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Unit-III Natural Disaster

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Hydro-Meteorological Disasters

Hydrometeorological hazards are processes or phenomena of atmospheric, hydrological or oceanographic nature may cause loss of life, injury or other health impacts, property damages, loss of livelihoods and services, social and economic disruptions, environmental damages. Hydrometeorological conditions also can be a factor in other hazards such as landslides, wild fires, locust plagues, epidemics, and volcanic eruptions.

The following are the most common Hydrometeorological hazards as defined by

- Flood
- Flash Flood
- Cloud Burst
- Drought
- Cyclone
- Forest Fire

Flood

Floods are among the most frequent and costly natural disasters. Conditions that cause floods include heavy or steady rain for several hours or days that saturate the ground. Flash floods occur suddenly due to rapidly rising water along a stream or low-lying area.

A flood is an excess of water (or mud) on land that's normally dry and is a situation where in the inundation is caused by high flow, or overflow of water in an established watercourse, such as a river, stream, or drainage ditch; or ponding of water at or near the point where the rain fell. This is a duration type event. A flood can strike anywhere without warning, occurs when a large volume of rain falls within a short time.

Types of Floods

Flash Floods: Floods occurring within six hours, mainly due to heavy rainfall associated with towering cumulus clouds, thunderstorms, and tropical cyclones or during passage of cold weather fronts, or by dam failure or other river obstruction. This type of flood requires a rapid localized warning system.

River Floods: Floods caused by precipitation over a large catchment's area, melting of snow or both. Built up slowly or on a regular basis, these floods may continue for days or weeks. The major factors of these floods are moisture, vegetation cover, depth of snow, size of the catchment's basin, etc.

Coastal Floods: - Floods associated with cyclonic activities like Hurricanes, Tropical cyclones, etc. generating a catastrophic flood from rainwater which often aggravates wind-induced storm and water surges along the coast.

Urban Flood: As land is converted from agricultural fields or woodlands to roads and parking lots, it loses its ability to absorb rainfall. Urbanization decreases the ability to absorb water 2 to 6 times over what would occur on natural terrain. During periods of urban flooding, streets can become swift moving rivers, while basements can become death traps as they fill with water.

Ice Jam: Floating ice can accumulate at a natural or human-made obstruction and stop the flow of water thereby causing floods. Flooding too can occur when there the snow melts at a very faster rate.

Glacial Lake Outbursts Flood (GLOF): Many of the big glaciers which have melted rapidly and gave birth to the origin of a large number of glacier lakes. Due to the faster rate of ice and snow melting, possibly caused by the global warming, the accumulation of water in these lakes has been increasing rapidly and resulting sudden discharge of large volumes of water and debris and causing flooding in the downstream.

Characteristics of flood Depth of water

Building foundations and vegetation will have different degrees of tolerance to bring inundated water.
Duration – Damage to structures, infrastructure vegetation related to duration l of time with water inundation.
Velocity – High velocities of flow create erosive forces, hydrodynamic pressure, which destroy foundation supports and may occur on floodplains or in the main river channel.
Frequency of occurrence – The frequency of occurrence measured over period of time determines types of construction or agricultural activities on the floodplain.
Seasonality – Flooding during a growing season destroy crops while cold weather, floods seriously affect the community.

Causes of Floods

Inadequate capacity of the rivers to contain within their banks the high flows brought down from the upper catchment areas following heavy rainfall, leads to flooding. The tendency to occupy the flood plains has been a serious concern over the years. Because of the varying rainfall distribution, many a time, areas which are not traditionally prone to floods also experience severe inundation. Areas with poor drainage facilities get flooded by accumulation of water from heavy rainfall. Excess irrigation water applied to command areas and an increase in ground water levels due to seepage from canals and irrigated fields also are factors that accentuate the problem of water-logging. The problem is exacerbated by factors such as silting of the riverbeds, reduction in the carrying capacity of river channels, erosion of beds and banks leading to changes in river courses, obstructions to flow due to landslides, synchronization of floods in the main and tributary rivers and retardation due to tidal effects. The primary causes for Floods are:

- Intense rainfall when the river is flowing full.

- Excessive rainfall in river catchments or concentration of runoff from the tributaries and river carrying flows in excess of their capacities.
- Cyclone and very intense rainfall when the EL Nino effect is on a decline.
- Synchronization of flood peaks in the main rivers or their tributaries.
- Landslides leading to obstruction of flow and change in the river course.
- Poor natural drainage system.
- Backing water in tributaries at their confluence with the main river.

Flood prone areas

India is one of the most flood prone countries in the world. The principal reasons for flood lie in the very nature of natural ecological systems in this country, namely, the monsoon, the highly silted river systems and the steep and highly erodible mountains, particularly those of the Himalayan ranges. The average rainfall in India is 1150 mm with significant variation across the country. The annual rainfall along the western coast and Western Ghats, Khasi hills and over most of the Brahmaputra valley amounts to more than 2500 mm. Most of the floods occur during the monsoon period and are usually associated with tropical storms or depressions, active monsoon conditions and break monsoon situations.

Floods occur in almost all rivers basins in India. The main causes of floods are heavy rainfall, inadequate capacity of rivers to carry the high flood discharge, inadequate drainage to carry away the rainwater quickly to streams/rivers. Ice jams or landslides blocking streams; typhoons and cyclones also cause floods. Flash floods occur due to high rate of water flow as also due to poor permeability of the soil. Areas with hardpan just below the surface of the soil are more prone to, floods as water fails to seep down to the deeper layers.

Flood Preparedness and Mitigation Since ages, people have coped and learned to live with floods. They have generally settled in areas away from flood and have adapted agricultural practices which can sustain in flood waters. Traditional methods based on locally available resources have been used to minimize the damages during flood. With the increase in population, flood prone areas have been occupied and this is a principal factor in the huge losses presently seen.

Regulation and Enforcement Unplanned and unregulated developmental activities in the flood plains of the rivers and encroachments into the waterways have led to increase in flood losses as well as flood risk. The colossal loss of lives and property due to the flooding of the towns and cities and the areas which get flooded almost every alternate year is a recent phenomenon and effective steps are required for regulating unplanned growth in the flood plains and preventing encroachment in the waterways.

Capacity Development The capacity development covers the aspects of flood education, target groups for capacity development, capacity development of professionals, training, research and development and documentation with respect to flood management. The proposals for strengthening the existing systems are also given therein. An action plan for capacity development has also been formulated.

Flood Safety Tips Do's and Dont's Before and During

- All your family members should know the safe routes to nearest shelter/raised pucca house.
- If your area is flood-prone, consider suitable flood resistant building materials.
- Tune to your local radio/TV for warnings and advice. Have an emergency kit ready.
- Keep dry food, drinking water and clothes ready. Drink preferably boiled water. Keep your food covered, don't take heavy meals.
- Do not let children and pregnant woman remain an empty stomach.
- Be careful of snakes, as snake bites are common during floods.

After

- Pack warm clothing, essential medication, valuables, personal papers, etc. in waterproof bags, to be taken with your emergency kit.
- Raise furniture, clothing and valuable onto beds, tables and in attic.
- Turn off the main electricity power supply. Do not use electrical appliances, which have been in flood water.
- Do not get into water of unknown depth and current.
- Do not allow children to play in, or near flood water.

Flash Flood

A flash flood is a rapid flooding of geomorphic low-lying areas like washes, rivers, dry lakes and basins.

- Common causes of flash flood:
- heavy rain with a severe thunderstorm
- tropical storm
- melt water from ice
- snow flowing over ice sheets or snowfields
- hurricane

Flash floods may occur after the collapse of a natural ice or debris dam, or a human structure such as man-made dam .Flash Floods are distinguished from regular floods by a timescale of less than six hours.

Preparedness (What to do before):

• Find out the frequency of occurrence of floods in locality, especially those that affect your area.

• Know the flood warning system in your locality. If none exists, recommend to the appropriate authority for the creation of one.

- Research from previous occurrences how fast the water floods occur in your area and how it rises.
- If it has been raining hard for several hours, or steadily raining several days, be alert to the possibility of a flood. Floods happen as the ground becomes saturated.
- Watch out for rapidly rising water and help prepare the family for evacuation.
- Switch off the electricity and lock the rooms after all have gone out.
- Have a handy survival kit. It should contain battery operated transistor radio, flashlight, emergency cooking equipment, candies, matches, and first aid kit.
- Use a radio or a portable, battery-powered radio (or television) for updated information. Local stations provide the best advice for your particular situation.
- Do not attempt to cross flowing streams unless assured that the water is below knee high level.
- Avoid areas prone to flash flooding and be cautious of water-covered roads,

bridges, creeks and stream banks and recently flooded areas.

- Do not go to swimming or boating in swollen rivers.
- Watch out for snakes in flooded areas.
- Eat only well-cooked food and drink only clean or preferably boiled water and throw away all food that has come into contact with flood water.

Rehabilitation (What to do after):

- Report broken utility lines (electricity, water, gas, etc.) immediately to appropriate agencies/authorities.
- Ensure that electrical appliances are checked by a competent electrician before switching them on.
- Avoid affected areas.
- Continue to listen to a radio or local television stations and return home only when authorities indicate it is safe to do so.
- Stay away from any building that is still flooded.

Cloud Burst

Cloudburst is an extreme amount of precipitation, sometimes with hail and thunder, which normally lasts no longer than a few minutes but is capable of creating flood conditions. Colloquially, the term cloudburst may be used to describe any sudden heavy, brief, and usually unforecastable rainfall. Rainfall rate equal to or greater than 100 mm (3.97 inches) per hour is a cloudburst. The associated convective cloud can extend up to a height of 15 km above the ground. During a cloudburst, more than 20 mm of rain may fall in a few minutes.

Cloudbursts have a very specific definition: if rainfall of about 10 cm or above per hour is recorded over a place that is roughly 10 km x 10 km in area, it is classified as a cloudburst event. And by this definition, 5 cm of rainfall in half an hour would also be classified as a cloudburst. That’s an anomaly for Indian conditions.

Impact of Cloudburst

It cause flood, Huge distraction, destroy vegetation and loss to human life.

Where do cloudbursts can occur?

Cloudbursts do happen in plains as well, but there is a greater probability of them occurring in mountainous zones; it has to do with the terrain. Cloudbursts happen when saturated clouds are unable to produce rain because of the upward movement of very warm current of air. Raindrops, instead of dropping down, are carried upwards by the air current. New drops are formed and existing raindrops gain in size. After a point, the raindrops become too heavy for the cloud to hold on to, and they drop down together in a quick flash. It is not essential that cloudbursts occur only when a cloud clashes with a solid body like a mountain. One such cloud burst in the Himalayan region occurred when the monsoon winds were rising along the slope of the Himalayas and were sucked further by the ascending jet streams resulting in a very heavy downpour that caused devastating floods and landslides in June 2013. Cloudbursts can also occur when hot water vapour laden winds mix with the cold winds resulting in sudden condensation. Hilly terrains aid in heated air currents rising vertically upwards in two ways

1. By allowing water laden winds to rise
2. By allowing water laden winds to absorb more moisture from Terai

3. And by allowing the jet stream to easily withdraw the convection aided orographic winds to be attenuated, thereby, increasing the probability of a cloudburst situation. Cloudbursts can happen in deserts due to enhanced convection.

Effect of Cloudbursts

1. Flash floods: Cloudbursts are also responsible for flash floods creation.

2. Accompanying effect of Cloudbursts on terrain

- Sheet floods
- Landslides
- Mudflows
- Land caving
- Flash floods, houses and establishments getting swept away and cave-ins lead to the deaths.
- Blocking path of rivers that may lead to temporary damming and creation of a reservoir and its consequent collapse

Drought

It is difficult to provide a precise and universally accepted definition of drought due to its varying characteristics and impacts across different regions of the world, such as rainfall patterns, human response and resilience, and diverse academic perspectives.

Drought is a temporary aberration unlike aridity, which is a permanent feature of climate. Seasonal aridity (i.e. a well-defined dry season) also needs to be distinguished from drought. Thus drought is a normal, recurrent feature of climate and occurs in all climatic regimes and is usually characterized in terms of its spatial extension, intensity and duration. Conditions of drought appear when the rainfall is deficient in relation to the statistical multi-year average for a region, over an extended period of a season or year, or even more. Drought differs from other natural hazards such as cyclones, floods, earthquakes, volcanic eruptions, and tsunamis in that:

- No universal definition exists;
- Being of slow-onset it is difficult to determine the beginning and end of the event;
- Duration may range from months to years and the core area or epicentre changes over time, reinforcing the need for continuous monitoring of climate and water supply indicators;
- No single indicator or index can identify precisely the onset and severity of the event and its potential impacts; multiple indicators are more effective;
- Spatial extent is usually much greater than that for other natural hazards, making assessment and response actions difficult, since impacts are spread over larger geographical areas;
- Impacts are generally non-structural and difficult to quantify;
- Impacts are cumulative and the effects magnify when events continue from one season or year to the next.

Types of Drought

Meteorological Drought is defined as the deficiency of precipitation from expected or normal levels over an extended period of time. Meteorological drought usually precedes other kinds of drought. According to the legend, meteorological drought is said to occur when the seasonal rainfall received over an area is less than 25% of its long-term average value. It is further classified as moderate drought if the rainfall deficit is 26–50% and *severe drought* when the deficit exceeds 50% of the normal.

Hydrological Drought is best defined as deficiencies in surface and subsurface water supplies leading to a lack of water for normal and specific needs. Such conditions arise, even in times of average (or above average) precipitation when increased usage of water diminishes the reserves.

Agricultural Drought, usually triggered by meteorological and hydrological droughts, occurs when soil moisture and rainfall are inadequate during the crop growing season causing extreme crop stress and wilting. Plant water demand depends on prevailing weather conditions, biological characteristics of the specific plant, its stage of growth and the physical and biological properties of the soil. Agricultural drought thus arises from the variable susceptibility of crops during different stages of crop development, from emergence to maturity.

Impacts of Drought

Drought produces wide-ranging impacts that span many sectors of the national economy. These impacts are felt much beyond the area experiencing physical drought. The complexity of these impacts arises because water is integral to our ability to produce goods and provide services.

Drought produces both direct and indirect impacts. Direct impacts or primary impacts are usually physical / material and include reduced agricultural production; increased fire hazard; depleted water levels; higher livestock and wildlife mortality rates; and damage to wildlife and fish habitats. When direct impacts have multiplier effects through the economy and society, they are referred to as indirect impacts. These include a reduction in agricultural production that may result in reduced income for farmers and agribusiness, increased prices for food and timber, unemployment, reduced purchasing capacity and demand for consumption, default on agricultural loans, rural unrest, and reduction in agricultural employment leading to migration and drought relief programmes. The more removed the impact from the cause, the more complex is the link to the cause. These multiplier effects are often so diffuse that it is very difficult to generate financial estimates of actual losses caused by a drought. The impacts of drought are generally categorized as economic, environmental, and social:

Economic impacts refer to production losses in agriculture and related sectors, especially forestry and fisheries, because these sectors rely on surface and subsurface water supplies. It causes a loss of income and purchasing power, particularly among farmers and rural population dependent on agriculture. All industries dependent upon the primary sector for their raw materials would suffer losses due to reduced supply or increased prices. Drought thus has a multiplier effect throughout the economy, which has a dampening impact on employment, flow of credit and tax collections. If the drought is countrywide, macroeconomic indicators at the national level are adversely impacted.

Environmental impacts, such as lower water levels in reservoirs, lakes and ponds as well as reduced flows from springs and streams would reduce the availability of feed and drinking water and adversely affect fish and wildlife habitat. It may also cause loss of forest cover, migration of wildlife and their greater mortality due to increased contact with agricultural producers as animals seek food from farms and producers are less tolerant of the intrusion. A prolonged drought may also result in increased stress among endangered species and cause loss of biodiversity. Reduced streamflow and loss of wetlands may cause changes in the levels of salinity. Increased groundwater depletion, land subsidence, and reduced recharge may damage aquifers and adversely affect the quality of water (e.g., salt concentration, increased water temperature, acidity, dissolved oxygen, turbidity). The degradation of landscape quality, including increased soil erosion, may lead to a more permanent loss of biological productivity of the landscape.

Social impacts arise from lack of income causing out migration of the population from the drought-affected areas. People in India seek to cope with drought in several ways which affect their sense of well-being: they withdraw their children from schools, postpone daughters‟ marriages, and sell their assets such as land or cattle. In addition to economic hardships, it causes a loss of social status and dignity, which people find hard to accept. Inadequate food intake may lead to malnutrition, and in some extreme cases, cause starvation. Access and use of scarce water resources generate situations of conflict, which could be socially very disruptive. Inequities in the distribution of drought impacts and relief may exacerbate these social tensions further.

Prevention and Preparedness

Prevention and Preparedness means predisaster activities designed to increase the level of readiness and improvement of operational and institutional capabilities for responding to a drought. Drought prevention and preparedness involve water supply augmentation and conservation (e.g. rainwater harvesting techniques), expansion of irrigation facilities, effective dealing with drought, and public awareness and education. Transport and communication links are a must to ensure supply of food and other commodities during and just after a drought. Successful drought management requires community awareness on the mitigation strategies, insurance schemes for farmers, crop contingency plans, etc.

Basic to drought management in the Indian context is the delineation of drought prone areas. At the block level, the following indicators are generally used.

Drought Prone Area Delineation Criteria and data base:

- Rainfall (long term average - 30 to 50 yrs) (Short Term average – 5 to 10 years for giving real picture as a rainfall pattern may change over the period for e.g. Cherapunji);
- Cropping pattern (past 3 to 5 years);
- Available supplement irrigation (well, tank, ponds, ground water etc.);
- Satellite derived indicators (last 10 years);
- Soil map;
- Ground water availability map;
- Cattle population and fodder demand;
- Socio-economic data;
- Other water demands like for drinking, industrial use etc.; and
- Collection and creation of data base and spatial framework for analysis

Gradation of Drought Prone Areas

(High, Moderate, Low): Areas should also be graded on the basis of degree of drought proneness since it would affect the steps required for greater preparedness. This would require multiple criteria approach that includes

- Sensitivity to Rainfall Variation;
- Frequency of Occurrence of Drought;
- Vulnerability of Community (people and livestock) to Drought

Monitoring of Drought Having delineated drought prone areas and their gradation one could move on to the criteria for monitoring relevant indicators. The monitoring indicators will be:

- Rainfall and other associated weather parameters
- Crop health (based on satellite derived NDVI and field reports)
- Available ground water (variation in ground water table) and surface water resources
- Migration and impact on community

Observational Network For such monitoring one would require a reasonably dense observational network.

- Automatic weather station (25 km x 25 km)
- Automatic rain-gauge (5 km x 5 km)
- Ground water table observation (5 km x 5 km in hard rock region and 10 km x 10 km in alluvial plains)
- Field reports from the block/mental level
- Satellite data of 50 m x 50 m resolution

Medium Range Weather Forecasting for Community Level Advisory Numerical weather prediction has emerged as one of the important discipline requiring increasing computing power. To have accurate timely forecasts, state-of-art computers are used all over the world. Currently forecasting in India suffers from following constraints:

- The information is too general in terms of space and time while forecasting needs are at local level
- The timing does not match user needs;
- Information received from different sources transmit conflicting messages;
- The language is not clearly understood by users.

Climate Change and Drought Forecasting weather related information could become more complex with climate change. Climate change and agriculture are interrelated processes, both of which take place on a global scale. Global warming is projected to have significant impacts on conditions affecting agriculture, including temperature, carbon dioxide, glacial run-off, precipitation and the interaction of these elements. These conditions determine the carrying capacity of the biosphere to produce enough food for the human population and domesticated animals.

Mitigation Mitigation actions, programs, and policies are implemented during and before drought to reduce the magnitude of risk to human life, property, and productive capacity. Emergency response will always be a part of drought management, because it is unlikely that government and others will anticipate, avoid, or reduce all potential impacts through mitigation programs. A future drought event will also exceed the "drought of record" and the capacity of a region to respond. However, emergency response will be used lesser and only, if it is consistent with the longer-term drought policy goals and objectives. Considering the increase in the frequency of droughts in different parts of the country, it is necessary that there is a shift in public policy from drought relief to drought mitigation measures. These measures are important for adapting to climate change, restoring ecological balance, and bringing development benefits to the people.

Judicious use of surface and groundwater In drought prone areas rainwater is the main source of surface and ground water recharge. Because of more intense use of ground water in most parts of the country during the last few years, recharge of ground water did not take place. The early decade of 1990-2000, witnessed many advances in the airborne instrumentation, radars, flares and software. Water management issues of current concern, therefore, are:

(a) less exploitation of groundwater for irrigation,

(b) increased concentration of salts in the soil profile and groundwater,

(c) increased concentration of specific ions like fluorides and nitrates in water and

(d) lack of availability/reduced availability of drinking water for animals in natural storage structures such as ponds, lakes etc.

Drought Safety Tips Do's and Dont's

- Never pour water down the drain, use it to water your indoor plants or garden.
- Repair dripping taps by replacing washers.
- Check all plumbing for leaks and get them repaired.
- Choose appliances that are more energy and water efficient.
- Develop and use cop contingency plan to meet drought situation
- Plant drought-tolerant grasses, shrubs and trees.
- Install irrigation devices which are most water efficient for each use, such as micro and drip irrigation.
- Consider implementing rainwater harvesting wherever it is suitable
- Avoid flushing the toilet unnecessarily
- Avoid letting the water run while brushing your teeth, washing your face or shaving.

Cyclone

Tropical Cyclone (TC), also known as „Cyclone" is the term used globally to cover tropical weather systems in which winds equal or exceed „gale force" (minimum of 34 knot, i.e., 62 kmph). These are intense low pressure areas of the earth atmosphere coupled system and are extreme weather events of the tropics.

A tropical cyclone is a storm system characterized by a large low pressure centre and numerous thunderstorms that produce strong winds and flooding rain. Tropical cyclones feed on heat released when moist air rises, resulting in condensation of water vapor contained in the moist air. The term „tropical" refers to both the geographic origin of these systems, which form almost exclusively in tropical regions of the globe, and their formation in maritime tropical air masses. The term „cyclone" refers to such storms" cyclonic nature, with counter clockwise rotation in Northern Hemisphere and clockwise rotation in the Southern Hemisphere.

Depending on its location and strength, a tropical cyclone is called by many other names, such as hurricane, typhoon, tropical storm, cyclonic storm, tropical depression and simply cyclone. While tropical cyclones can produce extremely powerful winds and torrential rain, they are also able to produce high waves and damaging storm surges. They develop over large bodies of warm water, and lose their strength if they move over land. This is the reason for coastal regions receiving a significant damage from a tropical cyclone, while inland regions are relatively safe from their effect. Heavy rains, however, can produce significant flooding inland, and storm surges can produce extensive coastal flooding up to 40 kilometres from the coastline.

Although their effects on human populations can be devastating, tropical cyclones can also relieve drought conditions. They also carry heat and energy away from the tropics and transport it toward temperate latitudes, which make them an important part of the global atmospheric circulation mechanism.

Classification of Tropical Cyclones The criteria followed by Meteorological Department of India (IMD) to classify the low pressure systems in the Bay of Bengal and in the Arabian Sea as adopted by World Meteorological Organization (WMO) are as under:

Type of Disturbances	Associated Wind Speed in the Circulation
Low pressure Area	Less than17 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	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)

Destruction caused by Cyclones There are three elements associated with cyclones which cause destruction during its occurrence. These are:

Strong Winds/Squall: Cyclones are known to cause severe damage to infrastructure through high speed winds. Very strong winds which accompany a cyclonic storm damages installations, dwellings, communications systems, trees etc., resulting in loss of life and property. Gusts are short but rapid bursts in wind speed are the main cause for damage. Squalls on the other hand, are longer periods of increased wind speed and are generally associated with the bands of thunderstorms that make up the spiral bands around the cyclone.

Torrential rains and inland flooding: Torrential rainfall (more than 30 cm/hour) associated with cyclones is another major cause of damages. Unabated rain gives rise to unprecedented floods. Rain water on top of the storm surge may add to the fury of the storm. Rain is a serious problem for the people which become shelter less due to cyclone. Heavy rainfall from a cyclone is usually spread over wide area and cause large scale soil erosion and weakening of embankments.

Storm Surge: A Storm surge can be defined as an abnormal rise of sea level near the coast caused by a severe tropical cyclone; as a result of which sea water inundates low lying areas of coastal regions drowning human beings and life stock, causes eroding beaches and embankments, destroys vegetation and leads to reduction of soil fertility. Brief details about damages caused by wind of different speed during cyclones are as under

Wind Speed Intensity	Damages expected.
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 Strom	34 to 47 knots (62 to 88 kmph)
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Super Cyclonic Strom	1120 knots and above (222kmph and above)

Tracking of tropical cyclones Tracking of the tropical cyclones in India is done with the help of:

- Conventional surface and upper air observations from inland and island stations, coastal Automatic Weather Station (AWS), ships and buoy observations;
- Cyclone detection radar including Doppler Weather Radar;
- Satellite cloud pictures from the Geostationary Satellite (INSAT 3A & Kalpana1).

Tropical cyclone warnings The bulletins and warnings issued in connection with tropical cyclones in India may be divided into the following broad categories:

- Warning bulletins for shipping on the high seas.
- Warning bulletins for ships plying in the coastal waters.
- Port warnings.
- Fisheries warnings. (Fishermen & Fisheries Officials)
- Four stage warnings for the State and Central Government officials.

Warnings for recipients who are registered with the department (Designated/registered users).

- Aviation.
- Warnings for the general public through All India Radio, Doordarshan and the Press.
- Warning for Indian Navy.
- Bulletins for Print / Electronic media.

Cyclone Forecasting and Emergency Management Networks Some countries have set up dedicated video/audio facilities and websites to communicate with other emergency organizations and technical groups. A consensus assessment of the cyclone forecast is arrived at through broad based consultation and coordination.

Parametric Wind Field and Cyclone Risk Models Parametric wind models form the basis of the TC hazard component of many risk models. The next-generation parametric wind model would provide a more realistic wind field and improve the TC hazard component of a risk model, which can lead to and thereby improve loss and cost estimates associated with TC landfall. Recent wind field observations collected with Global Positioning System (GPS) dripstones have many characteristics that are not represented by standard parametric models.

Structural Mitigation Measures1 An important aspect of cyclone risk reduction is to ensure availability of adequate numbers of shelters, community centres/school buildings, places of worship, etc., which can be utilized for moving people from vulnerable areas to safety. Besides this, the structural safety of various lifeline infrastructure such as roads/culverts/bridges, communication and transmission towers, power houses, water towers and hospitals will be ensured, so that the communication system at all levels remains useable, the electricity and water supply systems do not break down and adequate medical attention is possible.

It has been identified that design and maintenance considerations are the main focal points to be addressed which would improve the cyclone preparedness. This will cover:

- Buildings, including multi-purpose cyclone shelters;
- Road links, culverts and bridges; canals, drains, and surface water tanks, etc.;
- Saline embankments
- Communication towers and power transmission networks.

It is very important to provide safe shelters to protect human life at the time of cyclones. Many cyclone shelters constructed earlier were not connected by all-weather roads with nearby habitats from where affected people need to be shifted during emergency evacuation. There is a need to improve the existing road network and provide at least one link road, in all weather conditions, for each village that is accessible during cyclone or flooding periods as well.

The importance of coastal canals need not be over-emphasized as it serves as an alternative to road communication in the event of a cyclone or flood. Failure of even well-engineered structures such as communication and transmission towers during past cyclones brings the importance of the structural safety of such structures to the forefront.

Safety Tips Do's and Don'ts Before and During

- Listen to radio or TV weather reports and alert everyone through a loud speaker or by going home to home.
- Identify safe shelter in your area. These should be cyclone resistant and also find the closest route to reach them.
- Keep your emergency kit and basic food supply, medicines, torch and batteries etc. ready.
- Doors, windows, roof and walls should be strengthened before the cyclone season through retrofitting and repairing. Store adequate food grains and water in safe places.
- Conduct Mock Drills for your family and the community.
- Do not venture into the sea. Stay Indoors under the strongest part of the house if not moved to the cyclone shelter.
- Remain indoors until advised that the cyclone has passed away.

After

- Do not go out till officially advised that it is safe. If evacuated, wait till advised to go back.
- Use the recommended route to return to your home. Do not rush.
- Be careful of broken powers lines, damaged roads and house, fallen trees etc.

Forest Fire

The most common hazard in forests is forests fire. Forests fires are as old as the forests themselves. They pose a threat not only to the forest wealth but also to the entire regime to fauna and flora seriously disturbing the bio-diversity and the ecology and environment of a region. During summer, when there is no rain for months, the forests become littered with dry senescent leaves and twinges, which could burst into flames ignited by the slightest spark.

The Himalayan forests, particularly, Garhwal Himalayas have been burning regularly during the last few summers, with colossal loss of vegetation cover of that region. Forest fire causes imbalances in nature and endangers biodiversity by reducing faunal and floral wealth. Traditional methods of fire prevention are not proving effective and it is now essential to raise public awareness on the matter, particularly among those people who live close to or in forested areas.

Causes of Forest Fire

Forest fires are caused by Natural causes as well as Man made causes

- Natural causes- Many forest fires start from natural causes such as lightning which set trees on fire. However, rain extinguishes such fires without causing much damage. High atmospheric temperatures and dryness (low humidity) offer favorable circumstance for a fire to start.
- Man made causes- Fire is caused when a source of fire like naked flame, cigarette, electric spark or any source of ignition comes into contact with inflammable material.

Traditionally Indian forests have been affected by fires. The menace has been aggravated with rising human and cattle population and the consequent increase in demand for Forest products by individuals and communities. Causes of forest fires can be divided into two broad categories: *environmental* (which are beyond control) and *human related* (which are controllable).

Environmental causes are largely related to climatic conditions such as temperature, wind speed and direction, level of moisture in soil and atmosphere and duration of dry spells. Other natural causes are the friction of bamboos swaying due to high wind velocity and rolling stones that result in sparks setting off fires in highly inflammable leaf litter on the forest floor.

Human related causes result from human activity as well as methods of forest management. These can be intentional or unintentional, for example:

- graziers and gatherers of various forest products starting small fires to obtain good grazing grass as well as to facilitate gathering of minor forest produce like flowers of *Madhuca indica* and leaves of *Diospyros melanoxylon*
- the centuries old practice of shifting cultivation (especially in the North-Eastern region of India and inparts of the States of Orissa and Andhra Pradesh).
- the use of fires by villagers to ward off wild animals
- fires lit intentionally by people living around forests for recreation
- fires started accidentally by careless visitors to forests who discard cigarette butts.

The causes of forest fire have been increasing rapidly. The problem has been accentuated by the growing human and cattle population. People enter forests ever more frequently to graze cattle, collect fuelwood, timber and other minorforest produce. It has been estimated that 90% of forest fires in India are man-made

Classification of Forest Fire

Forest fire can broadly be classified into three categories;

- Natural or controlled forest fire.
- Forest fires caused by heat generated in the litter and other biomes in summer through carelessness of people (human neglect) and
- Forest fires purposely caused by local inhabitants.

Types of Forest Fire

There are two types of forest fire i) Surface Fire and ii) Crown Fire

SurfaceFire-

A forest fire may burn primarily as a surface fire, spreading along the ground as the surface litter (senescent leaves and twigs and dry grasses etc) on the forest floor and is engulfed by the spreading flames.

CrownFire-

The other type of forest fire is a crown fire in which the crown of trees and shrubs burn, often sustained by a surface fire. A crown fire is particularly very dangerous in a coniferous forest because resinous material given off burning logs burn furiously. On hill slopes, if the fire starts downhill, it spreads up fast as heated air adjacent to a slope tends to flow up the slope spreading flames along with it. If the fire starts uphill, there is less likelihood of it spreading downwards.

Effect of Forest Fire

Fires are a major cause of forest degradation and have wide ranging adverse ecological, economic and social impacts, including:

- loss of valuable timber resources
- degradation of catchment areas
- loss of biodiversity and extinction of plants and animals
- loss of wildlife habitat and depletion of wildlife
- loss of natural regeneration and reduction in forest cover
- global warming
- loss of carbon sink resource and increase in percentage of CO2 in atmosphere
- change in the microclimate of the area with unhealthy living conditions
- soil erosion affecting productivity of soils and production
- ozone layer depletion
- health problems leading to diseases
- loss of livelihood for tribal people and the rural poor, as approximately 300 million people are directly dependent upon collection of non-timber forest products from forest areas for their livelihood.

The needs of the fire management

The incidence of forest fires in the country is on the increase and more area is burned each year. The major cause of this failure is the piecemeal approach to the problem. Both the national focus and the technical resources required for sustaining a systematic forest fire management programme are lacking in the country. Important forest fire management elements like strategic fire centers, coordination among Ministries, funding, human resource development, fire research, fire management, and extension programmes are missing. Taking into consideration the serious nature of the problem, it is necessary to make some major improvements in the forest fire management strategy for the country.

The Ministry of Environment and Forests, Government of India, has prepared a National Master Plan for Forest Fire Control. This plan proposes to introduce a well-coordinated and integrated fire-management programme that includes the following components:

- Prevention of human-caused fires through education and environmental modification. It will include silvicultural activities, engineering works, people participation, and education and enforcement. It is proposed that more emphasis be given to people participation through Joint Forest Fire Management for fire prevention.
- Prompt detection of fires through a well coordinated network of observation points, efficient ground patrolling, and communication networks. Remote sensing technology is to be given due importance in fire detection. For successful fire management and administration, a National Fire Danger Rating System (NFDRS) and Fire Forecasting System are to be developed in the country.
- Fast initial attack measures.
- Vigorous follow up action.
- Introducing a forest fuel modification system at strategic points.
- Firefighting resources.

Geological Based Disaster

A geological disaster occurs when natural geological processes impact on our activities, either through loss of life or injury, or through economic loss. A geological hazard is a potential disaster.

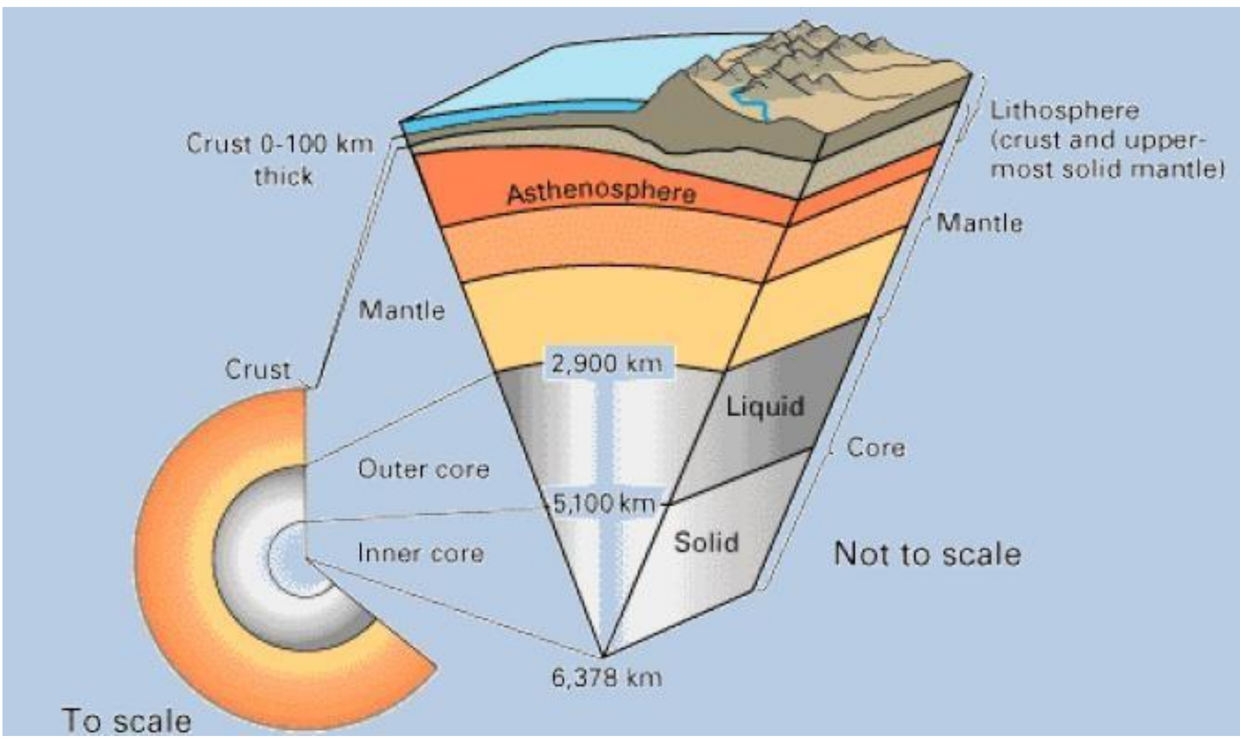
Earthquake

Earthquakes are one of the most destructive of natural hazards. An earthquake occurs due to sudden transient motion of the ground as a result of release of elastic energy in a matter of few seconds. The impact of the event is most traumatic because it affects large areas, occurs all of a sudden and is unpredictable. They can cause large scale loss of life and property and disrupts essential services such as water supply, sewerage systems, communication and power, transport, etc. They not only destroy villages, towns and cities but the aftermath leads to destabilize the economy and social structure of the nation.

What is an Earthquake

An earthquake is the movement or trembling of the ground produced by the sudden displacement of rock in the Earth's crust. Earthquakes result from crustal strain, volcanism, landslides, and collapse of caverns. Stress accumulates in response to tectonic forces until it exceeds the strength of the rock. The rock then breaks along a preexisting or new fracture called a fault. The rupture extends outward in all directions along the fault plane from its point of origin (focus). The rupture travels in an irregular manner until the stress is relatively equalized. If the rupture disturbs the surface, it produces a visible fault on the surface.

Causes of Earthquakes An Earthquake is a series of underground shock waves and movements on the earth's surface caused by natural processes within the earth's crust. To learn more about the occurrence of this event lets know more about the interior of the earth.



Internal Structure of Earth

Earthquakes are caused by natural tectonic interactions within the earth's crust and it is a global phenomena. They may arise either due to the release of energy from the strained rock inside the

Earth or tectonic movements or volcanic activity. The sudden release of accumulated energy or stresses in the earth or sudden movement of massive land areas on the earth's surface cause tremors, commonly called earthquakes.

Seismic Waves Large strain energy released during an earthquake travel as seismic waves in all directions through the Earth's layers, reflecting and refracting at each interface. These waves are of two types - body waves and surface waves; the latter is restricted to near the Earth's surface. Body waves consist of Primary Waves (P-waves) and Secondary Waves (S-waves), and surface waves consist of Love waves and Rayleigh waves. Under P-waves, material particles undergo extensional and compressional strains along the direction of energy transmission, but under S- waves, oscillate at right angles to it. Love waves cause surface motions similar to that by S-waves, but with no vertical component. Rayleigh wave makes a material particles oscillate in an elliptic path in the vertical plane (with horizontal motion along direction of energy transmission).

Magnitude Magnitude is a quantitative measure of the actual size of the earthquake. Professor Charles Richter noticed that (a) at the same distance, seismograms (records of earthquake ground vibration) of larger earthquakes have a bigger wave amplitude than those of smaller earthquakes; and (b) for a given earthquake, seismograms at farther distances have a smaller wave amplitude than those at close distances. This prompted him to propose the now commonly used magnitude scale, the Richter Scale. It is obtained from the seismograms and accounts for the dependence of waveform amplitude on epicentral distance. This scale is also called Local Magnitude scale. There are other magnitude scales, like the Body Wave Magnitude, Surface Wave Magnitude and Wave Energy Magnitude. These numerical magnitude scales have no upper and lower limits; the magnitude of a very small earthquake can be zero or even negative.

What are the various types of earthquake?

Classification of earthquake is based on several parameters. Based on scale of magnitude (M), earthquake may be of the Micro ($M < 3.5$) or macro ($M > 3.5$) type.

- Depending upon the extent of energy released and strength of the ground shaking it may be of several types, like moderate, strong, very strong, great and very great earthquake.

- Depending up on the scale of damage, the earthquake may be of various types, such as Less damaging earthquake, Moderate damaging earthquake, and catastrophic earthquake.

- Depending upon the focal depth (h) of the event, it could be a shallow earthquake ($d< 70$ km); intermediate depth earthquake ($70 < h < 300$ km); the deep earthquake ($300 < h < 700$ km).

- Depending upon the location of events in different tectonic settings, earthquake may be of intra-plate, inter-plate, and sub-oceanic earthquake.

- Depending upon involvement of other agencies / phenomena with earthquake genesis, it may be of several types, such as Reservoir induced; Fluid-driven earthquake; Tsunamigenic earthquake, and volcanic earthquake.
- Depending upon the type of faulting involved during earthquake genesis, earthquake may be categorized into several categories, such as normal faulting, reverse faulting, thrust faulting, and mega-thrust earthquake.
- Depending upon the frequency content, the earthquake may be of Low-Frequency tremors or high – Frequency tremors.
- Depending upon the epicenter distance (distance between earthquake main shock and the recording stations), the earthquake may be classified into Local, Regional and Global earthquake.

Can we predict Earthquakes With the present state of knowledge of science, it is not possible to predict earthquakes. It is so because the physics involved in earthquake genesis is very complex. The mechanism of earthquake generating processes is still not adequately understood us because of involvement of multi-component parameters in earthquake genesis.
Earthquake forecasting and prediction is an active topic of geological research.

Geoscientists are able to identify particular areas of risk and, if there is sufficient information, to make probabilistic forecasts about the likelihood of earthquakes happening in a specified area over a specified period. These forecasts are based on data gathered through global seismic monitoring networks, high-density local monitoring in knowing risk areas, and geological field work, as well as from historical records. Forecasts are improved as our theoretical understanding of earthquakes grows, and geological models are tested against observation.

Long-term forecasts (years to decades) are currently much more reliable than short to medium- term forecasts (days to months). It is not currently possible to make deterministic predictions of when and where earthquakes will happen. For this to be possible, it would be necessary to identify a „diagnostic precursor" – a characteristic pattern of seismic activity or some other physical, chemical or biological change, which would indicate a high probability of an earthquake happening in a small window of space and time. So far, the search for diagnostic precursors has been unsuccessful. Most Geoscientists do not believe that there is a realistic prospect of accurate prediction in the foreseeable future, and the principal focus of research is on improving the forecasting of earthquakes.

Earthquake Early Warning Earthquake early warning (EEW) can provide a few seconds to tens of seconds warning prior to ground shaking during an earthquake. Several countries, such as Japan, Taiwan, Mexico have adopted this methodology based on the fact that such warning can

(1) rapidly detect the initiation of an earthquake,

(2) determine the size (magnitude) and location of the event,

(3) Predict the peak ground motion expected in the region around the event, and

(4) Issued a warning to people in locations that may expect significant ground motion.

Prediction of an earthquake is still a subject of speculations yet several schools of thoughts are available. In the effort to predict earthquakes, people have tried to associate an impending earthquake with such varied phenomena as seismicity patterns, electromagnetic fields, weather conditions and unusual clouds, radon or hydrogen gas content of soil or ground water, water level in wells, animal behavior, and the phases of the moon.

Mitigation measures

When an earthquake strikes a building is thrown mostly from side to side, and also up and down along with the building foundation the building structure tends to stay at rest, similar to a passenger standing on a bus that accelerates quickly. Building damage is related to the characteristics of the building, and the duration and severity of the ground shaking. Larger earthquakes tend to shake longer and harder and therefore cause more damage to structures.

Earthquake Safety Tips Before & during

- Make your house earthquake resistant and secure heavy furniture and objects.
- Choose a couple of family meeting places; pick easy to identify, open and accessible places that you can easily reach. Prepare to be self-sufficient for a minimum of three days.
- If inside, stay inside."DROP, COVER and HOLD! Drop under firm furniture. Cover as much of your head and upper body as you can. Hold onto the furniture. Move to an inside wall and sit with your back to the wall, bring your knees to your chest and cover your head. Stay away from mirror and window. Do not exit the building during the shaking.
- If outdoors, move to an open area away from all structures, especially buildings, bridges, and overhead power lines.

After

- Move cautiously, and check for unstable objects and other hazards above and around you. Check yourself for injuries.
- Anticipate aftershocks, especially if the shaking lasted longer than two minutes.
- Stay out of damaged buildings. Listen to the radio or watch local TV for emergency information and additional safety instructions.

Tsunami

Tsunamis and earthquakes happen after centuries of energy build up within the earth. A tsunami (in Japanese „tsu" means harbor and „nami" means wave) is a series of water waves caused by the displacement of a large volume of a body of water, usually an ocean. In the Tamil language it is known as "Aazhi Peralai". Seismicity generated tsunamis are the result of abrupt deformation of sea floor, resulting vertical displacement of the overlying water. Earthquakes occurring beneath the sea level, the water above the reformed area is displaced from its equilibrium position. The release of energy produces tsunami waves which have small amplitude but a very long wavelength (often hundreds of kilometer long). It may be caused by non-seismic event also such as a landslide or the impact of a meteor.

Characteristics: Tsunami in the deep ocean may have very long wave length of hundred of kilometer and travels at about 800 km per hour, but an amplitude of only about 1 km. It remains undetected by ships in the deep sea. However, when it approaches the coast its wavelength diminishes, but amplitude grows enormously, and it takes very little time to reach its full height. The Computer model can provide tsunami arrival, usually within minutes of the arrival time. Tsunamis have great erosion potential, stripping beaches of sand, coastal vegetation and dissipating its energy through the destruction of houses and coastal structure.

How do landslides, volcanic eruptions, and cosmic collisions generate tsunamis?

A tsunami can be generated by any disturbance that displaces a large water mass from its equilibrium position. In the case of earthquake-generated tsunamis, the water column is disturbed by the uplift or subsidence of the sea floor. Submarine landslides, which often accompany large earthquakes, as well as collapses of volcanic edifices, can also disturb the overlying water column as sediment and rock slump down slope and are redistributed across the sea floor. Similarly, a violent submarine volcanic eruption can create an impulsive force that uplifts the water column and generates a tsunami.

Tsunami Preparedness Warning System Components and Instruments

- A Network of Land-based Seismic Stations for earthquake detection and estimation of source parameters in the two known tsunamigenic zones (viz. Java-Sumatra-Andaman- Myanmar belt and the North Arabian Sea) that would affect the Indian Ocean region and communicating the same to Early Warning Centre in near-real time.
- Detection of Tsunami generation through a network of 10-12 bottom pressure recorders (that could detect and measure a change in water level of 1 cm at water depths of up to 6 km of water) around these two tsunamigenic zones,
- Monitoring the progress of Tsunami and Storm Surges through a network of 50 real time tide gauges,
- Tsunami Modeling (addressing the inundation and amplification all along the coast and islands for different tsunami originating from different sources),
- Generating and updating a high resolution data base on bathymetry, coastal topography, coastal land use, coastal vulnerability as well as historic data base on Tsunami and Storm Surge to prepare and update Storm Surge/Tsunami hazard maps in 1:5,000 scale (for coastal areas within 1-3 km in general and for 10-25 km at selected areas near coastal water bodies),
- Setting up a dedicated National Early Warning Centre (NEWC) for monitoring tsunamis and storm surges in India for operation on 24x7 basis and for generation of timely advisories, and
- Capacity building, training and education of all stakeholders on utilization of the maps, warning and watch advisories.

Tsunami Terminology Arrival Time: Time of arrival of the first wave of a tsunami at a particular location.

Coastal Area: The area of land behind the sea coast up to the zero inundation line during the estimated future tsunamis and beyond the coast in the sea requiring tsunami management; the area on the landward side of the mean water line and the area up to 5m. Water depth on the seaward side of the mean water line.

Estimated Time of Arrival: Computed arrival time of the first wave of a tsunami at the coast after the occurrence of specific major disturbance in the ocean like earthquakes, landslides, volcanic activity in the ocean, meteorite impact on the ocean surface, etc.

Far field Tsunami: A tsunami capable of widespread destruction, not only in the immediate region of its generation, but across the entire ocean basin.

Green's Function: A type of function used to solve inhomogeneous differential equations subject to boundary conditions.

Inundation Distance: The distance that a tsunami wave penetrates onto the shore, measured horizontally from the mean water line.

Intensity: Intensity is the degree of damage caused by a tsunami.

Local Tsunami or near- field Tsunami: A tsunami which has destructive effects (confined to coasts within 200 Kms of the Source with arrival time less than 30 minutes).

Near-Field Tsunami: A tsunami from a nearby source, generally less than 200 km or associated with a short travel time of less than 30 minutes.

Regional Tsunami: A tsunami capable of destruction in a particular geographic region, generally within about1000 km of its source. Regional tsunamis also occasionally have very limited and localized effects outside the region.

Tsunami: A Japanese term meaning "harbour wave", derived from the characters "tsu" meaning harbour and "nami" meaning wave, to describe a system of ocean gravity waves having a long wave length and period (time between crests), formed as a result of large-scale disturbance of the sea caused by an earthquake.

Vulnerability Line: Vulnerability line is a setback line to be demarcated on the coastal stretches, taking into account the vulnerability of the coast to natural and man-made hazards.

Do's & Dont's before & during

- Find out if your home is in the danger zone.
- Know the height of your street/house above sea level and the distance from the coast.
- People living along the coast should consider an earthquake or strong ground rumbling as a warning signal.
- Try and climb a raised platform or climb the highest floor of any house or building which you might see.
- Make evacuation plans and a safe route for evacuation. Stay away from the beach.
- Never go down near the beach to watch the Tsunami.
- Listen to a radio or television to get the latest information and be ready to evacuate if asked to do so.
- If you hear an official warning, evacuate at once. Return home only after authorities advice it is safe to do so.

After

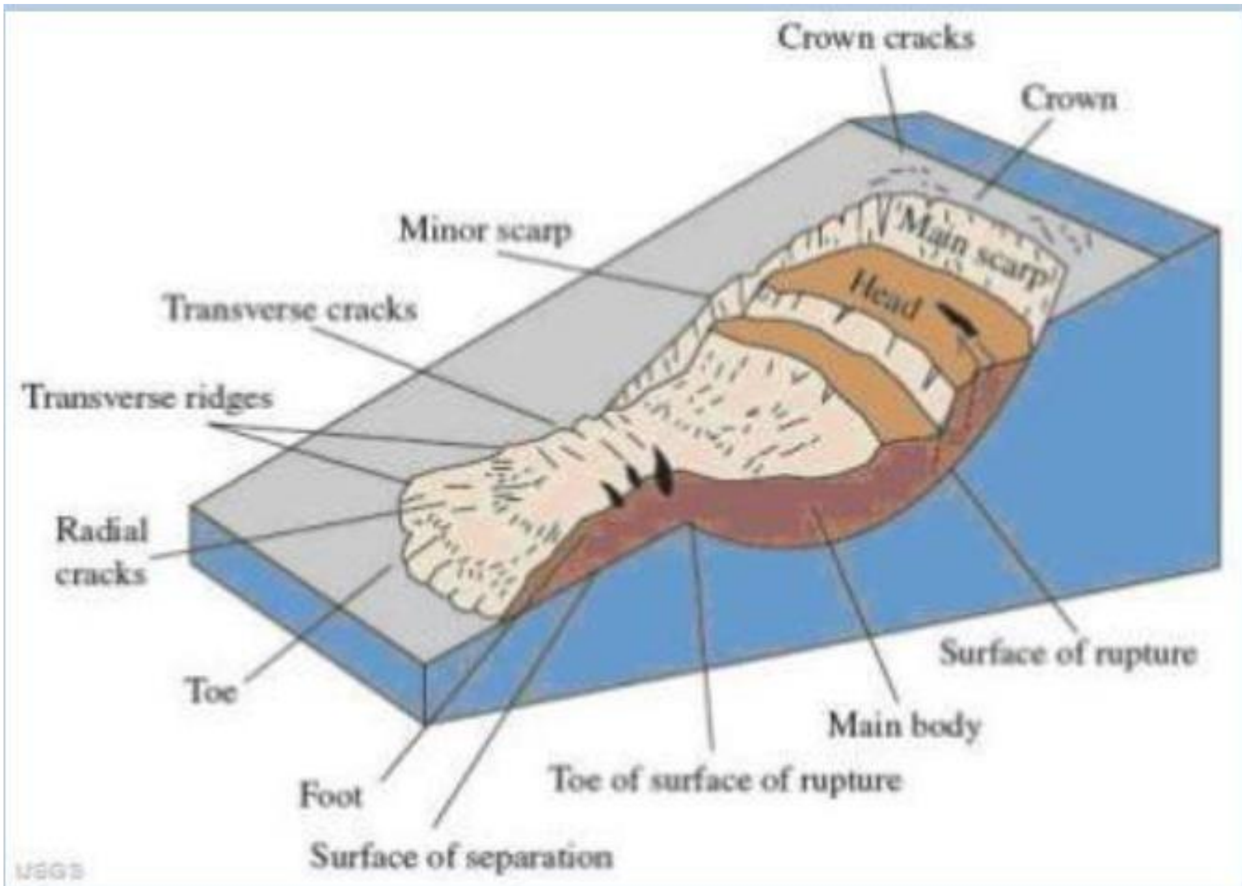
- Stay tuned to the battery-operated radio for the latest emergency information. Help injured and trapped persons.

- Stay away from flooded and damaged areas until officials say it is safe to return.
- Enter your home with caution.
- Use flashlight when entering damaged houses. Check for electrical short circuit and live wires.
- Check food supplies and test drinking water.

Landslide

Landslides are simply defined as down slope movement of rock, debris and/or earth under the influence of gravity. This sudden movement of material causes extensive damage to life, economy and environment. It is the most common and universally accepted collective term for most slope movements of the massive nature. The term has sometimes been considered unsuitable as the active part of the word denotes sliding, whereas it connotes even movements without sliding like fall, topple, flow etc.

Morphology of Landslides Before we discuss about different types of landslides, it would be good to learn about the morphology of landslides and its various features/parts as given below.



Components of Landslides

Parts of Landslides –

Description of Features Accumulation - The volume of the displaced material, which lies above the original ground surface

Crown – The practically undisplaced material still in place and adjacent to the highest parts of the main scarp

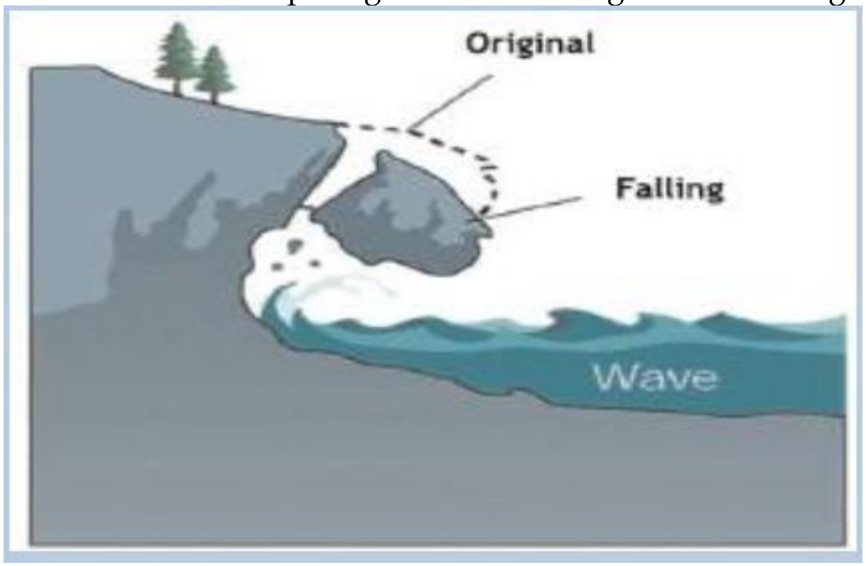
Depletion – The volume bounded by the main scarp, the depleted mass and the original ground surface

Depleted mass – The volume of the displaced material, which overlies the rupture surface but underlies the original ground surface

Displaced material – Material displaced from its original position on the slope by movement in the landslide. It forms both the depleted mass and the accumulation.
Flank – The undisplaced material adjacent to the sides of the rupture surface. Compass directions are preferable in describing the flanks, but if left and right are used, they refer to the flanks as viewed from the crown.
Foot – The portion of the landslide that has moved beyond the toe of the surface of rupture and overlies the original ground surface.
Head – The upper parts of the landslide along the contact between the displaced material and the main scarp.
Main body – The part of the displaced material of the landslide that overlies the surface of rupture between the main scarp and toe of the surface of rupture.
Main scarp – A steep surface on the undisturbed ground at the upper edge of the landslide, caused by movement of the displaced material away from undisturbed ground. It is the visible part of the surface of rupture.
Minor scarp – A steep surface on the displaced material of the landslide produced by the differential movement within the displaced material.
Original ground surface – the surface of the slope that existed before the landslide took place. **Surface of separation** – The part of the original ground surface overlain by the foot of the landslide
Surface of rupture – The surface that forms the lower boundary of the displaced material below the original ground surface.
Tip – The point of toe farthest from the top of the landslide.
Toe – The lower, usually curved margin of the displaced material of a landslide, it is the most distant part from the main scarp.
Top – The highest point of contact between the displaced material and the main scarp.
Toe of surface of rupture – The intersection (usually buried) between the lower part of the surface of rupture of a landslide and the original ground surface.
Zone of accumulation – The area of landslide within which the displaced material lies above the original ground surface.
Zone of depletion – The area of the landslide within which the displaced material lies below the original ground surface.

Landslide types based on process of failure Based on process types, there are five types of landslides i.e. fall, Topple, Slide, Spread, Flow and Subsidence.
Fall: is a very rapid to an extremely rapid movement which starts with a detachment of material from steep slopes such as cliffs, along a surface on which little or no shear displacement takes place. The material then descends through the air by free falling, bouncing or rolling onto the slopes below.

- The detachment of soil or rock from a steep slope along a surface on which little or no shear displacement takes place.
- Movement very rapid to extremely rapid.
- Free fall if slope angle exceeds 76 degrees and rolling at or below 45 degrees.



A sketch showing mode of failure in the fall

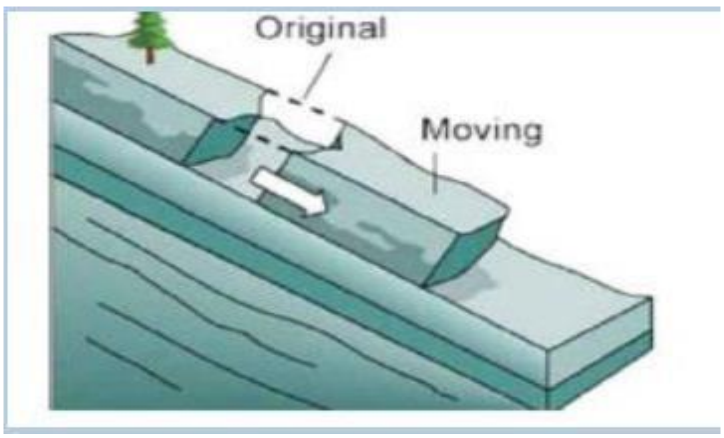
Topple: involves overturning of material. It is the forward rotation of the slope mass about a point or axis below the centre of gravity of the displaced mass. Topples range from extremely slow to extremely rapid movements.

- The forward rotation out of the slope of a mass or a rock about a point or axis below the centre of gravity of the displaced mass.
- Movement varies from extremely slow to extremely rapid.
- Driven by gravity and sometimes by water or ice in cracks in mass.

Sketch showing the end-over-end motion of rock down a slope during toppling

Slide: movement of material along a recognizable shear surface e.g. translational and rotational slides.

- Downslope movement of a soil or mass occurring dominantly on surfaces of or on relatively thin zones of intense shear strain.
- The sign of ground movement are cracks of the original ground.



Sketch showing movement parallel to planes of weakness and occasionally parallel to slope

Modes of Sliding:

- Translational / planar slides
- Wedge slides
- Rotational slide

Flow: is a landslide in which the individual particles travel separately within a moving mass. Spatially continuous movement, in which surfaces of shear are shortlived, closely spaced and usually not preserved. Flows are differentiated from slides, on the basis of water content, mobility and evolution of the movement.

Features for recognition of flows are

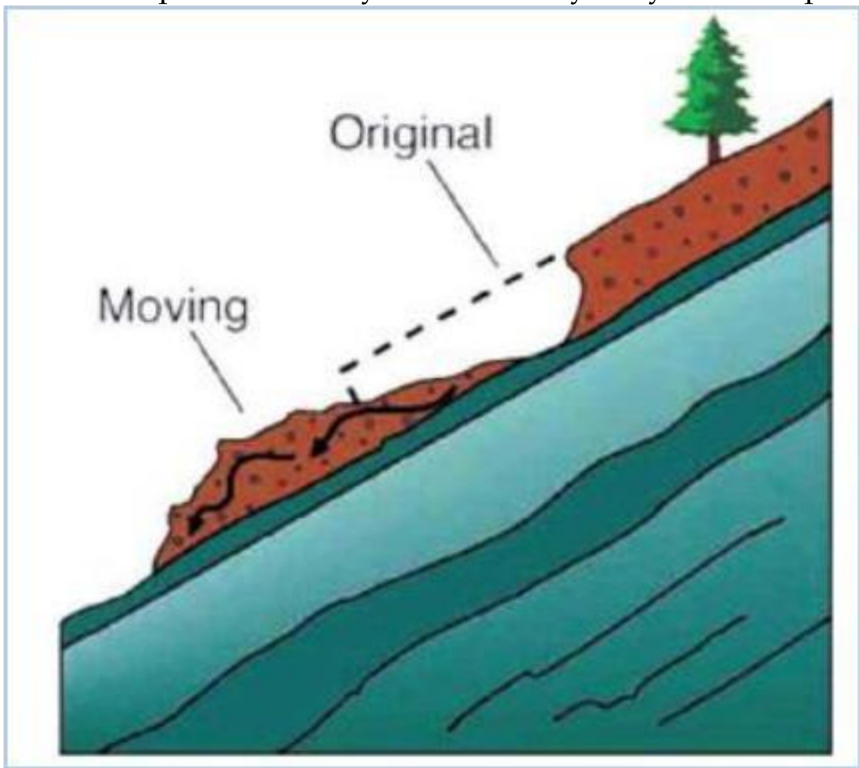
i. Crown may have few cracks.

ii. The main scarp typically has serrated or funnel shaped upper part; is long and narrow, bare and commonly striated.

iii. Flanks are steep and irregular in the upper part; may have levees built up in the middle and lower parts.

iv. The body has flowlines, follow drainage ways, is sinuous, and is very long compared to width.

v. The toe spreads laterally in lobes; if dry, may have steep front.

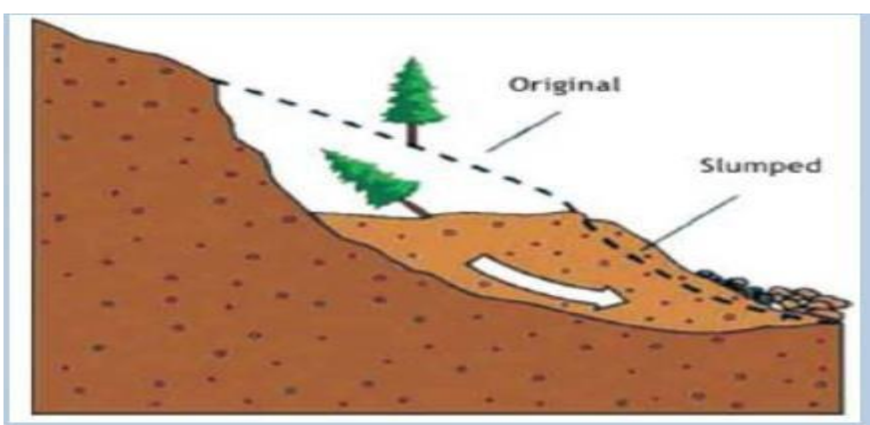


Sketch showing viscous to fluid like motion of debris, often channeled

Spread

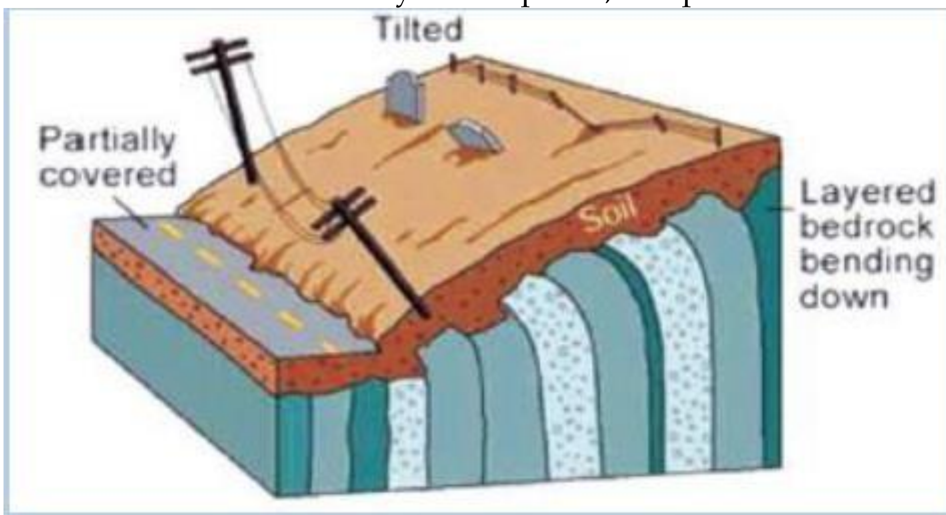
- Sudden movement on water- bearing seams of sand or silt overlain by homogeneous clays or loaded by fills.
- May result from liquefaction or flow of softer material.

Slump: It is a type of rotational failure on the slopes. The trees bend or fall backwards on towards the slope.



Sketch showing slump type failure

Creep: Very slow rates of slope movements, usually a few millimeter per year, that is imperceptible in nature) is covered under this category. However, one may find landslides that do not fall directly under any of these typical singular types of slope failures. Such landslides may be composite, complex or multi-tier.



Gradual movement of slope material during creep

Multi-tier / Multi-rotational landslides: When more than one main scars appears in a landslide site and slope mass has more than one slip surface along which movement takes place.

Complex Landslides: Those landslides where the nature of failure process is not consistent but changes with time. For example, a landslide that begins with rock sliding changes its nature to a rockfall due to a steepening of slopes during a failure, may again result into a debris flow due to the formation of a channel during the process of past failures. Thus, it becomes, often very difficult to prevent and control such complex landslides. It requires a persistent study to understand the causes of such landslides properly. These landslides are also found to be chronic and recurring in nature. For example, Kaliasaur landslide in Alaknanda valley, Uttarakhand has displayed complex failure.

Composite Landslides: The slopes which fail in different manners simultaneously at the same site are termed as composite landslides. These landslides display a composite nature as different parts of the landslide indicate a different process type. The types of failure vary due to changes in slope aspect, gradient, heterogeneity in slope mass, landcover, structural / tectonic controls etc. For example, Matli landslide in Bhagirathi valley, Uttarakhand is an example of composite landslide.

Causal Factors for Landslides There can be several different causative factors for the occurrence of landslides which may work individually or collectively to cause a landslide. Broadly these factors can categorize into ground conditions, geomorphological processes, physical processes and man-made processes. A brief list of these causal factors is given in the table below.

a. Ground Conditions

- Plastic weak material
- Sensitive material
- Collapsible material
- Weathered material
- Sheared material
- Jointed or fissured material
- Adversely oriented structural discontinuities including faults, unconformities, flexural shears, sedimentary contacts
- Adversely oriented mass discontinuities (including bedding, schistosity, cleavage)
- Contrasts in permeability and its effects on ground water
- Contrasts in stiffness (stiff, dense material over plastic material)

b. Geomorphological Processes

- Tectonic uplift
- Volcanic uplift
- Glacial Rebound
- Fluvial erosion of the slope toe
- Wave erosion of the slope toe
- Glacial erosion of the slope toe
- Erosion of the lateral margin
- Subterranean erosion (solution, piping)
- Deposition loading of slope at its crest

- Vegetation removal (by erosion, forest fire, drought)
- Ground Cracks
- Subsidence

c. Physical Processes

- Intense rainfall over a short period
- Rapid melt of deep snow
- Prolonged heavy precipitation
- Rapid drawdown following floods, high tides or breaching of natural dam
- Earthquake
- Volcanic eruption
- Breaching of crater lake
- Thawing of permafrost
- Freeze and thaw weathering
- Shrink and swell weathering of expansive soils

d. Man-Made Processes

- Excavation of the slope or its toe
- Loading of the slope or its crest
- Drawdown of reservoir
- Irrigation
- Defective maintenance of drainage system
- Water leakage from services like water supplies, sewage, storm water drains
- Vegetation removal (deforestation)
- Mining and quarrying in open pits or underground galleries
- Creation of dumps of very loose waste
- Artificial vibration including traffic, pile driving, heavy machinery,blasting and explosion
- Poor maintenance of remedial measures

Classification of Conditions/Factors responsible for Landslides Some slopes are susceptible to landslides whereas others are not so. Many factors contribute to the instability of the slopes, but the main factors indicating stability conditions are relief, drainage, bedrock, regolith, vegetation, climate, earthquake, paleo-features and man-made conditions. The conditions/factors governing landslides can be classified as inherent (terrain) and external factors as given below.

a. Inherent or basic

conditions Geology

- Lithology
- Structure

Hydrologic conditions and climate

- Vegetation

b. External Factors/conditions include precipitation, vibrations induced by earthquake / blasting / explosion, loading or unloading of slopes etc. These factors may actually produce two different types of changes, i.e. changes in stress conditions and changes in strength of materials. The different factors producing different changes are given below for illustration.

c. Factors producing unfavorable changes in conditions Those that change stress conditions

- Erosion or deposition
- Fluctuation in water level
- Seismic vibrations
- Construction activity
- Cuttings
- Reservoir fluctuations
- Land use practices

Those that change strength of materials

- Progressive softening of fissured clays
- Disintegration of granular rocks (freeze & thaw)
- Hydration of clay minerals
- Drying and cracking of clays
- Loss of cementations material from coherent material by solution

d. Landslide's Driving Force The principal driving force for any landslide is the gravitational force which tends to move out the mass due to the hill slope angle and its weight. The resisting forces preventing the mass from sliding down the slope are inversely proportional to the same hill slope angle and proportional to the friction angle of the material. Stability of the material resting on a slope will be reduced with an increased slope angle. In addition, the resisting forces can be significantly reduced in case of rain or earthquake vibrations.

Potential landslide risk indicators: The following simple observations and inspection by community, municipal officials and property owners, may assist in assessing potential landslide hazards. It is important to note that some of these features can also be due to causes other than landslides, such as swelling clays.

- Saturated ground or seeps in areas that are not typically wet
- New cracks and scarps or unusual bulges in the ground, roads or pavements
- Movement of ancillary structures such as decks and patios in relation to a house
- Sticking doors and windows, and visible open spaces, indicating jambs and frames out of plumb
- Soil moving away from foundations
- Tilting or cracking of concrete floors and foundations
- Broken water lines and other underground utilities
- Leaning telephone poles, trees, retaining walls or fences
- Offset fence lines or retaining walls
- Sunken or displaced road surfaces
- Rapid increase in creek water levels, possibly accompanied by an increase in turbidity (soil content)
- Sudden decrease in creek water levels, though rain is still pouring or just recently stopped
- Springs, seeps or saturated ground in areas that are not typically wet
- Thorough cracks in walls, gaps between roof and wall etc.
- Damage to building elements

Landslides Risk Reduction Measures

Drainage Corrections: The most important triggering mechanism for mass movements is the water infiltrating into the overburden during heavy rains and consequent increase in pore pressure within the overburden**.** Hence the natural way of preventing this situation is by reducing infiltration and allowing excess water to move down without hindrance. As such, the first and foremost mitigation measure is drainage correction. This involves maintenance of natural drainage channels, both micro and macro in vulnerable slopes.

Proper land use measures: Adopt effective land-use regulations and building codes based on scientific research. Through land-use planning, discourage new construction or development in identifying hazard areas without first implementing appropriate remedial measures.

Structural measures: Adopt remedial techniques (i.e., buttresses, shear keys, sub-drains, soil reinforcement, retaining walls, etc.) of existing landslides that are in close proximity to public structures.

Afforestation: The afforestation program should be properly planned so the little slope modification is done in the process. Bounding of any sort using boulders, etc. has to be avoided. The selection of suitable plant species should be such that can with stand the existing stress conditions of the terrain.

Landslides Safety Tips: Before and during:

- Avoid building houses near steep slopes, close to mountain edges, near drainage ways or along natural erosion valleys.
- Avoid going to places affected by debris flow. In mud flow areas, build channels to direct the flow around buildings.
- Stay alert and awake. Many deaths from landslides occur while people are sleeping.
- Listen for unusual sounds that might indicate moving debris, such as trees cracking or boulders knocking together.
- Move away from the landslide path or debris flow as quickly as possible.
- Avoid river valleys and low-lying areas. If you are near a stream or channel, be alert for any sudden increase or decrease in water flow and notice whether the water changes from clear to muddy.

After:

- Go to a designated public shelter if you have been told to evacuate.
- Stay away from the slide area as there may be danger of additional slides.
- Check for injured and trapped persons near the slide, without entering the direct slide area.

Volcanoes

What is a Volcano?

A volcano is a vent or chimney which transfers molten rock known as magma from depth to the Earth's surface. Magma erupting from a volcano is called lava and is the material which builds up the cone surrounding the vent.

A volcano is active if it is erupting lava, releasing gas or generates seismic activity. A volcano is dormant if it has not erupted for a long time, but could erupt again in the future. Once a volcano has been dormant for more than 10 000 years, it is termed extinct. The explosiveness of a volcanic eruption depends on how easily magma can flow and the amount of gas trapped within the magma. Large amounts of water and carbon dioxide are dissolved in magma causing it to behave in a similar way to gas expanding in fizzy drinks, which forms bubbles and escapes after opening.

Volcanoes can be different in appearance with some featuring perfect cone shapes while others are deep depressions filled with water. The form of a volcano provides a clue to the type and size of its eruption which is controlled by the characteristics and composition of magma. The size, style and frequency of eruptions can differ greatly, but all these elements correlated to the shape of a volcano. Three common volcanoes are:

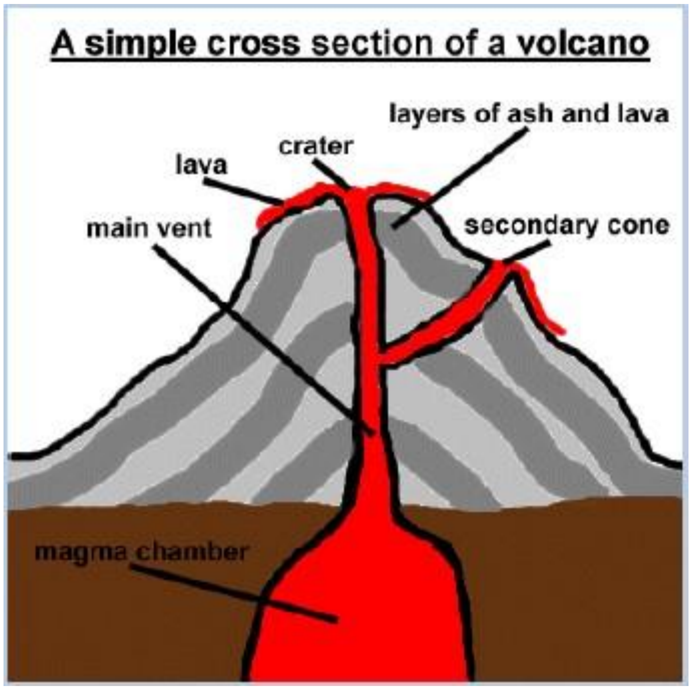
Shield volcano
When magma is very hot and runny, gases can escape and eruptions are gentle with considerable amounts of magma reaching the surface to form lava flows. Shield volcanoes have a broad, flattened dome-like shape created by layers of runny lava flowing over its surface and cooling. Because the lava flows easily, it can move down gradual slopes over great distances from the volcanic vents. The lava flows are sufficiently slow for humans to outrun or outwalk them. This type of magma has a temperature between 800°C and 1200°C and is called basaltic magma.

Composite volcano (Strato)
Also known as strato-volcanoes, these volcanoes are characterized by an explosive eruption style. When magma is slightly cooler it is thick and sticky, or viscous, which makes it harder for gas bubbles to expand and escape. The resulting pressure causes the magma to foam and explode violently, blasting it into tiny pieces known as volcanic ash. These eruptions create steep sided cones. They can also create lava flows, hot ash clouds called pyroclastic flows and dangerous mudflows called lahars. This type of magma has a temperature between 800°C and 1000°C and is called andesitic magma.

Caldera volcano
These erupt so explosively that little material builds up near the vent. Eruptions partly or entirely empty the underlying magma chamber which leaves the region around the vent unsupported, causing it to sink or collapse under its own weight. The resulting basin-shaped depression is roughly circular and is usually several kilometers or more in diameter. The lava erupted from caldera volcanoes is very viscous and generally the coolest with temperatures ranging from 650°C to 800°C and is called rhyolitic magma. Although caldera volcanoes are rare, they are the most dangerous. Volcanic hazards from this type of eruption include widespread ash fall, large pyroclastic surges and tsunami from caldera collapse into oceans.

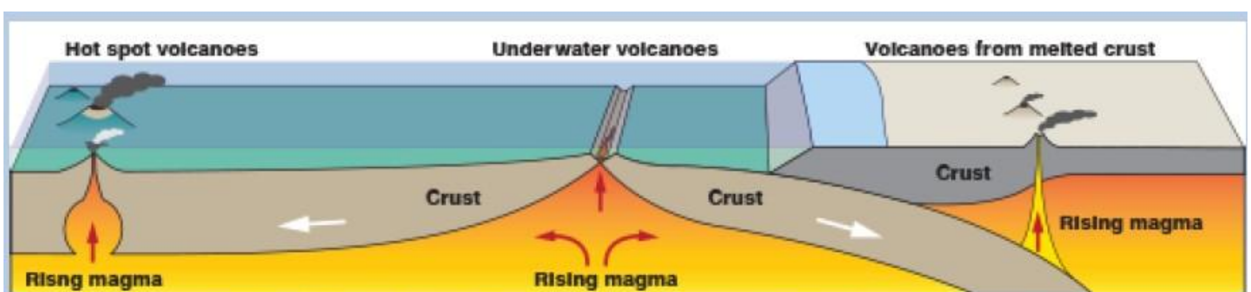
Volcanic hazards
Volcanic hazards include explosions, lava flows, bombs or ballistics, ash or tephra, pyroclastic flows, pyroclastic surges, mudflows or lahars, landslides, earthquakes, ground deformation, tsunami, air shocks, lightning, poisonous gas and glacial outburst flooding known as jökulhlaups. Each hazard has a different consequence, although not all occur in all eruptions or in association with all volcanoes. Volcanic eruptions are measured using a simple descriptive index known as the Volcano Explosivity Index, which ranges from zero to eight. The index combines the volume of material ejected with the height of an eruption column and the duration of the eruption.

What are the main features of a volcano?



What Causes Volcanoes?

Volcanoes occur when material significantly warmer than its surroundings is erupted onto the surface of a planet or moon from its interior. On Earth, the erupted material can be liquid rock ("lava" when it's on the surface, "magma" when it's underground), ash, cinders, and/or gas. There are three reasons why magma might rise and cause eruptions onto Earth"s surface.



Volcanoes on Earth form from rising magma. Magma rises in three different ways.

Volcanoes on Earth form from rising magma. Magma rises in three different ways

Magma can rise when pieces of Earth's crust called tectonic plates slowly move away from each other. The magma rises up to fill in the space. When this happens underwater volcanoes can form. Magma also rises when these tectonic plates move toward each other. When this happens, part of Earth's crust can be forced deep into its interior. The high heat and pressure cause the crust to melt and rise as magma. A final way that magma rises is over hot spots. Hot spots are exactly what they sound like-hot areas inside of Earth. These areas heat up magma. The magma becomes less dense. When it is less dense it rises. Each of the reasons for rising magma are a bit different, but each can form volcanoes.

Types of Volcano

If asked to draw a volcano, most people will sketch a steep, cone-shaped mountain, usually with clouds billowing from the summit. This is one type, but some of the most explosive volcanoes are less obvious, and represented by large depressions that may be filled with water. Although New Zealand"s active volcanoes look quite different from one another, they can be grouped into three main landform types:

- Classic cones or stratovolcanoes
- Volcanic fields
- Calderas and collapse craters.

Each of these has distinct landforms, and the violence and styles of eruptions are unique to each. These differences reflect the main type of magma erupted:

- Andesite at the cone volcanoes
- Basalt at the volcanic fields
- Rhyolite at the calderas.

How is the Volcano Formed? The glowing magma of Earth"s mantle pushes up towards the surface, searching for ways to escape through cracks in the Earth"s crust. It does not always get through. If the crust is too dense, the magma stops and flows back,until, with the gasses of the magma, it stays trapped. In time it succeeds in escaping- then, it explodes like a cork from a bottle. A volcano is „born". This erupts magma into the air in the form of molten lava, gas, ash and solid fragments.

How safe are Volcanoes? Volcanoes are much safer than other natural events such as earthquakes, floods, and hurricanes. However, volcanic eruptions can hurl hot rocks for at least 30 km. Floods, airborne ash, or noxious fumes can spread 160 km or more. If you live or work near a known volcano, active or dormant, be ready to evacuate at a moment"s notice. Stay out of the area. A lateral blast of a volcano can travel many km from the mountain. Trying to watch an erupting volcano is a deadly idea.

- Be prepared for these disasters that can be spawned by volcanoes: earthquakes, flash floods, landslides and mudflows, thunderstorms, tsunamis.

- Evacuation: Although it may seem safe to stay at home or in the office and wait out and eruption, doing so could be very dangerous. The rock debris from a volcano can break windows and set buildings on fire. Leave the area before the disaster begins.

Safety recommendations when visiting an active Volcano

Pre-Planning Read about past eruptions: Volcanic eruptions can repeat themselves. What the volcano has done in the past is what it is capable of doing in the future. While volcanoes are inherently unpredictable, studies of past eruptions at a particular volcano will give anindication of what is possible.

Read about past accidents: Analyze what went wrong in past accidents. The Bulletin of the Global Volcanism Network (Smithsonian Institute) has the best monthly volcanic activity reports including accident reports. Two accidents have happened on field trips associated with International Volcanology Conferences (Galeras in 1993 and Semeru 2000). Many scientists are inexperienced when it comes to climbing volcanoes. Theoretical knowledge is no replacement for field experience.

Observe the volcano for at least 24 hours before getting close to the danger zone: Record the number of explosions per hour and know what the volcano is doing. Sometimes a two to three day observation period is required before approaching the summit area. Simply arriving at the volcano and climbing straight to the summit is asking for trouble!

Know the current volcano warning level: How does this compare to the "normal" state of volcanic activity. Volcano warning levels may be expressed in different forms. Warning levels may mean different things on different volcanoes. Learn what the current activity level means for the particular volcano you are visiting. Remember, most volcanoes are not monitored by scientists so don't rely on the authorities knowing the danger level. Absence of evidence is not evidence of absence. If there is no current eruption warning, it does not necessarily mean the volcano is safe.

Take all precautions in Preventing an accident: Be very conservative in your actions. Don't assume the volcano is safe if everything looks quiet. It may be the "calm before the storm". A blocked vent can be quiet but the pressure can be building to a large eruption.

Precautions in the Danger Zone Wear the correct equipment at all times: Wear a helmet and take a gas mask. If your helmet is not strapped on at all times it is useless. Even effusive volcanoes like Kilauea may send dangerous projectiles into the air from lava sea-water interactions and methane explosions. Unstable ground can result in falls and head injuries.

Beware of many sources of danger on a volcano: Extreme heat, cold, windstorms, heavy rain/ acid rainfall, lightning, altitude sickness, blizzards, getting lost, volcanic activity, unstable terrain, dangerous plants, animals, and insects. Volcanoes generate their own weather which can be severe and different from that only a few km away. Localized wind storms may reach 150 km/hr without warning. Cooling lava flows may still be deadly, when rain falling on the hot surface may displace breathable air after it flashes to steam (people died from the effect at Nyiragongo eruption in 2002).

Survey the ground on approach to the crater: Look for evidence of recent ejecta. If you can see recent bombs on the ground then you can be hit. Limit your time in that area. It is preferable you relocate to a safer zone. Some vents eject projectiles in a particular direction. Don't stay in the firing line. Recent bombs are black and stand out from the brown colour of older lava.

Watch out for rock falls and avalanches when climbing the crater: Falling rocks and unstable ground pose one of the most immediate hazards when climbing a volcano. Don't kick rocks down the slope and try to limit your impact on the unstable terrain. Watch out for other climbers above and below you. The crater edge may be overhanging. Know where you are walking at all times. Be careful of new ground slumping or cracking.

Beware of Hazardous Gases: Hazardous gases emitted by volcanoes include carbon dioxide, sulfur dioxide, hydrogen sulfide, radon, hydrogen chloride, hydrofluoric acid, and sulfuric acid. Gases can be toxic directly or displace oxygen from the environment leading to anoxia. Never enter a depression near active fumaroles, especially on a day without wind. Toxic gases can pool in the depression leading to a dangerous situation.

Can you directly see the vent: If you can directly see the vent then the projectiles have a direct line of sight to you. Rocks and lava can be ejected at 200 m per second, sometimes even supersonic. You might be hit before you even hear the explosion. Lateral projectiles are some of the most dangerous and can be lethal in even a minor eruption.

Do’s & Dont’s

Before a Volcano There is usually plenty of warning that a volcano is preparing to erupt. Scientists monitor the Cascade range volcanoes as well as those in Hawaii and Alaska for information to help predict volcanic events. Many communities close to volcanoes now have volcano warning systems to alert citizens. But, if you live anywhere in Washington, Oregon, California, Idaho, Utah, and possibly Wyoming and Nevada you may be affected by an eruption in the Cascade range. Taking a few precautions now won't cost much and are a good idea to do anyway:

- Keep 3 extra air filters and oil filters on hand for your vehicle.
- Keep 3 extra filters for your home heating/cooling system.
- Keep a roll of plastic wrap and packing tape so you can wrap and protect computers, electronics, and appliances from ash.
- Store emergency food and water in your home.
- Find out if your community has a warning system and know the warning signs.
- Create an evacuation plan. It is best to head for high ground away from the eruption to protect against flood danger.
- Define an out-of-town contact for all family members to reach to check in.
- Besides your family emergency kit, have disposable breathing masks and goggles for each family member.

During an Eruption Much like a tsunami, a volcano is usually a sudden, explosive disaster requiring immediate evacuation to a safer location. The rock debris, pyroclastic flows, and floods will make the area around the volcano dangerous to anyone that stays. The lower valleys will be most dangerous.

- Follow the directions of authorities.
- Take your family emergency kit and evacuate.
- Evacuate to an area upwind rather than downwind if possible.
- When evacuating, if you are in a valley, or close to a stream, or crossing a bridge, check upstream for mudflows. A mud flow is extremely heavy and can destroy a bridge quickly. Take a different route or get to high ground quickly - mudflows can be extremely fast too.

If you are unable to evacuate,

- Seek shelter indoors if possible.

- Close all windows and doors to keep ash out. Seal up drafts. Do what you can to keep ash out.
- Seek higher ground - flash floods, mud, and poisonous gasses will accumulate in low- lying areas.
- Put on long pants, long-sleeved shirt, and hat.
- Wear a dust mask or wetted handkerchief to help filter ash.
- Leave your vehicles turned off until the eruption has ended and the dust can settle. Ash destroyed many vehicle engines during the Mount St. Helens eruption.

After an Eruption There is still danger after an eruption even if there is no flowing lava. The fact is, it may take years for the environment to recover from the changes caused by the volcano. And, ongoing tremors and further eruptions may make the area uninhabitable for a long time. In the short-term, recovery and clean-up includes:

Stay inside and listen for volcano information on your radio or tv.

- Minimize your movements and keep all windows and doors closed.
- Keep your skin covered with long pants, long-sleeved shirt and hat to avoid irritation from ash.
- If you have to go outside, where a dust mask and eye goggles.
- Drive slowly and carefully with your lights on - the ash is slippery and stirring it up will clog your enginge. If you do any driving in the ash, there is a good chance you will destroy your engine. Change your oil and air filters after 100 miles at the most when driving through heavy dust.
- Remove ash from your roof if you are concerned about its weight. More than 3 or 4 inches may be too much.
- Spray your yard with your water hose to dampen the ash. This helps keep it from blowing around more. Use as little water as possible.
- Check with your neighbors to see what help they need.
- Shake off and remove your outdoor clothes in your garage before going inside.
- Use your vacuum to dust - dustrags will act like sandpaper rubbing the ash around.
- Check in with your emergency contact to let them know your status and plan.
- Check with authorities on guidelines for ash removal and disposal.

Beyond Curriculum

Disaster Management Act and Policy in India

The Disaster Management Act of 2005 (DMA 2005) is an act passed by the government of India for the 'efficient management of disasters and other matters connected to it.

Features of the Disaster Management Act 2005?

The following governing bodies are established by DMA 2005.

1. National Disaster Management Authority (NDMA): The National Disaster Management Authority is headed by the Prime Minister of India as the chairperson and will have no more than nine members including a Vice-Chairperson. All the members will have a tenure of five years.

The main responsibility of the NDMA is to lay down the policies, plans and guidelines for disaster management to ensure an effective response in the event of any disaster.

2. National Executive Committee: The DMA empowers the Central Government to create a National Executive Committee (NEC) to assist the National Disaster Management Authority. The NEC consists of Secretary level officers of the government in the home, health, power, finance and agricultural ministries. The NEC is responsible for the preparation of the National Disaster Management Plan for the whole country and to ensure that it is "reviewed and updated annually".

3. State Disaster Management Authority: The State Disaster Management Authority (SDMA) is responsible for drawing the disaster plan for its respective state. It consists of the Chief Minister who is the chairperson and 8 members appointed by the Chief Minister.

The SDMA is mandated under section 28 to ensure that all the departments of the State prepare disaster management plans as prescribed by the National and State Authorities.

4. District Disaster Management Authority: The Chairperson of District Disaster Management Authority (DDMA) will be the Collector or District Magistrate or Deputy Commissioner of the district.

5. National Disaster Response Force (NDRF): The National Disaster Response Force is tasked with responding to a threatening disaster or a situation similar to it. The NDRF is led by a Director-General appointed by the Central Government. The NDRF has played a major role in rescuing people from many disaster-related events in the past such as the Kashmir floods of 2014 and the Kerala floods of 2018

What has been the progress made by DMA 2005?

The Disaster Management Act is based on the principle belief that mitigation of disaster-related losses is efficient that expenditure on relief and rehabilitation. The drawing up planes for strategic partnerships and course of actions to counter disasters of various degrees the act has made significant inroads in the following

- Detailed directions to guide disaster management efforts
- Capacity development in all spheres
- Consolidation of past initiatives and best practices
- Co-operation with agencies at national and international levels.

Criticism of the Disaster Management Act

- Even though the DMA has filled crucial gaps regarding Disaster Management in India it still comes with its fair share of criticism. One of its drawbacks is the absence of a provision for the declaration of 'disaster-prone zones'. The states can play a more active role when such provisions are made as this classification can help in mitigating the damages that will be caused
- The Act implies that disasters are a sudden occurrence when in fact they can be progressive in nature as well. For example, epidemics can be considered as disasters despite conventional definition as it does take thousands of lives in its wae. Epidemics of dengue and tuberculosis cause a lot of havoc yet no effective mechanism is in place to combat it.
- New disaster management guidelines are underway and one can only hope it incorporates provisions to overcome dysfunctions of the current authorities and not oversee yet again the valuable role that the civil society, private enterprises and NGOs can play towards building a safer India.

National Policy on Disaster Management

This policy aims at:

(i) Promoting a culture of prevention, preparedness and resilience at all levels through knowledge, innovation and education;

(ii) Encouraging mitigation measures based on technology, traditional wisdom and environmental sustainability;

(iii) Mainstreaming disaster management into the developmental planning process;

(iv) Establishing institutional and technolegal frameworks to create an enabling regulatory environment and a compliance regime;

(v) Ensuring efficient mechanism for identification, assessment and monitoring of disaster risks;

(vi) Developing contemporary forecasting and early warning systems backed by responsive and fail-safe communication with information technology support;

(vii) Ensuring efficient response and relief with a caring approach towards the needs of the vulnerable sections of the society;

(viii) Undertaking reconstruction as an opportunity to build disaster resilient structures and habitat for ensuring safer living; and

(ix) Promoting a productive and proactive partnership with the media for disaster management.