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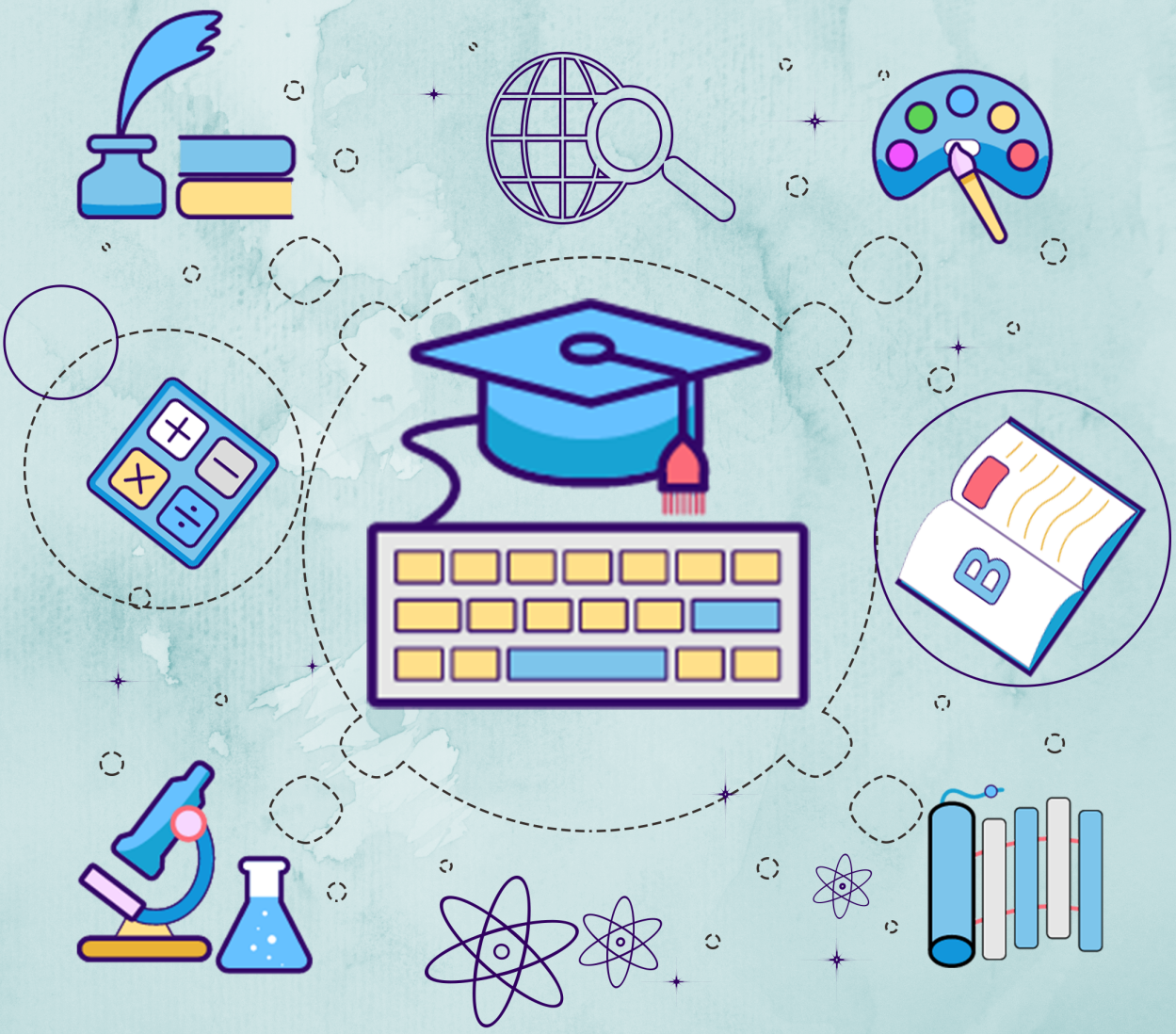

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DISASTER MANAGEMENT

MCN301

Module 2

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MCN 301 Disaster Management - Module 2 Notes

Syllabus:

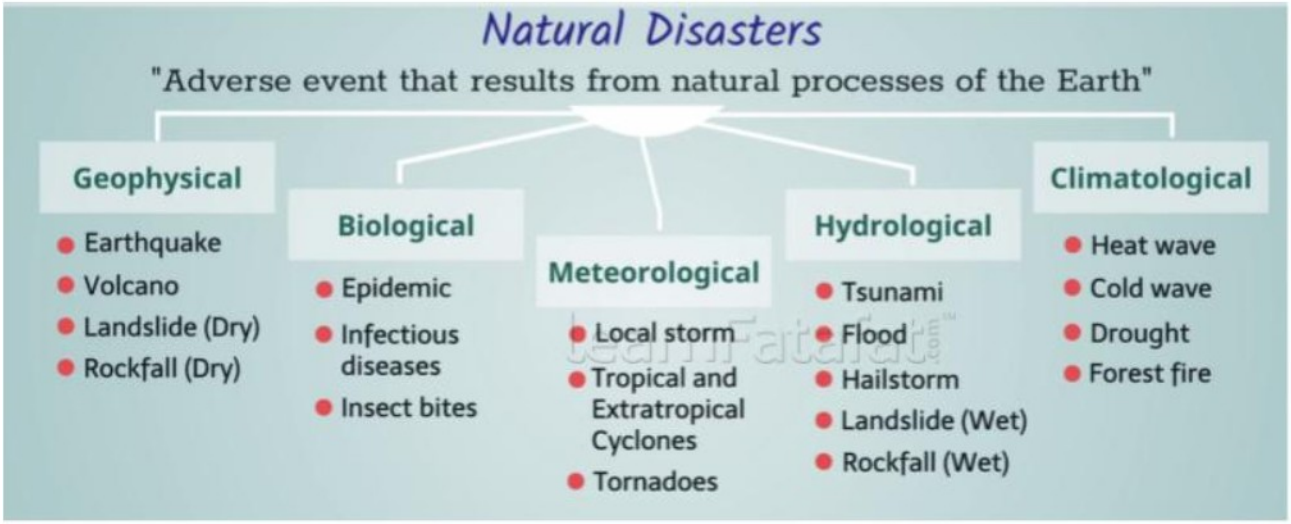
Hazard types and hazard mapping; Vulnerability types and their assessment- physical, social, economic and environmental vulnerability. Disaster risk assessment –approaches, procedures

Hazard

A hazard can be defined as a potentially damaging physical event, social and economic disruption or environmental degradation.

Types of Hazards

- 1. Geophysical Hazard
- 2. Hydrological Hazard
- 3. Meteorological Hazard
- 4. Climatological Hazard
- 5. Biological Hazard
- 6. Extraterrestrial Hazard



- **1. Geophysical hazard:** A hazard originating from solid earth. This term can be used interchangeably with the term geological hazard.
- **2. Hydrological hazard:** A hazard caused by the occurrence, movement, and distribution of the surface and subsurface freshwater and saltwater.
- **3. Meteorological hazard:** A hazard caused by short-lived, micro- to mesoscale extreme weather and atmospheric conditions that last from minutes to days.
- **4. Climatological hazard:** A hazard caused by long-lived, meso- to macro-scale atmospheric processes ranging from intra-seasonal to multi-decadal climate variability.
- **5. Biological hazard:** A hazard caused by the exposure to living organisms and/or the toxic substances or vector-borne diseases that they may carry.
- **6. Extraterrestrial hazard:** A hazard caused by asteroids, meteoroids, and comets as they pass near earth, enter the earth's atmosphere, and/or strike the earth, or change in interplanetary conditions that affect the earth's

Hazard Mapping

Hazard mapping involves a graphical representation of the location, magnitude and temporal characteristics of hazards on 2 or 3 dimensional surfaces. The objective of this it to represent the spatial and temporal characteristics of the hazard as well as its magnitude using graphical symbols.

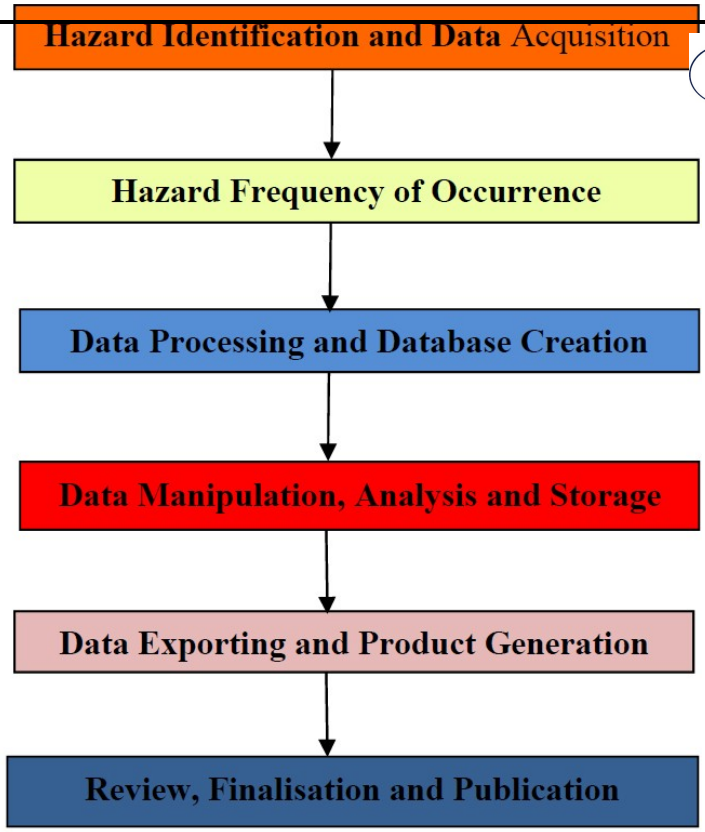
Data Requirements of Hazard Mapping

Spatial characteristics such as location, distribution and dimension; temporal and magnitude are the major data requirements for hazard mapping. Such information can be obtained through the following sources:

- **1. Base Maps:** Base maps represent topographic layers of data such as elevation, roads, water bodies, cultural features and utilities. Creation of a base map is a time-consuming activity. It is therefore desirable to use an existing map. It must also have sufficient geographic reference information to orient the user to the location of the hazard.
- **Remotely Sensed Images:** Satellite images are increasingly becoming preferred sources of readily available information of locations or events on the earth's surface compared to conventional ground survey methods of mapping that are labour intensive and time consuming.
  GeoEye, QuickBird and ALOS-PRISM are preferred sensors for visual mapping as they are of high spatial resolutions.
- **Field Data:** Through the advances of technology, ground surveying methods using electronic survey systems like Total Station, the global positioning systems (GPS) and Laser Scanners, have all greatly increased opportunities for data capture in the field.

Hazard Mapping Using Geographic Information System (GIS)

- GIS is increasingly being utilised for hazard mapping and analysis, as well as for the application of disaster risk management measures. The nature and capability of GIS provides an excellent basis for processing and presenting hazard information in the form of maps.
- GIS is very useful in arranging a high volume of data necessary to produce a hazard map. The flowchart represents the general procedure for the mapping of hazards in GIS.



GIS mapping of hazards

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Vulnerability

vulnerability was defined as the degree to which a system is exposed and susceptible to the adverse effects of a given hazard.

Vulnerability = (Exposure) + (Resistance) +

Resilience Exposure: at risk property and

population
Resistance: Measures taken to prevent, avoid or reduce loss Resilience: Ability to recover prior state or achieve desired post-disaster state.

• Types of Vulnerability

• Physical vulnerability

- This refers to the potential losses to physical infrastructure such as roads, bridges, railways, radio and telecommunication mast and other features in the built environment.
- Also includes impacts on the human population in terms of injuries or deaths.

• Social vulnerability

- Social vulnerability refers to losses as experienced by people and their social, economic, and political systems
- Vulnerability refers to the extent to which elements of society such as children, the aged, pregnant and lactating women, single parents, physically and mentally challenged, the poor and destitute, social class, caste, ethnicity, gender, family systems, political systems, economic systems and cultural values degrade after being exposed to a hazardous condition.

- **Economic vulnerability**

- This refers to the potential impacts of hazards on economic assets and processes and includes vulnerability of different economic sectors.

- **Ecological/environmental vulnerability**

- This refers to the degree of loss that an ecosystem will sustain to its structure, function and composition as a result of exposure to a hazardous condition.

• Vulnerability Assessment

- This refers to the quantification of the degree of loss or susceptibility to an element at risk.
- Variations exist in the method of quantification of vulnerability based on the following:

a. Type of vulnerability being measured

b. The scale at which vulnerability is being measured

c. The type of hazard.

• *Data needed for vulnerability assessment and their usefulness*

- Historical data on the magnitude of a hazard and the level of damage it caused
- Socio-economic data such as level of education, social networks, sanitation, income level, access to land, access to technology etc
- Level of exposure to hazardous conditions
- Data on policies, institutions and processes which influence capacity of individuals, households and communities

• Approaches to Physical Vulnerability Assessment

- There are a wide variety of ways to measure physical vulnerability.
- Two main methods are the empirical and analytical methods.
- The analytical methods rely on the use of geotechnical engineering software and are often limited to individual structures
- The empirical methods can be applied to groups of related structures.

Methods of measuring physical vulnerability

Group	Method	Description
	Analysis of observed damage	Based on the collection and analysis of statistics of damage that occurred in recent and historic events. Relating vulnerability to different hazard intensities.
Empirical methods	**Expert opinion**	Based on asking groups of experts on vulnerability to give their opinions, e.g. the percentage damage they expect for the different structural types having different intensities of hazard. This is meant to come to a good assessment of the vulnerability. Method is time consuming and subjective. Re-assessments of vulnerability after building upgrading or repair are difficult to accommodate.
	Score Assignment	Method using a questionnaire with different parameters to assess the potential damages in relation to different hazard levels. The score assignment method is easier to update, e.g. if we think about earthquake vulnerability before and after application of retrofitting.

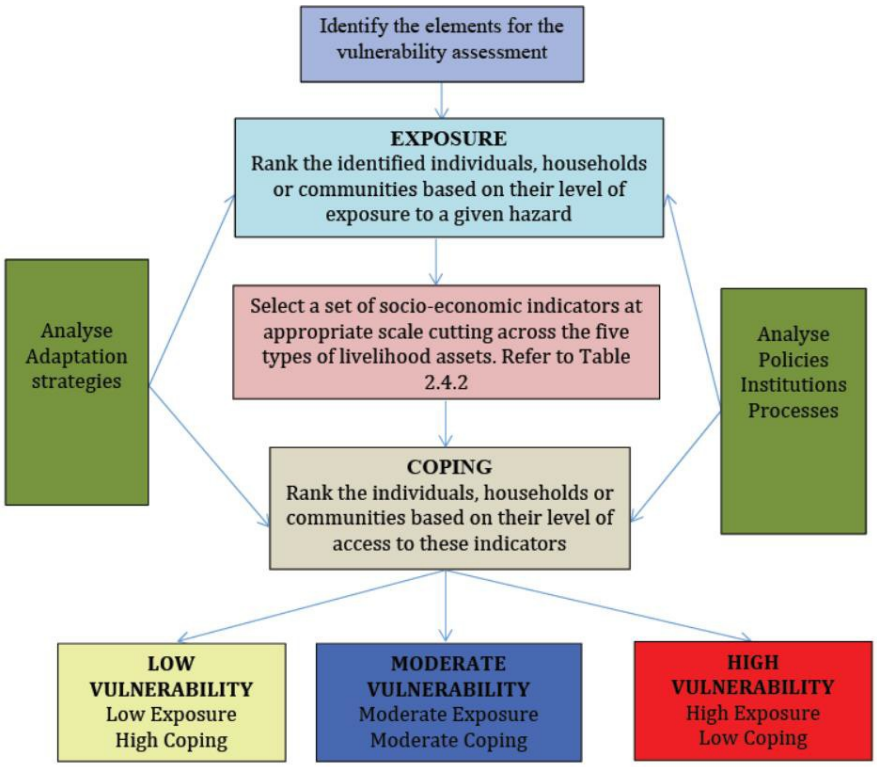
Methods of measuring physical vulnerability

Analytical models	**Simple Analytical models**	Studying the behaviour of buildings and structures based on engineering design criteria, analysing e.g. seismic load and to derive the likelihood of failure, using computer based methods from geotechnical engineering. Using, e.g. shake tables and wind tunnels, as well as computer simulation techniques.
	Detailed Analytical methods	Using complex methods. It is time consuming, needs a lot of detailed data and will be used for assessment of individual structures.

- **Methods of Measuring Socio-economic Vulnerability**

Socio-economic vulnerability is indicator-based and can be assessed by analysing the level of exposure and coping mechanisms of individuals, households and communities.

- **Method for assessing socio-economic vulnera**



Socio-economic indicators

Human Capital	Natural Capital	Social Capital	Physical Capital	Financial Capital
Health	Land and produce	Networks and connections	Infrastructure • Transport - roads, vehicles, etc. • Secure shelter & buildings water supply & sanitation	Savings
			• Energy communications	
Nutrition	Water & aquatic resources	Patronage	Tools and technology • Tools and equipment for production • Seed, fertiliser, pesticides • Traditional technology	Credit/debt - formal, informal, NGOs
Education	Forest products	Neighbourhoods		Remittances
Knowledge and skills	Wildlife	Kinship		Pensions
Capacity to work	Wild foods & fibres	Relations of trust and mutual support		Wages
Capacity to adapt	Biodiversity	Formal and informal groups		Dividends
	Environmental services	Common rules and sanctions		Return on Investments

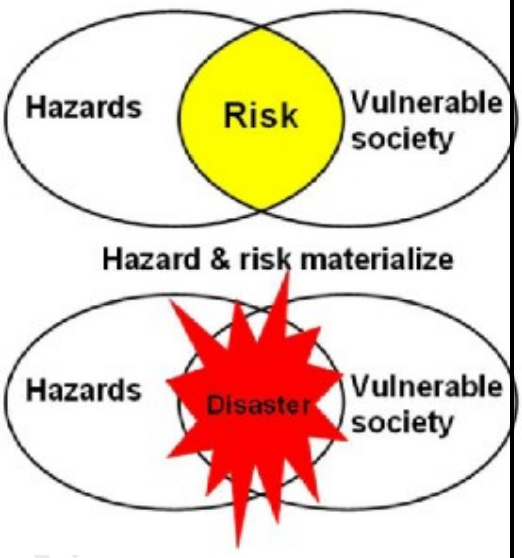
• Methods of Representing Vulnerability

- **Vulnerability indices**: Based on indicators of vulnerability
- **Vulnerability table**: The relation between hazard intensity and degree of damage can also be given in a table.
- **Vulnerability curves**: These are constructed on the basis of the relation between hazard intensities and damage data
  - Relative curves: They show the percentage of property value as the damaged share of the total value to hazard intensity.
  - Absolute curves: Show the absolute amount of damage depending on the hazard intensity
  - Fragility curves: Provide the probability for a particular group of elements at risk to be in or exceeding a certain damage state under a given hazard intensity.

Disaster Risk Assessment

Disaster risk

- It is the probability of serious damage, deaths and injuries occurring as a result of a potentially damaging hazard interacting with vulnerable elements such as people and properties.



Disaster Risk Assessment

- It is a methodology to determine the likelihood and magnitude of damage or other consequences by analysing potential hazards and evaluating existing conditions of vulnerability that jointly could likely harm exposed people, properties, services, livelihoods and the environment they depend on.

Components of Risk Assessment

There are two main components:

- Risk analysis: The use of available information to estimate the risk caused by hazards to individuals or populations, property or the environment. It contains the following steps: Hazard identification, hazard assessment, elements at risk/exposure, vulnerability assessment and risk estimation.
- Risk evaluation: This is the stage at which values and judgement enter the decision process by including the importance of the risk and associated social, environmental,

Contemporary approaches to risk assessments

Multi-hazard

- The same area may be threatened by different types of hazards.
- Each of these hazard types has different areas that might be impacted by hazard scenarios.
- Each of the hazard scenarios also might have different magnitudes.

Multi-sectoral:

- Hazards will impact different types of elements at risk.

Multi-level:

- Risk assessmentcan be carried out at different levels.
- Depending on the objectives of the risk study, it is possible to differentiate between national, regional, district and local policies, plans and activities to see how they have contributed to increased or reduced risk, their strengths and weaknesses in dealing with risks, and what resources are available at the different levels to reduce risks.

Multi-stakeholder:

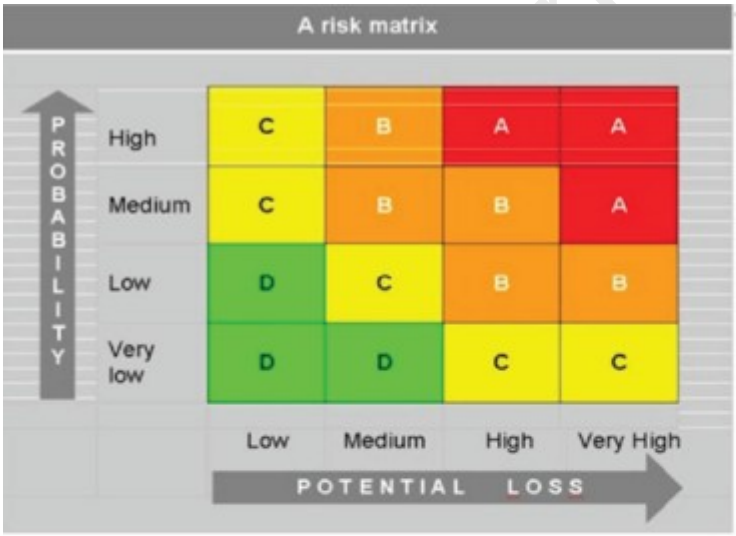
- Risk assessment should involve the relevant stakeholders, which can be individuals, businesses, organisations and authorities.

Multi-phase:

- Risk assessment should consider actions for response, recovery, mitigation and preparedness.

Qualitative methods:

- This involves qualitative descriptions or characterization of risk in terms of high, moderate and low.
- These are used when the hazard information does not allow us to express the probability of occurrence, or it is not possible to estimate the magnitude.
- Risk matrices can be constructed to show qualitative risk.
- A risk matrix shows on its y-axis probability of an event occurring, while on the x-axis potential loss.



Risk levels

A: Very high. Frequent events causing very high losses, or moderate frequent events causing very high losses

B: High. Frequent events with moderate losses/ moderate & low frequent events causing (very) high losses

C: Moderate. Frequent events with low losses or very low frequent events causing (very) high losses

D: Low. Low frequency events with low losses

Loss

Based on the potential by taking into account elements at risk

- Fatalities
- Injuries
- Impact on facilities, critical services and infrastructure
- Property damage
- Business interruption
- Environmental/ Economic impact

Probability

High	Events that occur more frequently than once in 10 years
Moderate	Events that occur from once in 10 years to once in 100 years
Low	Events that occur from once in 100 years to once in 1000 years
Very Low	Events that occur less frequently than once in 1000 years

Potential hazards

Earthquake	Lightening	Debris Flow	Civil unrest
Flood	Heat Wave	Hazardous materials release	Terrorism
Fire	Drought	Transportation accident	Market fires
Storms	Pandemic (e.g., HIV/AIDS, flu)		
Fire		Water shortage	
Food poisoning	Landslide	Power shortage	

Risk assessment matrix

A. Hazards	B. Hazard Likelihood **0 low – 5 is high**	C. Impact Severity **(Vulnerabilities/ Resources) 0 is low – 5 is high**	D. Risk Score **B x C** E. Priority	E. Priority

In Column A, enter all of those hazards that may affect your community.

In Column B, the likelihood of occurrence of this event (between 0 low to 5 high)

HAZARDS	1	2	3	4	5
B. Likelihood	Very low	Low	Medium	High	Very high

In Column C, enter the severity of the impact you expect. This would be based on your understanding of the various vulnerabilities and the measures your community has already taken to reduce them.

Vulnerability	1	2	3	4	5
C. Impact severity	Minor	Controllable	Critical	Devastating	Terminal

In Column D, Multiply your likelihood by impact rating. Column B x C. This would give you your risk score

Risk score	1-3	4-8	9-14	15-19	20-25
Description	Very low	Low	Medium	High	Very high

In Column E, convert your risk scores into simple priority scores. 3-Low, 2-medium, 1-high

Risk score	1-3	4-8	9-14	15-19	20-25
Priority level	3	3	2	1	1
Description	Low		Medium	High	

- Semi-quantitative methods:
- These techniques express risk in terms of risk indices.
- These are numerical values, often ranging between 0 and 1.
- The main difference between qualitative and semi-quantitative approaches is the assignment of weights under certain criteria which provide numbers as outcome instead of qualitative classes.

- Semi-quantitative methods:

- The semi quantitative estimation for risk assessment is found useful in the following situations:

➢ As an initial screening process to identify hazards and risks

➢ When the level of risk does not justify the time and effort

➢ Where the possibility of obtaining numerical data is limited

- Semi-quantitative methods:

- The semi-quantitative approach could be adapted to cover larger areas.

- Semi-quantitative risk can also be conceptualised as:

Risk = Hazard * Vulnerability / Capacity

- It allows incorporating the multi-dimensional aspects of vulnerability, and capacity.

- Quantitative methods:
- This aims at estimating the spatial and temporal probability of

risk and its magnitude.

Risk = Hazard * Vulnerability * Amount of elements-at- risk

- The amount of elements-at-risk are characterized the way in which the risk is presented.
- The hazard component in the equation actually refers to the probability of occurrence of a hazardous phenomenon with a given intensity within a specified period of time.
- Vulnerability is limited to physical vulnerability of the

Different ways of expressing risk

General	Type	Principle	
Qualitative	Qualitative	Based on relative risk classes categorised by expert judgment. Risk classes: High, Moderate and Low	
	Semi-Quantitative	Based on relative ranking and weights assignments by a given criteria. Risk index: Ranked values (0-1, 0-10 or 0-100). (dimensionless)	
Quantitative	Probability	Probabilistic values (0-1) for having a predefined loss over a particular time period	
	Economic risk	Quantification of the expected losses in monetary values over a specific period of time	
		Probable Maximum Loss (PML)	Probable Maximum Loss (PML) The largest loss believed to be possible in a defined return period, such as 1 in 100 years, or 1 in 250 years
		Average Annual Loss (AAL)	Expected loss per year when averaged over a very long period (e.g., 1,000 years). Computationally, AAL is the summation of products of event losses and event occurrence probabilities for all stochastic events in a loss model.
		Loss Exceedance Curve (LEC)	Risk curve plotting the consequences (losses) against the probability for many different events with different return periods.
	Population risk	Quantification of the risk to population	
		Individual risk	The risk of fatality or injury to any identifiable (named) individual who live within the zone impacted by a hazard; or follows a particular pattern of life that might subject him or her to the consequences of a hazard.
		Societal risk	The risk of multiple fatalities or injuries in society as a whole: one where society would have to carry the burden of a hazard causing a number of deaths, injury, financial, environmental, and other losses.