

Unit 1

Introduction, Definitions and Classification

Unit outcomes:

- Recognize the relevance of Nature and Natural calamities
- Understand the various types of disasters
- Differentiate between natural & man-made disasters
- Recognize the hazardous effects of disasters
- How to mitigate the risks due to disasters
- Identification of risk areas in India prone to disaster

1.0 Introduction

Disasters have been a natural phenomenon that has been re-occurring on this Earth from time immemorial. A study of scientific history has shown that earth and many life forms have developed after a major disaster on a cosmic scale, like the big bang. Hence, we need to understand the impact these disasters have on the life of humans and the direction in which future events will take place. The current century has witnessed a considerable increase in the awareness of the potential dangers that lurk in modern civilisation, which have been a result of both natural disasters and insensitive human activities. The resulting catastrophe has had a detrimental impact in terms of property damage, human live costs & ecological misuse. All these variables motivate us to understand disasters, how to manage them and reduce their impact. This course gives a detailed account of these factors.

1.1 Concepts and Definitions

Disaster, as defined by the United Nations, “Is a serious disruption of the functioning of a community or society”. Disaster management is how we deal with the human, material, economic or environmental impacts of the said disaster. It is



a process of how we “Prepare for or respond to and learn from the effects of major failures”

Hazard: Hazard is also considered as a potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption, or environmental degradation. Thus, an occurrence that has the potential to cause injuries to life or damage to property or environment is known as a hazard. The impact of hazard can be estimated as well as anticipated. Hazards can be classified into natural hazards or manmade hazards. An abundance of rain is an example of a Natural hazard and the operation of a dangerous factory near a residential area is an example of a Man-made hazard. Disaster occurs when a hazard impacts a vulnerable population and causes damage.

Vulnerability is a set of prevailing or consequential conditions arising from various physical, social, economic, and environmental factors which increase the susceptibility of a community to the impact of hazards

Risks measure the expected losses due to a hazard event occurring in each area over a specific time. Risk is a function of the probability of a hazardous event and the losses it would cause.

$$\text{Risk} = \text{Hazard} \times \text{Exposure} \times \left(\frac{\text{Vulnerability}}{\text{Manageability}} \right)$$

Resilience is the ability to flourish in the face of a disaster. An increased resilience allows us to be in a better position to anticipate disaster and thus lead to a plan to reduce the risks associated with the losses after the disaster.

1.2 Natural disasters

When we look through the world data, we can notice that over the past decade on average 0.1% of the total deaths is because of natural disasters. Natural disasters are catastrophic events that deal with atmospheric, geological, climatological and hydrological origins. These natural disasters lead to severe property damage, fatalities and even lead social-economic disruptions. Natural disasters are often the result of hazards affecting a very vulnerable community resulting in high morbidity and



mortality. The Asia Pacific region experienced the second largest number of natural disasters because of its size and susceptibility. These reasons make it imperative for us to study the types of natural disasters and their impact on human lives. The study helps us to reduce the risks that are a fall out of the natural disaster. Let us understand the various types of natural disasters that have impacted human lives.

1.2.1 Cloud bursts

Rains are a blessing to mankind and all forms of life. Water is the very essence of an ecosystem and the source of life. When precipitation forms water droplets that are larger than 0.5 mm, then it is referred to as "Rainfall". Other forms of water are snow, glaze, hail or even a cloudburst. A cloudburst is an extreme amount of precipitation in a short period accompanied by thunder and storms and can create a flood-like situation. Rain over 100 mm per hour is categorised as a cloudburst. India has long witnessed cloudbursts and recorded history dates to 1908 when around 15,000 people lost their lives during the Musi river flood which was caused by a cloudburst.

Why does a cloudburst occur?

Cloudburst occurs when clouds with high humidity stop at one place. The water droplets present there get mixed and the density of cloud becomes higher with the weight of the droplets. It usually occurs in high altitude areas due to the formation of a low-pressure area on the top of the mountain. The low-pressure zone attracts the clouds to the top of the mountain with great force. When they hit the peak the moisture content is released in the form of rain. In a cloudburst, up to 15 inches of rainfall can come in one hour. Cloudbursts are also known as flash floods because when clouds with high humidity stop at one place the droplets of water begin to mix and there would be heavy rainfall. In India, Cloudbursts occur frequently during monsoon in

- Himachal Pradesh
- Uttarakhand
- Jammu & Kashmir

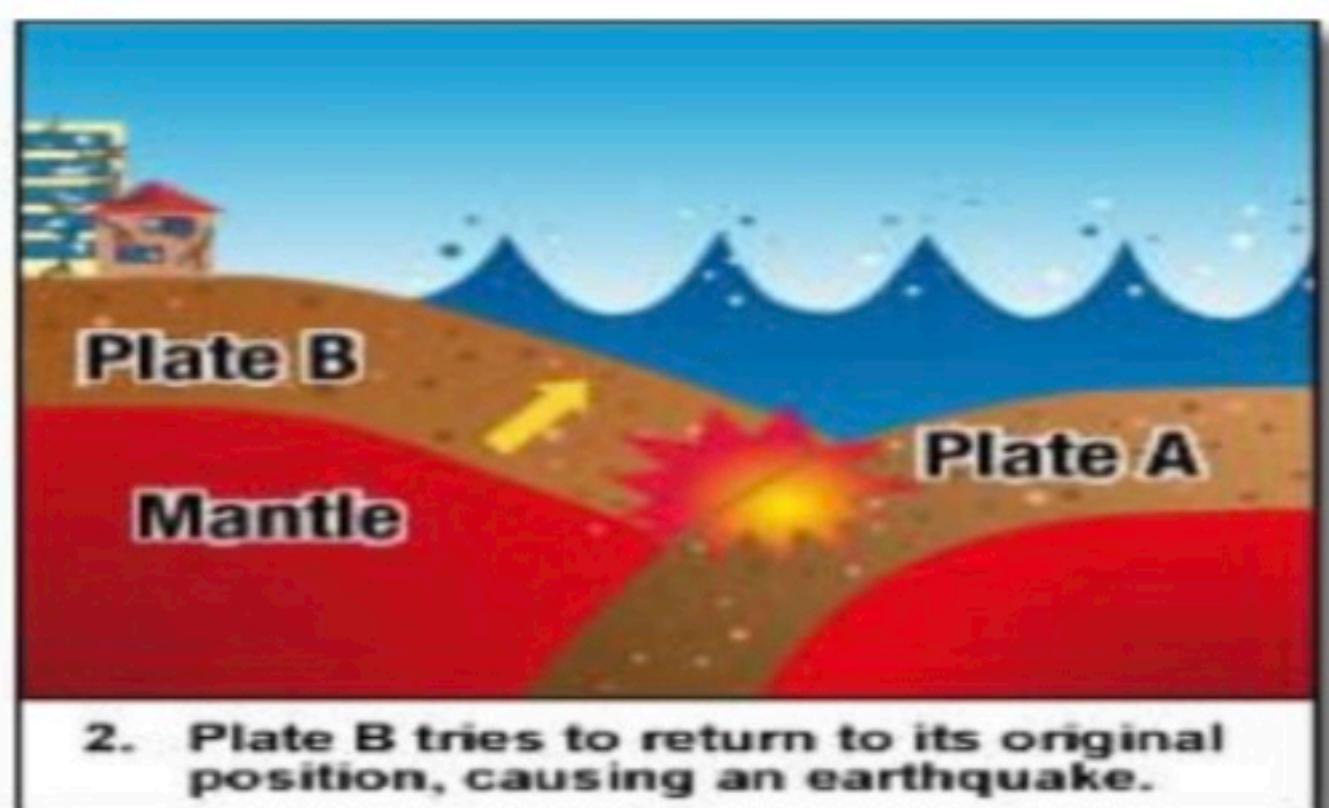
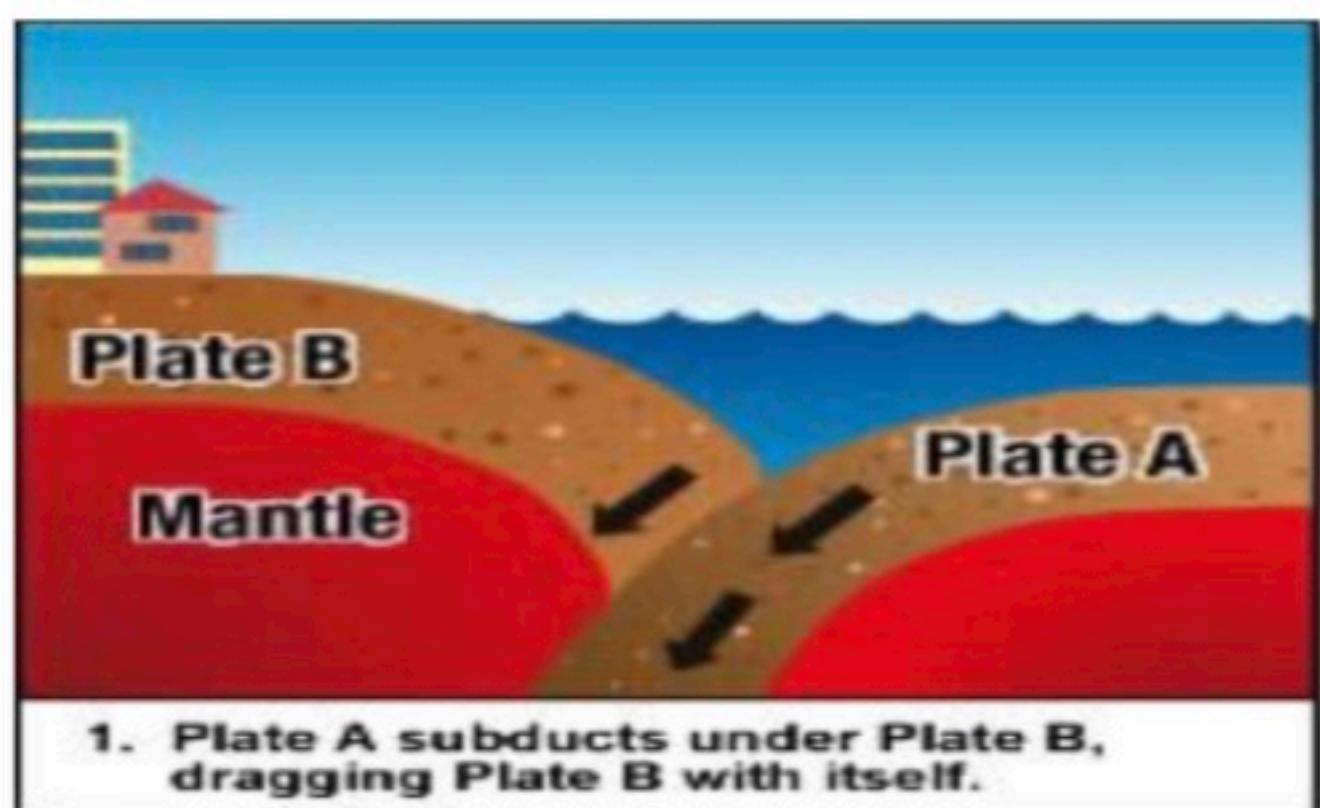
It's a natural phenomenon in the Himalayas. Garhwal & Kumaon regions of Uttarakhand also has witnessed numerous cloud bursts.

1.2.2 Earthquakes

Earthquakes, among the various types of natural disasters, have posed the biggest problem in terms of death tolls. It is one of the largest destructive natural hazards that mankind has witnessed. Earthquakes can be defined as a sudden movement of the earth's crust and can be experienced throughout the year. They leave a massive impact. Earthquakes occur due to the movement of the earth's crust. The crust of the earth is a rocky layer and has a varying thickness from about 10 kilometres to 65 kilometres depending on whether it is under the sea or beneath the continents. The crust is a collection of pieces of landmass and is called plates. Each plate would be running to a few thousand kilometres. According to the theory of plate tectonics, an earthquake is a result of sudden relief of pressure caused by compression of the earth 12-13 tectonic plates at their boundaries. Earthquakes are classified based on the depth of the focal point.

1. Deep (300 to 700 kilometres)
2. Medium (60 to 300 kilometres)
3. Shallow (less than 60 kilometres)

Depending upon the depth of the earthquake the impact of the earthquake varies. A seismograph is an instrument that is used to record the ground vibrations. The scale to measure earthquakes was developed by Charles Richter. Any earthquake which has a magnitude of 7.5 on the Richter scale releases thirty times the energy than with 6.5 magnitudes. The smallest earthquake that can be felt by humans is of the magnitude of 3 and the largest one would be above 7.5.

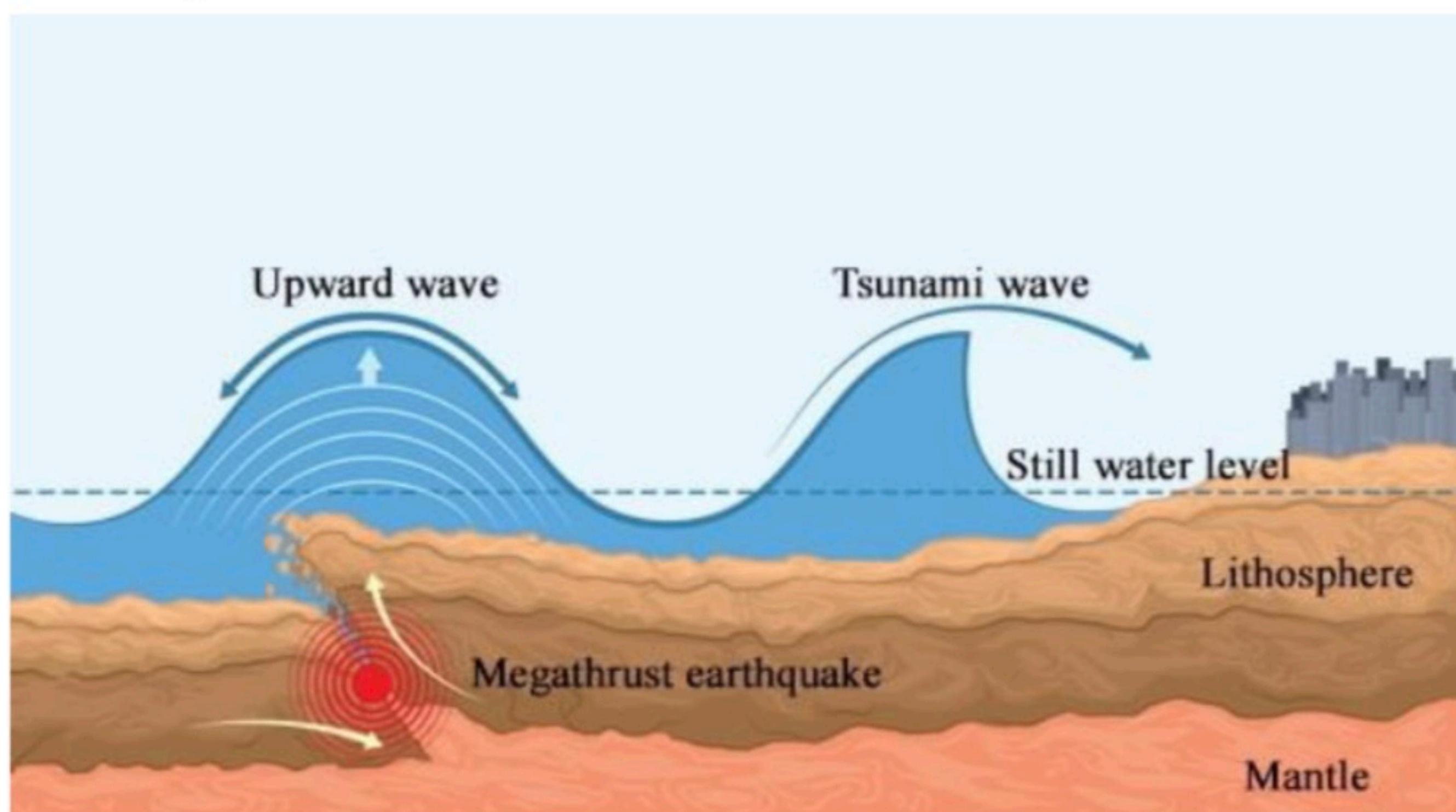


Source: [Earthquake | Intra and Inter-plate seismic events \(sms-tsunami-warning.com\)](http://Earthquake | Intra and Inter-plate seismic events (sms-tsunami-warning.com))

Figure1.1: Intra and interplate seismic events – earthquake

1.2.3 Tsunami

Tsunami is a Japanese term that denotes –“tsu” – harbour & “nami” – wave. A tsunami is a series of seismic sea waves caused by abrupt deformation of the seafloor, leading to vertical displacement of a large volume of overlying water. They cause widespread damage when they hit the land. A tsunami can occur due to earthquakes, volcanoes, underwater landslides, or any meteorite hitting the oceans. Most Tsunamis are caused by large underwater earthquakes at the tectonic boundaries. The tsunami can race the sea at up to 805 km per hour and the waves can go as high as 100 feet. They also create large scale hazards such as soil



Source: <https://www.iasparliament.com/article/indonesia-tsunami-causes>

Figure 1.2: Tsunami Formation

erosion, stripping beaches of sand, destruction of buildings & houses. The most devastating tsunami of recent times is of 2004, which hit the Indian ocean killing 2,30,000 people. Japan has been a country that has seen the longest recorded history of Tsunami and is well adapted towards reducing the devastation caused by the same. They are prone to earthquakes of varying magnitude and resulting tsunamis.

1.2.4 Snow Avalanches

Avalanche is derived from a French word that means descent. Avalanche is a mass of snow that slides down an inclined slope - such as a mountain or the roof of a building. Avalanches are triggered by natural forces such as wind drift, snow, rapid

temperature change, vibrations, earthquakes, or human activities. In the mountainous terrain, they are one of the most serious hazards to mankind. Avalanches are also called snow slides. Predicting an avalanche is nearly next to impossible but one can be prepared for the same. Usually, Avalanche occurs when the upper snow layers exceed the bonding force of a mass of snow. Some of the reasons that enhance the risk of avalanche are:

- Heavy snowfall combined with strong winds
- Unstable accumulation of wind-driven snow
- Rapid warming due to strong solar radiation

Avalanches occur more frequently on slopes that are more than 30 degrees steep, slopes that are close to a Ridge and are loaded with snow are also likely to increase the possibility of an avalanche. The human factor is another major reason that has triggered avalanches, especially sports such as skiing and hiking on snow-clad mountains. The intensity of the avalanche is based on weather conditions, human activities, and the terrains.

There are various forms of avalanches:

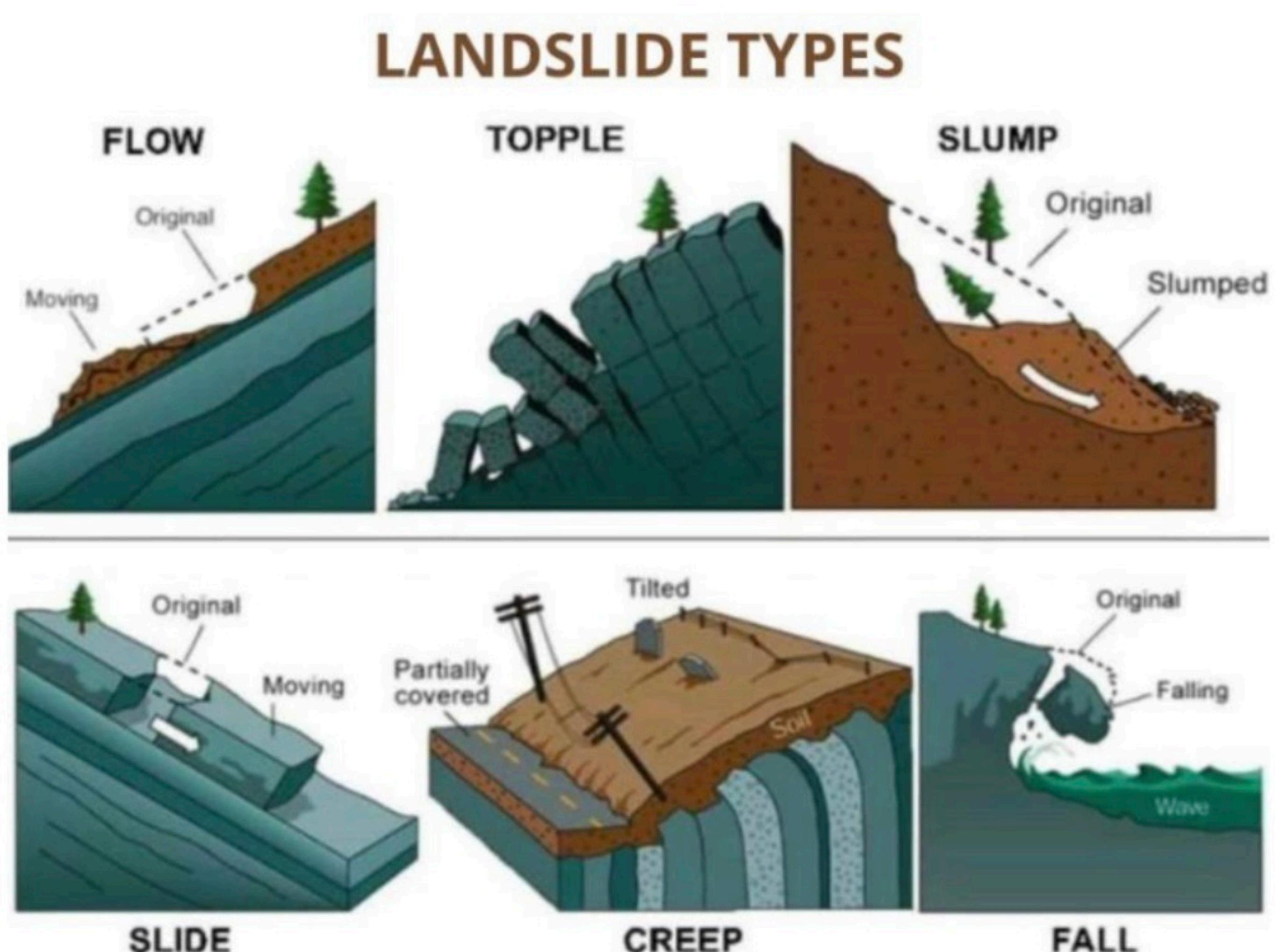
1. **Loose snow avalanches:** Is caused by fresh snow that spreads out as it falls down the mountain
2. **Icefall Avalanches:** These are normally seen on glaciers when a piece of glacier gets separated and droops down
3. **Roof avalanches:** These are the snow that accumulates on rooftops of houses and slides and falls off, causing injuries and death
4. **Slab avalanches:** With a speed of 120 miles an hour this is the most dangerous form of avalanche, where a huge chunk of snow slides down a mountainside

1.2.5 Landslides

Landslides refer to the downward movement of large masses of rocks and Soil. Landslides are caused by natural causes such as water precipitation, seismic activity, or volcanic activity. Numerous Anthropological activities like developmental activities, changing drainage patterns, irrigation, excavation or destabilising the slopes also trigger landslides. Landslides have damaged human settlements, agricultural fields, transport systems, communication lines and lead to massive losses annually.



The landslides are classified as follows:



Source: https://www.reddit.com/r/coolguides/comments/kju44z/landslide_types/

Figure 1.3: Types of Landslides

The landslides can be classified based on the sliding and materials involved

1. **Falls:** These are the sudden movement of the soil or debris or rocks that breaks away from the slopes or cliffs. There are numerous reasons for this kind of displacement viz. weathering, undercutting of slopes because of river flow, human activities like mining, excavation, road construction or earthquakes. The debris slides down and might bounce or roll down causing a massive impact on all that comes in its way. It causes innumerable hardship for days together till the debris settles down on the terrain.

2. **Topples:** They refer to a sudden forward rotation of a mass of soil or rocks around a point of axis. They occur due to the action of gravity and also due to the collection of water or ice or snow between the cracks of the masses. Topples can be extremely devastating if it is sudden and the velocity is high.
3. **Slide:** This is a kind of mass movement whereby the sliding material breakaways from the underlying stable material. The kinds of slides experienced during this type of landslide include rotational and transitional. Rotational slides are sometimes known as slumps since they move with rotation. Transitional slides consist of a planer or 2-dimensional surface of rupture.
4. **Spreads:** Spreads occur in places that have liquefiable soils. The speed of the spread is moderate compared to other types of slides. Generally, earthquakes trigger the spread. The velocity and impact of spread depends upon the extent of water saturation in the region
5. **Flows:** They are referred to as mudslides. They are common in volcanic areas. The flow is a rapid movement of the mass of earth where the mud, loose soil, rocks etc combine with water and form a sludge-like material that flows down the slope. The flow of this debris can be catastrophic.

The study of landslides is critical considering the annual economic losses they bring. Globally, landslides result in the expenditure of billions of dollars towards the rehabilitation of affected areas. Due to these astonishing annual losses, most governments have instituted bodies to deal specifically with landslides.

1.2.6 Forest fires

Forest fires are a serious threat to the entire flora and fauna of the environment. Recently we have seen the devastating impact of the forest fires in the Amazon jungle of Brazil, the fires razed around 19 million acres of the world's largest tropical forest. According to Britannica, "Forest fires are uncontrollable fire occurring in the combustible vegetation with more than 6ft height". 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.



Source: <https://www.ummid.com/news/2020/september/10.09.2020>

Figure 1.4: Forest Fires

Causes of Forest Fires:

- **Natural causes / Environmental causes (Uncontrollable)** - 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 favourable circumstances for a fire to start. A lot of climatic conditions such as temperature, speed of the wind and its direction, friction of bamboos swaying due to wind, rolling stones that sparks flames, Volcanic eruptions are other natural causes that trigger a forest fire.
- **Manmade causes (controllable)**- 90% of forest fire in India is attributed to human activities either intentionally or unintentionally. Burning of debris in the suburbs, campfires, electric sparks by engines, discarded beedi/cigarettes by careless visitors to the forest etc. trigger the forest fires. People who live close to the jungles have been a major source of forest fires. Accentuated human and cattle populations in these areas lead to a struggle for the use of natural resources and hence they end up using fire to ward off the wild animals or to increase the agricultural land. In most of these cases, forest fires are a result of sheer lack of care from the side of mankind.

The forest fires are classified into three categories:

- **Crown Fires:** These are referred to as Aerial or canopy fires. This kind of forest fire burns mainly above the ground. The crown fire burns the entire length of a tree from top to bottom. They are the most intense and dangerous wildfires.
- **Surface Fires:** These forest fires burn at the ground level. Dry leaves, vegetation found on the ground are burnt in this. They are referred to as crawl fires, as they spread in a crawling manner. They are less intense compared to crown fires and can be extinguished easily.
- **Ground Fire:** They are also referred to as subterrestrial, below the surface level. Fire is caught by the collected humus or dead vegetation that are dry enough to initiate a burn. These are the slowest of the forest fires but may go on for an entire season in a suppressed manner and are difficult to be put out completely.

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.

1.2.7 Floods

A flood is a state of high-water level along a river channel or on the coast that leads to inundation of land, which is not usually submerged. Floods may happen gradually and may take hours or even happen suddenly without any warning due to breaches in the embankment, spillover, heavy rains etc. India is one of the most flood-prone countries in the world. It is estimated that around 40 million hectares of land, spread over 23 states (roughly one-eighth of the country's geographical area), is prone to floods. Almost all river basins are prone to floods in India. Most floods in India occur during the monsoon season (south-west monsoon/summer monsoon) and are usually associated with tropical storms or depressions.

Causes of Floods: Floods are caused by various natural reasons such as

- Climate change
- Heavy rainfall
- Landslides, that block the flow of water
- Cloudbursts
- Opening of dams or reservoirs



- Storms or cyclones are accompanied by heavy rainfall

They are also caused by manmade reasons such as deforestation, unplanned development, urbanisation, etc., there are now increased frequencies of floods. Flooding has increased sedimentation and reduced capacity of drainage capacity of the rivers. Due to reduced capacity, streams and rivers overflow their banks, flooding large tracts in the plains and the downstream. Human-induced waterlogging also plays havoc where unscientific surface irrigation is done.

Floods have been categorised as follows:

- **River flood:** Flooding of rivers occur naturally and frequently. While most floods occur seasonally during monsoon or spring rains, torrential rains could also produce flooding.
- **Coastal flood:** Ocean water is driven to the shore due to winds generated from tropical storms and hurricanes, tsunamis, tidal waves, or offshore low-pressure systems. This flooding that drives ocean water inland is known as coastal-flooding.
- **Urban flood:** Due to urbanisation, the land loses its ability to absorb runoff. During rainy seasons streets are converted into swift-moving rivers due to the inadequate carrying capacity of drains, and the entire area becomes flooded with water.
- **Flash flood:** Flash floods are floods that rise rapidly and fall even faster. It allows scope for little or no warning. Flash floods occur usually due to intense excessive rainfall over a relatively small area.
- **Ice jam:** Ice jam is a dam-like natural or artificial obstruction due to the accumulation of ice, stopping the flow of water and causing floods. The rapid melting of snow can also cause floods.

Floods are local and short-lived events that happen suddenly and mostly without any warning. Due to the unique topography and climatic characteristics of the Indian Sub-continent, many of its parts are susceptible to different types of floods. During the year 2019-2020, many states in India have suffered huge economic losses and displacement of people due to the floods. Untimely rains and unpreparedness to meet this natural disaster have taken a huge death toll in the country.

1.2.8 Drought

"Water in excess is trouble and in absence is detrimental". In the previous subsection, we saw the calamity that excess water in the form of flood causes, now we focus on the impact of the shortage of water – which is referred to as "Drought". Drought is either absence or deficiency of rainfall from its normal pattern in a region for an extended period leading to general suffering in the society. An unusual dry spell in the climate can cause an acute shortage of potable water. Drought is a Hydrometeorological hazard.

Droughts have been caused by numerous environmental reasons like global warming, & deficit rainfall. Besides, man-made issues such as overpopulation, deforestation, overgrazing, unlimited use of ground and surface water and loss of biodiversity have adversely contributed to an increase in droughts.

Types of droughts: Based on the concept of utilisation, droughts have been classified as follows:

- **Meteorological drought:** Meteorological drought is a simple absence/deficit of rainfall from the normal. It is the least severe form of drought and is often identified by sunny days and hot weather.
- **Hydrological drought:** Hydrological drought often leads to the reduction of natural stream flows or groundwater levels, plus stored water supplies. The main impact is on water resource systems.
- **Agricultural drought:** This form of drought occurs when the moisture level in the soil is insufficient to maintain average crop yields. Initial consequences are in the reduced seasonal output of crops and other related products. Extreme agricultural drought can lead to famine, which is a prolonged shortage of food in a restricted region causing widespread disease and death from starvation.
- **Socio-economic drought:** Socio-economic drought correlates the supply and demand of goods and services with the three above-mentioned types of droughts. When the supply of some goods or services such as water and electricity are weather dependant then drought may cause shortages in the supply of these economic goods.



Droughts play havoc mostly in developing countries that are dependent on rain-fed agriculture. In addition to untold miseries, droughts can cause economic costs of astronomical proportion. Economic costs of drought are dependent on several factors, like the severity of the hazard, duration and location of the vulnerability, the people affected by it, and the extent of exposure. According to WHO, 68% of India is susceptible to drought, hence due diligence must be taken in handling this natural disaster.

1.2.9 Cyclones

Cyclones develop due to conventional air currents. When warm oceans give rise to hot air, they create a sequence of convectional air currents. Cyclones occur when these conventional air currents are being displaced. Because of the earth's rotation cyclones happen anticlockwise in the Northern Hemisphere, and clockwise in the southern hemisphere. Cyclones can be of various sizes, with the largest spanning thousands of kilometres. It could last for days or even weeks.



Source: <https://www.jagranjosh.com/general-knowledge/list-of-cyclones-in-india-1591178815-1>

Figure 1.5: Formation of a cyclone

There are mainly three classes of cyclones

- **Tropical cyclones:** Tropical cyclones are formed over the oceans in the area near the equator, between the Tropic of Cancer and Capricorn. They have different names in different parts of the world like 'typhoons' & 'hurricanes'. Cyclones can also bring in thundershowers and flooding rains. They could cause severe property damage and deaths by drowning. When cyclones are strong, they are highly damaging. They produce violent winds over hundreds of square kilometres in area, combined with torrential rainfall, often combined with storm surge.

- **Extra-tropical cyclones:** Extra-tropical cyclones occur in non-tropical regions due to the unequal distribution between the equatorial regions and the poles. A developing Extra-tropical cyclone could produce very strong winds over a large region, and wind speed could reach up to about 10 meters per second, which could cause large scale devastation to structures, vegetation, and extensive loss of human life. Extra-tropical cyclones could lead to several different types of storms in succession, even within 24 hours. Some of them include severe thunderstorms with hail, tornados, rainstorms, ice storms, snowstorms, etc.
- **Polar cyclones:** These cyclones are called Polar lows. They are normally less than 100 km in diameter and are accompanied by heavy snowfalls and thunderstorms and hurricanes. The landfall of polar cyclones could be surprising and devastating and could pose danger to shipping and aircraft industries

India is one of the worst affected in the world by cyclones with its coast ranging to 7516 km. The East coast is more prone to cyclones and nearly 10% of the tropical cyclone of the world affect India. Climatic changes and hence the change in sea levels have increased the vulnerability of the people who live in the coastal belts of India. It is a natural disaster that is given maximum importance by the government to mitigate the risk that is posed by it.

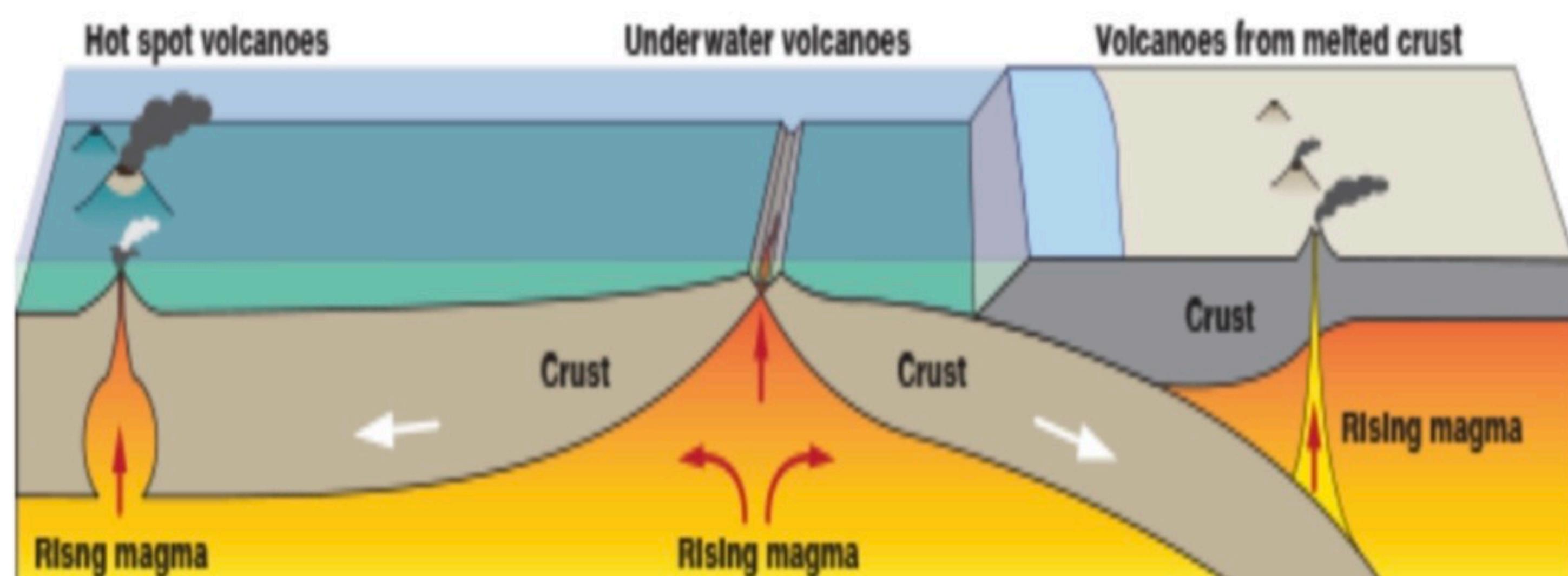
1.2.10 Volcanic hazards/ Mud volcanoes



Figure 1.6: Volcano eruption

A volcano is an opening on the surface of the earth, that allows material warmer than its surroundings to escape from its interior. When this material escapes, it causes an

eruption. Volcanoes occur when material significantly warmer than its surroundings erupts onto the surface of a planet 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.



Source: <https://spaceplace.nasa.gov/volcanoes2/en/>

Figure 1.7: Eruption of magma

- Magma can rise when pieces of Earth's crust called tectonic plates slowly move away from each other. The magma rises 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 magma. The magma becomes less dense. When it is less dense it rises.

Each of the reasons for rising magma is a bit different, but each can form volcanoes.

Mud volcanoes

Mud volcanoes are called mud pots. It is created by a series of slurries, water and gasses combined. There are numerous reasons for the formation of mud volcanoes. One of them is the hot water is steams out from the heat under the earth's surface, it mixes with the minerals and forms a sludgy material that seeps out of the fissure on

the earth's surface. They don't produce lava-like other volcanoes, but the eruption contains salts, acids, and hydrocarbons. A mud volcano occurs when pressures deep within the Earth cause the spewing of mud, gases, and liquids, like acidic water, onto the surface. A mud volcano occurs in subduction zones, when one of the earth's tectonic plates moves under another, causing it to sink due to gravity at their convergent points. Mud volcano eruptions usually release gases, especially large quantities of methane, and smaller quantities of nitrogen and carbon dioxide. A mud volcano can appear hill or mound-shaped. In India, these types of mud volcanoes are in the Andaman Islands.



Source: <https://www.worldatlas.com/articles/what-is-a-mud-volcano.html>

Figure 1.8: Mud volcano

1.3 Hazardous effects and environmental impacts of natural disasters

Natural disasters can cause life-changing situations in a matter of seconds. The disaster impacts human lives, causes ecological imbalances, disrupts transportation and communication, and causes death. The magnitude of the disaster depends on the vulnerability of the people and the geological conditions. Each natural disaster has a different impact on the environment. This section of the chapter dwells on the hazardous effects of natural disasters.

Cloudbursts:

Cloud burst is extremely detrimental and leads to dire consequences. The cloud bursts result in a flood-like situation causing chaos. Cloudburst and associated disasters affect thousands of people every year and cause loss of life, property, livelihood, infrastructure, and the environment. They also lead to total power disruption, landslides and hence disconnectivity through loss of transportation

and communication. Besides this, there is severe damage to the dams and other reservoirs due to excessive water flow and hence leads to other collateral damages. In India, the Himalayan terrains have witnessed the consequences of cloud burst every year. Severe change in the natural habitat because of the landslides and loss of property and life is seen due to cloudbursts.

Floods:

- Casualties arising due to drowning and people getting washed away
- Flood water can often be contaminated with drainage and hence leads to diseases and the spread of an epidemic. It also leads to a severe shortage of potable water.
- Power supplies can be disrupted, and the transportation networks would be affected.
- Collateral damage to public and private property, leading to habitat displacement of people
- Economic and social losses due to loss of business, livelihood and employment
- Severe damage to cattle and crops due to silt and sediments deposited on banks of the river
- Wildlife can be severely affected due to floods
- Rivers can swell up and change their course, causing another hazard
- Uprooting of trees and thus leading to soil erosion

Earthquakes:

Earthquakes are natural disasters that have a cascading impact. They result in numerous other natural disasters like Tsunami, Landslides & avalanches, floods, and volcanoes. Besides this, the earthquakes also result in

- Fire
- Loss of human and animal life
- Mass wasting
- Demolition of man-made structures
- Infections and contamination of water due to floods
- Liquefaction

❖ **Tsunami:** Impact of Tsunami:

- Environmental degradation
- Casualties & diseases
- Economic losses
- Ruthless Destruction

Table 1.1: List of the worst Tsunami's that have shaken the world:

Country	Date	Impact	Cause of Tsunami
Sumatra, Indonesia	26 th Dec,2004	Death :2,30,000	Magnitude :9.3
North Pacific Coast, Japan	11 th March, 2011	Death:18,000	Magnitude :9.0
Lisbon, Portugal	01 st , November,1755	Death:60,000	Magnitude :8.5
Krakatau, Indonesia	27 th August ,1883	Death:40,000	Volcano eruption
Enshunada, Japan	20 th , September,1498	Death:31,000	Magnitude :8.3

Cyclone:

Over the past years, nearly one million people have lost their lives owing to the massive devastations caused by Cyclones. The most recent of the killer cyclones was Katrina, which left a whooping loss of 100 billion euros. Every year, cyclones claim millions of lives across the globe, the damage to life and material damage is very severe as the strong torrential winds are followed by heavy rainfall leading to floods and storm surges. Even very mitigated cyclones cause severe damages and landslides. Because of cyclones, storm surges occur and because of the same, the seawater inundates low lying areas leading to death due to drowning. They also erode the sea beaches and embankments, reduce soil fertility, and destroy the vegetation. The risk assessment of Indian coasts indicates that nearly 32 crore people are vulnerable to the cyclonic hazards.



Volcano:

Volcanos are very different from most of the natural disasters that are described so far. Besides the loss of life and collateral damage that volcanoes can create, there are other threats that this natural disaster can cause such as:

- Ash discharged high up in the air can cause damage to the ozone layers
- People might suffer from gastrointestinal problems, lung issues and eye issues due to the ash and lava in the atmosphere
- Contamination of water in the nearby areas
- Ash mixed with rainwater and mud, may lead to the formation of lahar.
- Volcanic eruptions inside the sea may lead to an imbalance in sea life.

These were a few of the hazardous impacts the natural disaster might have on human lives as well as the environment.

1.4 Mitigation Measures

Mitigation measures refer to the actions taken for prevention or reduction of risk to the life of people, property damage and social-economic activity damage due to natural hazards. Awareness, education, preparedness, proper prediction, and warning systems are a must for a good mitigation system. Through these things, we can reduce the impact of natural disasters on society. Various Mitigation measures can be adopted such as

- Zoning of the land to understand the impact of an earthquake
- Proper land-use practices to provide safety for infrastructure
- Building codes to avoid developmental activities in flood-prone areas or landslide-prone areas

What would be required for a proper mitigation system is the participation of people in developing and implementing the mitigation measures. Close coordination between the researchers, practitioners' implementers and government officials is essential mitigation to be successful. Two types of mitigation measures are done:

- **Structural mitigation methods**

Structural Mitigations are the physical changes or acts of protection from disasters or hazards considering the geographical location, rainfall intensity, rainfall pattern, area



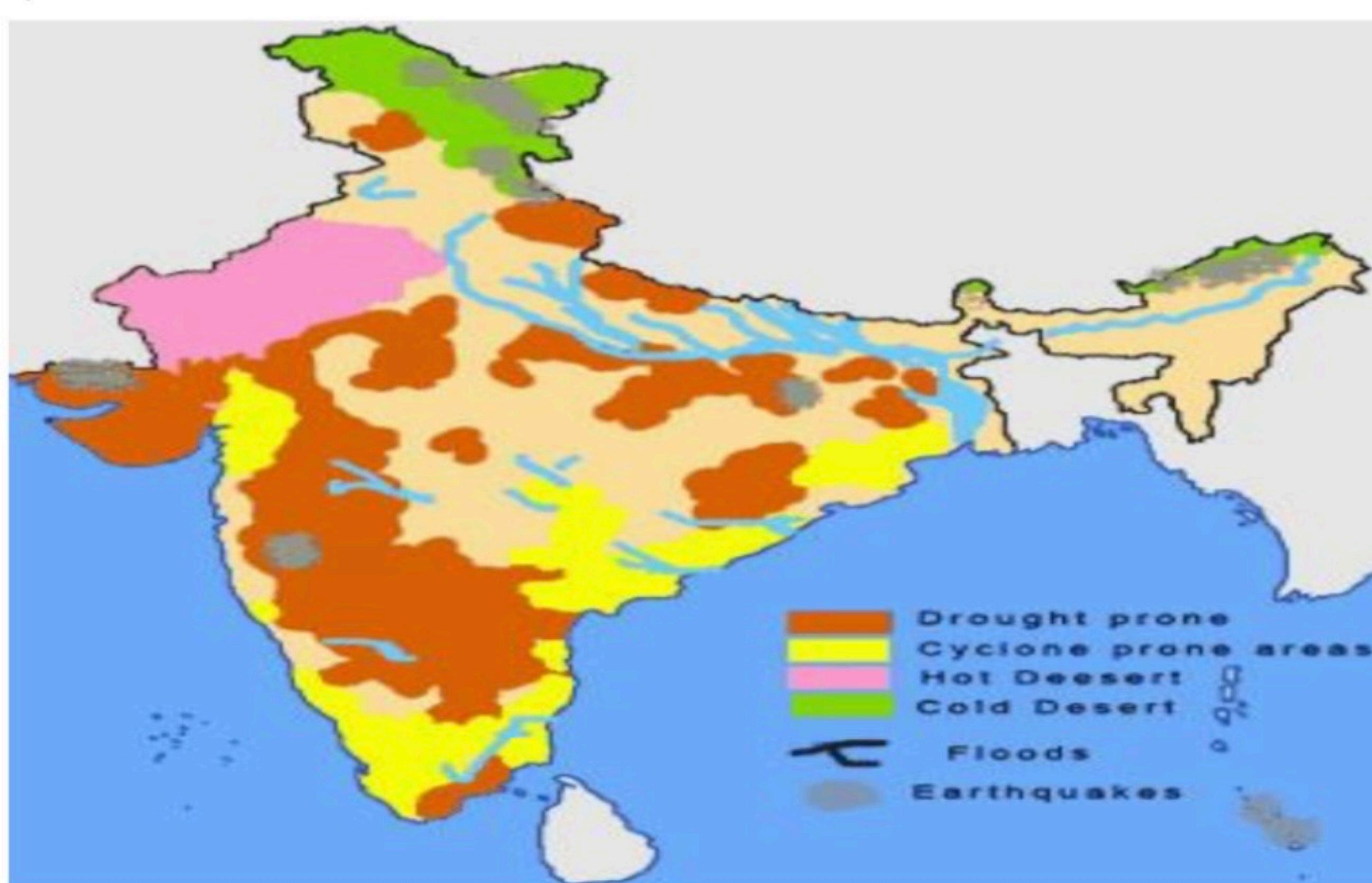
under land use. In general, structural mitigation is the direct actions that people take to build or move to a safer location to better preserve their life and or property.

- Non-structural mitigation methods

Non-structural Mitigation involves activities that are done on a personal level that is not structurally or physically evident as a protective defence. Any mental preparedness, training, insurance, discussion, and planning would be considered items of non-structural mitigation.

1.5 Natural disaster-prone areas in India

India is highly vulnerable to many kinds of natural hazards. Many studies have indicated that the losses due to natural disasters in the country are equated to 2% of the GDP of the nation. The following section of the unit gives details of the states in India prone to natural disasters.



Source: <http://www.maps-of-india.com/india-climatic-map/india-natural-hazards-map/>

Figure 1.9: Indian regions prone to Natural Disaster

Floods

Floods occur in almost all the river basins of the country. Around 12 per cent (40 million hectares) of land in India is prone to floods. Most of the flood-affected areas lie in the

- Ganga basin, Brahmaputra basin (comprising of Barak, Tista, Torsa, Subansiri, Sankosh, Dihang and Luhit),

- The north-western river basin (comprising Jhelum, Chenab, Ravi, Sutlej, Beas and the Ghagra),
- The peninsular river basin (Tapti, Narmada, Mahanadi, Baitarani, Godavari, Krishna, Pennar and the Kaveri)
- The coastal regions of Andhra Pradesh, Tamil Nādu, Orissa and Kerela.
- Assam, Uttar Pradesh, Bihar, and Orissa are some of the states who have been severely prone to floods

Cyclone

13 coastal states/UTs are encompassing 84 coastal districts which are affected by cyclones. Four States (Andhra Pradesh, Odisha, Tamil Nadu, and West Bengal) and one UT (Pondicherry) on the East Coast and One State (Gujarat) on the West Coast are more vulnerable to cyclone disasters. 40% of the total population lives within 100 km of coastline. Analysed data for the period 1980-2000 shows that on average, annually 370 million people are exposed to cyclones in India. Cyclones occur in the month of May-June and October-November, with the primary peak in November and the secondary peak in May.

Drought Prone Areas

Of the Indian States – Maharashtra, Odisha, Telangana, Karnataka, Rajasthan, Madhya Pradesh, Jharkhand, Andhra Pradesh, Uttar Pradesh & Chhattisgarh are categorised as drought-prone areas due to acute shortage of water.

Forest fires

Uttarakhand and Himachal Pradesh account for the maximum number of forest fires in India.

Earthquakes

The total number of seismic zones in India is four – Zone II, III, IV, and V. Zone V is the most active zone and Zone II is the least active.

- Zone V covers entire North-Eastern India, some parts of Jammu and Kashmir, some parts of Ladakh, the Rann of Kutch in Gujarat, Himachal Pradesh, Uttarakhand, some parts of North Bihar, and the Andaman & Nicobar Islands.
- Zone IV covers the remaining parts of Jammu & Kashmir, Himachal Pradesh, Ladakh, Delhi NCR, Sikkim, northern parts of Uttar Pradesh, Bihar, West Bengal, parts of Gujarat, small portions of Maharashtra, and Rajasthan.

- Zone III covers fragments of Uttar Pradesh, some shares of Punjab, Rajasthan, Gujarat, Kerala, Goa, Madhya Pradesh, Bihar, Jharkhand, Chhattisgarh, Lakshadweep islands, West Bengal, Maharashtra, Odisha, Andhra Pradesh, Tamil Nadu, and Karnataka.
- Zone II covers the remaining parts of the country. These are the least earthquake-prone areas in India.

1.6 Major natural disasters in India with special reference to Uttarakhand

Uttarakhand has all been in news, whether for its eye-catching landscapes or for the devastating natural disasters that struck the beautiful land. The geographical structure of Uttarakhand has been prone to various forms of natural disasters. From Earthquakes to landslides, cloudbursts, forest fires, avalanches and floods, this land has seen it all. Natural disasters have claimed numerous lives and crores of worth property. Uttarakhand falls in Zone V of earthquake-prone areas and is hence highly vulnerable to earthquakes. It also falls in the top two states that account for forest fires in the country. Besides, due to its location, the area is prone to landslides & Ice avalanches. A look through the major disasters that the state has witnessed:

- **1991:** Uttarkashi Earthquake. An earthquake of 6.8 hit Uttarkashi and 768 people lost their lives.
- **1998:** Malpa landslide, Pithoragarh district was wiped out and 255 people died.
- **1999:** Chamoli earthquake of 6.8 hit the district, 100 people died and the neighbouring Rudraprayag district too was affected. Several ground deformations were formed, roads were cracked, changes in water flow were also noticed along with landslides.
- **2013:** A cloudburst centred on Uttarakhand caused devastating floods and landslides. 5700 were presumed to be killed in the incident. 3,00,000 people were trapped in the valley leading to the Chardham pilgrimage.

- **2021:** Uttarakhand floods also referred to as the Chamoli disaster, was caused by a large rock and snow avalanche. It reported the death of 200 people and much more missing & homeless, especially from the Tapovan dam site.



Source: <https://theexampillar.com/ukgk/natural-disaster-in-uttarakhand/>

Figure 1.9: A glimpse of the natural disasters that struck Uttarakhand



Figure 1.9(a): A glimpse of the natural disasters that struck Uttarakhand

1.7 Manmade Disasters

Man-made disasters are catastrophes that mankind has invited through its selfish motives of indiscriminate urbanisation and developmental activities. Mother Nature has been bearing the brunt of mankind unsympathetic attitude towards nature. From chemical spills in the ocean to nuclear explosions numerous disasters have occurred to our developmental activities. The following section lists out the various manmade disasters that we are seeing across the globe.

1.7.1 Waterlogging

Indiscriminate urbanisation has led to waterlogging of the streets. One of the most common reasons for floods in major metropolitans like Mumbai and Chennai is due to waterlogging. The rains that these places receive are almost similar in the past years yet, the cities today get submerged in water due to waterlogging. Because of commercialisation and over-exploitation of the space available, overburdened drainage, unregulated constructions no space has been left for percolation of water into the water table and hence water flows on the streets. The waterlogging reduces the oxygen level in the root zone and hence changes the chemical equilibrium. These factors change the natural topography and are detrimental to the environment and living beings.

1.7.2 Groundwater depletion

India is witnessing a serious threat of groundwater depletion like the rest of the globe. Due to rapid urbanisation, overpopulation, and ever-increasing demands for water especially for irrigation, there has been acute exploitation of water tables. Based on scientific reports, India is one of the largest users of groundwater, especially for irrigation purposes. The Indo Gangetic plain, north-western and central part of India accounts for irrigation that is based on groundwater. Due to this overuse, these regions are facing a drought-like situation every two years because the natural recharge of water during the monsoon is insufficient. Rapid electrification, backed by good quality electric pumps has led to extensive use of pumps to draw water from the bore wells, adding to the misery of water depletion. Weak regulatory action, industrialisation and erratic rainfalls have added to the woes of groundwater table management. Though earth is filled with water sources like oceans and seas, if timely action isn't taken to save groundwater table, there would be a time when mankind would suffer from no water to drink.

1.7.3 Soil erosion

Soil is the uppermost layer of mother earth that nurtures the complex ecosystem. In the last 150 years, the earth has unfortunately lost half the quality of its topsoil due to erosion. Man-made hazards are mainly the reason that contributes to this pollution. Conversion of land filled with natural vegetation for the ever-growing demand for agriculture has resulted in the loss of soil fertility, increased salinity of the soil, degradation in the quality of nutrients and overall pollution of soil. The major reasons for soil erosion are:

- Deforestation
- Overgrazing
- Use of fertilisers and agrochemicals

The soil erosion gradually leads to the creation of new deserts, polluted waterways, and increased flooding.

1.7.4 Release of toxic gases and hazardous chemicals into the environment

A lot of toxic gases and chemicals are released into the environment because of industrialisation, transportation, and agriculture. Substances such as explosives, radioactive material, chemical materials that are harmful are being released into the



atmosphere. These toxics are posing a threat to the health and safety of people and are causing severe damage to the flora and fauna of the places. Based on reports from Toxic release inventory, in the last two years, around 3.4 billion pounds of toxics have been released through the industries. The oil spills in the oceans have a devastating impact on sea life. Pesticides and fertilisers sprayed to save agro-products have had a tremendous impact on insect life and the fertility of the soil has decreased. Many of the species of plants and animals have got extinct because of this man-made disaster. The smoke emitted by vehicles across the world is rampaging the atmospheric air. The incineration of plastic and other solid wastes in open premises is adding to the woe of environmental protection. The burning of fossil fuels, Mining activities & industrialisation is the major reasons for air pollution. The use of nuclear and chemical weapons for war also releases a huge amount of poisonous chemicals into the atmosphere. These pollutants are harming the environment and global warming is the biggest fallout of the same. Smog, acid rains and ozone depletion are the side effects of the release of these toxins into the atmosphere. Bhopal gas tragedy, endosulfan tragedy are examples of these manmade disasters and their long-term impact on human lives.

1.7.5 Nuclear explosion

The undesirable impact of radioactive substances in the environment is called nuclear pollution. Nuclear explosions are the most dangerous of manmade disasters. The atomic bomb dropped in Hiroshima Nagasaki still brings shivers down the spine of people. The effects of nuclear explosions are mainly divided into three phases – air blast, thermal radiation, and initial/residual nuclear radiation. The air blast generally results in casualties mainly due to structural damage and flying debris or deafening noise. But the major calamity of nuclear explosion comes during the last phase after the detonation / the radioactive material gets mixed with the ground surface (fall outs) and the acute effects of being exposed to radiation then emerge. The next generation also sees the fall out in the form of mutations, cancers, and deformation in children. It affects almost everything in the environment from planktons to humans. The land loses its fertility and lays barren for years. The plants, animals and vegetation get damaged to a point beyond description. Radioactive contamination is perhaps the most hazardous of all the pollutions as they remain for thousands of years. There is no way to have them assimilated in the soil, water, or air in the initial form. All these reasons

play a primary role in the UNO trying to see that countries refrain from going for nuclear explosions. Even the testing of these nuclear weapons also has the same cascading impact. Nuclear explosions and the use of radioactive material must be done with due diligence and can turn out to be the most dangerous man-made disaster if not.

Manmade disasters can always be mitigated through proper planning. A strategy that would encourage the developmental activities of mankind without disrupting or damaging the environment has been the main motto of various corporate and governments. With the growing awareness about these measures, we will be seeing a reduction in the impact of manmade disasters in the years to come.

1.8 Conclusion

The unit has introduced the reader to the concept of disaster management and taken through a journey of various kinds of disasters some natural and some manmade. The hazardous impacts of these disasters and how vulnerable are Indians to this disaster have been discussed in this unit. The next unit introduces the reader to the link that exists between disasters and the developmental activities of mankind.

Review Questions

1. Define the terms:
 - a. Risk
 - b. Resilience
 - c. Hazards
 - d. Disaster
2. Differentiate between Hazards & disasters with suitable examples
3. List of the various man-made disasters that have impacted earth.
4. Define Disaster. Explain in detail the classification of disasters.
5. What is a Natural Disaster? Which among the natural disasters do you think has impacted India the most
6. Enumerate on the various man-made disasters.
7. Discuss the economic and social impacts of any two types of disasters.
8. Discuss the various natural calamities that have struck India.
9. Discuss how our country is ready to face challenges that are posed by an earthquake.

