UNIT 2

UNIT II - NATURAL DISASTER

Disaster:

A Disaster is a serious disruption of the functioning of a society involving widespread human, material, economic or environmental losses & impacts which exceeds the ability of the affected community or society to cope using it's own resources.

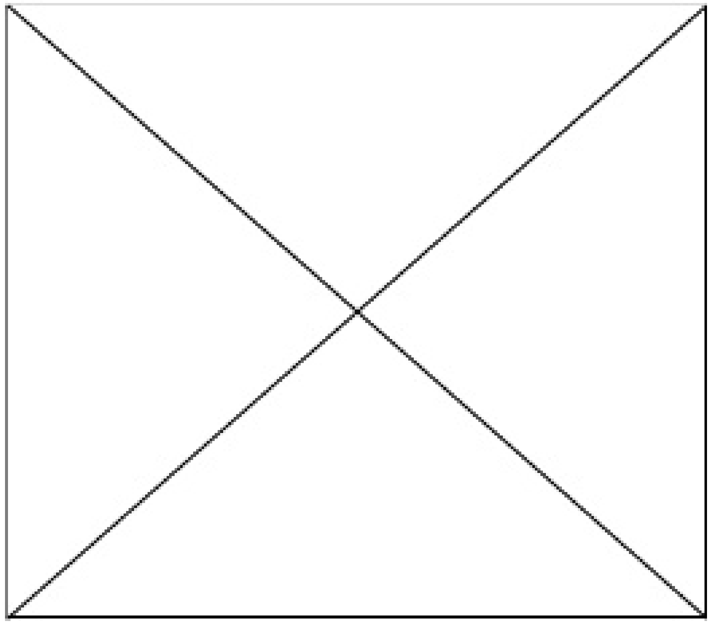
Types of Disasters

Natural Disasters	Human-Made Disasters
Earthquakes	Nuclear Disasters
Floods	Chemical Disasters
Landslides	Biological Disasters
Avalanches	Accidental or Ignorance Disasters
Cyclones	
Tsunamis	
Heat Waves	
Droughts	

Natural Disasters:

A Natural Disaster is a major adverse event resulting from natural processes of the Earth such as floods, volcanic-eruptions, earthquakes, tsunamis & other geologic processes, such events leads to loss of life & property.

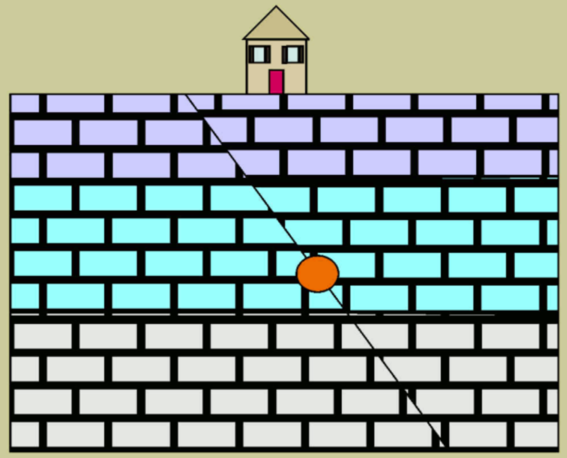
The severity of such events depends on the affected population's ability to recover.



Earthquakes

Vibrations induced in the earth's crust due to internal or external causes that virtually shake up a part of the crust and all the structures and living and non-living things existing on it.

Strongest, Quickest and most unexpected natural calamities.

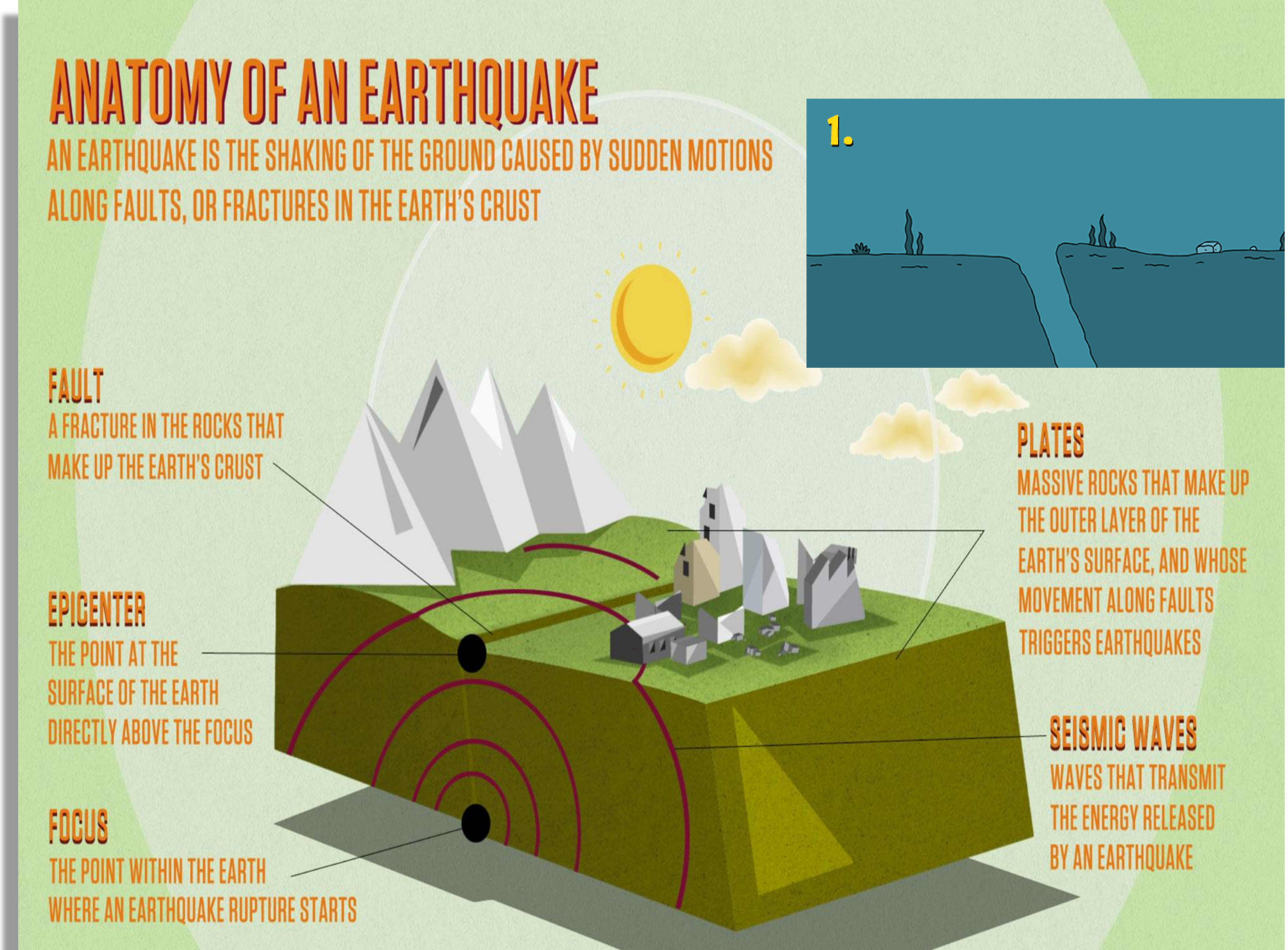


Earthquake

- An earthquake is the result of a sudden release of energy in Earth's crust that creates seismic waves.
- Seismic activity of an area refers to the frequency, type & size of earthquakes experienced over a period of time & are measured using seismometers.
- At the Earth's surface, earthquakes manifest themselves by shaking & sometimes displacement of the ground.

Study of Earthquake

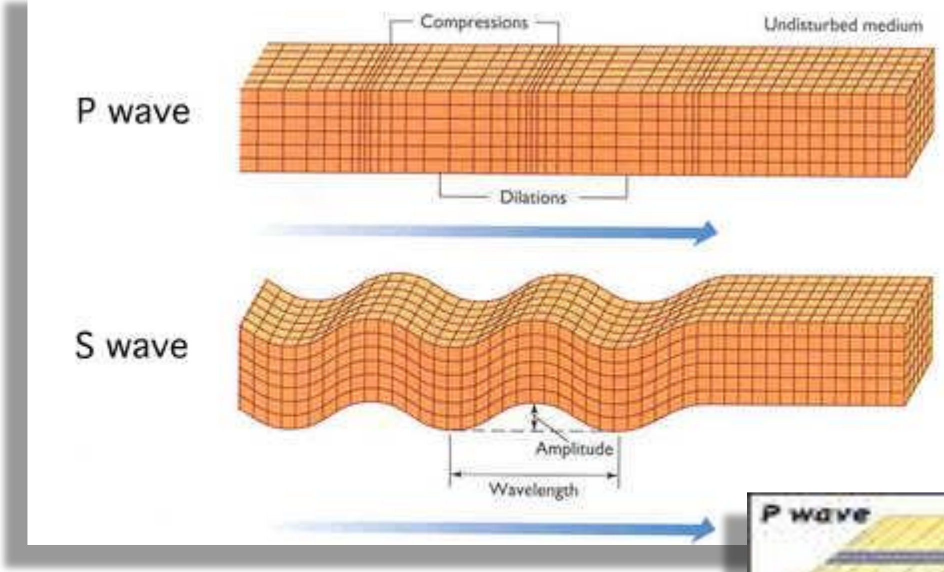
- Ascertain the factors that lead to earthquake
- Predict the occurrence of an earthquake
- Design and Provide structures that will protect during an earthquake


ANATOMY OF AN EARTHQUAKE
AN EARTHQUAKE IS THE SHAKING OF THE GROUND CAUSED BY SUDDEN MOTIONS ALONG FAULTS, OR FRACTURES IN THE EARTH'S CRUST
1.
FAULT
A FRACTURE IN THE ROCKS THAT MAKE UP THE EARTH'S CRUST
EPICENTER
THE POINT AT THE SURFACE OF THE EARTH DIRECTLY ABOVE THE FOCUS
FOCUS
THE POINT WITHIN THE EARTH WHERE AN EARTHQUAKE RUPTURE STARTS
PLATES
MASSIVE ROCKS THAT MAKE UP THE OUTER LAYER OF THE EARTH'S SURFACE, AND WHOSE MOVEMENT ALONG FAULTS TRIGGERS EARTHQUAKES
SEISMIC WAVES
WAVES THAT TRANSMIT THE ENERGY RELEASED BY AN EARTHQUAKE

Earthquakes

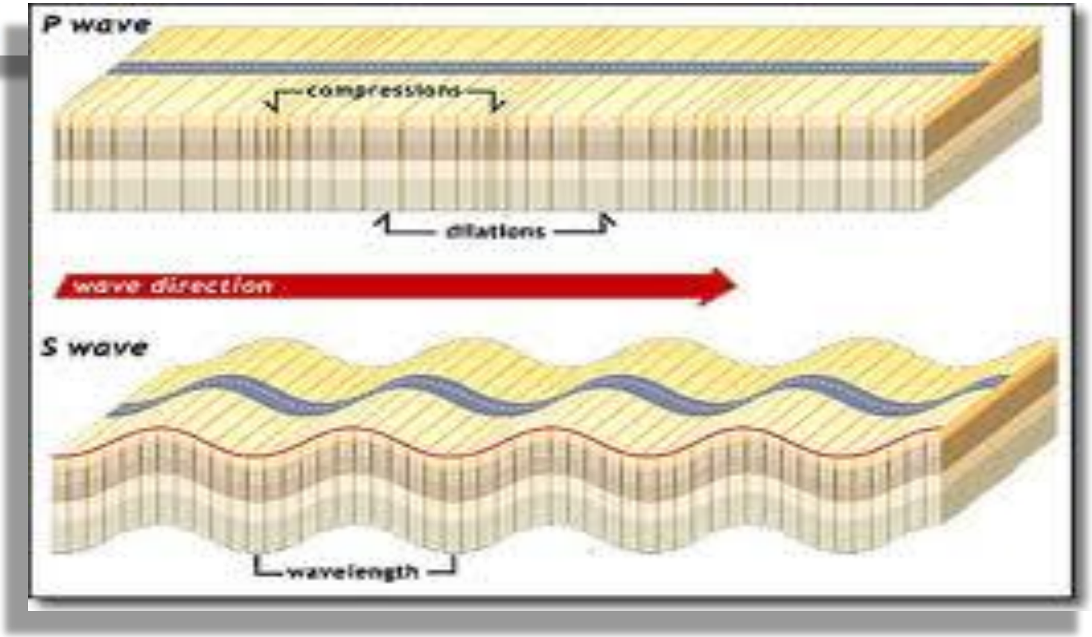
- The vibrations that are set up when an earthquake takes place are propagated as a number of different types of waves. Different types of seismographs are designed to record these waves. A major shock is recorded by seismographs all over the world, and its epicentre, time of origin, depth of focus, magnitude etc. can be worked out from these records called seismograms.
- Of the various types of waves set up by an earthquake the most important are i) P primary waves, which are the fastest. ii) S waves or secondary waves which are slower and iii) L or long wave which arrive at a station later than P & S wave as they follow zig zag path.

Earthquakes



Fastest wave

Helps in understanding the core



Magnitude

- Rating of an Earthquake on the basis of **amplitude** of seismic waves.
- Charles F. Richter in 1935 – Scale of Magnitude.
- **Richter Magnitude is the logarithm of the maximum seismic wave amplitude at a distance of 100 km from the epicenter.**

$$M = \log A - \log A_0$$

- Magnitude Scale – M_b and M_s
- M_s : Shallow earthquake and M_b : Stronger and wide spread earthquake

Intensity

- Rating of an Earthquake **on the basis of its effects on living and non-living things**.
- Degree of shacking.
- Building collapse; Landslide triggered; river changes course; land may burst open.
- Scales for seismic Intensity **Rossi Forrel (Rossi in 1883)** and **Mercalli scale (1902)- M.M.Scale.**
- Intensity is indicated as a set of whole number.

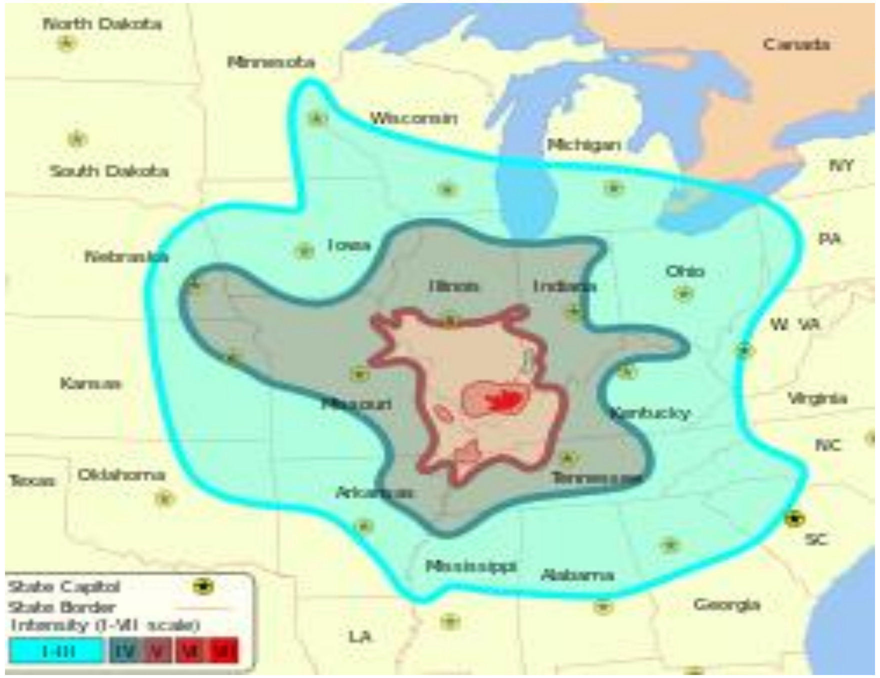
I. Instrumental
II. Weak
III. Slight
IV. Moderate
V. Rather Strong
VI. Strong
VII. Very Strong
VIII. Destructive
IX. Violent
X. Intense
XI. Extreme
XII. Catastrophic

Modified Mercalli Scale

- **I.** Not felt.
- **II.** Felt by persons at rest, on upper floors, or favorably placed.
- **III.** Felt indoors. Vibration like passing of light trucks.
- **IV.** Vibration like passing of heavy trucks.
- **V.** Felt outdoors. Small unstable objects displaced or upset.
- **VI.** Felt by all. Furniture moved. Weak plaster/masonry cracks.
- **VII.** Difficult to stand. Damage to masonry and chimneys.
- **VIII.** Partial collapse of masonry. Frame houses moved.
- **IX.** Masonry seriously damaged or destroyed.
- **X.** Many buildings and bridges destroyed.
- **XI.** Rails bent greatly. Pipelines severely damaged.
- **XII.** Damage nearly total.

Isoseismals

- **Hypothetical** lines – Same Intensity
- A line joining all the similar intensity points are known as Isoseismals.
- Isothermal Records.
- Factors controlling Isoseismals
    - ✓ Nature of Shocks – Shallow origin give rise to high Isoseismals; Deep origin produce moderate Isoseismals.



- ✓ Nature of Rocks – Uniform nature (Isoseismals is regular and circular) - Structural and lithological variations (Isoseismals is irregular and elliptical in shape).

Classification of Earthquake

1. **Depth of focus**
   - **Shallow** – upto 60km
   - **Intermediate** – between 60 and 300 km
   - **Deep seated** – between 300 and 700 km

2. **Causes of origin**
   - **Tectonic Earthquake** – faulting of blocks of the crust along rupture plane.
   - **Non-Technotic Earthquake** – volconic eruption, atomic explosions, landlsides and subsidence.

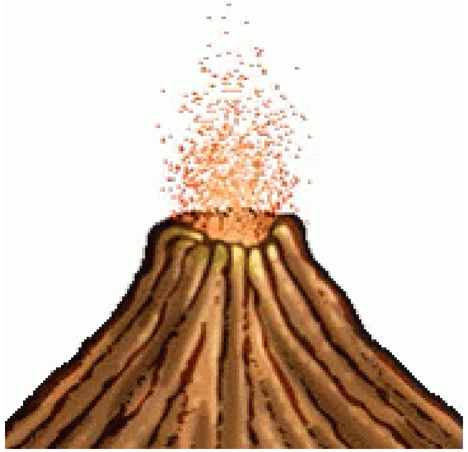
3. **Magnitude**

Class	Magnitude
A	7.8 and above
B	7.0 – 7.7
C	6.0 – 7.0
D	5.3 – 6.0
E	Less than 5.3

Causes of Earthquake

1. **Non-tectonic Causes**

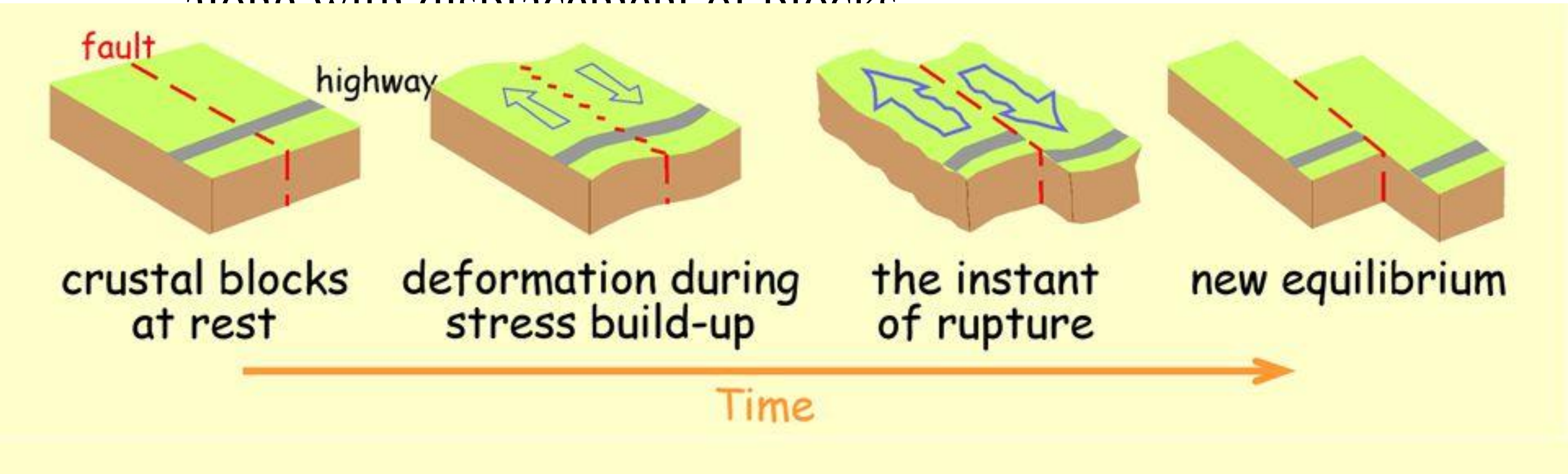
- Volcanic eruptions – forceful eruption of lava
- Atomic Explosions
- Collapse (**Collapse Earthquakes)** of ground by natural or artificial cause – Local nature and rare occurrence.
- Severe local tremors are caused by huge landslides, rock bursts.



Causes of Earthquake

2. Tectonic Earthquakes

- Displacement of blocks along fractures called faults.
- **Elastic Rebound Theory** (H.F.Reid 1906).
- Rocks behave as elastic masses.
- As the first reaction, when these are stressed, the rocks respond to bend.
- The elastic limit may be reached and rupture may develop along with displacement of blocks.



Causes of Earthquake

2. Tectonic Earthquakes

- Displacement is associated with a rebound of curvature developed due to bending during stressing.
- Most of the elastic energy is released at the place of focus in the form of energy waves.

1. **First –** the preparatory process; Non-Hydrostatic stress;

   ‘**Foreshocks**’ are observed.

2. **Second –** The rupture phase. The stored elastic energy released and transformed into potential energy. ‘**Main shock**’

3. **Third–** the post failure adjustment.

   ‘after shocks’ as a residual strain from rock bodies.

Causes of Earthquake

3. Reservoir Associated Earthquake

- Impounding water in Reservoir.
- Aseismic region experiences Earthquake.

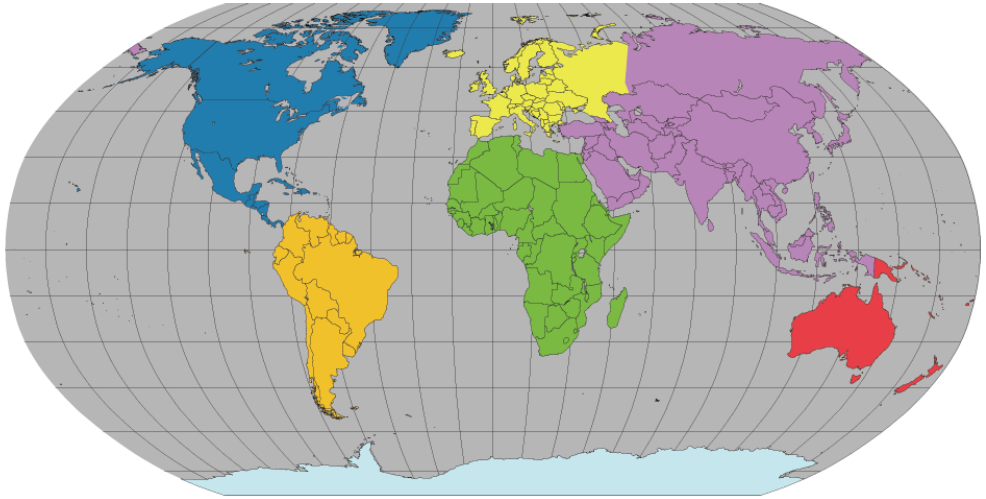
Cause

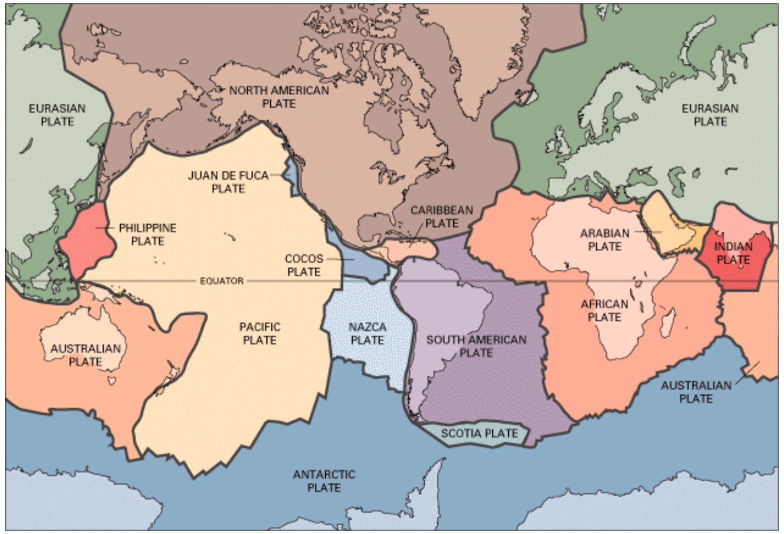
Sagging Effect of the land – when the rock of the basin bear additional load by impound water, it starts bending – stress and redistribution in the region. Readjustment triggers seismic shocks.

Increased pore pressure– Increment of pore pressure has an adverse effect on the shearing strength of the basin rocks which may lead to failure and slippage.

Plate Tectonics and Earthquakes

- The Earth's crust is divided into 12 major plates which are moved in various directions.
- The plates collide, pull apart, or scrape against each other.
- Each motion causes different types of features on the Earth's crust.
- The word, tectonic, refers to changes in the crust because of plate interaction.





What are tectonic plates made of?

- Plates are made of rigid **lithosphere**.

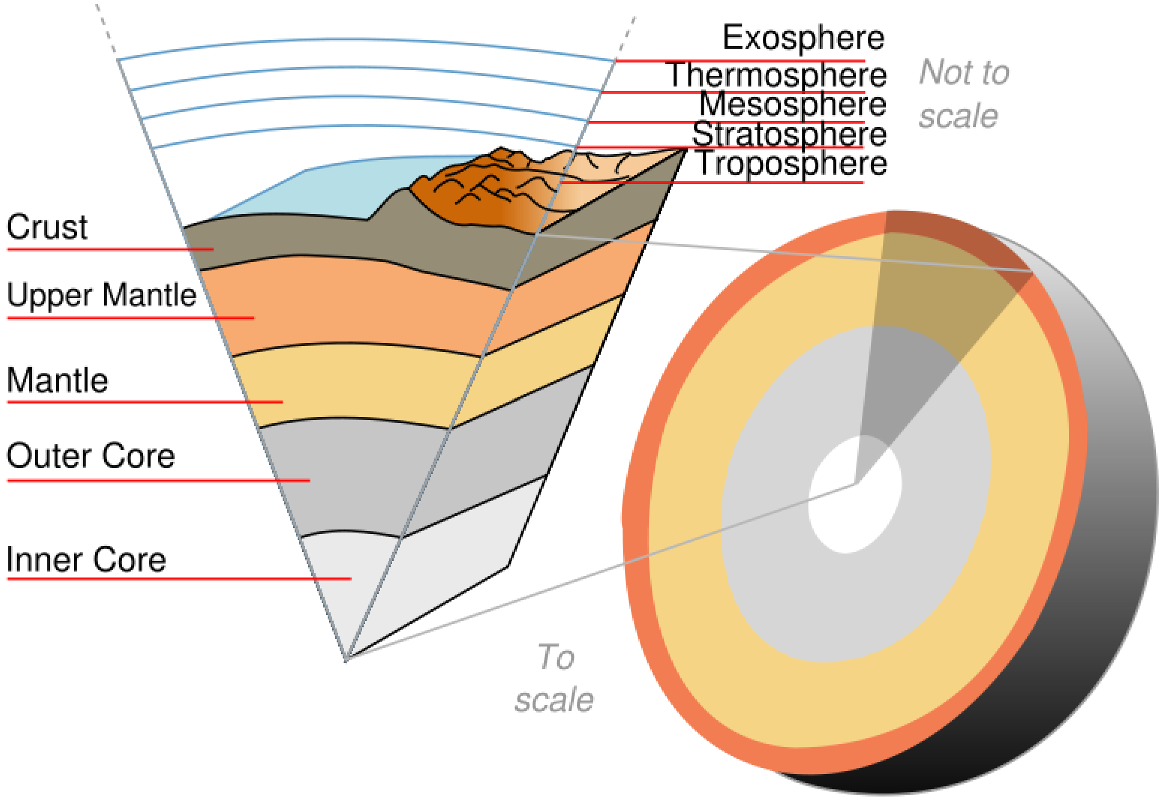
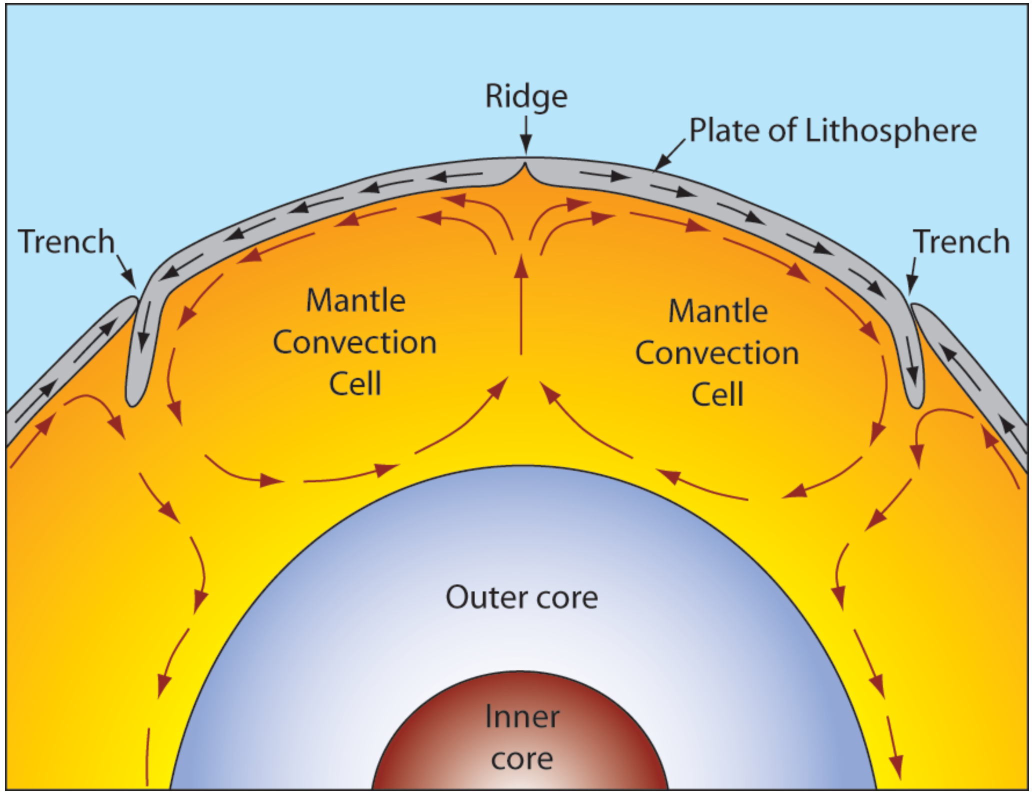


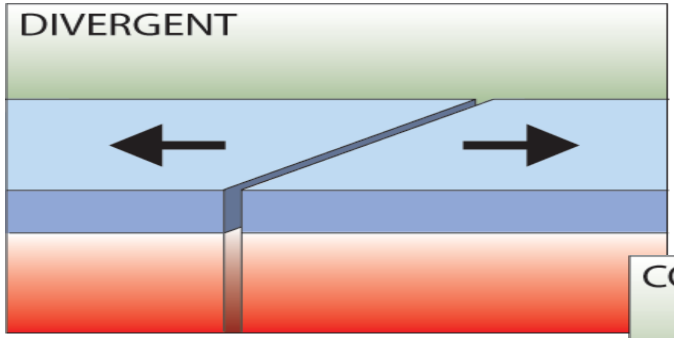
Plate Movement

"Plates" of lithosphere are moved around by the underlying hot mantle convection cells

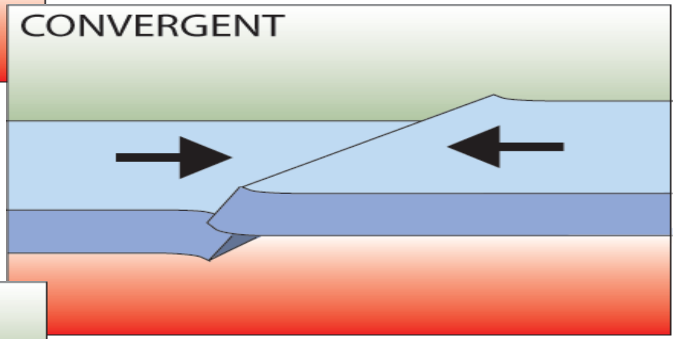


- Earthquakes occurs along the boundaries of the plates.
- Thrust faulting and block faulting.
- Divergent – rise in molten material (sub-oceanic ridges ex.volcanism).
- Convergent – subduction of one plate under another plate (Faulting + displacement)

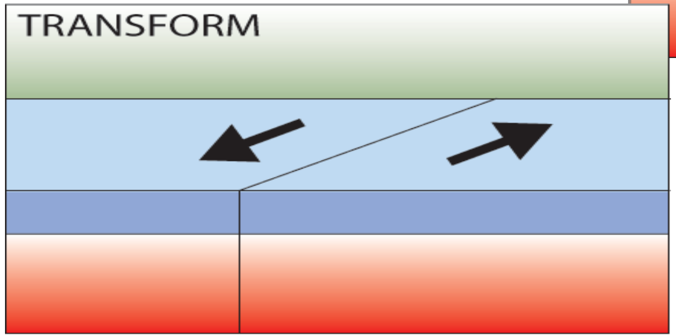
- Divergent

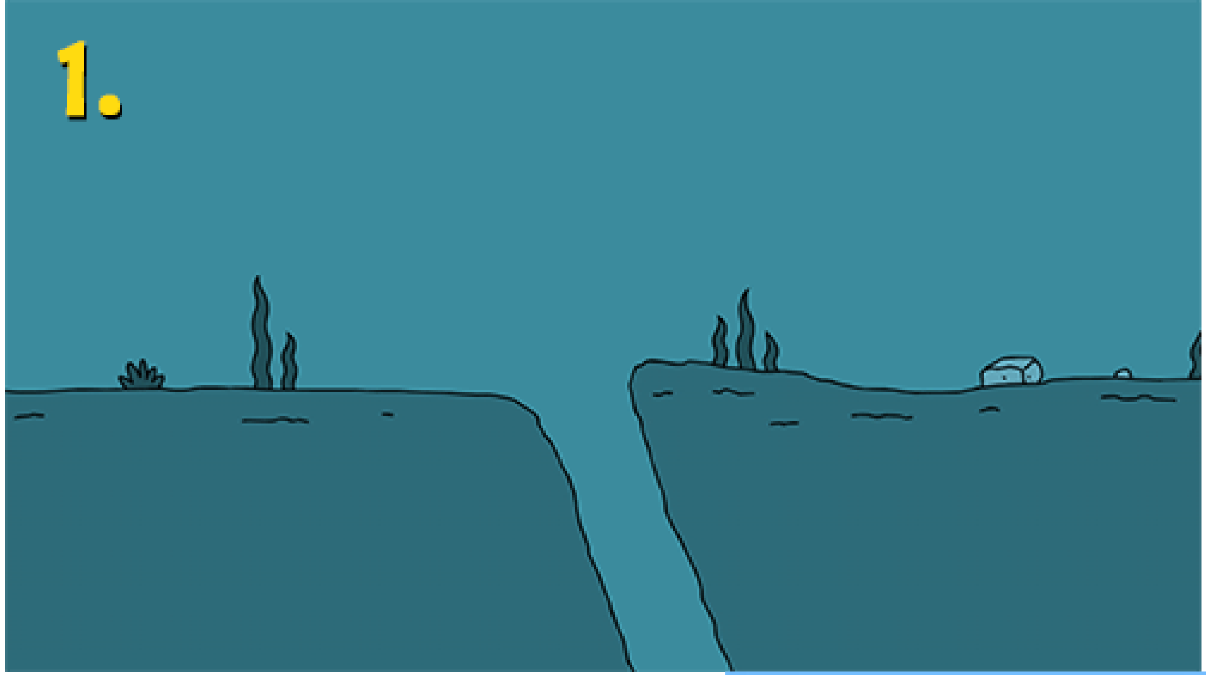


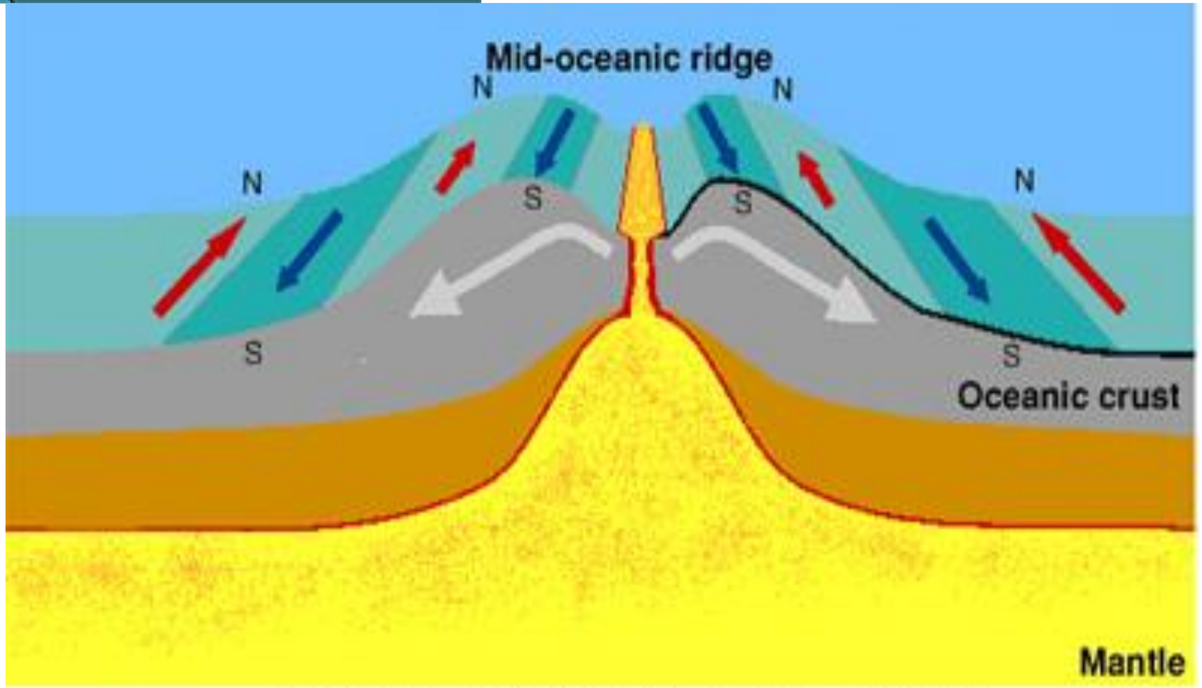
- Convergent



- Transform







Sea floor spreading at the mid-oceanic ridge

Effects of Earthquake

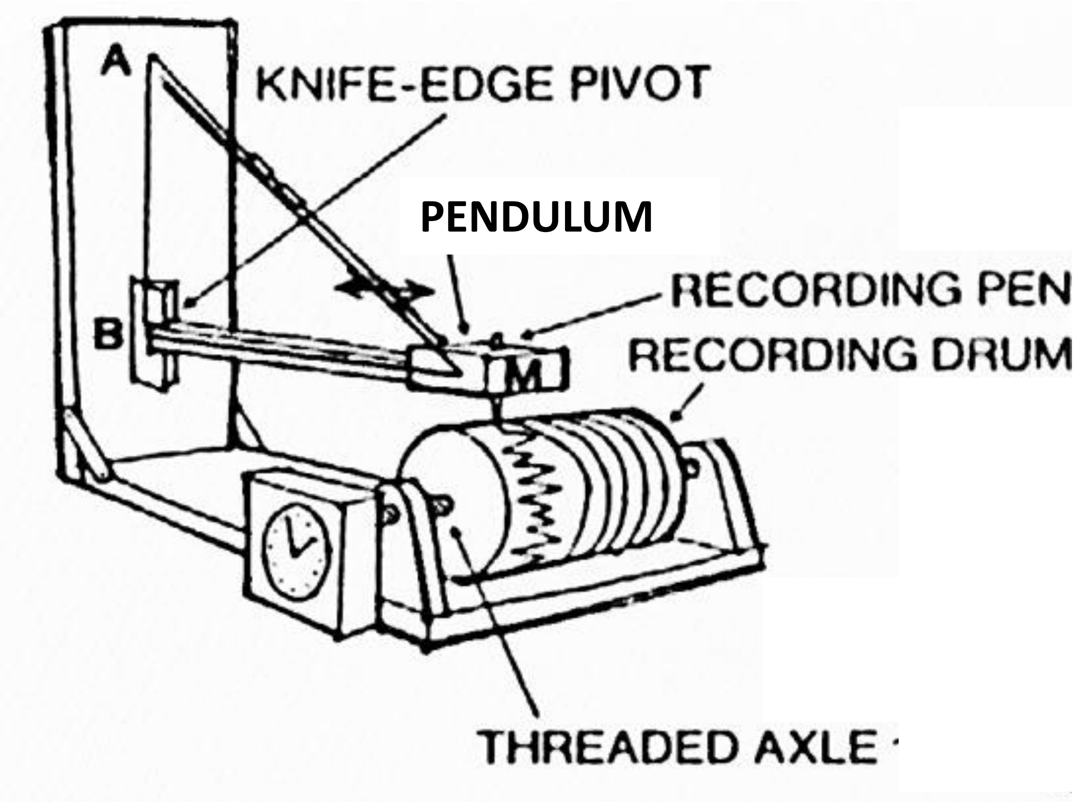
- Primary Effect – Related to the cause of origin of an Earthquake. Tectonic Earthquakes – geological structures.
- Secondary Effect – related to passage of seismic waves and associated shaking motion of the ground. It is observed on constructions of all types. Landslides are triggered; standing structures are collapsed; Tsunamis; trees are uprooted; loose objects are thrown away.

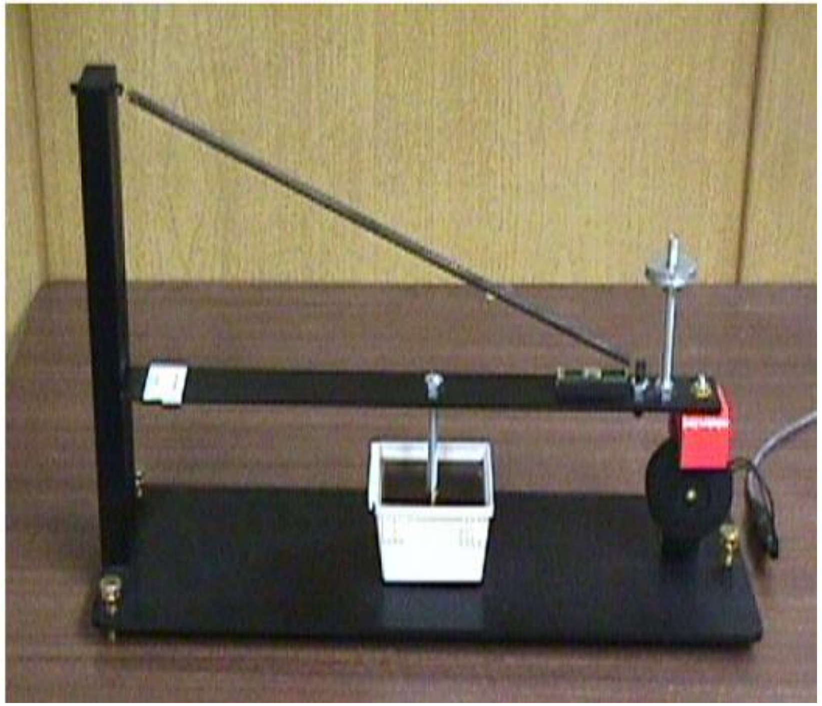
Recording an Earthquake

Earthquake may be the result of combined action of

1. Release of elastic energy
2. Propagation of the seismic waves through the ground
3. Acceleration of the ground.

Seismographs

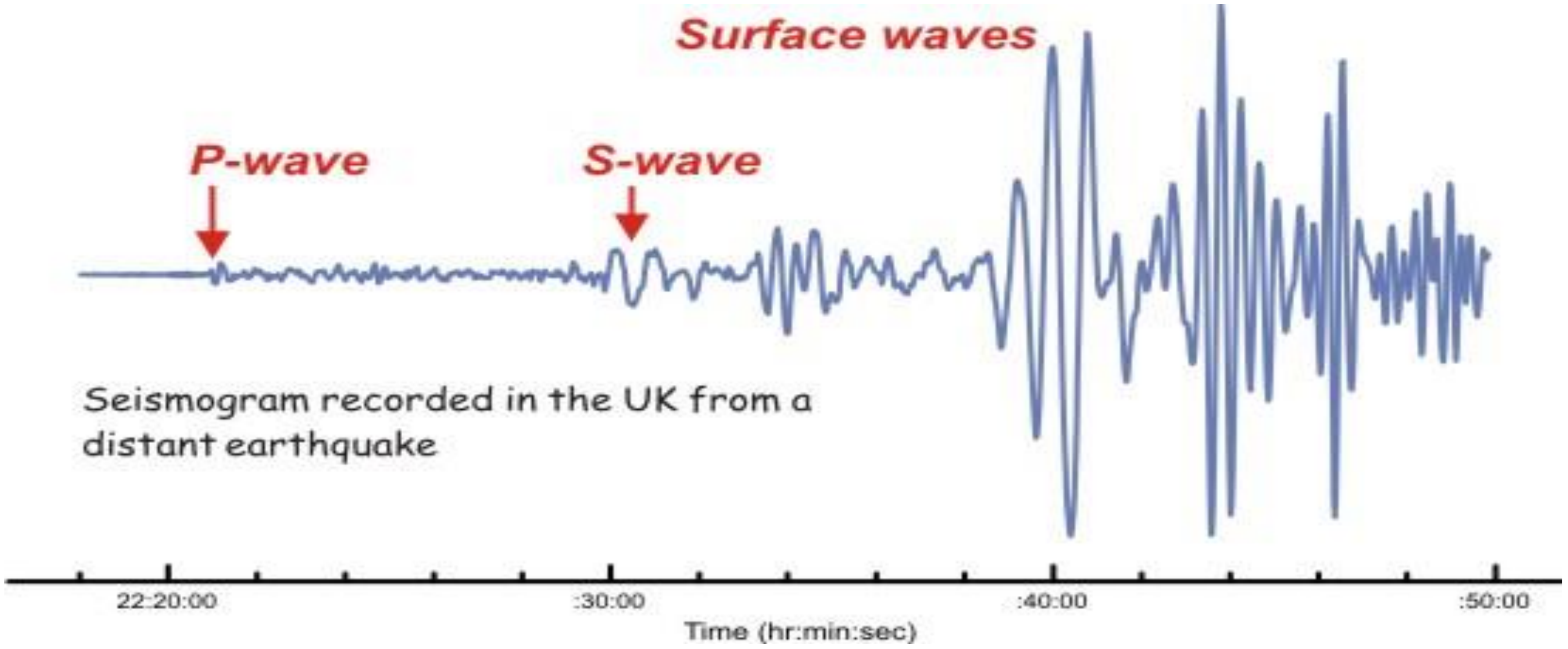




Instrument designed to record the earth motion by seismic waves is called **Seismographs**.

Seismogram? **Horizontal and Vertical?**

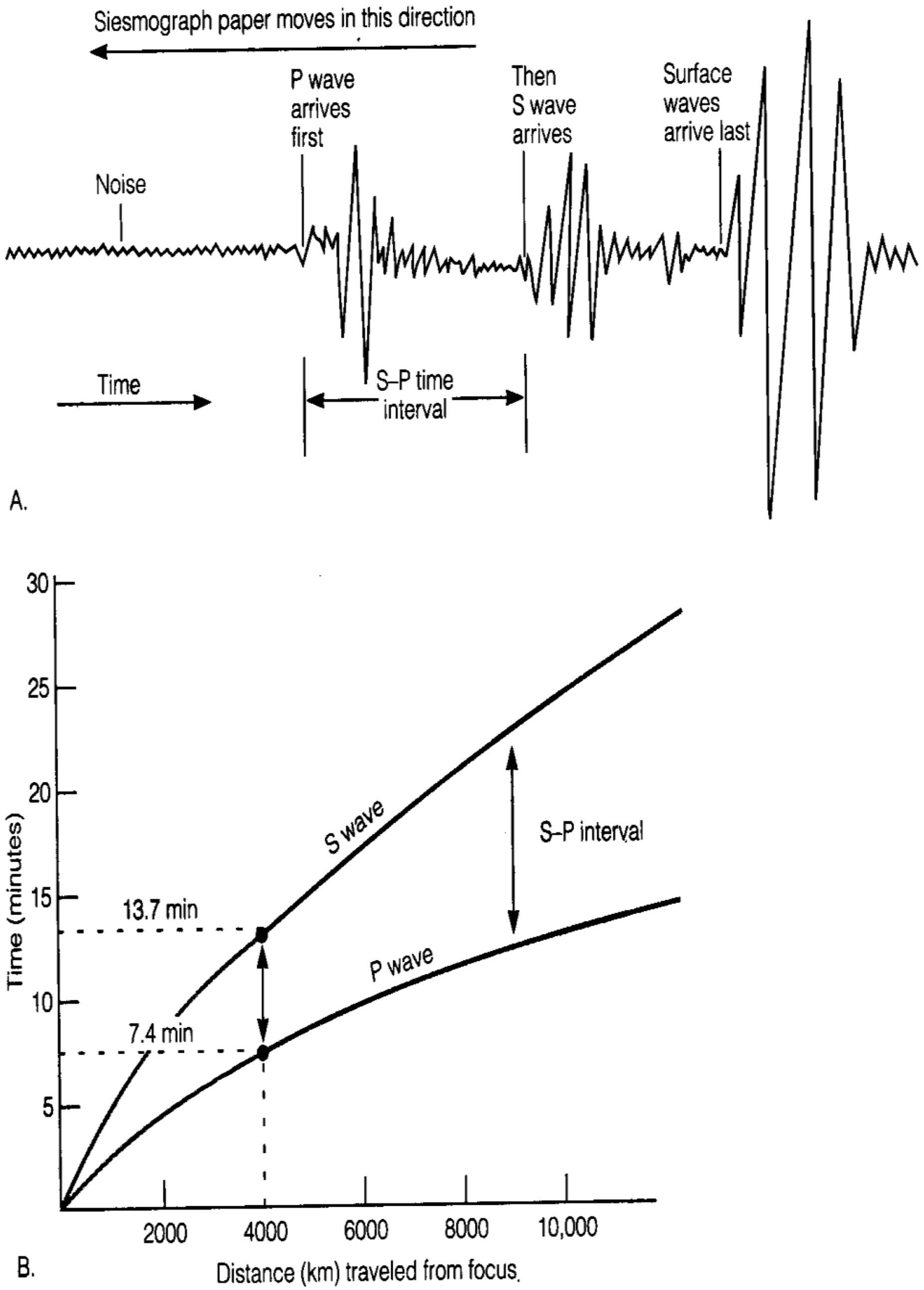
Seismogram



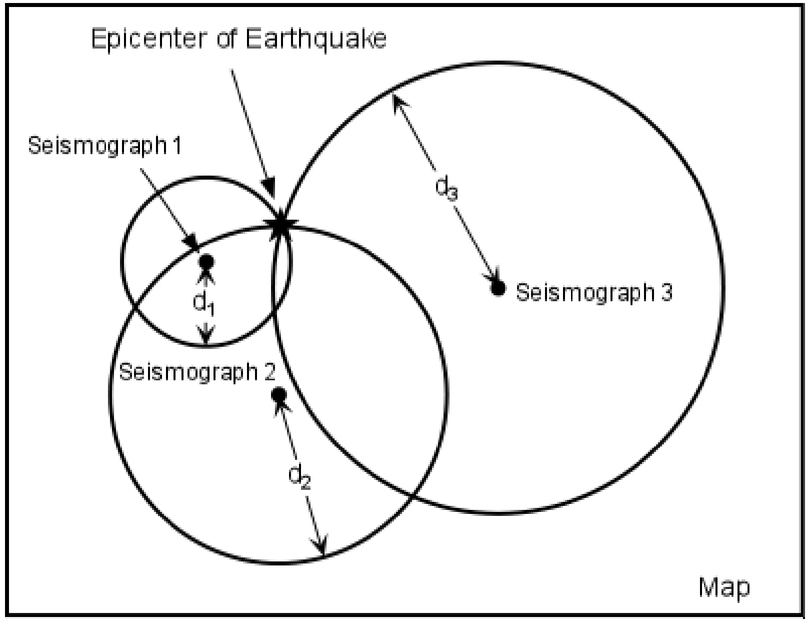
Seismograph - Ground Acceleration, Ground Velocity and ground displacement

Travel time Records

- Marked difference in the velocities of P, S and L waves.
- Travel time curve
- The distance of the epicenter and time of the origin can be calculated.

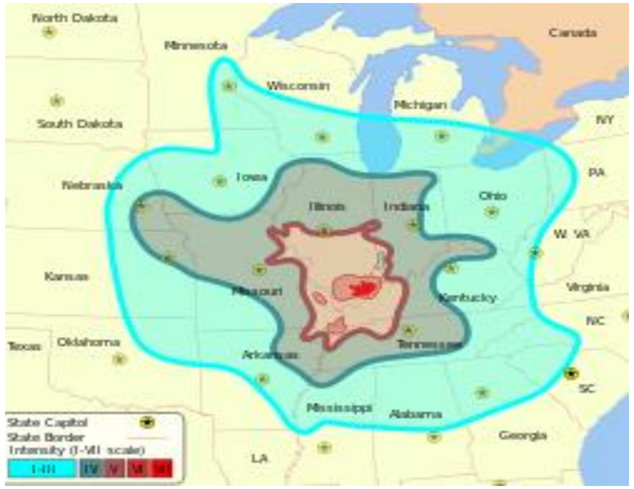


Location of Epicenter



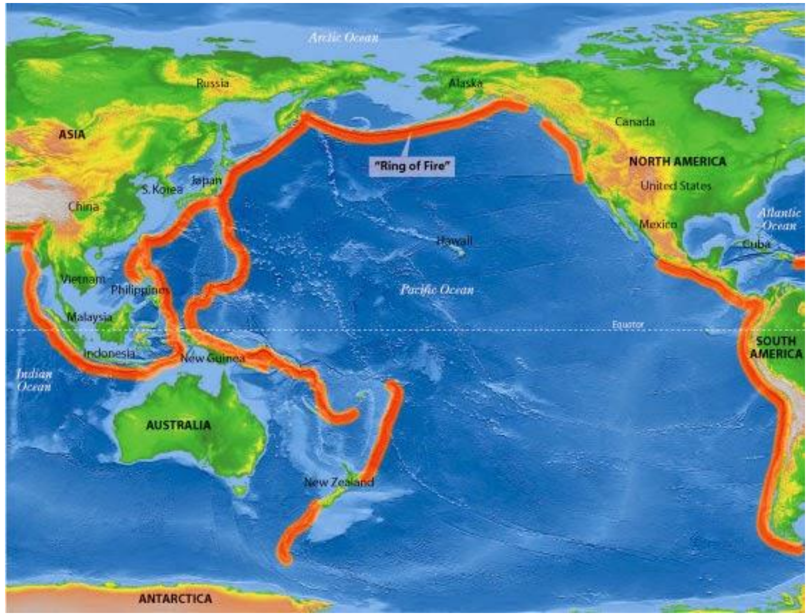
- S-P travel time curve

- From Isoseismals



Distribution of Earthquake

- Shocks of the past confined with two large geographical belts
- The Circum-Pacific belt
- The Mediterranean Belt



Seismic History

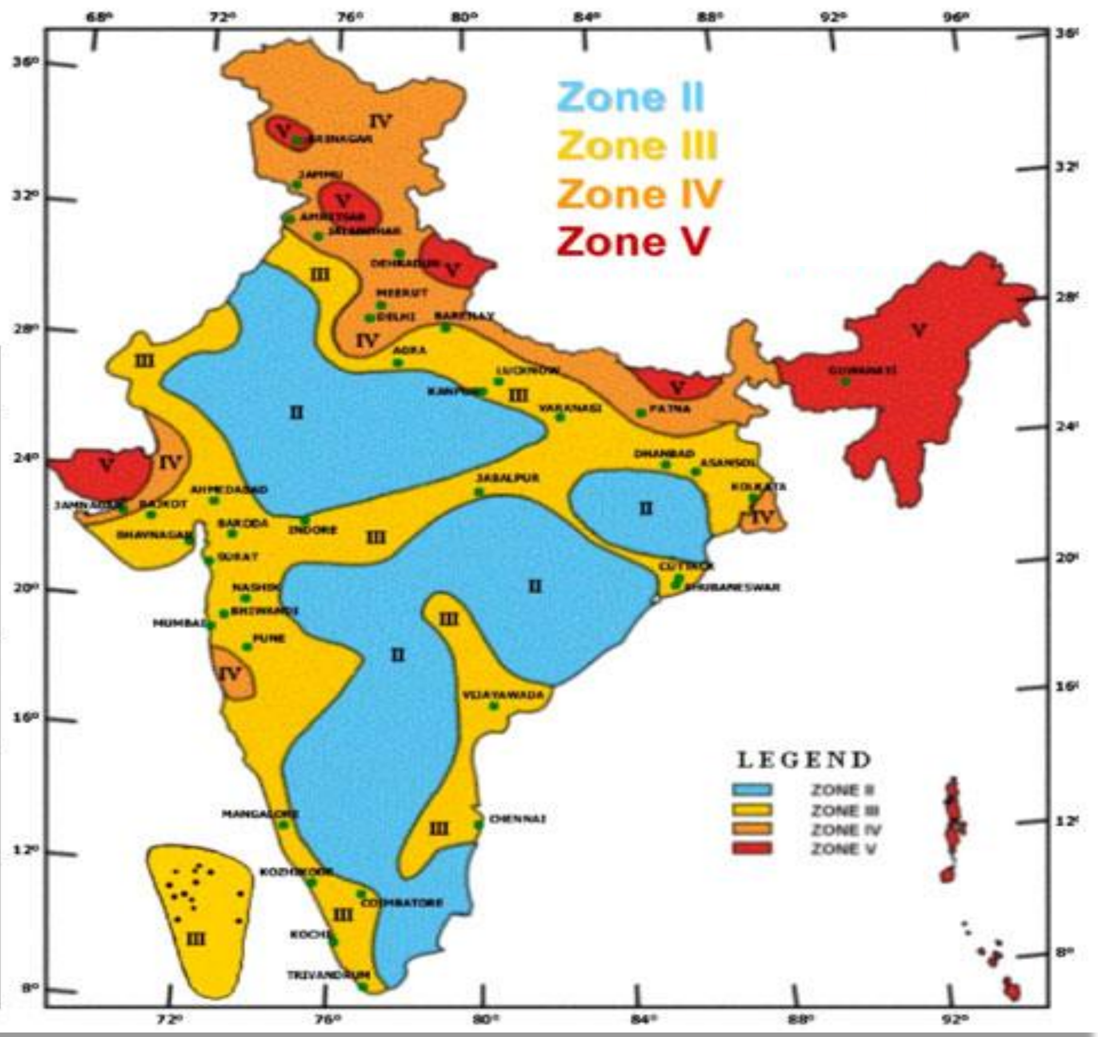
- Seismic events w.r.t **Intensity and Magnitude**.
- The **heavily populated regions** are classified into seismically zones and sub-zones.
- **Seismic zonation** – Qualitative records and geological setting of the area. Extrapolations and computations are required.
- **Microzonation** – Actual seismic data used.
- Facilitates the job of an engineer to **decide the type of construction**.

Earthquake Zoning of India

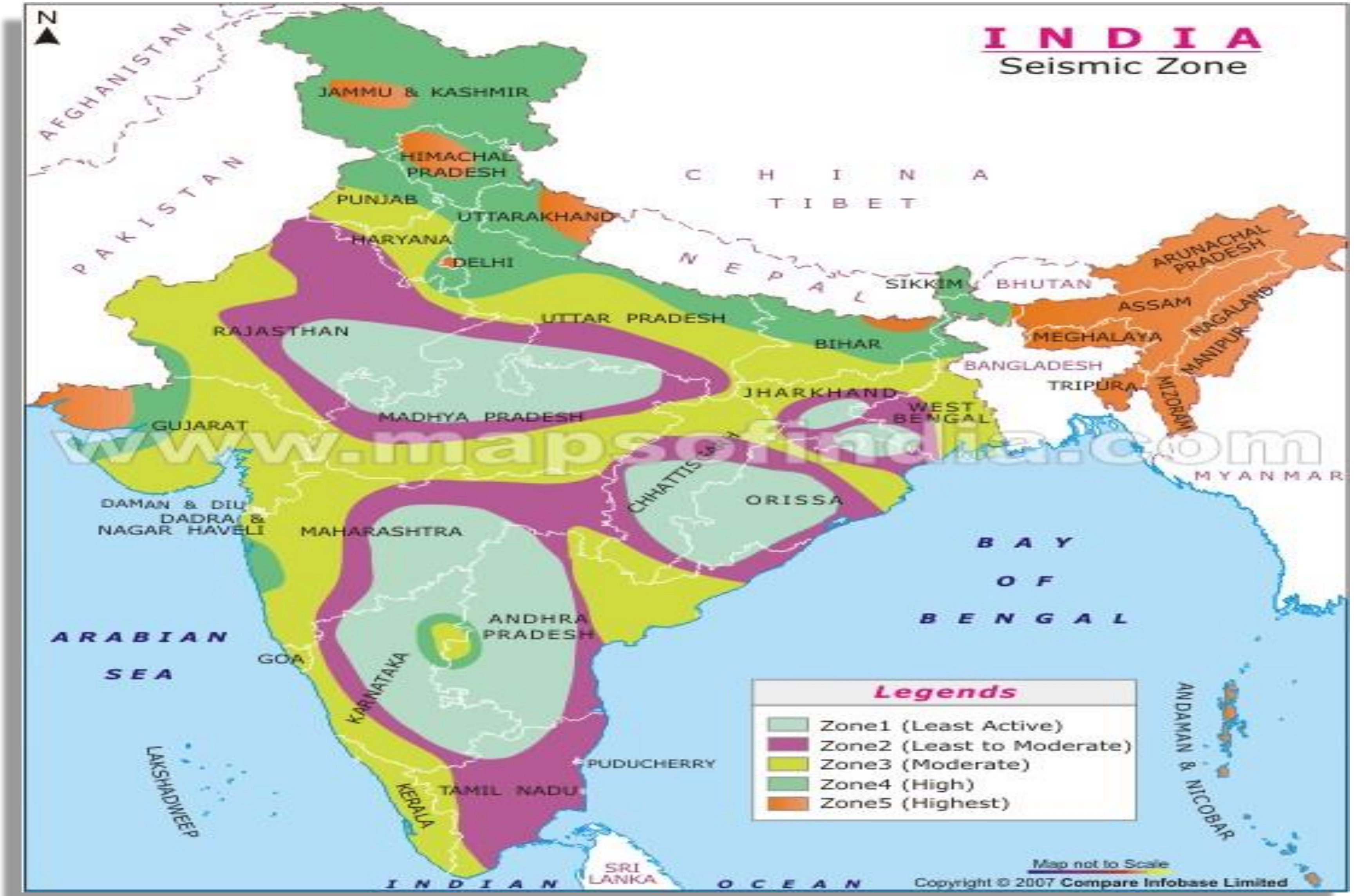
Seismic Zone Map of India: -2002

About 59 percent of the land area of India is liable to seismic hazard damage

Zone	Intensity
Zone V	Very High Risk Zone Area liable to shaking Intensity IX (and above)
Zone IV	High Risk Zone Intensity VIII
Zone III	Moderate Risk Zone Intensity VII
Zone II	Low Risk Zone VI (and lower)



Earthquake Zoning of India

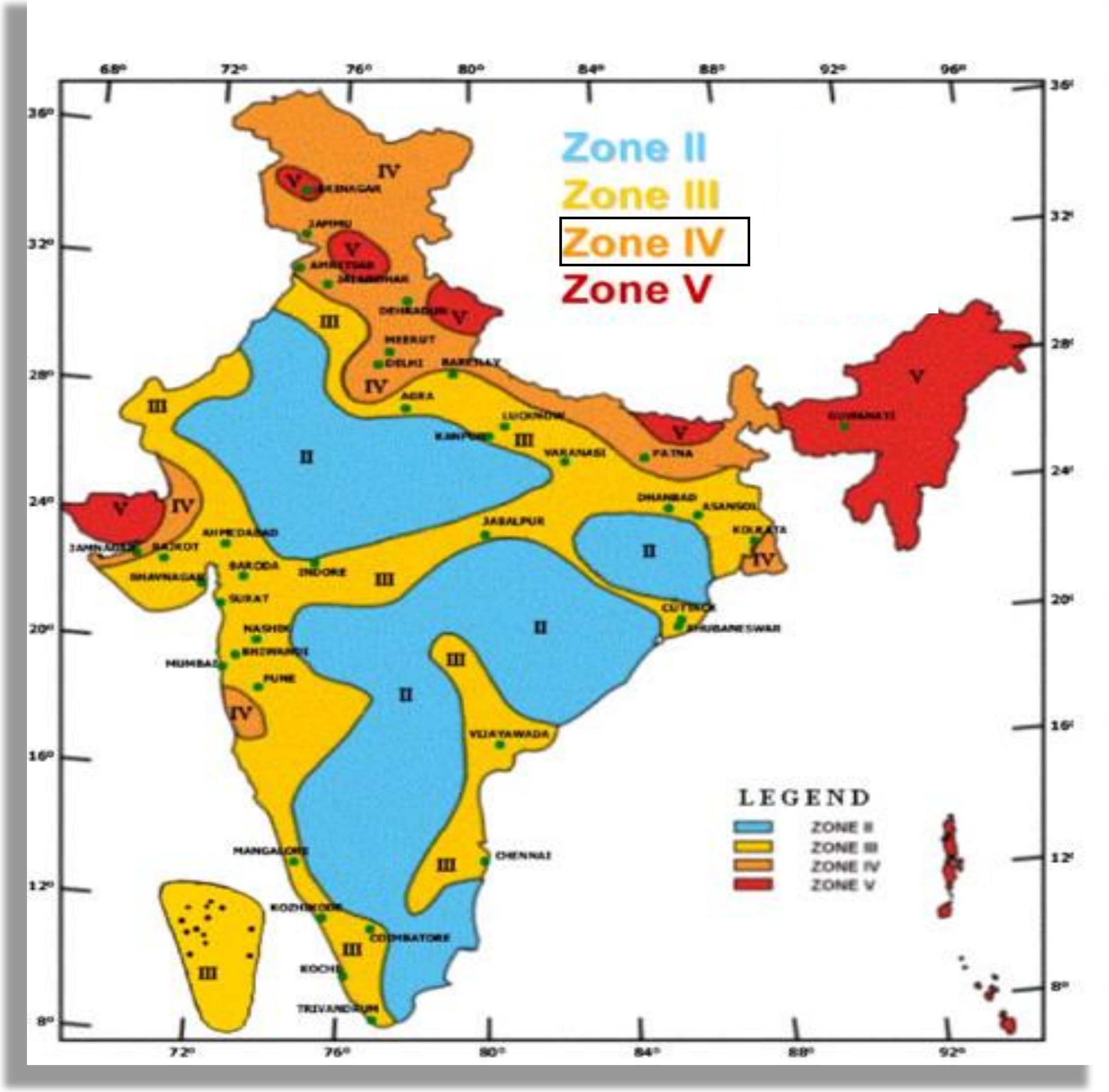


Earthquake Zoning of India

Zone 5

- Zone 5 covers the areas with the highest risks zone that suffers earthquakes. The **IS code** assigns zone factor of 0.36 for Zone 5. **Structural designers** use this factor for earthquake resistant design of structures in Zone 5. The zone factor of **0.36 is indicative** of effective (zero period) **peak horizontal ground accelerations of 0.36 g (36% of gravity) that may be generated during Maximum Considered Earthquake** (MCE) level earthquake in this zone. It is referred to as the Very High Damage Risk Zone. The state of **Kashmir,the western and central Himalayas, the North-East Indian region and the Rann of Kutch** fall in this zone.
- Generally, the areas having trap or basaltic rock are prone to earthquakes.

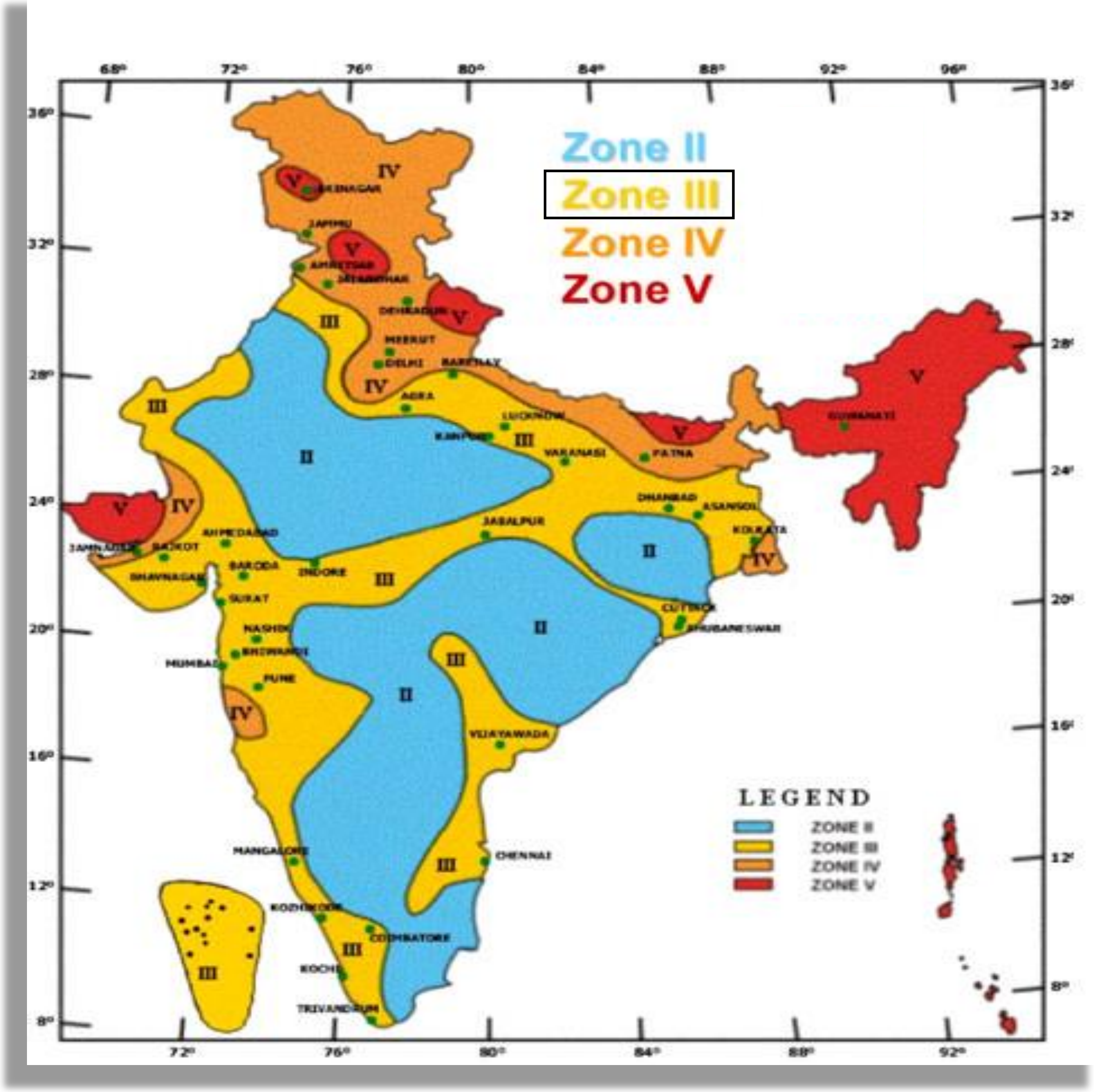
Earthquake Zoning of India



Zone 4

This zone is called the **High Damage Risk Zone**. The IS code assigns zone factor of **0.24** for Zone 4. The **Indo-Gangetic basin and the capital of the country (Delhi), Jammu and Kashmir fall in Zone 4**. In Maharashtra Patan area(Koyananager) also in zone 4.

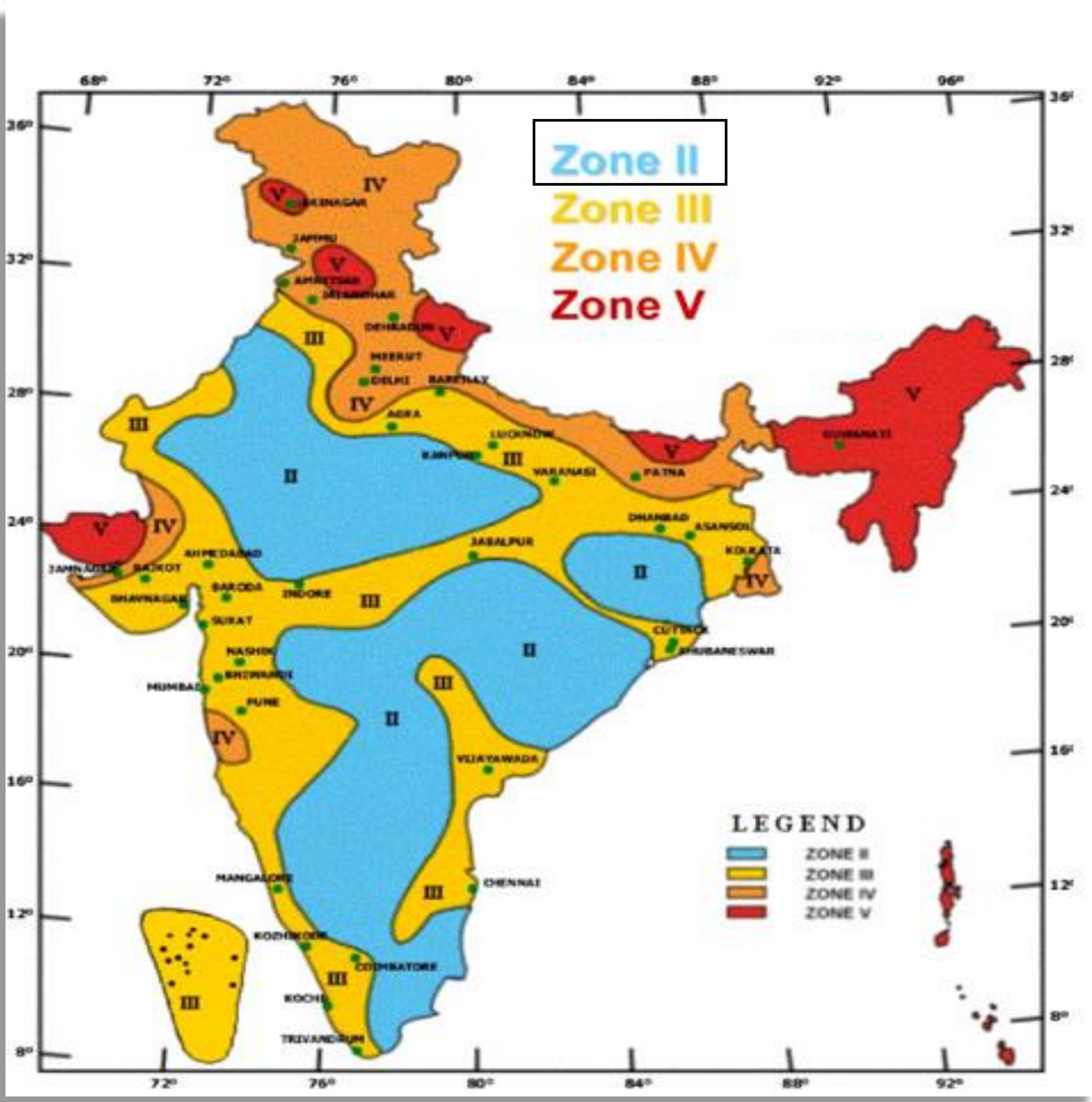
Earthquake Zoning of India



Zone 3

The Andaman and Nicobar Islands, parts of Kashmir, Western Himalayas fall under this zone. This zone is classified as Moderate Damage Risk Zone. The IS code assigns zone factor of 0.16 for Zone 3.

Earthquake Zoning of India



Zone 2

This region is classified as the Low Damage Risk Zone. The IS code assigns zone factor of 0.10 (maximum horizontal acceleration that can be experienced by a structure in this zone is 10% of gravitational acceleration) for Zone 2.

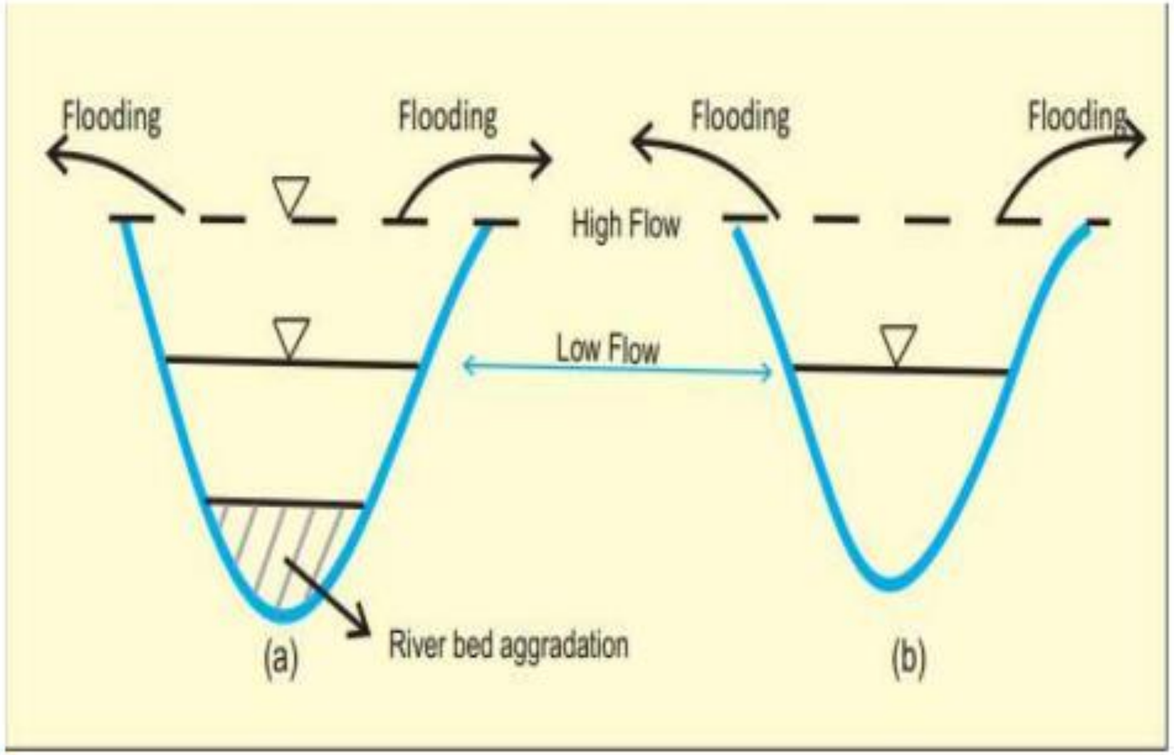
Flood

- A flood is an overflow of water that submerges land, may occur as an overflow of water from water bodies, such as a river or lake, in which the water overtops, resulting in some of that water escaping it’s usual boundaries or it may occur due to accumulation of rainwater on saturated ground in an areal flood. Floods often cause damage to livelihood & structures.

A flood occurs when the Geomorphic Equilibrium in the river system is disturbed because of intrinsic or extrinsic factors or when a system crosses the geomorphic threshold.

(a) Flooding in a river due to aggradation of river bed (intrinsic threshold);

(b) Flooding in a river due to heavy rainfall (extrinsic threshold)



Floods in major cities especially during rainy season are proving to disastrous not only to the environment but also have serious implications for human life and property.

TYPES OF FLOODS

- Types of floods
  - Flash floods
  - River floods
  - Coastal Floods
  - Urban Flood
- According to their duration flood can be divided into different categories:
  - Slow-Onset Floods: Slow Onset Floods usually last for a relatively longer period, it may last for one or more peeks, or even months.
  - Rapid-Onset Floods: Rapid1Onset Floods last for a relatively shorter period, they usually last for one or two days only.
  - Flash Floods: Flash Floods may occur within minutes or a fe1w hours after heavy rainfall, tropical storm, failure of dams or levees or releases of ice dams. And it causes the greatest damages to society.

The time from peak rainfall to peak discharge is the **LAG TIME**.

The soil becomes saturated and overland flow and through flow reach the river and discharge increases. Overland flow arrives first.

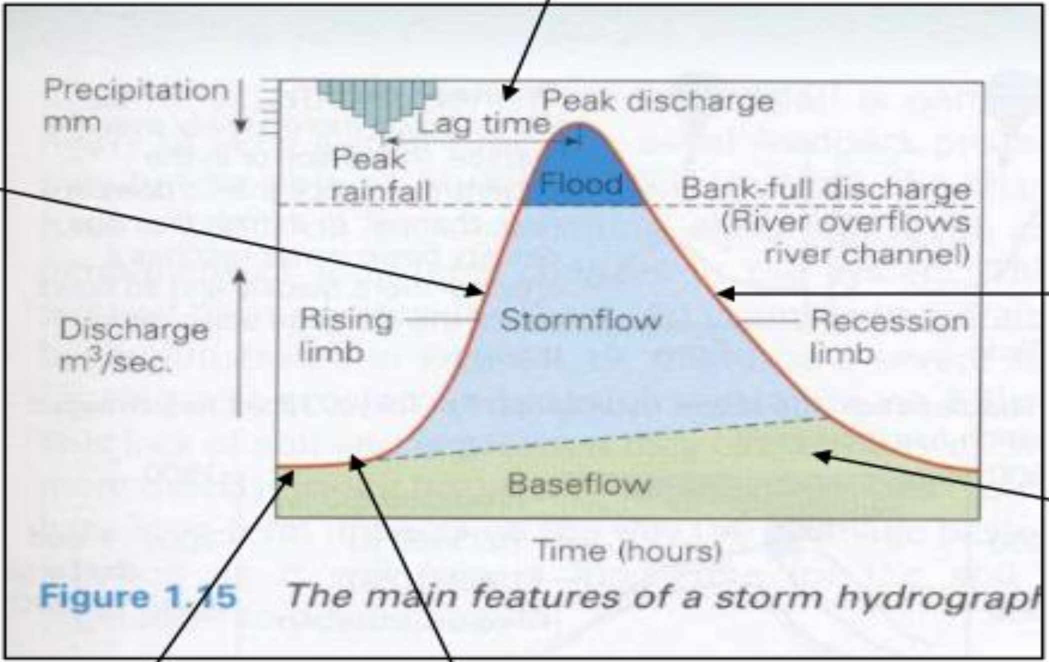


Figure 1.15 *The main features of a storm hydrograph*

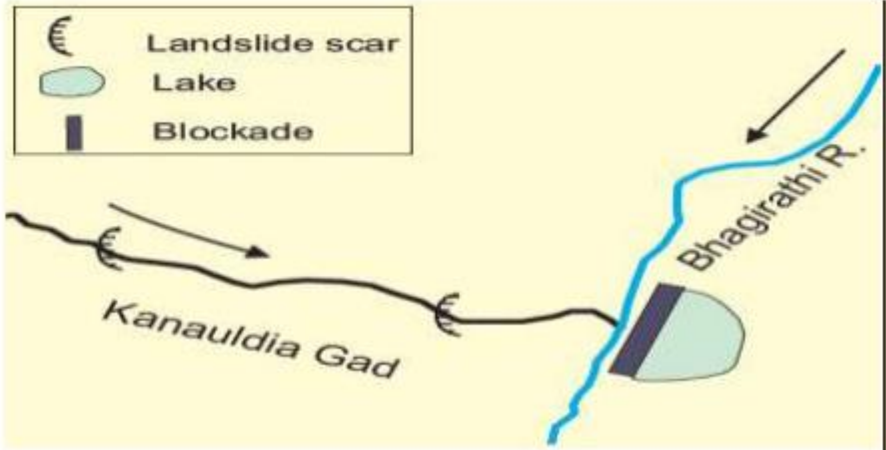
The discharge starts to fall slowly as water is added from through flow and groundwater flows which are much slower.

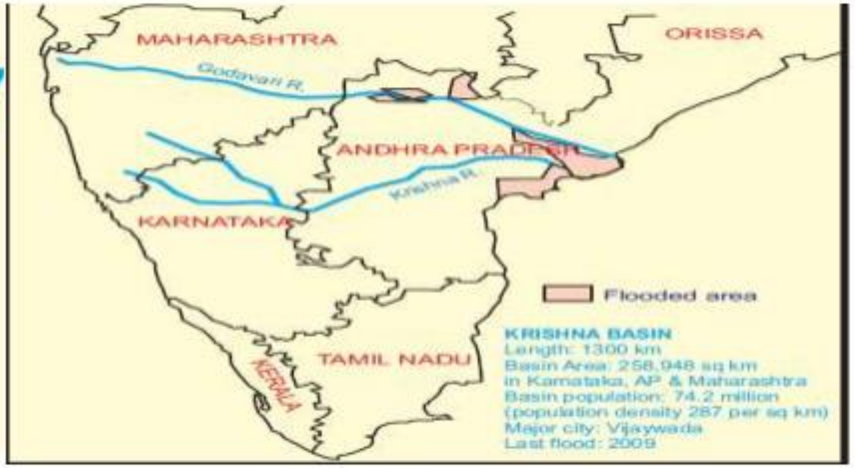
The base flow supplies the river with water between storms and keeps it flowing in summer.

Start of the storm there is a slow rise in discharge, as only a small amount of water falls into the channel

Rainfall is intercepted or infiltrated into the soil moisture store

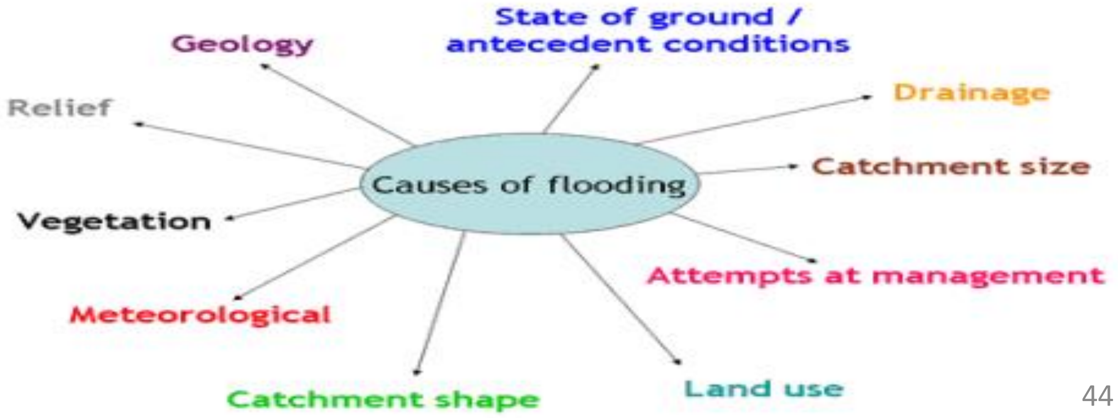
- Floods
  - Natural
    - Storm Surge, Tsunami, Glacial Melt, Landslide, Riverine, Estuarine & Marine Flood
      - Eg: bursting of landslide blockades in the catchment areaof the Bhagirathi River in August 1978 (Gupta and Dave, 1982).
  - Man made
    - Breach of Dam/ Barrage/ Embankment Release from Reservoir, Urban Flood
      - Eg: In the year 2009,Almatti and Naryanpur dams on the Krishna River in Karnataka. This water along with rain water reached Andhra Pradesh near the Srisailam dam. It causes a hevy floods in andhrapradesh





Causes of floods

Causes	Factors leading to causes of flood: Natural factors	Man-made factors
Silting of the river bed	Due to bank erosion Earthquake loosening the soil	Due to dams, embankments and bunds
Inadequate capacity within the banks	High runoff or rise in the water level Silting of river bed due to bank erosion	High discharge from the river due to silting Decrease in bank height – deforestation
River bank erosion	High discharge of water due to rain Shifting river courses	Decrease in vegetative cover due to deforestation
Flow obstruction and change in river course	Landslides Falling of the trees	Construction activities in the river bed
Common floods in the main and tributary rivers	Flash flood due to high discharge in the main river	Breaking of bunds constructed on the tributary rivers for irrigation purposes
Poor natural drainage	Obstruction of the natural drainage Absorbing capacity of the soil	High rate of urbanization – pressure on the drainage system
Cyclones	High precipitation Absorbing capacity of the soil	
Retardation of flow and back water effect	High runoff Topography and obstruction of the natural drainage	Inadequate drainage capacity and; Urbanization in the low lying areas
Heavy rainfall	Same as above	Decreasing vegetative cover High urbanization leads to high runoff



VEGETATION COVER
This varies seasonally. The type and amount will affect interception and stemflow/throughfall. Overland flow is reduced. Lag time will be increased.

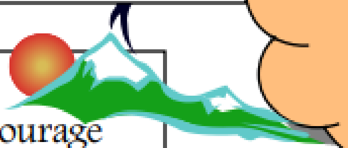
ROCK TYPE
Impermeable rocks prevent groundwater flow and encourage through flow and overland flow. These rocks will decrease lag time. Permeable rock will have the opposite effect.

CLIMATE
The distribution of rainfall over the year and the temperatures will affect the lag times.

FACTORS

LAKES & RESERVOIRS
These will store floodwater and thus reduce lag time and control river response to heavy rainfall.

SLOPES
Steep slopes will encourage overland flow and gentle slope will slow run off down.



RAINFALL INTENSITY & DURATION
Intense rain will increase overland flow and reduce lag times. Gentle rain over a longer time will allow more infiltration.

LAND USE
Impermeable surfaces created by urbanisation will reduce infiltration and encourage overland flow. Different types of crops affect interception rates e.g. cereals 7-15%.

SOIL TYPE & DEPTH
Deep soils store more water, pipes in the soil encourage through flow. Soils with small pore spaces will reduce infiltration and increase overland flow.

FLOODS IMPACTS

- Human Loss
- Property Loss
- Affects the Major Roads
- Disruption of Air / Train / Bus services
- Spread of Water-borne Communicable Diseases
- Communication Breakdown
- Electricity Supply Cut off
- Economic and Social Disruption
- Increase in Air / Water Pollution

Flood forecasting

- Anticipating floods before they occur allows for precautions to be taken and people to be warned so that they can be prepared in advance for flooding conditions.
- For example,
  - Farmers can remove animals from low-lying areas and utility services can put in place emergency provisions to re-route services if needed. Emergency services can also make provisions to have enough resources available ahead of time to respond to emergencies as they occur.
- In order to make the most accurate flood forecasts for waterways, it is best to have a long time-series of historical data that relates stream flows to measured past rainfall events
- Radar estimates of rainfall and general weather forecasting techniques are also important components of good flood forecasting.

Flood Control

- In many countries around the world, waterways prone to floods are often carefully managed. Defences such as levees, bunds, reservoirs, and weirs are used to prevent waterways from overflowing their banks.
- In the riparian zone near rivers and streams, erosion control measures can be taken to try and slow down or reverse the natural forces that cause many waterways to meander over long periods of time.
- Flood controls, such as dams, can be built and maintained over time to try and reduce the occurrence and severity of floods as well.

Flood benefits

- Floods (in particular more frequent or smaller floods) can also bring many benefits, such as
  - Recharging ground water,
  - Making soil more fertile and increasing nutrients in some soils.
- Flood waters provide much needed water resources in arid and semi-arid regions where precipitation can be very unevenly distributed throughout the year.
- Freshwater floods particularly play an important role in maintaining ecosystems in river corridors and are a key factor in maintaining floodplain biodiversity.
- Flooding can spread nutrients to lakes and rivers, which can lead to increased biomass and improved fisheries for a few years.
- For some fish species, an inundated floodplain may form a highly suitable location for spawning with few predators and enhanced levels of nutrients or food.
- Fish, such as the weather fish, make use of floods in order to reach new habitats. Bird populations may also profit from the boost in food production caused by flooding.

Landslide

- A landslide is a geological phenomenon that includes a wide range of ground movements, such as rock falls, deep failure of slopes & shallow debris flows. Landslides can occur in offshore, coastal & onshore environments. Although the action of gravity is the primary driving force for a landslide to occur, a landslide often requires a trigger before being initiated.

Definition

- Temporary instability of the mass body such as soil & rock.
- These masses may leave their original position gradually or abruptly and start downward movement. These movements resulted in loss of life and property, especially when it occurs near populated areas, along highways, dams & reservoirs or under heavy structures.
- Such movements of the superficial masses have been termed as landslides or landslips.
- These mass movements highly influence the stability of the Civil Engineering projects.

What is Landslide ?

downward and outward movement of slope forming materials composed of rocks, soils, artificial fills or combination of all these materials along surfaces of separation by falling, sliding and flowing, either slowly or quickly from one place to another.

Classification

Mass movement are classified according to

- Wide variety of geological conditions in which these movements take place.
- Heterogeneity in the type of material involved in failure.
- Nature of the surface along which the landslide takes place
- Speed of the movement.

The mass movement is divided into three groups on the basis of type of failure

1. Flowage - A downgrade movement of mass along no definite surface of failure. Mass involved in this type of failure is primarily unconsolidated or loosely packed or rendered so by natural processes of decay and disintegration. The result is that the movement is distributed mass of irregular shape.

2. Sliding - A true landslide is a type of mass failure in which a superficial mass fails by moving as a whole along a definite surface of failure. The surface of failure may be planar or semicircular in outline. The mass above the failure surface is unstable whereas the material lying below this surface is generally stable. Sliding may involve material of any composition, shape and of varying degree of consolidation.

3. Subsidence - It is defined as sinking or settling of the ground in a vertically downward direction which may occur because of removal of natural support from the underground or due to compaction of weaker rocks under the loam. The resultant product from this process is artificial hill which suffers sinking Downward movement.

Causes of Mass movement

- Internal Factors – 1. The Nature of Slope, 2. Role of Water, 3. Composition of Mass, 4. Geological Structures
- External Factors – 1. vibrations from artificial and natural phenomena. Vibrations due to natural causes such as earthquakes often initiate mass failures on a large scale that may continue much after the quake. 2. Another important external factor, often overlooked, is the removal of the support at the foot of the slope, as during excavation for road widening, without due regards to the critical conditions of the stability. 3. The stresses due to the additional load add to the stresses due to the mass of the slope.

Monitoring Mass Movements

- Continuous monitoring of slope movement is very useful in detecting the symptoms that are indicative of sudden failure of the slope.
- The data collected through monitoring system may be of great help in deciding control methods for subsequent failures.
- Monitoring of slope can be done by
    - Conventional surveying
    - Advanced techniques like EDM, Laser equipment, Settlement gauges & extensometers.
    - Piezometer (pore water pressure)
    - Interferometry

Controlling Mass Movements

Before deciding the effective measures it is essential to study

- The history of a slide area – in order to reveal the areal extent as well as depth upto which the mass is unstable, extent & frequency with which it has failed during a period of time.

This can be done by detailed geotechnical examination of the slide area,

- Composition of failing mass
- Structural decomposition of the mass
- Position of GW table within & around the critical mass
- Relation of the mass prone to failure to any surface water body
- The slope of the ground

Mitigation Strategies

- Hazard mapping
- Retaining walls
- Surface drainage control works
- Engineered structures with strong foundation
- Increasing vegetation cover
- Flattening of the slope
- Stitching of the debris cover to the rock
- Grouting
- Geotextiles
- Rock fall protection
- Mudflow barriers
- Debris basins

Mitigation Measures

- Providing Drainage
- Construction of Structures
  1. Retaining Wall
  2. Gabion Wall
- Slope treatment
  1. Soil nailing
  2. Rock bolting
  3. Rock netting
  4. Vegetation cover
  5. Geocell

Construction of Structures

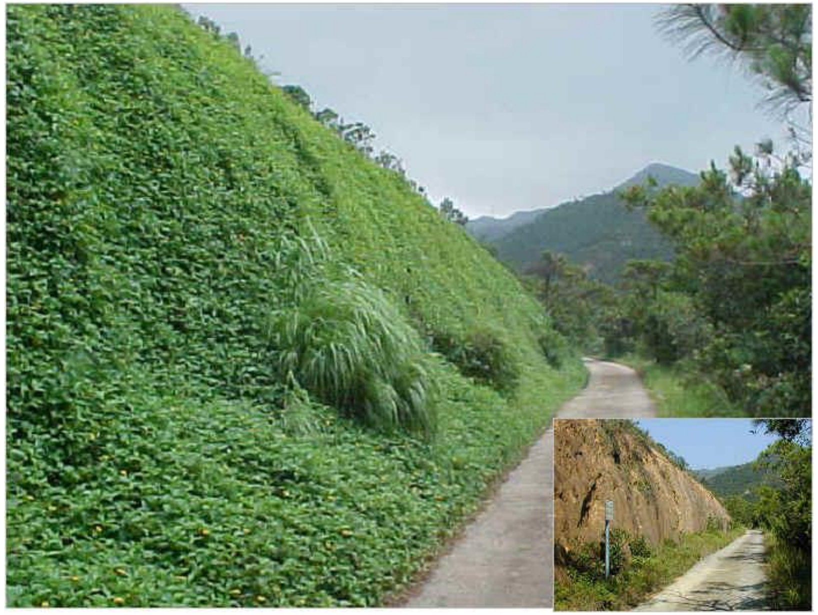
1.Retaining Wall
2.Gabion Wall

Slope treatment

1. **Soil nailing**
2. **Rock bolting**
3. Rock netting
4. Vegetation cover
5. Geocell

Slope treatment

1. Soil nailing
2. Rock bolting
3. **Rock netting**
4. **Vegetation cover**
5. Geocell



Avalanche

- An avalanche is a rapid flow of snow down a sloping surface. Avalanche is typically triggered in a starting zone from a mechanical failure in the snowpack(slab avalanche) after initiation, avalanches usually accelerate rapidly & grow in mass & volume as they collect more snow.

Definition

Technically, an avalanche is any amount of snow sliding down a mountainside. It can be compared to a landslide, only with snow instead of earth. Another common term for avalanche is “snowslide”. As an avalanche becomes nearer to the bottom of the slope, it gains speed and power, this can cause even the smallest of snowslides to be a major disaster.

Types of Avalanches

1. **Surface Avalanche** that occurs when a layer of snow with different properties slides over another layer of snow. For example, when a layer of dry loosely packed snow slides over a dense layer of wet snow.
2. **Full-Depth Avalanche** which, as it’s name would lead you to believe, occurs when an entire snow cover, from the earth to the surface, slides over the ground.

4 Types of Avalanches

1. Loose Snow Avalanches: First of these are the Loose Snow Avalanches. They are common on steep slopes and are seen after a fresh snowfall. Since the snow does not have time to settle down fully or has been made loose by sunlight, the snow-pack is not very solid. Such avalanches have a single point of origin, from where they widen as they travel down the slope.
2. Slab Avalanches: Loose Snow Avalanches in turn could cause a Slab Avalanche, which are characterized by a the fall of a large block of ice down the slopes. Thin slabs cause fairly small amounts of damage, while the thick ones are responsible for many fatalities.

4 Types of Avalanches

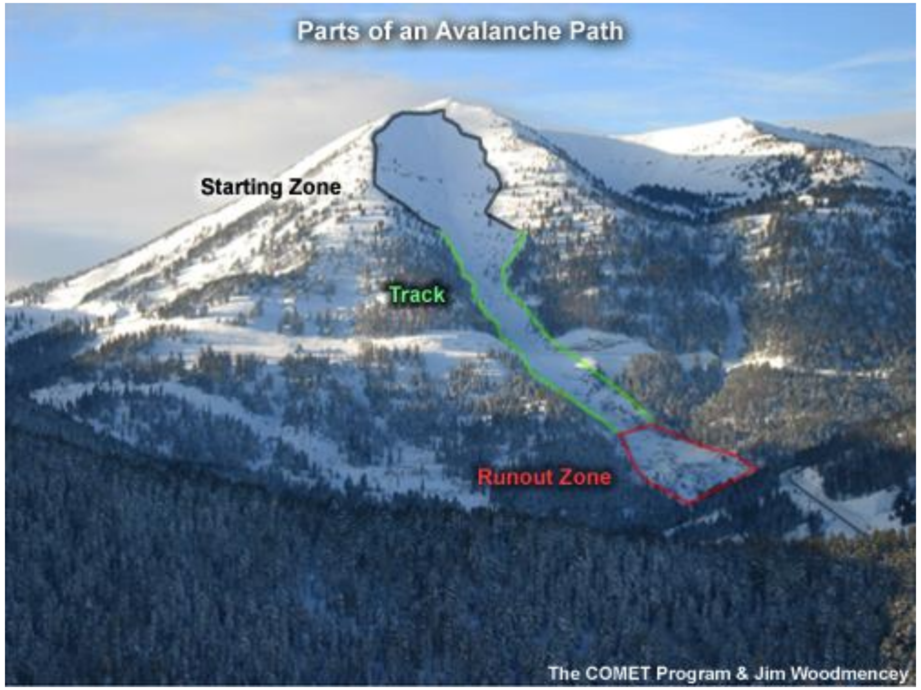
3. Powder Snow Avalanches: Powder Snow Avalanches are a mix of the other forms, Loose Snow and Slab. The bottom half of this avalanche consists of a slab or a dense concentration of snow, ice and air. Above this is a cloud of powdered snow, which can snowball into a larger avalanche as it progresses down the slope. The speed attained by this avalanche can cross 190 miles per hour and they can cross large distances.
4. Wet Snow Avalanches: Finally, there are Wet Snow Avalanches. These are quite dangerous as they travel slowly due to friction, which collects debris from the path fairly easily. The avalanche comprises of water and snow at the beginning, but understanding of avalanches has showed us that it can pick up speed with ease.


Loose Snow
Avalanche (Sluff)
Jim Woodmencey


Slab Avalanche

Main parts of Avalanche

- The **starting zone** is the most volatile area of a slope, where unstable snow can fracture from the surrounding snow cover and begin to slide. Typical starting zones are higher up on slopes. However, given the right conditions, snow can fracture at any point on the slope.
- The **avalanche track** is the path or channel that an avalanche follows as it goes downhill. Large vertical swaths of trees missing from a slope or chute-like clearings are often signs that large avalanches run frequently there, creating their own tracks. There may also be a large pile-up of snow and debris at the bottom of the slope, indicating that avalanches have run.
- The **runout zone** is where the snow and debris finally come to a stop. Similarly, this is also the location of the deposition zone, where the snow and debris pile the highest.



Causes of Avalanche

Snowstorm and Wind Direction: Heavy snowstorms are more likely to cause Avalanches. The 24 hours after a storm are considered to be the most critical. Wind normally blows from one side of the slope of mountain to another side. While blowing up, it will scour snow off the surface which can overhang a mountain.

Heavy snowfall: Heavy snowfall is the first, since it deposits snow in unstable areas and puts pressure on the snowpack. Precipitation during the summer months is the leading cause of wet snow avalanches.

Causes of Avalanche

Human Activity: Humans have contributed to the start of many avalanches in recent years. Winter sports that require steep slopes often put pressure on the snow-pack which it cannot deal. Combined with the heavy deforestation and soil erosion in mountain regions, it gives the snow little stability in the winter months. Further natural causes include earthquakes and tremors, since they can often create cracks in the snowpack.

Vibration or Movement: The use of All Terrain Vehicles and Snowmobiles creates vibrations within the snow that it cannot withstand. Coupled with the gravitational pull, it is one of the quickest ways to cause an avalanche. The other is construction work done with explosives, which tend to weaken the entire surrounding area.

Causes of Avalanche

Layers of Snow: There are conditions where snow is already on the mountains and has turned into ice. Then, fresh snow falls on top which can easily slide down.

Steep Slopes: Layers of snow build up and slide down the mountain at a faster rate as steep slopes can increase the speed of snow. A rock or piece of huge ice can shake the snow and cause it to come down.

Warm Temperature: Warm temperatures that can last several hours a day can weaken some of the upper layers of snow and cause it to slide down.

Effects of Avalanches

- **Damage to Life and Property:** A large number of casualties takes place after avalanches hit heavily populated areas. Infrastructure is damaged and the blockage caused, impacts the livelihood of many. People who enjoy skiing, snowboarding and snowmobiling are at a greater risk of losing their lives. A powerful avalanche can even destroy buildings and power supplies can be cut off.
- **Flash floods:** When an avalanche occurs, it brings down all the debris with it and can cause havoc in low lying areas. Flash floods are seen to happen after avalanches, which is a long term problem many villagers and townspeople have to deal with. They can also change weather patterns and cause crop failure in farms present on the lower fields.
- **Economic Impact:** An avalanche can block anything in its path and even restrict the normal movement of traffic. Various ski resorts depend on tourists to run their business successfully. Ski resorts and other businesses are forced to close until the avalanche decreases and weather conditions become suitable.

Drought

- **Drought**, lack or insufficiency of rain for an extended period that causes a considerable hydrologic (water) imbalance and, consequently, water shortages, crop damage, stream flow reduction, and depletion of groundwater and soil moisture. It occurs when evaporation and transpiration (the movement of water in the soil through plants into the air) exceed precipitation for a considerable period. Drought is the most serious physical hazard to agriculture in nearly every part of the world.
- Drought is caused by not only lack of precipitation and high temperatures but by overuse and overpopulation.

Categories of Drought

- **Meteorological drought** is specific to different regions, depending on the amount of yearly precipitation that's average for that area. For example, the southwest portion of the United States averages less than 3 inches (7.6 centimeters) of precipitation per year, while the Northwest gets more than 150 inches (381 cm) per year, according to the U.S. Department of Interior. A decrease in precipitation compared to the historical average for that area would qualify as a meteorological drought.
- **Agricultural drought** accounts for the water needs of crops during different growing stages. For instance, not enough moisture at planting time may hinder germination, leading to low plant populations and a reduction in yield.
- **Hydrological drought** refers to persistently low water volumes in streams, rivers and reservoirs. Human activities, such as drawdown of reservoirs, can worsen hydrological droughts. Hydrological drought is often linked with meteorological droughts.
- **Socioeconomic drought** occurs when the demand for water exceeds the supply. Examples of this kind of drought include too much irrigation or when low river flow forces hydroelectric power plant operators to reduce energy production.

Tracking Drought

- In the United States, the **Palmer Drought Severity Index (PDSI**, weekly index from CPC shown), devised in 1965, was the first comprehensive drought indicator. It is considered most effective for unirrigated cropland. The PDSI combines temperature, precipitation, evaporation, transpiration, soil runoff and soil recharge data for a given region to produce a single negative number that indicates drought conditions.
- This index serves as an estimate of soil moisture deficiency and roughly correlates with drought severity. The PDSI is the most commonly used index for drought monitoring and research. It has been widely used in tree-ring-based reconstructions of past droughts in North America and other regions.
- In 1999, the U.S. Drought Monitor replaced the PDSI as the nation's drought indicator.

The nationwide Drought Monitor categorizes drought into five levels of severity:

1. abnormally dry (category D0, corresponding to a PDSI between -1.0 and 1.9)
2. moderate drought (D1, PDSI between -2.0 and -2.9)
3. severe drought (D2, PDSI between -3.0 and -3.9)
4. extreme drought (D3, PDSI between -4.0 and -4.9)
5. exceptional drought (D4, PDSI between -5.0 and -5.9)

Drought Mitigation Measures

- The components of a drought preparedness and mitigation plan are the following:
  1. Prediction
  2. Monitoring
  3. Impact assessment
  4. Response.
- **Prediction** can benefit from climate studies which use coupled ocean/atmosphere models, survey of snow packs, anomalous circulation patterns in the ocean and atmosphere, soil moisture, assimilation of remotely sensed data into numerical prediction models, and knowledge of stored water available for domestic, stock, and irrigation uses.
- **Monitoring** exists in countries which use ground-based information such as rainfall, weather, crop conditions and water availability. Satellite observations complement data collected by ground systems. Satellites are necessary for the provision of synoptic, wide-area coverage.
- **Impact assessment** is carried out on the basis of land-use type, persistence of stressed conditions, demographics and existing infrastructure, intensity and areal extent, and its effect on agricultural yield, public health, water quantity and quality, and building subsidence.
- **Response** includes improved drought monitoring, better water and crop management, augmentation of water supplies with groundwater, increased public awareness and education, intensified watershed and local planning, reduction in water demand, and water conservation.

Drought preparedness and mitigation can be accomplished

- (1) soil and water conservation
- (2) herd management.

Soil and Water Conservation

Conservation practices minimize the disruption of the soil's structure, composition and natural biodiversity, thereby reducing erosion and soil degradation, surface runoff, and water pollution. The following are established practices of soil and water conservation

1. Crop rotation
2. Contoured row crops
3. Terracing
4. Tillage practices
5. Erosion-control structures
6. Water retention and detention structures
7. Windbreaks and shelterbelts
8. Litter management
9. Reclamation of salt-affected soil.

Engineering measures

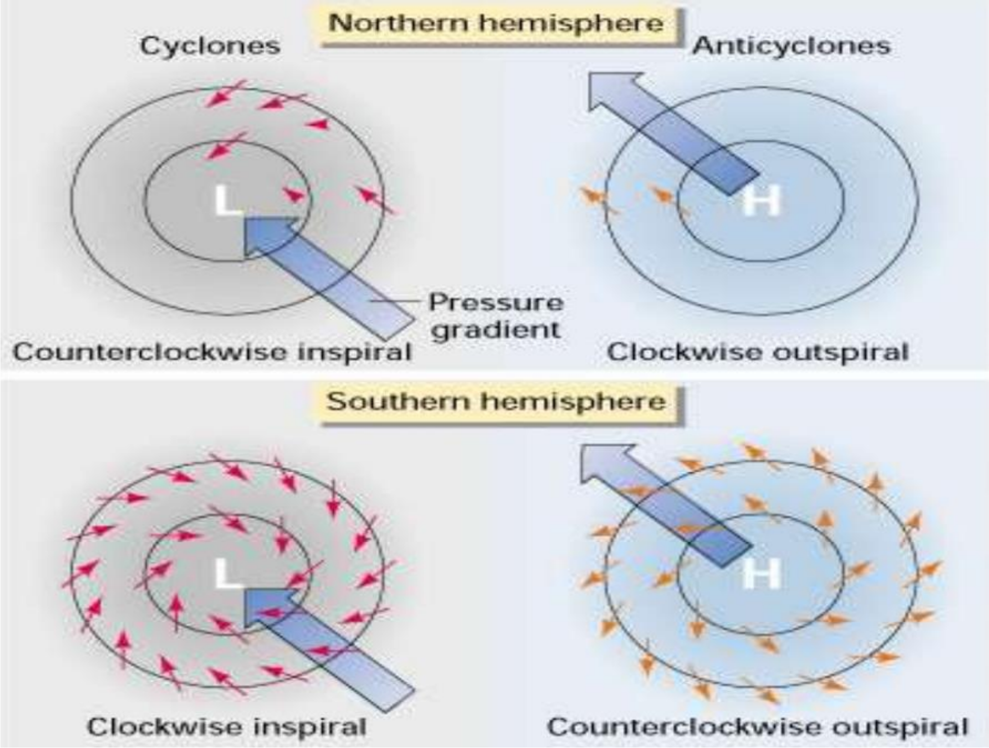
- Engineering measures differ with location, slope of the land, soil type, and amount and intensity of rainfall. Measures commonly used are the following:
- **Contour bunds, trenches and stone walls** These features prevent soil erosion and obstruct the flow of runoff. The retained water increases soil moisture and recharges the groundwater.
- **Check dams and other gully-plugging structures** Check dams are temporary structures constructed with locally available materials. Types of check dams are the brush-wood dam (Fig. 2 a), the loose-rock dam (Fig. 2 b) and the woven-wire dam.
- **Percolation ponds** These features store water for livestock and recharge the groundwater. They are constructed by excavating a depression to form a small reservoir, or by constructing an embankment in a natural ravine or gully to form an impoundment.

Moisture-conservation practices

- For agricultural crops, measures include ridges and furrows, basins, and water spreading.
- For tree crops, measures include saucer basins (Fig. 3), semi-circular bunds, crescent-shaped bunds, catch pits and deep pitting.
- Rainwater harvesting collects rainfall or moisture for immediate or eventual use in irrigation or domestic supplies. Part of the rainwater collected from roofs can be stored in a cistern or tank for later use.
- Landscape contouring is used to direct runoff into areas planted with trees, shrubs, and turf.

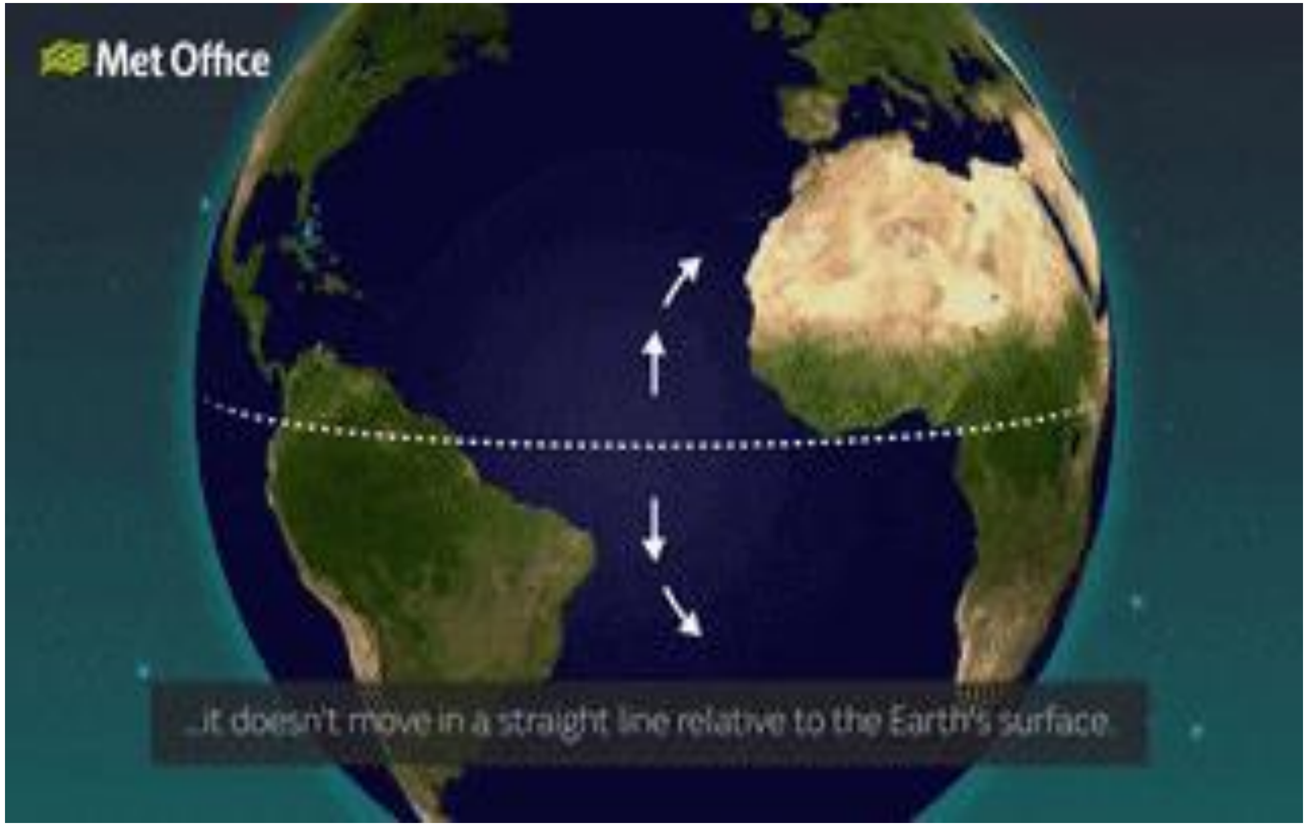
Cyclone

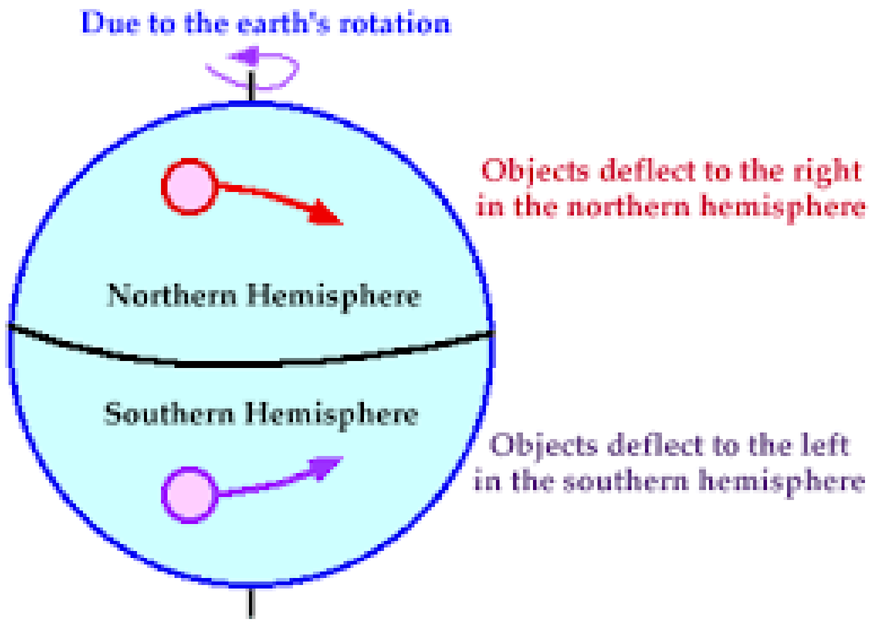
- "Cyclonic Storm" or a "Cyclone" is an intense vortex or a whirl in the atmosphere with very strong winds circulating around it in anticlockwise direction in the Northern Hemisphere and in clockwise direction in the Southern Hemisphere.

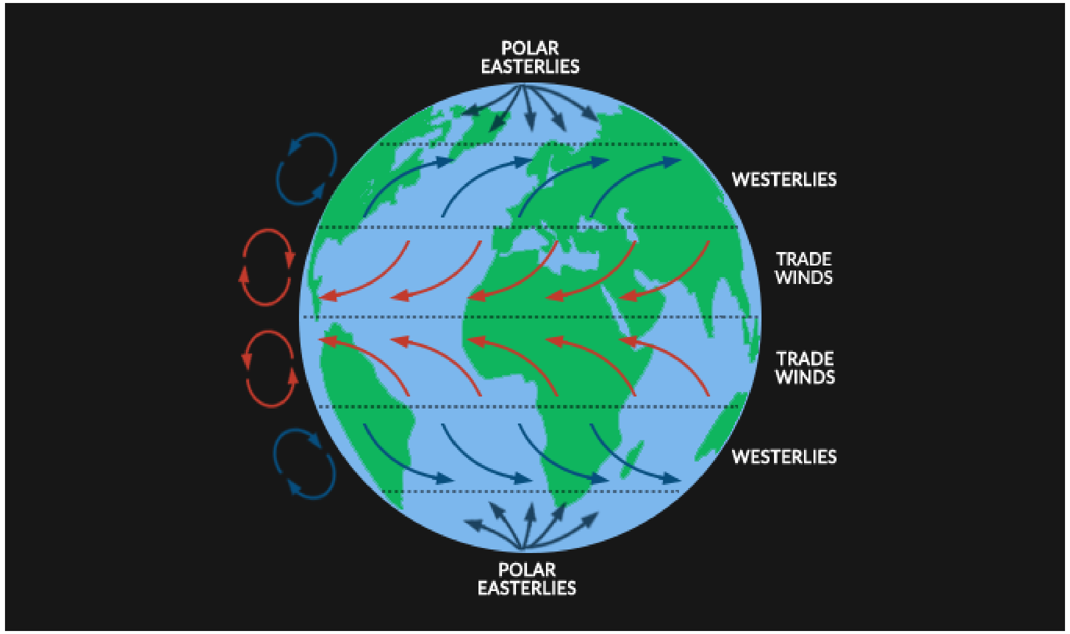


- Hurricanes, typhoons and cyclones are all rotating storms spawned in the tropics. As a group, they can be referred to as **tropical cyclones**.
- Because of the Coriolis effect, these storms rotate counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere.

Coriolis effect

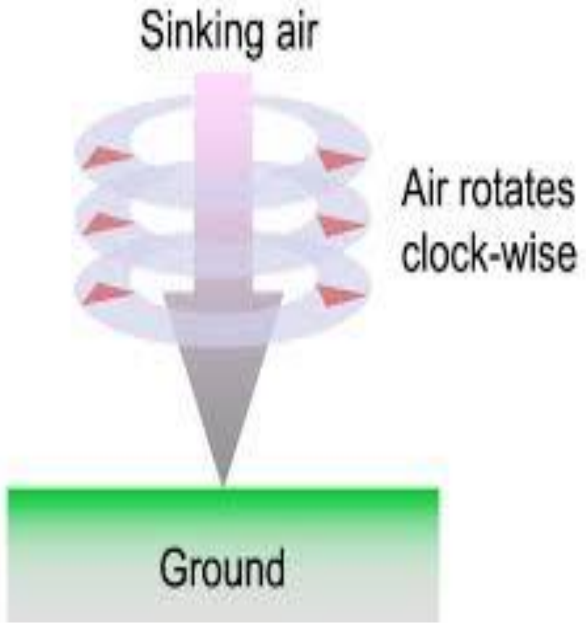




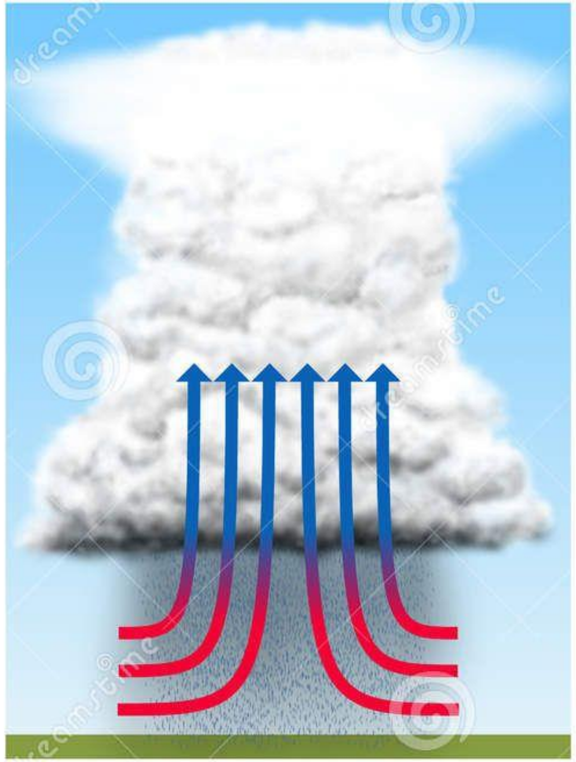


Anticyclones

- Defined as a large-scale circulation of winds around a central region of high atmospheric pressure, clockwise in the Northern Hemisphere and counterclockwise in the Southern Hemisphere.
- **Anticyclones** are **regions** of relatively high pressure on horizontal surfaces, or high geopotential height on isobaric surfaces, around which air circulates clockwise in the Northern Hemisphere and counterclockwise in the Southern Hemisphere.
- They are an area of **high** atmospheric pressure where the air is **sinking**.
- The winds may be very light.
- In summer, anticyclones bring dry, hot weather. In winter, clear skies may bring cold nights and frost.

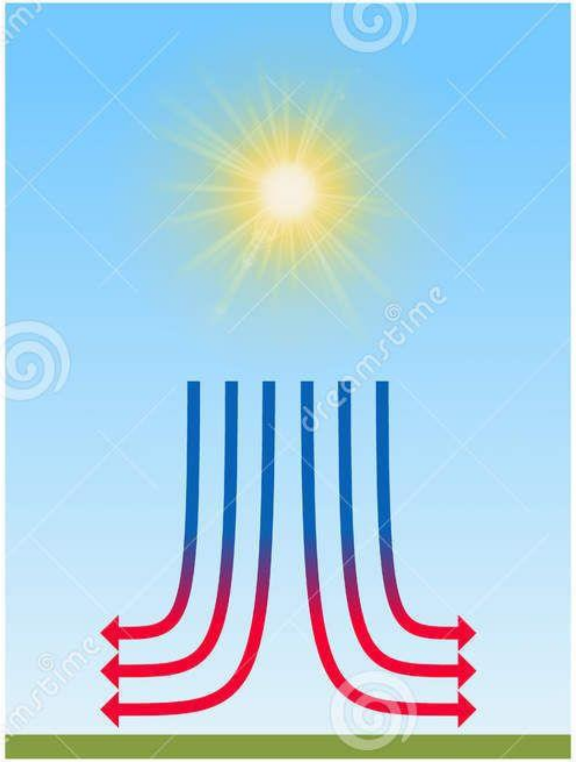


CYCLONE

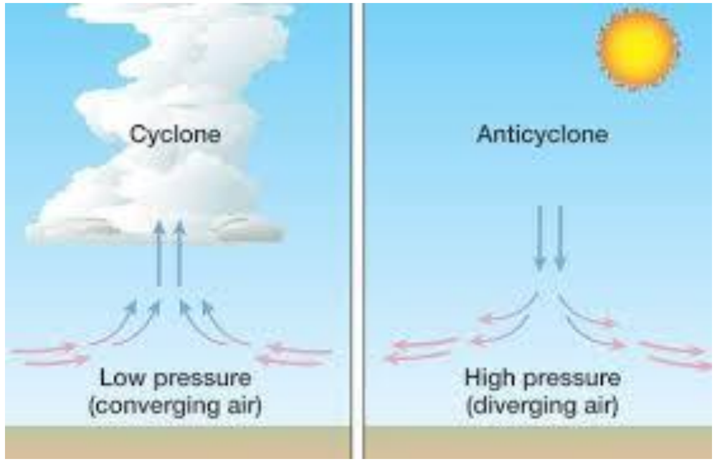


Low pressure
Rising warm, moist air
Cloudy weather

ANTICYCLONE



High pressure
Descending cool, dry air
Clear weather



Cyclones

- **Cyclones** are huge revolving storms caused by winds blowing around a central area of ***low atmospheric pressure.***

Wind blows anti-clockwise in the NH and clockwise in the SH

Typhoon- termed used when it formed in the Pacific ocean
Hurricane- termed used when it formed in the Atlantic ocean
Cyclone- termed used when it formed in the southern ocean and Indian ocean
Willy-willy- termed used in Australia

Types of Cyclone

- Classification of cyclone according to synoptic scale

1. Polar cyclone (polar regions, vast)
2. Polar lows (polar regions, short)
3. Extratropical cyclone (mid-latitude cyclone)
4. Subtropical cyclone (between the equator and 50^{o} N and S)
5. Mesocyclone (associated with tornado formation)
6. Tropical cyclone (tropics)

Cyclone	Tornado
Formed over water	Land event
Diameter-2-4 miles	Diameter- upto 300 miles
Time-few mins/hours	Time-hours/day
Air speed-0-100 miles/hr	Air speed-40-110 miles/hr
Less damage	More damage
Forms of precipitation-rain	Forms of precipitation-rain,hail,sleet
Occurrence-warm areas	Occurrence-almost everywhere
Cyclone->->->->->tornado	Tornado>/->/->/->/-cyclone

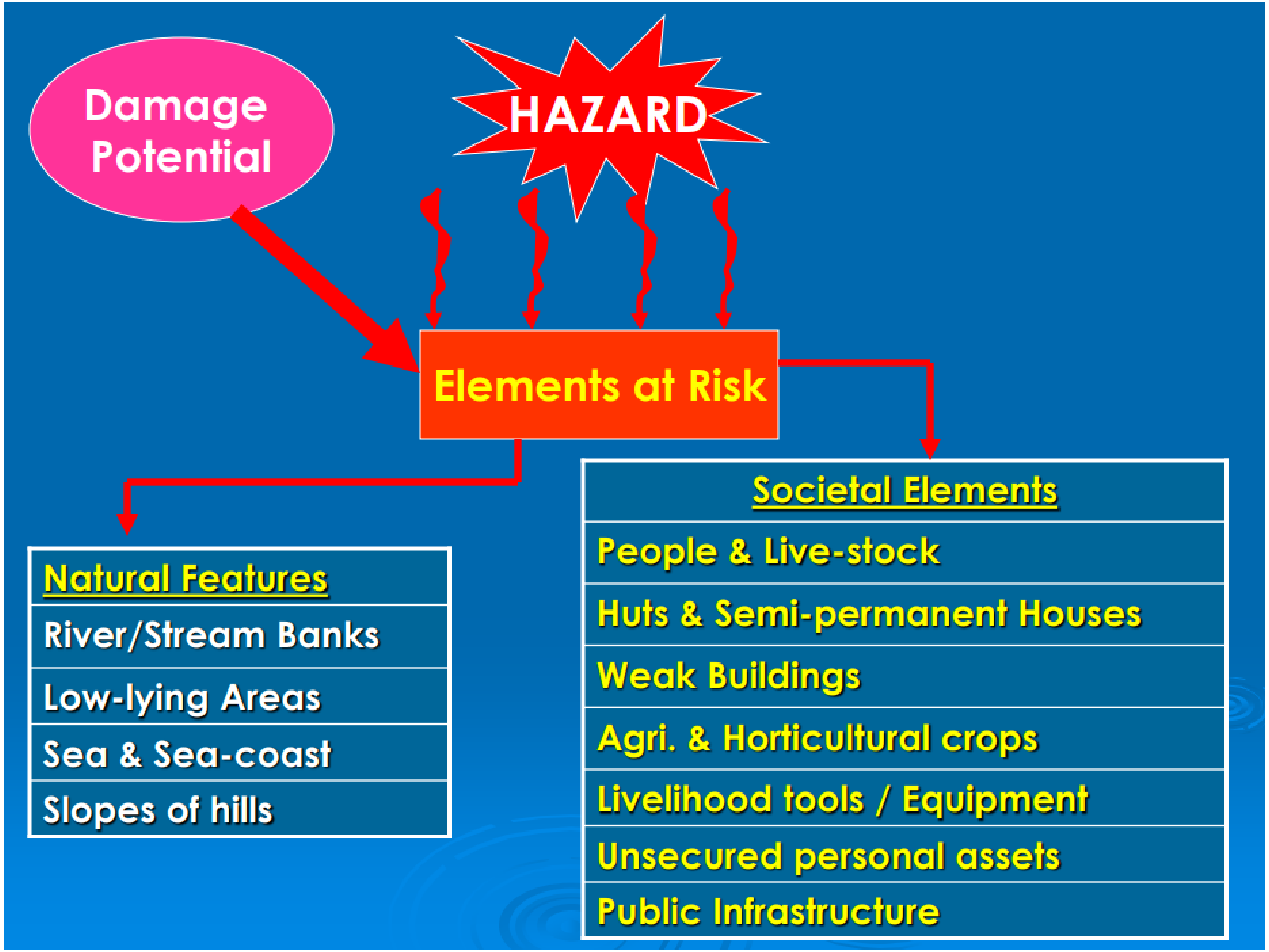
Distribution of cyclones

Types of Disturbances	Associated wind speed in the Circulation
Low Pressure Area	Less than 17 knots (< 31 kmph
Depression	17 to 27 knots (31 to 49 kmph)
Deep Depression	28 to 33 knots (50 to 61 kmph)
Cyclonic Storm	34 to 47 knots (62 to 88 kmph)
Severe Cyclonic Storm	7.) 48 to 63 knots (89 to 118 kmph)
Very Severe Cyclonic Storm	64 to 119 knots (119 to 221 kmph)
Super Cyclonic Storm	120 knots and above (222 kmph and above

Cyclones in INDIA

1.	Coringa, India	1839	Bay of Bengal	300,000
2.	India	1833	Bay of Bengal	50,000
3..	India	1854	Bay of Bengal	50,000
4.	India	1935	Bay of Bengal	60,000
5.	Calcutta, India	1864	Bay of Bengal	60,000

MOST DEADLIEST CYCLONE OCTOBER 7, 1737
PLACE-HOOGLY RIVER,INDIA
DEATH-320,000+


Damage Potential
HAZARD
Elements at Risk
Natural Features
River/Stream Banks
Low-lying Areas
Sea & Sea-coast
Slopes of hills
Societal Elements
People & Live-stock
Huts & Semi-permanent Houses
Weak Buildings
Agri. & Horticultural crops
Livelihood tools / Equipment
Unsecured personal assets
Public Infrastructure

Potential Damage Elements

- **1. Strong Winds (150-250 Km/Hr) – Damage installations, dwellings, communication systems; trees, roofs may be blown off, Roads/ Railway tracks affected. Stronger winds on the right semi-circle with reference to storm motion**
- **2. Heavy Rains- Prolonged heavy rains(20-30 cm/day) and over large area may lead to floods, soil erosion, water polluted. Outbreak of epidemics. Problem during post-cyclone relief works**

Surge prone coasts of India

- Storm surge heights depend on the intensity of the cyclone, i.e., very high-pressure gradient and consequent very strong winds and the topography of seabed near the point where a cyclone crosses the coast. Sea level also rises due to astronomical high tide. Elevation of the total sea level increases when peak surge occurs at the time of high tide.
- Cyclones that struck the coasts of India

1. Rameswaram Cyclone of 17th to 24th December 1964 wiped out Dhanuskodi in Rameswaran Island from the map.
2. Bangla Desh Cyclone of 8-13 November 1970 toll of about 3,00,000 people.
3. Andhra Cyclone of 14-20 November 1977 that crossed coast near Nizampatnam in the evening of 19th, took a toll of about 10,000 lives.

The West coast of India is less vulnerable to storm surges than the east coast of India in terms of both the height of storm surge as well as frequency of occurrence. However, the following segments are vulnerable to significant surges :

i) Maharashtra coast, north of Harnai and adjoining south Gujarat coast and the coastal

Tropical Cyclone Warning System

- A full-fledged national cyclone warning system
- **Cyclone Warning Division, New Delhi**
- Weather Forecasting Division, Pune
- **3 Area Cyclone Warning Centres (ACWC)**
  Kolkata, Chennai and Mumbai
- **3 Cyclone warning Centres (CWC)**
  Bhubaneshwar, Visakhapatnam and Ahemadabad
- Cyclone warning messages indicating storm location, intensity and movement

Destruction caused by Cyclones

- Consequent strong winds. These, in turn, generate storm surges.
- Abnormal rise of sea level near the coast caused by a severe tropical cyclone.
- Very strong winds may damage installations, dwellings, communication systems, trees., etc. resulting in loss of life and property.
- Heavy rains due to cyclones may cause river floods

PROTECTION AGAINST CYCLONE

- Four Stage Warning

STAGE	STAGE OF WARNING	TIME
First Stage	PRE CYCLONE WATCH	Before 72hrs
Second Stage	"CYCLONE ALERT"	Before 48hrs
Third Stage	CYCLONE WARNING	Before 24hrs
Fourth Stage	POST LANDFALL OUTLOOK	Before 12hrs

- De-warning – message is issued when the Tropical Cyclone weakens into Depression State.

Cyclone Operation in India

- Cyclone warnings are provided by IMD from the Area Cyclone Warning Centres (ACWCs) at Calcutta, Chennai and Mumbai and Cyclone Warning Centres (CWCs) at Bhubanes-war, Visakhapatnam and Ahmedabad.
- Meteorological Department, by providing Cyclone Surveillance Radars at Calcutta in the east coast and at Goa, Bombay in the west coast.
- Satellite picture receiving equipments at Delhi, Bombay, Madras are receiving satellite pictures of the cyclones from the polar-orbiting Satellites of the U.S.A. and U.S.S.R. Since April 1982.
- A.V.H.R.R. (Advance very High Resolution Radio-meter) Indian GeoStationary Satellite INSAT-LB has become operational since October 1983. Monitoring of the cyclone by taking hourly pictures has helped the forecaster to improve his skill in issuing the timely warnings to the public.

Cyclone Monitoring Satellites

- SATCAT no. SCATSAT-1 (Scatterometer Satellite-1) is a satellite providing weather forecasting, cyclone prediction, and tracking services to India.
- It has been developed by ISRO Satellite Centre, Bangalore whereas its payload was developed by Space Applications Centre, Ahmedabad.

SOME INDIAN ASSOCITIONS

- Area Cyclone Warning Centres (ACWC)
- Cyclone Warning Centres (CWC)
- Numerical Weather Prediction (NWP)
- Northern Hemispheric Analysis Centre (NHAC)
- Cyclone Warning Research Centre (CWRC)
- Regional Specialized Meteorological Centre

National Level Disaster Prevention Team

- The Team of Govt. of India establish in 1969,set up "Cyclone Distress Mitigation Committee" (CDMC) with the objective of preventing loss of life and minimizing damage to properties.

Automatic Weather Stations

- A very modern concept
- A satellite based system
- The meteorological parameters recorded every hour with the help of sensors
- Data can be obtained even from remote areas without human intervention
- Data transmitted the values to a Central Receiving Earth Station.
- IMD has 100 land-based Automatic Weather Stations

Tsunami

- A Tsunami also known as seismic sea wave, it is a series of water waves caused by displacement of a large volume of a body of water, generally an ocean or a large lake. Tsunami waves do not resemble normal sea waves as their wavelength is longer. Rather than appearing as a breaking wave. A tsunami may initially resembles a rapidly rising tide & for this reason tsunamis are often referred to as tidal waves.

How are tsunamis generated?

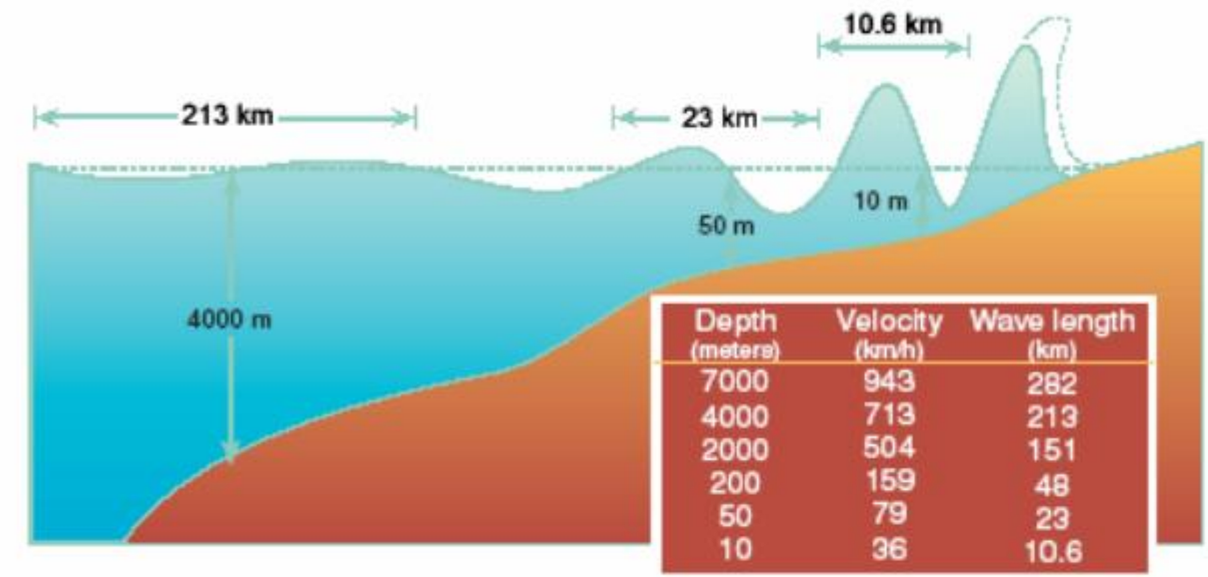
- Tsunamis are generated by any large, impulsive displacement of the sea bed level.
- Earthquakes generate tsunamis by vertical movement of the sea floor. If the sea floor movement is horizontal, a tsunami is not generated. Earthquakes of $M > 6.5$ are critical for tsunami generation.
- Tsunamis are also triggered by landslides into or under the water surface, and can be generated by volcanic activity and meteorite impacts.

How often do tsunamis occur?

- On the average, there are two tsunamis per year in the Pacific Ocean somewhere, which cause damage near the source.
- Approximately every 15 years a destructive tsunami occurs in Pacific.
- The destructive tsunami on Dec 26th, 2004 on the Indian Coast in terms of its impact seems to have occurred for the first time in the history.

How fast does a tsunami travel?

- Tsunami velocity is dependent on the depth of water through which it travels (Velocity equals the square root of water depth h times the gravitational acceleration g, that is V =√g h).
- Tsunamis travel approximately at a velocity of 700 kmph in 4000 m depth of sea water. In 10 m of water depth the velocity drops to about 36 kmph.



Tsunamis in India

S	Date	Remarks
1	April 12, 1762	Eq. in the Bay of Bengal generated tsunami wave of 1.8 m in coastal Bangladesh
2	August 19, 1868	Earthquake Mw 7.5 in the Bay of Bangal. Tsunami wave run-up level at Port Blair, Andaman Island 4.0 m.
3	December 31, 1881	Earthquake of magnitude Ms 7.9 in the Bay of Bangal, reported tsunami run-up level of 0.76m at Car Nicobar, 0.3m at Dublat , 0.3 m at Nagapattinam and 1.22 m at Port Blair in Andaman Island
4	1883	Karakatau, volcanic explosion in Indonessia. 1.5 m tsunami at Chennai, 0.6 m at Nagapattinam.
5	1884	Earthquake in the western part of the Bay of Bengal. Tsnamis at Port Blair & mouth of Hoogly River
6	June 26, 1941	Earthquake of magnitude MW 8.1 in the Andaman Sea at 12.9^0 N,92.5° E. Tsunamis on the east coast of India with amplitudes from 0.75 to 1.25 m. Some damage from East Coast was reported.
7	November 27, 1945	Mekran Earthquake (Magnitude Ms 8.3). 12 to 15 M wave height in Ormara, 13 m at Pasni, and 1.37 m at Karachi (Pakistan) . In Gulf off Cambay of Gujarat wave heights of 11.0 m was estimated, and 2 m at Mumbai, where boats were taken away from their moorings.
8	December 26, 2004	An earthquake of rear Magnitude (M_W9.3) generated giant tsunami waves in North Indian Ocean. Tsunmai made extensive damage to many coastal areas of Indonesia, India, Malaysia, Maldives, Srilanka and Thailand. A trans-oceanic tsunami, observed over areas beyond the Ocean limit of origin. More than 2,00,000 people lost their lives in above countries which is a record.

Tsunami risk

- **TSUNAMI RISK = TSUNAMI HAZARD * EXPOSURE * VULNERABILITY.**
- **Tsunami Hazard assessment:** • Preparation of data-base of historical and archival information of relevant Indian Tsunamis, with the emphasis clearly on the December 26, 2004 event. • Supplement the data from computer based simulations. • Analyses of these data, to -define the scenario Tsunamis from various earthquake sources -prepare the Tsunami hazard map.
- **Exposure:** • List all habitations below 10 m contour level and locate on a map. • List and locate all vital installations below 10 m contour level.
- **VULNERABILITY assessment:** • Based on the earthquake vulnerability assessment, define the vulnerability of various exposed elements on the coastal, island and reef environments and in the Ports and Harbours • Prepare vulnerability maps (based on Remote Sensing, Geographical information system and other data related to various hazards).

Key factors to reduce potential losses due to tsunami

1 Building Codes (potential damage due to wave action and flooding)

2. GIS Mapping

3. Land-Use Planning (taking note of wave action & flooding)

4. Disaster Planning (in identified hazard zones)

5. Emergency Management

6. Emergency Personnel Training (necessary aspects relevant to marine situations)

7. Rescue and Response (marine situations related to shipping) (cargo, tourist, inter-islands fishing community, recreational boating)

8. Insurance Needs

9. Community Education

10. Simulated Tsunami Exercises

Measures for safety from Tsunamis

Structural Measures

1. Construction of cyclone shelters
2. Plantation of mangroves and coastal forests along the coast line
3. Development of a network of local knowledge centers (rural/urban) along the coast lines to provide necessary training and emergency communication during crisis time
4. Construction of location specific sea walls and coral reefs in consultation with experts
5. Development of well designed break waters along the coast to provide necessary cushion against cyclone and tsunami hazards
6. Development of tsunami detection, forecasting and warning dissemination centres
7. Development of a “Bio-Shield” - a narrow strip of land along coastline.
8. Identification of vulnerable structures and appropriate retrofitting for tsunami/cyclone resistance of all such buildings as well as appropriate planning, designing, construction of new facilities.

Measures for safety from Tsunamis

Non-structural Measures

1. Strict implementation of the coastal zone regulations (within 500 m of the high tide line with elevation of less than 10 m above mean sea level).
2. Mapping the coastal area for multiple hazards, vulnerability and risk analysis upto taluka /village level. Development of Disaster Information Management System (DIMS) in all the coastal states.
3. Aggressive capacity building requirements for the local people and the administration for facing the disasters in wake of tsunami and cyclone, ‘based on cutting edge level’
4. Developing tools and techniques for risk transfer in highly vulnerable areas
5. Launching a series of public awareness campaign throughout the coastal area by various means including AIR, Doordarshan & Other Media.
6. Training of local administration in forecasting warning dissemination and evacuation techniques
7. Awareness generation and training among the fishermen, coast guards, officials from fisheries department and port authorities and local district officials etc., in connection with evacuation and post tsunami storm surge management activities. Regular drills should be conducted to test the efficacy of the DM plans.
8. Studies focusing on the tsunami risk in India may be taken under NCRM project.

The Present status of Tsunami Warnings in India.

- Tsunami is very low probability event in India. As such, there are no Codal provisions for Tsunami warnings in India as yet though; there is a good seismological network in India to record any earthquake within the country and its neighborhood.
- The need of a Tsunami Warning Centre (TWC) in India is now being conceptualized at the Government of India level.
- Indian Meteorological Department (IMD), is working on a proposal to set up a real time earthquake monitoring system in India.
- The Department of Ocean Development in collaboration with Departments of Space and IMD under Department of Science and Technology is evolving a plan of tsunami warning system in the Bay of Bengal and the Arabian Sea.
- The data from observing points to Warning Centre(s) will be sent through satellite links. Specific systems called Deep Ocean Assessment and Reporting of Tsunamis (DART) using Bottom Pressure Recorder, acoustic modem, acoustic release system, battery pack bolted to platform and float action and recovery aids will be deployed.
- The warning centres in the Indian context could be the Emergency Operation Centre at the State & District level, which are being designed to function round the clock under the District Collector at District level and under the Chief Minister at State level.

Heat Wave

- A heat wave is a prolonged period of excessively hot weather accompanied by high humidity, especially in oceanic climate countries, a heat wave is measured relative to the usual weather in the area & relative to normal temperatures for the season, heat wave is considered extreme weather & a danger because heat & sunlight may damage the Human body.

Health Impacts of Heat Waves

- The health impacts of Heat Waves typically involve dehydration, heat cramps, heat exhaustion and/or heat stroke. The signs and symptoms are as follows:
- Heat Cramps: Ederna (swelling) and Syncope (Fainting) generally accompanied by fever below 39^{o}C i.e. 102^{o}F.
- Heat Exhaustion: Fatigue, weakness, dizziness, headache, nausea, vomiting, muscle cramps and sweating.
- Heat Stoke: Body temperatures of 40^{o}C i.e. 104^{o}F or more along with delirium, seizures or coma. This is a potential fatal condition

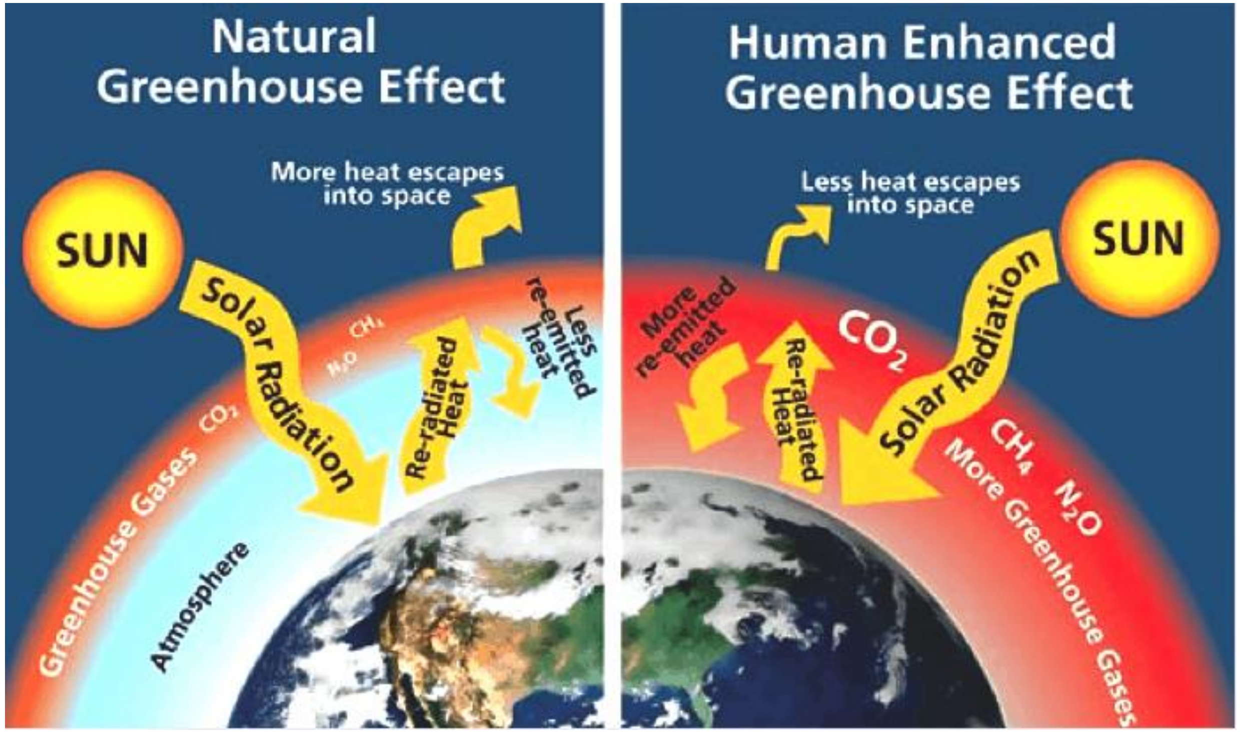
Climate Change -Global warming, Sea level rise, ozone depletion

- Climate Change is the defining issue of our time and we are at a defining moment.
- From shifting weather patterns that threaten food production, to rising sea levels that increase the risk of catastrophic flooding, the impacts of climate change are global in scope and unprecedented in scale.
- Without drastic action today, adapting to these impacts in the future will be more difficult and costly.

Global warming

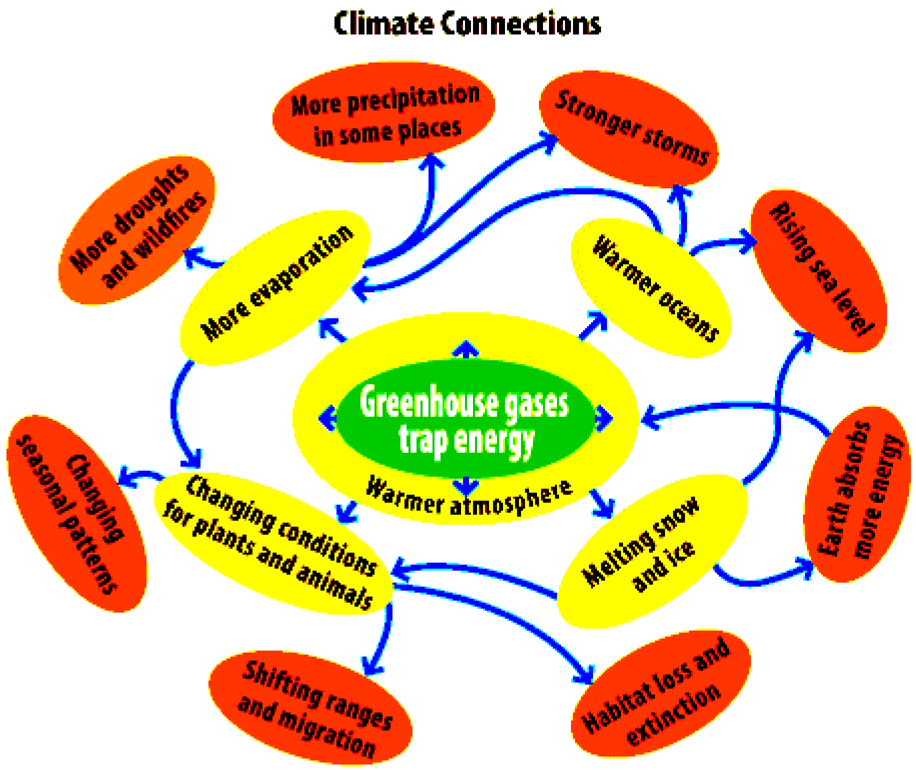
- The earth's atmosphere has always acted like a greenhouse to capture the sun's heat, ensuring that the earth has enjoyed temperatures that permitted the emergence of life forms as we know them, including humans.

- Global warming is the slow increase in the average temperature of the earth's atmosphere because an increased amount of the energy (heat) striking the earth from the sun is being trapped in the atmosphere and not radiated out into space.



How does Global Warming drive Climate Change?

- Heat is energy and when you add energy to any system changes occur.
- Because all systems in the global climate system are connected, adding heat energy causes the global climate as a whole to change.
- Much of the world is covered with ocean which heats up. When the ocean heats up, more water evaporates into clouds.
- Where storms like hurricanes and typhoons are forming, the result is more energy-intensive storms. A warmer atmosphere makes glaciers and mountain snow packs, the Polar ice cap, and the great ice shield jutting off of Antarctica melt raising sea levels.
- Changes in temperature change the great patterns of wind that bring the monsoons in Asia and rain and snow around the world, making drought and unpredictable weather more common.



Causes of Global Warming

That global warming is occurring as a result primarily of human activity and so climate change is also the result of human activity.

The most important greenhouse gases(GHGs)

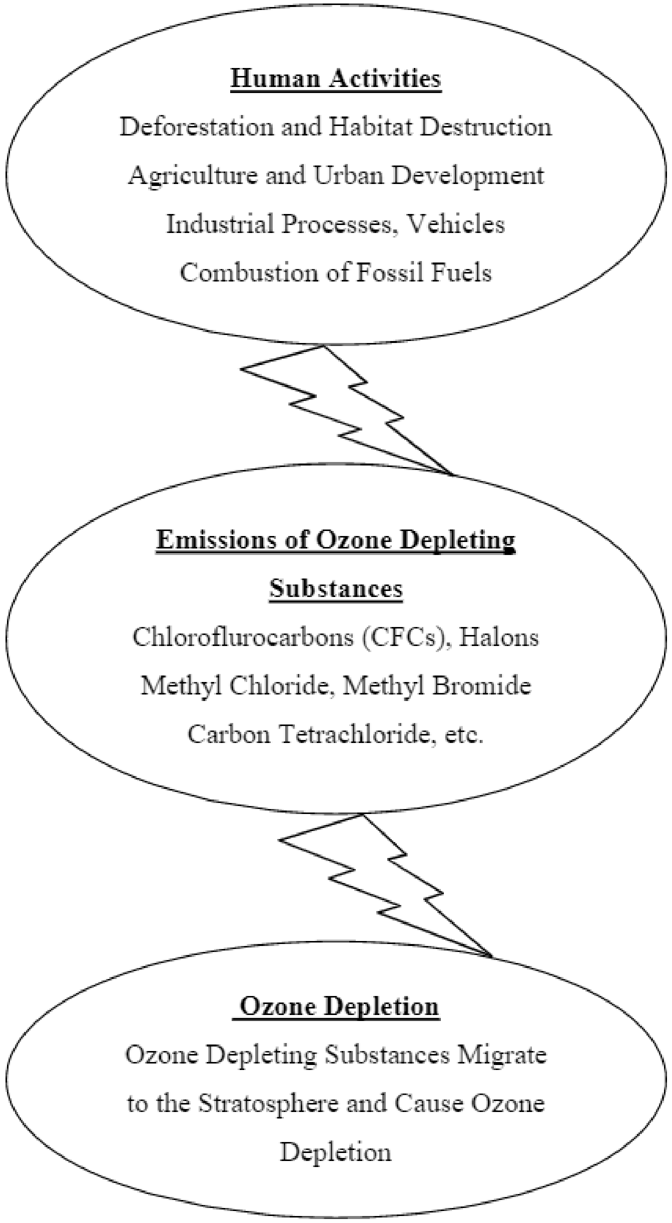
- **CO2 or carbon dioxide** is produced any time something is burned. It is the most common GHG, constituting by some measures almost 55% of total long-term GHGs.
- **Methane or CH4** is produced in many combustion processes and also by anaerobic decomposition. Methane breaks down in approximately 10 years, but is a precursor of ozone, itself an important GHG.
- **Nitrous oxide** in parean (laughing gas), is a byproduct of fertilizer production and use, other industrial processes and the combustion of certain materials. Nitrous oxide lasts a very long time in the atmosphere, but at the 100 year point.
- **Fluorinated gases** were created as replacements for ozone depleting refrigerants, but have proved to be both extremely long lasting and extremely warming GHGs. They have no natural sources, but are entirely man-made. At the 100 year point of comparison
- **Sulphur hexafluoride or SF6** is used for specialized medical procedures, but primarily in what are called dielectric materials, especially dielectric liquids. These are used as insulators in high voltage applications such as transformers and grid switching gear. SF6 will last thousands of years in the upper atmosphere.

Sea-level Rise

- Climate change impacts rising sea levels. Average sea level around the world rose about 8 inches (20 cm) in the past 100 years; climate scientists expect it to rise more and more rapidly in the next 100 years as part of climate change impacts.
- Coastal cities such as New York are already seeing an increased number of flooding events and by 2050 many such cities may require seawalls to survive. Estimates vary, but conservatively sea levels are expected to rise 1 to 4 feet (30 to 100 cm), enough to flood many small Pacific island states (Vanatu), famous beach resorts (Hilton Head) and coastal cities (Bangkok, Boston).
- If the Greenland ice cap and/or the Antarctic ice shelf collapses, sea levels could rise by as much as 20 ft (6 m), inundating, for example, large parts of Florida, the Gulf Coast, New Orleans and Houston.

Ozone depletion

- Atmospheric ozone absorbs ultraviolet (UV) radiation from the sun, particularly harmful UVB-type rays. Exposure to UVB radiation is linked with increased risk of skin cancer and cataracts, as well as damage to plants and marine ecosystems.
- Ozone, on the other hand, consists of three atoms of oxygen bound together (O3).
- Most of the atmosphere's ozone occurs in the region called the stratosphere. Ozone is colourless and has a very harsh odour.



Ozone at different levels

- Ozone also occurs in very small amounts in the lowest few kilometres of the atmosphere, a region known as the troposphere.
- It is produced at ground level through a reaction between sunlight and volatile organic compounds (VOCs) and nitrogen oxides (NOx), some of which are produced by human activities such as driving cars.
- Stratospheric ozone blocks harmful solar radiation - all life on Earth has adapted to this filtered solar radiation.
- Ground-level ozone, in contrast, is simply a pollutant. It will absorb some incoming solar radiation, but it cannot make up for ozone losses in the stratosphere.

Ozone Hole

- Frequently, the term is employed to describe ozone depletion.
- Technically, the term "ozone hole" should be applied to regions where stratospheric ozone depletion is so severe that levels fall below 200 Dobson Units (D.U.), the traditional measure of stratospheric ozone.
- Normal ozone concentration is about 300 to 350 D.U [3]. Such ozone loss now occurs every springtime above Antarctica, and to a lesser extent the Arctic, where special meteorological conditions and very low air temperatures accelerate and enhance the destruction of ozone loss by man-made ozone depleting chemicals (ODCs).

EFFECTS OF OZONE DEPLETION

- Effects on Human and Animal Health
- Effects on Terrestrial Plants
- Effects on Aquatic Ecosystems
- Effects on Bio-geo-chemical Cycles
- Effects on Air Quality
- Effects on Materials
- Effects on Climate Change
- Effects on Ultraviolet Radiation

INTERNATIONAL ACTIONS

- **Montreal Protocol** - On the basis of the Vienna Convention, the Montreal Protocol on Substances that Deplete the Ozone Layer was negotiated and signed by 24 countries and by the European Economic Community in September 1987. The Protocol called for the Parties to phase down the use of CFCs, halons and other man-made ODCs.
- **Australian Chlorofluorocarbon Management Strategy** - It provides a framework for the responsible management and use of CFCs in Australia. The strategy recognizes some continuing need for these chemicals in pharmaceutical and laboratory uses, but commits to their gradual phasing out.
- **Environmental Protection (Ozone Protection) Policy2000** - This WA policy aims to minimize the discharge of ozone-depleting substances into the environment, and has been extended to cover use of alternative refrigerants (where relevant).
- **United Nations Environment Programme** - Has published several assessments of the environmental effects of ozone depletion (United Nations Environment Programme, 1998; World Meteorological Organization, 2002)
- **Ozone Protection and Synthetic Greenhouse Gas Management Act 1989** (and associated regulations and amendments) - Was implemented by the Commonwealth Government to meet its commitments under the Montreal Protocol.
- **Ultraviolet index forecast** - The Bureau of Meteorology has developed a model to predict the amount of ultraviolet exposure and the times of day at which it will occur for 45 WA locations. It is designed to help people minimize their exposure to dangerous levels of ultraviolet radiation.

END