Hazard Analysis

Definition: "The process of studying the nature of hazards determining its essential features (degree of severity, duration, extent, impact on the area) and their relationship".

The hazard assessment should begin with the identification of what natural hazards can be expected and how they might change in the short and medium term as a result of climate change. First of all, all of the potential hazards are identified. Then the areas that could be affected by the hazard are marked, this is called Hazard Mapping. The magnitude, intensity and frequency of the hazards are determined and the causes of the hazards are investigated. Hazards could include earthquakes, volcanic eruptions, floods, drought, cyclones and epidemics.

To evaluate the degree of risk and the characteristics and scale of the possible loss from extreme natural events, it is necessary not only to estimate the probability of occurrence but also to investigate the force and duration of the event. It can be made possible using historical data available in written form as well as in the memories of the people of the community. Moreover, scientific data such as meteorological, geological, hydrological, agricultural, environmental and epidemiological data can also be collected from relevant sources and departments for detailed analysis. However, before this detailed study it is necessary to establish how susceptible population groups are to the event and how vulnerable they are to this hazard. If there are no vulnerable populations or elements at the site of the hazard, no hazard analysis is required. This is because in this case the extreme natural event does not pose a threat to human life. These are the first steps in vulnerability analysis, and they are needed before any detailed hazard analysis.

Steps in Hazard Assessment - Natural Hazards

Following are the steps in hazard assessment:

1. Identification of the Type of Hazard:

The first stage in hazard analysis is to identify the types of hazards. Depending on the types of hazards identified, the process may need to be continued on a separate basis for each type of hazard or group of hazard types. Earthquakes, for example, require different instruments and specializations for analysis than e.g. landslides or floods.

There are many ways to classify hazard types, e.g. natural events occurring suddenly or gradually, of an atmospheric, seismic, geological, volcanic, biological and hydrological nature while others summarize mass movements under the heading of “geomorphological hazards”.

2. Frequency:

This investigation aims at finding the seasonality of the occurrence of hazards like how frequent and in which seasons which kind of hazards are expected. For instance Monsoon Rainfall

3. Risk and Coverage:

Afterwards the identification and characterization of hazard prone locations is undertaken and then identification and determination of the probabilities of occurrence on an ordinal scale (high – medium – low) is completed.

4. Magnitude:

The next step is to estimate or calculate the scale (strength, magnitude) of the hazardous event, also on an ordinal scale.

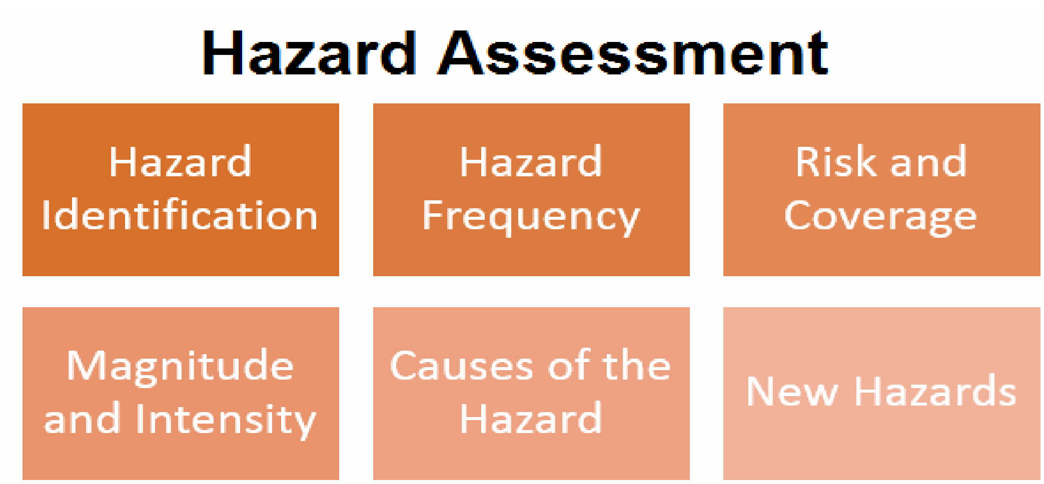
5. Causes of the Hazards:

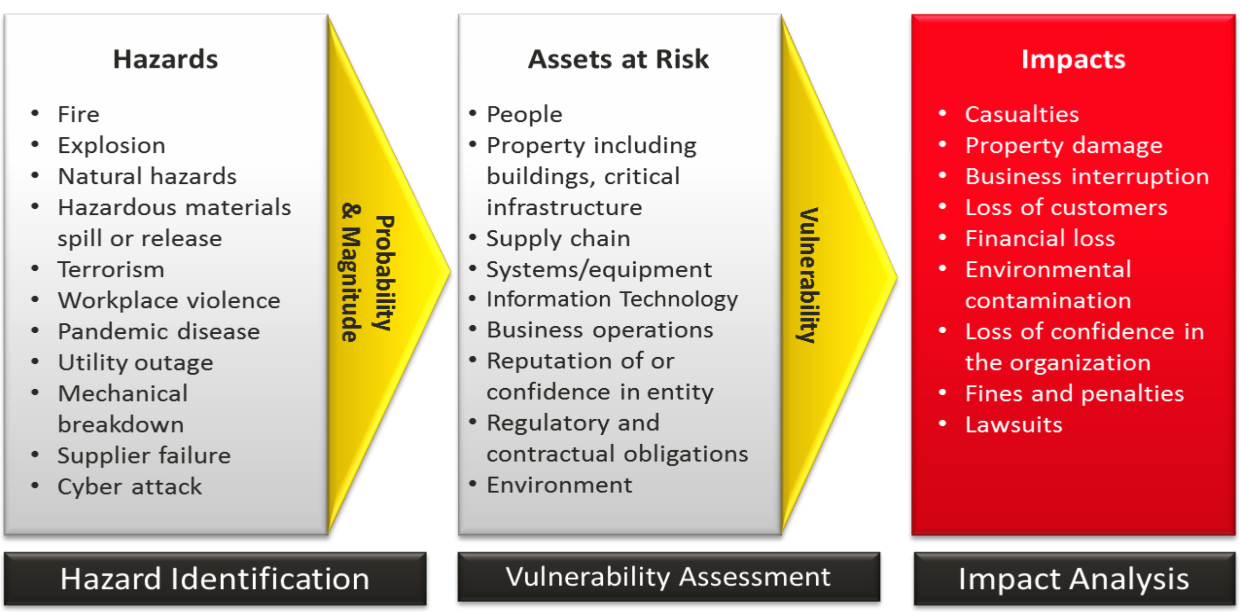
Then identify the factors influencing the hazards, e.g. climatic change, environmental destruction and resource degradation, major infrastructural facilities such as dams etc.

6. Likelihood of new hazards emerging

The study should also investigate possible reasons for new hazards due to the following factors:

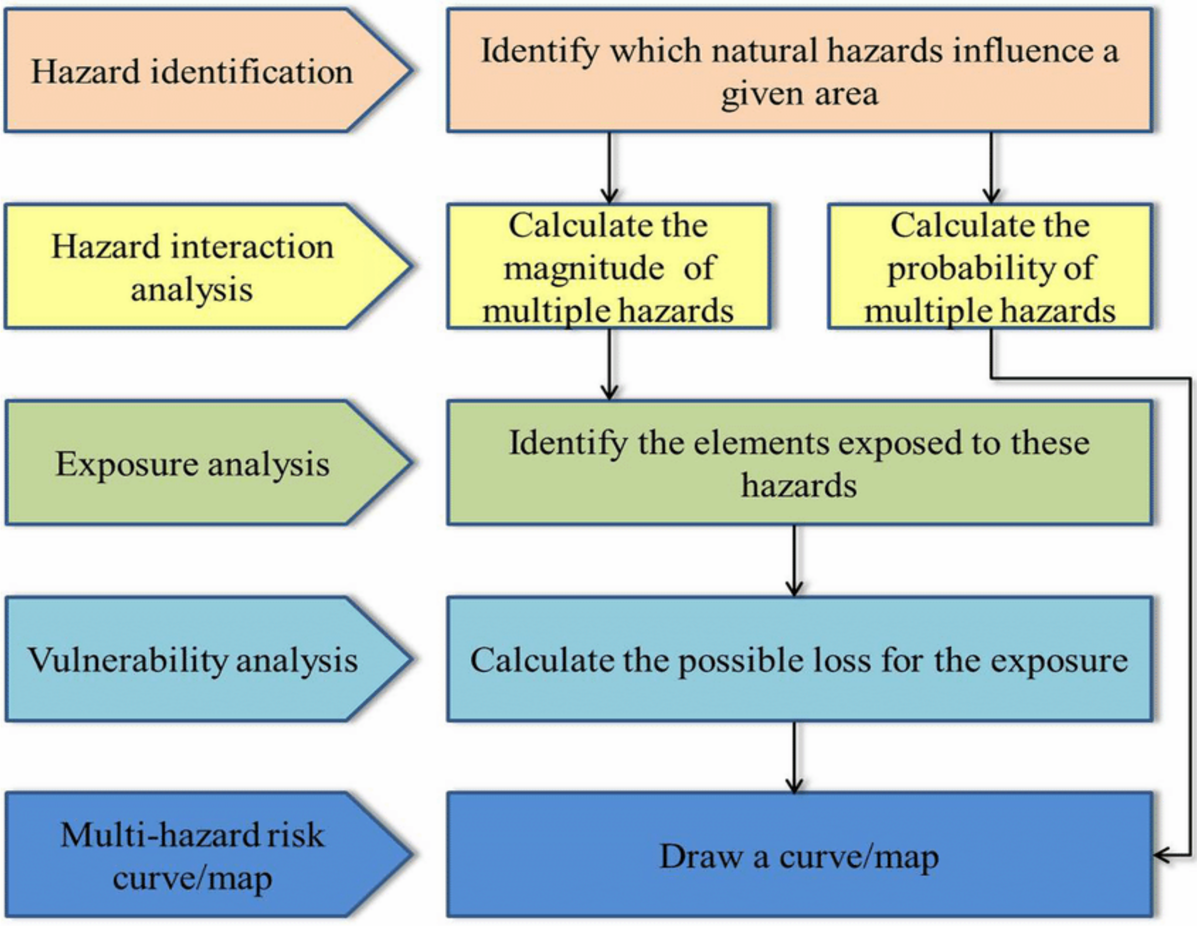
- **Natural factors -** changes in the pattern of weather leading to new hazards like drought, frequent and extreme flood events.
- **Economic -** Fluctuations in the value of currency affecting livelihoods, trade related policy changes, loss of raw materials, industrial damages and destruction.
- **Social and political trends -** Changes in policies, Re-locations of people, Conflicts.
- **Industrial hazards -** chemical accidents, poisoning.
- **New forms of epidemics and diseases -** Bird Flu, AIDS, Hepatitis B & C, Ebola

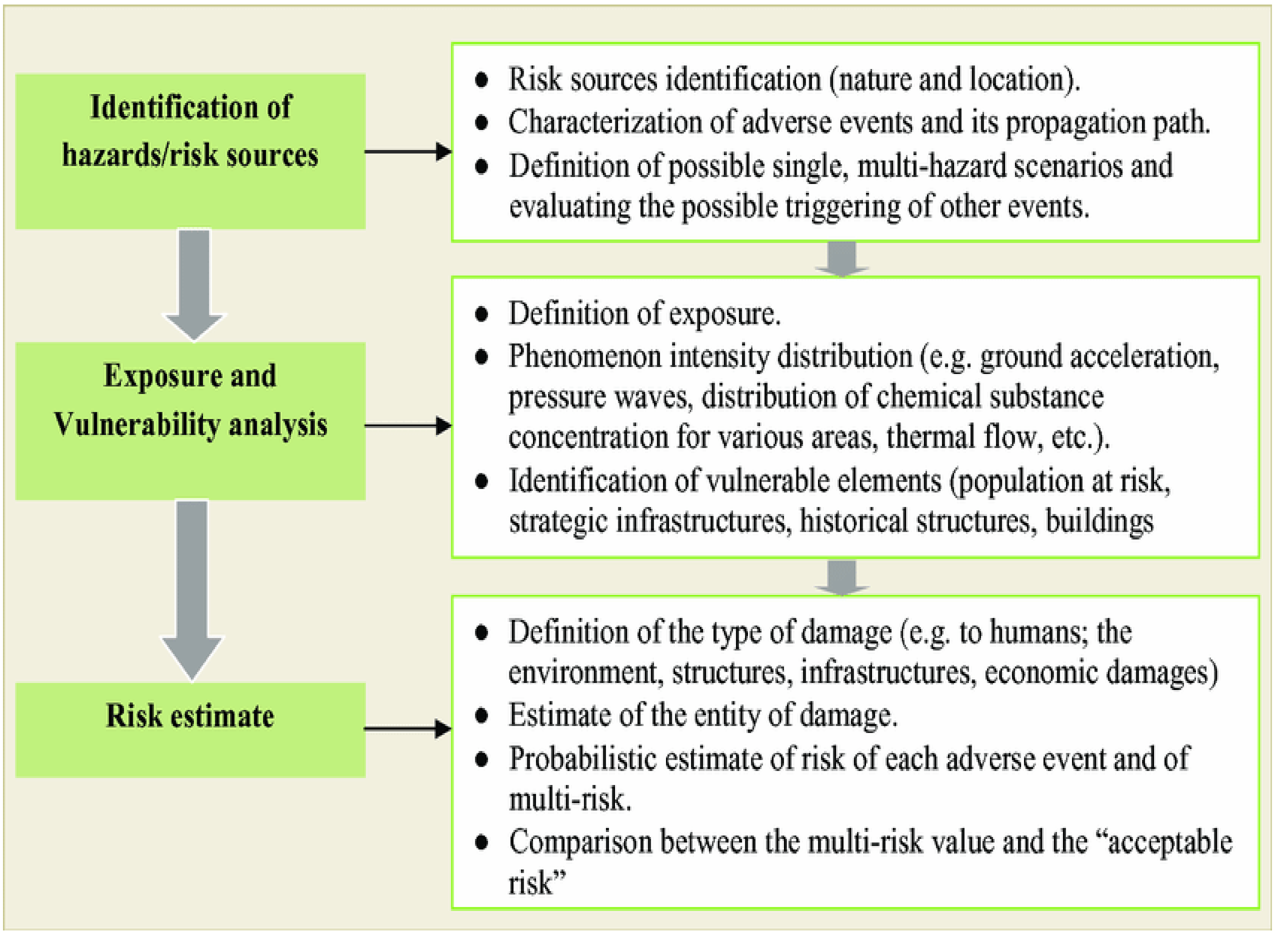




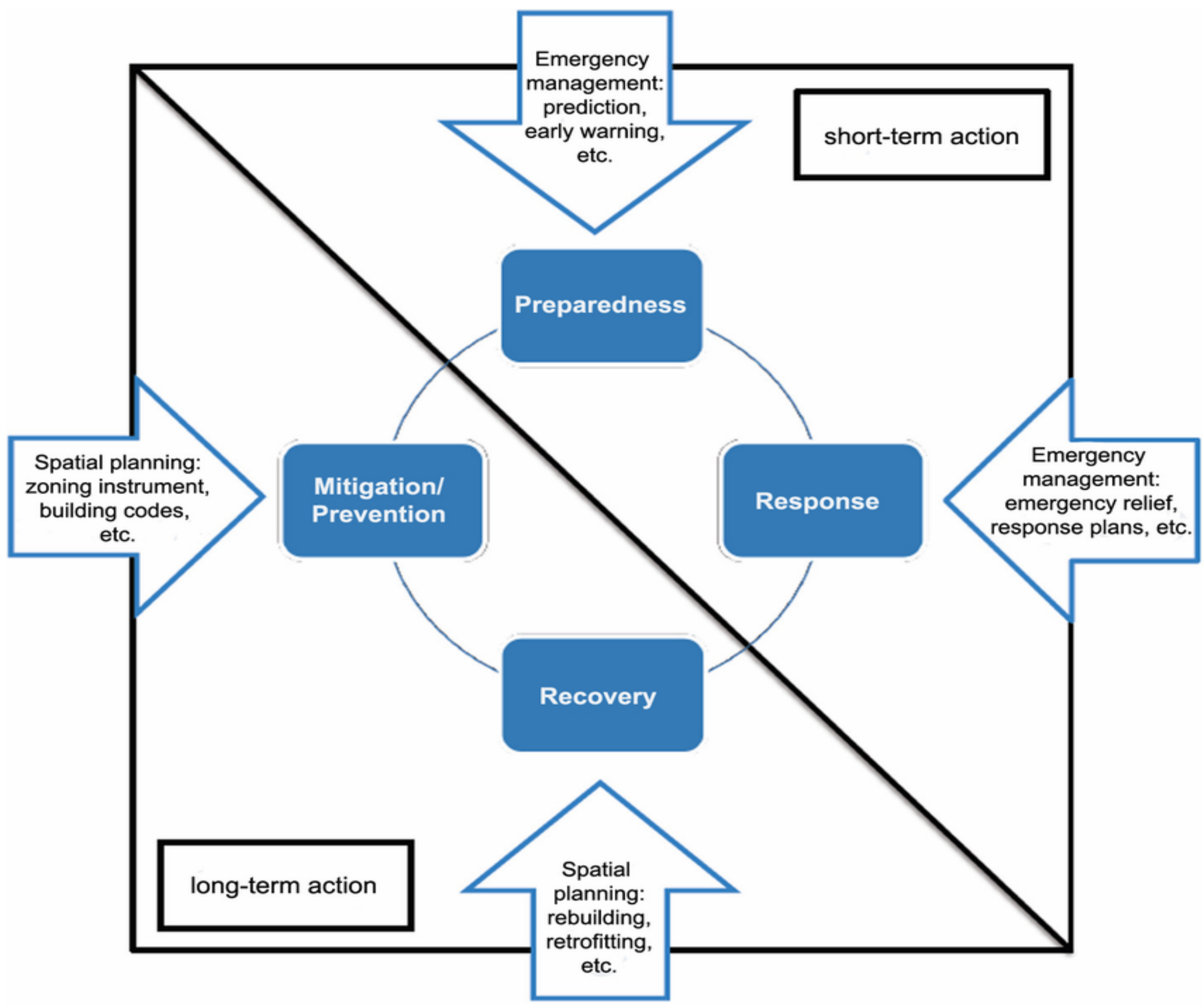
Multi- Hazard Assessment

MULTI-HAZARD assessment is a relatively new concept in civil–structural engineering that deals with loss estimation of different portfolios of structure and infrastructure systems located over an extended geographical area and subjected to multiple natural or accidental/man-made hazards. A multi-hazard approach considers more than one hazard at a given location that takes into effect the possible interrelations between these hazards, including their simultaneous or cumulative occurrence and their potential interactions. Being one of the 10 most disaster-prone countries of the world, India experiences both natural as well as accidental (technical)/man-made hazards, which are initiated most likely due to geoclimatic conditions, topographic features, environmental degradation, population growth, urbanization and industrialization, and nonscientific/non-engineered development practices. Over 25 states and Union Territories (UTs) out of the 36 have been experiencing more than a single natural hazard such as earthquakes, winds/cyclones, floods, droughts, landslides and avalanches, and forest fires for several decades1 (https://nidm.gov.in). According to the National Disaster Management Plan (2019), almost 58.6% of the total area of the country is prone to earthquakes of moderate to very high intensity. More than 75% of the total coastline is prone to gusty wind/ cyclones and tsunamis, whereas ~12% of the land is prone to floods and river erosion (https://ndma.gov.in). In addition to the naturaldisasters, technological/man-made disasters that are caused by chemical, mechanical, civil, electrical or other process failures due to accident, negligence or incompetence have resulted in intense consequences, wherein 130 such incidents have been recorded from 2002 to 2010 in more than 15 states and UTs in India. Moreover, the threats induced by natural hazards have been ranked fourth among the possible 12 threats looming in the country, according to India Risk Survey , whereas terrorism and insurgency is ranked second and fire hazard is ranked fifth. These numbers are quite alarming in the Indian context, where the economy is growing by leaps and bounds compared to other larger/populous countries in the world. In this regard, preparedness and response mitigation strategies for the ever-existing multiple hazards must be devised for site-specific and scenario-based risks, wherein viable holistic technological solutions are required to be developed and implemented in order to build resilient structure and infrastructure systems against such multiple hazard scenarios.


Hazard identification
Identify which natural hazards influence a given area
Hazard interaction analysis
Calculate the magnitude of multiple hazards
Calculate the probability of multiple hazards
Exposure analysis
Identify the elements exposed to these hazards
Vulnerability analysis
Calculate the possible loss for the exposure
Multi-hazard risk curve/map
Draw a curve/map


Identification of hazards/risk sources
Risk sources identification (nature and location).
Characterization of adverse events and its propagation path.
Definition of possible single, multi-hazard scenarios and evaluating the possible triggering of other events.
Exposure and Vulnerability analysis
Definition of exposure.
Phenomenon intensity distribution (e.g. ground acceleration, pressure waves, distribution of chemical substance concentration for various areas, thermal flow, etc.).
Identification of vulnerable elements (population at risk, strategic infrastructures, historical structures, buildings
Risk estimate
Definition of the type of damage (e.g. to humans; the environment, structures, infrastructures, economic damages)
Estimate of the entity of damage.
Probabilistic estimate of risk of each adverse event and of multi-risk.
Comparison between the multi-risk value and the "acceptable risk"

Short term and Long Term Prediction in Hazard Analysis



Short term prediction in hazard analysis:

1) Forecast

2) Early warning

3) Preparedness

4) Tracking/monitoring approach of disaster

5) Alertness/evacuation.

Long term prediction in hazard analysis:

1) Safe construction for houses/strict implementation of safety codes

2) Hazard-proof roads, bridges, canals, water reservoirs, power transmission lines, etc.

3) Flood-protection measures

4) Improvement of warning systems

5) Organizing people for counter-disaster activities.

6)Soil conservation/afforestation in river catchments

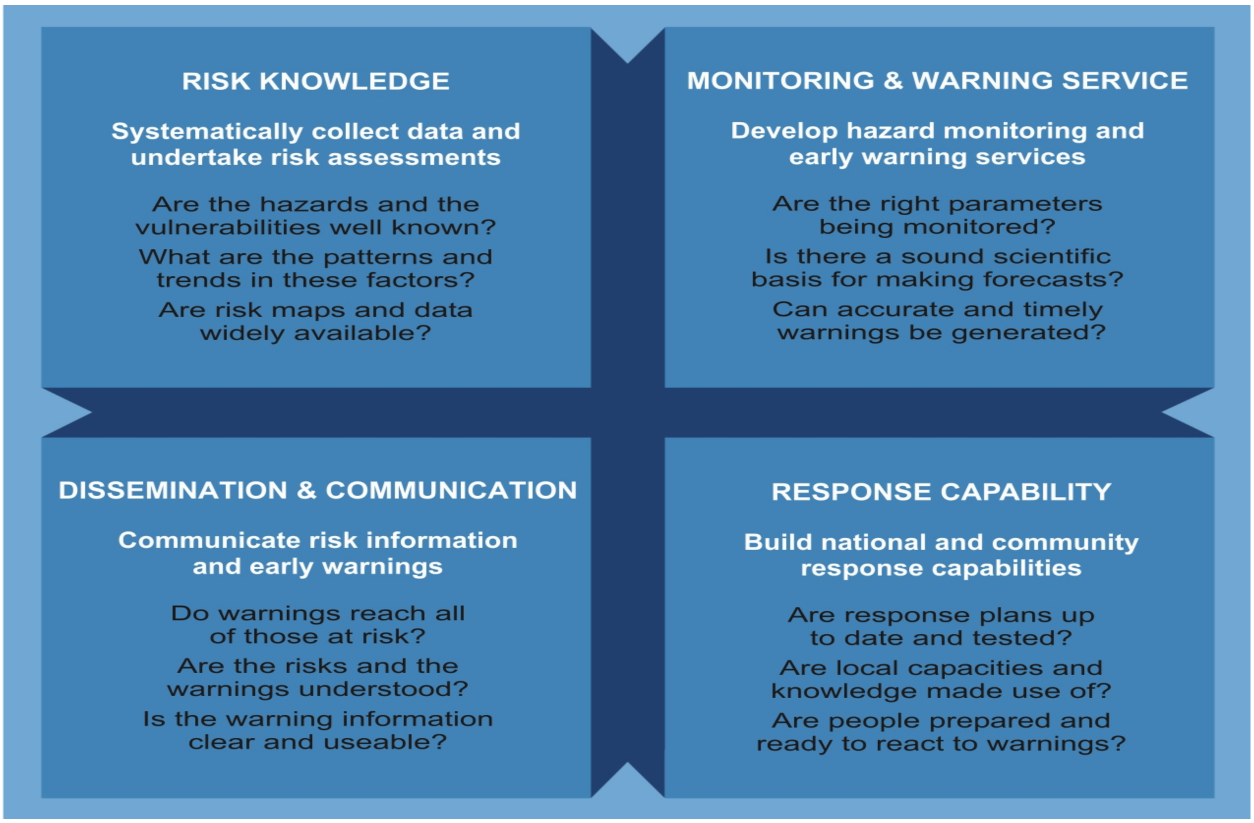
7) Planting shelter belts/mangroves in coastal areas

8) New cropping patterns to minimize crop loss

9) Prevent human settlements in low-lying areas, relocate settlements to safer places.

Early warning system

An early warning system is a warning system that can be implemented as a chain of information communication systems and comprises sensors, event detection and decision subsystems for early identification of hazards. They work together to forecast and signal disturbances that adversely affect the stability of the physical world, providing time for the response system to prepare for the adverse event and to minimize its impact. To be effective, early warning systems need to actively involve the communities at risk, facilitate public education and awareness of risks, effectively disseminate alerts, and warnings and ensure there is constant state of preparedness. A complete and effective early warning system supports four main functions: risk analysis, monitoring and warning; dissemination and communication; and a response capability



1. Disaster risk knowledge based on the systematic collection of data and disaster risk assessments
2. Detection, monitoring, analysis and forecasting of the hazards and possible consequences
3. Dissemination and communication, by an official source, of authoritative, timely, accurate and actionable warnings and associated information on likelihood and impact
4. Preparedness at all levels to respond to the warnings received

Types of early warning systems

There are various ways of classifying early warning systems.

1) **By type of hazard**

Early warning systems have been developed and implemented for:

- Geological hazards like tsunamis, earthquakes, volcanic activity, and landslides
- Hydro meteorological hazards including severe weather in land and at sea, floods, droughts, hurricanes, typhoons and cyclones, tornados, cold and heat waves, etc.
- Forest fires
- Biological hazards including insect plagues like locust outbreaks and harmful algae blooms
- Health hazards including vector-borne diseases, viruses and other types of diseases

2) **By the level at which it is operated**

- Community or people-centred early warning systems, operated at a more local level by a municipal government or a community. The most typical systems of this kind address flood.
- National early warning systems operated by a national-level government agency like a meteorological department, a geological observatory or institute, a health or an agricultural ministry.
- Regional systems operated at a more regional level.
- Global systems operated at the international level by international organizations like the WHO and FAO.

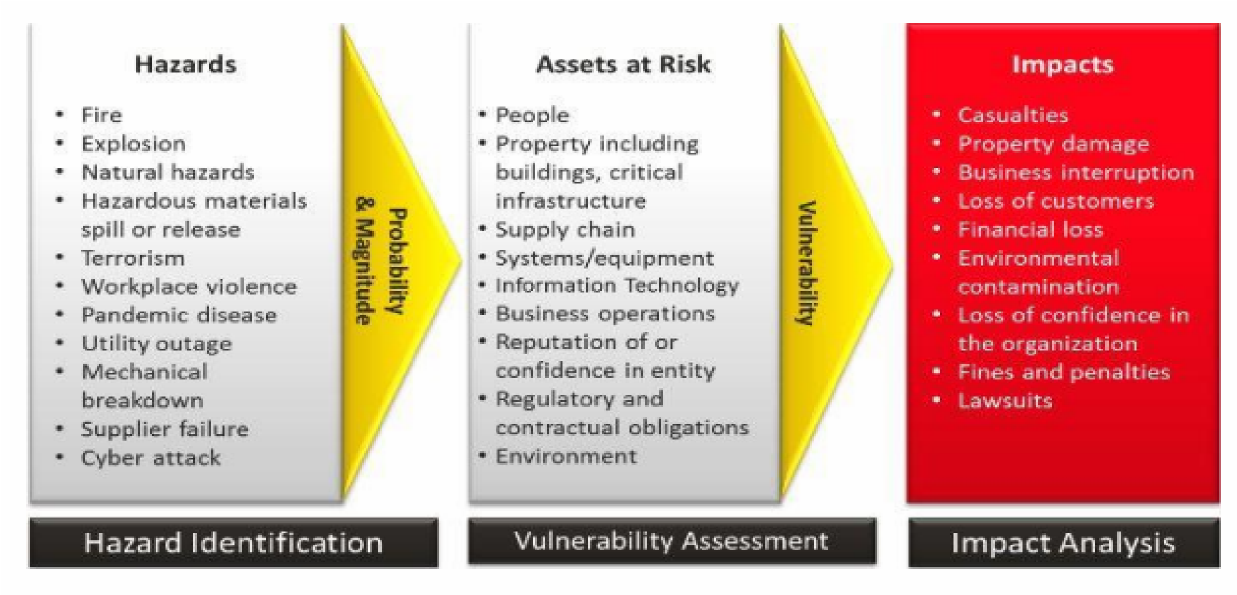
What is a risk analysis?

It defines as a risk , as the probability of harmful consequences casualties, damaged property, lost livelihoods, disrupted economic activity, and damage to the environment resulting from interactions between natural or human-induced hazards and vulnerable conditions. Risk assessment is a process to determine the nature and extent of such risk, by analyzing hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods and the environment on which they depend. Risk assessment, therefore, is an integral part of decision and policy-making processes and requires close collaboration among various parts of society.

Risk assessment is a term used to describe the overall process or method where you:

- Identify hazards and risk factors that have the potential to cause harm (hazard identification).
- Analyze and evaluate the risk associated with that hazard (risk analysis, and risk evaluation).

- Determine appropriate ways to eliminate the hazard, or control the risk when the hazard cannot be eliminated (risk control).



Comprehensive risk assessment consists of the following steps:

1. Understanding of current situation, needs and gaps.

2. Hazard assessment: to identify the nature, location, intensity and likelihood of major hazards prevailing in a community or society.

3. Exposure assessment to identify population and assets at risk and delineate disaster proneareas

4. Vulnerability analysis to determine the capacity (or lack of it) of elements at risk to withstand the given hazard scenarios.

5. Loss/impact analysis to estimate potential losses of exposed population, property, services, livelihoods and environment, and assess their potential impacts on society.

6. Risk profiling and evaluation to identify cost-effective risk reduction options in terms of the socio-economic concerns of a society and its capacity for risk reduction.

Why is risk assessment important?

Risk assessments are very important as they form an integral part of an occupational health and safety management plan. They help to:

- Create awareness of hazards and risk.
- Identify who may be at risk (e.g., employees, cleaners, visitors, contractors, the public, etc.).

- Determine whether a control program is required for a particular hazard.
- Determine if existing control measures are adequate or if more should be done.
- Prevent injuries or illnesses, especially when done at the design or planning stage.
- Prioritize hazards and control measures.
- Meet legal requirements where applicable.

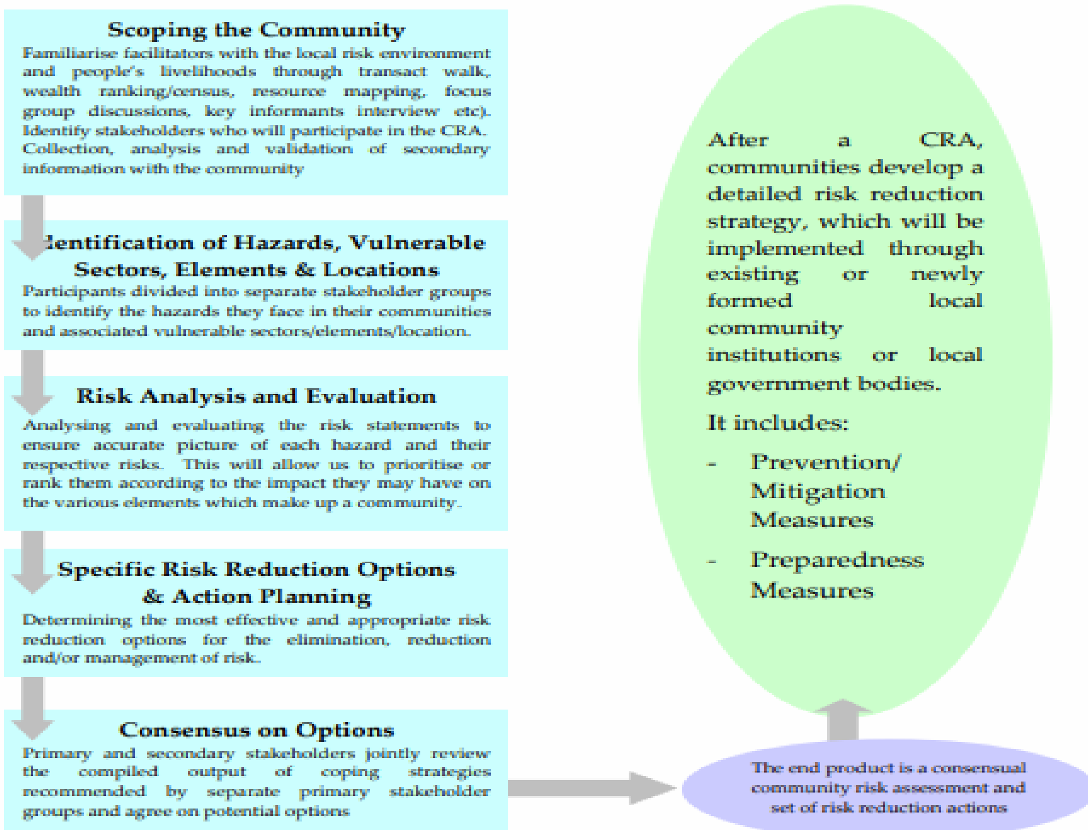
Risk Analysis for Individuals:

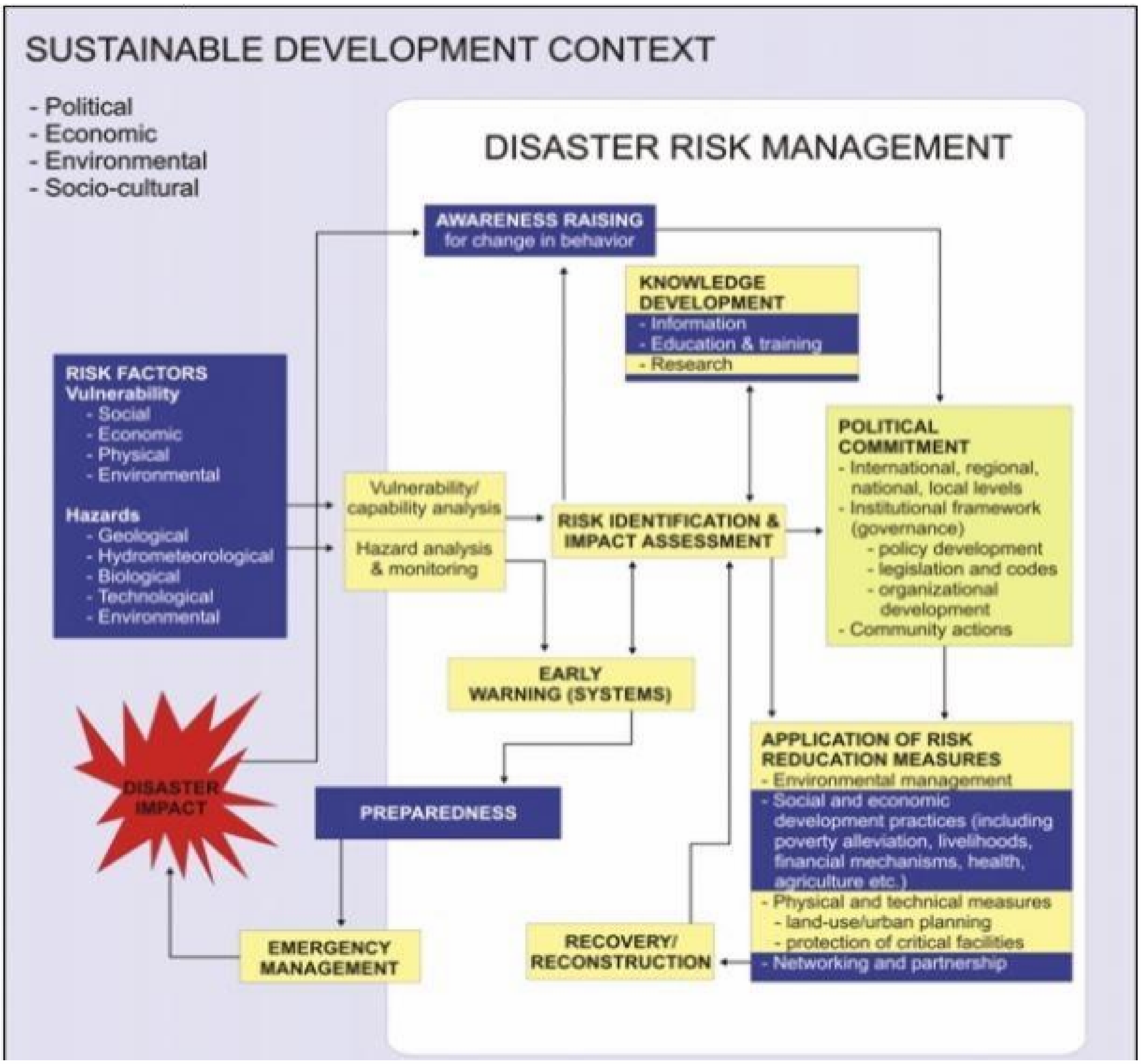
Personal risk assessment is the process by which to identify hazards, define the risks associated with that hazard, and determine the best way to eliminate or control the hazard. Personal risk assessment requires taking a thorough inspection of the workplace in order to identify all of the situations, processes and equipment that may cause harm. Having identified the risks, you then evaluate how likely the risk is to occur and its probable severity. You then make decisions regarding the measures that can be taken to control the harm

Risk Analysis for communities:

CRA (Community Risk Assessment) is a participatory process for assessing hazards, vulnerabilities, risks, ability to cope, preparing coping strategies and finally preparing a risk reduction options implementation plan by the local community. CRA uses scientific information and predictions and participatory discourses to identify, analyse and evaluate risk environment of a particular community, reach consensus amongst the community on actions that are needed to manage the risk environment. The method recognizes that the vulnerability, loss, reduction or mitigation strategy and coping mechanism vary from community to community and group to group (women, person with disability, landless, farmers-fisher folks, etc) of a same community. So it ensures representation of professional, community and other groups and that their points of views are reflected. CRA encourages community participants to respect others' concerns. A flowchart below shows the CRA process sequentially.

Figure 1: Flow chart showing major steps of CRA





Frame work of Disaster Risk Reduction

Role of GIS (Geographical Information System) in disaster management:

Introduction:

Geographic Information System (GIS) is a computer based application of technology involving spatial and attributes information to act as a decision support tool. It keeps information in different layers and generates various combinations pertaining to the requirement of the decision making. In the recent times, GIS has emerged as an effective tool in management of disasters since, geo-spatial data and socio-economic information need to be amalgamated for the better decision making in handling a disaster or to plan for tackling a disaster in a better way. GIS could be utilized by the different line departments and agencies who are stakeholders in the disaster management process. Some basic hardware like computer system, printer, network systems, along with GIS software are required to set up the GIS in any organisation.

Objectives:

The prime objectives of developing the GIS database are to help disaster managers at State, District and Block level for:

i) Pre-disaster planning and preparedness

ii) Prediction and early warning

iii) Damage assessment and relief management

Application of GIS in disaster management

GIS has been effectively used in the following cases as a decision support tool.

1. Identification of location for construction of multipurpose cyclone shelters

2. Grid analysis for setting up the Automated Weather Stations (AWS)

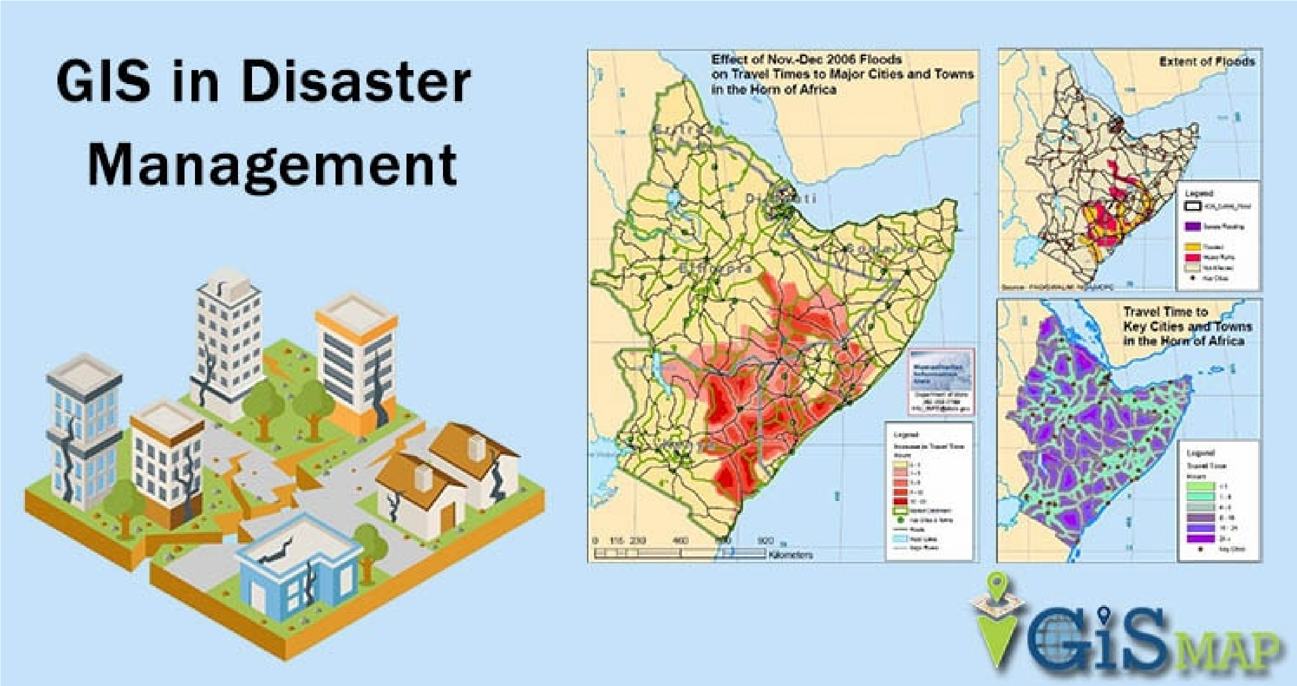
3. Preparation of the district and gram panchayat level vulnerability maps

4. Strengthening of embankment, repair of roads

5. Identification and demarcation of weak points in the embankments, area to be affected by flood for preparedness planning

6. Preparing the base map indicating location and operation of boats and deployment of rescue personnel

7. GIS was extensively used as a part of the Incident Command System and Decision Support System during the Air dropping operations in management of floods in 2007 and 2008



Today, current technology is advancing in various fields, especially in science and technology, while technological advances pose many challenges. We can use technology to artificially adapt and replicate things, but human beings and other living organisms are more important compared to development. Technological advances also increase the likelihood of disasters. A disaster can be a natural or man-made disaster or an accident, depending on several factors. The main factor is climatic conditions due to human activities such as air, water, and soil pollution. Geographic Information System (GIS) technology plays an important role in combating such disasters. Combining geographic information systems with remote sensing and photogrammetry technologies enables the seamless application of this technology at all stages of the disaster management cycle, from mitigation to recovery processes.

» 2. Geographical Information System (GIS)

Geographic Information Systems are systems that process including, store, manipulate, analyze, integrate, and display data. Disaster prediction can be made using a lot of data, which is available in hundreds of thousands of information such as population and their age, gender details, utility service information, land details of the whole state, and so on.

» 3. Disasters

Natural disasters are dangerous events caused by natural processes on earth. An example of a natural disaster is a flood, earthquake, hurricane/cyclone, volcanic eruption, tsunami, and other geological processes. Man-made or anthropogenic disasters are caused by human activities. Anthropogenic disasters adversely affect humans, other organisms, and finally the ecosystems. Examples of man-made disasters include all types of pollution, nuclear disasters, chemical disasters, biological disasters, terrorism attacks, and other accidental disasters.

• 3.**1 Floods** – With the help of Remote Sensing & GIS techniques, floods can be predicted. National Disaster Management Authority (NDMA) & State Disaster Management Authority (SDMA) utilized remote sensing techniques in combination with GIS/Photogrammetric technology for Effective & Economic way management of disasters. GIS technology plays a key role in identifying flood-affected locations and providing shelter for affected people. In addition to that, the suitable places for constructing the retaining wall structures and an alternate route for draining the stormwater. This process also helps to create different levels of vulnerability maps which indicate the areas that are frequently affected by floods and base maps (Gram Panchayat, District) to show the location and setup of boats and the rescue team's plans.

The 3-Dimensional of Flood simulation results will give more strong information to understanding the disaster impacts quickly.

Flash Flood is one type of flood and it is a sudden flood that flushes water paths and is caused by many reasons like Heavy Rain, and melted water from snow/ice on a snowfield. Flash Flood before & after images were shown in Figures 1 & 2 using IGiS (Integrated GIS and Image Processing) software.

• 3.2 Earthquake– It is one of the oldest enemies of humankind and now it is possible to map and analyze earthquakes in a detailed manner. GIS supports national, regional, and local emergency organizations in planning and managing preparatory programs. The GIS-based Urban Information Systems is used to analyze demographic data and infrastructure locations.Remote sensing and GIS Technology provides the exact position of the spatial data of historical sites. The vision of remote sensing and GIS technology is to visualize the critical vulnerabilities & damages and reduce the impact of the disaster. The GIS Technology results could be responded to quickly during the disaster.

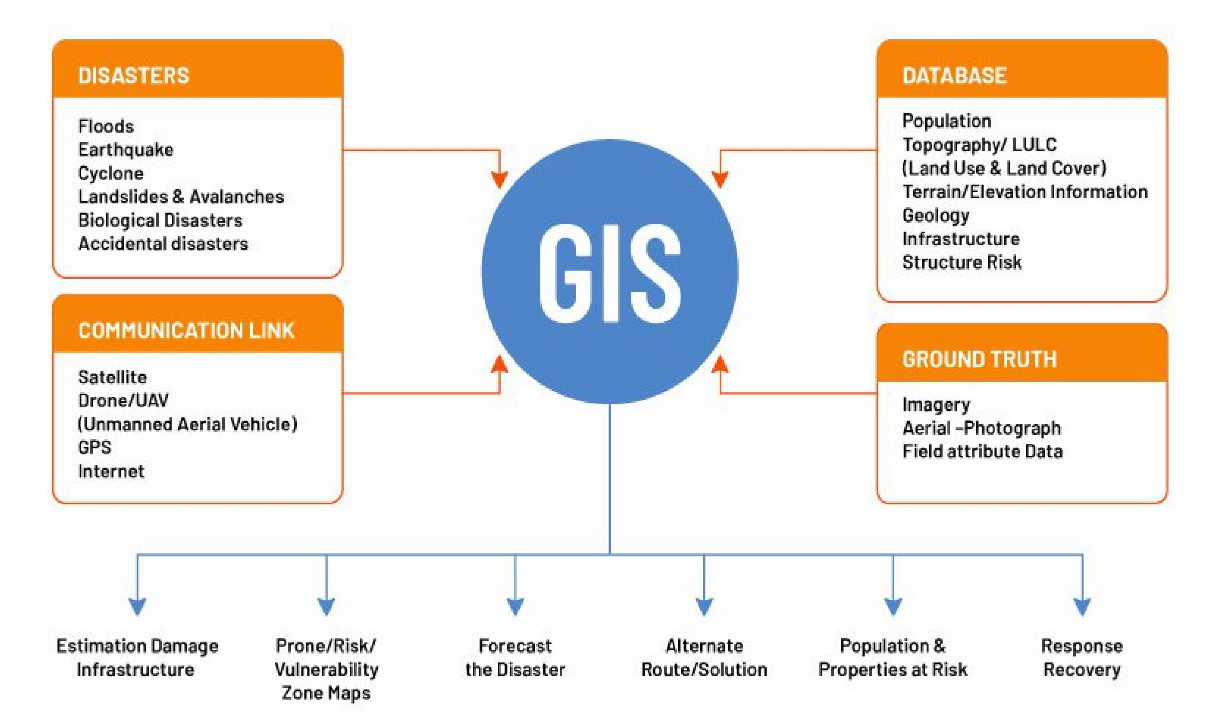
Experience has shown that earthquake deaths can increase due to secondary disasters such as tsunamis and fires. Buffer analysis serves as a good remedy to reduce vulnerabilities to predict the damage that could be caused by a tsunami. The GIS-based Network analysis tool is used to identify the location and routes that provide the fastest response to emergency needs like a hospital, fire station, and so on The real-time location tracking platform or web/mobile GIS-based applications are enabled to interact with the maps which contain the details of the earthquake location & its intensity, health facility, nearby base camp information, and Damage assessment. The GIS-based application also acts as a collective platform for data gathering around the incident of infrastructure damage or fire and information dissemination to relief teams involved in providing aid to those affected by the disasters.

3.3 Cyclone – It is the most destructive force of nature, causing widespread loss. Remote Sensing technology is used to monitor & collect acute information for the entire earth globe concerning the topography and meteorological/climate data. The Temporal data of the same place has become strong and dominant in determining as well as forecasting the natural calamities for the environment & ecosystem protection and development. Similarly, Remote Sensing & GIS technology acting a major role in other disasters like Drought, Heatwaves & Cold waves, Climate Change, and Global Warming & its Effects.

The pollution disasters like air pollution, water pollution, and soil pollution are consequences of climate and Global warming effects. These types of disasters are based on the meteorological conditions of the locations/place.

GIS technology has been vital for emergency preparedness through planning & execution and has saved many lives in previously occurred cyclones. It has improved certain extended limits like environmental understanding, strategic decision making, monitoring of climate change impact, and ascertaining future risks. It is mathematics functional algorithms to analyze the geo-spatial data and display the output in a visual format.

The data is visualized and patterns & their relationships can be identified. Government agencies, as well as NGOs that support disaster management, can benefit from this technology because they know which regions are most affected.



Concluding of Role of GIS in Disaster Management

» GIS technology helps identify disasters before they occur, using forecasts or risk zone maps.

» Remote sensing and GIS technology for Disaster Management create an emergency database for people in need of all assistance in the event of a disaster.

» The emergency database contains information about nearby hospitals, emergency shelters, and more. Disaster risk or impact maps focus on taking corrective action against disasters.

» The GIS Technology is combined with Global Positioning System (GPS), which will help to receive/update the help from disaster rescue teams.

» GIS for Disaster Management uses remote sensing data to forecast climate conditions and climate anomalies at any given point by latitude-longitude coordinates.

» The alternate routes can be created by using Disaster Management technology i.e. GIS for rescuing from disasters.The details of the disaster like the occurred place, severity level, and how many areas are affected & disaster directions all will be mapped using GIS Technology.

» The GIS Maps will give also historical/past disaster events details, from this disaster management action will be taken more strongly.

» The Risk zone map of disasters may reduce the vulnerability of the disasters.

» In the event of a disaster or post-disaster emergency, GIS technology uses a combination of GPS & 5G to enhance assistance.

» Remote Sensing and GIS technology have strong essence to provide the solution to all types of disasters but only the method, and consideration of the factors are different.

So, disasters occur naturally or accidentally and cannot be stopped, but technology can be used to minimize the impact and damage.

Remote sensing: Remote Sensing is the science and art of acquiring information about material objects, area, or phenomenon, without coming into physical contact with the objects, or area, or phenomenon under investigation.

(or)

Remote sensing is the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance (typically from satellite or aircraft). Special cameras collect remotely sensed images, which help researchers "sense" things about the Earth. Some examples are:

- Cameras on satellites and airplanes take images of large areas on the Earth's surface, allowing us to see much more than we can see when standing on the ground.
- Sonar systems on ships can be used to create images of the ocean floor without needing to travel to the bottom of the ocean.
- Cameras on satellites can be used to make images of temperature changes in the oceans.

Some specific uses of remotely sensed images of the Earth include:

- Large forest fires can be mapped from space, allowing rangers to see a much larger area than from the ground.
- Tracking clouds to help predict the weather or watching erupting volcanoes, and help watching for dust storms.
- Tracking the growth of a city and changes in farmland or forests over several years or decades.
- Discovery and mapping of the rugged topography of the ocean floor (e.g., huge mountain ranges, deep canyons, and the "magnetic striping" on the ocean floor).

Types

1. In respect to the type of Energy Resources:

Passive Remote Sensing: Makes use of sensors that detect the reflected or emitted electromagnetic radiation from natural sources.

Active remote Sensing: Makes use of sensors that detect reflected responses from objects that are irradiated from artificially-generated energy sources, such as radar.

2. In respect to Wavelength Regions:

Remote Sensing is classified into three types in respect to the wavelength regions

1. Visible and Reflective Infrared Remote Sensing.

2. Thermal Infrared Remote Sensing.

3. Microwave Remote Sensing.

Advantages of Remote Sensing

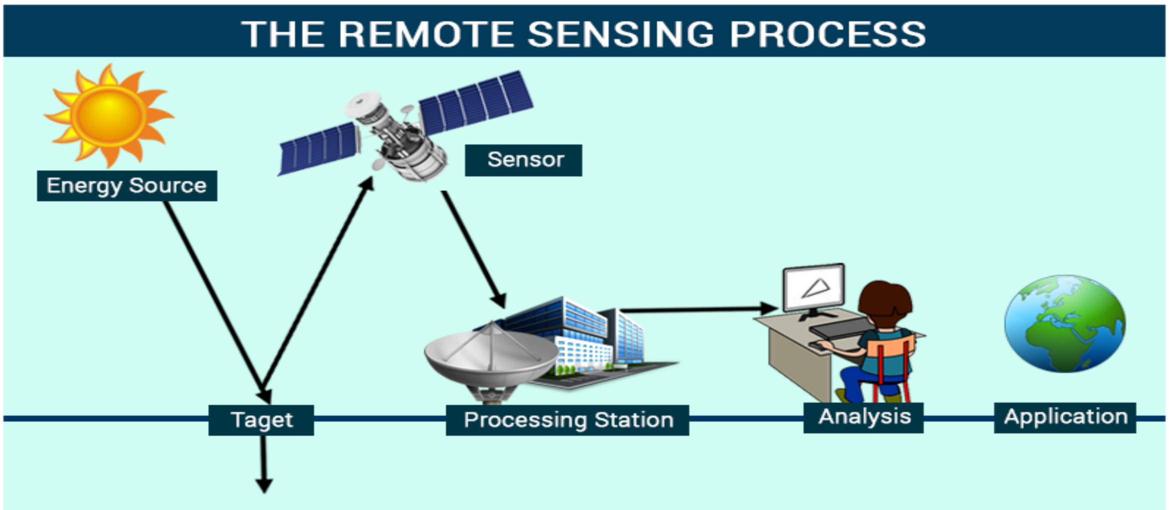
1. A large or wide area can be covered by a single image/Photo. Different Satellites with different sensor systems may cover different extent of areas.

2. We can get the data of any area repeatedly at regular intervals of time, enabling monitoring of changes.

3. Coverage of inaccessible or difficult terrain like mountains, thick forests etc are imaged.

4. Since data is obtained in digital form & in different channels, computer processing and analysis becomes possible.

5. Economic in cost and time.



Role of remote sensing in Disaster management:

Disaster	Response	Preparedness	Mitigation	Recovery
cyclone	Impact Assessment, identifying routes to escape,	Early warning signs, long range climate modelling	Vulnerability Analysis and Risk Modelling	Damage assessment; spatial planning.

	Crisis Mapping, Regular monitoring of cyclones and Storm surge predictions.			
Drought	Assessing the extent of damage, monitoring vegetation	Weather forecasting; vegetation monitoring; crop water requirement mapping; early warning.	Risk modeling; vulnerability analysis; land and water management planning	Informing drought mitigation.
Earthquake	Identifying escape routes, planning routes for search and rescue	Measuring strain accumulation.	Hazard mapping and assessment of building stock	Damage assessment; identifying sites for rehabilitation.
fire	Coordinating fire fighting efforts	Fire detection; predicting spread/direction of fire; early warning	Identifying and mapping fire-prone areas, monitoring fuel load, risk modelling	Damage assessment
Flood	Flood mapping; evacuation planning; damage assessment	Flood detection; early warning; rainfall mapping	Identifying and mapping flood prone areas, delineating floodplains, land-use mapping	Damage assessment. Spatial planning