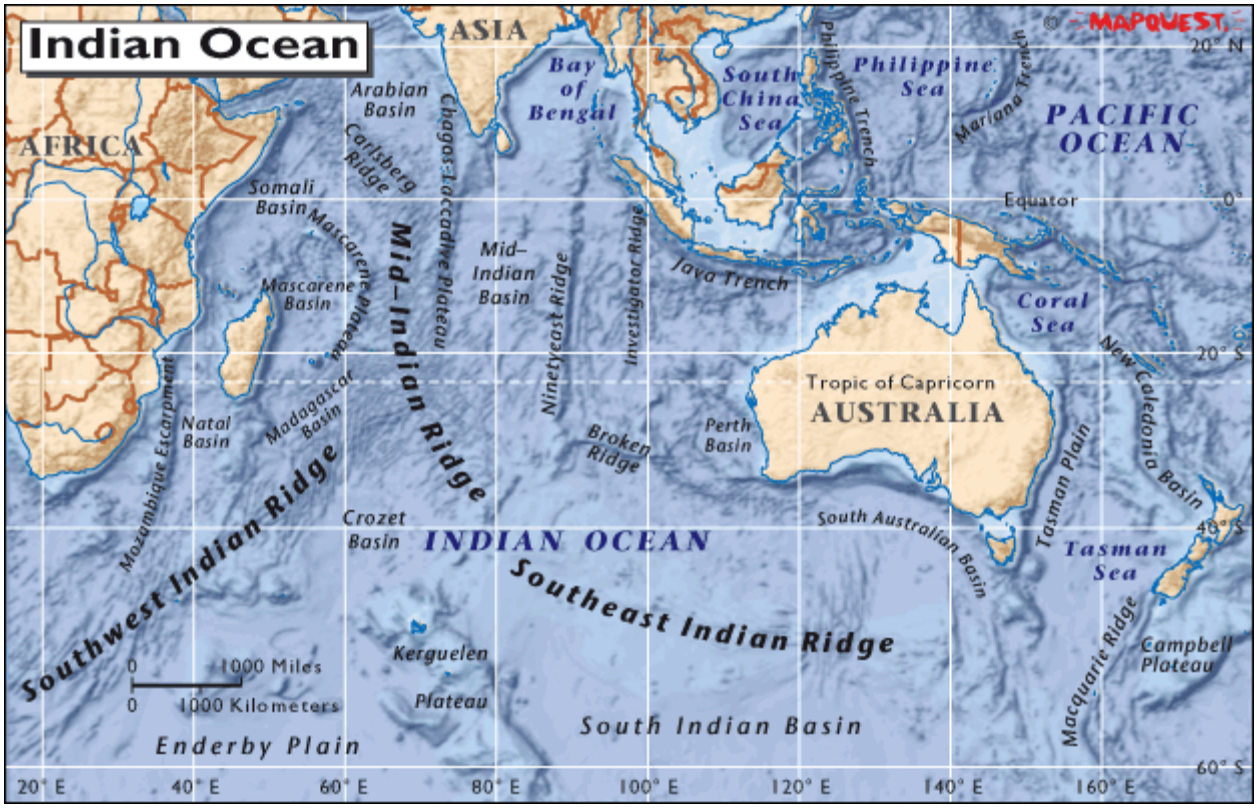
Ocean Floor Maps


North Pacific Ocean
© MAPQUEST.
Arctic Circle
0 750 Miles
0 750 Kilometers
Bering Sea
Sea of Okhotsk
ASIA
Aleutian Basin
Aleutian Trench
Gulf of Alaska
NORTH AMERICA
60° N
PACIFIC
OCEAN
Tufts Plain
Northeast Pacific Basin
Mendocino Fracture Zone
40° N
Sea of Japan
Kuril Trench
Northwest Pacific Basin
Emperor Seamounts
Hess Rise
Japan Trench
Shatsky Rise
Murray Fracture Zone
Ryukyu Trench
Mapmaker Seamounts
Hawaiian Ridge
Molokai Fracture Zone
Tropic of Cancer
Kyushu-Palau Ridge
Mid-Pacific Mountains
20° N
Clarion Fracture Zone
Mariana Trench
Central Pacific Basin
Clipperton Fracture Zone
120° E
140° E
160° E
180°
160° W
140° W
120° W


South Pacific Ocean
© MAPQUEST.
Central Pacific Basin
Northeast Pacific Basin
East Pacific Rise
Peru Basin
Peru-Chile Trench
SOUTH AMERICA
0° Equator
Coral Sea
20° S
Tropic of Capricorn
New Hebrides Trench
Tonga Trench
AUSTRALIA
New Caledonia Basin
Louisville Ridge
Sala y Gomez Ridge
Nazca Ridge
PACIFIC OCEAN
Challenger Fracture Zone
Tasman Plain
Kermadec Trench
Southwest Pacific Basin
Southeast Pacific Basin
Tasman Sea
40° S
Campbell Plateau
Macquarie Ridge
Eltanin Fracture Zone
Udintsev Fracture Zone
Humboldt Plain
0 750 Miles
0 750 Kilometers
60° S
Pacific-Antarctic Ridge
140° E
160° E
180°
160° W
140° W
120° W
100° W
80° W


North Atlantic Ocean
© MAPQUEST.
Arctic Circle
Norwegian Sea
Hudson Bay
60° N
Northwest Atlantic Mid-Ocean Canyon
Imarssuak Seachannel
Reykjanes Ridge
Maury Seachannel
North Sea
NORTH AMERICA
EUROPE
Biscay Plain
Sohm Plain
ATLANTIC OCEAN
Mid-Atlantic Ridge
40° N
ASIA
Mediterranean Sea
Hatteras Plain
Bermuda Rise
Gulf of Mexico
Cape Verde Plain
Tropic of Cancer
20° N
Puerto Rico Trench
0 750 Miles
0 750 Kilometers
AFRICA
Caribbean Sea
Middle America Trench
Demerara Plain
Doldrums Fracture Zone
PACIFIC OCEAN
SOUTH AMERICA
100° W
80° W
40° W
20° W
0°
20° E
40° E


80° W
60° W
40° W
20° W
0°
20° E
40° E
Pernambuco Plain
Ascension Fracture Zone
Peru-Chile Trench
SOUTH AMERICA
AFRICA
Angola Plain
20° S
Tropic of Capricorn
Walvis Ridge
Mid-Atlantic Ridge
Natal Basin
Rio Grande Rise
Cape Plain
PACIFIC OCEAN
Agulhas Plateau
40° S
Argentine Plain
Agulhas Basin
ATLANTIC OCEAN
Humboldt Plain
Falkland Plateau
South Sandwich Trench
South Georgia Ridge
Atlantic-Indian Ridge
0 750 Miles
0 750 Kilometers
America-Antarctic Ridge
60° S
Weddell Plain
South Atlantic Ocean
© MAPQUEST.

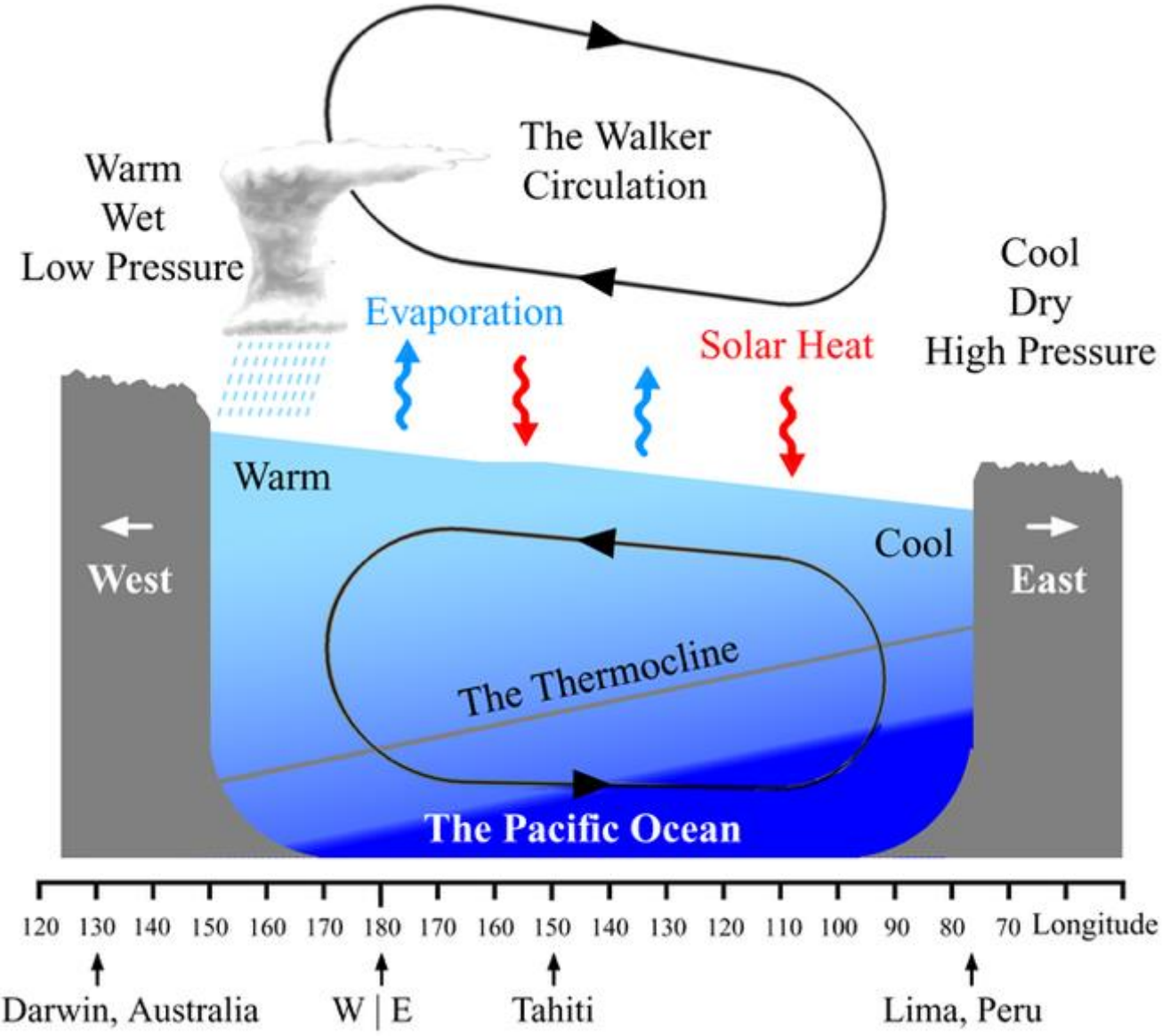


Ocean Waters and Their Circulation

1. Annual range of temperature is lowest in Pacific due to its larger size. Also the range is greater in N hemisphere than in S hemisphere due to more expanse of water in south.
2. In tropical zones, western sections of the oceans are warmer than the eastern sections as currents and winds blow from east to west (they carry with them water vapor hence the latent heat of evaporation is lost by the eastern sections). In temperate zones, westerlies prevail so the eastern sections of oceans are warmer than the western sections of the oceans.
3. Ice floes vs ice bergs: The extreme north and south oceans have ice fields. During summers they move polewards and during winters they move equator-wards. In summer the marginal ice fields break away and begin to drift towards equator. These are called ice floes. In summers only parts of glaciers also break away from its tongue as it reaches the sea and begin to drift towards equator. They are called ice bergs.
4. Sub-surface temperature: There is a decrease in temperature with increase in depth. Up to a depth of 100 meters, there is no change in temperature. Below that up to 1800 meters, it falls to 2º C. From 1800 meters to 4000 meters the temperature falls from 2ºC to 1.6ºC. The rate of decrease is higher @ equator than @ poles (surface temperature is higher @ equator).
5. Upwelling & downwelling: Upwelling is when the warm surface water is replaced by cooler water from the depth which is rich in nutrients and hence provides good fisheries ground. Upwelling leads to dry coastal areas. In tropical zone it takes place as the trade winds and N & S equatorial currents drag the surface water from east of the ocean to the

west. Thus a vacancy is created in the east @ the surface and water from below moves up along the coast of S America. Downwelling is the opposite i.e. surface water sinking to the ground when it becomes more saline and dense. Downwelling causes O_2 to mix in layers below.

6. Distribution of salinity: Highest salinity is found near tropics and decreases towards equator (heavier rains) and poles (less evaporation). @ poles, the freezing of ice leaves salt in the water which becomes more saline, dense and hence sinks. So most saline areas in poles are deep waters and surfaces have low salinity. In general, salinity decreases with depth. In middle latitudes, it increases up to 35 meters and thereafter decreases. In tropics it decreases with depth.
7. Al-Nino & La-Nina: La-Nina condition is the strengthening of normal condition in the Pacific. In the normal condition, there is low pressure over west Pacific ocean or Indian ocean (Australia coast) and high pressure over east Pacific ocean (S America coast). The ocean temperature is cooler near S America due to upwelling. In Al-Nino, these conditions are reversed.



The **Walker circulation**is seen at the surface as easterly trade winds which move water and air warmed by the sun towards the west. The western side of the equatorial Pacific is characterized by warm, wet low pressure weather as the collected moisture is dumped in the form of typhoons and thunderstorms. The ocean is some 60 cm higher in the western Pacific as the result of this motion. The water and air are returned to the east. Both are now much cooler, and the air is much drier. An El Nino episode is characterised by a breakdown of this water and air cycle, resulting in relatively warm water and moist air in the eastern Pacific.

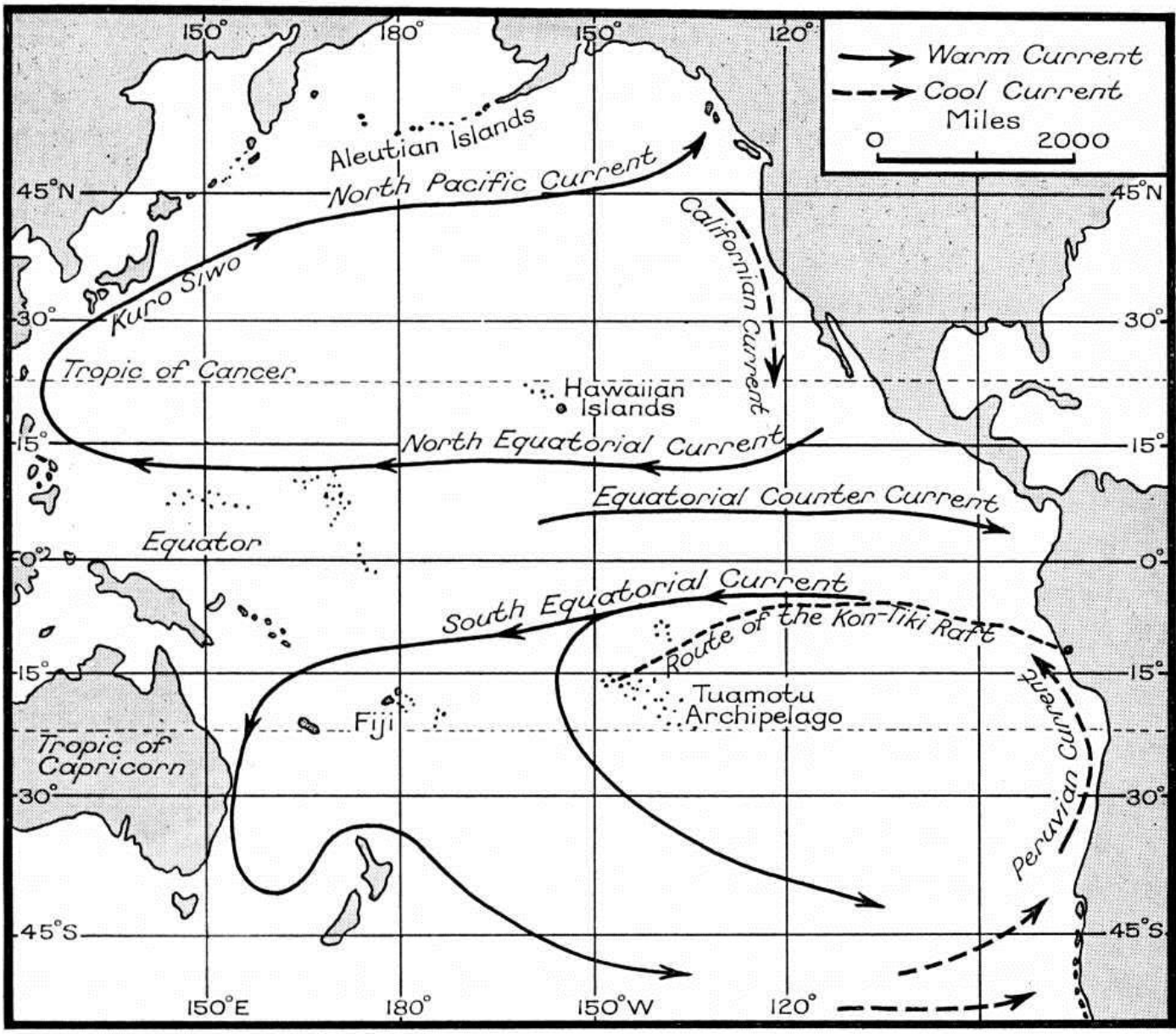
8. Sound speed with depth: It decreases with decreasing temperature, pressure and salinity. Temperature decreases rapidly in the upper kilometer of the ocean and dominates in this region. Thereafter the temperature change with depth is small and speed is determined by the pressure increase with depth. Vertical changes of salinity are too small to have an impact.
9. Waves: The size and force of the wave depends on - (a) velocity of the wind. (b) duration of the wind. (c) distance over which the wind blows unhindered (the fetch). If the water is deep

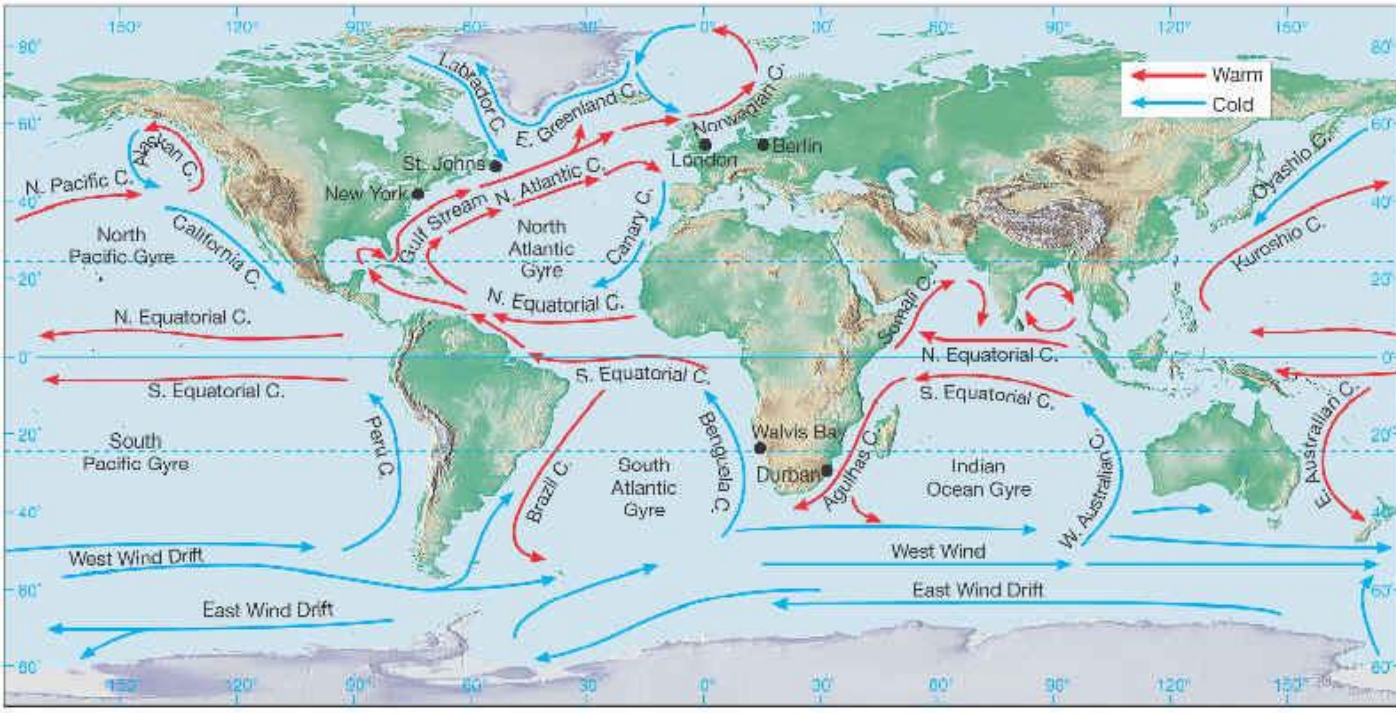
(so that bottom doesn't interfere with the wave), winds blow over long distances for long, waves are bigger.

10. Sea wave, swell wave, surf wave, swash and backwash: Normally several trains of differing wave lengths and directional movements of waves occurs in seas. This overall irregular and chaotic wave pattern is called sea. If the wave moves away from the disturbance zone into a smooth zone, there appears a uniform pattern of equivalent wavelength and amplitude. This is called swell. But as the swell reaches shore, the pattern gets disturbed due to friction from the shallow sea floor and the wave breaks. The lower part of the wave travels more slowly than the upper part so its height increases, they crowd together and eventually break. This breaking is called surf. Once the wave breaks the top fallen over part is carried over to the shore. This is called swash. As the water goes back to the sea it is called backwash.

Ocean Currents

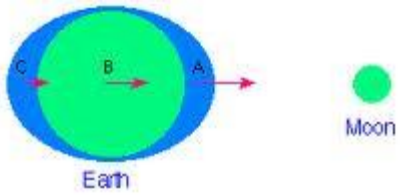
1. In lower altitudes, warm currents flow on the eastern shores while cold currents flow on the western shores of the continents.
2. In middle latitudes, warm currents flow along the western shores of the continents while cold currents on the eastern shores.
3. Drift is slower and less clearly defined than a current which is slower and less clearly defined than a stream.
4. Gyres: They are the loops of the currents formed in the oceans. N Atlantic gyre is also called Sargasso sea (due to presence of seaweed called Saragossa on the surface). S Atlantic gyre is called Navigator gyre (after the Portuguese prince Henry, the navigator), N Pacific gyre is called Turtle gyre, S Pacific gyre is called Hyerdahl gyre, Indian ocean gyre is called Majid gyre.
5. Deep water currents: They are created by density differences which in turn are created by temperature and salinity difference (hence they are also called thermo-haline circulations). They are much slower (10-20 km per year) and bigger in mass than the surface currents.
6. Ekman spiral and transport: When the wind pushes the water in its direction, the surface layer begins to move but gets deflected towards the right (in N hemisphere) due to Coriolis force. This surface layer pulls along the layer immediately below with it. But as that layer moves it gets deflected further to right. Successive layers move progressively right until a layer moves 90º to the direction of the wind. This is called Ekman spiral. Ekman transport is the movement of the 90º layer.
    - (A) There r 2 types of ocean circulations- Wind induced and Thermohaline. Thermohaline circulations are due to changes in density (which in turn is caused due to changes in temperature and salinity...hence the name). Thermohaline circulations can be both - Vertical(i.e upwelling or downwelling eg: when Gulf stream meets East n West greenland currents) or Horizontal(eg: Density differences btw Mediterranean Sea and Atlantic Ocean cause a surface current flowing into Mediterranean and sub-surface current flowing out of it).
    - (B) Ekman Transport is a result of friction and coriolis force on all moving objects i.e winds and ocean currents. Coriolis force is a fn. of velocity and velocity of winds increases as we go higher up due to reduced friction. hence more coriolis force which implies more rightward movement in the Northern Hemisphere. Thus a schematic of the wind velocity as a fn. of its height would be a spiral called Ekman Spiral.


Warm Current
Cool Current
Miles
0
2000
150°
180°
150°
120°
45°N
30°
15°
0°
15°
30°
45°S
150°E
180°
150°W
120°
Aleutian Islands
North Pacific Current
Kuro Siwo
Californian Current
Tropic of Cancer
Hawaiian Islands
North Equatorial Current
Equatorial Counter Current
Equator
South Equatorial Current
Route of the Kon-Tiki Raft
Tuamotu Archipelago
Fiji
Tropic of Capricorn
Peruvian Current



Tides

1. Tidal bulges: Tidal bulge appears not only @ A but also @ C. This is because @ C, the centrifugal force is the highest.



1. Spring tides & neap tides: Spring tides are maximum tides which occur when moon, earth and sun are in one line (either in same direction or opposite). Neap tides are minimum tides which occur when moon, earth and sun are @ 90º.

1. Tidal bore: When a tide enters a narrow and shallow estuary of a river, the front of the tide appears to be vertical (due to piling up of water because of bottom friction). This is called tidal bore.
2. Tidal current: When a gulf is connected with a sea through a narrow channel, during tides water flows in and out. This is called tidal current.
3. Kallakkadal: These are ocean swells which occur in Indian ocean during April-May. They originate in S Indian ocean due to storms and propagate northward with ocean currents. They get amplified as they reach shores. The flooding is most severe on spring tides.

Atmosphere

Composition & Structure

1. Hygroscopic nuclei: They are the dust particles around which the water vapor condense to form clouds.
2. Normal lapse rate: 1ºC fall in temperature with every 165 m advance in troposphere.
3. Tropopause: Height of tropopause is highest @ equator (18 km) compared to poles (8 km). The temperature is also lowest @ equator (-80ºC) as compared to poles (-45ºC). This is because convectional currents are strongest @ equator.
4. Stratosphere: It extends from tropopause to 50 km. From 20 km height, the temperature starts rising due to presence of O_3. The air movements are almost horizontal.
5. Mesosphere: It extends from 50 km to 80 km. Temperature decreases with height again and reaches up to -100ºC.
6. Thermosphere: Its lower layer is called ionosphere where temperature rises with height again due to proximity to sun. It reflects radio waves.

Insolation & Temperature

1. @ 45º latitude, insolation is ~75% of that @ equator. @ 66.5º latitude it is ~50% and @ poles it is ~40% of that @ equator.
2. Isotherms: They are straighter and more widely spaced in S hemisphere than in N hemisphere because of more water.
3. Temperature anomaly: The difference between mean temperature of a place and the mean temperature of its latitude is called temperature anomaly. +ve anomaly means local temperature > latitude temperature. Above 40º N, continents have -ve anomaly and oceans have +ve anomaly for the year as a whole and vice versa for oceans.
4. Temperature inversion: This happens when earth surface is able to radiate solar energy directly into space. Clear sky and dry still air is necessary for it. When such a thing happens, the air near the surface becomes cool due to conduction and settles. The air above it remains warm as convectional currents are not possible. Such a thing often happens on intermontane valleys when during long winter nights, mountain slopes radiate energy quickly. The air cools, becomes dense and descends on the valley thus freezing it.

The warm air of the valley is pushed up, so while valley freezes, the mountain slopes remain warm. This is also called a katabatic process. Temperature inversion may occur @ frontal situations when warm air climbs above the cool air mass. Finally in anti-cyclonic conditions over cold regions, when air descends it may get katabatically heated up before reaching the surface while the surface air remains cold.

5. Sub-solar point and Sun's declination: The point on earth where the sun is directly overhead @ a given point of time is called sub-solar point. The latitude of the sub-solar point is called Sun's declination.
6. Albedo: This is the amount of insolation reflected by the body. Earth's albedo is ~ 30-35%. In tropics it is as low as 20-40% and in poles it reaches 80%. When sun is overhead albedo is less.

Heat Budget

1. 35% is radiated by atmosphere (27% from clouds, 2% from ice), 14% is absorbed by it. Rest 51% reaches earth's surface which is absorbed by it and later radiated back.
2. 34% is absorbed by atmosphere again (19% via latent heat of condensation) while 17% is radiated directly to space. Atmosphere together radiates back 48% to the space.

Latitudinal Heat Balance

1. @ latitudes below 40º, insolation is ≥ that radiated back. @ latitudes above 40º, insolation is ≤ that radiated back. ~80% of the latitudinal heat transfer takes place via atmosphere and 20% via ocean currents.
2. Temperature contrast between continents and oceans are greater during winters than in summers.

Air Pressure

1. The atmospheric pressure is 1013.25 mb = 76 cm of Hg column. It normally falls @ a rate of 34 mb per 300 meters of ascent.

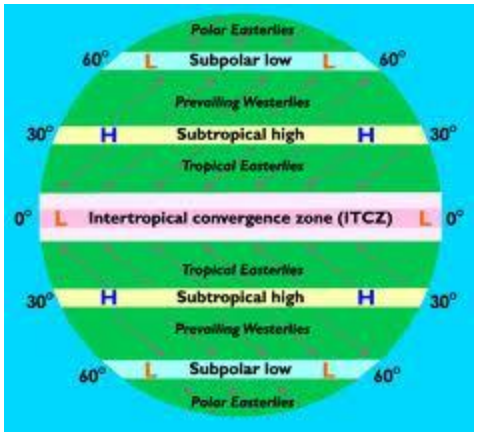
Pressure Belts

Headley's Model

1. His model assumed only one cell in each hemisphere. Low pressure @ equator and high pressure @ pole with air from pole flowing towards equator.
2. It assumed a non-rotating earth and uniform earth surface.

Ferrel's Model

1. The cell between equator low pressure belt and sub-tropical highs is called Headley cell, the one between sub-tropical high and sub-polar low is called Ferrel cell and the one between sub-polar low and poles is called polar cell.
2. It assumes a rotating earth, uniform surface (i.e. either land or water throughout) and sun being stationary overhead @ equator.



1. Equatorial low: 10º N - 10º S. Calm conditions persist here despite the low pressure because as the air from sub-tropical high pressure belt reaches the margins of this belt, it warms up and ascends vertically instead of flowing horizontally. Thus only vertical currents are found in this belt. So it is also called doldrums.
2. Sub-tropical highs: 23.5º - 35º latitudes. There is subsidence and piling up of air leading to calm conditions and hence known as horse latitudes (30º - 35º latitudes).
3. Season shift of pressure belts: The shift is less in S hemisphere due to abundant water. The shift of the pressure belts is also higher in lower latitudes than in higher ones. The ITCZ can shift ~ 20º N and only 10º S of equator.
4. Air current: The vertical or nearly vertical movement of air is called air current.

Reasons for sub-tropical high belt

1. As the warm air of equator low pressure rises, it cools. Upon reaching upper layers it begins to move towards poles. It further cools down, becomes dense and by 25-35º latitude it begins to subside.
2. Due to Coriolis effect, in these latitudes the movement of air becomes effectively west to east instead of going north. This produces a blocking effect and the dense air begins to subside heavily.

Wind Types

Planetary Winds

1. Trade winds: They blow from sub-tropical highs (30º latitudes) towards equatorial low pressure. They are extremely steady. In N hemisphere they get deflected towards right and in S hemisphere towards left.
2. Westerlies: Westerlies of S hemisphere are stronger and more consistent in direction due to predominance of water.

Periodic Winds

1. Valley breeze and mountain breeze: During day mountain slope gets heated up more than the valley floor. So air from the valley begins to flow up the slope. This is the valley breeze. During night, mountain slope cools faster than the valley. So the cold slope air begins to descend on the valley from higher slope. This is called mountain breeze.

Local Winds

1. Foehn & Chinook: Due to pressure gradient, winds get pulled up from the windward side to the leeward side. After causing precipitation on the windward side, as it descends on the leeward side, it becomes warm and increases the temperature of the surrounding. In Alps it is called foehn and in Rockies it is called Chinook.
2. Mistral: Cold winds descending from snow capped mountains into the valley are called mistral in the Alps.

Jet Streams

1. They blow from west to east near tropopause @ very high speeds (120 kmph in winters and 50 kmph in summers). They are embedded in the prevailing westerlies and encircle the globe.
2. Sub-tropical jet stream: They prevail over the lower latitudes of westerlies. It is produced by the rotation of earth and its spherical shape. The air over equator has the highest velocity (Coriolis effect). As it rises and moves towards north, it has a higher velocity than the air @ lower altitude prevailing @ same latitude. So it begins to flow from west to east around 30º latitude.
3. Mid-latitude or polar front jet stream: It is more variable and is produced by a temperature difference. In summers its position shifts towards poles and in winters towards equator.

Air Masses

1. Source region: The region where an air mass is produced. Necessary conditions are large scale subsidence of air over the source region. The subsiding air acquires the properties of the source region.
2. Classification of air masses: They are classified based on the source region and air mass modification. Thus there can be tropical maritime air mass, tropical continental air mass, polar maritime air mass and polar continental air mass.
3. Thermodynamic modification in air mass: When the air mass is heated or cooled from the surface below, it is a thermodynamic change. When a warm air moves over a cold surface, temperature inversion results which inhibits further vertical cooling. If a cold air mass moves over a warm surface, convectional currents are formed. This leads to formation of vertical clouds (cumulus) and air turbulence. Addition or loss of latent heat also is an example of thermodynamic modification.
4. Dynamic modification in air mass: These modifications are independent of surface heating or cooling. Examples are subsidence caused by anti-cyclones or cyclones. Surface friction adds to the turbulence of air flow aiding the upward transfer of the effect of thermodynamic modifications.
5. Warm front and cold front: When warm air mass rises above a cold air mass it is warm front. When the cold air mass forces its way under the warm air mass it is the cold front.

Air Moisture

Humidity

1. Absolute humidity: It is the weight of water vapor per unit volume of air. Since the volume may be impacted by a change in temperature or pressure, such factors affect absolute humidity.
2. Specific humidity: It is the weight of water vapor per unit mass of air. Since it is the mass of the air now, it is not impacted by change in temperature or pressure.
3. Relative humidity: Proportion of actual water vapor to the water vapor carrying capacity.
4. Hygrometer is an instrument used to measure humidity. Psychrometer is a hygrometer with one dry bulb thermometer and one wet bulb thermometer. The difference between the two readings gives the humidity.

Condensation

1. Dew point: Temperature @ which the sample of air becomes saturated.
2. Dry adiabatic rate vs wet adiabatic rate: As air rises, it expands and cools adiabatically. However, the rate of cooling depends on the water vapor content of the air. Higher the water vapor present, lower the rate of cooling due to release of latent heat of condensation. Rate of cooling in a saturated air sample is called wet adiabatic rate and that in an unsaturated air sample is called dry adiabatic rate. Wet adiabatic rate is ~2x the dry adiabatic rate.
3. White frost: When under dew forming conditions, the dew point of the air is ≤ 0° C, water vapor condenses as minute ice. This is called white frost.
4. Radiation fog, advection fog and frontal/precipitation fog: Radiation fog results when the ground cools rapidly due to radiation and the adjacent air too cools and its water vapor condenses. Such fog is not very thick. Advection fog is formed when moist warm air moves horizontally over a cold surface. Such fogs are thick and persistent. Frontal fog occurs when warm air mass is forced to rise over the cold air mass. It cools, condensation and precipitation takes place. If the cold air below is near the due point, its temperature falls further (as some water from the rain gets converted into water vapor thus absorbing latent heat of evaporation) and excess moisture condenses as fog. It is formed @ convergence zone.

Clouds

1. Cirrus clouds: They are high (6-12 km), thin, white clouds made of ice crystals.

2. Cumulus clouds: They are dome like, cauliflower shaped clouds.

3. Stratus clouds: They represent sheets of layers which cover almost whole of sky.

4. Alto clouds: It is a prefix/suffix used to specify medium height clouds (2-6 km).
5. Nimbo clouds: It is a prefix/suffix used to specify low height clouds (0-2 km).
6. Thus various types of clouds possible according to height are: (a) Low clouds - stratocumulus, stratus, nimbostratus, cumulus, cumulonimbus. (b) Medium clouds - altocumulus, altostratus. (c) High clouds: cirrus, cirrostratus, cirrocumulus.
7. Collision - coalescence hypothesis of precipitation: This explains precipitation in tropical areas where the temperature in clouds is too high for the formation of ice. So water droplets condense, positive charge attracts negative charge, they come together, become big and fall.
8. Ice crystal hypothesis / Bergeron - Findesein hypothesis: Saturation vapor pressure is lower over ice than over water surface. Initially a cloud may contain both ice and water. Since vapor pressure is lower over ice, it attracts more water vapor in the cloud. Thus the vapor present in the cloud begins to decrease and the water droplets evaporate to replenish the diminishing vapor. So ice crystals grow @ the expense of water droplets. As they descend, they may melt and form as rain else snow.
9. Smog: Smog refers to photochemical fog haze produced when insolation reacts with hydrocarbons, nitric oxides and PAN (peroxy acetyl nitrates) present in the air.

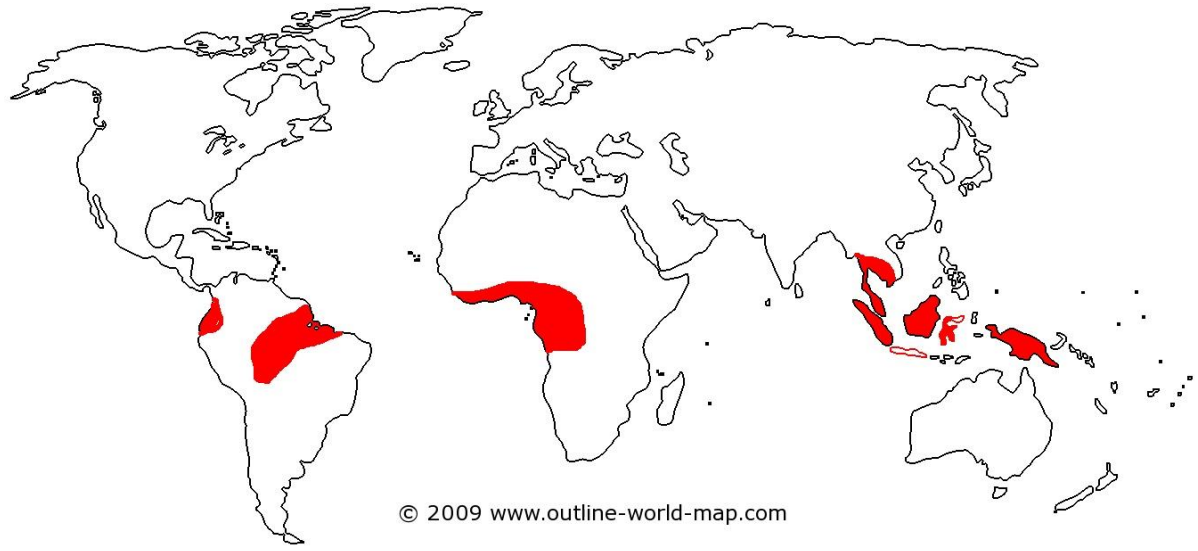
Precipitation

1. Sleet: They are refrozen ice. Lets say condensation and precipitation happens @ higher levels below freezing temperature and snow falls. If there is a layer of warm air between the cold layers above and below it, then as snow passes through this layer, it will melt. As it leaves the layer and enters cold layer again, it will refreeze. Thus precipitation takes place in form of sleet.
2. Hail: Precipitation in form of hard round pellets. Sometimes strong ascending currents take water vapor to great heights where it condenses and precipitates as snow. As it comes

down, it melts but strong currents push them up again increasing the size. Thus size keeps on increasing until it becomes very hard and big.

Climate

Equatorial Climate



Distribution

1. Main regions are Amazon belt, Congo, SE Asia between 10º N-S. Further away from equator, the influence of trade winds leads to monsoonal influences.

Temperature

1. Consistently high, annual range < 2º C. Even on highlands the annual range of temperature < 2º C.

Rainfall

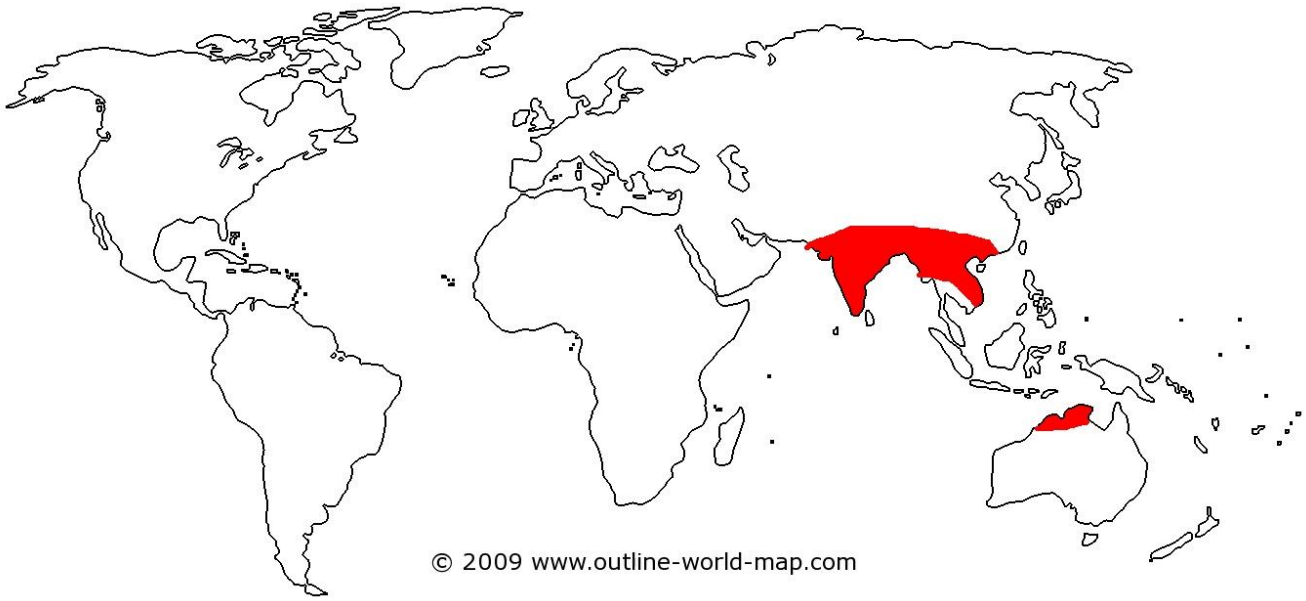
1. No month is without range. Rainfall has twin monthly peaks - in March and September (equinoxes) because the sun is directly overhead during these times and rainfall is convectional. Rainfall is least on solstices.
2. As one goes north from the equatorial regions, the rainfall pattern starts to get disturbed by monsoon winds.

Vegetation

1. Tropical rain forests (called selvas in Amazon) are found. Growing season is entire year and no distinct season of seeding, flowering, shedding of leaves.
2. Epiphytes: They are plants that grow upon other plants non-parasitically. They usually derive only physical support and not nutrition from their host. They use photosynthesis for energy obtain moisture from the air or from dampness on the surface of their hosts.

1. Forest is arranged in 3 canopy layers vertically. So many species of trees are intermixed and hardwood logs sink in water so that commercial logging is not feasible.
2. Main crops are plantation crops like rubber (SE Asia), cocoa (W Africa - Ghana & Nigeria), coconuts, sugar, coffee, tobacco, spices, banana.
3. *Belukar* is the secondary forest growing as a result of shifting cultivation activities in Malaysia.
4. Agriculture and developmental activities are difficult because thick grass and undergrowth grows as soon as the forest is cut.

Tropical Monsoon Climate



Distribution

1. South and SE Asia and N Australia. Outside this zone the climate is modified by the onshore trade winds and rainfall is distributed more evenly throughout the year (tropical marine climate).

Seasons

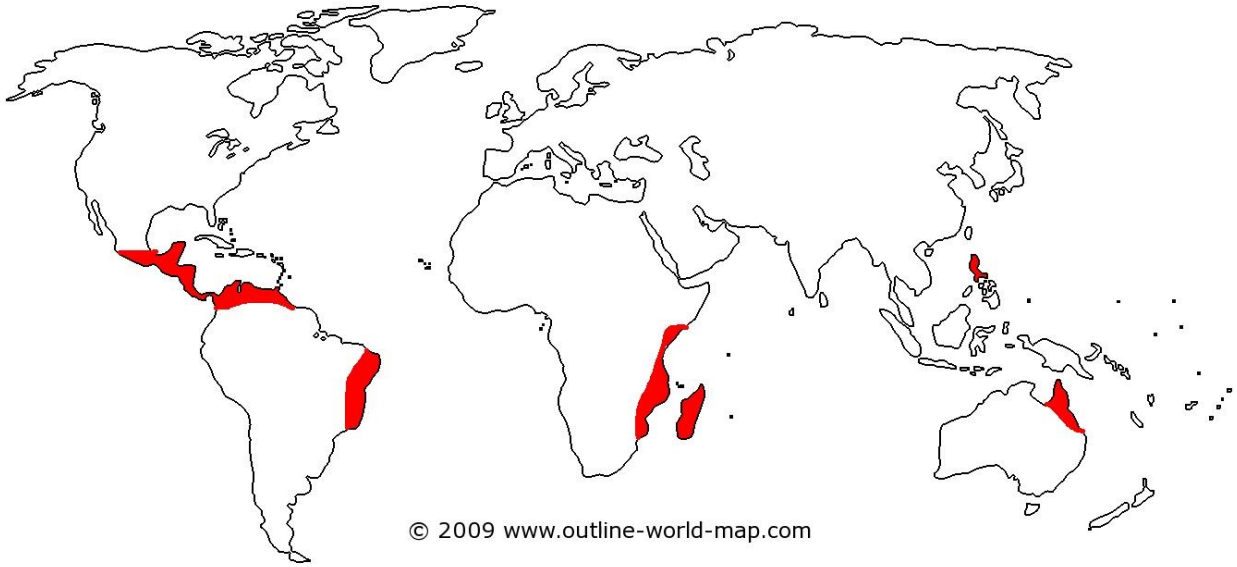
1. Cool, dry winters (October - February).

2. Hot, dry summers (March - June).
3. Rainy season (June-September). Orographic rainfall.

Vegetation

1. It is deciduous due to marked dry season during which leaves are shed. Forests are generally logged but the vegetation differs with the rainfall.
2. Main crops are rice, sugar, jute (hemp in Manilla), cotton. Coffee is grown in Brazil. Tea requires modest temperatures (15 - 20ºC), heavy rainfall (150 cm) and well drained slopes.

Tropical Marine Climate



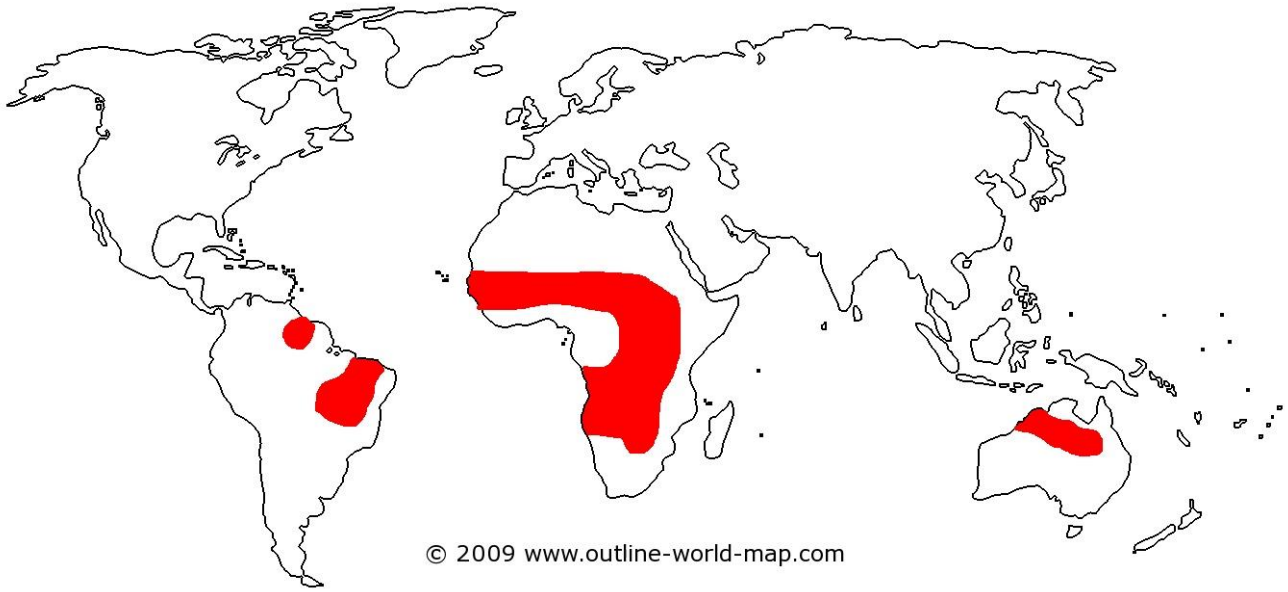
Distribution

1. Occurs on the easter casts in tropics under the influence of trade winds. Philippines, central america, NE Australia, Madagascar, east Africa and east Brazil.

Rainfall

1. It is both orographic and convectional. It is maximum in summer season but without any distinct dry season.
2. It is prone to severe tropical storms and typhoons.

Tropical Savanna / Sudan Climate



Distribution

1. It is found between equatorial forests and the trade wind hot deserts. The grasses are called *llanos* in Orinoco basin and *campos* in Brazil.

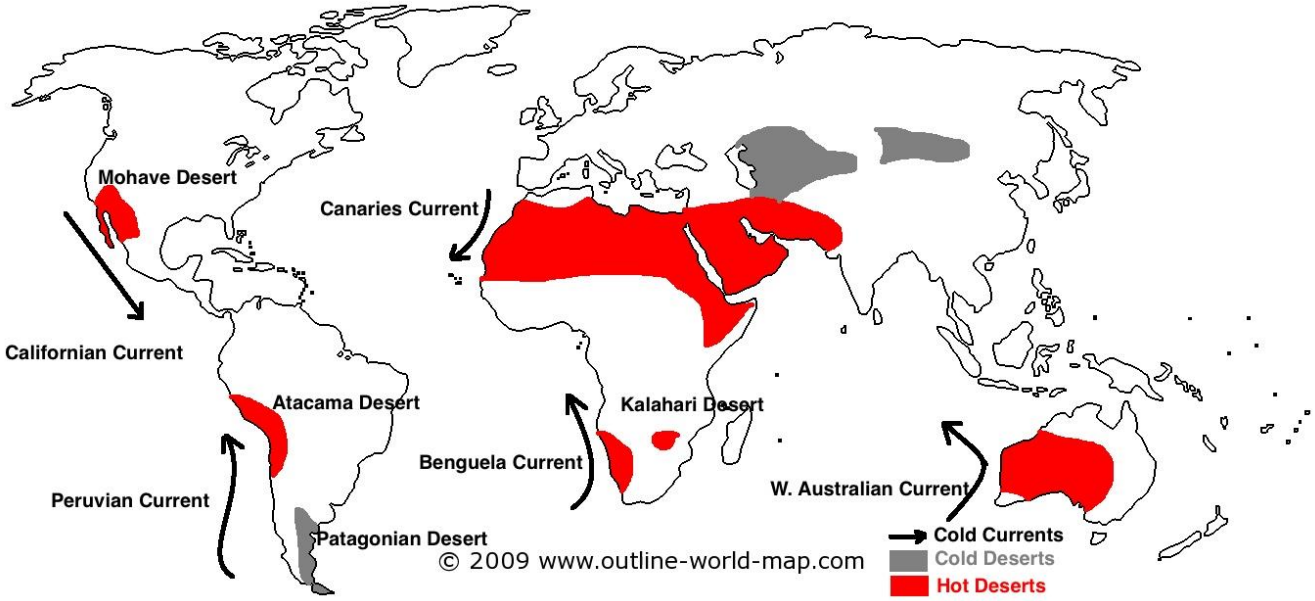
Seasons

1. Hot, rainy season (May - September in N hemisphere, October - March in S hemisphere). The amount of rainfall and the length of the rainy season decreases from equator to polewards towards the desert fringes. Trade winds bring rains to the eastern coasts but become dry by the time they reach interiors of the continents.
2. Cool, dry season.
3. Annual range of temperature is ~ 10ºC and the range increases as we move polewards. Highest temperatures don't coincide with period of highest sun but fall just below the onset of rains. Daily range of temperature is also high.
4. *Harmattan* (the doctor) are the north east trades which blow from interior Africa to the Atlantic coast in Guinea. They come from deserts and humidity rarely exceeds 30%. It is called the doctor because it gives relief from moist sea winds.

Vegetation

1. Tall savanna grasses. Grasses have deep roots. It lays dormant during cool, dry season.
2. Trees decrease in height and density polewards. Some trees are deciduous shedding their leaves in cool, dry season to prevent water loss. Some trees have broad trunks with water storing devices. Many trees are umbrella shaped exposing only a narrow edge to the winds.
3. Heavy rainfall in hot, wet season lead to intense leaching of the soil and all the nutrients are washed away.
4. Domestication of animals is popular in Australia.

Desert Climate



Distribution

1. Aridity of hot deserts is mainly due to off-shore trade winds. Aridity of cold deserts is because of off-shore westerlies or leeward side effects. Cold deserts are also generally located on high plateaus. Major hot deserts are located on the west side of continents in 15 - 30º latitude range. Atacama / Peruvian desert is the driest of all deserts (< 1.25 cm p.a.).
2. Apart from this, the hot deserts lie in the horse latitude belt where the air is subsiding - a condition least favorable to precipitation. Further winds blow from cooler to hotter regions, hence the lack of water content.
3. Cold currents have the effect of cooling the air. When this comes in contact with the hot air on the land mass, relative humidity drops further.

Rainfall

1. Whatever occurs, occurs mostly because of convectional rainfall and with thunderstorms.
2. In cold deserts in Asia, whatever rainfall happens occurs because of occasional western disturbances and in form of snow.

Temperature

1. Coastal deserts generally have less temperature than interiors due to cold currents. Ranges are also high in interiors.
2. Annual range of temperature is higher in cold deserts compared to hot deserts. Mostly because they are located in mid-latitudes where variation in insolation is highest and because they are located deep inside continents.

Vegetation

1. Shrubs remain dormant for years waiting for rainfall. They also have long roots, modified leaves and stems. Seeds have thick tough skins and lie dormant until it rains.
2. High evaporation means salts are brought upwards and they accumulate on the surface forming hard pans. Soil is also deficient in humus.

Minerals

1. Gold is mined in Australia, diamonds and copper in Kalahari desert, copper and nitrates in Atacama desert.

Warm Temperate / Mediterranean Climate

Distribution

1. It is confined between 30 - 45º latitudes on the western margins of the continents. It is caused by shifting of pressure belts and comes under the effect of trade winds during summers (continental trades and hence dry) and westerlies during winters (onshore winds and hence wet).

Temperature

1. Highest temperatures are experienced as we move inland away from maritime influence.

Rainfall

1. Cyclonic rainfall is prevalent from westerlies. The rain comes as heavy showers and only on few days with bright sunny intervening days.

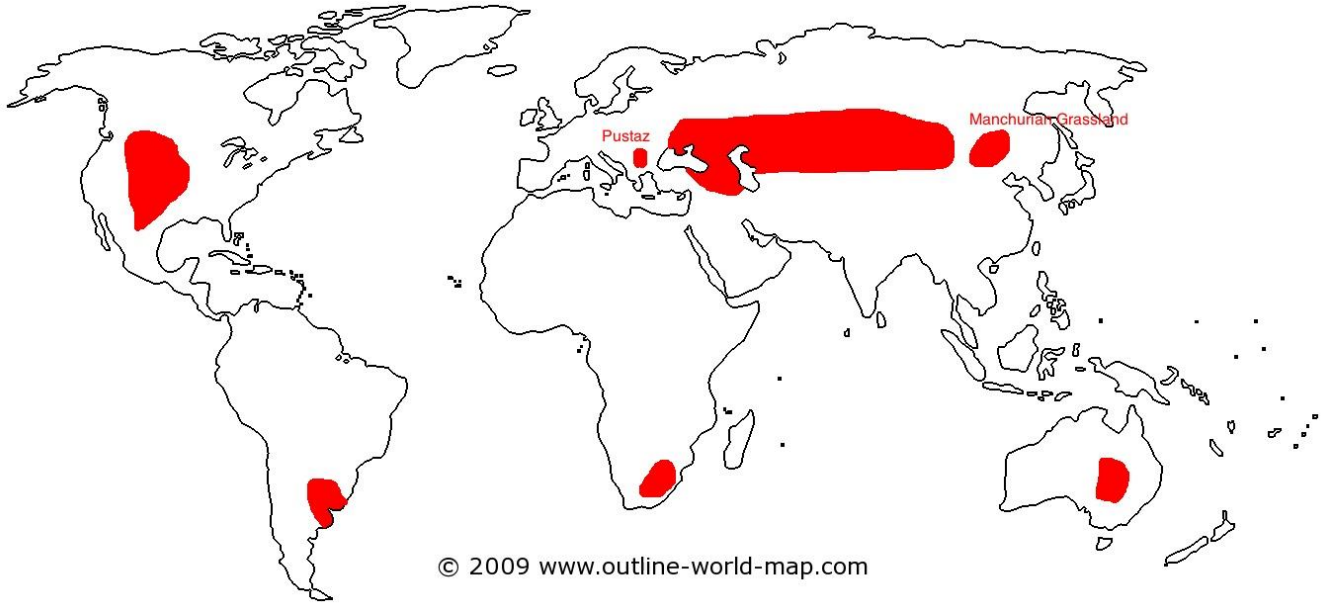
Local Winds

1. Sirocco: They are the south-westerlies blowing from Sahara desert into the mediterranean climate. They are hot and dry and remain dry even after passing above Mediterranean sea. It is most frequent during spring and is bad for crops.
2. Mistral: It is a cold wind from north in Alps region which rushes down in winter into the valleys to fill the low pressure towards the sea.It is fast and may take the temperature below the freezing point.
3. Bora: In the Adriatic coast, the cold winds blowing from the continent to the sea in winters are called Bora. They are very fast.

Vegetation

1. Mediterranean evergreen forests: They are found in regions of high rainfall. Cork oak trees are common in Europe while eucalyptus are grown in Australia.
2. Evergreen coniferous forests: They are found in highlands.
3. Mediterranean shrubs: They are the dominant vegetation.
4. Orchard farming: Fruit trees have long roots enabling them to fetch water in hot summer season as well. The thick leathery skin of the fruits also prevents transpiration.

Temperate Continental Grasslands / Steppe Climate



Distribution

1. They border the deserts and lie in the interiors of the continents in N hemisphere and near the oceans in S hemisphere. Though they lie in the westerly belt, they are far removed from the maritime influence.
2. Grasslands in S hemisphere are less continental due to proximity to oceans. They have less extreme temperatures (milder winters and less annual range) and rainfall is higher as well.

Temperature

1. Warm summers and cold winters. Extreme variation of temperature.

Rainfall

1. Annual precipitation is light with maximum rainfall in summers. Winters get occasional rains from western disturbances and in the form of snow.
2. Annual precipitation is higher in S hemisphere due to proximity to ocean and warm ocean currents.

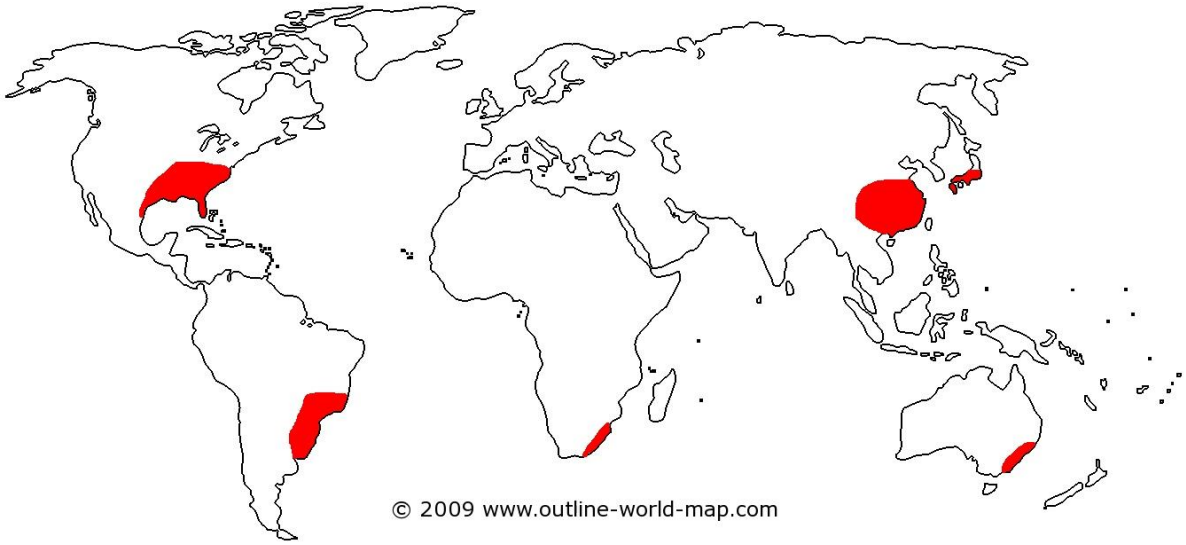
Local Winds

1. Chinooks: They are south-westerly winds pulled over from the Rockies. They are hot winds and can raise the temperatures by 20º C in 20 minutes.

Vegetation

1. The grasses lie dormant in the winters and become active in the spring when the temperature is hot enough. In summers they get scorched but in autumn they grow again.
2. Polewards, an increase in precipitation gives way to coniferous trees while equatorward they merge with desert shrubs.

Warm Temperate / China Climate



Distribution

1. China type: East and central China. Trade winds take the warm current moist air inside and causes rain in summers. In winters however there is a reversal of wind direction due to cooling of Asian land mass and temperatures plummet. So annual range of temperature is high. Typhoons are carried in by the trades.
2. Gulf type: SE US. The monsoonal characteristics are less here as the pressure gradient between continental N America and the Atlantic ocean is never high enough to reverse the wind direction completely. Rainfall has summer maximum.
3. Natal type: In southern hemisphere. These lands have no monsoonal climate due to thinness of the land masses which is not sufficient to cause any wind change. So annual range of temperature is less, rainfall is more and distributed throughout the year.

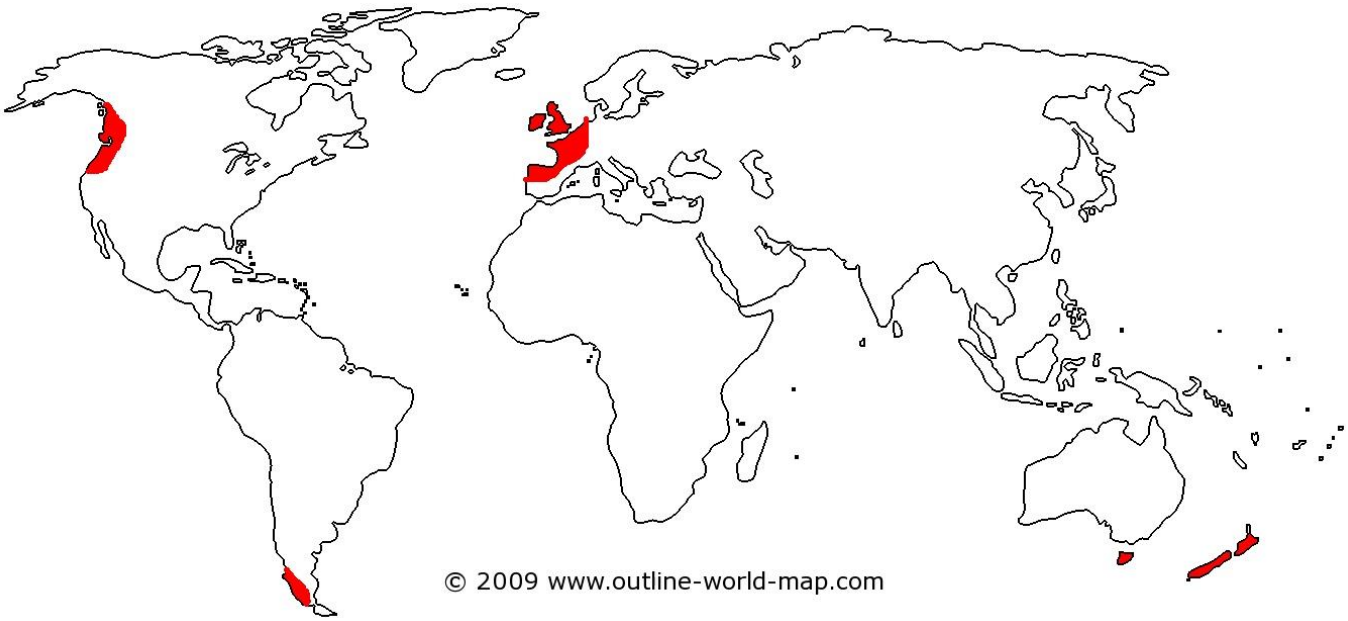
Rainfall & Temperature

1. It has more rainfall than Mediterranean climates for same latitude because of influence of warm currents. They are under the influence of trade winds.
2. Summers are warm and winters are cool. Rainfall varies from 60 - 150 cm.

Vegetation

1. Eastern margins get more rainfall and hence more luxuriant vegetation. Such regions have evergreen and deciduous forests. The perennial plant growth is not checked wither by cold or a dry season.
2. Crops grown are rice, maize, cotton, tobacco. Cotton needs 200 days frost free and moderate rainfall. Tobacco needs humid atmosphere and well drained soils.

Cool Temperate Western Margin / £ Climate



Distribution

1. They are under the influence of westerlies all through the year but westerly influence is blocked by Rockies and Andes in N and S America respectively.

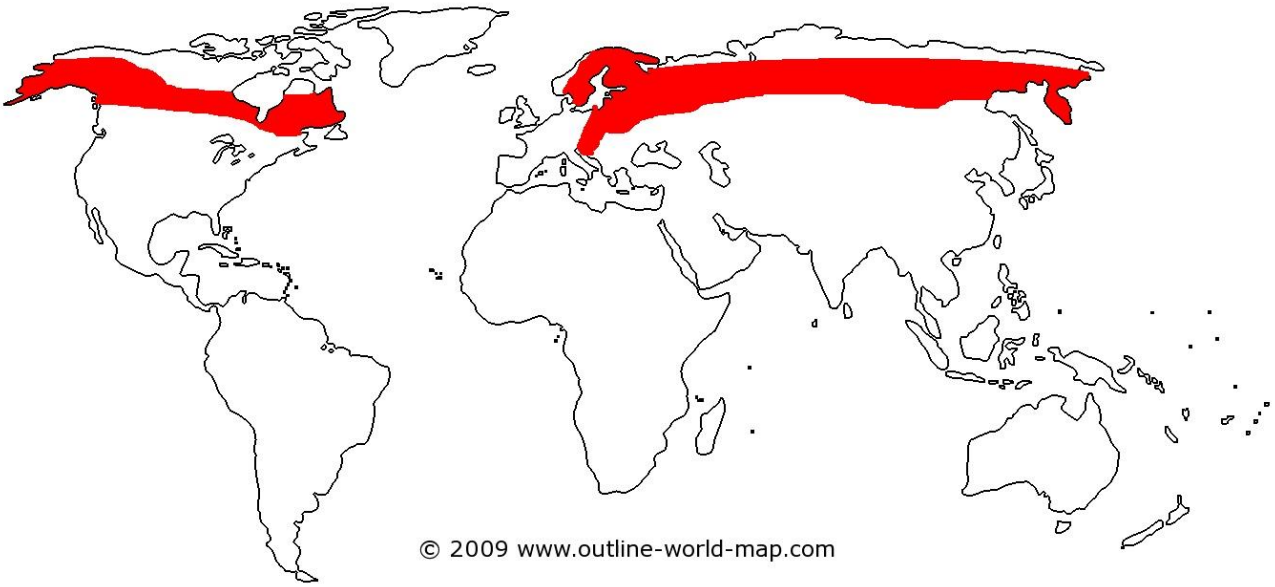
Temperature & Rainfall

1. Low annual range of temperature. Summers are never very warm.
2. Rainfall is throughout the year with winter or autumn maximum because of cyclonic conditions.

Vegetation

1. Deciduous forests are found and they shed their leaves in autumn to prepare for the cold season.

Cool Temperate Continental / Taiga Climate



Distribution

1. It has tundra towards the north and steppes towards the south. Taiga is the Russian name.

Cool Temperate Eastern / Laurentian Climate

Distribution

1. It is the intermediate types and has both maritime and continental traits.

Rainfall and Temperature

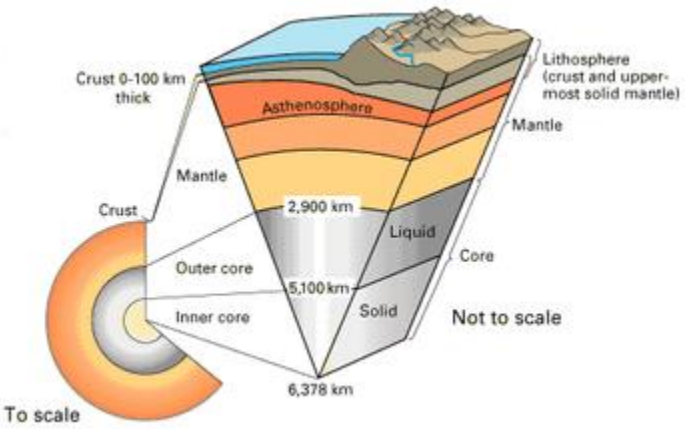
1. Winters are cold and dry while summers are warm and wet. Summers would be warmer but for the cold continental winds.
2. Rainfall has summer maximum due to easterlies from the ocean but occurs throughout the year. Gulf Stream and Oya Shio keeps it warm.

Lithosphere

Interior of the Earth

Composition

1. Pedosphere: The uppermost part of the lithosphere that chemically reacts with the atmosphere, hydrosphere and biosphere through the soil forming process is called the Pedosphere.
2. Crust: The surface of the crust has mostly sedimentary, igneous and metamorphic rocks. Below them are basalt and ultra-basic rocks. Ocean beds have dark basalt followed by thick greenish hot layer. Ocean layer is also called MAFIC layer (Magnesium & Iron) while continental layer is divided into 2 - (a) FELSIC layer or feldspar + silica which is the topmost. It consists of granitic rocks and is the Sial layer. It is lighter. (b) MAFIC layer which lies below the FELSIC layer. It is denser and is the sima layer.
3. Mantle: The upper mantle is in solid state while the lower mantle is in plastic state. A part of is called Asthenosphere which is the area just below lithosphere (crust + upper solid mantle) and is plastic and involved in plate tectonics. Mantle is the SiMa layer. At lower mantle depths, the pressure is so high that the liquid behaves like a solid and is in a plastic state. It is 2900 km deep.



1. Core: Outer core is Nife layer. It is 2200 km deep and is in liquid state. Inner core is Barysphere layer and is 1200 km deep and is in solid state.

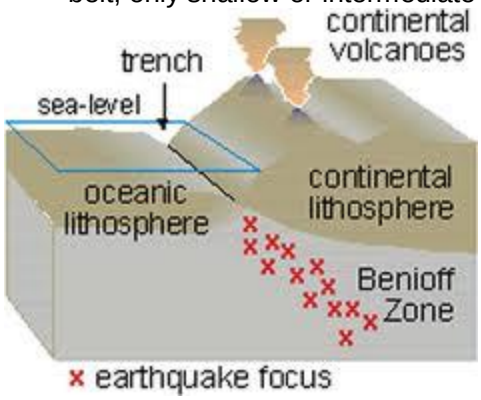
Increase in temperature

1. In upper 100 km, increase is 12º C per km. For next 300 km it is 2º C per km. Below it the increase is 1º C per km.

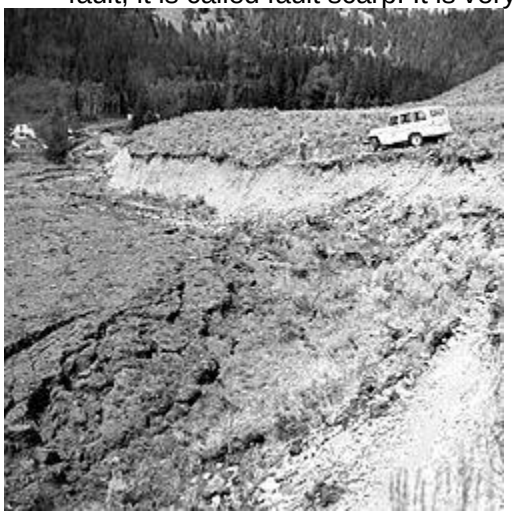
Earth Movements

1. Epeirogenic movements vs orogenic movements: Epeirogenic movements are the slow continent building movements. They are because of upward or downward forces. Orogenic movements are on the other hand due to horizontal forces.
2. Orogenic movements: Pre-cambrian: 600-3500 mya. Caledonian: 320 mya. Hercynian: 240 mya. Alpine: 30 mya.
3. Active margins and passive margins: Continental margins are called active types if the oceanic and continental plates are pushing towards each other. Continental margins are called passive types if the oceanic and continental plates are pulling away from each other.
4. Divergent movement: Both plates pulling apart from each other. It is constructive in nature as it leads to formation of new crust.
5. Continental shields: They are large stable relatively flat expanses of very old rocks. Eg. Deccan plateau.
6. Anti-center and anti-pode: Anti-pode of a point on earth is a point which is diametrically opposite to it. Anti-center is the anti-pode of the epicenter.
7. Magnitude vs intensity of an earthquake: Magnitude refers to the energy released in earthquake. Intensity refers to the impact felt in a locality. Thus an earthquake may have different intensities in different locations. So magnitude scales (like Richter) measure the energy released in the quake. Intensity scales (like Mercalli) measure the impact felt in a location.
8. Seismic scales: Moment magnitude scales consider the area of fault, the displacement of rocks on the fault and the rigidity of earth to arrive at the magnitude. Richter scale is a local magnitude scale. In both scales if we go from 6 to 7 energy released is ~32x and from 6 to 8 is ~1000x. Mercalli scale is an intensity scale.

9. Benioff zones: The subduction zone is inclined and goes inside the continental plate as we go deeper. Deeper earthquakes are confined to the circum-pacific belt and in trans-eurasian belt, only shallow or intermediate earthquakes occur.

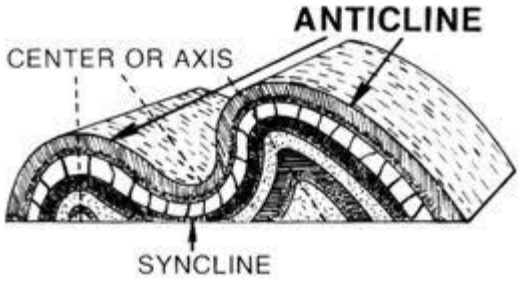


1. The 3rd earthquake prone belt is the global system of mid-oceanic ridges with an extension to east African rift valley system.
2. Homoseismal lines vs isoseismal lines: Lines joining places on earth which receive earthquake waves @ the same time are called homoseismal lines. Lines joining places on earth where same intensity of the earthquake is felt are called isoseismal lines.
3. Intra-plate earthquakes: They happen as the stress building on the edges gets transferred inwards and a new fault emerges within a plate or an old one reactivates.
4. Fault scarp: When the surface rocks get displaced and detached from each other due to a fault, it is called fault scarp. It is very prone to erosion.



- Land advancing against sea is -ve movement. Sea advancing against land is +ve movement.

- Anticline & Syncline: After folding rock strata becomes like a wave crest (anticline) and trough (syncline).



Earthquake Waves

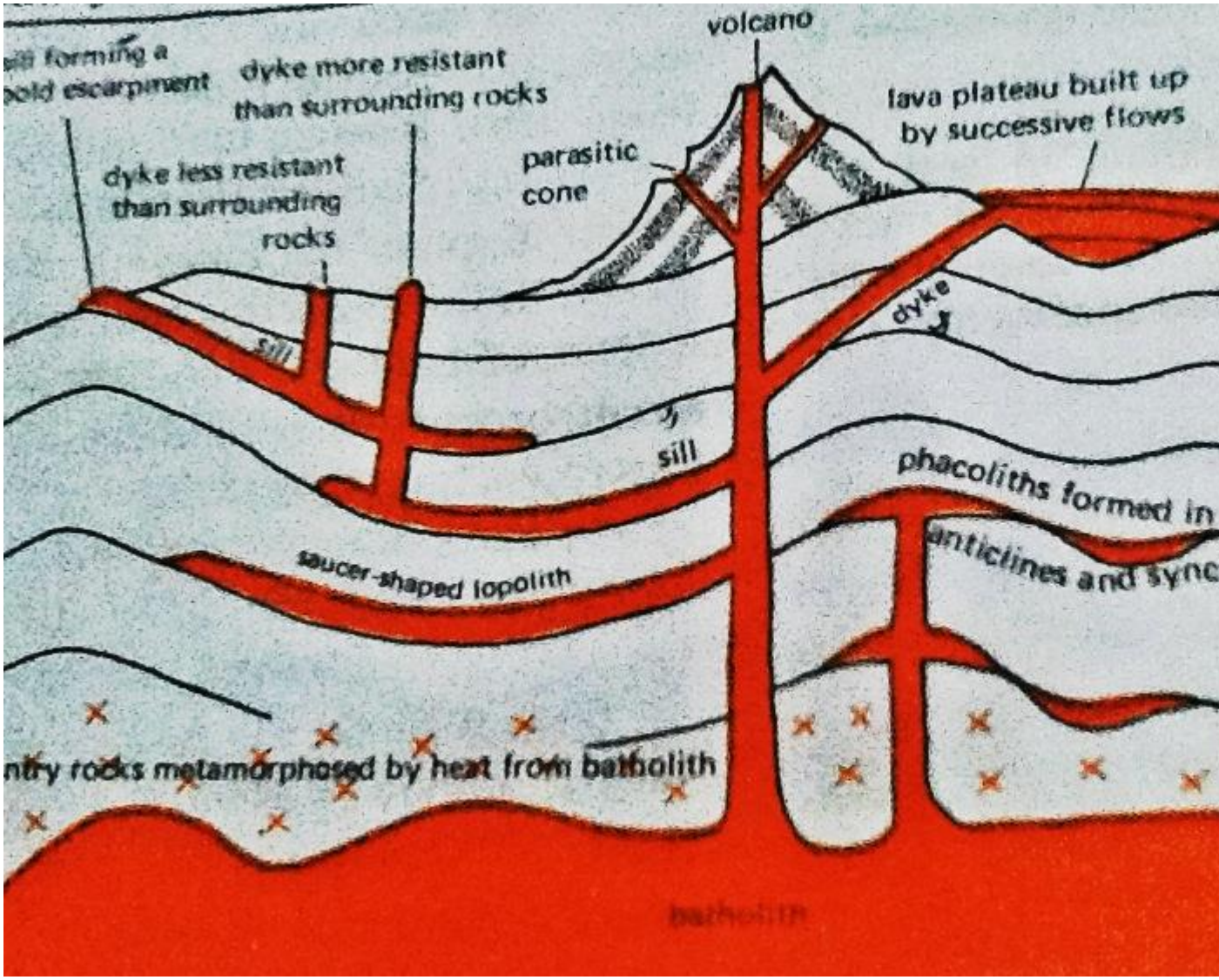
There are 3 type of earthquake waves:

1. Primary (P) waves: They are longitudinal waves so can pass through both solids and liquids. But they travel slowly through liquids. Also as the density of medium increases their velocity also increases. At a depth of 2900 km, they reach liquid molten core so their velocity reduces. As they reach inner core (which is a solid) their velocity increases again.
2. Secondary (S) waves: They are transverse waves so can't pass through liquids. They travel to a depth of 2900 km after which they get deflected since they reach outer core which is liquid.
3. Love (L) waves & Raleigh (R) waves: They are surface waves and don't go deeper into the earth. L waves are faster than R waves so the sequence of arrival is PSLR. R waves are analogous to water waves i.e. movement of particles takes place in the vertical plane. In L waves movement of particles takes place in the horizontal plane only but @ 90º to the direction of propagation of the wave. L waves are most destructive. The surface waves get significantly amplified when they pass through a soft ground like alluvial deposits. There is compression and rolling over of soft alluvial deposits which is called liquefaction.

Volcanoes

Intrusive Volcanic Land Formations

1. Sills and dykes: When the intrusive cooling happens horizontally, it is called sill. It may be exposed to the surface upon denudation of above material. If the cooling is vertical, it may be called a dyke. Dykes are narrow. When exposed to denudation, they may appear as upstanding walls (if made of resistant material) or trenches (if made of non-resistant material).
2. Laccoliths, lopoliths, phacoliths, batholiths: Locolith is a large blister with a dome shaped upper surface and flat lower surface fed by a conduit from below. Lopolith is a saucer shaped intrusive formation. Phacolith is a lens shaped mass of igneous rock occupying the crest of an anticline and trough of a syncline and being fed by a conduit from below. Batholith is the huge mass of bed igneous rocks.
3. Calderas: A violent eruption weakens the structure of the volcano and after the eruption ceases, much of the volcano subsides into the magma beneath. The depression formed in the crater is large and is called caldera.



Types of lava

1. Acidic: It is viscous and rich in silica. It is light colored and flows slowly and cools fast. It comes out with an explosion since the viscous lava blocks the outflow path. The pieces of rocks thrown out by explosion are called pyroclasts. Sometimes the lava is so viscous, it forms a spine or a plug above the crater itself. When it solidifies in a valley it is called lava tongue.
2. Basic: It is fluid, dark colored and rich in iron and magnesium. It is the hottest lava and flows fast (up to 45 kmph). It affects extensive area and spreads out as thin sheets. It doesn't explode rather comes out quietly. Leads to the formation of shield volcano.

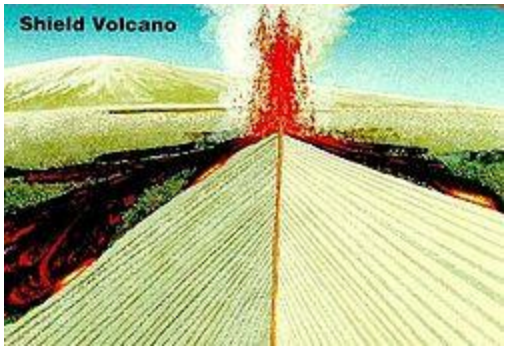
Examples in India

1. Barren Island in Andamans is a dormant volcano.
2. Lake Lonar and Lake Caldera in Maharastra are examples of volcanic craters.

Volcanic Types

1. Volcanic hotspots: Places on earth where volcanic plumes rise through the crust.
2. Crater Volcanoes

Shield Volcanoes: Basaltic lava having low silica content flows out quietly and gives the shape of a shield (spreading out thin and gentle slopes). Volcanoes which form in the mid ocean are basaltic.



Dome Volcanoes: They are formed generally in high silica lava which has high viscosity (thus preventing it from spreading out far). Basaltic lava break apart quickly in weathering or when new lava is added so they typically don't form domes.

Rocks

Igneous Rocks

Rock Formation

1. Extrusive Rocks: When the magma comes out to surface, gases escape and it cools rapidly. So very small grains if anything are formed. Basalt is a common extrusive rocks and constitutes lava flows over Deccan Trap. Such a rock has basic oxide and is basic in nature. Lack of silica gives dark color.
2. Intrusive Rocks: When magma cools below the surface of the earth, cooling is slow and large crystals are formed. Granite and dolerite are examples. Color of granite is because of presence of silica. Silica presence also gives acidic nature to the rock. Granite is an acidic rock.
3. Plutonic Rocks: When solidification takes place deep below the surface, cooling is very slow and crystals are mammoth. Lack of silica gives dark color.

Rock Bodies

1. Mineral lodes: Ores are found in fissures of the rocks. When water containing minerals fills these fissures and evaporates, it leaves behind the minerals leading to ore formation.
2. Batholiths: These are the mammoth granite cores of the fold mountains which are exposed only when a large chunk of rock falls off.

3. Laccoliths: They are miscarried volcanoes, mushroom shaped and are basically igneous rock bodies near but below the earth surface. It is the intrusive equivalent of extrusive volcano.
4. Dykes: They are long, near vertical igneous formations which are formed when magma solidifies in the rock fissures.
5. Sill: When magma solidifies in a thin horizontal sheet between 2 rock layers, it is called a sill.

Sedimentary Rocks

Rock Formation

1. Compaction / mechanical action: Due to pressure of above layers, loose sediments get packed. Sand --> sandstone, clay --> shale. They are found in strata.
2. Cementation: Water carries some sort of cementing material like silica or calcite. It deposits them around the grains and pebbles and binds them together into a solid mass. Conglomerates are collection of round pebbles held together by some cementing material and found @ sea shore or river beds. Breccia are collection of angular pebbles held together by some cementing material and found @ sea shore or river beds. The angular formations indicate work of agents other than water and ice.
3. Organic rocks: Marine animals like corals and algae extract CaCO3 form sea water and deposit it in their skeletons. When they die, their skeletons together form limestone.
4. Chemical action: Such rocks are precipitated chemically from solutions of one kind or another. Gypsum is an example.

Metamorphic Rocks

Rock Formation

1. Dynamic: Rock formation under pressure. Granite ==> gnessis and shale ==> schists.
2. Thermal: Rock formation under heat contact. Sandstone ==> quartzite, clay ==> slate, coal ==> anthracite and graphite, limestone ==> marble.

Landforms

1. Tors: They are the granitic uplands in the form of big sized domes present in Telangana & Rayalseema.

Mountain Types

Fold Mountains / Mountains of Elevation

1. These mountains have granitic core surrounded by metamorphic rocks and sedimentary layers @ the outer.
2. They are formed as sedimentary rock strata, originally laid down in geosynclines (shallow sea / lake depressions) get folded and uplifted.
3. When the crest of a fold is pushed too far, it progresses from simple fold ==> asymmetric fold ==> overfold ==> recumbent fold ==> nappe. In the nappe stage, a fracture occurs, a thrust plane is formed and the overthrust fold portion is called nappe.

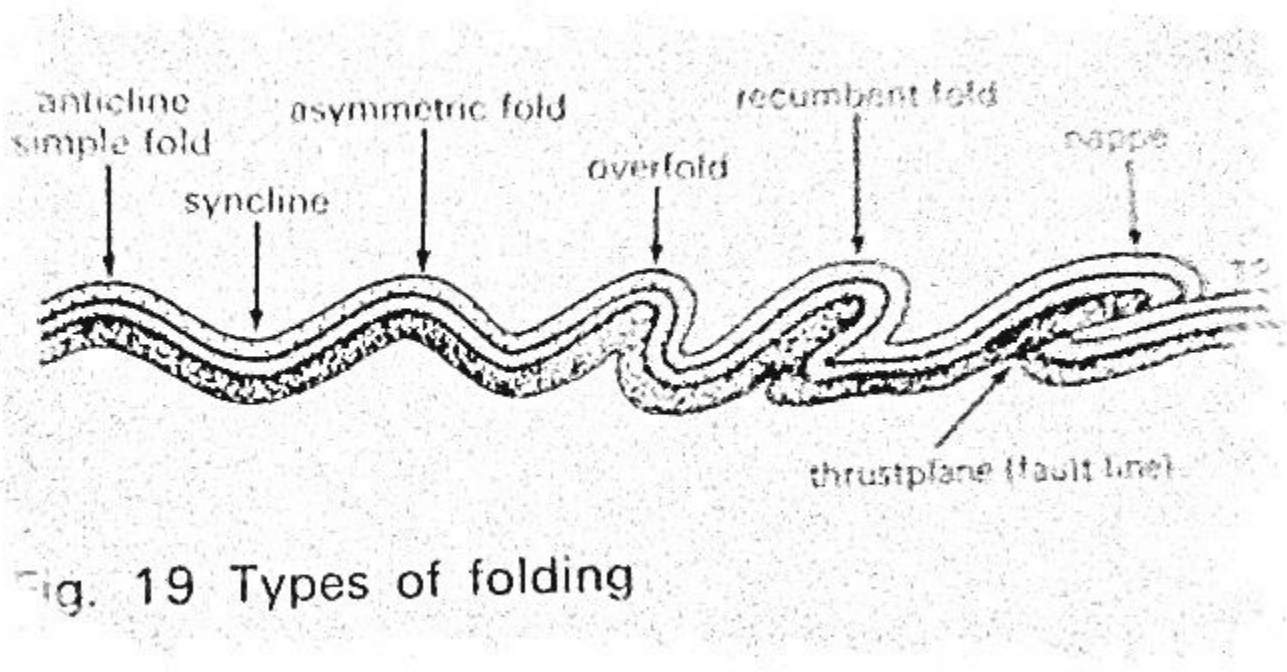
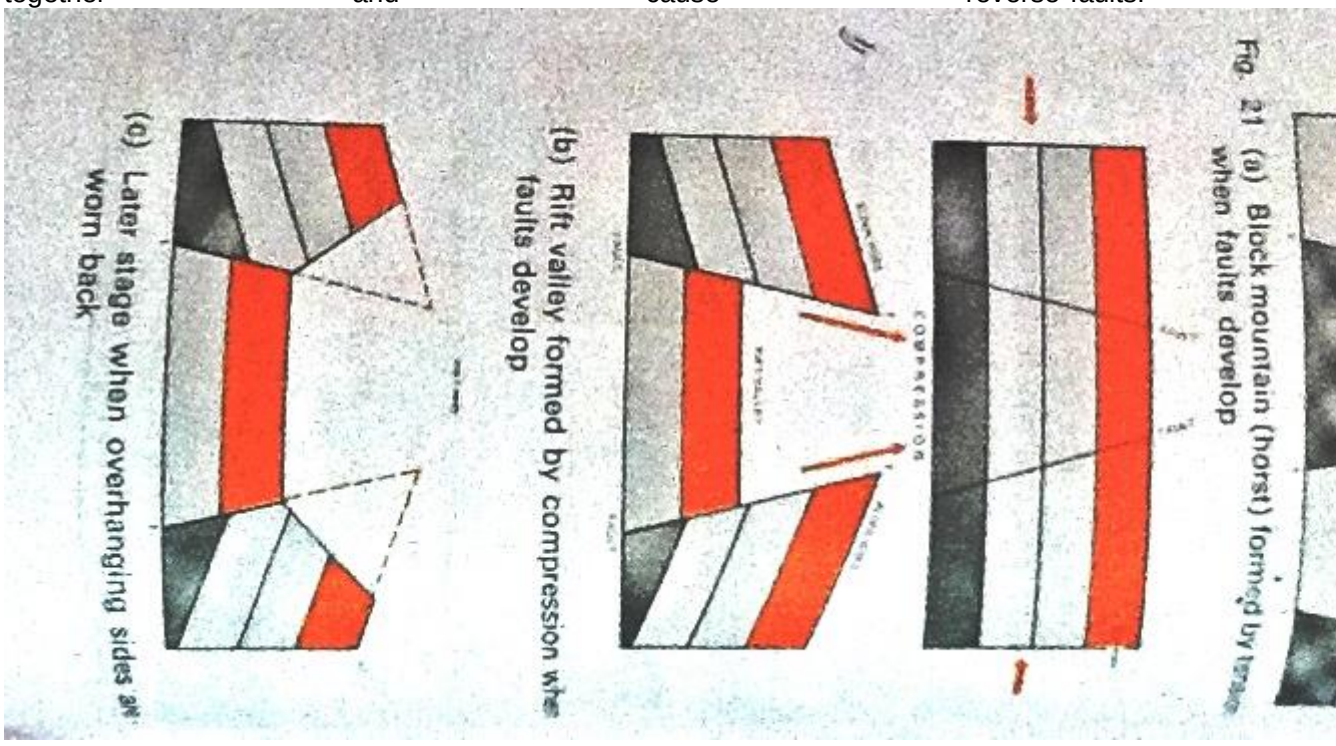


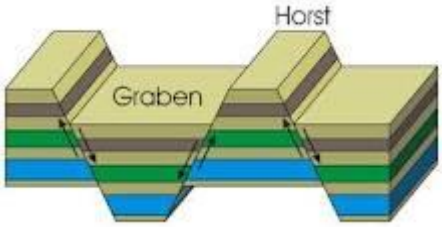
Fig. 19 Types of folding

Block Mountains

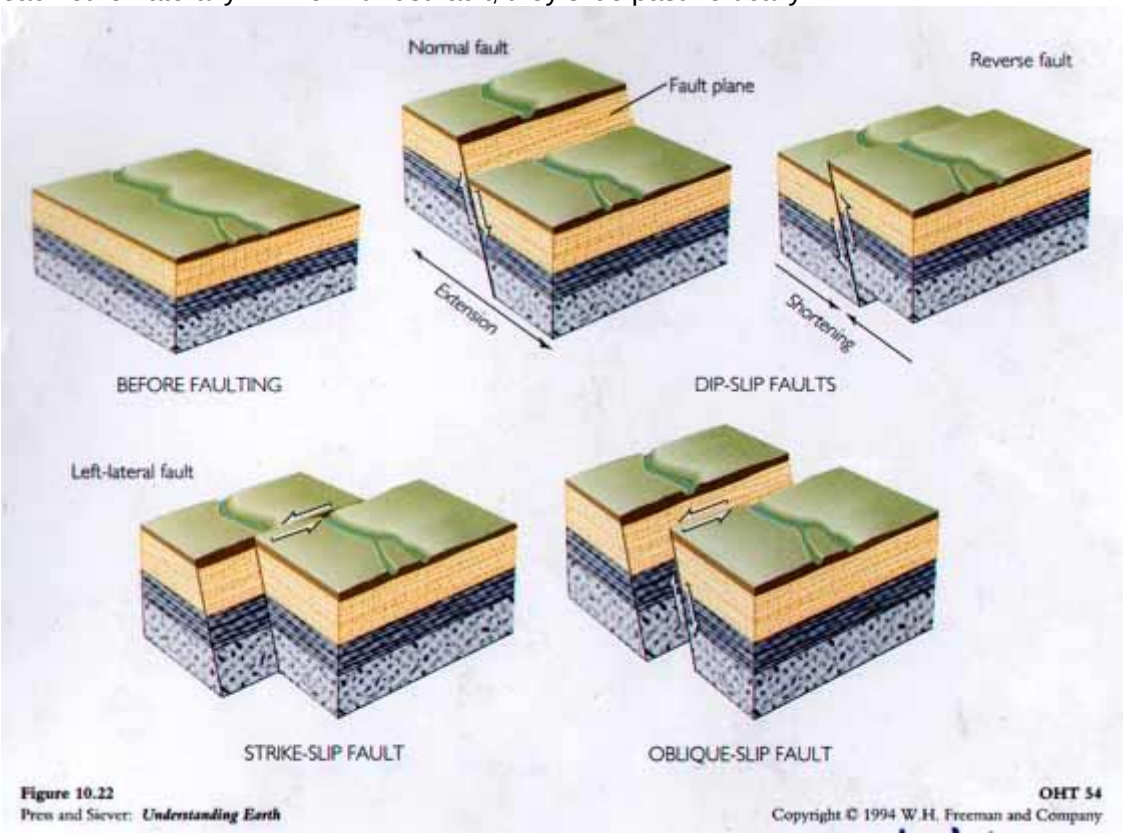
1. They are formed when great blocks of land get uplifted or subside during the late stages of mountain building. During the uplift, sometimes magma flows up. On cooling beneath the surface, it contracts and the overlying rock may crack resulting in vertical movements. The uplands formed are called horsts or block mountains and the lowlands are called rift valleys of graben.
2. Tensional forces tend to pull apart and cause faults. Compressional forces tend to push together and cause reverse-faults.



3. Fractures & Faults: A simple break in rock due to tension without any movement is fracture. When a movement occurs along with the break, it is called a fault. Fault can lead to one side of the land going up (upthrow side) or going down (downthrow side). It can lead to rift valleys (graben) or horst.



1. Strike-slip fault vs thrust fault: In case of strike-slip fault, the fractured crust parts slide past each other laterally. While in thrust fault, they slide past vertically.



Volcanic Mountains / Mountains of Accumulation

Residual Mountains / Mountains of Denudation

1. When the general level of the land has been lowered, some resistant areas may remain as uplands. They may also evolve from a plateau getting dissected.

Plateau Types

Intermontane Plateau

1. They are partly or fully enclosed by mountains. They are a result of mountain building process which was accompanied by a vertical uplift of adjoining lands. Example is Tibetan Plateau.

Piedmont Plateau

1. They have mountain on one side and sea / low plain on the other. Example is Malwa Plateau. They are also called plateau of denudation because they were once high but have been reduced by erosion.

Continental Plateau

1. They rise abruptly from sea coast or low lands as a result of uplifting. Example is Chota Nagpur Plateau.

Tectonic Plateau

Volcanic Plateau

1. Caused by basaltic lava flow.

Dissected Plateau

1. Formed by erosion.

Plain Types

Structural Plains

1. They are formed as a result of uplifting of continental shelf. They can also refer to structurally low lying areas.

Erosional Plains

1. When a highland gets eroded, it is also called peneplain (almost plains) or erosional plain. Mechanical weathering in arid and semi-arid areas may wear the mountain slopes leading to pediplains.

Depositional Plains

1. The Ganga delta in the west is dying since streams there get choked. So the delta is moving eastward.

Soils

1. The air contained in the soil pores has ore CO_2 as compared to atmosphere.
2. Clay < silt < sand in size.
3. Clay soil has small pore spaces and hence the rate of passage of water through it is low. Hence clay soils are more water retentive. Sandy soil has large pore spaces so water passes down quickly. Loam has a mixture of sand, clay and silt and has good water retentive capacity as well as is easy to plough.
4. Soils with low lime content are acidic and those with high lime content are alkaline.
5. Parent rock, topography and the time period are called passive agents while climate and biological factors are called active agents.
6. Climate tends to reduce the differences caused by the different parent materials. Granite rock gives laterite soil in moist parts of monsoonal regions while non-lateritic soil in drier parts. Hot summer and low rainfall leads to black soil in TN irrespective of parent rock. In Rajasthan both granite and sandstone give sandy soil.
7. Residual soil: On steep rocks, only a thin layer of soil is left after erosion. This is called residual soil.

Soil Classification

Pedalfers

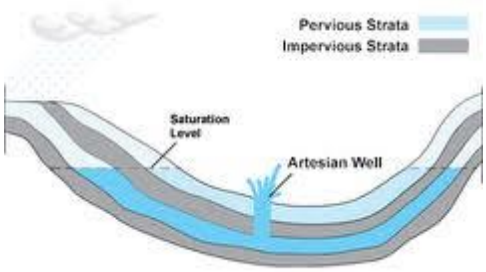
1. This soil is found in humid conditions. They are generally acidic and are deficient in calcium and other mineral salts (due to precipitation leaching takes place).
2. Ash-grey soils / Podosols: Found in high latitude coniferous forests. Winters are long and cold, summers are short and cool, precipitation is moderate throughout the year. There is strong leaching and slow formation of humus (due to scant bio cover). The soils are acidic and have limited agricultural value.
3. Grey-brown soils: They are found in mid latitude deciduous forest regions of US and Europe. They are less leached, have good humus content and fertile.
4. Red & yellow soils: They are found in tropical regions of high rainfall. Leaching is intense, high bacterial activity leaves little humus, they are acidic (lime content is low) and red color is due to iron oxides.

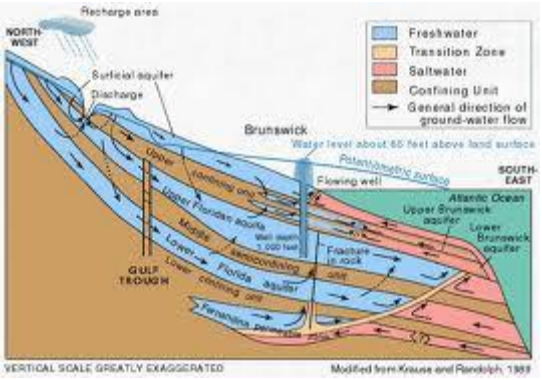
Pedocals

1. They are found in arid conditions. They are rich in calcium and other mineral salts (due to evaporation, water and the dissolved salts move up). Prairies are a region of such soils.
2. Black soils: They are most fertile, rich in humus, rich in calcium, unleached and are crumby. They have higher moisture holding capacity.
3. Desert soils: They are unleached and alkaline but lack humus (due to scant bio cover).
4. Usar: The are patches of barren soil in pedocal belt under dry steppe like conditions. They are found in UP.
5. Reh: Clay soil with bad drainage lying in low-lying areas. Due to bad drainage, salts come up from below and these soils are saline and alkaline. Even canal irrigation can't help due to salt presence.

Underground Water

1. Porosity, permeability & aquifers: Porosity is the water holding capacity of the rocks and depends on the pore spaces. When pore spaces of rocks join together, water can flow through the rock making it permeable. If the pores are not interconnected rock may be porous but not permeable. When such pore spaces are large and connected such that water can flow freely, it is called aquifers. Clay is porous but has a low permeability. Granite is non-porous but permeable because of the joints or cracks through it.
2. Zone of saturation, water table & zone of intermittent saturation: Zone of saturation is when all pore spaces are fully filled by water. Water table is the line which separates zone of saturation and unsaturation. Intermittent saturation zone is the difference between permanent water table and highest water table.
3. Artesian wells: When due to pressure water in a well automatically rises to the ground surface. It occurs in 2 conditions shown below:



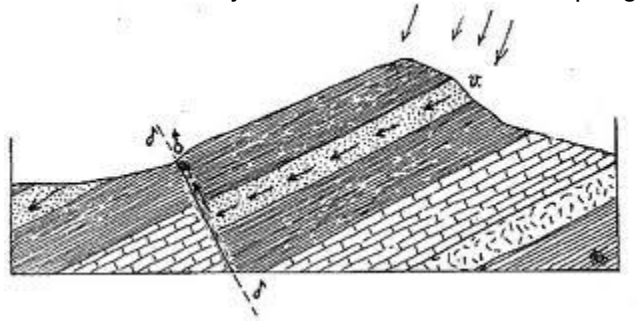


In India, Neyveli lignite mining area suffers from this problem.

Springs

1. They are places when flow of water rises to the surface due to pressure. They open out at the junctions of permeable and impermeable rocks. Basically water falls on the hill top, a layer of impervious rock is below at some depth. At some point on the slope, it comes out and flows on the surface.
2. Pit spring: When the impervious rock is in the form of a flat depression, the spring flows out of the bed's lowest point which reaches the surface.
3. Scarp foot spring: They are marked along the foot of a scarp in the hills up to which level the rain water percolates and cannot move further down due to impervious rock.
4. Fissure spring: In hard rocks, water flows mainly through fissures. When such a fissure reaches the surface on a hill slope, it is called fissure spring.
5. Dyke spring: If the dyke is of impervious nature and it has pervious rocks to both sides, then at a place where it is exposed, water flows out and is called dyke spring.
6. Vauclusion spring: Underground rivers cut across limestone beds and make way. But when the limestone passage is exposed to the surface and there is an impervious bed below, river comes out again as vauclusion spring.

Fault spring: Due to faulting, a pervious bed comes to rest against an impervious bed. So water flows out from the junction and is called fault spring.



Karst Topography

1. It is the topography made by underground water in limestone rock areas. Limestone rocks get readily dissolved by rain water. Water percolates down until it hits an impervious bed and then flows underground dissolving away limestone.

2. Sink hole: It is a funnel shape depression at the surface from where water or running stream percolates down.

1. Blind Valleys: Due to sink holes, sometimes river streams go underground leaving their beds dry. The beds of dry streams are called blind valleys.
2. Swallow Holes: They are like pots and lie below a sink hole when an impervious bed is reached. So water begins to flow in underground caves.
3. Caverns: They are a network of caves and chambers formed underground in a limestone topography.

Gradation Process

Weathering

Mechanical weathering

1. No chemical reaction takes place and rock particles are only separated from each other. It is most rapid on sedimentary rocks. Temperature induced expansion and contraction is one reason. Dark colored / multi colored rocks are easier to break than light colored ones.
2. Rectangular edges of the rocks are weathered into round edges because the stresses and pressures are highest along sharp angles.
3. Mass movement: Mass movement is the movement of weathered material down the slope due to gravity.
4. Talus / Scree: The angular debris formed as a result of rock weathering which move down the slope and accumulate at the foot under the effect of gravity.
5. Exfoliation: The alternate expansion and contraction of the outer surface sometimes results in its peeling off in the form of concentric shells. It is called exfoliation.
6. Frost weathering: Ice occupies more volume than water. So when inside rock fissures in cold temperatures, ice freezes it expands the fissures leading to breakup of the rock.
7. Soil creep, soil flow and landslides: Soil creep is the slow but steady and barely noticeable movement of soil down the slope under gravity. It is most common in damp soil where water acts as a lubricant. Though the movement can't be seen, it can be inferred as trees having roots or pillars rooted on the soil bend and soil accumulates near the base of a wall on the slope. When soil gets too much water, it flows as a suspension in the water. This is called soil flow. Landslides are common when permeable layers lie above an impermeable layer. Then water accumulates at the base and acts as a lubricant.

Bio weathering

1. It consists of both mechanical (roots, burrowing) as well as chemical (excretions contain acids).

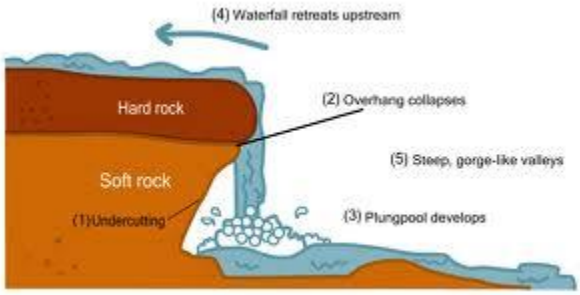
Chemical weathering

1. Here the rocks decompose chemically instead of disintegrating. It is higher in high temperature and moisture. Mechanical action of rain is smaller than its chemical action. Granite is composed of crystals of quarts, felspar and mica. Out of these felspar is quickly weathered in rain and leaves the surface rough. The quartz crystals are loosened subsequently.
2. Regolith: It is the weathered material remains of the rock. It is different from soil because soil has organic content while regolith has no organic content.
3. When a soil cover exists over the rock bed, chemical weathering is generally enhanced and not reduced. This is because water goes down via soil pores and remains there for a long time creating a moist environment. It also absorbs organic acids from the soil making it a stronger weathering agent.
4. Sedimentary rocks are more affected by chemical weathering (specially solution type where rock material gets dissolved in the water) because water can enter the pore spaces in these rocks.
5. Hydration: Aluminum bearing rocks react with rain water and this leads to breaking of the outer shell.

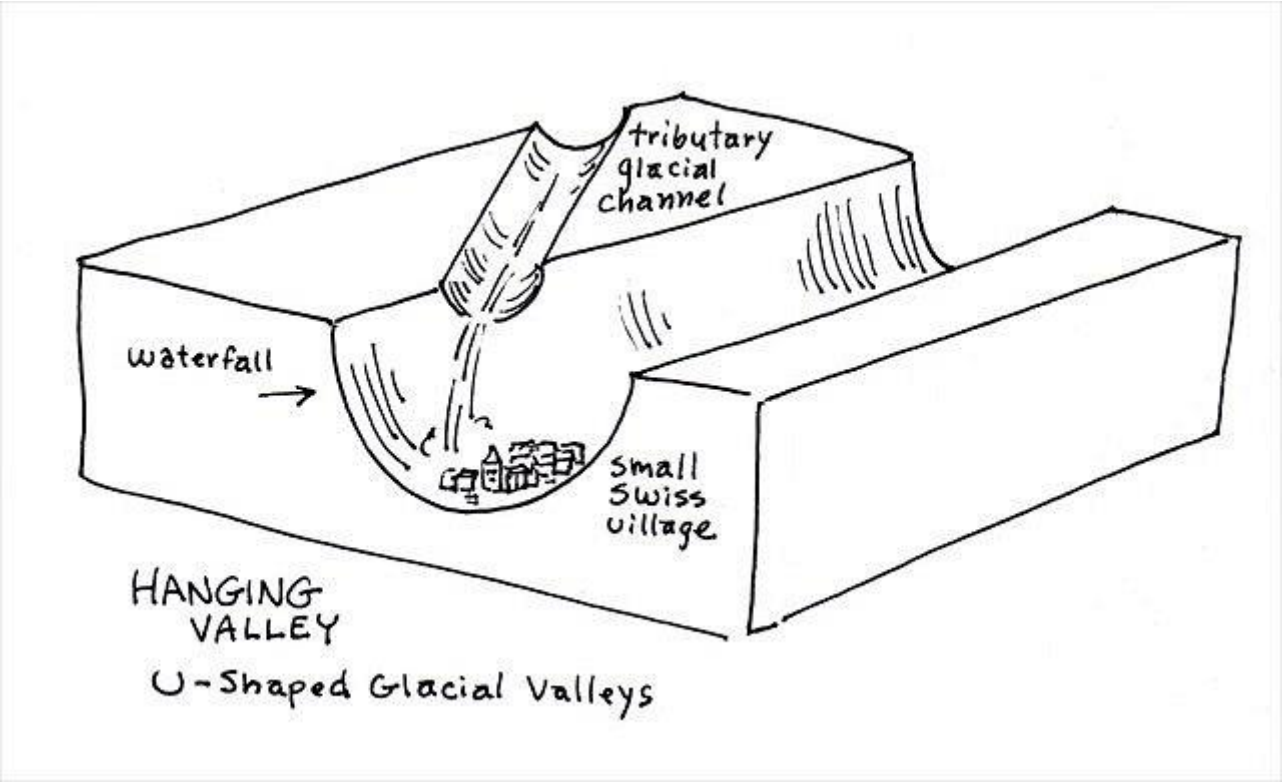
Running Water

1. Carrying capacity of rivers increases 64x if velocity is doubled and only 2x if volume is doubled.
2. Erosion power increases with the amount of sediments already being carried. So during floods when sediment load is high, large boulders stuck in the river bed are moved as well.
3. Corrasion or abrasion: This is the mechanical grinding of river's load against the bed (vertical corrasion) and the banks (lateral corrasion).
4. Corrosion or solution: It is the chemical weathering action of river water.
5. Hydraulic action: This is the mechanical loosening of materials by the river water itself.
6. Attrition: This is the wear and tear of carried load in the river when it rolls or collides with other particles.
7. River capture: Due to head cutting, a river may extend backwards. If it cuts across the watershed, it may capture a tributary of another river. The bend at which the other river is captured is called *elbow.* The old main river of the captured tributary is called *misfit.* The dry valley of the captured tributary below the elbow is called *wind gap.*
8. Gorges: They are formed when side rocks are very resistant, the valley becomes low and sides very steep as river cuts down its own bed. Canyons are deepest gorges and are formed in drier areas or areas with limestone beds, river fails to widen and cuts its own bed.

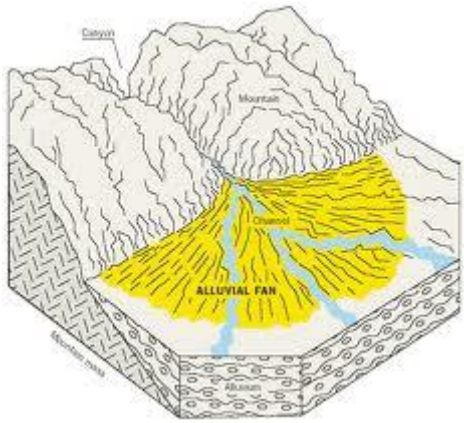
1. Rapids: Occurrence of a band of hard rocks on the river beds makes it go up and down.



1. Hanging valley: In glaciated areas at points where tributary stream joins the main stream, the over-deepening of the main valley leaves the side valleys hanging high above the main valley. A mini-waterfall emerges where tributaries fall into the main river. This is because the smaller glaciers filling tributary valleys don't erode as deep as that filling the main valley.

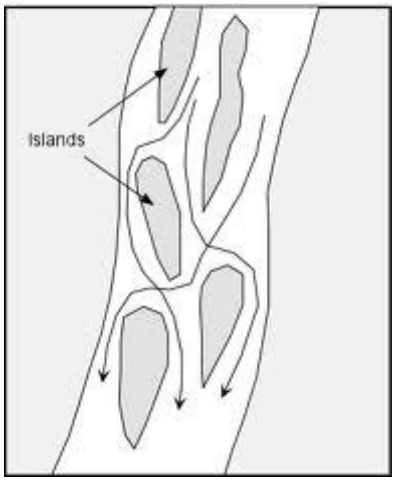


1. Alluvial fans: The merging of adjoining alluvial fans gives rise to bhabhar plain @ the foot of himalyas in Ganga plain.

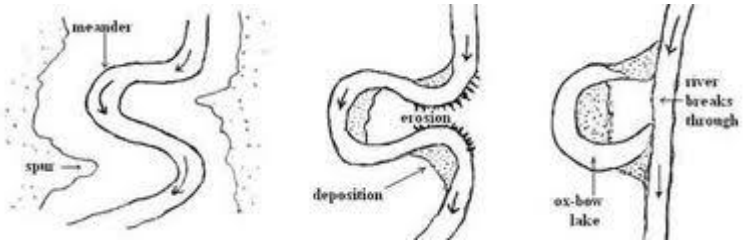


1. Braided stream: In the lower river basin, deposition is in excess of erosion. So a network of islands emerges in the river course. The stream gets divided into a network of channels flowing between and around these islands.

Braided Channel



1. Meanders & oxbow lakes: In a meander, water velocity is higher on the outer side of the bend. So while there is erosion on the outer side, there is deposition on the inner side. Initially due to an obstruction, river bends. Now deposition will take place on the inner side of the bend and erosion on the other side leading to formation of oxbow lake.

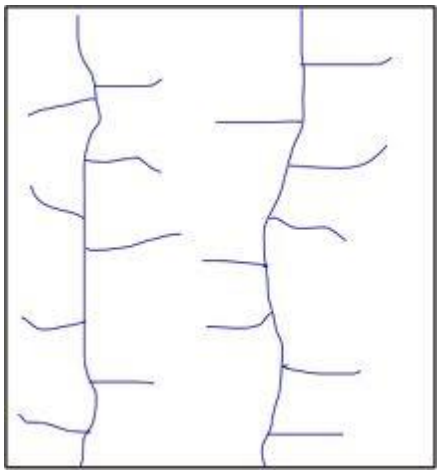


1. Due to continuous deposition on the river bed, the river bed and the levees may rise higher than the adjoining flood plain.
2. Deltas: Large supply of fine alluvium, sheltered coast, absence of large lakes which 'filter' off river's sediments, absence of strong tides, winds, currents is needed @ the river mouth for the formation of deltas.
3. Watershed: The higher ground separating 2 drainage basins is called watershed.

4. Consequent streams vs antecedent streams: Consequent streams are streams whose flow is a result of the original slope of the land. If continuous downcutting enables the rivers to make their way through the mountain ranges rising subsequently, they are called antecedent streams.
5. River rejuvenation: When there is a negative movement, the river's erosional activities come back to life in the lower course. The point where the new and old profile meet is called *knick point* and river often forms rapids there. It may also lead to vertical downcutting of its meanders and formation of deep gorges and canyons.
6. Subsequent streams vs insequent streams:

1. Dendritic drainage: It is a tree like patter formed by insequent streams. It is formed when the entire bed is of uniform rocks.

1. Parallel drainage: It develops on steep slopes when master stream and tributaries run almost parallel for long distances before merging.
2. Trellis drainage: It develops when tributaries meet main stream almost @ 90º. It develops when the landform has resistant anticline ridges separated by synclinal valleys or where resistant and non-resistant rocks are alternate.



1. Radial drainage: Drainage radiating from a central part to all directions.

Moving Ice

1. Snowline's height depends on latitude as well as amount of precipitation. Higher the precipitation, lower the snowline. It also depends on the slope. Steep slopes lead to snow lines going higher. In N hemisphere, snowlines to the north side are lower than those to the southern side.
2. A glacier erodes via abrasion as well as plucking.
3. Ice caps: They are the covers of snow and ice on mountains from which the valley or mountain glaciers originate.

4. Piedmont glaciers: @ the foot of the mountains several glaciers may converge like in Alaska.
5. Boulder clay: The material carried by glacier is heterogenous and contains both boulders and clay, hence the name.
6. Ice velocity: It increases with thickness of glacial ice. So speed is higher in the middle and lower @ the edges.
7. Crevasses: The top portion of the glacier moves faster than the bottom due to less friction. So cracks appear on the top specially when the slope of the bed drops suddenly. The ice can't keep pace with its faster movement. Downwards where the gradient is gentler, crevasses unite. Crevasses in the direction of flow generally appear when the glacier becomes wide on leaving a narrow valley.

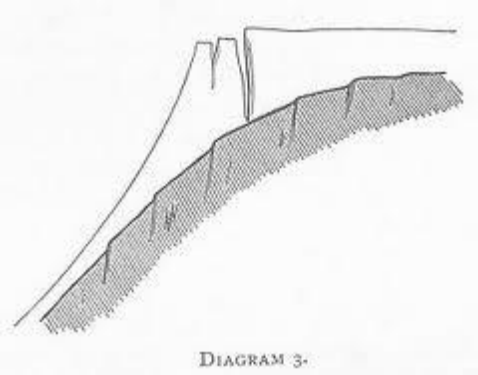
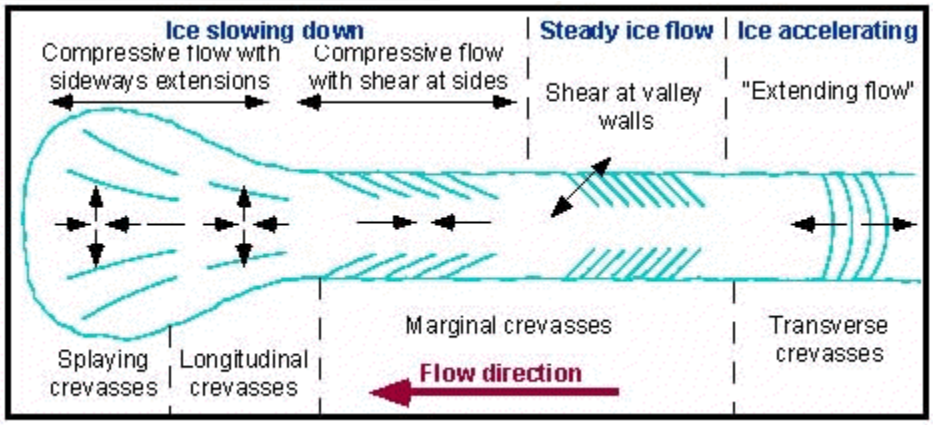
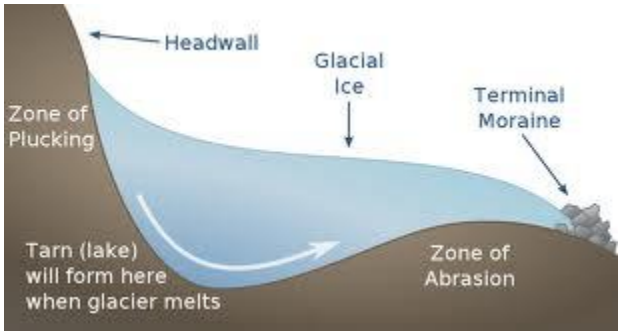


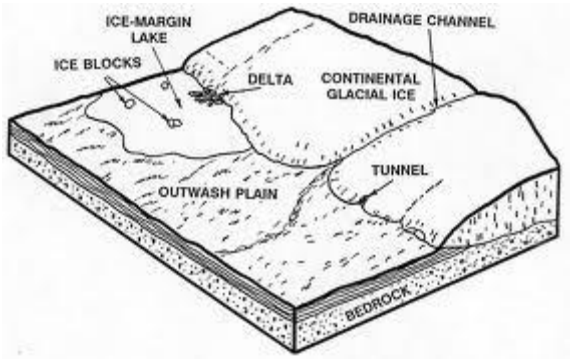
DIAGRAM 3.



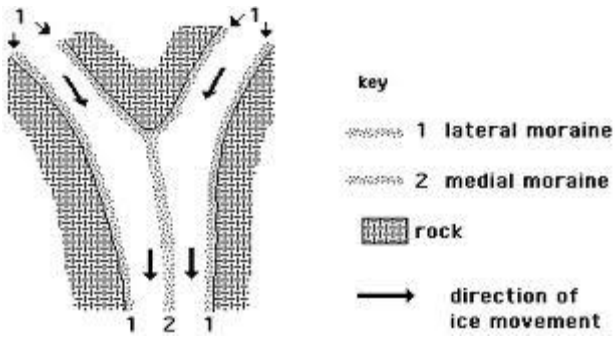
1. Cirque: It is a large arm-chair like hollow cut into the mountain ridge. The edge of the open end is slightly higher. When it melts lakes called *tarn* are formed. On the back wall, plucking occurs steepening it. If cirques occur on 2 sides of the peak, it leads to formation of *aretes*. If cirques occur on 3 sides, it leads to pyramidical peaks. The abrasive action leads to deepening of the cirque floor depression.



1. Sheep rocks and crags: Ice, unlike water, doesn't avoid obstacles but flows over it. Thus the upward slope becomes smooth and gentler while the other slope becomes steep and rougher. A crag is a rock with a steep side over which the glacier flew and gentle other side.
2. Glacial till: The moraine piles of stones and boulders are called glacial tills.
3. Ground moraine: The excessive load which can't be carried by a glacier and is deposited on its own bed is called ground moraine.
4. Drumlins: If the ground moraine is deposited on a smooth surface, it leads to formation of small hills. These small hills are called drumlins. If deposited on a rough surface, it tends to fill the gaps and make it smooth.
5. Outwash plain, valley trains & eskers: When the glacier melts, the water stream can carry the sediments of the moraine to some distance and sort them. They deposit the material in the shape of alluvial fans, it is called outwash plain. If these sediments are deposited along the river banks, they run parallel and are called valley trains. Long winding and very low ridges of sand and gravel looking like natural embankments and made by these sub-glacial streams are called Eskers.



1.
2. Terminal moraine: The material dropped at the end of the valley in the form of a ridge. Each time a glacier recedes, a fresh terminal moraine is created behind the first one.
3. Lateral moraine: Moraine formed on the sides.
4. Medial moraine: When 2 lateral moraines join, their confluence is called medial moraine.



Wind

1. Barkhan: They are the crescent sand dunes. Extremities of the dune move more rapidly than the middle portion giving rise to the horns. A constant wind direction and limited supply of sand are needed.
2. Seif or longitudinal dunes: Seifs are long narrow ridges of sand running parallel to the direction of wind. The dominant winds blow straight in the corridor between the dunes. Barkhan will be transformed into a Seif if a cross wind blows consistently thus its horns will rearrange.

Sea Waves

1. Coast & shore: Coastline is the high tide level. Shore is the low tide level.
2. Sea-cliffs: The wave initially wears a groove in the rock @ sea level. As the groove deepens, the upper portion falls into the sea and a steep wall of the rock remains which is called sea cliff.
3. Sea-Caves: Caves generally form when the overhanging rock is able to stand without the support from below which has been cut by the sea waves.
4. Sea Arch: When sea waves working from both sides cut through the caves, it is called sea arch.
5. Stack: When the upper portion of the sea arch falls, the remaining portion which stands is called stack.

1. Spit, bar & lagoon: Sea waves deposit their load @ some distance. If a ridge or embankment of such sediments is formed which is attached to land on one side and opens into the open sea on the other and at the same time is also parallel to the coast, it is called a spit. If such a spit is also enclosed by land on the other side such that it works to cordon of a part of the sea it is called a bar. A bar extends between 2 headlands and the sea water so enclosed is called a lagoon.

1. <u>Headlands and bay:</u> Headlands are formed in resistant rocks while bays are formed in non-resistant rocks.

Coastlines

1. <u>Submergence vs emergence coastlines:</u> When sea level rises or the coastal land subsides it is called coastline of submergence. When the sea level falls or the continental shelf adjacent to the coast rises, it is called coastline of emergence.
2. <u>Fiord coastline:</u> It is a coastline of submergence of a glaciated area. They have long and narrow inlets with steep sides (from U shaped valleys) and many tiny islands which were once outlying hills.
3. <u>Ria coastline:</u> It is a coastline of submergence of a non-glaciated area. The slopes of the inlets are gentle (from V shaped valleys) and they become progressively deeper towards sea. Generally there are no islands.
4. <u>Lowland coastline:</u> It is formed by submergence of a low lying area. It is characterized by the presence of bars and lagoons.
5. <u>Dalmatian coastline:</u> It is formed when a mountain range running parallel to the coast subsides.