MODULE 3

Syllabus:
Types of Natural Disasters II- Floods, Coastal disasters- Cyclones, Tsunamis. Nature of impacts.

FLOODS

You read in newspapers and watch images of floods on televisions occurring in some regions during rainy seasons. Inundation of land and human settlements by the rise of water in the channels and its spill-over presents the condition of flooding. Unlike other natural disasters, the causes of floods are well established.

Floods are relatively slow in occurrences and often, occur in well-identified regions and within expected time in a year. Floods occur commonly when water in the form of surface run-off exceeds the carrying capacity of the river channels and streams and flows into the neighboring low-lying flood plains. At times, this even goes beyond the capacity of lakes and other inland water bodies in which they flow. Floods can also be caused due to a storm surge (in the coastal areas), high intensity rainfall for a considerably longer time period, melting of ice and snow, reduction in the infiltration rate and presence of eroded material in the water due to higher rate of soil erosion. Though floods occur frequently over wide geographical area having disastrous ramifications in many parts of the world, floods in the South, Southeast and East Asian countries, particularly in China, India and Bangladesh, are frequent and equally disastrous.

Once again, unlike other natural disasters, human beings play an important role in the genesis as well as spread of floods. Indiscriminate deforestation, unscientific agricultural practices, disturbances along the natural drainage channels and colonization of flood-plains and river-beds are some of the human activities that play an important role in increasing the intensity, magnitude and gravity of floods.

FLOODS

Flood is a state of high water level along a river channel or on the coast that leads to inundation of land, which is not usually submerged. Floods may happen gradually and also may take hours or even happen suddenly without any warning due to breach in the embankment, spill over, heavy rains etc.

- Every stream flows in a particular stage at a particular place during different intervals of time in a year such as a **dry stage, half-full stage and bank full stage.**
- This depends upon climate and precipitation in the catchment area.
- A **flood occurs when the volume of water in the river becomes greater than bank-full stage**: the extra water spills over the banks and spreads in sheets all along and away from the banks governed by available slope. This condition is called flood.

TYPES OF FLOODS

According to their duration flood can be divided into different categories:

(a) **Slow-Onset Floods**: Slow Onset Floods usually last for a relatively longer period, it may last for one or more weeks, or even months.
(b) **Rapid-Onset Floods**: Rapid Onset Floods last for a relatively shorter period, they usually last for one or two days only.
(c) **Flash Floods**: Flash Floods may occur within minutes or a few hours after heavy rainfall, tropical storm, failure of dams or levees or releases from dams, and it causes the greatest damages to society.

Flash floods

Flash floods, which are short-lived extreme events, prove the exception. They usually occur under slowly moving or stationary thunderstorms, which last for less than 24 hours. The resulting rainfall intensity exceeds infiltration capacity, so run-off takes place very rapidly. Flash floods are frequently very destructive as the high energy flow can carry much sedimentary material

- Flash floods are local floods of great volume and short duration.
- A flash flood generally results from a torrential rain or "cloudburst" on relatively small and widely dispersed streams.
- Runoff from the intense rainfall results in high flood waves.
- Discharges, quickly reach a maximum and diminish almost as rapidly.
- Flood flows frequently contain large concentrations of sediment and debris.
- Flash floods also result from the failure of a dam.
- Flash floods are particularly common in mountainous areas and desert regions but are a potential threat in any area, where the terrain is steep, surface runoff rates are high, streams flow in narrow canyons, and severe thunderstorms prevail.

River floods

- River floods are caused by precipitation over large areas or by melting of the winter's accumulation of snow, or by both.
- These floods differ from flash floods in their extent and duration. Whereas flash floods are of short duration in small streams, riverine floods take place in river systems whose tributaries may drain large geographic areas and encompass many independent river basins
- Floods on large river systems may continue for periods ranging from a few hours to many days. Flood flows in large river systems are the distribution of precipitation.
- The condition of the ground (amount of soil moisture, seasonal variations in vegetation, depth of snow cover, imperviousness due to urbanization, etc.) directly affects runoff.

Coastal floods/Storm surge

- Storm surge or tidal surge is an offshore rise of water associated with a low pressure weather system, typically a tropical cyclone.
- Storm surge is caused primarily by high winds pushing on the ocean's surface.
- The wind causes the water to pile up higher than the ordinary sea level
- Low pressure at the center of a weather system also has a small secondary effect, as can the bathymetry of the body of water.
- It is this combined effect of low pressure and persistent wind over a shallow water body which is the most common cause of storm surge flooding problems.
- The term "storm surge" in casual (non-scientific) use is storm tide; that is, it refers to the rise of water associated with the storm, plus tide, wave run-up, and freshwater flooding.

CAUSES OF FLOODS

There are several causes of floods and differ from region to region. The causes may vary from a rural area to an urban area. Some of the major causes are:

a. Heavy rainfall
b. Heavy siltation of the river bed reduces the water carrying capacity of the rivers/stream.
c. Blockage in the drains lead to flooding of the area.
d. Landslides blocking the flow of the stream.
e. Construction of dams and reservoirs
f. In areas prone to cyclone, strong winds accompanied by heavy down pour along with storm surge leads to flooding.

The geological factors that facilitate floods are defined by the topography, lithology and character of the drainage basin.

a. **Topography:** The nature of slopes along the river bank may vary from slightly sloping to steeply sloping. The steeply sloping land **conveys the run-off after heavy rains directly to the stream within a short time** from both the sides thereby reaching the bank full stage.

b. **Lithology (i.e. type of soil or rock):** when majority of slopes in the catchment are made of pervious open-texture soils or highly permeable rocks, a good part of rainwater is absorbed and infiltrates as ground water. However, where slopes are made up of **impervious, compacted, solid and massive rocks or soils, greater volumes of run-off reach the streams** contributing towards the flood-stage situation.

c. **Vegetation:** Vegetation in the form of grasses, bushes or even forests with well- developed root network system act as effective barriers and retarders against run-off. Conversely **bare slopes not only allow the run-off an easy path, they also contribute by providing lot of debris to the down-rushing waters.** This debris when reaching the streams flattens their channels thereby decreasing their water carrying capacity. Short-time sudden floods (flash floods) may be caused on rare occasions by cloud bursts and collapse of darns against reservoir.

TYPICAL ADVERSE EFFECTS:

The most important consequence of floods is the loss of life and property. Structures like houses, bridges; roads etc. get damaged by the gushing water, landslides triggered on account of water getting saturated, boats and fishing nets get damaged. There is huge loss to life and livestock caused by drowning. Lack of proper drinking water facilities, contamination of water (well, ground water, piped water supply) leads to outbreak of epidemics, diarrhoea, viral infection, malaria and many other infectious diseases.

Flooding also leads to a large area of agricultural land getting inundated as a result there is a huge crop loss. This results in shortage of food, and animal fodder. Floods may also affect the soil characteristics. The land may be rendered infertile due to erosion of top layer or may turn saline if sea water floods the area

MONITORING OF FLOODS

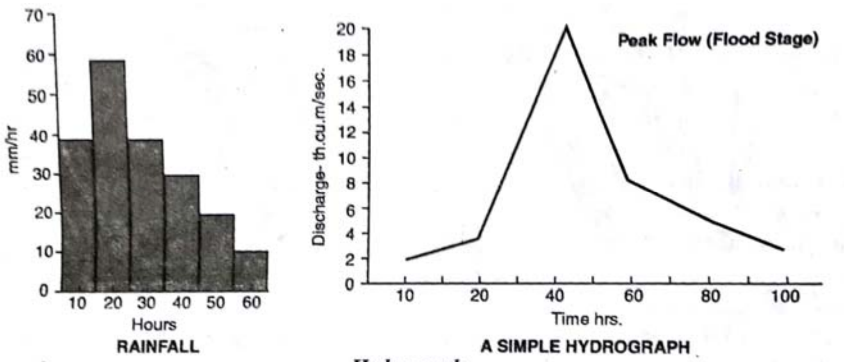
Anticipating floods before they occur allows for precautions to be taken and people to be warned so that they can be prepared in advance for flooding conditions.

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 measure past rainfall events.

Radar estimates of rainfall and general weather forecasting techniques are also important components of good flood forecasting.

Magnitude and Frequency of flood

- The magnitude of a flood is generally indicated by the discharge of water from a channel at a particular point. The discharge of flow is commonly indicated by means of a hydrograph.
- As the name indicates, a hydrograph is a **plot between discharge of a stream at a particular place in cubic meters/sec or cubic feet/sec over a period of time (day/week/month/year).** A flood is often indicated by the Peak in a hydrograph



Hydrograph

- If we have hydrographs of a river for longer periods (or years) then it can be used for flood prediction studies
- If we have longer periods of hydrographs, the frequency of flood i.e. its recurrence or periodicity can be predicted.
- If a flood has return period of 10 years it means it occurs once in 10 years.

POSSIBLE RISK REDUCTION MEASURES:

Mapping of the flood prone areas is a primary step involved in reducing the risk of the region. Historical records give the indication of the flood inundation areas and the period of occurrence and the extent of the coverage. Warning can be issued looking into the earlier marked heights of the water levels in case of potential threat. In the coastal areas the tide levels and the land characteristics will determine the submergence areas. Flood hazard mapping will give the proper indication of water flow during floods.

Land use control will reduce danger of life and property when waters inundate the floodplains and the coastal areas. The number of casualties is related to the population in the area at risk. In areas where people already have built their settlements, measures should be taken to relocate to better sites so as to reduce vulnerability. No major development should be permitted in the areas which are subjected to high flooding. Important facilities like hospitals, schools should be built in safe areas. In urban areas, water holding areas can be created like ponds, lakes or low-lying areas.

Construction of engineered structures in the flood plains and strengthening of structures to withstand flood forces and seepage. The buildings should be constructed on an elevated area. If necessary build on stilts or platform. Flood Control aims to reduce flood damage. This can be done by decreasing the amount of runoff with the help of reforestation (to increase absorption could be a mitigation strategy in certain areas), protection of vegetation, clearing of debris from streams and other water holding areas, conservation of ponds and lakes etc. Flood Diversion include levees, embankments, dams and channel improvement. Dams can store water and can release water at a manageable rate. But failure of dams in earthquakes and operation of releasing the water can cause floods in the lower areas. Flood Proofing reduces the risk of damage. Measures include use of sand bags to keep flood water away, blocking or sealing of doors and windows of houses etc. Houses may be elevated by building on raised land. Buildings should be constructed away from water bodies.

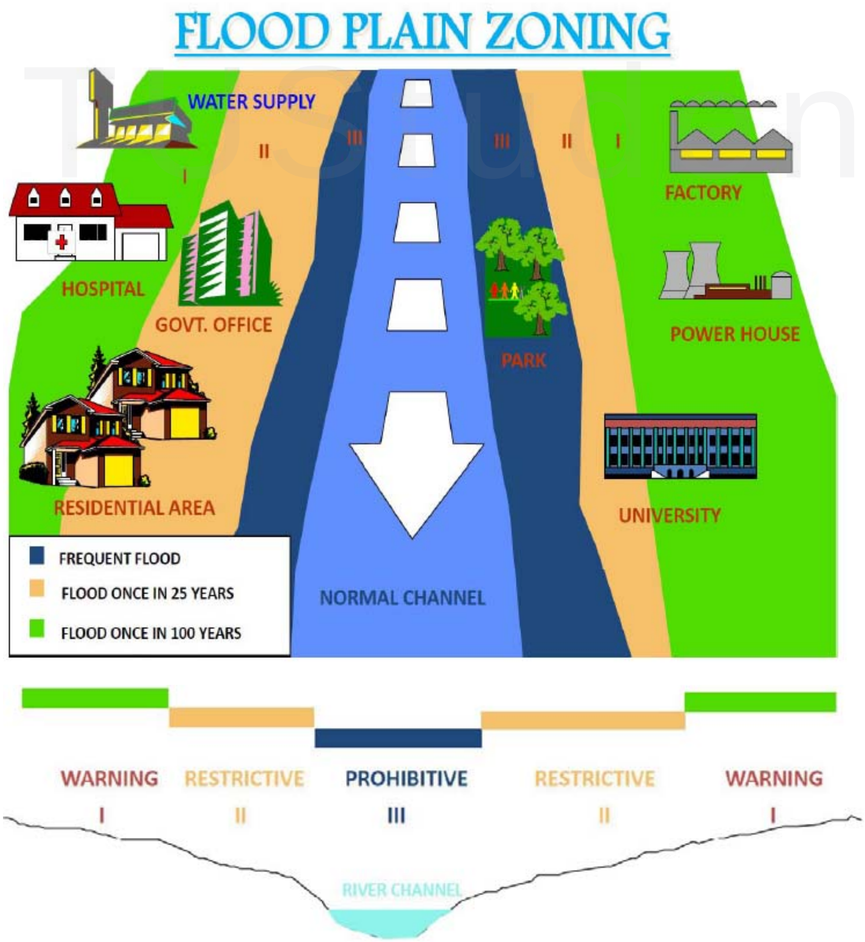
Flood Management. In India, systematic planning for flood management commenced with the Five Year Plans, particularly with the launching of National Programme of Flood Management in 1954. During the last 48 years, different methods of flood protection structural as well as nonstructural have been adopted in different states depending upon the nature of the problem and local conditions. **Structural measures include storage reservoirs, flood embankments, drainage channels, anti-erosion works, channel improvement works, detention basins etc. and non-structural measures include flood forecasting, flood plain zoning, flood proofing, disaster preparedness** etc. The flood management measures undertaken so far have provided reasonable degree of protection to an area of 15.81 million hectares throughout the country.

Flood embankments, Dams & Reservoir

Drainage improvement, Diversion of Flood River

Diversion canals. Floods can be controlled by redirecting excess water to purpose-built canals or floodways, which in turn divert the water to temporary holding ponds or other bodies of water where there is a lower risk or impact to flooding.

Flood plain zoning



Flood plain zones can be designated for specific types of land use: that is, in the channel zone water should be allowed to flow freely without obstruction;

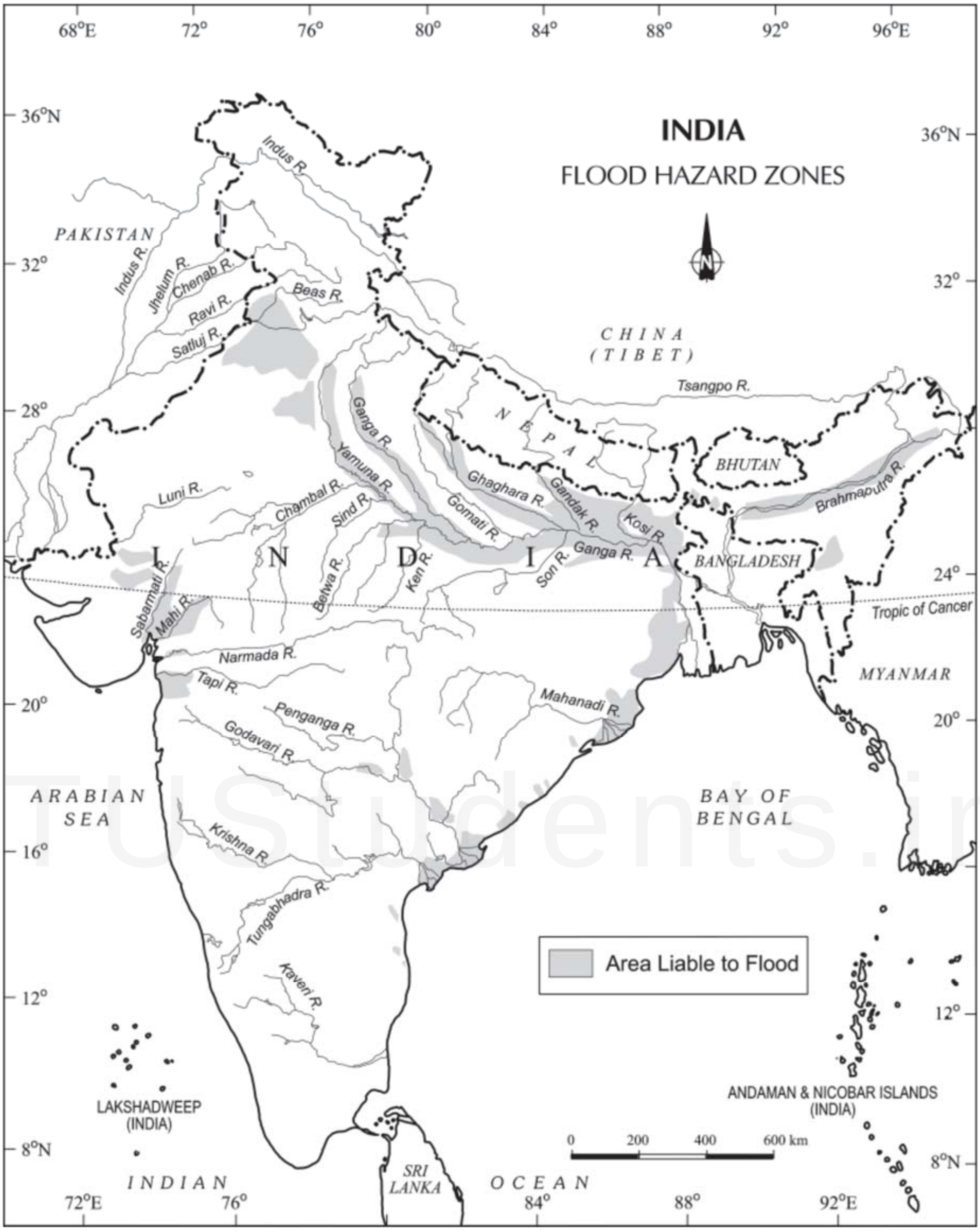
- ***Flood hazard zone I* (Active flood plain area):**
  Prohibit development (business and residential) within flood plain Maintain area in a natural state as an open area or for recreational uses only.
- **Flood hazard zone II *(Alluvial fans and plains with channels less than a metre deep, bifurcating, and intricately interconnected systems subject to inundation from overbank flooding)*:**
  Flood-proofing to reduce or prevent loss to structures is highly recommended. Residential development densities should be relatively low; development in obvious drainage channels should be prohibited.
  Dry stream channels should be maintained in a natural state and/or the density of native vegetation should be increased to facilitate superior water drainage retention and infiltration capabilities.
  Installation of upstream stormwater retention basins to reduce peak water discharges.
  Construction should be at the highest local elevation site where possible.
- ***Flood hazard zone III* (Dissected upland and lowland slopes; drainage channels where both erosional and depositional processes are operative along gradients generally less than 5%):**
  Similar to flood hazard zone II
  Roadways that traverse channels should be reinforced to withstand the erosive power of a channeled stream flow.

DISTRIBUTIONAL PATTERN OF FLOODS IN INDIA

Floods occur in almost all the river basins of the country. Various states of India face heavy loss of lives and property due to recurrent floods. National Flood Commission identified 40 million hectares of land as flood-prone in India. The Figure below shows the flood-affected areas in India.

Assam, West Bengal and Bihar are among the high flood-prone states of India. Apart from these, most of the rivers in the northern states like Punjab and Uttar Pradesh, are also vulnerable to occasional floods. It has been noticed that states like Rajasthan, Gujarat, Haryana and Punjab are also getting inundated in recent decades due to flash floods. This is partly because of the pattern of the monsoon and partly because of blocking of most of the streams and river channels by human activities. Sometimes, Tamil Nadu experiences flooding during November- January due to the retreating monsoon.

Most of the flood affected areas lie in the Ganga basin, Brahmaputra basin (comprising of Barak, Tista, Torsa, Subansiri, Sankosh, Dihang and Luhit), the northwestern river basin (comprising Jhelum, Chenab, Ravi, Sutlej, Beas and the Ghagra), peninsular river basin (Tapti, Narmada, Mahanadi, Baitarani, Godavari, krishna, Pennar and the Kaveri) and the coastal regions of Andhra Pradesh, Tamilnadu, orissa and Kerela. Assam, Uttar Pradesh, Bihar and Orissa are some of the states who have been severely prone to floods. Our country receives an annual rainfall of 1200 mm, 85% of which is concentrated in 3-4 months i.e June to September. Due to the intense and periodic rain, most of the rivers of the country are fed with huge quantity of water, much beyond their carrying capacity.



Warning:

Flood forecasting and warning has been highly developed in the past two decades. With the advancement of technology such as satellite and remote-sensing equipments flood waves can be tracked as the water level rises. Except for flash floods there is usually a reasonable warning period. Heavy precipitation will give sufficient warning of the coming river flood. High tides with high winds may indicate flooding in the coastal areas. Evacuation is possible with suitable monitoring and warning. Warning is issued by the Central Water Commission (CWC), Irrigation & Flood Control Department, and Water Resources Department. CWC maintains close liaison with the administrative and state engineering agencies, local civil authorities to communicate advance warning for appropriate mitigation and preparedness measures.

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 y 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.
- 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.

TSUNAMI

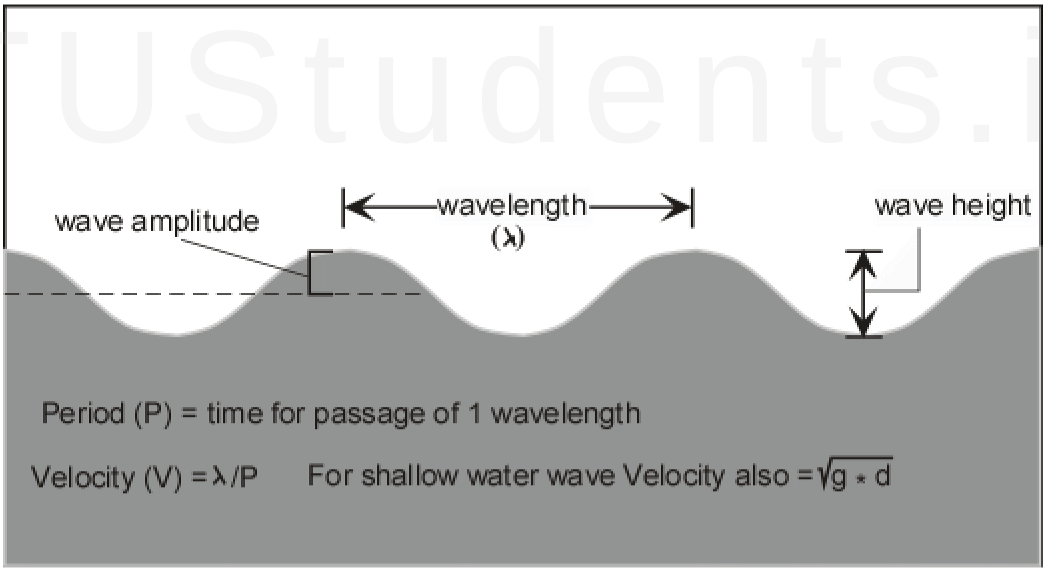
The term Tsunami has been derived from a Japanese term **Tsu** meaning 'harbor' and **nami** meaning 'waves'. Tsunamis are popularly called tidal waves but they actually have nothing to do with the tides. These waves which often affect distant shores, originate by rapid displacement of water from the lake or the sea either by seismic activity, landslides, volcanic eruptions or large meteoroid impacts. Whatever the cause may be sea water is displaced with a violent motion and swells up, ultimately surging over land with great destructive power. The effects of a tsunami can be unnoticeable or even destructive.

What is a Tsunami?

A tsunami is a very long-wavelength wave of water that is generated by sudden displacement of the seafloor or disruption of any body of standing water. Tsunami are sometimes called "seismic sea waves", although they can be generated by mechanisms other than earthquakes. Tsunami have also been called "tidal waves", but this term should not be used because they are not in any way related to the tides of the Earth. Because tsunami occur suddenly, often without warning, they are extremely dangerous to coastal communities.

Physical Characteristics of Tsunami

All types of waves, including tsunami, have a wavelength, a wave height, an amplitude, a frequency or period, and a velocity.



- **Wavelength** is defined as the distance between two identical points on a wave (i.e. between wave crests or wave troughs). Normal ocean waves have wavelengths of about 100 meters. Tsunami have much longer wavelengths, usually measured in kilometers and up to 500 kilometers.
- **Wave height** refers to the distance between the trough of the wave and the crest or peak of the wave.
- **Wave amplitude** - refers to the height of the wave above the still water line, usually this is equal to 1/2 the wave height. Tsunami can have variable wave height and amplitude that depends on water depth as we shall see in a moment
- **Wave frequency or period** - is the amount of time it takes for one full wavelength to pass a stationary point.

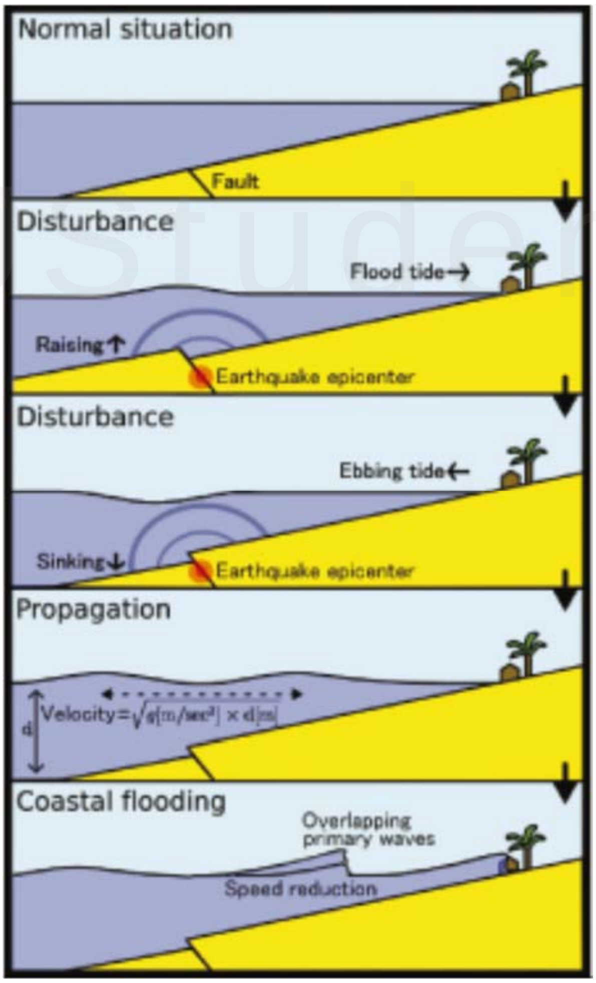
- **Wave velocity** is the speed of the wave. Velocities of normal ocean waves are about 90 km/hr while tsunami have velocities up to 950 km/hr (about as fast as jet airplanes), and thus move much more rapidly across ocean basins. The velocity of any wave is equal to the wavelength divided by the wave period.

$$\mathbf{V = \lambda/P}$$

Tsunami are characterized as shallow-water waves. These are different from the waves most of us have observed on the beach, which are caused by the wind blowing across the ocean's surface. Wind-generated waves usually have period (time between two successive waves) of five to twenty seconds and a wavelength of 100 to 200 meters. A tsunami can have a period in the range of ten minutes to two hours and wavelengths greater than 500 km.

<u>How Tsunami are Generated</u>

The geological movements that cause tsunamis are produced in three major ways. The most common of these are fault movements on the sea floor, accompanied by an earth-quake. They release huge amount of energy and have the capacity to cross oceans. The degree of movement depends on how fast the earthquake occurs and how much water is displaced. Fig blow shows how an earthquake causes tsunami.



The second most common cause of the tsunami is a landslide either occurring under water or originating above the sea and then plunging into the water. The largest tsunami ever produced by a landslide was in Lituya Bay, Alaska 1958. The massive rock slide produced a wave that reached a high water mark of 50 - 150 meters above the shoreline

There is an average of two destructive tsunami per year in the Pacific basin. Pacific wide tsunami is a rare phenomenon, occurring every 10 - 12 years on the average. Most of these tsunamis are generated by earthquakes that cause displacement of the seafloor, but, as we shall see, tsunami can be generated by volcanic eruptions, landslides, underwater explosions, and meteorite impacts.

- ***Earthquakes***
  Earthquakes cause tsunami by causing a disturbance of the seafloor. Thus, earthquakes that occur along coastlines or anywhere beneath the oceans can generate tsunami. The size of the tsunami is usually related to the size of the earthquake, with larger tsunami generated by larger earthquakes. But the sense of displacement is also important. Tsunami are generally only formed when an earthquake causes vertical displacement of the seafloor
- ***Volcanic Eruptions***
  Volcanoes that occur along coastal zones, like in Japan and island arcs throughout the world, can cause several effects that might generate a tsunami. Explosive eruptions can rapidly emplace pyroclastic flows into the water, landslides and debris avalanches produced by eruptions can rapidly move into water, and collapse of volcanoes to form calderas can suddenly displace the water.
- ***Landslides***
  Landslides moving into oceans, bays, or lakes can also generate tsunami. Most such landslides are generated by earthquakes or volcanic eruptions.
- ***Underwater Explosions***
  Nuclear testing by the United States in the Marshall Islands in the 1940s and 1950s generated tsunami.
- ***Meteorite Impacts***
  While no historic examples of meteorite impacts are known to have produced a tsunami, the apparent impact of a meteorite at the end of the Cretaceous Period, about 65 million years ago near the tip of what is now the Yucatan Peninsula of Mexico, produced tsunami that left deposits all along the Gulf coast of Mexico and the United States.

General Characteristics

Tsunami differs from ordinary ocean waves, which are produced by wind blowing over water. The tsunamis travel much faster than ordinary waves. Compared to normal wave speed of 100 kilometers per hour, tsunami in the deep water of the ocean may travel the speed of a jet airplane - 800 kilometers per hour! And yet, in spite of their speed, tsunami increases the water height only 30-45cm and often passes unnoticed by ships at sea.

Contrary to the popular belief, the tsunami is not a single giant wave. It is possible for a tsunami to consist of ten or more waves which is then termed as 'tsunami wave train'. The waves follow each other 5 to 90 minutes apart. Tsunami normally causes flooding as a huge wall of water enters the main land.

Predictability:

There are two distinct types of tsunami warning:

a) International tsunami warning systems and
b) Regional warning systems.

Tsunamis have occurred in all the oceans and in the Mediterranean Sea, but the great majority of them have occurred in the Pacific Ocean. Since scientists cannot exactly predict earthquakes, they also cannot exactly predict when a tsunami will be generated.

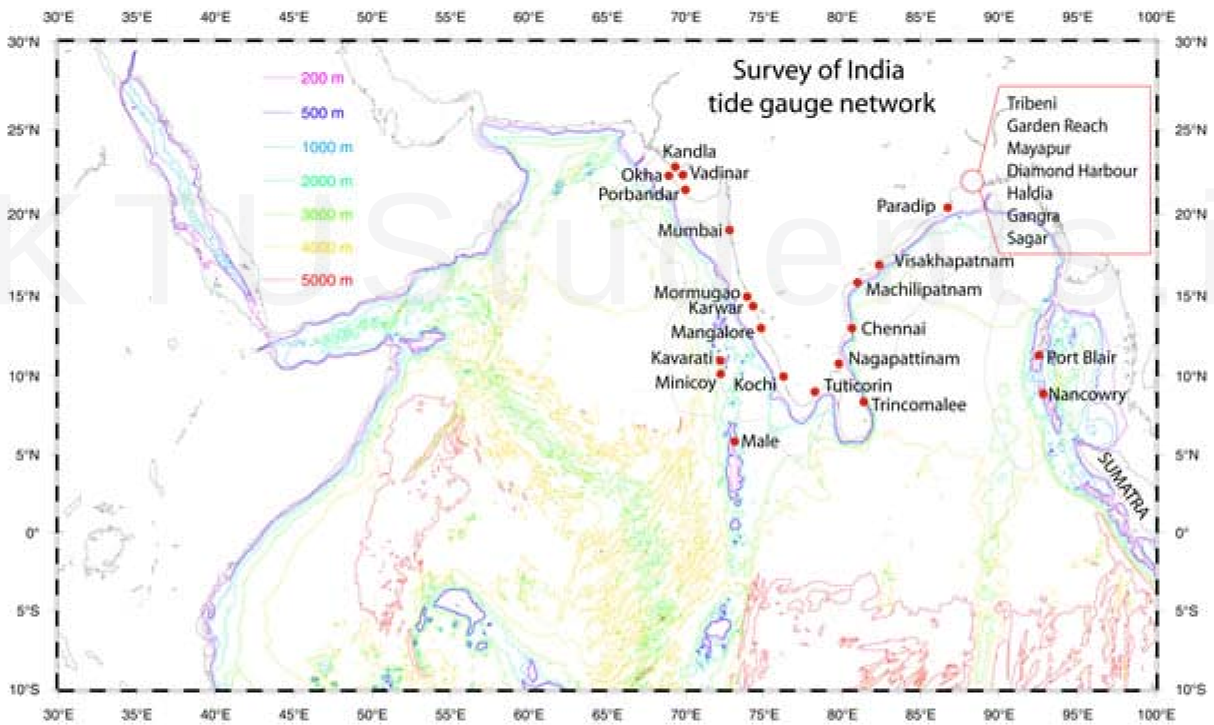
a) International Tsunami Warning Systems:

Shortly after the Hilo Tsunami (1946), the Pacific Tsunami Warning System (PTWS) was developed with its operational center at the Pacific Tsunami Warning Center (PTWC) near Honolulu, Hawaii. The PTWC is able to alert countries several hours before the tsunami strikes. The warning includes predicted arrival time at selected coastal communities where the tsunami could travel in few hours. A tsunami watch is issued with subsequent arrival time to other geographic areas.

b) Regional Warning Systems

It use seismic data about nearby earthquakes to determine if there is a possible local threat of a tsunami. Such systems are capable enough to provide warnings to the general public in less than 15 minutes.

In India, the Survey of India maintains a tide gauge network along the coast of India. The gauges are located in major ports as shown in the figure. The day-to-day maintenance of the gauge is carried with the assistance from authorities of the ports.



Apart from the tide gauge, tsunami can be detected with the help of radars. The 2004 Indian Ocean tsunami, recorded data from four radars and recorded the height of tsunami waves two hours after the earthquake. It should be noted that the satellites observations of the Indian Ocean tsunami would not have been of any use in delivering warnings, as the data took five hours to process and it was pure chance that the satellites were overhead at that time. However, in future it is possible that the space-based observation might play a direct role in tsunami warning.

Mitigation of Risks and Hazards

The main damage from tsunami comes from the destructive nature of the waves themselves. Secondary effects include the debris acting as projectiles which then run into other objects, erosion that can undermine the foundations of structures built along coastlines, and fires that result from disruption of gas and electrical lines. Tertiary effects include loss of crops and water and electrical systems which can lead to famine and disease.

Typical adverse effects:

Local tsunami events or those less than 30 minutes from the source cause the majority of damage. The force of the water can raze everything in its path. It is normally the flooding affect of the tsunami that causes major destruction to the human settlements, roads and infrastructure thereby disrupting the normal functioning of the society.

Withdrawal of the tsunami causes major damage. As the waves withdraw towards the ocean they sweep out the foundations of the buildings, the beaches get destroyed and the houses carried out to sea. Damage to ports and airports may prevent importation of needed food and medical supplies. Apart from the physical damage, there is a huge impact on the public health system. Deaths mainly occur because of drowning as water inundates homes. Many people get washed away or crushed by the giant waves and some are crushed by the debris, causes.

There are very few evidences which show that tsunami flooding has caused large scale health problem. Availability of drinking water has always been a major problem in areas affected by a disaster. Sewage pipes may be damaged causing major sewage disposal problems. Open wells and other ground water may be contaminated by salt water and debris and sewage. Flooding in the locality may lead to crop loss, loss of livelihood like boats and nets, environmental degradation etc.

Possible risk reduction measures:

While it is of course not possible to prevent a tsunami, in certain tsunami prone countries some measures have been taken to reduce the damage caused on shore. Japan has implemented an extensive programme of building tsunami walls of up to 4.5m (13.5 ft) high in front of populated coastal areas. Other localities have built flood gates and channels to redirect the water from incoming tsunamis. However, their effectiveness has been questioned, as tsunamis are often higher than the barriers.

For instance, the tsunami which hit the island of Hokkaido on July 12, 1993 created waves as much as 30m (100 ft) tall - as high as a 10-story building. The port town of Aonae on Hokkaido was completely surrounded by a tsunami wall, but the waves washed right over the wall and destroyed all the wood-framed structures in the area. The wall may have succeeded in slowing down and moderating the height of the tsunami but it did not prevent major destruction and loss of life.

Some other systematic measures to protect coastlines against tsunamis include:

- *Site Planning and Land Management-*
  Within the broader framework of a comprehensive plan, site planning determines the location, configuration, and density of development on particular sites and is, therefore, an important tool in reducing tsunami risk.
  - The designation and zoning of tsunami hazard areas for such open-space uses as agriculture, parks and recreation, or natural hazard areas is recommended as the first land use planning strategy. This strategy is designed to keep development at a minimum in hazard areas.
  - In areas where it is not feasible to restrict land to open-space uses, other land use planning measures can be used. These include strategically controlling the type of development and uses allowed in hazard areas, and avoiding high-value and high occupancy uses to the greatest degree possible.

- *Engineering structures*
  Most of the habitation of the fishing community is seen in the coastal areas. The houses constructed by them are mainly of lightweight materials without any engineering inputs. Therefore there is an urgent need to educate the community about the good construction practices that they should adopt such as:
  - Site selection – Avoid building or living in buildings within several hundred feet of the coastline as these areas are more likely to experience damage from tsunamis.
  - Construct the structure on a higher ground level with respect to mean sea level.
  - Elevate coastal homes: Most tsunami waves are less than 3 meters in height. Elevating house will help reduce damage to property from most tsunamis.
  - Construction of water breakers to reduce the velocity of waves.
  - Use of water and corrosion resistant materials for construction.
  - Construction of community halls at higher locations, which can act as shelters at the time of a disaster.

- *Flood management*
  Flooding will result from a tsunami. Tsunami waves will flood the coastal areas. Flood mitigation measures could be incorporated.

Plan for a Tsunami

Develop a Family Disaster Plan. Tsunami-specific planning should include the following:

- **Learn about tsunami risk in your community**. Contact your local emergency management office or Red Cross chapter. Find out if your home, school, workplace or other frequently visited locations are in tsunami hazard areas. Know the height of your street above sea level and the distance of your street from the coast or other high-risk waters. Evacuation orders may be based on these numbers.
- **If you are visiting an area at risk from tsunamis, check with the hotel, motel, or campground operators for tsunami evacuation information and how you would be warned.** It is important to know designated escape routes before a warning is issued.

If you are at risk from tsunamis, do the following:

- **Plan an evacuation route from your home, school, workplace, or any other place you'll be where tsunamis present a risk**. If possible, pick an area 100 feet above sea level or go up to two miles inland, away from the coastline. If you can't get this high or far, go as high as you can. Every foot inland or upwards may make a difference. You should be able to reach your safe location on foot within 15 minutes. After a disaster, roads may become impassable or blocked. Be prepared to evacuate by foot if necessary. Footpaths normally lead uphill and inland, while many roads parallel coastlines. Follow posted tsunami evacuation routes; these will lead to safety. Local emergency management officials can help advice you as to the best route to safety and likely shelter locations.
- **Practice your evacuation route.** Familiarity may save your life. Be able to follow your escape route at night and during inclement weather. Practicing your plan makes the appropriate response more of a reaction, requiring less thinking during an actual emergency.
- **Use a radio to keep informed of local watches and warnings.**
- **Talk to your insurance agent.** Homeowners' policies do not cover flooding from a tsunami. Ask about flood insurance.
- **Discuss tsunami with your family.** Everyone should know what to do in case all family members are not together. Discussing tsunamis ahead of time will help reduce fear and anxiety and let everyone know how to respond. Review flood safety and preparedness measures with your family.

Assemble ***"Disaster Supplies Kit".*** Tsunami-specific supplies should include the following:

- Evacuation Supplies Kit in an easy-to-carry container (backpack) near your door
- Disaster Supplies Kit

How to Protect Your Property

- **Avoid building or living in buildings within several hundred feet of the coastline.** These areas are more likely to experience damage from tsunamis, strong winds, or coastal storms.
- **Make a list of items to bring inside in the event of a tsunami.** A list will help you remember anything that can be swept away by tsunami waters.
- **Elevate coastal homes.** Most tsunami waves are less than 10 feet. Elevating your house will help reduce damage to your property from most tsunamis.
- **Follow flood preparedness precautions.** Tsunamis are large amounts of water that crash onto the coastline, creating floods.
- **Have an engineer check your home and advise about ways to make it more resistant to tsunami water.** There may be ways to divert waves away from your property. Improperly built walls could make your situation worse. Consult with a professional for advice.

Media and Community Education Ideas

- If your community is at risk, build and publicize locations of tsunami evacuation routes. Post signs directing people to higher ground away from the coast.
- Review land use in tsunami hazard areas so no critical facilities, such as hospitals and police stations; or high occupancy buildings, such as auditoriums or schools; or petroleum-storage tank farms are located where there is a tsunami hazard. Tsunami damage can be minimized through land use planning, preparation, and evacuation.
- Publish a special section in your local newspaper with emergency information on tsunamis. Localize the information by printing the phone numbers of local emergency services offices, the American Red Cross chapter, and hospitals.
- Periodically inform your community of local public warning systems.
- Work with local emergency services and Red Cross officials to prepare special reports for people with mobility impairments on what to do if an evacuation is ordered, and develop plans to assist them with evacuation if necessary.
- Interview local officials and insurance companies about the proper types of insurance to cover a flood-related loss. Include information on the economic effects of disaster.

What to Do When a Tsunami WARNING Is Issued

- Listen to a radio, Coast Guard emergency frequency station, or other reliable source for updated emergency information. Authorities will issue a warning only if they believe there is a real threat from tsunami.
- Follow instructions issued by local authorities. Recommended evacuation routes may be different from the one you use, or you may be advised to climb higher.
- If you are in a tsunami risk area, do the following:
  - If you hear an official tsunami warning or detect signs of a tsunami, evacuate at once. A tsunami warning is issued when authorities are certain that a tsunami threat exists, and there may be little time to get out.
  - Take your Disaster Supplies Kit. Having supplies will make you more comfortable during the evacuation.

- Get to higher ground as far inland as possible. Officials cannot reliably predict either the height or local effects of tsunamis. Watching a tsunami from the beach or cliffs could put you in grave danger. If you can see the wave, you are too close to escape it.

Return home only after local officials tell you it is safe. A tsunami is a series of waves that may continue for hours. Do not assume that after one wave the danger is over. The next wave may be larger than the first one.

What to Do After a Tsunami

- **Continue listening to the radio, Coast Guard emergency frequency station, or other reliable source for emergency information.** The tsunami may have damaged roads, bridges, or other places that may be unsafe.
- **Help injured or trapped persons. Give first aid where appropriate.** Call for help. Do not move seriously injured persons unless they are in immediate danger of further injury.
- **Help a neighbor who may require special assistance--infants, elderly people, and people with disabilities.** Elderly people and people with disabilities may require additional assistance. People who care for them or who have large families may need additional assistance in emergency situations.
- **Use the telephone only for emergency calls.** Telephone lines are frequently overwhelmed in disaster situations. They need to be clear for emergency calls to get through.
- **Stay out of the building if waters remain around it.** Tsunami waters, like flood waters, can undermine foundations, causing buildings to sink, floors to crack, or walls to collapse.
- **When re-entering buildings or homes, use extreme caution.** Tsunami-driven flood waters may have damaged buildings where you least expect it. Carefully watch every step you take.
  - **Wear sturdy shoes**. The most common injury following a disaster is cut feet.
  - **Use battery-powered lanterns or flashlights when examining buildings.** Battery-powered lighting is the safest and easiest, preventing fire hazard for the user, occupants, and building.
  - **Examine walls, floors, doors, staircases, and windows to make sure that the building is not in danger of collapsing.**
  - **Inspect foundations for cracks or other damage.** Cracks and damage to a foundation can render a building uninhabitable.
  - **Look for fire hazards.** There may be broken or leaking gas lines, flooded electrical circuits, or submerged furnaces or electrical appliances. Flammable or explosive materials may come from upstream. Fire is the most frequent hazard following floods.
  - **Check for gas leaks.** If you smell gas or hear a blowing or hissing noise, open a window and quickly leave the building. Turn off the gas using the outside main valve if you can, and call the gas company from a neighbor's home. If you turn off the gas for any reason, it must be turned back on by a professional.
  - **Look for electrical system damage.** If you see sparks or broken or frayed wires, or if you smell burning insulation, turn off the electricity at the main fuse box or circuit breaker. If you have to step in water to get to the fuse box or circuit breaker, call an electrician first for advice. Electrical equipment should be checked and dried before being returned to service.
  - **Check for sewage and water line damage.** If you suspect sewage lines are damaged, avoid using the toilets and call a plumber. If water pipes are damaged, contact the water company and avoid using water from the tap. You can obtain safe water from undamaged water heaters or by melting ice cubes.
  - **Use tap water if local health officials advise it is safe.**

- **Watch out for animals, especially poisonous snakes that may have come into buildings with the water**. Use a stick to poke through debris. Tsunami flood waters flush snakes and animals out of their homes.
- **Watch for loose plaster, drywall and ceilings that could fall.**
- **Take pictures of the damage, both building and its contents, for insurance claims.**

- **Open the windows and doors to help dry the building**.
- **Shovel mud while it is still moist to give walls and floors an opportunity to dry**.
- **Check food supplies.** Any food that has come in contact with flood waters may be contaminated and should be thrown out.

CYCLONE

What is a Cyclone?

Cyclone is a region of low atmospheric pressure surrounded by high atmospheric pressure resulting in swirling atmospheric disturbance accompanied by powerful winds blowing in anticlockwise direction in the Northern Hemisphere and in the clockwise direction in the Southern Hemisphere. They occur mainly in the tropical and temperate regions of the world.

Cyclones are known by different names in different parts of the world:

- **Typhoons** in the Northwest Pacific Ocean west of the dateline
- **Hurricanes** in the North Atlantic Ocean, the Northeast Pacific Ocean east of the dateline, or the South Pacific Ocean.
- **Tropical cyclones** - the Southwest Pacific Ocean and Southeast Indian Ocean.
- **Severe cyclonic storm** (the North Indian Ocean)
- **Tropical cyclone** (the Southwest Indian Ocean)
- **Willie-Willie** in Australia
- **Tornado** in South America

Types of Cyclones

The term 'cyclone' actually refers to several different types of storms. They occur in different places, and some occur over land while others occur over water. What they all have in common is that they are spinning storms rotating around that low -pressure center.

***Tropical cyclones**:* are what most people are familiar with because these are cyclones that occur over tropical ocean regions. Hurricanes and typhoons are actually types of tropical cyclones, but they have different names so that it's clear where that storm is occurring. Hurricanes are found in the Atlantic and Northeast Pacific, typhoons are found in the Northwest Pacific. If you hear 'tropical cyclone,' you should assume that it's occurring in the South Pacific or Indian Ocean, but for this lesson, we'll use it refer to all types of tropical ocean cyclones.

We can also further describe tropical cyclones based on their wind speeds. They are called category 1, 2, 3, 4 or 5, increasing with intensity and wind speed as the number increases. A category 1 cyclone is the weakest, with wind speeds of 74-95 mph. A category 5 cyclone, on the other hand, is extremely dangerous and has the potential for major damage. Category 5 cyclones have wind speeds of 155 mph and above!

Polar cyclones: are cyclones that occur in Polar Regions like Greenland, Siberia and Antarctica. Unlike tropical cyclones, polar cyclones are usually stronger in winter months. As you can see, these storms really do prefer the colder weather! They also occur in areas that aren't very populated, so any damage they do is usually pretty minimal.

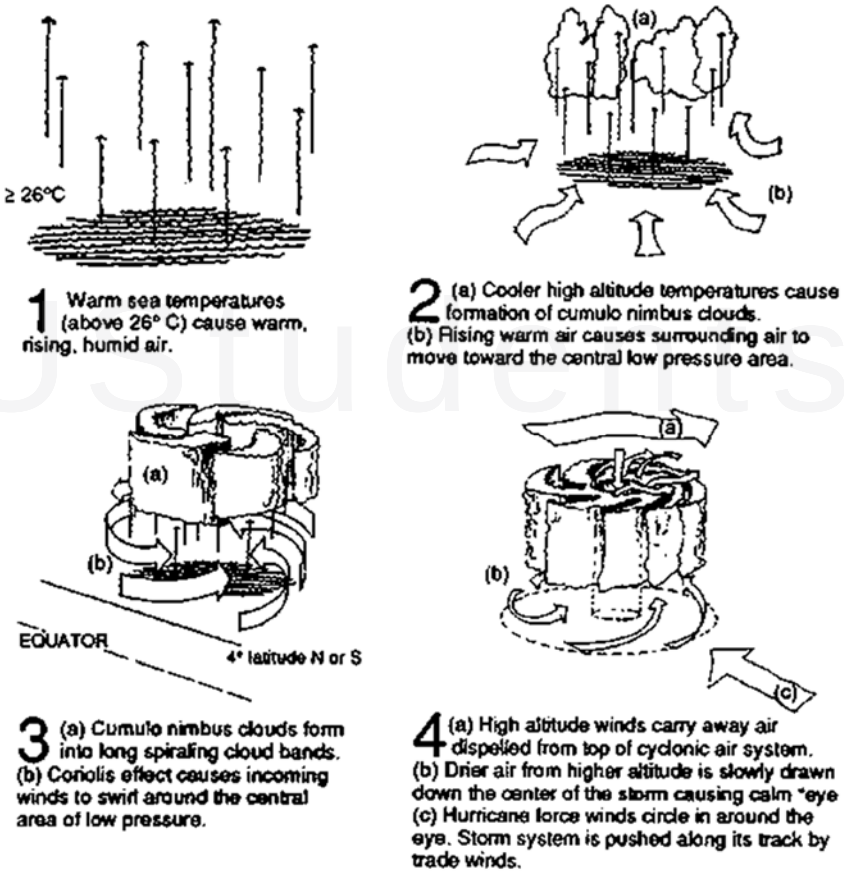
Mesocyclone: is when part of a thunderstorm cloud starts to spin, which may eventually lead to a tornado. 'Meso' means 'middle', so you can think of this as the mid -point between one type of storm and the other. Tornadoes all come from thunderstorm clouds, but not all thunderstorm clouds make tornadoes. In order for a tornado to occur, part of that cloud has to spin, and though you can't really see this happening, this is the intermediate, or 'meso' step from regular cloud to dangerous spinning cloud running along the ground.

General Characteristics:

Cyclones in India are moderate in nature. Some of the general characteristics of a cyclone are:

1. Strong winds
2. Exceptional rain
3. Storm surge

Cyclones are generally accompanied by strong winds which cause a lot of destruction. In some cases it is accompanied by heavy downpour and also the rise in the sea which intrudes inland there by causing floods.



The development of a cyclone covers three stages namely

a) *Formation and initial development state:*

Four atmospheric/ oceanic conditions are necessary for the formation of a cyclone namely:

- A warm sea temperature in excess of 26 degree centigrade, to a depth of 60 meters, which provides abundant water vapour in the air by evaporation.
- High relative humidity (degree to which the air is saturated by to a height of about 7000 meters, facilitates condensation of water vapor into droplets and clouds, releases heat energy and induces drop in pressure.
- Atmospheric instability (an above average decrease of temperature with altitude) encourages considerable vertical cumulus cloud convection when condensation of rising air occurs.

- A location of at least 4-5 latitude degrees from the Equator allow the influence of the force due to the earth's rotation (Coriolis force) to take effect in inducing cyclonic wind circulation around low pressure centers.

b) <u>Fully matured:</u>

The main feature of a fully mature tropical cyclone is a spiral pattern of highly turbulent giant cumulus thundercloud bands. These bands spiral inwards and form a dense highly active central cloud core which raps around a relatively calm zone. This is called the "eye" of a cyclone. The eye looks like a black hole or a dot surrounded by thick clouds. The outer circumference of the thick cloud is called the 'eye wall'.

c) <u>Weakening or decay</u>

A tropical cyclone begins to weaken as soon as its source of warm moist air is abruptly cut off. This is possible when the cyclone hits the land, on the cyclone moves to a higher altitude or when there is the interference of another low pressure.

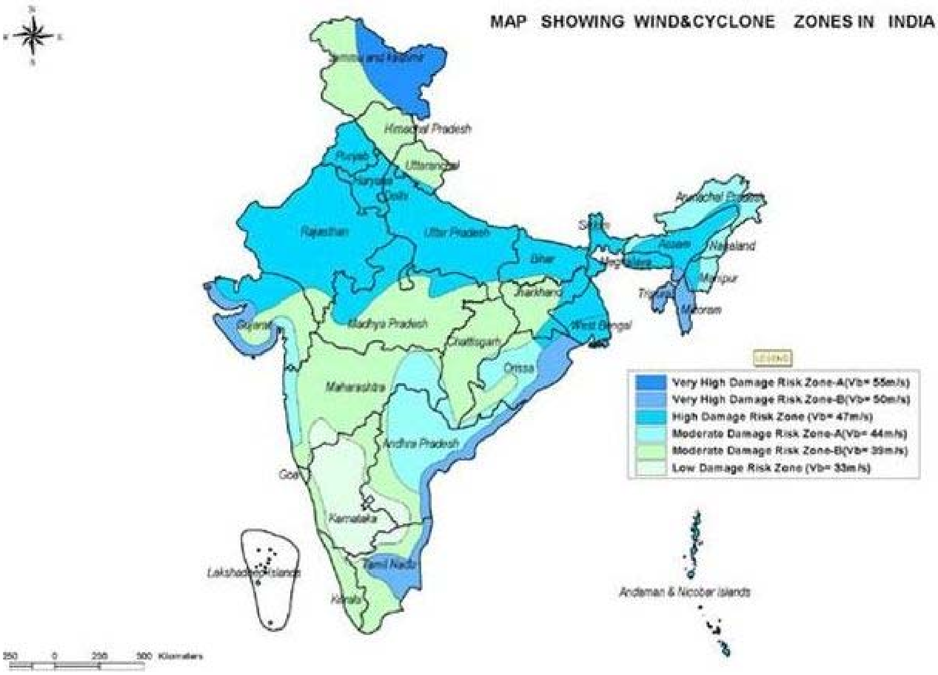
Depending on their track on the warm tropical sea and proximity to land a cyclone may last for less than 24 hours to more than 3 weeks. On an average the life cycle of a cyclone (a cyclone to complete these three stages mentioned above) takes six days. The longest cyclone is typhoon John which lasted for 31 days (August to September, 1994 in the north east and north west pacific basins).

<u>Indian Cyclones</u>

Cyclones vary in frequency in various parts of the world. The 7516.6 kilometers long Indian coastline is the earth's most cyclone battered stretch of the world. Around 8 per cent of the total land area in India is prone to cyclones. About two-third of the cyclones that occur in the Indian coastline occur in the Bay of Bengal. The states which are generally affected in the east coast are West-Bengal, Orissa, Andhra Pradesh; Tamil Nadu and on the west coast Gujarat, Maharashtra, Goa, Karnataka and Kerala.

Distributional Pattern:

The map of India shows the areas that are generally affected by strong winds/ cyclones.



Some of the major cyclones that have affected the country in the past are as mentioned in table below. Some of the major cyclones that have affected the country in the past are as mentioned damage. The satellites track the movement of these cyclones based on which the people are evacuated from areas lively to be affected. It is difficult to predict the accuracy. Accurate landfall predictions can give only a few hours' notice to threatened population.

Sl No	Year	Area	Death toll
1	1971	Eastern Coast	9658
2	1972	Andhra Pradesh and Orissa	100
3	1977	Chennai, Kerala & Andhra Pradesh	14,204
4	1979	Andhra Pradesh	594
5	1981	Gujarat	470
6	1982	Gujarat & Maharashtra	500
7	1984	Tamil Nadu & Andhra Pradesh	512
8	1985	Andhra Pradesh	5000
9	1990	Andhra Pradesh	957
10	1990	Orissa	250
11	1999	Orissa	8913

Warning

Low pressure and the development can be detected hours or days before it causes damage. The satellites track the movement of these cyclones based on which the people are evacuated from areas lively to be affected. It is difficult to predict the accuracy. Accurate landfall predictions can give only a few hours' notice to threatened population.

India has one of the best cyclone warning systems in the world. The India Meteorological Department (IMD) is the nodal department for wind detection, tracking and forecasting cyclones. Cyclone tracking is done through INSAT satellite. Cyclone warning is disseminated by several means such as satellite based disaster warning systems, radio, television, telephone, fax, high priority telegram, public announcements and bulletins in press. These warnings are disseminated to the general public, the fishing community especially those in the sea, port authorities, commercial aviation and the government machinery.

Elements at Risk: Strong winds, torrential rains and flooding cause a huge loss to life and property. The 1999 Super Cyclone of Orissa killed more than 10,000 precious lives with women and children greatly affected. Apart from loss to life there is a huge loss to infrastructures like houses built of mud, older buildings with weak walls, bridges, settlements in low lying areas.

Effects of Cyclones and Hurricanes:

- Tropical cyclones cause heavy rainfall and landslides.
- They cause a lot of harm to towns and villages, causing severe damage to kuccha houses. Coastal businesses like shipyards and oil wells are destroyed.
- They harm the ecosystem of the surrounding region. iv. Civic facilities are disturbed.
- Agricultural land is severely affected, especially in terms of water supply and soil erosion.
- It causes harm to human, plant and animal life.
- Communication systems are badly affected due to cyclones.

Typical Adverse effect:

First, in a sudden, brief onslaught, high winds cause major damage to infrastructure and housing, in particular fragile constructions. They are generally followed by heavy rains and floods and, in flat coastal areas by storm surge riding on tidal waves and inundating the land over long distances of even upto 15 kilometer inland damaged or destroyed by the wind force, flooding and storm surge. Light pitched roofs of most structures especially the ones fitted on to industrial buildings will suffer severe damage.

Casualties and public heath – caused by flooding and flying elements, contamination of water supplies may lead to viral outbreaks, diarrhea, and malaria.

Water supplies – Ground and pipe water supply may get contaminated by flood waters.

Crops and food supplies – high winds and rains ruin the standing crop and food stock lying in low lying areas. Plantation type crops such as banana and coconut are extremely vulnerable. Salt from the sea water may get deposited on the agricultural land and increase the salinity. The loss of the crop may lead to acute food shortage.

Communication – severe disruption in the communication links as the wind may bring down the electricity and communication towers, telephone poles, telephone lines, antennas and satellite disk and broadcasting services. Transport lines (road and rail) may be curtailed, Lack of proper communication affects effective distribution of relief materials.

Management and Mitigation of Cyclones and Hurricanes:

- Coastal areas should be well prepared to meet eventualities that arise from cyclones.
- Houses should be constructed such that they can withstand the heavy rainfall and forceful winds.
- Shelter beds should be created to check soil erosion and speed of winds.
- Remote sensing techniques should be used to forecast cyclones appropriately. v. When a cyclone does occur, rescue and relief operations should be in place.
- Possible Risk Reduction Measures:

Coastal belt plantation - green belt plantation along the coastal line in a scientific interweaving pattern can reduce the effect of the hazard. Providing a cover through green belt sustains less damage. Forests act as a wide buffer zone against strong winds and flash floods. Without the forest the cyclone travel freely inland. The lack of protective forest cover allows water to inundate large areas and cause destruction. With the loss of the forest cover each consecutive cyclone can penetrate further inland.

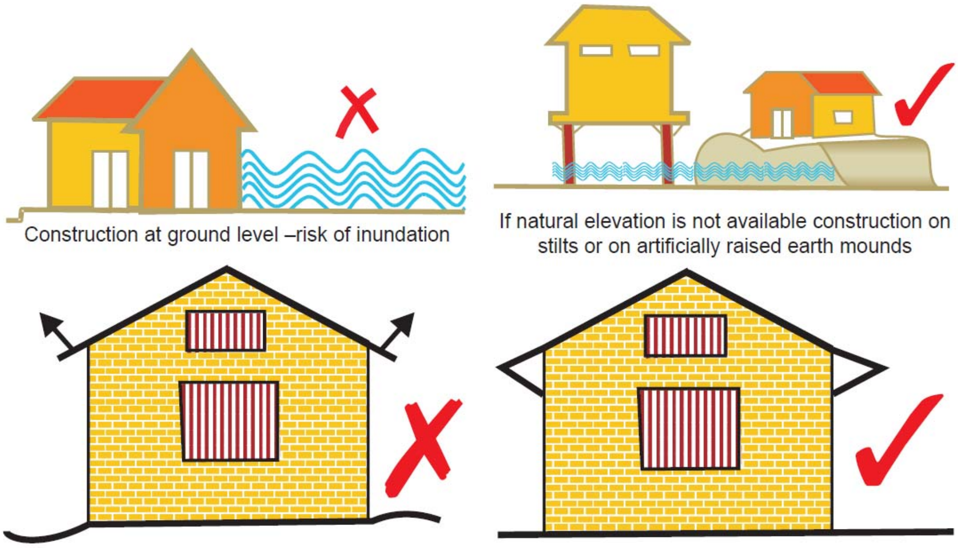
Hazard mapping – Meteorological records of the wind speed and the directions give the probability of the winds in the region. Cyclones can be predicted several days in advance. The onset is extensive and often very destructive. Past records and paths can give the pattern of occurrence for particular wind speeds. A hazard map will illustrate the areas vulnerable to cyclone in any given year. It will be useful to estimate the severity of the cyclone and various damage intensities in the region. The map is prepared with data inputs of past climatological records, history of wind speed, frequency of flooding etc.

Land use control designed so that least critical activities are placed in vulnerable areas. Location of settlements in the flood plains is at utmost risk. Siting of key facilities must be marked in the land use. Policies should be in place to regulate land use and building codes should be enforced.

Engineered structures – structures need to be built to withstand wind forces. Good site selection is also important. Majority of the buildings in coastal areas are built with locally available materials and have no engineering inputs. Good construction practice should be adopted such as:

- Cyclonic wind storms inundate the coastal areas. It is advised to construct on stilts or on earth mound.
- Houses can be strengthened to resist wind and flood damage. All elements holding the structures need to be properly anchored to resist the uplift or flying off of the objects. For example, avoid large overhangs of roofs, and the projections should be tied down.
- A row of planted trees will act as a shield. It reduces the energy.

- Buildings should be wind and water resistant.
- Buildings storing food supplies must be protected against the winds and water.
- Protect river embankments.
- Communication lines should be installed underground.
- Provide strong halls for community shelter in vulnerable locations.



Construction at ground level –risk of inundation

If natural elevation is not available construction on stilts or on artificially raised earth mounds

Large overhangs get lifted and broken.

For large overhangs, use ties.

Flood management – Torrential rains strong wind and storm range leads to flooding in the cyclone affected areas. There are possibilities of landslides too. Flood mitigation measures could be incorporated (see section on floods for additional information).

Improving vegetation cover – The roots of the plants and trees keep the soil intact and prevent erosion and slow runoff to prevent or lessen flooding. The use of tree planted in rows will act as a windbreak. Coastal shelterbelt plantations can be developed to break severe wind speeds. It minimizes devastating effects. The Orissa calamity has also highlighted the need for urgent measures like shelterbelt plantation along cyclone-prone coastal areas. Species chosen for this purpose should not only be able to withstand the impact of strong cyclonic winds, but also check soil erosion.

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