KTU STUDY MATERIALS

DISASTER MANAGEMENT
MCN301

Module 2

MODULE 2

Hazard:

- A hazard is a situation that has the potential to cause damage
- 'hasard' means 'chance'
- Hazard becomes a disaster when risk associated with it are not managed well
- Example
  - ➢ People living in coastal area live in hazardous situation as cyclone may strike them any time
  - ➢ Construction workers working in heights are in a hazardous situation of falling. It may lead to injuries and even death
- Three states of hazard : (i) Dormant (ii) Armed (iii) Active

Dormant:

- ➢ A dormant hazard is one which has the capacity for potential threat but presently does not affect people or property. People living on the banks of a river are on dormant hazard of floods during heavy rain. They are not presently subject to damage but face a threat of possible flooding

Armed:

- ➢ A state of armed hazard occurs when people are likely to be subjected to a threat because the hazard is developing A cyclone moving towards a habitat is a typical example

Active:

- ➢ A hazard is said to be active when it strikes a habitat When this happens it is no longer a hazard but a disaster

CLASSIFICATION OF HAZARDS

Based on the origin hazard is classified into:

Biological Hazard: Process or phenomenon of organic origin or conveyed by biological vectors, including pathogenic micro-organisms, toxins and bioactive substances. Examples of biological hazards include epidemic and pandemic diseases, plant or animal contagion, insect or other animal plagues and infestations.

Geological Hazards: Geological process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage. Geological hazards include internal earth processes, such as earthquakes, volcanic activity and emissions, and related geophysical processes such as mass movements, landslides, rockslides, surface collapses, and debris or mud flows. Hydro-meteorological factors are important contributors to some of these processes. Tsunamis are difficult to categorize; although they are triggered by undersea earthquakes and other geological events, they essentially become oceanic process that is manifested as a coastal water-related hazard.

Hydro-metrological Hazards: Process or phenomenon of atmospheric, hydrological or oceanographic nature that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage. Hydro-meteorological hazards include tropical cyclones (also known as typhoons and hurricanes), thunderstorms, hailstorms, tornados, blizzards, heavy snowfall, avalanches, and coastal storm surges, floods including flash floods, drought, heat waves and cold spells. Hydro meteorological conditions also can be a factor in other hazards such as landslides, wild land fires, locust plagues, epidemics, and in the transport and dispersal of toxic substances and volcanic eruption material.

Anthropogenic Hazards: Hazards induced entirely or predominantly by humans, including technological and socio- natural hazards. Man-made hazards (also known as human-induced hazards or anthropogenic hazards) are a collective term that covers the range of hazards that result from human activities. They are distinguished from natural hazards. The range of man-made hazards includes technological and socio-natural hazards, and those that may arise from the relationships within and between communities

Natural Hazards: Natural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage. Natural hazards are a sub-set of all hazards. The term is used to describe actual hazards as well as the latent hazard conditions that may give rise to future events. Natural hazards can be characterized by their magnitude or intensity, speed of onset, duration, and area of extent. For example, earthquakes have short durations and usually affect a relatively small region, whereas droughts are slow to develop and fade away and often affect large regions. In some cases hazards may be coupled, as in the flood caused by a hurricane or the tsunami that is created by an earthquake.

Radiation Hazards: Radiation hazards are due to electromagnetic radiation from many sources such as nuclear accidents, nuclear waste, mobile phones or transmission towers. They are very harmful and can have immediate or long term effects depending upon the type, exposure and amount of radiation.

HAZARD MAP

- A **hazard map** is a map that highlights areas that are affected by orare vulnerable to a particular hazard.
- They are typically created for natural hazards, such as earthquakes, volcanoes, landslides, flooding and tsunamis.
- Hazard maps help prevent serious damage and deaths.
- The purpose of hazard mapping is to gather together different hazard related information in one map.
- Hazard mapping involves a graphical representation of the location, magnitude and temporal characteristics of hazards on 2 or 3 dimensional surfaces.
- Two objectives of hazard map
  - To make the people of the region aware of the hazards likely in the region
  - To help disaster managers and other stake holders to plan and be prepared for the disaster as and when it occurs

Methods to hazard information collection

- Undertaking field travel and “overflights” of the study area
- Contacting local officials and community leaders
- Maintaining contact with appropriate national planning officers
- Determining the availability of existing data.
- Using experienced staff members or consultants to get an overview

Data Requirements of Hazard Mapping:

Spatial characteristics such as location, distribution and dimension; temporal (duration and speed of onset)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 aselevation, roads, water bodies, cultural features and utilities. It must be plan metric, i.e. a representation of information on a plane in true geographic relationshipand with measurable horizontal distances.

2. **Remotely sensed images:** Satellite images are sources of readily available information of locations on the earth’s surface comparedto conventional ground survey methods of mapping thatare labour intensive and time consuming.
3. **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.

Cartographic Representation of Hazard

Maps are the most operative way to convey actual and relative location. Maps can be simply defined as flat geographic portrayals of information through the use of symbols. Such approaches help hazard maps not to just convey the existence of natural hazards, but also to note their location, severity, and likelihood of occurrence in an accurate, clear, and convenient way. The application of cartography in hazard mapping will eventually lead to the creation of:

Base map which contains sufficient geographic reference information to orient the user to the location of the hazard.

Scale and coverage which draw the relationship between linear measurement on the map and the actual dimension on the ground. Small-scale maps show less detail for a large area and are applicable for regional development planning. Large-scale maps, on the other hand, reveal more detail for a small area and are more suitable for local or community level development planning. The scale used for a hazard map is dependent upon not only the hazard information to be shown, but also upon the scale of the base map. Therefore, the choice of scale for a hazard map may consider the following issues:
o Number of hazards to be displayed at a go;
o The hazard elements necessary to be displayed;
o Range of relative severity of hazards to be shown;
o The area of interest to cover;
o The use of the map with other planning documents and; and
o Function of the map, for example, whether it is to be an index or detail map.

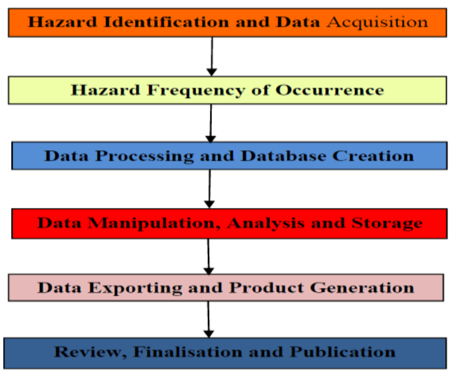
Types of symbols: On a hazard map, symbols are used to represent reality. Symbols are selected for their legibility and clarity and/or map production characteristics. Location, for instance, can be depicted using one of these basic geometric symbols – point, line or an area. Points are more preferred for displaying volcanoes, while areas have been used for showing flooding.

Approaches to Hazard Mapping
Many approaches to hazard mapping have been developed. In all such approaches used, the key factors of consideration in the spatial analysis (valuation of likelihood losses of hazards) is appreciating that:

- all components of a hazard assessment vary in space and time; and
- as the consequences of hazards are usually large, it is prudent to include vulnerability and risk reduction strategies in the process.

1. *Hazard Mapping using 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 three-dimensional representation available in modern GIS offers opportunity to model hazard.
- GIS also provides various methodologies in creating and analysing hazards.



2. *Participatory mapping*

- Participatory mapping is a technique that allows for the integration of local level participation and knowledge in the map production and decision taken process.
- It is an interactive process that draws on local people's knowledge and allows them to create visual and non-visual data to explore social problems, opportunities and questions.
- In participatory mapping, the main objectives are to:
    - collect evidence assets of the study area and issues during the mapping process;
    - interpret the study area mapping experience and related experience to answer questions that have been developed about the study area; and
    - develop a presentation that synthesises the participatory mapping experience and presents the conclusion and possible questions for further investigation.

How to Conduct Participatory Mapping

- Whenever participatory mapping is to be conducted, the foremost issue of consideration is the 'goal of the work' which outlines the nature and essence of activities to be done.
- Once the goal has been decided, the next stage is the organisation of activities of participatory mapping in two blocks – preparation and implementation.
- The preparation involves 'scouting' and 'designing survey instrument, materials and directions'.
- The implementation may be organised into sessions (usually four) - preparation of participants or people involved in the participatory mapping activity; undertake participatory mapping field trip; make presentations and carry out debriefing exercises.

Applications of Hazard Maps

Hazard maps have various applications that may be broadly captured as in spatial planning, risk reduction measures, instruments used in emergency planning and raising awareness among the population

- Spatial planning: Hazard maps provide a basis for communal and district spatial planning processes (e.g. definition of hazard zones in development plans and formulation of building regulations).

- Risk reduction measures: Hazard maps assist in the localisation and dimensioning of hazard protection measures (e.g. flood protection structures, avalanche barriers, etc.)

- Instruments used in emergency planning: Hazard maps indicate where the biggest risks arise and the events most likely to occur. This information can be used as a source of orientation in emergency planning.
- Raising awareness among the population: Hazard maps help to demonstrate potential risks to the population and to increase awareness of eventual protective measures.

VULNERABILITY

Vulnerability Types

- It denotes the characteristics and circumstances of an individual, community or area that could be subjected to harm from a hazardous situation.

- There are four types of vulnerability (UNISDR) –Physical –Economic –social –Environmental

- In a disaster situation, the vulnerable population includes the poor, women and children and the disabled. In general, they are the most affected.

- •The vulnerable areas are those which are very close to the disaster site.

- •In the case of a bomb explosion, assets and people living or present near the site of the blast are the most seriously affected than people far off from the area.

Factors of Vulnerability

- Poorly designed and maintained infrastructure
- Inadequate safety awareness and safety measures for assets
- Lack of awareness and adequate information about hazards and risk
- Inappropriate management of risks identified and lack of preparedness to face hazards
- Lack of proper management of resources and environment

Physical Vulnerability:

- Physical Vulnerability may be determined by aspects such as population density levels, remoteness of a settlement, the site, design and materials used for critical infrastructure and for housing. Physical vulnerability also includes impacts on the human population in terms of injuries or deaths.
- •Example: Wooden homes are less likely to collapse in an earthquake, but are more vulnerable to fire.

Social Vulnerability

- •Social Vulnerability refers to the inability of people, organisations and societies to withstand adverse impacts of hazards due to characteristics inherent in society.
- •It is linked to the level of wellbeing of individuals, communities and society.
- •It includes aspects related to levels of literacy and education, the existence of peace and security, access to basic human rights, systems of good governance, social equity, positive traditional values, customs and ideological beliefs and overall collective organisational systems.
- •Example: When flood occurs, elderly people and children are unable to protect themselves

Economic Vulnerability

- •The level of vulnerability is highly dependent upon the economic status of individuals, communities and nations.
- •The poor are usually more vulnerable to disasters because they lack the resources to build sturdy structures in their homes and put other engineering measures in place to protect themselves from being negatively impacted by disasters.
- •Example: Poorer families may live in low-lying slum areas because they cannot afford to live in safer (more expensive) areas. They are more vulnerable when a flood occurs and their belongings or even their homes get washed away.

Environmental Vulnerability

- •Natural resource depletion and resource degradation are key aspects of environmental vulnerability.
- •Example: People living in hilly areas become vulnerable because of environmental degradation. Their habitats have to necessarily be on hill slopes due to the terrain features. Deforestation and cutting of trees on hill slopes makes them vulnerable to hazards from landslides.

Vulnerability Assessment

- This refers to the quantification of the degree of loss or susceptibility to an element at risk. The assessment is essential when conducting a risk assessment.
- Vulnerability assessments have not always been a part of risk assessment, but in recent times, they have become indispensable due to the recognition that disasters occur as a result of interactions between hazards and vulnerable elements.
- Variations exist in the method of quantification of vulnerability based on the following:
  a) Type of vulnerability being measured, that is, it is physical, social, economic or ecological.
  b) The scale at which vulnerability is being measured, whether at the individual, household or community level.

c) The type of hazard. Different hazard types call for different methods of quantification as not all methods of vulnerability quantification are used for the different hazard types.

Data needed for vulnerability assessment and their usefulness

- Historical data on the magnitude of a hazard and the level of damage it caused to specific elements such as buildings built from sand Crete or wood.
- Socio-economic data such as level of education, access to pipe borne water, access to secure shelter, social networks, sanitation, income level, access to credit, access to land, access to technology etc. The emphasis here is on the level of access that an individual, household or community has to various assets.
- Level of exposure to hazardous conditions
- Data on policies, institutions and processes which influence capacity of individuals, households and communities.

Physical Vulnerability:

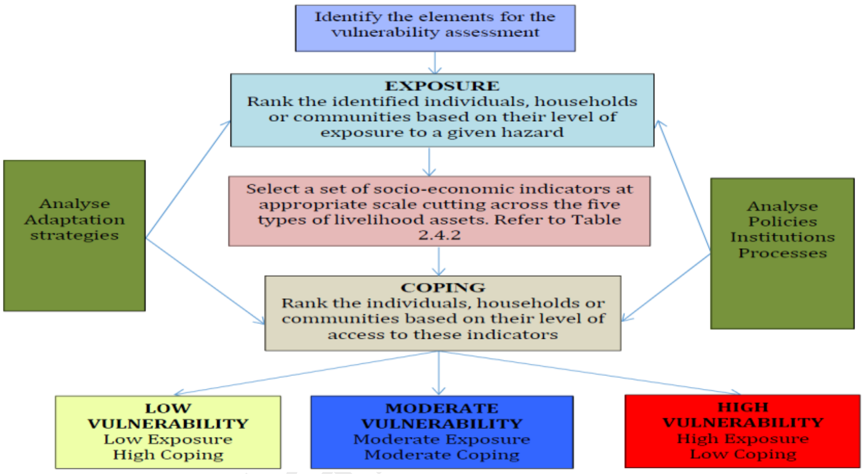
- Buildings: The vulnerabilities of buildings are based on the location of the site, the design, materials used for construction, construction techniques used, and its proximity with other buildings
- Infrastructure: In considering infrastructure, three broad groups are to be considered—they include transportation systems like roads, railways, bridges, airports, etc., utilities like water supply, sewage and power supply; and communication network.
- Other critical facilities: Critical facilities are vital to the functioning of the societies during times of disaster and are considered as lifelines. Examples include hospitals and other essential services; emergency services; communications systems; buildings and structures with cultural importance; and certain structures such as dams that are essential to the long-term sustainability of the economy.

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.
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.

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. Analysis of exposure and coping is done taking into consideration policies and processes and adaptation strategies of affected individuals, households and communities.

- Certain groups of people like single parent families, pregnant or lactating women, mentally and physically handicapped people, children and the elderly require special attention and focus.
- Certain other groups like migrants, people residing at remote areas also require special attention. Risk perceptions for these groups have to be assessed, and the required awareness programs have to be initiated
- Direct losses potential: Direct losses could include damage or destruction of physical and social infrastructure and the likely cost incurred to repair or replace it. It could also include costs related to the damages to crops and other means of production.
- Indirect losses potential: Indirect losses include the impact due to loss of production, employment, income generating activities, and the likely inflation in the society. While direct cost is easy to calculate, assessment of indirect costs is difficult.



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

Socio – Economic Indicators

Methods of Representing Vulnerability

- Vulnerability indices: Based on indicators of vulnerability; mostly no direct relation with the different hazard intensities. These are mostly used for expressing social, economic and environmental 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; i.e., the value of the asset is already integrated in the damage function;
- ➢ 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 arises out of an interaction between a hazardous condition and vulnerable elements. However, disasters only occur when the risk materialises

- The Sendai framework for disaster risk reduction and its immediate predecessor, the Hyogo framework for action, both call for identification and assessment of disaster risk. Thus, risk assessments form an important aspect of risk reduction strategies.

- 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. Risk analyses generally contain 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, and economic consequences, in order to identify a range of alternatives for managing the risk.

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. For instance, water depth and velocity in the case of flooding, acceleration and ground displacement in the case of earthquakes. These hazard magnitudes would also have different impacts on the various elements at risk, and therefore require different vulnerability curves.

- *Multi-sectoral:* Hazards will impact different types of elements at risk.

- *Multi-level:* Risk assessment can 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 characterisation of risk in terms of high, moderate and low.

  - o 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.

- This approach has widespread application in the profiling of vulnerability using participatory methodologies.
- 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.
- The probability is described categorically as low, medium and high, while the potential loss is also described similarly.

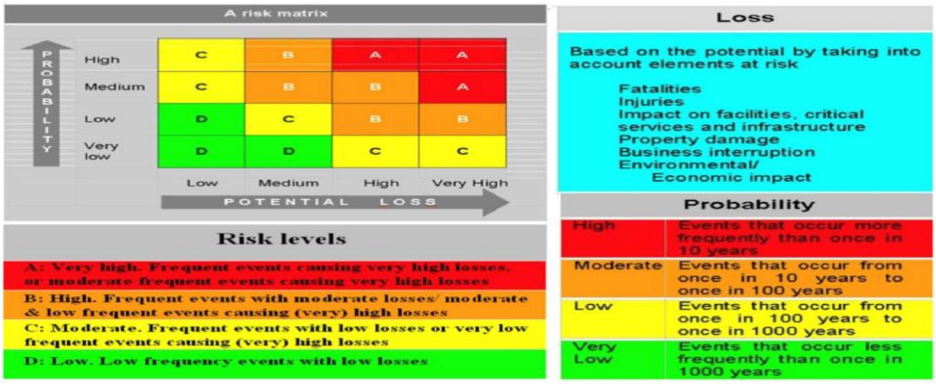


Figure 2.5.2: An example of a risk matrix used for assessing risk qualitatively

- *Quantitative methods:* This aims at estimating the spatial and temporal probability of risk and its magnitude.
    - In this method, the combined effects, in terms of losses for all possible scenarios that might occur, are calculated.
    - There are several approaches; they express the risk in quantitative terms either as probabilities, or expected losses.
    - In this approach, risk is perceived as follows: Risk = Hazard * Vulnerability * Amount of elements-at- risk

Table 2.5.3: 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.

- *Semi-quantitative methods:* These techniques express risk in terms of risk indices.
  - These are numerical values, often ranging between 0 and 1.
  - They do not have a direct meaning of expected losses; they are merely relative indications of risk.
  - 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 (pre-assumed) does not justify the time and effort
    - Where the possibility of obtaining numerical data is limited
  - The semi-quantitative approach could be adapted to cover larger areas
  - Semi-quantitative risk can also be conceptualised as: Risk = Hazard * Vulnerability/Capacity.