Classification of Natural Hazards and Disasters

Natural Hazards and the natural disasters that result can be divided into several different categories:

- Geologic Hazards - These are the main subject of this course and include:
  - Earthquakes
  - Volcanic Eruptions
  - Tsunami
  - Landslides
  - Floods
  - Subsidence
  - Impacts with space objects
- Atmospheric Hazards - These are also natural hazards but processes operating in the atmosphere are mainly responsible. They will also be considered in this course, and include:
  - Tropical Cyclones
  - Tornadoes
  - Droughts

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- Severe Thunderstorms
- Lightening

- Other Natural Hazards - These are hazards that may occur naturally, but don't fall in to either of the categories above. They will not be considered to any great extent in this course, but include:
  - Insect infestations
  - Disease epidemics
  - Wildfires

Natural Hazards can also be divided into catastrophic hazards, which have devastating consequences to huge numbers of people, or have a worldwide effect, such as impacts with large space objects, huge volcanic eruptions, world-wide disease epidemics, and world-wide droughts. Such catastrophic hazards only have a small chance of occurring, but can have devastating results if they do occur.

Natural Hazards can also be divided into rapid onset hazards, such as Volcanic Eruptions, Earthquakes, Flash floods, Landslides, Severe Thunderstorms, Lightening, and wildfires, which develop with little warning and strike rapidly. Slow onset hazards, like drought, insect infestations, and disease epidemics take years to develop.

Anthropogenic Hazards

These are hazards that occur as a result of human interaction with the environment. They include Technological Hazards, which occur due to exposure to hazardous substances, such as radon, mercury, asbestos fibers, and coal dust. They also include other hazards that have formed only through human interaction, such as acid rain, and contamination of the atmosphere or surface waters with harmful substances, as well as the potential for human destruction of the ozone layer and potential global warming.

Effects of Hazards

Hazardous process of all types can have primary, secondary, and tertiary effects.

- Primary Effects occur as a result of the process itself. For example, water damage during a flood or collapse of buildings during an earthquake, landslide, or hurricane.
- Secondary Effects occur only because a primary effect has caused them. For example, fires ignited as a result of earthquakes, disruption of electrical power and water service as a result of an earthquake, flood, or hurricane, or flooding caused by a landslide into a lake or river.

Tertiary Effects are long-term effects that are set off as a result of a primary event. These include things like loss of habitat caused by a flood, permanent changes in the position of river channel caused by flood, crop failure caused by a volcanic eruption etc.

Vulnerability to Hazards and Disasters

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- Vulnerability is the way a hazard or disaster will affect human life and property Vulnerability to a given hazard depends on:
- Proximity to a possible hazardous event
- Population density in the area proximal to the event
- Scientific understanding of the hazard
- Public education and awareness of the hazard
- Existence or non-existence of early-warning systems and lines of communication
- Availability and readiness of emergency infrastructure
- Construction styles and building codes
- Cultural factors that influence public response to warnings
- In general, less developed countries are more vulnerable to natural hazards than are industrialized countries because of lack of understanding, education, infrastructure, building codes, etc. Poverty also plays a role since poverty leads to poor building structure, increased population density, and lack of communication and infrastructure.
- Human intervention in natural processes can also increase vulnerability by
- Development and habitation of lands susceptible to hazards, for example, building on floodplains subject to floods, sea cliffs subject to landslides, coastlines subject to hurricanes and floods, or volcanic slopes subject to volcanic eruptions.
- Increasing the severity or frequency of a natural disaster. For example: overgrazing or deforestation leading to more severe erosion (floods, landslides), mining groundwater leading to subsidence, construction of roads on unstable slopes leading to landslides, or even contributing to global warming, leading to more severe storms.
- Affluence can also play a role, since affluence often controls where habitation takes place, for example along coastlines, or on volcanic slopes. Affluence also likely contributes to global warming, since it is the affluent societies that burn the most fossil fuels adding CO_2 to the atmosphere.

1.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.

Facts about 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

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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. Earthquakes are recorded by seismograph consisted of a seismometer, a shaking detector and a data recorder. The moment magnitude of an earthquake is conventionally reported, or the related and mostly obsolete Richter magnitude, with magnitude 3 or lower earthquakes being mostly imperceptible and magnitude 7 causing serious damage over large areas. Intensity of shaking is measured on the modified Mercalli scale. In India Medvedev-Sponheuer-Karnik scale, also known as the MSK or MSK-64, which is a macroseismic intensity scale, is used to evaluate the severity of ground shaking on the basis of observed effects in an area of the earthquake occurrence. Due to earthquake seismic waves are generated and measurements of their speed of travel are recorded by seismographs located around the planet.

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. Earthquakes are caused by natural tectonic interactions within the earth's crust and it is a global phenomenon. 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 Swaves, oscillate at right angles to it. Love waves cause surface motions similar to that by Swaves, 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 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.

Intensity

Intensity is a qualitative measure of the actual shaking at a location during an earthquake, and is assigned as Roman Capital Numerals. There are many intensity scales. Two commonly used ones are the Modified Mercalli Intensity (MM!) Scale and the MSK Scale. Both scales are quite similar and range from I (least perceptive) to XII (most severe). The intensity scales are based on three features of shaking - perception of people and animals, performance of buildings, and changes in natural surroundings. The distribution of intensity at different places during an earthquake is shown graphically using isoseismals, lines joining places with equal seismic intensity.

Classification 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.

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Intensity scale

It manifests the degree of damage, which gets diminished as we go away from the main shock source zone and the reverse is also true. Mercalli intensity scale The Mercalli intensity scale is a seismic scale used for measuring the intensity of an earthquake. It measures the effects of an earthquake, and is distinct from the moment magnitude usually reported for an earthquake (sometimes described as the obsolete Richter magnitude), which is a measure of the energy released. The intensity of an earthquake is not totally determined by its magnitude.

Scale quantifies the effects of an earthquake on the Earth's surface, humans, objects of nature, and man-made structures on a scale from I (not felt) to XII (total destruction). Values depend upon the distance to the earthquake, with the highest intensities being around the epicentre area. Data gathered from people who have experienced the quake are used to determine an intensity value for their location. The Mercalli (Intensity) scale originated with the widely-used simple ten-degree Rossi-Forel scale which was revised by Italian volcanologist, Giuseppe Mercalli in 1884 and 1906.

In 1902 the ten-degree Mercalli scale was expanded to twelve degrees by Italian physicist Adolfo Cancani. It was later completely re-written by the German geophysicist August Heinrich Sieberg and became known as the Mercalli-Cancani-Sieberg (MCS) scale. The Mercalli-Cancani-Sieberg scale was later modified by Harry O. Wood and Frank Neumann in 1931 as the Mercalli-Wood-Neumann (MWN) scale. It was later improved by Charles Richter, the father of the Richter magnitude scale. The scale is known today as the Modified Mercalli scale (MM) or Modified Mercalli Intensity scale (MMI).

Modified Mercalli Intensity Scale

The lower degrees of the Modified Mercalli Intensity scale generally deal with the manner in which the earthquake is felt by people. The higher numbers of the scale are based on observed structural damage

The small table is a rough guide to the degrees of the Modified Mercalli Intensity scale. The colors and descriptive names shown below differ from those used on certain shake maps in other articles

Magnitude	Typical Maximum Modified Mercalli Intensity
1.0 - 3.0	I
3.0 - 3.9	II - III
4.0 - 4.9	IV - V
5.0 - 5.9	VI - VII
6.0 - 6.9	VII - IX
7.0 and higher	VIII or higher

Modified Mercalli scale intensities that are typically observed at locations near the epicentre of the earthquake. The correlation between magnitude and intensity is far from total, depending upon several factors, including the depth of the earthquake,

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terrain, population density, and damage. For example, on May 19, 2011 an earthquake of magnitude 0.7 in Central California, United States 4 km deep was classified as of intensity III by the United States Geological Survey (USGS) over 100 miles (160 km) away from the epicentre (and II intensity almost 300 miles (480 km) from the epicentre), while a 4.5 magnitude quake in Salta, Argentina 164 km deep was of intensity I.

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.

(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 behaviour, 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.

Structural

No buildings can be made 100% safe against earthquake forces. Instead buildings and infrastructures can be made earthquake resistant to a certain extent depending upon serviceability requirements. Earthquake resistant design of buildings depends upon providing the building with strength, stiffness and inelastic deformation capacity, which are great enough to withstand a given level of earthquake-generated force. This is generally accomplished through the selection of an appropriate structural configuration and the careful detailing of structural members, such as beams and columns, and the connections between them. There are several different experimental techniques that can be used to test the response of structures to verify their seismic performance, one of which is the use of an earthquake shaking table (a shaking table, or simply shake table). This is a device for shaking structural models or building components with a wide range of simulated ground motions, including reproductions of recorded earthquakes time-histories.

Non-structural

The non-engineered traditional construction commonly practiced in different areas of the country depends greatly on the respective local context of the area. In other words, the technologies vary significantly from area to area. These technologies have evolved and as a result have got optimized. In India an overwhelming majority of houses, are of non-engineered load bearing type. These structures, especially houses, have been traditionally built over the past century or longer, using the locally available materials and the locally practiced technologies that have been most common in the area, including stone, bricks, earth, lime and timber for walls, and clay tiles, stone or mud for roofing supported on under-structure made of local timber such as Teak, Acacia, Neem, Deodar, Pine and also Bamboo. In the recently built structures one also finds a mix of the traditional and new materials/technology such as cement, concrete and steel. The structures have a pitched roof or flat roof, and are single story or double story. After earthquake, significant effort was taken to repair and strengthening of damaged buildings. A guideline for Repair and strengthening guide for earthquake damaged low rise domestic buildings in Gujarat is made.

VOLCANIC ERUPTION

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About Volcano

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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.

As magma rises quickly through the Earth's crust, gas bubbles form and expand up to 1000 times their original size.

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

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eruptions can differ greatly but all these elements correlated to the shape of a volcano.

EFFECTS OF VOLCANOES

A volcano eruption is one of the most impressive events in the planet and the effects of volcanoes and their eruptions could be felt as far away as a different continent. The type of effects of volcanoes depends on the size of the eruption. Some volcanoes could be erupting and not cause much damage even to people nearby while others are so massive that should they erupt they could trigger a world sized catastrophe. So what type of disturbances would you see if there was a massive eruption today? To answer that question, we need to be clear about the type of volcano that we are talking about. Volcano eruptions are measured in what is called VEI or Volcano Eruption Index which goes to a most powerful eruption of a VEI8.

An Explosive Eruption

If there were an explosive eruption in your area the effects of volcanoes could be devastating. During an explosive eruption the volcano will spew lava, magma and volcanic material which could travel several miles away from the mountain. The explosiveness of the eruption could also cause pyroclastic flows which would destroy anything within their path. The ash could also cause severe damage to structures depending on the amount of it and those who breathe it in would be at risk of choking on it.

Effects on the Environment

There are several ways in which effects of volcanoes can be felt on the environment. Even smaller eruptions can have a measureable effect. That is because while an eruption is taking place gases are released by the volcano. Some of the gases which are released into the air include carbon monoxide, carbon dioxide, sulphur dioxide, fluorine, chlorine, hydrogen sulphide and others. The effects of volcanoes on the environment depend on climate patterns, the overall scale of the eruption and how much the gases spread. Another problem the environment is the ash that is released when a volcano erupts. Depending on the size of the eruption you could be looking at a volcanic winter.

Effects of Super volcanoes

Out of all the effects of volcanoes on the daily life of people, the one that is the scariest is what is known as the super volcano. These volcanoes are the ones that will reach the VEI8 and VEI7 rankings in the scale. These are also volcanoes which are very massive and could destroy most of the life on earth if they were to erupt today.

In the case of the super volcano in Yellowstone Park several states and their citizens would stand no chance against the lava flow and the ash. However, those are not the only people that would be affected. During the explosion a lot of ash would be released into the atmosphere, dropping temperatures by an average of

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well over 20 degrees Fahrenheit worldwide. That would cause crops and vegetation to die which would mean no food for animals or people.

LANDSLIDING

About Landslide

Landslides are among the many natural disasters causing massive destructions and loss of lives across the globe. According to a survey study by the International Landslide Centre at Durham University, UK, 2,620 fatal landslides occurred between 2004 to 2010. These landslides resulted in the death of over 32,322 people. The figure does not include landslides caused by earthquakes. This research result is astonishing considering the number of people killed by landslides. It is, thus, paramount to know the causes and warning signs of a potential landslide to minimize losses.

A landslide, sometimes known as landslip, slope failure or slump, is an uncontrollable downhill flow of rock, earth, debris or the combination of the three. Landslides stem from the failure of materials making up the hill slopes and are beefed up by the force of gravity. When the ground becomes saturated, it can become unstable, losing its equilibrium in the long run. That's when a landslide breaks loose. When people are living down these hills or mountains, it's usually just a matter of time before disaster happens.

Causes of Landslides

While landslides are considered naturally occurring disasters, human-induced changes in the environment have recently caused their upsurge. Although the causes of landslides are wide ranging, they have two aspects in common; they are driven by forces of gravity and result from failure of soil and rock materials that constitute the hill slope:

Natural Causes of Landslides

1. **Climate:** Long-term climatic changes can significantly impact soil stability. A general reduction in precipitation leads to lowering of water table and reduction in overall weight of soil mass, reduced solution of materials and less powerful freeze-thaw activity. A significant upsurge in precipitation or ground saturation would dramatically increase the level of ground water. When sloped areas are completely saturated with water, landslides can occur. If there is absence of mechanical root support, the soils start to run off

2. **Earthquakes:** Seismic activities have, for a long time, contributed to landslides across the globe. Any moment tectonic plates move, the soil covering them also moves along. When earthquakes strike areas with steep slopes, on numerous occasion, the soil slips leading to landslides. In addition, ashen debris flows instigated by earthquakes could also cause mass soil movement.

3. **Weathering:** Weathering is the natural procedure of rock deterioration that leads to weak, landslide-susceptive materials. Weathering is brought about by

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the chemical action of water, air, plants and bacteria. When the rocks are weak enough, they slip away causing landslides.

4. **Erosion:** Erosion caused by sporadic running water such as streams, rivers, wind, currents, ice and waves wipes out latent and lateral slope support enabling landslides to occur easily.

5. **Volcanoes:** Volcanic eruptions can trigger landslides. If an eruption occurs in a wet condition, the soil will start to move downhill instigating a landslide. Stratovolcano is a typical example of volcano responsible for most landslides across the globe.

6. **Forest fires:** Forest fires instigate soil erosion and bring about floods, which might lead to landslides

7. **Gravity:** Steeper slopes coupled with gravitational force can trigger a massive landslide.

Human causes of landslides

1. **Mining:** Mining activities that utilize blasting techniques contribute mightily to landslides. Vibrations emanating from the blasts can weaken soils in other areas susceptible to landslides. The weakening of soil means a landslide can occur anytime.

2. **Clear cutting:** Clear cutting is a technique of timber harvesting that eliminates all old trees from the area. This technique is dangerous since it decimates the existing mechanical root structure of the area.

Effects of Landslides

1. **Lead to economic decline:** Landslides have been verified to result in destruction of property. If the landslide is significant, it could drain the economy of the region or country. After a landslide, the area affected normally undergoes rehabilitation. This rehabilitation involves massive capital outlay. For example, the 1983 landslide at Utah in the United States resulted in rehabilitation cost of about $500 million. The annual loss as a result of landslides in U.S. stands at an estimated $1.5 billion.

2. **Decimation of infrastructure:** The force flow of mud, debris, and rocks as a result of a landslide can cause serious damage to property. Infrastructure such as roads, railways, leisure destinations, buildings and communication systems can be decimated by a single landslide.

3. **Loss of life:** Communities living at the foot of hills and mountains are at a greater risk of death by landslides. A substantial landslide carries along huge rocks, heavy debris and heavy soil with it. This kind of landslide has the capacity to kills lots of people on impact. For instance, Landslides in the UK that happened a few years ago caused rotation of debris that destroyed a school and killed over 144 people including 116 school children aged between 7 and 10

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years. In a separate event, NBC News reported a death toll of 21 people in the March 22, 2014, landslide in Oso, Washington.

4. **Affects beauty of landscapes:** The erosion left behind by landslides leaves behind rugged landscapes that are unsightly. The pile of soil, rock and debris downhill can cover land utilized by the community for agricultural or social purposes.

5. **Impacts river ecosystems:** The soil, debris, and rock sliding downhill can find way into rivers and block their natural flow. Many river habitats like fish can die due to interference of natural flow of water. Communities depending on the river water for household activities and irrigation will suffer if flow of water is blocked.

Types of Landslides

- **Falls:** Falls are sudden movements of loads of soil, debris, and rock that break away from slopes and cliffs. Falls landslides occur as a result of mechanical weathering, earthquakes, and force of gravity.
- **Slides:** This is a kind of mass movement whereby the sliding material breakaways from 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. They involve landslide mass movement following a roughly planar surface with reduced rotation or backward slanting. Slides occur when the toe of the slope is undercut. They move moderately, and the consistency of material is maintained.
- **Topples:** Topple landslides occur when the topple fails. Topple failure encompasses the forward spinning and movement of huge masses of rock, debris, and earth from a slope. This type of slope failure takes place around an axis near or at the bottom of the block of rock. A topple landslide mostly lead to formation of a debris cone below the slope. This pile of debris is known as a Talus cone.
- **Spreads:** They are commonly known as lateral spreads and takes place on gentle terrains via lateral extension followed by tensile fractures.
- **Flows:** This type of landslide is categorized into five; earth flows, debris avalanche, debris flow, mudflows, and creep, which include seasonal, continuous and progressive. Flows are further subcategorized depending upon the geological material, for example, earth, debris, and bedrock. The most prevalent occurring landslides are rock falls and debris flow. The study of landslides is critical considering the annual economic losses they bring. Globally, landslides result in expenditure of billions of dollars towards rehabilitation of affected areas. Due to these astonishing annual losses, most governments have instituted bodies to deal specifically with landslides. For example, the U.S. government created the National Landslide Information Centre to collect and distribute all kinds of data related to landslides. The body

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is intended to cater to landslide researchers, geotechnical practitioners involved in landslide mobilization and other individuals and organizations focused on landslide hazard analysis and mitigation. The aim is to reduce the financial burden and deaths from landslides.

CYCLONES - (A CLIMATIC DISASTERS)

About Cyclones

Location, location, location! This is especially important when we're talking about ocean storms because the location of the storm determines what we call it. For example, if the storm occurs in the Atlantic Ocean and Northeast Pacific, it's called a hurricane. If the exact same type of storm occurs in the Northwest Pacific, this is a typhoon. And if we find those same storms in the South Pacific and Indian Ocean, these are called tropical cyclones.

Cyclone refers to any spinning storm that rotates around a low-pressure center. The low-pressure center is also referred to as the 'eye' of the storm, which is well known for being eerily calm compared with the areas under the spinning 'arms' of the storm. You could say that the eye is watching what's going on down below, so it needs a clear path, but the arms are where all the action happens because this is where the storm is throwing out all of its rain and wind.

Types of Cyclones

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

1. Tropical cyclones are what most people are familiar with because these are cyclones that occur over tropical ocean regions. Hurricanes and typhoons are actually types of tropical cyclones, but they have different names so that it's clear where that storm is occurring. Hurricanes are found in the Atlantic and Northeast Pacific; typhoons are found in the Northwest Pacific. If you hear 'tropical cyclone,' you should assume that it's occurring in the South Pacific or Indian Ocean, but for this lesson, we'll use it refer to all types of tropical ocean cyclones.
   We can also further describe tropical cyclones based on their wind speeds. They are called category 1, 2, 3, 4 or 5, increasing with intensity and wind speed as the number increases. A category 1 cyclone is the weakest, with wind speeds of 74-95 mph. A category 5 cyclone, on the other hand, is extremely dangerous and has the potential for major damage. Category 5 cyclones have wind speeds of 155 mph and above!
2. Polar cyclones are cyclones that occur in Polar Regions like Greenland, Siberia and Antarctica. Unlike tropical cyclones, polar cyclones are usually stronger in winter months. As you can see, these storms really do prefer the colder weather! They also occur in areas that aren't very populated, so any damage they do is usually pretty minimal.

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

Formation of a Cyclone

Even though they form over different areas, cyclones tend to come about in the same way and revolve around that low-pressure eye. Warm air likes to rise, and as it rises, it cools. Cool air can't hold as much moisture as warm air, so that water gets squeezed out of the condensing air and a cloud begins to form. If the warm air rises very quickly, this creates an updraft.

Likewise, if the water in the cloud builds up enough, it may fall back to the ground as rain and draw cool air down with it as a downdraft. When they work together, that warm updraft and cool downdraft create a storm cell. As this process continues, the cloud grows and we eventually get a large thunderstorm cloud.

This thunderstorm cloud is now ready to diversify into other storms like tropical cyclones and tornadoes. But this can't happen unless the air in the cloud starts spinning horizontally. If this occurs over the tropical ocean, this is called a tropical depression. This is like a baby tropical cyclone, with wind speeds less than 39 mph.

If it starts spinning even faster and has wind speeds between 40-73 mph, we have a tropical storm. If the storm grows even larger over the tropical ocean and has wind speeds above 74 mph, we have our full-grown hurricane, typhoon or cyclone, depending on where that storm is found.

Harmful Effects of Cyclones and Hurricanes

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

Management and Mitigation of Cyclones and Hurricanes.

i. Coastal areas should be well prepared to meet eventualities that arise from cyclones.
ii. Houses should be constructed such that they can withstand the heavy rainfall and forceful winds.
iii. Shelter beds should be created to check soil erosion and speed of winds.

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iv. Remote sensing techniques should be used to forecast cyclones appropriately.
v. When a cyclone does occur, rescue and relief operations should be in place.

El Niño–Southern Oscillation (ENSO)

What is the El-Niño Southern Oscillation?

El Niño–**Southern Oscillation** (ENSO) is an irregularly periodical variation in winds and sea surface temperatures over the tropical eastern Pacific Ocean, affecting much of the tropics and subtropics. The warming phase is known as El Niño and the cooling phase as La Niña.

The El Niño-Southern Oscillation (ENSO) is a naturally occurring phenomenon that involves fluctuating ocean temperatures in the equatorial Pacific. The warmer waters essentially slosh, or oscillate, back and forth across the Pacific, much like water in a bath tub. For North America and much of the globe, the phenomenon is known as a dominant force causing variations in regional climate patterns. The pattern generally fluctuates between two states: warmer than normal central and eastern equatorial Pacific SSTs (El Niño) and cooler than normal central and eastern equatorial Pacific SSTs (La Niña).

Often, sea surface temperatures (SSTs) are used to identify this oscillation, but it is important to understand that changes in sub-surface ocean temperatures are the first to respond to an oncoming change in the ENSO phase. For instance, when ENSO is transitioning into a warm phase the sub-surface temperatures begin to warm above average, while a shallow layer of near average temperature remains at the surface. Eventually, the surface ocean temperatures will respond to the warming of the sub-surface temperatures, and a warm phase of the ENSO cycle ensues. The same cycle occurs, only opposite, for the cool phase of ENSO. When temperatures in the ENSO region of the Pacific are near average it is known as ENSO neutral, meaning that the oscillation is neither in a warm nor cool phase. Typically, atmospheric patterns during ENSO neutral are controlled more by other climate patterns (NAO, PNA) that vary on shorter timescales.

El Niño (Warm Phase)

The warm phase of the ENSO cycle features warmer than normal SSTs across the central and eastern equatorial Pacific along with:

- Weaker low-level atmospheric winds along the equator
- Enhanced convection across the entire equatorial Pacific
- Effects are strongest during northern hemisphere winter due to the fact that ocean temperatures worldwide are at their warmest. This increased ocean warmth enhances convection, which then alters the jet stream such that it becomes more active over parts of the U.S. during El Niño winters. This results in enhanced precipitation across the southern U.S
- In the southeast, winter temperatures are often cooler than normal
- During hurricane season (June to November), the jet stream is aligned in such a way that the vertical wind shear is increased over the Caribbean and Atlantic.

The increased wind shear helps to prevent tropical disturbances from developing into hurricanes

La Niña (Cool Phase)

This phase of the ENSO cycle features cooler than normal SSTs across the central and eastern equatorial Pacific along with:

- Stronger low-level atmospheric winds along the equator
- Decreased convection across the entire equatorial Pacific results in a more suppressed southern jet stream. Consequently, the southern U.S., including NC, sees less precipitation
- In the U.S., winter temperatures are often warmer than normal in the southeast, and cooler than normal in the Northwest
- During hurricane season (June to November), upper level winds are much lighter, and therefore more favourable for hurricane development in the Caribbean and Atlantic

Why are "El-Niño" and "La-Niña" so named?

"El-Niño" is named after a Peruvian Christmas festival where the warming of the waters off Peru is said to occur near the birthday of "The Boy" (El Niño), or the Christ child. Meteorologists thus named the phenomenon the "El-Niño Southern Oscillation", or ENSO for short. The reverse phenomenon, the cooling of the eastern Pacific waters, was at first called "Anti-El-Niño", until it was realized that this literally meant the Anti-Christ! To avoid this unfortunate connotation, it was renamed "La-Niña" (or "The Girl").

Southern Oscillation Index

The Southern Oscillation Index, or SOI, gives an indication of the development and intensity of El Niño or La Niña events in the Pacific Ocean. The SOI is calculated using the pressure differences between Tahiti and Darwin.

Sustained negative values of the SOI below 7 often indicate El Niño episodes. These negative values are usually accompanied by sustained warming of the central and eastern tropical Pacific Ocean, a decrease in the strength of the Pacific Trade Winds, and a reduction in winter and spring rainfall over much of eastern Australia and the Top End. You can read more about historical El Niño events and their effect on Australia in the detailed analysis of past El Niño events.

Sustained positive values of the SOI above +7 are typical of a La Niña episode. They are associated with stronger Pacific trade winds and warmer sea temperatures to the north of Australia. Waters in the central and eastern tropical Pacific Ocean become cooler during this time. Together these give an increased probability that eastern and northern Australia will be wetter than normal. You can read more about historical La Niña events and their effect on Australia in the detailed analysis of past La Niña events..

THUNDERSTORMS

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Florida has more thunderstorms per year than any other state in the U.S. or that if you are male you are 4.6 times more likely to get struck by lightning than if you are female? Or that sound travels one mile in five seconds, so if you hear a lightning strike you can figure out how far away it was by counting the seconds until you hear the thunder clap

Thunderstorms are amazing and interesting events! Thunderstorms can occur almost anywhere and are the beginnings of some other dangerous storms like hurricanes and tornadoes. But just what is a thunderstorm, and how does it form? A thunderstorm is a storm with lightning and thunder. They are caused by an updraft, which occurs when warm, moist air rises vertically into the atmosphere. The updraft creates a cumulus cloud, which will eventually be the thunderstorm cloud.

Updrafts can occur anywhere warm, wet air raises quickly, which is why most people, no matter where they live, have experienced a thunderstorm at some point in their life. However, some places, like Florida, are more prone to thunderstorms because the conditions that create thunderstorms are more common.

The Formation of a Thunderstorm

A warm updraft is just the beginning of a thunderstorm, though. Once the air rises into the atmosphere, it begins to cool. Cool air can't hold as much water as warm air, so as the air cools, the water in the air gets kicked out as condensation and may eventually fall back to the ground as rain. In order for this to happen, though, the cumulus cloud has to grow very tall.

Think about it this way: If you're playing a game of Red Rover and try to break through the human wall on the other side by yourself, you may not be very successful because there's only one of you. But if you get all of your friends to crash into that line of people with you, you'll have greater success because you are a large group with a greater force.

The same is true for water in the thunderstorm cloud. By itself, that single water droplet is not heavy enough to fall back to the ground as rain. But if the cloud is tall enough, that one little droplet will pick up other droplets with it and eventually grow into a large enough water droplet to break through and fall back to Earth.

Just like the updraft was warm air rising upward into the atmosphere, a downdraft is cool air sinking back to the ground. Downdrafts are created by the falling water droplets because they don't just drag other water down with them as they fall; they drag cooler air down with them as well. The combined warm updraft and cool downdraft create a storm cell. As the process of warm air rising and cool air sinking continues, the cloud grows vertically into the shape of an anvil, which is called an anvil head cloud. This is now a full-fledged thunderstorm cloud, ready to storm away!

Thunder and Lightning

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As you are probably aware, thunderstorm clouds can produce a lot of thunder and lightning. What you may not know is that these are both produced from the same event. Lightning is what you see, thunder is what you hear. They appear not to occur at the same time because light travels faster than sound, so the image of the lightning reaches your eyes before the sound it creates reaches your ears.

Here's how it works: As the water droplets in the cloud fall downward, they bump into each other, which gives the cloud an electrical charge. The charge, however, is not uniform within the cloud; there is a negative charge in the warm areas and a positive charge in the cool areas. Eventually electricity builds up and electrical energy is released, flowing to the points of opposite charge because opposites attract! Much of this occurs within the cloud, but sometimes it leaves the cloud and heads toward the ground because the ground holds an opposite charge to the lower part of the cloud. When this happens, we get lightning.

If you've ever touched a light bulb that has been on for a while, you know that light produces a lot of energy as heat. When the electrical energy leaves the cloud as lightning, it also releases energy as heat, which warms the air around it. When things heat up, they expand, and as the air expands, it releases a giant sonic boom - the thunder you hear. So you can see that while you may have lightning without thunder, you certainly won't get thunder without a lightning strike.

Types of thunderstorm

Multicell Cluster Storms

A group of cells moving as a single unit, with each cell in a different stage of the thunderstorm life cycle. Multicell storms can produce moderate size hail, flash floods and weak tornadoes.

Multicell Line Storms

Multicell line storms consist of a line of storms with a continuous, well developed gust front at the leading edge of the line. Also known as squall lines, these storms can produce small to moderate size hail, occasional flash floods and weak tornadoes.

Supercells

It is defined as a thunderstorm with a rotating updraft, these storms can produce strong downbursts, large hail, occasional flash floods and weak to violent tornadoes

Causes of thunderstorms

Thunderstorms form when an air mass becomes so unstable that it overturns (convects) violently. "Unstable" means that the air in the lowest layers is unusually warm and humid, or that the upper layers are unusually cool, or oftentimes, both.

Pockets of rising near-surface air in an unstable air mass expand and cool, and as some of the vapor present condenses into a cloud it releases heat, which then makes the air parcel even warmer, forcing it to rise still higher in the atmosphere.

If the lower level air is sufficiently warm and humid, and the higher altitude air is sufficiently cool, this process continues until a tall convective cloud -- the thunderstorm -- is formed. The result can be a storm extending as high as 40,000 to 60,000 feet (8 to 12 miles). The upper portions of the storm which even in the warm tropics -- are made of ice: ice crystals, grapple, snow, and sometimes hail. About 50% of the rain reaching the surface in a thunderstorm originated as ice in the upper reaches of the storm.

The updrafts in thunderstorms can be very strong -- 50 knots or more -- which can help support the weight of hailstones as they grow. Such updrafts cause extreme turbulence for aircraft, which will only fly through the strongest portions of thunderstorms if the pilots have no other choice. Despite the large stresses this puts on planes (and their passengers), modern jet aircraft are designed to withstand those stresses.

The following enhanced photograph shows the classic supercell thunderstorm, a particularly large, intense, and destructive storm that can produce large hail and tornadoes:

Thunderstorms are most common in the afternoon over land, when daytime heating of the land by the sun causes the lower part of the troposphere to become unstable from higher temperatures and more water vapor in the air.

or, some thunderstorms can form as result of the upper atmosphere becoming unusually cool, due to the approach of an upper air disturbance. In this case storms can form at any time of day, even when there hasn't been daytime heating of the lower atmosphere over land.

There must be sufficient water vapour in order for the storm to form, since cloud and precipitation originates as water vapour. This is the fuel for the thunderstorm. As the storm uses this fuel, it is converted to rainfall. Eventually, the storm stabilizes the atmosphere by using up the excess water vapour and cooling the lower atmosphere, and warming the upper atmosphere.

Technically, lightning must be produced in order for the resulting cloud system to be called a thunderstorm.

Effects of Thunderstorms

- Thunderstorm updrafts and downdrafts result in heavy precipitation. Wind gusts pick up hurricane force, accompanied by thunder and lightning.
- Thunderstorms disrupt human life in more than one way. The felling of millions of trees, deaths due to lightning hazard and wind shear are just some of the dissipation manifestations.
- Thunderstorms commonly result in local atmospheric instability, catastrophic flooding, very strong winds, tornadoes and multi-cell storms.
- These storms have a pronounced effect on the weather over a large area, with energy released at the rate of more than 10,000,000 kilowatt-hours on an

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average!

- Thunderstorms occur in varied force, throughout the world. While they are a common occurrence in the tropical rainforest regions, the Polar Regions are not spared either.
- Thunderstorms are commonly associated with the onset of the monsoons. The electrical discharge referred to as lightning is responsible for striking terrestrial structures at the speed of sound. This poses a great threat to human life and property.

Thunderstorms and lightning have always held a myth and mystique about them and have fascinated and terrified human since the dawn of civilization. All thunderstorms produce lightening which often strikes away from the area where it is raining and is known to fall as far as 10 miles away from the rainfall area. Roughly, there are about 1800 thunderstorms occurring at any moment across the world. Though today we have a greater understanding about them after intense study through various methods like weather radars, weather stations and video photography

FLOOD IN INDIA

It is a natural event or occurrence where a piece of land (or area) that is usually dry land, suddenly gets submerged under water. Some floods can occur suddenly and recede quickly. Others take days or even months to build and discharge.

When floods happen in an area that people live, the water carries along objects like houses, bridges, cars, furniture and even people. It can wipe away farms, trees and many heavier items.

Floods occur at irregular intervals and vary in size, duration and the affected area.

It is important to note that water naturally flows from high areas to low lying areas. This means low-lying areas may flood quickly before it begins to get to higher ground.

In this lesson, we shall see more about what causes flooding, the types of flooding, some effects of floods and what we can do before, during and after floods occur.

Causes of flooding.

- **Rains:** Each time there are more rains than the drainage system can take, there can be floods. Sometimes, there is heavy rain for a very short period that result in floods. In other times, there may be light rain for many days and weeks.
- **River overflow:** Rivers can overflow their banks to cause flooding. This happens when there is more water upstream than usual and as it flows downstream to the adjacent low-lying areas (also called a floodplain), there is a burst and water gets into the land.
- **Strong winds in coastal areas:** Sea water can be carried by massive winds and hurricanes onto dry coastal lands and cause flooding. Sometimes this is made worse if the winds carry rains themselves. Sometimes water from the sea resulting from a tsunami can flow inland to cause damage.

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- **Dam breaking:** (raptured dam or levee) (Embankments, known as levees, are built along the side of a river and are used to prevent high water from flooding bordering land)
  Dams are man-made blocks mounted to hold water flowing down from a highland. The power in the water is used to turn propellers to generate electricity. Sometimes, too much water held up in the dam can cause it to break and overflow the area. Excess water can also be intentionally released from the dam to prevent it from breaking and that can also cause floods. February 26, 1972 - Buffalo Creek Valley, West Virginia the failure of a coal-waste impoundment at the valley's head took 125 lives, and caused more than $400 million in damages, including destruction of over 500 homes.
- **Ice and snow-melts:** In many cold regions, heavy snow over the winter usually stays un-melted for some time. There are also mountains that have ice on top of them. Sometimes the ice suddenly melts when the temperature rises, resulting in massive movement of water into places that are usually dry. This is usually called a snowmelt flood.

Types of floods

Some would like to see the causes of floods as types of floods, but here we shall look at three major flood types: Flash floods, Rapid on-set floods and slow on-set floods.

- **Flash floods:** This kind occurs within a very short time (2-6 hours, and sometimes within minutes) and is usually as a result of heavy rain, dam break or snow melt. Sometimes, intense rainfall from slow moving thunderstorms can cause it. Flash floods are the most destructive and can be fatal, as people are usually taken by surprise. There is usually no warning, no preparation and the impact can be very swift and devastating.
- **Rapid on-set floods:** Similar to flash floods, this type takes slightly longer to develop and the flood can last for a day or two only. It is also very destructive, but does not usually surprise people like Flash floods. With rapid on-set floods, people can quickly put a few things right and escape before it gets very bad.
- **Slow on-set floods:** This kind is usually as a result of water bodies over flooding their banks. They tend to develop slowly and can last for days and weeks. They usually spread over many kilometres and occur more in flood plains (fields prone to floods in low-lying areas). The effect of this kind of floods on people is more likely to be due to disease, malnutrition or snakebite.

EFFECTS OF FLOODING

Floods can have devastating consequences and can have effects on the economy, environment and people.

- **Economic:** During floods (especially flash floods), roads, bridges, farms, houses and automobiles are destroyed. People become homeless. Additionally, the government deploys firemen, police and other emergency apparatuses to help the affected. All these come at a heavy cost to people and the government. It usually takes years for affected communities to be re-built and business to come back to normalcy.

- **Environment:** The environment also suffers when floods happen. Chemicals and other hazardous substances end up in the water and eventually contaminate the water bodies that floods end up in. In 2011, a huge tsunami hit Japan, and sea water flooded a part of the coastline. The flooding caused massive leakage in nuclear plants and has since caused high radiation in that area. Authorities in Japan fear that Fukushima radiation levels are 18 times higher than even thought. Additionally, flooding causes kills animals, and others insects are introduced to affected areas, distorting the natural balance of the ecosystem.
- **People and animals:** Many people and animals have died in flash floods. Many more are injured and others made homeless. Water supply and electricity are disrupted and people struggle and suffer as a result. In addition to this, flooding brings a lot of diseases and infections including military fever, pneumonic plague, dermatopathia and dysentery. Sometimes insects and snakes make their ways to the area and cause a lot of havoc. There is also something good about floods, especially those that occur in floodplains and farm fields. Floodwaters carry lots of nutrients that are deposited in the plains. Farmers love such soils, as they are perfect for cultivating some kinds of crops.

DROUGHT A NATURAL DISASTER

Drought is a prolonged dry period in natural climate cycle. It is a slow-onset phenomenon caused by rainfall deficit combined with other predisposing factors.

Drought often results in mass displacements of population.

Drought leads to water and food shortages and is likely to have a long-term environmental, economic and health impact on the population.

Droughts are often predictable: periods of unusual dryness are normal in all weather systems. Advance warning is possible.

Factors affecting drought

Factors influencing the impact of drought are:

- Demographic pressure on the environment;
- Food insecurity;
- Economic systems strictly dependent on agriculture;
- Poor infrastructure e.g. irrigation and water supply and sanitation systems;
- Poor health status of the population before the disaster;
- Time of the year, with the most critical period being before the harvest;
- Absence of warning systems;
- Population displacement;
- Other concurrent situations: economic crisis, political instability, armed conflict.

CLOUDBURST

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About cloudburst

- A cloudburst is sudden copious rainfall. It is a sudden aggressive rainstorm falling for a short period of time limited to a small geographical area.
- Meteorologists say the rain from a cloudburst is usually of the shower type with a fall rate equal to or greater than 100 mm (4.94 inches) per hour.
- Generally, cloudbursts are associated with thunderstorms. The air currents rushing upwards in a rainstorm hold up a large amount of water.
- If these currents suddenly cease, the entire amount of water descends on to a small area with catastrophic force all of a sudden and causes mass destruction. This is due to a rapid condensation of the clouds.
- They occur most often in desert and mountainous regions, and in interior regions of continental landmasses.

Definition

A cloudburst is a sudden aggressive downpour within the radius of a couple of kilometres. Though, cloudbursts usually do not last for more than few minutes, they are capable of flooding the entire area. Rainfall from a cloudburst is usually equal to or greater than 100 mm per hour. Cloudbursts are generally associated with thunderstorms. However, the above definition has been given by a particular school of thought. In reality, there is no specific amount of rain associated with a cloudburst, either in time or duration.

How does it happen?

Cloud burst is actually a situation when the inter-molecular forces between the H_2O molecules get very high due to the rapid decrease in the temperature or excess of electrostatic induction in the clouds causing the lighting to remain inside the cloud only, which causes hyperactive energy inside the cloud. The water molecules get denser and denser and get condensed but do not leave the cloud due to excess of electro- forces. As the water concentration get higher and higher and so the weigh gets heavier the water no longer is able to maintain force with the clouds and so they fall and it precipitates. A cloudburst can suddenly dump 72,300 tons of water over one square acre. This is quite a wallop and luckily it does not happen very often. A real cloudburst is very rare. Sometimes we call a sharp shower in the mountains a cloudburst when it really is not. The runoff from the slopes creates such a deluge that is seems that a cloud has burst open like a paper bag.

Of course, even in a real cloudburst, the cloud does not break open. It happens because the rain forming in the cloud has been unable to fall down in a steady shower. Sometimes this happens when the cloud is ready to rain and the ground below is scorching hot. Or maybe a very warm current of air is blowing under the rain cloud. Either of these events causes a strong updraft of warm air. Raindrops find it very hard to fall through a current of rising air. When they start down, up they are whisked again. If this goes on for any length of time, the cloud gets an overload of rain. The drops that should have fallen are returned back up and new drops are being: formed all the time. Finally, something happens to change the

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situation. The weight of rain is able to break through or maybe the updraft suddenly stops for some reason. Then all the raindrops, new ones and old ones come tumbling down at once. Truly it seems as if the rain clouds burst.

Effect of cloudbursts on hills and plains

The catastrophic nature of cloudbursts differs on the virtue of terrain. In the hills, large volume of water keeps getting momentum as it flows in gushes. On its way, it demolishes everything and gravity of the situation increases due to landslides, mudslides, etc. On the other hand, cloudbursts in the plains only leads to waterlogging and inundation.

Causes a cloudburst.

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Some of the harm from improperly disposed material includes:

- **Affecting Human Populations**: Humans are significantly impacted by exposure to levels of radiation. Oftentimes, this exposure will affect many future generations, as it leads to a number of birth and developmental disabilities. Down syndrome, thyroid cancer, and a number of other issues have been found in people affected by radiation.
- **Affecting Wildlife**: One only need look to the Chernobyl disaster to see what the effects of radiation can be on wildlife in the area. Unfortunately, despite the fact that the event was 30 years ago, most of the animals are deemed to be affected by radioactivity. This manifests in reduced brain sizes, physical deformities, and other concerns that impact the survival of these creatures.
- **Affecting Local Flora**: Plant life is also susceptible to damage from nuclear radioactive waste. After Chernobyl, an entire pine forest needed to be destroyed because it was affected by radiation. Not to mention, radioactive soils and plants dissuade bees and other important creatures from fertilizing and

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