HAZARD, TYPES AND ASSESSMENT

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Study materials for Semester VI

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DIFFERENT TYPES OF HAZARDS, HAZARD ASSESMENT

Definition:

A Rare or Extreme Events in the natural or manmade environment that adversely affects human lives, properties or activities to the extent of causing a disaster is known as **Hazard**. Hazards are potentially damaging physical events, phenomena, or human activities that cause loss of life, injury, property damage, social and economic disruption, or environmental degradation (Makoka & Kaplan, 2005). They are external factors that affect the society or elements at risk. Hazards have the potential to cause disasters. (UNISDR 2009).

So overall, a **hazard** is any source of **potential** damage, harm or adverse health effects on something or someone.

A Hazard is a threat. A future source of danger, which has the potential to cause harm to

- People - death, injury, disease and stress
- Human activity – economic, educational etc.
- Property - property damage, economic loss of
- Environment - loss fauna and flora, pollution, loss of amenities. Some examples of hazards are earthquakes, volcanic eruptions, cyclones, floods, landslides, and other such events.

Natural Phenomena vs Hazard:

Hazard Event It is the physical parameter of the hazard event that causes the harm. Environmental events become hazards once they threaten to affect society and/or the environment adversely. A physical event, such as a volcanic eruption, that does not affect human beings is a natural phenomenon but not a natural hazard. A natural phenomenon that occurs in a populated area is a hazardous event. A hazardous event that causes unacceptably large numbers of fatalities and/or overwhelming property damage is a natural disaster. In areas where there are no human interests, natural phenomena do not constitute hazards nor do they result in disasters. The level of harm is governed by

- Magnitude of the hazard
- Frequency of hazard or recurrence
- Intensity at the impact point

Characteristics of Hazard:

Hazard

contains four important elements:

1) **Hazard is expressed as a probability,** the likelihood that something may happen in the future. When, where and how much is not sure, but it is possible to identify areas where a hazard is more likely to occur than in other areas.

2) **The hazard probability is restricted to a specified period of time**; usually a year. The annual probability is the likelihood that an event will happen in the next year. Without this restriction, the probability

expression would be useless. The likelihood that a floodplain will be flooded is 100%, but it could take a 1000 years before it actually happens. It is more relevant to know what the probability is that it is flooded in the coming year, or the year after, …

3) It is valid for a specified area; Earthquakes happen near fault zones, floods on floodplains, landslides on slopes. The site specific characteristics co-define the hazard conditions.

4) The intensity – or magnitude – of the event. To be capable of causing loss of life or damage, the event must be of a certain intensity or magnitude. The intensity may be expressed as the energy released by an earthquake or volcanic eruption, the volume of water during a flood or the size and speed of a landslide. It is clear that the more energy or momentum released by the event, the more damaging potential it has. A mass movement of a few kilograms may cause no problems (unless it is a rock falling on someone's head), but a mud flow of several thousand cubic meters can be quite devastating.

Multiple hazards:

When more than one hazard event impacts the same area, there arises a multiple hazard situation. These different hazard events may occur at the same time or may be spaced out in time.

The Return Period:

Majority of hazards have return periods on a human time-scale. Examples are five-year flood, fifty-year flood and a hundred year flood. This reflects a statistical measure of how often a hazard event of a given magnitude and intensity will occur. The frequency is measured in terms of a hazard's recurrence interval. Such extreme events have very low frequencies but very high magnitudes in terms of destructive capacity. This means that an event considered being a hundred year flood would cause severe damage compared to a five-year flood.

Classification of Hazards:

There are many different ways of classifying hazards. One the basis of nature of origin, hazards are as follows:

(i) Natural hazards such as earthquakes or floods arise from purely natural processes in the environment.

(ii) Quasi-natural hazards such as smog or desertification arise through the interaction of natural processes and human activities.

(iii)Manmade hazards such as the toxicity of pesticides to fauna, accidental release of chemicals or radiation from a nuclear plant. These arise directly as a result of human activities.

(i) Natural Hazards:

Natural disasters are further classified in the following categories:

1) Geophysical: The phenomena originating from inside the earth as a result of the various geological, geophysical and tectonic activities. The dynamic nature of earth's crust resulted in the geophysical hazards. These are classified under the following categories and sub-categories:

Sl No	Category	Subcategory
A	**Earthquake**	**a) Ground Shaking** If an earthquake generates a large enough shaking intensity, structures like buildings, bridges and dams can be severely damaged, and cliffs and sloping ground destabilized. Ground shaking will vary over an area due to such factors as topography, bedrock type, and the location and orientation of the fault rupture. These all affect the way the seismic waves travel through the ground. **b) Tsunami** Tsunamis are long wavelength oceanic waves generated by the sudden displacement of seawater by a shallow earthquake, volcanic eruption or submarine landslide. The height of a tsunami varies and may be affected by the sea floor depth and shape, and other factors.

B	**Volcanism**	**a) Lava Flows:** Lava flows normally follow the topography, sinking into depressions and valleys and flowing down the volcano. Lava flows will bury roads farmlands and other forms of personal property. This lava could destroy homes, lives standing in the way. **b) Debris and Mud Flow:** Pyroclastic materials mix with water from a nearby stream or river, they can turn the watercourse into a fast moving mudflows. These are called lahars;[8] when the lahar contains large material such as blocks of rock and trees, it is a volcanic debris flow. **c) Ground Shaking:** It causes ground shaking and poses serious threats to human capacity.
Sl No	**Category**	**Subcategory**
C	**Landslide (Dry)**	**a) Rockfall:** Ground shaking due to earthquakes or any local factors destabilizes cliffs and steep slopes, causing rockfalls as a significant side-effect. **b) Landslide:** Ground shaking due to earthquakes or any local factors destabilizes cliffs and steep slopes, causing rockfalls as a significant side-effect. **c) Avalanches:** Most avalanches occur spontaneously during storms under increased load due to snowfall and/or erosion. The second largest cause of natural avalanches is metamorphic changes in the snowpack such as melting due to solar radiation. Other natural causes include rain, earthquakes, rockfall and icefall. Avalanches can completely destroy houses, cabins and shacks on its pathway. Avalanches also can cause roads and railroad lines to close. **d) Liquefaction:** Liquefaction occurs when waterlogged sediments are agitated by seismic shaking. This separates the grains from each other, reducing their load bearing capacity. Buildings and other structures can sink down into the ground or tilt over, whilst underground pipes and tanks may rise up to the surface. **e) Subsidence:** This may be due to downward vertical displacement on one side of a fault, and can sometimes affect a huge area of land. Coastal areas can become permanently flooded as a result. Subsidence can also occur as ground shaking causes loose sediments to "settle' and to lose their load bearing strength (see liquefaction, below) or to slump down sloping ground

2) **Hydrological:** Events caused by imbalance in the normal hydrological cycle and/or overflow of bodies of water caused by wind set-up tectonic activities. These are classified under the following categories and sub-categories:

Sl No	Category	Subcategory

A	**Flood**	a) **Riverine Flood**: Overbank flooding of rivers and streams is the most common type of flood event. Riverine floodplains range from narrow, confined chan- nels in the steep valleys of hilly and mountainous areas, and wide, flat areas in the Plains States and low-lying coastal regions. The volume of water in the floodplain is a function of the size of the contributing watershed and topographic characteristics such as watershed shape and slope, and climatic and land-use characteristics. b) **Flash Flood:** Flash floods are characterized by a rapid rise in water level, high velocity, and large amounts of debris. They are capable of tearing out trees, undermining buildings and bridges, and scouring new channels. Major factors in flash flooding are the intensity and duration of rain- fall and the steepness of watershed and stream gradi- ents.
Sl No	**Category**	**Subcategory**
		c) Alluvial Fan Flood: Due to rain runs off steep valley walls, it gains velocity, carry- ing large boulders and other debris. When the debris fills channels on the fan, floodwaters spill out and cut new channels. The process is then repeated, resulting in shifting channels and combined erosion and flooding problems over a large area. Alluvial fan floods can cause greater damage than typi- cal riverine flooding because of the high velocity of flow, the amount of debris carried, and the broad area affected. **d) Ice Jam Flood:** Ice jam formation causes a rapid rise of water at the jam and extending upstream. Failure or release of the jam causes sudden flooding down- stream. Damage from ice jam flooding usually exceeds that caused by open water flooding. Additional physical damage is caused by the force of ice impacting buildings and other structures.
B	**Coastal Erosion**	Coastal erosion is a hydrologic hazard defined as the wearing away of land and loss of beach, shoreline, or dune material as a result of natural coastal processes. Natural coastal processes that cause coastal erosion include the actions of winds, waves, and currents.
C	**Riverine Erosion**	The flood land topography experiences riverbank erosion hazard due to sudden and rapid channel shifting and due to avulsions particularly in the major floodplain areas. Consequently, valuable cultivable land is lost; also village settlements, markets and towns are destroyed, displacing tens of thousands of people.

D	**Mass Wasting (Wet)**	Hazards arising from mass movements are a common problem in mountain regions, particularly in a temperate humid climate, where the annual rate of precipitation in the form of rain or snow is fairly high. During rainy season, due to high intensity of rainfall water washes away debris, soil, rock in hilly area along the slope and causes damage to agricultural field, settlements, roads and economic activities.

3) **<u>Meteorological</u>:** Events caused by short-lived/small to meso scale atmospheric processes (in the spectrum from minutes to days). These are classified under the following categories and sub-categories:

Sl No	Category	Subcategory
A	**Heat and Cold Waves**	Heat wave occurs when the temperature of an area becomes excessively hot and exceeds normal seasonal limits. Hot weather during a heat wave might also be accompanied by high levels of humidity. Severe heat waves can result in massive crop failure, power outages across large areas, and even deaths. Similarly, cold waves are experienced in winter season. Most of the cold waves occur in North West India and are associated with western disturbances.
Sl No	**Category**	**Subcategory**
	Tornadoes	Tornadoes are extremely dangerous and violent rotating air columns that move at high speeds across a large area and damage everything in their path. The base of a tornado is always in touch with the Earth's surface, while the top is in contact with a cumulonimbus cloud. A tornado generally appears like a condensation funnel, with the narrow edge touching the Earth.
	Thunderstorm	Thunderstorm is a meteorological phenomenon associated with intense lightning and its acoustic effect, thunder. Such storms can also be called electrical storms or thundershowers. These weather events are usually accompanied by heavy rainfall and strong winds. Occasionally, snow, hail or sleet might also fall during thunderstorms. Lightning can kill people, animals, and plants that come in direct contact with the electrical flashes, as well as triggering fires or damaging buildings.
	Hailstorm	Hailstorm is a phenomenon in which ice pellets fall to the ground as a form of solid precipitation. The irregular lumps of ice that fall during such storms are called hailstones. Hail is highly damaging to property, as well as vegetation and crops. In the absence of proper cover, hailstones of large size can also cause physical harm to people and animals.
	Blizzards	Blizzard is severe snowstorm with a strong and sustained wind speed of more than 35 mph is considered a blizzard. Such storms last for several hours and cause great harm to life and property in the area of occurrence. Blizzards are not only caused by falling snow but might also result from strong winds blowing away loose snow on the ground.

	Cyclonic storm	Cyclonic storm is a destructive meteorological phenomenon that forms when a large air mass rotates around a central low atmospheric zone. Such storms originate over oceans and usually move towards land where they cause great destruction to life and property. A cyclone can also be referred to as a hurricane or typhoon, depending on its origin.
	Local storms	Local severe storms are small scale disturbances which are formed due to strong connective motions in a moist and unstable atmosphere and originate from well grown cumulonimbus clouds. The destructive effects of local severe storms are associated with thunderstorms, strong winds, hail storms, lightening, and heavy rains.
		As winter intensifies, fogs descend on most of northern India and parts of eastern India. The biggest hazard is to physical safety as low visibility potentially causes more accidents than vehicular failure. So, one need to be a little more alert when you venture outside your home for walking, jogging, exercising, riding, or driving.

3) <u>Climatological</u>: Events caused by long-lived/meso to macro scale atmospheric processes (in the spectrum from intra-seasonal to multi-decadal climate variability). These are classified under the following categories and sub-categories:

Sl No	Category	Subcategory
A	**Tropical Cyclonic storm**	Cyclonic storm is a destructive meteorological phenomenon that forms when a large air mass rotates around a central low atmospheric zone. Such storms originate over oceans and usually move towards land where they cause great destruction to life and property. A cyclone can also be referred to as a hurricane or typhoon, depending on its origin.
Sl No	**Category**	**Subcategory**
B	**Extra Tropical Cyclonic storm**	Storm surges associated with extra tropical cyclones in the North Atlantic Ocean and the Gulf of Mexico, and severe winter low-pressure systems in the North Pacific Ocean and the Gulf of Alaska are responsible for coastal flooding and erosion. The storms that generate the large waves of coastal surges can develop year-round.
C	**Drought**	Drought, which is defined as a water shortage caused by a deficiency of rainfall, differs from other natural hazards in two significant ways. First, a drought's onset and end are difficult to determine since the effects accumulate slowly and may linger even after the apparent termination of an episode. Third, unlike most other natural hazards, drought impacts are less obvious and are spread over a larger geographic area. During severe droughts, agricultural crops do not mature, wildlife and livestock are undernourished, land values decline, and unemployment increases. Droughts can cause a shortage of water for human and industrial consumption, hydroelectric power, recreation, and navigation. Water quality may decline and the number and severity of wild- fires may increase.

5) **Biological:** A hazard caused by the exposure to living organisms and their toxic substances (e.g. venom, mold) or vector-borne diseases that they may carry. These are classified under the following categories and sub-categories:

Sl No	Category	Subcategory
A	**Micro Organism**	**a) Bacterial:** Bacterial hazards are defined as those bacteria that, if they occur in food, may cause illness in humans, either by infection or intoxication. Foodborne infections are caused by swallowing live pathogens that grow within the body, usually in the intestinal tract. **b) Viral:** Viruses differ from other microorganisms in what they need to live and how they multiply. Viruses exist in foods without growing, so they need no food, water or air to survive. Viruses cause illness by infection. They can infect living cells and reproduce inside the host cell using material from it. Viruses only grow once they enter a suitable host. **c) Parasite:** Parasites are organisms that need a host to survive, living on or within it. There are two types of parasites that can infect people through food or water: parasitic worms and protozoa. Parasitic worms vary in size from barely visible to several feet in length. Protozoa are single-cell animals, and most cannot be seen without a microscope.
B	**Insect Infestation**	Insect infestation described as the pervasive influx, swarming and/or hatching of insects affecting humans, animals, crops, and perishable goods. Examples are locusts, plague and African Bees. Pest removal isn't just about getting rid of these creatures we dislike – it's about creating a healthier environment. Many pests cause potentially serious health hazards if they're left unchecked without proper pest control.
Sl No	**Category**	**Subcategory**
C	**Animal Accident**	Animal accidents includes – animal biting and scratches, animal stamped, respiratory problem etc.

6) **Extraterrestrial**: A hazard caused by asteroids, meteoroids, and comets as they pass near-earth, enter the Earth's atmosphere, and/or strike the Earth, and by changes in interplanetary conditions that effect the Earth's magnetosphere, ionosphere, and thermosphere.

(ii) Quasi- Natural Hazards:

Quasi-natural hazard refers to those hazards that occur due to the interaction between the activities done by the humans and the various types of natural processes that take places on the surface of the earth. These are the some important quasi-natural hazards:

Sl No	Category	Subcategory

A	**Dam Failure**	Dam failures can occur as a result of structural failures, such as progressive erosion of an embankment or overtopping and breaching by a severe flood. Disastrous floods caused by dam failures, although not in the category of natural hazards, have caused great loss of life and property damage, primarily due to their unexpected nature and high velocity floodwater.
	Earthquake	Due to construction of large dams in mountain areas, which insert pressure on land and intensifying the intensity of earthquake.
B	**Desertification**	**Desertification** is the process by which natural or human causes reduce the biological productivity of dry lands (arid and semiarid lands). Declines in productivity may be the result of climate change, deforestation, overgrazing, poverty, political instability, unsustainable irrigation practices, or combinations of these factors. The concept does not refer to the physical expansion of existing deserts but rather to the various processes that threaten all dry land ecosystems, including deserts as well as grasslands and scrublands.
C	**Smog**	**Smog** is a type of intense air pollution. The word "smog" was coined in the early 20th century, and is a contraction (portmanteau) of the words smoke and fog to refer to smoky fog; its opacity, and odor. Man-made smog is derived from coal combustion emissions, vehicular emissions, industrial emissions, forest and agricultural fires and photochemical reactions of these emissions.

(i) Man-made Hazards:

Man-Made Hazards are events that are **caused by humans** and occur in or close to human settlements. The events leading up to a man-made hazard may be the result of deliberate or negligent human actions, but their impact can be equally as devastating.

Sl No	Category	Subcategory

A	**Technological Hazards**	**a) Industrial Hazard:** It includes industrial pollution, industrial accidents like gas explosion, radioactive chemical explosion, poisons, oil spill, gas leak, hazardous materials (HazMat) accidents, raw material extraction (mining) accidents and structural (building) fires and failures. **b) Transport Hazard:** These involve land, sea, and air transportation systems and include the infrastructure that supports such systems. Examples of transportation hazards include - roadway, aviation, nautical, and railway accidents, transportation systems failures or shutdowns and any impediment to travel. **c) Infrastructural Hazard:** These are hazards related to government-critical utilities and other public service systems. Hazards of infrastructure include - failures of power, telecommunications, computer network, water, sewer, and gas distribution systems, dam failure, food shortage, overburdened public health resources, and economic failure.
B	**Social Hazards**	**a) Terrorism:** Terrorism is characterized by the threatened or actual use of force or violence against persons or property to coerce or intimidate governments or communities. Terrorism hazards can include the use of chemical weapons, biological weapons, radiological / nuclear weapons, explosives, and cyber (computer-related) attacks. **b) Racial and Religious Conflicts:** Religious conflict or racial conflict is war primarily caused or justified due insert superiority of one over another. Since the awakening of religion, wars have been fought in the name of different gods and goddesses. Still today most violent conflicts contain religious elements linked up with ethnonational, inter-state, economic, territorial, cultural and other issues. **c) Famine:** A famine is a widespread scarcity of food, caused by several factors including war, inflation, crop failure, population imbalance, or government policies. This phenomenon is usually accompanied or followed by regional malnutrition, starvation, epidemic, and increased mortality. **d) War:** It includes use of chemical weapons, biological weapons, radiological / nuclear weapons, explosives, and cyber (computer-related) attacks.

Hazards are also classified on the basis of their speed of onset as:

1. **Slow Onset –** Slow onset events provide response time, i.e. the time to raise warning and time required for preparedness and response. E.g. Drought, Heat waves.

2. **Fast Onset –** These events give no response time, and affects instantaneously. e.g. Earthquake, Cloud Bursts etc.

3. **Medium onset –** Though not well defined, but these can be considered as events which fall in between slow and fast onset. These provide a very short time window to generate warnings and prepare for the hazard. e.g. Cyclones, Floods. (Although traditionally considered under fast onset hazards).

There is another classification scheme based on hazard frequency as-

1. **Single time Event –** Major events which occur once and does not follow a seasonal or temporal pattern. e.g. Earthquake
2. **Chronic Event –** Major events which follow a seasonal pattern or occur repeatedly after a certain interval of time. e.g. Floods, Cyclones etc.

Further, hazards are also classified into two categories based on the spatial characteristics-

1. **Concentrated –** The events which affect a significant number of populations located in a single location. e.g. Floods
2. **Dispersed –** are hazardous events affecting a significant number of populations spreading across the geographical locations.

While discussing about hazards, it would be worthwhile to discuss about the characteristics of Hazards as under -

- **Magnitude –** is the strength or force of the hazard event. The scale of measurement varies across hazards. While earthquake is measured in Richter scale or Modified Mercalli Intensity scale , Hurricanes are measured in Saffir Simpson Hurricane scale. Certain hazards have no well-defined scale of measurement and are measured based on their impacts.
- **Duration –** is the time during which a hazard event persists
- **Seasonality –** The particular season in which the hazards are more likely to occur
- **Spatial Extent –** The area affected by hazard.

Assessment of Hazards:

The hazard related study is named **Hazard Assessment** and it involves the analysis of the physical aspects of the phenomena through the collection of historic records, the interpretation of topographical, geological, hydrological information to provide the estimation of the temporal and spatial probability of occurrence and the magnitude of the hazardous event.

1. Analysis of Hazards
2. Vulnerability Assessment
3. Risk Assessment

1. Analysis of Hazards:

The term hazard include a wide variety of phenomena, ranging from local events like tornadoes to events at continental scale like climate change, or from very fast phenomena like lightening to very slow events as desertification. In order to analyze the different hazard types, six main characteristics can be defined. These are as follows:

a) **Triggering Factors:**

Natural causes of hazards can be divided into two main groups: exogenic and endogenic factors. The first class contains all the triggering processes that occur on the Earth's surface. Exogenic factors are mainly related to atmospheric conditions like precipitation, wind, temperature and other atmospheric parameters that can trigger natural hazards like landslides, rivers and coastal floods, and land degradation. Analysis these two will help in several ways: I) **Forecasting**:

Atmospheric phenomena have been widely studied in the last decades and many progresses in forecasts have been achieved; nowadays different techniques of weather forecasting are available.

II) **Prediction of Intensity**:

Analysis of different elements of a particular hazard, gives possible amount of intensity of the hazard accurately. Like amount of rainfall gives idea of flood level.

III) **Spread of Hazard**:

Analysis of real time data relating to triggering factors of hazards gives idea of spatial expansion of hazards in near future time.

b) **Spatial occurrence:**

One of the main targets of hazard assessment activities is to identify which areas are more prone to hazard events considering topographical, geological, hydrological, climatic characteristics. Hazards don't occur in random areas, but they often follow defined patterns identified by the presence of certain characteristics. Spatial Analysis helps in finding: **I) Spatial Pattern:**

It includes geometric pattern of hazards and differential intensity zone – High, Medium, and Low. Such analysis helps identifying different zones of vulnerability and risk.

II) Forecasting:

Study on spatial occurrence helps identifying hazard susceptibility zones. Just like landslides can occur only in areas with sufficient slope gradients, but not all the slopes are prone to landslides; activity of previous mass movements in an area in combination with additional stability affecting conditions (landcover-landuse, internal and external drainage system, precipitation rates) may be used to forecast the occurrence of future landslides in that area.

III) Identification of Mapping Tool:

The areal extension of the hazardous event is a key point in order to choose the appropriate mapping and analysis tools. The areal dimension can widely vary among the same hazard type: if we consider flood hazard, flood events can be small and affect a small village crossed by a seasonal stream in a mountainous area or a wide floodplain area covering many square kilometers. Once again, the analysis and the mapping tools have to be appropriate to the hazard's spatial extension; at the same time the observation scale can depend on the nature of the hazard.

IV) Correlating different variables of Hazards:

Spatial analysis of hazards highlights on differential intensity of hazards and tries to establish relationship between hazards and its different variables. Just like intensity of landslide is related with slope amount, vegetation cover, soil characteristics, ground water level, weathering amount and so on.

C) Duration of Event:

The duration of a hazardous event refers to the time span in which such event takes place. To quantify the duration, the starting and the ending points have to be defined. For sudden phenomena like earthquakes or landslides it is easy to define the beginning and the ending points; but for other gradual events this is more complex. The duration of event helps in determining:

I) Extent of vulnerability and assessment of risk amount II) To prepare disaster management plan and to implement it.

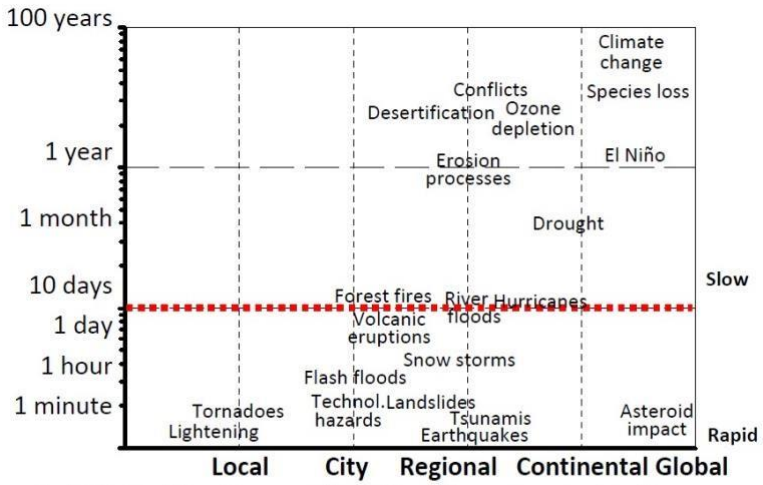
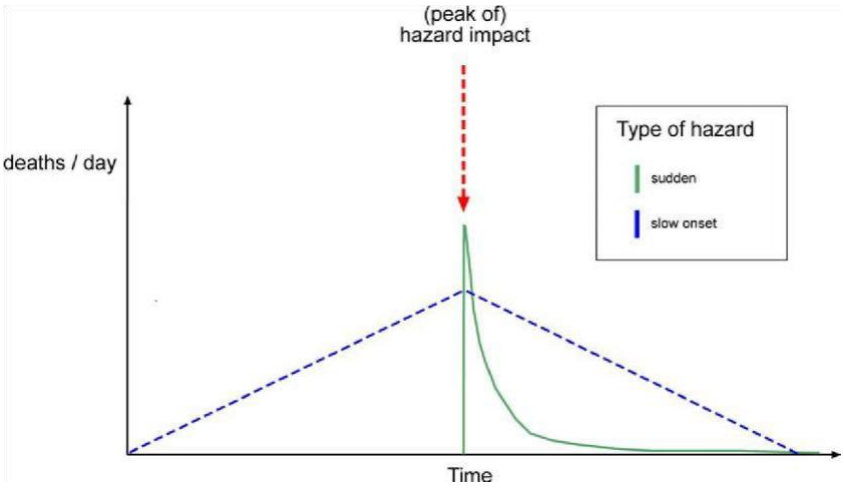


Fig 3.1.5: Spatial and temporal distribution of the major natural and human-induced major hazardous events (the red line represents the boundary between fast and slow processes, with the threshold set on 10 days).



D) **Time of onset:**

Before a hazard occurs, some foregoing events can anticipate the main phenomenon. These events are defined as **precursors**. Depending on the hazard type, such "signs" can occur days, hours, or seconds before or there cannot be at all. In order to better explain the concept, few examples will be shown:

a) Landslides and mass movements are hazardous phenomena that can be triggered by various causes like heavy rain falls, earthquakes, soil weathering, increase of superficial load due to snow, etc. Areas prone to landslides can show forewarning features that "announce" the occurrence of such events.

b) Floods are mostly caused by heavy and/or persistent precipitations. Rainfall can be considered flood triggering factors and a precursor of flood hazards as well; because when heavy rainfall is observed in a flood prone area, it is likely to expect a flood event in a short period of time.

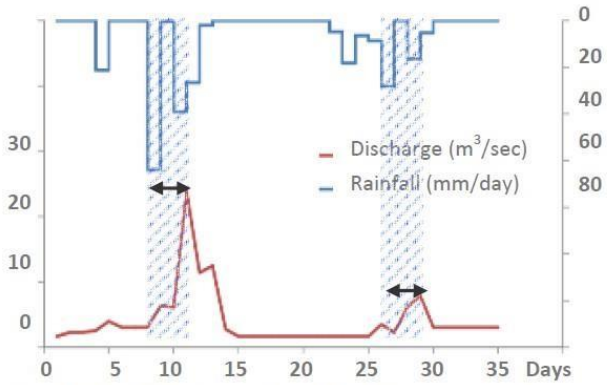


Fig. 3.1.11: A Discharge-Rainfall relation graph: the area with blue stripes and the two arrows show the time lapse between the precursor (rainfall) and the hazard pick (flood max discharge).

E) **Magnitude and Intensity**:

In general, a hazard is a phenomenon that, for its intensity, represents an exceptional and harmful condition. **Magnitude** is related to the amount of energy released during the hazardous event, or refers to the size of the hazard. **Intensity** is used to refer to the damage caused by the event. It is normally indicated by scales, consisting of classes, with arbitrarily defined thresholds, depending on the amount of damage observed.

Magnitude and intensity of hazard helps in analyzing the following aspects of hazard analysis: I)

Hazard Zonation:

The magnitude of hazard varies one region to another. Even it varies within a region. Based on the magnitude of events, hazard map is prepared as high, medium, low magnitude zone that helps in planning for disaster management.

II) **Vulnerability and Risk calculation**:

The magnitude as well as intensity of hazard is directly proportional to vulnerability. Hence analysis of magnitude and intensity help to calculate vulnerability of region as well as risk amount.

F) **Frequency**:

The temporal characteristic of a hazardous event is the frequency of occurrence. **Frequency is:** the (temporal) probability that a hazardous event with a given magnitude occurs in a certain area in a given period of time (years, decades, centuries etc.). The importances of frequency of hazard are following: I. **Probability of Hazard**:

In hazard assessment, frequency is a key point to study the occurrence probability of hazardous events in the future. The analysis of historical records and their frequency allows scientists to understand when a certain hazard with a certain magnitude is likely to occur in a given area. In most of the cases there is a fixed relation between magnitude and frequency for natural events (see figure). The frequency of events with a low magnitude is high, while the frequency of events with great magnitude is low: i.e. small flood events occur every year while enormous and devastating inundations are likely to happen once every one or more centuries. Frequency is generally expressed in terms of probability; which is defined as the chance that during the year an event with a certain magnitude is likely to occur. The probability can be shown as a percentage: a hazard, that statistically occurred once every 25 years, has an probability equal to 0.25 (or 25%).

II) **Calculation of return Period**:

Another method is the calculation of the return period: it indicates the period in years in which the hazards is likely to occur based on historic records; an example can be a flood with a return period of 100 years (100 years return period flood = 1 event in 100 years. III. **Vulnerability calculation**:

Frequency of a hazard with varying intensity gives different values of probability for a region. Considering all these values gives total exposure of the region in terms of the particular hazard. Hence, overall it gives physical vulnerability of the region.

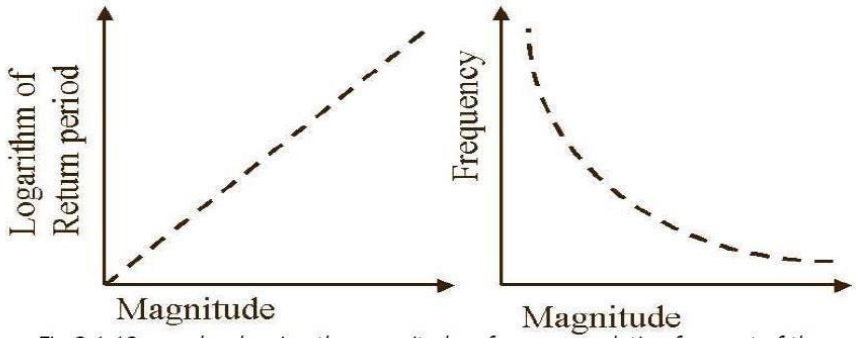


Fig.3.1.12: graphs showing the magnitude – frequency relation for most of the natural hazards.